DISASTER EMERGENCY RELIEF SHELTER

by

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Accepted by
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on Graduate Students

To Birdie, who understands

ABSTRACT

DISASTER EMERGENCY RELIEF SHELTER

David Joseph Kinel

Submitted to the Department of Architecture on May 11, 1973, in partial fulfillment of the requirements for the degree of Master of Architecture.

The recent earthquake in Managua, Nicaragua, is the latest example of the destructive capabilities of nature. Nearly 300,000 people were left homeless when the earthquake flattened over 80% of the city. This is but the latest violent reminder of the potentialities of natural disaster. Man is at the mercy of a capricious environment. For all of his advancements in technology, he still lacks the tools to forecast or mitigate the circumstances of disaster. So he must struggle with after-the-fact disaster contingency plans.

This research then deals with one area of such contingency preparations, namely disaster emergency relief shelter design. One of the most pressing needs following disaster impact is that of sheltering the homeless. This is not only an immediate need, but one that continues for a substantial length of time -- often a year or more. At present, in the United States, there is no adequate guarantee of meeting the interim housing needs following large-scale disaster events. Housing of a temporary or semipermanent type to span the period from mass shelter care to recovery presently cannot be made available in sufficient quantity with any certainty in the short time desirable. This was recently brought to focus in this country when the fury of Hurricane Agnes destroyed over 116,000 homes in June of last year. It was late September before an adequate number of mobile home units were finally provided. This disaster drove home the warning that the shelter industry was incapable under current contingency planning of supplying the large instantaneous demands of large-scale disaster.

This thesis concentrates on the development of performance guidelines for the design of temporary shelter for use during the post-disaster period of situation stabilization. These guidelines have been produced because none existed previously. As an architect, my first desire was to produce a real design for emergency relief shelter. It quickly became apparent that in the absence of any real guidelines, such an attempt would be another shot-in-the-dark approach, and that until such guidelines were to become available, further design attempts would be meaningless. With such in mind, this thesis was undertaken and performance guidelines for temporary disaster shelter were established. These guidelines were the result of research which dealt not only with the investigation of disaster and disaster response, but also with the physiological, psychological, and social needs of the victims, as well as the implications of current technology.

Through a process of investigation and evaluation in each of these areas, a working set of guidelines was developed.

In order to give these guidelines greater relevancy, a process of using, testing, and refinement was undertaken. By means of constructive feedback from a number of qualified officials and by working with these guidelines in evaluating existing and proposed alternative forms of relief shelter, a refinement and reformulation was accomplished.

These finalized performance guidelines represent the end result of this study and are meant to be used as a basis for the initiation of new design as well as for the evaluation of existing shelter systems.

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I particularly thank my advisor, Asst. Professor Arthur D. Bernhardt, whose genuine interest and wise direction, especially in the areas of problem definition and methodology design, helped to bring this work through to conclusion. I am also grateful for the sense of organization which he prompted me to grasp early in the process.

I finally wish to express my appreciation to Mr. William Cosby, Mr. Ugo Morelli, Mr. Roy S. Popkin, and Mr. Robert Berne, who took time from their busy schedules to answer my inquiries, and to assist me in evaluating the results of my work through their comments and criticisms.

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<u>Headings</u>:
- B&R: Books and Reports
- P&J: Periodicals and Journals
- P&D: Pamphlets and Documents
- BIB: Bibliographies
- REF: Reference Material

SECTION I

INTRODUCTION

1. STATEMENT OF PROBLEM

1.1 DISASTER: CONSEQUENCES AND RESPONSES

Natural disasters have caused destruction and suffering throughout the world on a fairly regular basis since recorded history began. Thus far, man has been unable to prevent such unfortunate occurrences. He has, however, developed a science and technology that allows him to predict somewhat their coming and the course they will likely follow. In addition, procedures and resources have been established to deal with the post-disaster situation from rescue through recovery. In this country, these actions are primarily provided and coordinated by the federal government through its various agencies and also by other private and public relief organizations. Federal agencies such as Civil Defense, the Army Corps of Engineers, the Office of Emergency Preparedness, and many others participate in rescue and recovery as well as in advanced preparation. In addition, the American Red Cross and the Salvation Army fulfill many coordinating and service functions necessary to survival and relief. There have been established over the years a set of procedures and standards for responding to emergency disaster situations, depending on the type, scope, and area of impact.

One serious consequence of natural disaster is the destruction of housing and personal property, often on a major scale, creating the need for short- or long-term emergency shelter alternatives for large numbers of displaced persons. The current strategy is to relocate evacuees, homeless, and injured in temporary mass shelters (usually hastily set up in large public buildings such as schools, town halls, auditoriums, armories, etc.) until some semblance of order has been returned to the community and the threat of further danger has subsided. As many as possible are then returned to their own homes, or to the homes of relatives or friends, or relocated temporarily in vacant housing stock, or in hotels and motels. In some cases of widespread destruction of housing stock, mobile homes have been brought into the area to be used as temporary semipermanent housing until the community can be repaired or rebuilt.

1.2 PHYSIOLOGICAL AND PSYCHOLOGICAL PROBLEMS OF MASS SHELTER RESPONSE

There are numerous psychological and physiological problems attendant to this course of action. These include: 1) overcrowding and the lack of privacy and the confusion that is inevitable; 2) the institutional character of mass shelter; 3) the splitting up of families, friends, and relatives; or at the very least, the difficulty of resuming normal family relations in such an atmosphere; 4) the disruption of the activities which normally occur in such buildings, or at least, the serious impairment of their efficiency in carrying on their duties; and 5) the tendency to rely on such shelter arrangements for protracted lengths of time, exposing the victims to the increased likelihood of group tensions. These problems which arise are not intentional, rather they are unfortunate consequences of the stop-gap system which has been developed to deal with emergency situations.

1.3 THESIS OF RESEARCH

It is the thesis of this research paper that perhaps the traditional response to natural disasters with respect to the particular problem of providing relief shelter should be re-evaluated in an effort to determine if, in fact, the previously stated problems might be eliminated or at least mitigated to some degree if another sort of shelter response were developed. One immediate observation is that under the current scheme, agencies and organizations, many of which have also been charged with relief shelter activities in time of war or civil disturbance, are planning and providing shelter to meet natural disaster needs. There seems to be some conflict of goals. These groups rely on a type of approach that appears by its very nature to concentrate more on the survival aspects of shelter than on the return-to-normal possibilities that such shelter might represent. The emphasis seems to be on life rather than living, on house rather than home. The differences are subtle but important.

Since architecture is a field that concerns itself with the physical as well as the spiritual and asethetic qualities of shelter, and since the architect plays an important part in the designing and planning of normal housing stock, it would seem then, that some investigation should be made as to his possible role in the planning of disaster relief shelter also. Thus, perhaps an architectural approach to the problems of relief shelter design and implementation might provide an interesting and illustrative comparison to traditional relief shelter programs. It is with this thought in mind that this paper has been undertaken. The desire is for relief shelter that is more responsive to user needs, both physically and spiritually.

In no way is this study meant to imply that there do not now exist mechanisms and means of helping people to meet their shelter needs in natural disaster situations. What this study hopes to make clear is that perhaps there do exist, or can exist, more desirable alternatives to protracted stays in mass public shelters, or the practice of doubling-up with friends or relatives as is presently done. Simply stated, perhaps the whole relief shelter problem can or should be dealt with in a more dignified and compassionate manner than is currently the practice.

1.4 RESTRICTIONS ON RESEARCH

Such a re-evaluation as I have just suggested would require an undertaking of a scope and magnitude beyond the resources of one person and one study. Therefore the area of primary study will have to be restricted, and necessary limitations placed on the avenues of research.

First, tremendous differences in culture, climate, geography, and standards of living throughout the world necessitate the restriction of this research to the consideration of one specific region and one specific culture.

Second, there exist a myriad of possible disaster situations. Since this research deals exclusively with shelter needs, only those types of natural disaster which damage or destroy large segments of housing stock and which are likely to occur in the region under study will be considered.

Third, disasters may strike in any type of area: urban, suburban, or rural. The consequences can be entirely different in terms of shelter needs, however. Therefore, the types of areas under study must be carefully considered and specified.

Fourth, disaster recovery involves several consecutive phases, each of which involves changing needs and resources. A choice as to research concentration must be made in this regard.

Fifth, in a disaster situation, there are shelter needs for various groups including elderly, children, single persons, and families. It will be necessary to restrict this study to the investigation of the shelter needs of one such group specifically.

Sixth, disaster presents a whole score of social, political, and economic ramifications. This study has neither the requisite time nor capacity to deal with this scope and intent in a rigorous manner. It shall, however, attempt to identify and briefly discuss those aspects which have a very specific influence upon the objectives.

2. STATEMENT OF OBJECTIVES

2.1 PRIMARY OBJECTIVE

As previously stated, the intent of this study is that traditional methods of providing for the emergency shelter needs of people in disaster situations need to be re-evaluated and reformulated so as to better meet the physical and spiritual requirements of the displaced victims. In accordance with this intent, the primary objective of this research will be to develop, test, and consequently refine a set of performance guidelines for the design of emergency relief shelter meant for use during the post-disaster periods of stabilization and recovery.

2.2 SUB-OBJECTIVES

Pursuant to this major objective is a group of sub-objectives that are to be dealt with in a sequential order. These interim objectives are:

1) to establish a basic understanding of the process of natural disasters and their consequences as specifically related to the shelter problems which they create.

2) to determine the physiological and psychological needs of the victims during the post-disaster recovery period.

3) to investigate the technologies available and suitable to the problem of providing suitable relief shelter.

4) to develop a preliminary set of performance guidelines for relief shelter design.

5) to test these performance guidelines by submitting them to a number of key officials in organizations which have a special interest and expertise in dealing with disaster problems, and to utilize their feedback for modification and refinement.

6) to investigate alternative forms of relief shelter, both existing and conjectural, and then to evaluate their effectiveness and desirability on the basis of the refined guidelines.

7) to further revise the guidelines by utilizing the working

experience gained in step #6 as an additional means of evaluation and criticism.

2.3 SCOPE OF RESEARCH

The nature of this research necessitates that these objectives be dealt with in accordance with certain imposed limitations. The reasons for these limitations will become apparent in the discussions in the main text of this paper. These limitations include:

First: this research is restricted to shelter design for use within the continental United States.

Second: this research is based on providing relief shelter for use in four types of natural disaster: floods, earthquakes, hurricanes, and tornadoes.

Third: this research will concern itself strictly with disaster relief in moderately populated regions, namely suburban and town-type areas.

Fourth: this research shall address the more immediate periods of life-sustaining and situation stabilization following the impact of natural disaster, leaving the final long-term recovery period to the traditional methods which seem fairly adequate.

Fifth: this research shall address the shelter needs of the family unit.

Sixth: this research shall consider social, political, and economic factors only in terms of their effect upon the development of the performance guidelines.

3. STATEMENT OF METHODOLOGY

This study is primarily a research-type endeavor. It is carried forth with the idea of involving the architect to a greater degree in an area where his knowledge and expertise may enable him to make a meaningful contribution, but where thus far, "traditional" methodologies have prevailed.

The plan of attack is to arrive at the overall major objective through a process of considering smaller sub-objectives in a sequential manner. The whole is derived from the parts. This pursuit can be broken down into several basic stages:

3.1 COLLECTION OF PERTINENT INFORMATION

This stage involves the gathering of information necessary to the research. Three types of approaches were used -- field research, correspondence, and library research.

A) Field Research: Personal discussion concerning disaster relief shelter/housing with key governmental agency officials in Washington DC, and attendance of a trade exposition in Chicago presented by the manufacturers of one broad area of shelter to be investigated in this research.

B) Correspondence: Communication with a number of groups and agencies from the international and national, as well as the public and private sectors, which deal with disaster and disaster relief. In addition, correspondence was conducted with a number of companies which either produce disaster relief-type shelter, or have developed systems which possess the potential for such use.

C) Library Research: Extensive library research was undertaken of disaster-related literature including books and reports, periodicals and journals, pamphlets and documents, and relevant bibliographies. Use was made of both university and public library facilities.

3.2 DEVELOPMENT OF PERFORMANCE GUIDELINES

Development of specific performance guidelines for the design of emergency relief shelter. Digesting and weighing all inputs from the previous research to establish such an initial working set of guidelines.

3.3 TESTING AND REFINING PERFORMANCE GUIDELINES

By soliciting criticisms and comments from a number of individuals with a wide range of disaster-related backgrounds, a process of evaluation and modification shall commence. This process shall be furthered by the experiences gained in identifying and analyzing potential shelter alternatives. The feedback and insight gained through these dual approaches shall be used to reformulate the initial guidelines into a final form.

SECTION II

BACKGROUND MATERIAL: DISASTER IN THE UNITED STATES.

1. PROLOGUE

The prime intent of this research is to develop a more effective approach for dealing with the problems which man must face in trying to recover from the disruptive effects of natural disaster. An attempt will be made to collect and to analyze information concerning the real needs of people in the post-disaster situation. Methods will be considered for meeting these needs. The hope is that not only will communities be better able to restore their pre-disaster situations, but moreover, that they might be able to use the disaster as a vehicle for re-evaluation and for the implementation of desired improvements and necessary changes. The emphasis will be upon studying the shelter needs arising from disaster, since these are of paramount importance to the welfare of the victims themselves; but more significantly, because they provide the potential necessary to recover/develop the spirit of family and community that are requisite to restoration and growth.

As a beginning, the background of natural disaster in the United States will be considered. This will provide the necessary basis for understanding, and the subsequent rationale for proceeding.

2. DEFINITION OF DISASTER

One of the best definitions of disaster is that given by John Walker Powell in a 1954 report of the Psychiatric Institute, University of Maryland:

> "Disaster means the impinging upon a structured community of an external force capable of destroying human life or its resources for survival, on a scale wide enough to excite public alarm, to disrupt normal patterns of behavior, and to impair or overload any of the central services necessary to the conduct of normal affairs or to the prevention or alleviation of suffering and loss. Usually, the term disaster refers to an episode with tragic consequences to a substantial portion of the population." (P&J:7,p.2)

Another definition, given from a slightly different perspective is that offered by A. F. C. Wallace, a pioneer in disaster behavioral study:

> "Situations involving the threat of, or experience of, an interruption of normally effective procedures for reducing certain tensions, together with a dramatic increase in tensions, to the point of causing death or major personal and social readjustment, may be called 'extreme situations'. Such situations may occur in almost any social context or in connection with, any felt need, and may involve a single individual or a whole population. We are concerned here with extreme situations affecting groups of people; such extreme situations, especially when they involve injury or death, are often called disasters." (B&R:2,p.1)

These definitions are fairly complete except that they neglect the important time elements of disaster. Disaster of either natural or human origin has three distinct sequential time periods -- warning, impact, and recovery.

3. THREE PERIODS OF DISASTER

3.1 WARNING

In the warning period, events occur which give rise to the likelihood of disaster. This period may involve a reasonable time span, but typically involves only a very short time, often hardly enough for sufficient preparation. During this time, the extent, duration, and course of the disaster can only be speculated. Experiences in prior emergencies are often the only guides of what to expect. In the warning phase, preparations can be made to withstand or to retreat from the onslaught of the disaster. Little can be done presently in the areas of prevention and mitigation. Technologies that would allow man to stave off the events which are to transpire have yet to be developed, if, in fact, they are possible at all. Man's best tools thus-far, are those of prediction.

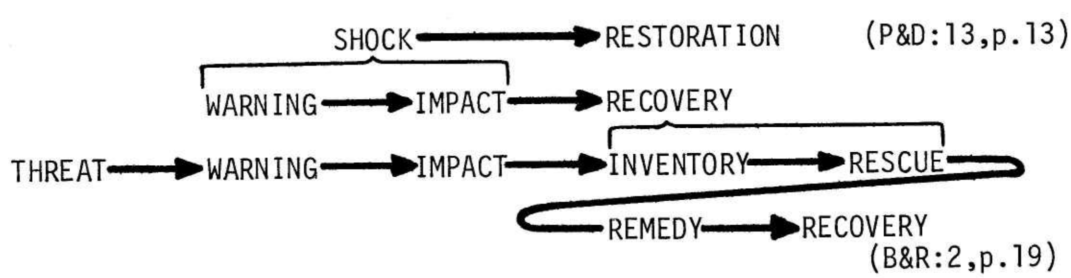
3.2 IMPACT

During the impact period, man simply has to 'sit-it-out' and try to survive. Natural disasters frequently run their course in a very short time, sometimes minutes, and then abruptly end. After the impact, it is usually safe to come out of protective shelters and get on with life. For example, tornadoes and hurricanes are normally of fleeting duration in any one particular area, while earthquakes though similarly short-lived, are sometimes accompanied by a number of after-shocks which continue for a number of days, prolonging the danger and complicating the damage. Still other disasters such as floods typically build up over a period of days or weeks, then crest and subside over a similar period. Man-made disasters, on the other hand, have an impact period that often depends on the whims of man himself. Wars can last for years. Civil disorders can flare-up abruptly and end just as quickly, or smoulder and re-emerge.

3.3 RECOVERY

Finally, the recovery period begins when the impact period ends. Recovery commences only after the danger of further impact has disappeared. In this period, the short-run emphasis is on life-saving and situation stabilization, while the long-term emphasis is on the attempts to restore life to the quality it possessed prior to disruption. This period offers real challenges and opportunities to man -- challenges and opportunities of which he is often unaware, or unprepared to manipulate to their full advantage. Recovery is a very positive experience which follows directly on the heels of a very negative experience. There is the opportunity not only to rebuild, but to build anew; to structure and restructure. Not only can material things like built-form and services be re-evaluated and re-instituted, but also non-tangible things like relationships and attitudes can be rediscovered, reformulated, or developed. Unfortunately, this opportunity is often missed, as in the case of Europe, following World War II.

Numerous authorities have developed their own 'periods' of disaster, varying from 2 periods to 7 periods, but basically these are just abridgements or expansions of the three that have been considered:



In light of current practices, a disaster situation can be pictorially graphed to appear as shown in illustration #1 on page 33. However, in light of the opportunities for reassessment and redevelopment which disaster can provide, such a graph could hopefully appear as similar to that shown in illustration #2 on the same page. In this situation, a new higher level of life could be established in the recovery process. The aim should not simply be to re-establish the original order, but rather to attempt to surpass it. I feel that this is an extremely important point which should be stressed in all disaster considerations.

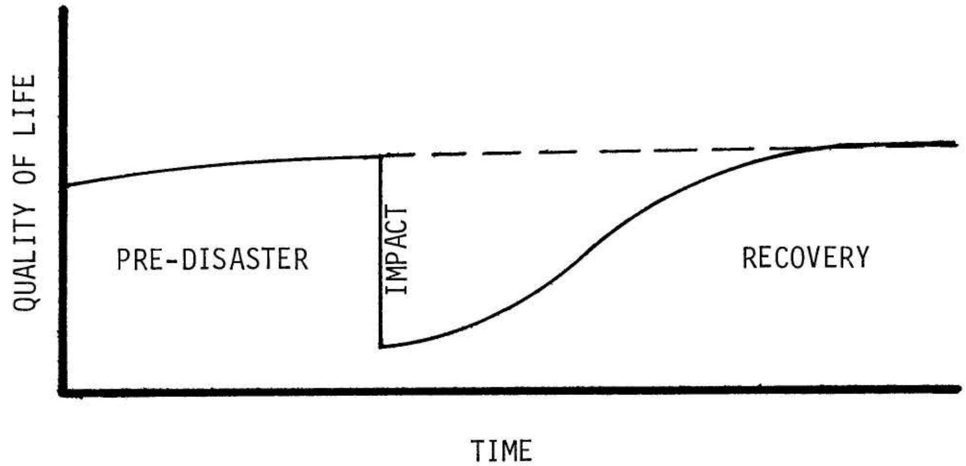


ILLUSTRATION #1

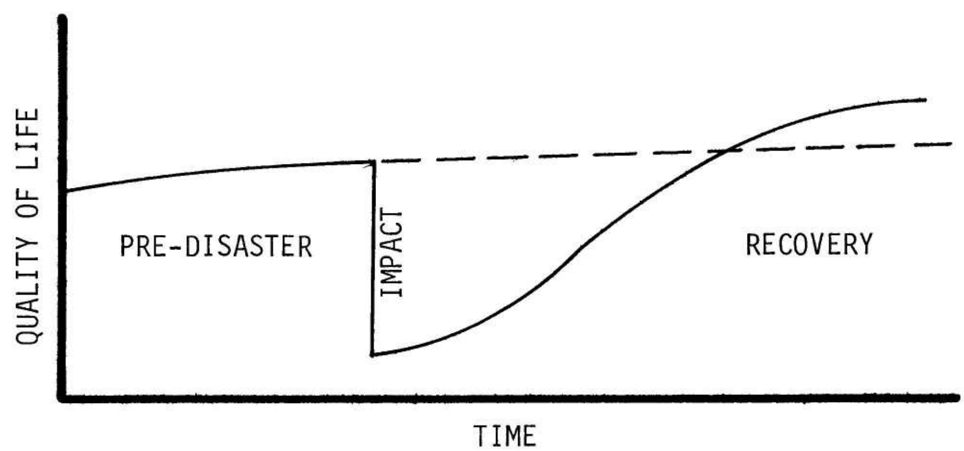


ILLUSTRATION #2

4. DISASTER TYPES

In order to understand exactly what disaster means, methods of classification of various disaster types are important. Disasters possess two easily identifiable traits -- their motive force and their physical characteristics.

4.1 MOTIVE FORCE

Disasters occur because something precipitates them. There are two such causal agents -- man and nature. Disasters in which man is the precipitating cause will not be considered in this research. Disasters caused by man are of an entirely different scope than those caused by nature. In the former, hate, greed, and power often determine the course of events and the extent of physical and psychological suffering, as well as the length of duration. Man's inhumanity to man is a much more difficult thing to cope with than nature's vagaries. In a real sense, natural disaster is a much nobler and much easier situation to deal with than that which originates with the actions of man. "Natural disasters are no respecters of status or privilege. Rich and poor alike are struck . . ." (P&D:14,p.6) Nature is much fairer it would seem. Natural disaster has the potential of evoking love and unity between men as they struggle to rebuild. Disaster brought on by actions of man will always leave lingering shadows of hate and distrust.

4.2 PHYSICAL CHARACTERISTICS

4.2.1 Primary Threats

There are a number of ways of viewing the physical characteristics of disaster. Of primary concern are the nature, frequency, severity, and effects of the occurrence. We are only interested in studying those types of natural disaster which are of sufficient frequency and severity so as to be a constant potential threat, and which by their nature are capable of inflicting a great deal of suffering and destruction upon man and his environment. In the United States, there are four primary natural disaster types which present this sort of constant potential threat. These are: hurricanes, tornadoes, earthquakes and floods.

4.2.2 Physical Effects

Table #1 on page 38 summarizes the Red Cross disaster experience from 1925-1955 and illustrates the major impact that these four types of natural disaster have had in the United States. Especially important in this study is the concern for the number of homes destroyed or damaged, and the number of families suffering losses. It must be remembered that while some disasters such as fires and explosions took their toll in suffering, these types of disaster are often of human origin and occur in a large number of smaller isolated cases that in total add up to a large amount of suffering and damage. Because of this, these are not of real concern in a study dealing solely with large-scale natural disaster. Table #1 gives a good indication of the severity of the four types of disaster being considered, and a vague notion as to their frequency.

As a further measure of frequency and severity, table #2 on page 39 charts the incidences of more recent major disasters occurring between 1954 and 1965. This table does not include a listing of the more recent disasters through 1973. Especially prominent in such a listing would have been the 1972 impact of Hurricane Agnes, for which a final damage estimate placed public and private destruction at $2.5 billion with 118 deaths. (P&D:11,p.21)

The United Nations Disaster Relief Office in its World-Wide Summary of Disaster Impacts, 1947-1970, lists nearly 8,000 deaths due to natural disaster in the United States during that 23 year period. Of these 8,000 deaths, a total of 4,500 were the result of hurricanes, tornadoes, earthquakes and floods. During this period, the U.N. lists a total of 210 disaster impacts for the United States. This averages to about 40 deaths per disaster impact. (B&R:62,pp.9,10)

Table #3, on page 40 lists property loss and loss of life due to the four principal types of disaster being considered. This table deals with the period from 1925 to 1965. One significant observation is that earthquakes are the least threatening in terms of loss of life and extent of property damage in this country. (B&R:16,p.6) In the world-wide experience, however, earthquakes are the number one agent of destruction.

The preceding compilation of statistics should present sufficient justification for limiting this study to four principal types of natural disaster in the United States, namely: hurricanes, tornadoes, earthquakes, and floods. The frequency, severity, and nature of their effects make them a constant threat to man and his environment. Furthermore, these statistics give only an overview of the suffering and destruction caused by natural disaster. A more thorough listing of probable effects includes the following: 1) death and injury; 2) damage and destruction of housing stock; 3) damage and destruction of commercial/industrial facilities; 4) interference with services, including communication, transportation, and utilities; and 5) ecological damage. In the post-disaster recovery period, efforts are aimed at restoring the first four of these consequences to as near the pre-disaster situation as possible. It is unfortunate that in this process, the fifth consequence -- ecological damage -- is often ignored or given much less attention. However, present concern for the quality of the environment may help to reverse this oversight. Environmental ecology is of the utmost importance if a community is ever to return to normalcy, or to become an attractive and healthy place in which to live, from both a physiological and psychological point of view.

TABLE #1

DISASTER EFFECTS BY TYPES OF DISASTER: RED CROSS EXPERIENCE
1925-1955

Type of Disaster	Number of Fatalities	Number of Injured	Homes		Families Suffering Loss
			Destroyed	Damaged	
Hurricanes	3,644	15,516	23,200	324,259	522,111
Tornadoes	6,117	46,681	31,094	93,510	155,474
Other Windstorms	137	1,368	1,172	74,788	128,915
Floods	2,125	16,098	29,608	492,823	1,068,552
Flash Floods	409	9,494	1,837	50,892	91,940
All Other Storms[a]	103	1,289	201	31,004	86,359
Explosions	4,288	8,702	499	7,392	17,893
Fires	3,289	16,433	8,045	2,113	52,329
Wrecks	2,797	7,153	88	24	9,343
Other Disasters[b]	335	11,488	2,019	34,718	14,632
Total	23,244	134,222	97,763	1,111,523	2,177,548

[a] Snowstorm, hailstorm, cold weather, dust storm, electrical storm, etc.

[b] Earthquake, landslide, draught, structural collapse, epidemic, etc.

(P&J:7,p.13)

TABLE #2

MAJOR DISASTERS -- 1954-1965

DISASTER	MONTH/ YEAR	REGION	DAMAGE ($ MILLION)	DEATHS
Hurricane Carol	9/54	Northeast	456	60
Hurricane Hazel	10/54	Southeast	232	94
Hurricane/Floods Diane	8/55	Northeast	832	180
Northwest Flood	12/55	Western	193	74
Hurricane Audrey	6/57	Southeast	150	390
Hurricane Donna	9/60	Southeast	360	60
Hurricane Carla	9/61	South Central	431	46
Great Atlantic Storm	3/62	Northeast	245	33
Ohio Basin Floods	3/63	Ohio Valley	98	26
Alaska Earthquake	3/64	Western	311	115
Pacific Northwest Flood	12/64	Western	462	45
Upper Mississippi Floods	4/65	North Central	140	16
Palm Sunday Tornadoes	4/65	North Central	200	247
Colorado and Kansas Floods	6/65	Western	405	16
Hurricane Betsy	9/65	Southeast	1420	89

(B&R:16,p.12)

TABLE #3

LOSS OF LIFE AND PROPERTY DAMAGE IN THE UNITED STATES DUE TO HURRICANES, FLOODS, TORNADOES, AND EARTHQUAKES -- 1925-1965

GEODETIC SURVEY: U.S. DEPT. OF COMMERCE

PROPERTY LOSS IN MILLION $ DUE TO

Years	Hurri-canes	Floods	Torna-does	Earth-quakes	Total	Total In 1964 Prices*
1925-29	133	495	95	8	731	1550
1930-34	51	76	44	40	211	563
1935-39	314	966	39	4	1333	3327
1940-44	222	481	60	7	770	1537
1945-49	298	133	126	34	1291	1953
1950-54	802	1680	331	65	2778	3619
1955-59	539	1695	209	16	2459	2842
1960-64	1576	1151	207	405	3339	3409
1965	1420	788	500	13	2721	2667

LOSS OF LIFE DUE TO

Years	Hurri-canes	Floods	Torna-does	Earth-quakes	Total
1925-29	2114	579	1944	13	4650
1930-34	80	146	1018	117	1361
1935-39	1026	783	921	4	2734
1940-44	149	315	835	9	1308
1945-49	67	304	953	8	1332
1950-54	217	293	885	15	1410
1955-59	660	498	523	34	1715
1960-64	175	242	230	115	762
1965	75	119	299	3	496

(B&R:16,p.6)

5. IMPACT OF NATURAL DISASTER ON MAN

In order to determine what the response should be to natural disaster in terms of recovery, it is important to focus on the real effects of disaster on man himself. Tables and statistics give an overview of the problem, but a much closer look is necessary. There are three main areas of suffering to consider -- physiological, material, and psychological. These considerations shall provide the groundwork for the remainder of this study.

5.1 PHYSIOLOGICAL SUFFERING

When one has been through a disaster experience, a number of physiological complications may result either directly, due to the destructive forces of the disaster, or indirectly, because of the deprivation of necessary life-sustaining resources. There are three levels of physiological suffering -- death, injury, and loss of life-sustaining systems. The most severe physiological consequence is death. For that there is no remedy. For injury, there is first-aid and hospitalization if necessary. The shelter-less make up the largest class of victims. While they are generally uninjured, or only slightly so, their dilemna consists of finding the means to cope with their immediate physical needs. They must find alternate ways of providing the life-sustaining functions which they are no longer in a position to provide for themselves.

> ". . . clearly the objective is the survival of all or a maximum proportion of the population. Are these goals realistic and acceptable to the public? As they are stated, these goals would undoubtably rank, for the great majority of Americans, at the top of their hierarchy of values. Perhaps more important, what sacrifices are the people willing to make to obtain these goals? Would they be willing to evacuate their cities and subsist for a time on roots and berries in the woods? How much

> inconvenience will they tolerate? How far back are they willing to turn the clock of medical progress in order to survive? It is important that such questions be answered, because in deciding on the means to be proposed, it is necessary that the means as well as the goals not clash violently with value system of the affected public. Previous field studies of disasters would indicate that the survival goal is of such over-riding value that almost any inconvenience is tolerable. . . Perhaps the question boils down to: For how long a period of time will people tolerate what kinds of inconvenience bolstered by what kind of expectation of return to normalcy? . . . Past field studies of disaster offer few answers to these and similar questions." (B&R:1,pp.45-46)
>
> (emphasis by this writer)

Of most importance to sustaining life are: 1) protection from the elements; 2) provision of means for maintenance of body temperature; 3) protection from epidemic and disease; and 4) provision of adequate nourishment. These functions are essential to survival. They must be provided in order to prevent sickness or further deaths.

In disaster situations, these important life-sustaining functions are usually provided by the Red Cross and Civil Defense agencies which utilize surviving public and private buildings as make-shift temporary mass shelters. The mass shelter concept is employed because it is currently the only tried-and-tested means of providing such emergency relief quickly to large numbers of victims. In a letter received from Mr. Roy S. Popkin, the Assistant National Director of Disaster Services of the American National Red Cross, he described the lack of real alternative systems for meeting these emergency needs:

> "However, I don't think anyone has come up with a completely satisfactory design that combines weather-resistance, insulation against heat or cold, easy transportability, life-support systems (water, gas,

electricity, sanitation) and basic functional equipment."

5.2 MATERIAL LOSS

In addition to physiological suffering, there is also the personal material loss that results from disaster. These consist principally of possessions, shelter, and income. Possessions and income are of less immediate importance to man's survival, but they are of extreme importance to his eventual recovery. As previously shown, loss of shelter presents immediate physiological survival problems that must be met with temporary emergency shelter. Loss of possessions can cause discomfort and despondence, but do not threaten man's survival. Insurance will often restore much of that which has been lost in terms of shelter and possessions, but this usually requires a certain period of time for the claims to be processed, damage to be estimated, and the goods and services to be made available once again within the impact area. The poor, however, generally lack insurance and suffer the most in these terms. Loss of income can result because of either the loss of the breadwinner due to death or injury; the destruction of the industrial/commercial facilities and resources which provided employment within the area; the loss of one's own business; or the abandonment of the area by local businesses and industries which choose to suspend operations and begin anew elsewhere. Unemployment compensation, welfare, etc., can provide a subsistence level of income, yet offer no real hope for recovery of the pre-disaster way of life. In order to insure the recovery process, attempts must be made to restore income-producing resources as quickly as possible within the impact area.

5.3 PSYCHOLOGICAL SUFFERING

Finally, the most subtle and yet the most potentially dangerous form of suffering is psychological. This is the most difficult to deal with since it involves a field of knowledge that is as yet, theoretical at best. It is easy to overstate the case of psychological suffering, yet at the same time, it is important not to underestimate it. As a basis, M. V. Layman has developed a set of hypotheses concerning the social-psychological impact of disaster. These hypotheses are supported by a convincing variety of research:

> "I.) Residents of a community which has experienced a severe disaster will be more social-psychologically maladjusted than residents of communities which have experienced less severe or no disasters.
>
> II.) Those individuals who have experienced stress because of a disaster will be more social-psychologically maladjusted than those individuals who have not experienced stress because of disaster.
>
> III.) Those individuals who have experienced the most stress in a disaster will be more social-psychologically maladjusted than those individuals who have experienced the least stress in disasters." (P&J:11)

These hypotheses are logical and straightforward and are a good foundation on which to expand. In order to build upon this foundation, it will be necessary to consult a number of disaster research studies. A very calm and reasoned attempt to present a realistic picture of the psychological aspects accompanying the aftermath of natural disaster is presented by E. L. Quarantelli and Russel R. Dynes, two pioneers in disaster behavioral study:

> "Because of the frequency, vividness, and potential significance of such events, a number of widespread

> stereotypes have developed about behavior in disaster. The popular image of disaster has often centered on the theme of personal and social chaos. Such an image is frequently documented by isolated anecdotes used to prove the universality of such behavior. This image suggests that individuals panic and that individuals lose their concern for others in their immediate social scene. . . .
>
> This image of disaster behavior is widespread, reinforced by popular literature, through the mass media, and occasionally by studies assumed to be scholarly. More careful research does not support this image. In general, research suggests that after recognizing danger, the behavior of people is adaptive, aimed at protecting their families, and others, and themselves. Panic is infrequent and does not occur on a mass scale. Disaster victims act positively, not irrationally or passively. Mutual help and self-help are frequent. Psychological disturbances do not render the impacted population helpless. Much of the initial work is done by the victims themselves, who do not wait to be told what to do. Contrary to the public image, movement toward the impact area is more significant than movement away. Those who converge on the impact area do present problems, but their actions are usually motivated by anxiety for those in the area, by a desire to assist victims, and by a need to understand what happened, rather than by exploitation. Authenticated cases of looting are extremely rare. While disasters create personal and community problems, they do not result in chaos. The individual and the community are confronted with new and unfamiliar tasks under difficult and threatening conditions. What people have learned about social life in the past is not suddenly discarded, however.
>
> The social networks which ordinarily sustain people do not disintegrate into the social jungle which disaster stereotypes imply. The pre-disaster social networks become the basis -- indeed, the central core -- of the efforts to cope with the disaster." (P&J:22)

Nevertheless, a number of people do exhibit behavioral irregularities following disaster. A disaster syndrome is frequently referred to in disaster studies and has a supporting basis for its psychological behavior description. This documented behavioral syndrome can affect numbers of victims for various lengths of time.

> "The disaster syndrome is a psychologically determined defensive reaction pattern. During the first stage, the person displaying it appears to the observer to be 'dazed,' 'stunned,' 'apathetic,' 'passive,' 'immobile,' or 'aimlessly puttering around'. This stage presumably varies in duration from person to person, depending on circumstances and individual character, from a few minutes to hours; apparently severely injured people remain 'dazed' longer than the uninjured, although this emotionally dazed condition is no doubt often overlaid by wound shock. The second stage is one of extreme suggestability, altruism, gratitude for help, and anxiousness to perceive that known persons and places have been preserved; personal loss is minimized, concern is for the welfare of family and community. This stage may last for days. In the third stage, there is a mildly euphoric identification with the damaged community, and enthusiastic participation in repair and rehabilitation enterprises; it sometimes appears to observers as if a revival of neighborhood spirit has occurred. In the final stages, the euphoria wears off, and 'normally' ambivalent attitudes return, with the expression of criticism and complaints, and awareness of the annoyance of the long term effects of the disaster. The full course of the syndrome may take several weeks to run." (B&R:13,p.109)

> "The precipitating factor in the disaster syndrome seems to be a perception: the perception that not only the person himself, his relatives, and his immediate property (house, car, clothing, etc.) have been threatened or injured, but that practically the entire visible community is in ruins." (B&R:13,p.127)

The psychological outcome of disaster depends on the nature of the disaster itself, the nature of the victim, and the type of help he receives in coping with the situation.

> "No doubt many factors having to do with the nature of the disaster enter into determining the psychological outcome for a stricken population.
> 1.) Whether sudden and unexpected (e.g. earthquake or atom bomb) or preceded by a warning and a time

> for preparation (e.g. hurricanes); 2.) The duration of the threat, whether short-lived or prolonged (e.g. explosion or epidemic); 3.) The nature of the damage, whether primarily to property or to human life (e.g. hurricane vs. epidemic); and 4.) Whether the disaster is natural or the result of the hostility of other men (e.g. earthquake or atom bomb). Perhaps, even more important in determining the outcome for a population and community in the crisis of disaster is what happens during and after the fact, what measures are taken to help people protect themselves and their property, and what is done later to help them recover and reorganize." (P&D:14,p.1)

Literature and research dealing with the psychological aspects of disaster suggest a number of definite types of psychological suffering that are induced by the impact of disaster. These include:

1.) The trauma brought about by the very occurrence of the disaster.

> "Most persons who directly experience a disaster who are closely identified with the victim population suffer some form of emotional or psychosomatic aftereffect in the early post-disaster period." (P&J:7,p.47)

2.) The anxiety for lost relations and friends.

> ". . . many symptons arise out of such situational factors as fear for the safety of self and intimates, separation of family members . . ." (P&J:7,p.47)

3.) The suffering caused by the injury or death of a loved one.

> "A sense of failure during a crisis may haunt some individuals, especially if they suspect others died or suffered unduly because of their own inadequacies." (P&J:7,p.158)

4.) The confusion resulting from an unfamiliar predicament.

> ". . . he has been deprived of the instrumentalities by which he has manipulated his environment; he has been, in effect, castrated, rendered impotent, separated from all sources of support, and left naked and alone, without a sense of his own identity, in a terrifying wilderness of ruins." (B&R:3,p.127)

"Severe personal loss of family or possessions may so dislocate a person that continuing problems after the disaster will tend to overwhelm him." (P&J:7,p. 158)

5.) Despair for the future.

". . . many symptons arise out of such situational factors as . . . anxieties concerning the future . . ." (P&J:7,p.47)

6.) Feelings of helplessness.

". . . that when the objects with which the individual has been identified are threatened, damaged, or destroyed, the individual (not sure of his own capacity to survive unaided) becomes anxious to assure himself that the whole supporting world has not collapsed." (P&J:27,p.22)

7.) Religious implications.

"The sight of a ruined community, with houses, churches, trees, stores, and everything wrecked, is apparently often consciously or unconsciously interpreted as a destruction of the whole world." (B&R:3,p.127)

Many of these psychological and emotional disturbances give rise to psychophysical effects. For example, in a study of persons who survived the impact of a tornado in Arkansas, some ninety percent reported "some form of acute emotional, physiological, or psychosomatic aftereffect". In many instances (53%) the physiological-psychosomatic effects lasted a day or longer as well as the psychological problems (72%). Some such disturbances included:

	% of Respondents Reporting
Nervousness, excitability, hypersensitivity	49%
Sleeplessness or poor sleep	46%
Inability to concentrate	37%
Loss of appetite	29%
Headaches	19%
Anxiety dreams, nightmares	18%
'Dazed,' confused condition	14%

Also: nausea, soreness or stiffness of muscles,
and general malaise. (P&J:15,p.34)

Also, "Thyroid disease is occasionally precipitated by the stress of disaster. Rates of actual insanity are not increased by even prolonged disasters . . ." (P&J:7,p.158)

The possibility of disaster-induced mental illness appears to be rather remote according to a number of studies, yet the problem is not fully understood and bears further investigation. In the book Man and Society in Disaster, a number of such studies are reviewed:

> "In overwhelming disasters, the impoverishment of the interpersonal and physical environment will lead in the long run to perceptual and cognitive difficulties classifiable as mental illness. Fortunately we do not (yet) have any instances of disaster on such a massive scale. (Soloman et.al. 1959) . . .
>
> It is probably fair to say that we know comparatively little about the long-run mental health consequences of disaster experiences. At least one observer (Leighton, 1959) has identified disaster as a background factor in community disintegration, with the implication that the mental health level of a given community is likely to be adversely affected by disaster . . .
>
> It is probable that special attention should be given to the family group in disaster-related mental health and illness. All accounts (e.g. Fritz and Williams 1957) stress the significance of family ties, the vigorous searching behavior of separated family members, the heightened interaction and solidarity within the family. Just as deprivation (e.g. bereavement) in the family system is seen as a pathogenic implication of disaster, so the strengthening of family bonds may be one of the chief counteracting forces to disaster-induced illness, . . .
>
> The very nature of the phenomena of disaster is then reminiscent of one's worst fear - the nightmare that turns into reality. It is the uncanny, the schizophrenic-like, some to life. The first and most poignant necessity is to find some formulae for putting the disaster into some frame of

> reference. We cannot stay long sane and view disaster of catastrophic proportions without trying to fit it into some explainable framework . . ." (B&R:1,pp.128-133)

It is my feeling that the whole question of dealing with the psychological problems arising from the aftermath of natural disaster can best be summed up in the following way:

> "In spite of the remarkable ability we find in the majority of human beings to recover psychologically from the commoner disasters, it is obviously advantageous to accelerate this recovery whenever possible. Restoration of contact with the immediate situation and its possibilities is the crux of psychological first aid." (P&J:7,p.158)

One final postscript can be added to the question of disaster induced mental illness. Some interesting and timely information concerning the psychological consequences of Hurricane Agnes in Pennsylvania is just now beginning to come forth. For instance, in the county of Wyoming Valley which includes Wilkesbarre, one of the hardest hit cities by Agnes in the June of 1972 (70,000 homes destroyed), a number of revealing statistics are currently being compiled. After nine post-Agnes months, the area is still in serious straits in terms of housing and clean-up. In addition, there are a number of significant developments. During this past nine-month period, admissions to area mental hospitals are up 33%, mostly schizophrenic related cases; suicides are up 50%; and drug use has skyrocketed 162%! Also, it seems that older people, those over 55, are having an especially difficult time in adjusting to the situation. Deaths in this age group have risen sharply. Finally, young marrieds are having a number of marital problems which are thought to be caused by the cramped and temporary mobile home living accommodations which they have been forced to use for an extended period. (Source: CBS Evening News with Walter Kronkite, 6:30 PM, April 13, 1973)

6. FACTORS INFLUENCING THE SCOPE OF DAMAGE AND DESTRUCTION

6.1 TYPE OF DISASTER

When disaster strikes, its impact can range from mild to severe, from harmless to devastating. There are a number of factors which influence the scope of damage and destruction. Of primary importance is the type of disaster, and the level of development within the impact area. Other factors such as time of year, time of day, and extent of preparedness are of secondary importance.

Different natural disaster types have varying characteristics, and consequently, a wide range of effects. Tornadoes, earthquakes, hurricanes, and floods vary extremely from one-another in a number of important respects, including: physical description, agent of destruction, frequency, severity, duration, and probable area of impact. In disaster terminology, there are two basic types of natural disaster: instantaneous-focalized, and progressive-diffuse. Tornadoes and earthquakes are two examples of instantaneous-focalized disaster. They occur suddenly and without warning, and are usually confined to one region. Hurricanes and floods are two examples of progressive-diffuse disasters. They normally involve a period of warning preceding impact. Their impact is characterized by a progressive worsening of conditions over a fairly widespread region.

6.1.1 Instantaneous Focalized

TORNADOES

Description: A tornado is a violent rotary storm of usually small diameter, accompanied by a funnel-shaped cloud around which the winds revolve spirally in an upward, counter-clockwise manner. This vortex cloud is like a "monstrous rotary mower" that moves along its course in contact with the ground, occasionally rising and falling, leaving some sections along its path unscathed, and others obliterated. Most tornadoes move from the Southwest toward the Northeast, veering to a more northerly course as they die out. (B&R:32,pp.70-71) When tornado storm conditions are present, a number of tornado funnels may be spawned by the same system and travel somewhat in unison causing destruction along a number of parallel paths. Tornadoes form over land and therefore are always a threat to man. Modern methods allow tornado warnings six hours or more before they occur.

Motive Force: Wind: within the vortex, high rotational wind speeds cause a partial vacuum capable of uprooting trees and buildings. (B&R:32,p.72)

Frequency: Tornadoes are primarily a seasonal occurrence. They generally form in the warm rainy seasons of spring and summer.

Severity: The paths of tornadoes are usually fairly short, with alternate sections of touching down and rising up. Tornadoes rarely cut a swath more than 15 miles long, yet paths as long as 293 miles have been recorded. (Illinois, 1917). (B&R:32,p.70) The width of a tornado's path may vary from as narrow as 9 feet to as wide as a mile, but on the average is about 250 yards. Rotational wind speeds within the funnel are in the range of 200 to 500 mph. (B&R:32,p.71) These winds are even more violent than those of hurricanes, making the tornado the most violent of small storms.

Duration: Tornadoes move with an average speed of about 40 mph. usually in a straight line. Thus, the duration of impact is generally quite short -- less than an hour. But, tornadoes have been known to make complete U-turns or complete circles and return to ravage the same area a short time later. However, this is not a frequent occurrence. Tornado systems usually last only a few hours, before they have spent their fury, and diminish to mere thundershowers.

Area of Impact: Tornadoes strike primarily in the central portion of the continental United States, especially in the areas around Kansas, Nebraska, and Missouri. Tornadoes also strike, though less frequently in the East and South. The far West is virtually free of tornado disturbances. A detailed map of tornado distribution in the United States can be found on page 58, illustration #3. A similar map, of a more general nature, is found in illustration #6 on page 61.

EARTHQUAKES

Description: Earthquakes are a vibratory ground-shaking caused by a sudden disturbance of natural origin within the earth. These vibrations are elastic waves which travel at high speed through the earth. Such shocks occur many times daily, but only a small proportion are of sufficient magnitude to be felt. There are two primary types of earthquake causes: tectonic and volcanic. In the continental U. S., tectonic earthquakes are the only real danger. These earthquakes are caused by the sudden release of strain by slippage along a fault or line of dislocation in the outer part of the earth. (REF:1,pp.649-650)

Motive Force: Earth-borne shock waves.

Frequency: Earthquakes can occur during any period. There is no real means of prediction. Since the inner portion of the earth is constantly under stress, earthquakes are a constant threat.

Severity: Earthquakes vary in severity from mild tremors that are barely felt and cause virtually no damage to large disturbances such as the San Francisco earthquake of 1906, in which the San Andreas fault broke for a distance of some 270 miles on the surface, with a maximum displacement of 21 feet. (REF:1,p.650) The largest earthquakes are sometimes felt as far as 1,000 miles from the source.

Duration: Earthquakes usually last for only a few minutes. However, aftershocks or secondary earthquakes sometimes accompany larger disturbances, and are felt periodically for the next several days. They are frequently more of a frightening nuisance than of a destructive threat.

Area of Impact: Earthquakes occur primarily in areas of substrata geological faults. These are spread throughout the U. S., with high seismic risk areas in parts of California, Nevada, Washington State, Montana, Idaho, Utah, Illinois, Missouri, Kentucky, Tennessee, Arkansas, S. Carolina, and areas of New England. (P&D:8,p.10) A more detailed mapping is presented in the seismic risk map, illustration #4 on page 59, and in the general map found in illustration #6 on page 61.

6.1.2 Progressive Diffuse

HURRICANES

Description: A hurricane is an intense storm, as yet not fully understood, which erupts suddenly in the tropics and moves in a northerly direction with high winds and torrential rains which can cause widespread destruction and flooding when it passes over land. Since hurricanes are spawned far away from the U. S., they can be monitored for a number of days before they become a threat to the continental areas of this country, and warnings of several days or more are often possible. In the northern hemisphere, these hurricanes move with a counterclockwise motion, and appear as "a rotating disk of cloud, rain and wind, with a cylindrical tower about the center which spews air out the top as high as 60,000 feet above earth. The center, or 'eye' of the hurricane often contains no clouds." (B&R:32,p.21) Hurricanes may have as many as 3 eyes.

Motive Force: Wind and rain: heat and water vapor provide the energy by which the whirling storm is maintained.

Frequency: Hurricanes are seasonal storms occurring primarily in the summer, but known to spawn as early as January. Each year, a handful of hurricanes form, but only a few reach dangerous proportion and threaten land areas.

Severity: Hurricanes sweep out a generally circular area, varying in diameter from as small as 50 miles, to as wide as 500 miles. (B&R:32,p.21) The average is usually up to 100 miles. Wind speeds vary from 75 to 125 mph, with speeds up to 200 mph on record. (P&D:8,p.10) Thus, due to their large area of impact, intensity of wind, and volume of rainfall, this type of storm is the most violent of all large storms.

Duration: Hurricanes generally move with a speed of 15 to 40 mph. (P&D:8,p.10) Thus, their duration is generally measured in hours, sometimes as much as a day in any one particular area. Hurricanes have been known to 'stall' over one area for longer periods of time, but this is infrequent. In time, usually within a couple of weeks at most, the hurricane has spent its major fury and degenerates to a mere thunderstorm system which is relatively harmless.

Area of Impact: In the United States, the incidence of hurricanes is almost exclusively along the Atlantic coast and the Gulf of Mexico region, although some, like the recent Agnes (1972) have surged inland as far as Pennsylvania and Ohio. (P&J:7,p.5) For a more thorough listing, see the illustration #6 on page 61.

FLOODS

Description: Flooding describes the overflowing of normally dry areas, often after heavy rains. Flooding usually results along natural water basins such as rivers and streams, when the influx of water due to heavy rains or spring thawing is of such a magnitude, and occurs with such a speed, as to cause the water to back-up and rise over its normal boundaries and to flow into areas that are not normally submerged. The blockage of waterways by large masses of ice can also cause flooding in surrounding areas upstream. The collapse of dams, such as occurred in South Dakota in 1972 is another way in which flooding can invade normally dry areas.

Motive Force: Water: large rainfall, the melting of snow and ice, the blockage of rivers or streams, or the collapse of water-holding reservoirs precipitate flooding.

Frequency: Flooding can occur at almost any time of year, but spring is the most frequent season. Normally heavy spring rainfalls and the thawing of winter's ice and snow are prevalent in springtime.

Severity: Flooding is one of the most damaging forms of disaster in terms of property damage. There is little that man can do to combat rising waters. The forces involved are astronomical. Flooding can extend for hundreds of miles along major waterways and flood plains, and extend for many miles in width. Many areas of flooded low-lands can pock-mark a region, making it virtually impassible, disrupting transportation and utilities, as well as forcing evacuation of homes and farms, even whole towns.

Duration: Flood waters can rise over a period of days or weeks, then crest for a period of days, and finally begin to recede over a similar period of weeks. Floods can cause damage, inconvenience, and danger for periods ranging to a month or so. Post-disaster clean-up operations take months, or even years to complete.

Area of Impact: Flooding is a real threat throughout the country, with the exception of the dry South-West. Large river flood basins, such as those of the Ohio, Missouri, and Mississippi are especially susceptible to wide-scale flooding on a fairly regular basis. (P&J:6,p.77) A map of estimated flood losses for various regions of the U. S. can be found on page 60, in illustration #5.

6.2 TYPE OF IMPACT AREA

As previously stated, the type of natural disaster is not the only consideration in determining the extent of damage and destruction. The level of development within the impact area is also extremely important. It is analogous to the age-old question of whether a noise made in the middle of a woods where there is no one there to hear it makes a sound at all. Natural disaster that occurs where there is no built form or people really then isn't a disaster at all, but rather a natural process. In this country, there are three principal areas in which disaster might occur -- rural, suburban/town type, and urban. Disaster will have differing effects in each type of area.

6.2.1 Rural

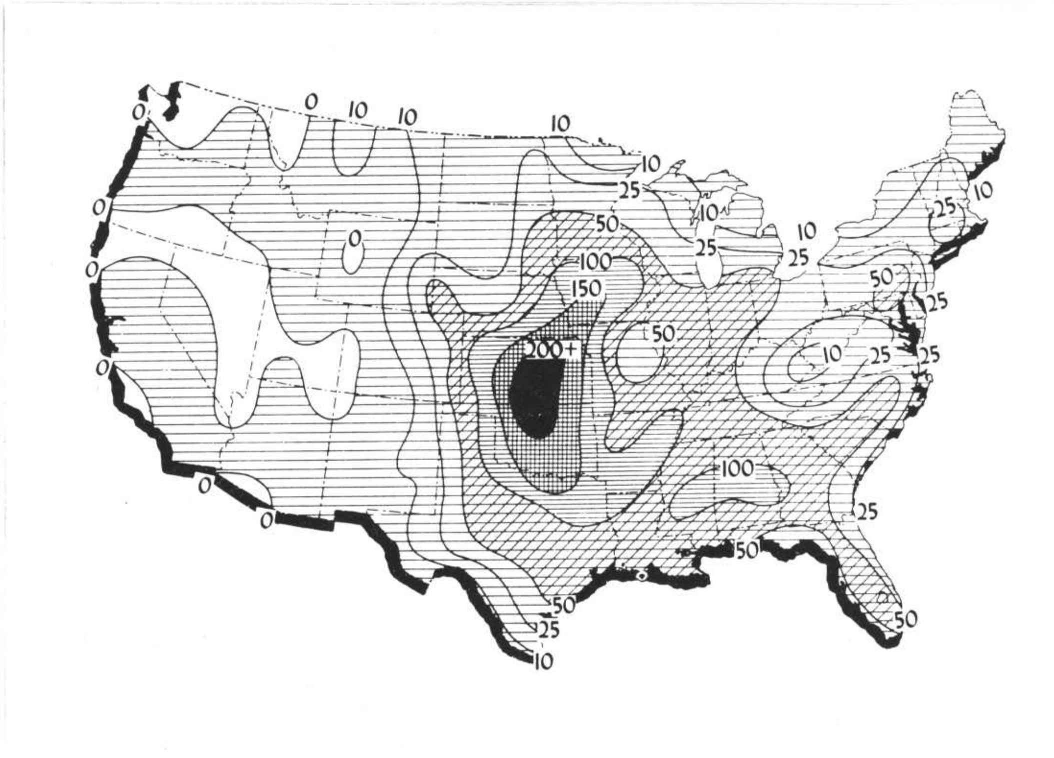
Rural areas are characterized by large open areas with only minimal amounts of built form scattered in small clusters. Population density is very slight. Homes in these areas are fairly independent, frequently having their own water and sewage systems. A disaster here would affect relatively small numbers of people. This would not be classified as a large-scale natural disaster of the type which this paper intends to deal with.

ILLUSTRATION #3

TORNADO DISTRUBITION IN THE UNITED STATES

1916-1955

WEATHER BUREAU CHART

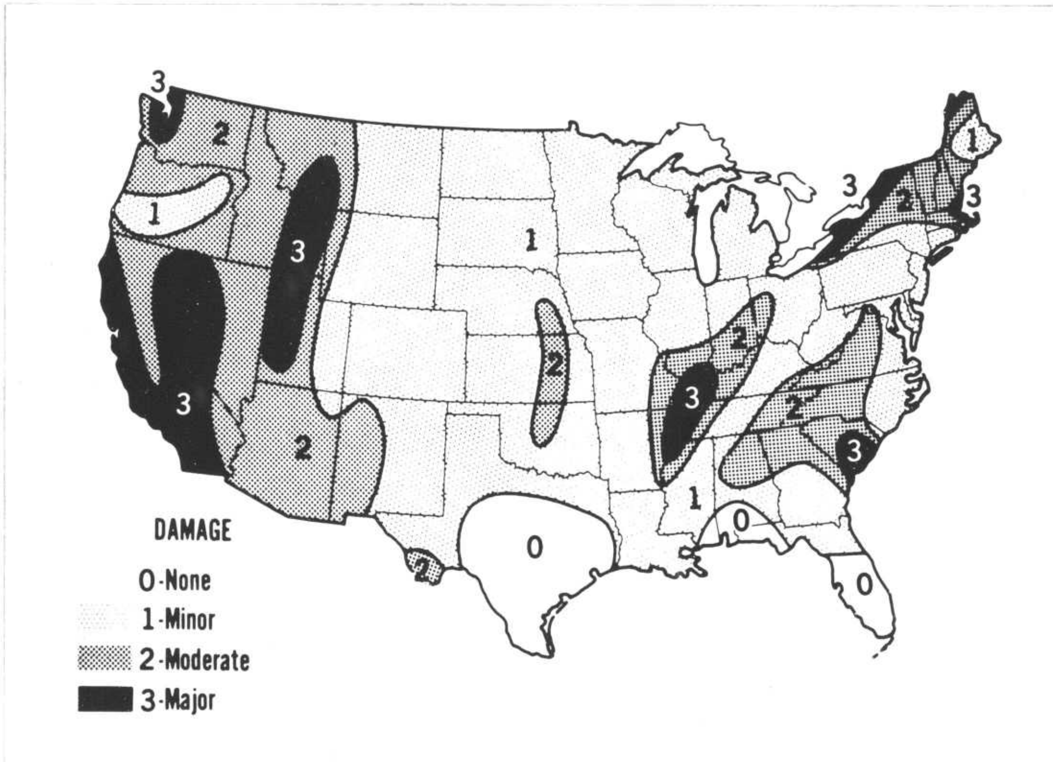


(P&J:7,p.32)

ILLUSTRATION #4

SEISMIC RISK MAP

ESSA/COAST AND GEODETIC SURVEY

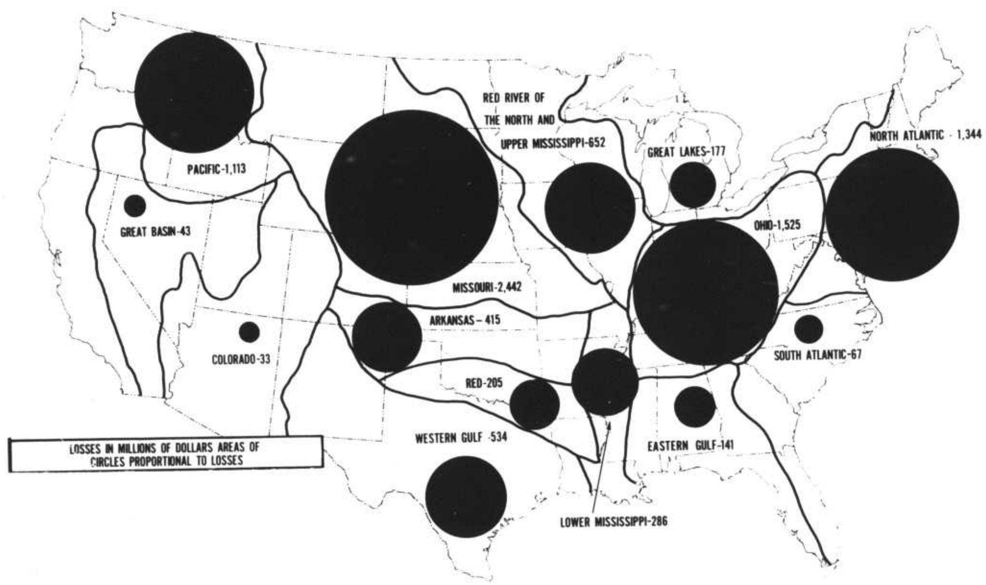


(P&D:8,p.10)

ILLUSTRATION #5

DISTRIBUTION OF ESTIMATED FLOOD LOSSES IN THE UNITED STATES

BY MAJOR RIVER SYSTEMS, 1925-1970

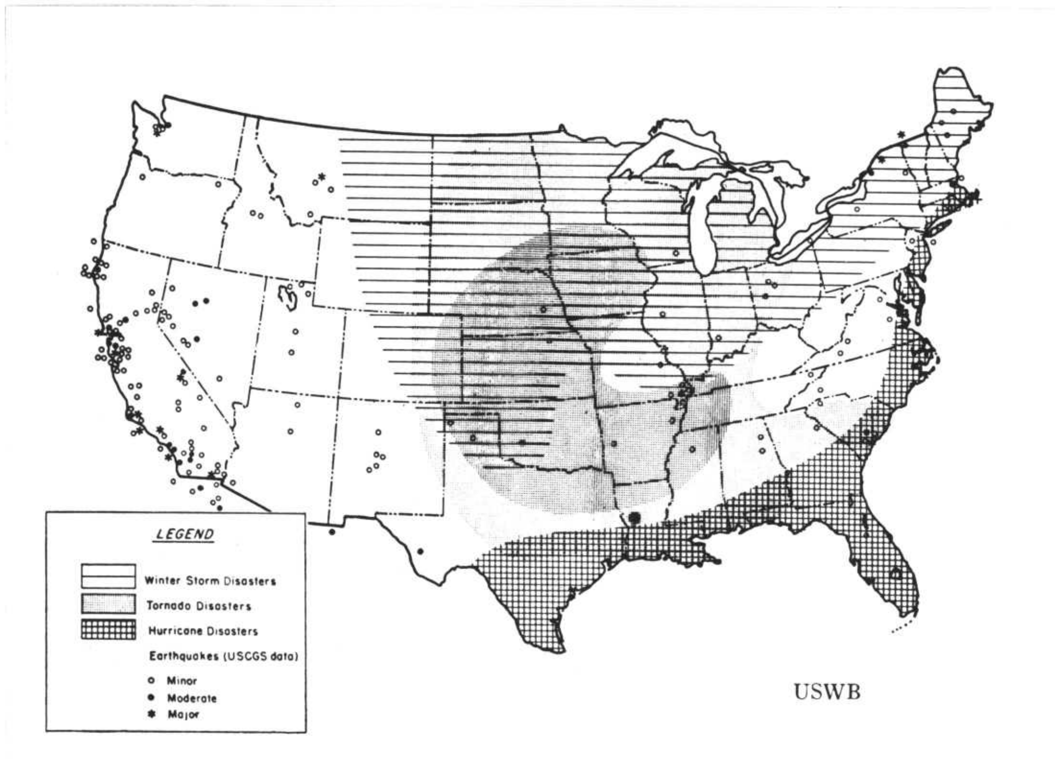


(P&J:6,p.77)

ILLUSTRATION #6

INCIDENCE OF DISASTERS IN THE UNITED STATES

WEATHER BUREAU CHART



(P&J:7,p.5)

6.2.2 Suburban/Town

Suburban/town areas are characterized by moderate amounts of built form in fairly tight closely-spaced clusters. Population density is moderate. Homes are usually single-family dwellings or small apartments. These units are generally tied into central services provided by the city. These types of communities characteristically utilize the housing stock intensively. There are few vacant houses or apartments. Destruction of a good portion of this housing would leave people with few shelter resources. The possibility of bringing in temporary relief shelter systems is extremely important in this type of location, where home owners desire and need to return to the immediate area of their damaged or destroyed homes as soon as possible in order to begin reconstruction and salvage. A disaster here would affect a great many people. This would be classified as large-scale natural disaster. Sizeable resources would be required from outside the community for life-sustaining and recovery operations. This is the type of situation which this research will primarily focus upon.

6.2.3 Urban

Urban areas are characterized by large amounts of built form situated in very tight, closely-spaced clusters. Homes are almost exclusively of the multi-story, multi-family apartment type. They are completely dependent upon central services provided by the municipality. A disaster here would affect a very large number of people. Sections of the city which were struck would be left in shambles with a good deal of rubble blocking streets and other open areas. Furthermore, city disasters frequently spawn fires that become the real force of destruction, especially when watermains are ruptured and roads are blocked by rubble, preventing fire equipment from responding effectively. In all likelihood, the residents would have to be evacuated from the area until it could be cleared and rebuilt. This rebuilding would take a reasonable length of time, at least a year or more. If the disaster is city-wide, alternative settlements will have to be established outside of the city. However, if the disaster is localized within only some sections of the city, then resettlement may be unnecessary. Fortunately, the housing stock in large urban areas is frequently under-utilized. By this I mean, that there are many vacant apartments, which though unsuitable for immediate occupancy, could be brought up to standards fairly quickly, and also a number of hotels and motels which could be utilized. Areas outside of the city, on the suburban fringe could also be set up as alternative communities. This research will not deal with the urban disaster situation, but it will attempt to show that certain responses in suburban/town disaster situations might also be pertinent to the urban situation.

7. ORGANIZATIONAL RESPONSE TO NATURAL DISASTER

7.1 ORGANIZATIONS

A number of organizations are active in responding to the various needs which arise from natural disaster. Some mention has previously been made of their efforts. These groups include private organizations, industrial and business groups, governmental agencies, and religious orders. A fairly complete listing includes:

PRIVATE ORGANIZATIONS

American National Red Cross
American Legion
National Urban League
Goodwill Industries of America
Radio Emergency Associated Citizens Teams (REACT)
Amateur Radio Relay League

INDUSTRIAL AND BUSINESS GROUPS

American Hospital Association
American Pharmaceutical Association
National Medical Association
AFL-CIO Community Services
National Defense Transportation Association

GOVERNMENTAL AGENCIES

Office of Emergency Preparedness
Office of Civil Defense, Department of Defense
National Weather Service, National Oceanographic and Atmospheric Agency
Department of Agriculture
Office of Economic Opportunity
ACTION
U. S. Public Health Service, Department of Health, Education, and Welfare
Department of Housing and Urban Development
Small Business Administration
U. S. Coast Guard, Department of Transportation
Department of Labor
Army Corps of Engineers

RELIGIOUS ORDERS

Catholic Charities

Mennonites
Seventh Day Adventists
Southern Baptist Convention
Christian Reformed World Relief Committee
(P&D:7,p.4)

7.2 TYPES OF RESPONSE

These organizations provide services which include: economic aid, manpower, materials, machinery, shelter, food, transportation, communication, medical aid, clean-up, and counseling. These types of assistance usually come from outside the stricken community. They are necessary because:

> ". . . disasters are traumatic experiences which encompass so many people at one and the same time that the ordinary socially-institutionalized means whereby individuals meet their needs for rehabilitation do not suffice." (B&R:24,p.5)

7.3 SPECIAL PROBLEMS

The principle that recovery begins with self-help is especially important following disaster. A self-help policy is extremely important in building people's confidence and initiative. Large organizations by their very nature sometimes tend to forget this. In their bureaucracy and large-scale operation, good intentions sometimes become distorted. Care must be exercised less bureaucracy and large-scale operations roll over the individual in the process.

> "The rapid shift in values from normal to emergency, from social differentiation to social homogenity, and the uneven selective return to normal standards often create difficulties for organizations which have standardized policies and procedures for administrating disaster relief and rehabilitation aid." (P&J:7,p.49)

In considering the question of how best to provide shelter for the homeless following natural disaster, it must be remembered that these organizations are presently the keystone of emergency relief. They possess the resources, manpower, and experience necessary for large-scale survival and recovery. Efforts to provide shelter that is more responsive to the needs of the victims must include consideration of the organizations that will likely be charged with this type of operation. Responsive shelter systems will be a tool, but that tool will be worthless unless it is used properly and effectively by competent people.

8. BASIC CONCLUSIONS

In closing this section on the background of natural disaster in the United States, it is necessary to identify a number of implications for further action.

8.1 NEED FOR FURTHER STUDY

There is the need for further study in the area of disaster causes. Research is needed that will give man better tools for disaster prediction, and a better basis on which to develop preparedness plans. The possibilities of disaster abatement and control should also be investigated.

8.2 PREVENTITIVE PRACTICES

Real preventitive practices need to be instituted. Many disasters are more severe than need be simply because people in especially disaster-prone regions of the country insist on staying in the same location despite the reasonable certainty of recurring calamity. People living within flood plains are one example. People living along the San Andreas fault are another. Building codes in these areas need to be amended so as to really provide for buildings which will have a reasonable chance of surviving a disaster without complete destruction, or, in some cases, these codes should simply prohibit further building in these disaster-prone areas. Warning procedures must be developed that people will have confidence in and will know how to react to. Warnings today often go unheeded, partly due to the inaccuracy of present prediction techniques, and partly due to inadequate public education in this area.

8.3 METHODOLOGY AND RESOURCES

Thirdly, more efforts should be expended in developing the necessary methodology and resources for recovery. On the organizational level, many things must be ironed out. Territorial disputes must be eliminated. Greater inter-group cooperation is essential. Duplication of effort must be avoided. Information and technologies must be shared. Real efforts must be made to provide for the needs of the victim population. Traditional methodologies should be re-evaluated and restructured where necessary.

On this level, attention must be given to both the software and hardware aspects of providing resources for survival and recovery. New innovations in computerized storage and retrieval systems should be applied to the gathering and cataloguing of resources that might be needed in the event of disaster. As an example, one of the real problems resulting from the devastation caused by Hurricane Agnes was that sufficient numbers of mobile homes for use as emergency housing could not be assembled when needed. The whole summer was spent in trying to accumulate the requisite number of mobile homes before the onset of winter. (P&D:11,p.45) This problem was compounded by two things -- the difficulty in locating sufficient inventories and stockpiles because an industry-wide program of regularly reporting information concerning the suitability of units for emergency application had never been implemented; and the difficulty encountered because of the nature of the mobile home industry which chooses to maintain full-production during the spring and summer months when demand is high, and decrease production during the rest of the year when demand slackens, rather than stockpiling during the winter for sale in the summer. Such problems could be reduced by implementing efficient software systems for monitoring and locating the output and production of shelter units applicable for use in emergency situations. A well-thought-out program of federal subsidy and legislation might also encourage production and inventory techniques that would maintain a sufficient level of availability of emergency shelter units. This thought will be expanded upon later in the text.

There is a real need to provide better hardware systems for use during emergency relief operations. Such hardware systems need to be developed in terms of both user effectiveness and cost effectiveness. The primary hardware system needed following disaster is that of shelter. Various shelter systems need to be investigated -- both new and innovative types as well as the suitability of using existing housing alternatives, such as mobile homes, recreational vehicles, modular units, panelized structures, military-use shelters, and others which are currently available, and which, with some modification might be adapted for emergency relief service. In order to attempt this investigation, a set of guidelines and standards are necessary that will spell-out user needs and outline possible modes of satisfaction. The remainder of this paper will deal with this question of developing performance guidelines for emergency relief shelter.

SECTION III

DEVELOPMENT OF PERFORMANCE GUIDELINES FOR RELIEF SHELTER DESIGN

1. PROLOGUE

In this section, performance guidelines for emergency relief shelter will be developed. These guidelines are intended to aid both in the process of initiating new design of emergency shelter systems, as well as in the selection and modification of existing alternative systems for emergency applications. In choosing the best possible system for the purposes intended, three types of considerations must be given -- an evaluation of user needs, an evaluation of the technologies involved, and an analysis of cost-effectiveness. This latter consideration of cost will not be undertaken in this research for the following reason. The primary intent of this study is to develop a means for assuring that the real shelter needs of the victims are provided for. This can be done by first determining what those needs are exactly, and then by suggesting what constraints are placed on the way in which those needs are to be translated into actual shelter details by the technologies required for their development and deployment. Once this has been accomplished, cost-effectiveness then plays the role of deciding which of the systems determined responsive should be selected. This will involve analysis of the costs of all phases of operation, from design to placement and possible recovery. It will require the use of statistical projections and mathematical models in estimating the economies of scale, the ever-changing costs of labor and materials, etc. This should be left to persons experienced and proficient in such operations.

In determining user needs, both the physiological and the psychological must be investigated. The procedure will be to first determine exactly when and for how long such shelter will be placed in use, and whom the intended user will be. Then his needs will be identified in a qualitative manner. Once identified and placed in the context of the others, those needs relating to shelter will be translated into quantitative form if possible. From this compilation, needs will be transformed into specifications. A subsequent exploration of the technological systems necessary in the transformation of specifications to feasible product solutions will provide further guideline criteria. The synthesis of these two areas of investigation will yield the final set of performance guidelines for emergency shelter design.

In providing shelter following natural disaster, great care must be taken in evaluating the real housing situation in order that proper responses may be initiated and in order that proper resources may be called into action. Not only must the real life-sustaining needs of the victims be considered, but also those dealing with life recovery and rehabilitation.

> "After a disaster one of the most critical policy decisions to be made relating to housing is the temporary accommodation of the homeless. A correct decision on policy, well administered, will do much to insure the success of reconstruction." (P&D:12,p.39)

2. APPLICATION

2.1 DETERMINATION OF PERIOD OF OCCUPANCY

The post-disaster period is not a single period at all, but rather three consecutive periods, during which the real needs of the victims change. These periods are described as life-sustaining, situation stabilization, and recovery. During each of these periods, housing (identified as emergency, temporary, and semipermanent housing) of various degress of quality and livability would be required. (B&R:31,p.7)

> "Disaster assistance housing includes: 1.) emergency housing, defined as immediate shelter, providing minimal comfort, convenience, and privacy to help dislocated persons through the immediate post-disaster period; 2.) temporary housing, defined as shelter providing minimal comfort and convenience and assuring the semi-family living conditions (sleeping/sitting/privacy) needed to stabilize the family unit during the intermediate post-disaster periods; and 3.) semipermanent housing, defined as housing providing sufficient comfort and convenience to help restore the well-being of the family unit for the balance of the first year following the disaster." (B&R:31,p.1)

Emergency housing should be occupiable within 48 hours and be serviceable for up to ten days. Temporary housing is to succeed emergency housing and should be serviceable for six weeks. Semipermanent housing is to follow temporary housing and is to be serviceable for one year. (B&R:31)

These preceding thoughts and recommendations are contained in the federal government study entitled: Housing Technology Alternatives For Use In Planning Post-Disaster Housing Assistance Programs. The reasoning behind this thinking seems to be based on a combination of experience, reality, and economy. It is clear that immediately after impact, only the barest essentials can be provided, such as food, medicine, and the gathering of survivors into a safe area. This will take at least a whole day. Once some feeling can be obtained for the number of survivors and the extent of available resources left within the immediate area, emergency shelters can be set up in buildings which have survived the disaster and which have some rudimentary services. This acquisition and conversion will hopefully be completed within the first 24 to 48 hours following disaster. In the succeeding week, many victims will be able to return to their homes if they were only slightly damaged and if some services have been restored; others will move into the homes of friends and neighbors in the immediate area that were not damaged. Still others will leave the area entirely. By the time this trend has wound its course, only a certain proportion will be left in the emergency shelters. The plan then is to move these people from the mass shelter to some forms of temporary housing that will give them a greater degree of privacy and independence and that will enable the mass shelters, which by now are only operating at partial capacity, to be shut down. The desire is to complete this switch within a week or two following disaster. As I say, this is the desire, but it is often not possible.

In the aftermath of Hurricane Betsy which struck New Orleans in September, 1965, and required the billeting of 9,000 people at the Eighth Naval District H. Q. in Algiers, Louisiana, a fairly good indication was obtained as to what happens when people are kept in mass shelter situations for long periods of time. It seemed that on the fourth day post-Betsy, the people were still stunned and exhausted for the most part; by the sixth day, groups were initiated among the refugees to deal with questions concerning housing and complaints; by the eighth day, many of the men had returned to work leaving the women and children at the shelter during the day, rejoining them in the evening. Also, the refugee population had decreased from 9,000 to

7,000 in two days. By this time, complaining and apathy had become increasingly evident and people were less sympathetic to their neighbor's plight. Finally by the tenth day, these changes were even more apparent and complaints about the unpleasantness of the shelter were especially prevalent. (P&D:14, pp.2-4) What this example shows is that during the first week, people suffer from fatigue and appear to be best suited for group living arrangements, but that after the initial week, people return to their 'normal' state and become less inclined to favor such accommodations.

Prolonged use of emergency shelter is not uncommon. In the case of Hurricane Audrey which struck in June, 1957:

> "In Cameron Parish, Louisiana, an area half again as large as Rhode Island was left without electricity and drinking water for three months. More than 23,000 homes were in ruins and people 'had no place to live except in a tent, no place to eat, except in a Red Cross chow line'." (B&R:9,p.199)

The primary problem is that shelter systems have not yet been developed that can provide for victim needs during the transition from emergency housing to semipermanent housing. Emergency housing in mass shelters is acceptable it would seem, for the first week or so. And suitable forms of semipermanent housing exist, such as mobile homes. But, it is the temporary form of housing for use during the period of situation stabilization which we are in dire need of. The other problem is that in disasters of large scale, sufficient quantities of semipermanent housing often take as long as several months to assemble. Such was the case with Hurricane Agnes in June, 1972, when 200,000 people were still homeless two weeks after the disaster struck and 11,000 mobile home units were required (30% of the total national monthly product). It took nearly three months to assemble the entire 11,000 units. (Source: interview with Mr. William Cosby, Building

Research Advisory Board.)

This places the category of temporary housing in an even more vital position. For these reasons, the post-disaster period of situation stabilization is the period upon which this research shall concentrate. Design guidelines will be developed for temporary housing for use during this period.

2.2 DETERMINATION OF USER

The last decision to be made before beginning the process of establishing performance guidelines is to determine exactly who is to be the user. In an earlier section of this paper, the family was identified as the potential user. Two questions should be clarified now: What is a family? Also, why the family?

The family was chosen fortwo reasons. First, it includes the largest number of people in our population. In statistics from 1971, households in which 2 or more persons lived together made up 82% of the population. Situations in which 2 or more persons normally live together could be considered a family. Of these families then, 88% contained between 2 and 5 people. Or, if you want to consider 2 people living together as a couple, rather than a family, then 53% of the families contained between 3 and 5 people. Comparatively, families containing more than 7 people are statistically infinitesimal in number. (REF:3,p.41) Nevertheless, larger families must be considered, because they do exist, and because in some parts of this country, large families are the rule, rather than the exception. What these figures then show is that the optimum design should provide for from 3 to 5 people, yet possibly be adaptable for use by as few as 2, or as many as 7 or more.

The second reason for choosing the family is that it is the basis of society in our Western culture. In putting the pieces back together following disaster, it is necessary to start with the grass roots -- the sense of family. This is the building block of our society. It is only after the sense of family has returned that a revitalized sense of community can be effectively channeled into the commencement of the arduous process of recovery and rebuilding. The family situation requires a sense of privacy and intimacy which group accommodation in mass shelter cannot provide. It is therefore that much more important that the transition from emergency housing to temporary housing take place as quickly as possible in order that the process of situation stabilization might occur within the family structure. This concern for the family situation is well established. Mr. Roy S. Popkin, the Assistant National Director of Disaster Services of the American Red Cross, in a recent letter reiterated this same concept:

> "The major problem in this country, from our point of view, is providing housing in which families can resume family living when there has been large scale destruction of homes or while they are waiting for their homes to be repaired or are being relocated."

2.3 SUMMARY OF SCOPE

The scope has now been outlined and the identification and evaluation of criteria for guideline standards can commence. Recounting these decisions which have just been made concerning the scope and intent of application for such performance guidelines, and combining them with the decisions made during the investigation of disaster background, the following summary of total scope can now be made.

USER:	The family group.
PERIOD OF OCCUPANCY:	Situation stabilization -- beginning within one week following impact and lasting for up to two months, after which time either semipermanent housing should be available, or the owner's home should be sufficiently repaired for occupancy.
AGENT OF DESTRUCTION:	Natural disaster in the form of tornado, earthquake, hurricane, or flood.
AREA OF IMPACT:	Suburban/town type location within the continental U. S.

3. DETERMINATION OF USER NEEDS

3.1 BACKGROUND

User needs arising from natural disaster result primarily from two causes -- deprivation and trauma. Natural disaster can deprive man of many of the normal resources upon which he depends, including his home, his property, his source of livelihood, his sense of family, and his sense of community. This deprivation is of both a physiological and psychological nature. In addition, needs of a primarily psychological type arise due to the mind-wrenching aspects of disaster itself.

> ". . . after a disaster one's energies on a conscious and an unconscious level are much in use in the service of somehow integrating the disaster experience." (B&R:24,p.54)

In attempting to identify and satisfy user needs, it is probably the best course to realize that these needs can be isolated into two groups -- those which deal with deprivation and which would be the same even if they had not been brought on by the events of disaster; and those which result from the particular trauma of living through the impact of disaster.

Physical deprivation can be overcome by providing some semblance of that which existed prior to disaster. Psychological deprivation requires an insight into the workings of the mind, and an undertstanding of the relations that govern the family and the community. Trauma involves an understanding of man's psyche.

In terms of shelter, man's basic needs have been evaluated and itemized in various scholarly reports. These needs are also basic to disaster victims, although some additions and qualifications will be necessary. Further amendments will be required in considering the needs arising from the psychological deprivation and trauma of disaster. Table #4 on pages 81 and 82 lists "Basic Principles of Healthful Housing" which were developed nearly a quarter of a century ago by C. E. A. Winslow and the Committee on the Hygiene of the American Public Health Association. This work is cited because it has been used as a standard reference by the United Nations in determining housing policies in developing countries. (B&R:12,pp.43-44) Four major areas of concern were developed, each encompassing a number of principles. Those principles which I feel should apply in the provision of responsive disaster housing have been identified with an asterisk.

As one can see, nearly all of these principles have application to the physiological needs which arise in natural disaster. Most of these are simply commonsense descriptions of the basic aspects of shelter which man takes for granted. When he has been deprived of these things, he quickly begins to appreciate their value. Any type of living situation of a month's duration or more requires that these basic needs be accounted for in one fashion or another. While the Western standard of living requires that these needs be met, the methods in which they are satisfied need not be along traditional lines. The American family has adapted quite well to living in cramped recreational vehicles for weeks at a time. These vehicles provide the basic necessary services and comforts, yet fall far short of the full scope of comforts found in the home. They have adapted so well to this style of temporary living that they call it a vacation. From what are they seeking to vacate one might ask? This spirit of 'roughing it' and 'getting away from it all' compels millions of American families to spend their whole vacations in cramped quarters, to cook using a minimum of equipment, to use power and water sparingly, and to camp amidst scores of similar 'itinerants'.

TABLE #4

BASIC PRINCIPLES OF HEALTHFUL HOUSING

FUNDAMENTAL PHYSIOLOGICAL NEEDS

* 1) Maintenance of a thermal environment which will avoid undue heat loss from the human body.
* 2) Maintenance of a thermal environment which will permit adequate heat loss from the human body.
3) Provision of an atmosphere of reasonable chemical purity.
* 4) Provision of adequate daylight illumination and avoidance of undue daylight glare.
* 5) Provision for admission of direct sunlight.
* 6) Provision of adequate artificial illumination and avoidance of glare.
* 7) Protection against excessive noise.
* 8) Provision of adequate space for exercise and for the play of children.

FUNDAMENTAL PSYCHOLOGICAL NEEDS

* 9) Provision of adequate privacy for the individual.
*10) Provision of opportunities for normal family life.
*11) Provision of opportunities for normal community life.
*12) Provision of facilities which make possible the performance of the tasks of the household without undue physical and mental fatigue.
*13) Provision of facilities for maintenance of cleanliness of the dwelling and of the person.
14) Provision of possibilities for aesthetic satisfaction in the home and its surroundings.
15) Concordance with prevailing social standards of the local community.

TABLE #4 (cont.)

PROTECTION AGAINST CONTAGION

*16) Provision of a water supply of safe sanitary quality, available to the dwelling.
*17) Protection of the water supply system against pollution within the dwelling.
*18) Provision of toilet facilities of such a character as to minimize the danger of transmitting disease.
*19) Protection against sewage contamination of the interior surfaces of the dwelling.
*20) Avoidance of unsanitary conditions in the vicinity of the dwelling.
*21) Exclusion from the dwelling of vermin which may play a part in transmission of disease.
*22) Provision of facilities for keeping milk and food undecomposed.
*23) Provision of sufficient space in sleeping-rooms to minimize the danger of contact infection.

PROTECTION AGAINST ACCIDENTS

*24) Erection of the dwelling with such materials and methods of construction as to minimize danger of accidents due to collapse of any part of the structure.
*25) Control of conditions likely to cause fires or to promote their speed.
*26) Provision of adequate facilities for escape in case of fire.
*27) Protection against danger of electrical shocks and burns.
*28) Protection against gas poisoning.
*29) Protection against falls and other mechanical injuries in the home.
30) Protection of the neighborhood against the hazards of automobile traffic.

(B&R:11,pp.11-12)

To do such does not reduce one's standard of living, it merely casts off the embellishments of luxury that obscure primeval needs. Perhaps the experience of living in temporary forms of shelter can restore some of the excitement and spontaneity that modern housing tends to stifle with layers of plastic and kilowatts of electricity.

3.2 PHYSIOLOGICAL NEEDS

With these principles and goals in mind, the physiological needs arising from disaster deprivation can be investigated. There are two basic categories in which physiological needs can be placed -- life-sustaining and life recovery. The former refers to the immediate needs of maintaining the bodily functions and providing for the means to deal with various environmental factors which affect life processes. The latter refers to the restoration of the normal physical activities from which man draws strength and happiness, and to the provision of the basic necessities for self-care which give some measure of the physical independence to which he is accustomed. The period of situation stabilization deals with life recovery. However, life-sustaining needs are always present, even in the later periods of post-disaster relief.

3.2.1 LIFE-SUSTAINING

The immediate post-disaster period is called life-sustaining. The physiological problems that must be dealt with during this time are those vital to life itself. Life saving and the prevention of further death, injury, and sickness are the immediate concerns. But these basic concerns do not simply disappear with time. The maintenance of bodily functions and the provision of means for dealing with environmental influences are of constant necessity for survival. Thus, even in the following situation-stabilization period, these needs must be met.

In the maintenance of his normal bodily functions, man is like any machine in that he takes in energy in various forms, acts upon that energy, and then expends energy in the form of work and waste products. An environment must be provided in which man can maintain this energy cycle as efficiently as possible. See illustration #7 on page 86 for a schematic representation of this process. (This illustration was taken from a lecture in environmental technologies given by Edward Allen at the Massachusetts Institute of Technology on September 14, 1972.) Man requires adequate supplies of oxygen, water, food, and heat for survival. His body is in effect, a large heat engine which acts upon these sources of energy to fuel its operation. This operation is called metabolism, which describes the sum total chemical processes by which living organisms maintain themselves and perform the activities characteristic of the living state. Energy taken in as food may be converted to heat, used to perform work, or stored in the form of cellular material. Heat production occurs because of inefficiency in utilization of energy inputs. In warm-blooded animals such as man, this heat released in the metabolic process is used to keep the body warm. Work performed may be mechanical or chemical, but in man, it is mostly of the mechanical nature of muscle contraction. In contrast, energy demands for mental work are almost negligible. Energy is also stored in the potential form of tissue within the body for use when food intake does not occur. When man is placed in a condition where no external work is done, this total energy output will appear as heat, and, if food intake is prevented, this heat production will be at the cost of stored reserves. Under these conditions, the metabolism is called basal metabolism. The rate of basal metabolism generally falls with age. (REF:2,pp.695a-695b)

It is this operation of metabolism then that is basic to man's survival. In order for this process to continue to operate in a satisfactory manner, the body must be free of serious injuries and it must be able to rest periodically. These concerns are especially significant following natural disasters, where physical injury and exhaustion are common. The provision of a suitable

ILLUSTRATION #7

PHYSIOLOGICAL ASPECTS OF LIFE

OUTPUTS:

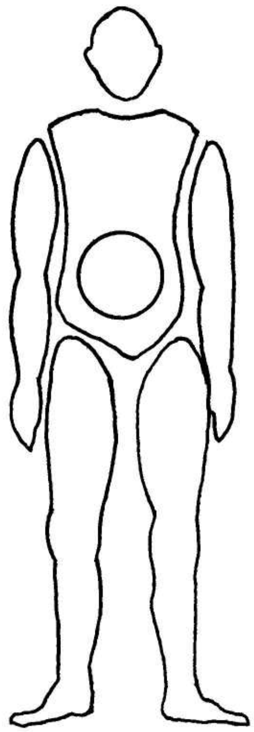
CO_2 -- 600 l./day

H_2O -- .4 l./day
(respiration)
-- .5 l./day
(perspiration)

Urine -- 1.4 l./day

Fecal -- .1 l./day

Heat -- 350 Btu/hr.
(at rest)



INPUTS:

O_2 -- 700 l./day

H_2O -- 2 l./day

Food -- 2-4,000 kcal/day

Heat

OUTPUTS:

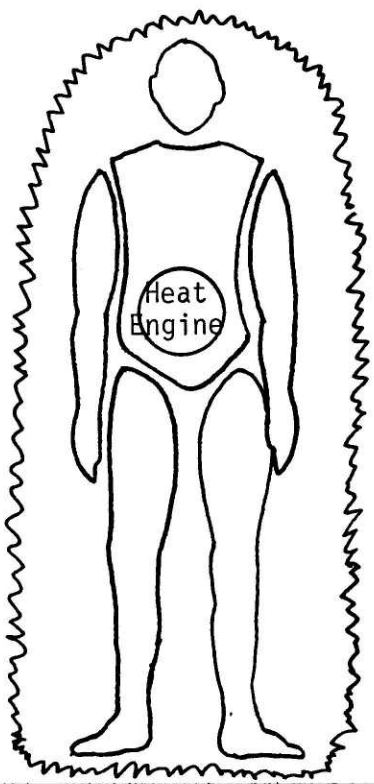
Radiant Heat

Convection

Conduction

Evaporation

Useful Work



INPUTS:

Food

Radiant Heat

Convection

Conduction

HEAT ENGINE: 20% eff.

CLOTHING & SHELTER

environment for healing and resting is especially important in the first post-disaster week. Injury and exhaustion are not major problems during the following situation stabilization period, however, and special provisions for these are not of real concern in temporary housing.

Finally, the body must be able to eliminate the waste products which are generated in the metabolic process. These include: carbon dioxide, water, body wastes, and heat. Carbon dioxide is released in the exhalation process. A proper supply of fresh air is necessary to prevent the build-up of carbon dioxide which would reduce the oxygen content of the air which man breathes. Proper ventilation techniques will insure an adequate supply of fresh air. Water is released from the body in two ways -- through evaporation and urine. The rate of evaporation depends on the rate of work and the humidity of the air. In normal shelter activities, the rate of work is usually quite low. Provision for adequate control of humidity levels is essential. Urine is a liquid bodily waste product, just as fecal matter is a solid bodily waste. Proper sanitary practices are necessary to prevent contamination, sickness, and unpleasant odors. In addition, cultural norms require that such bodily waste products be kept out of sight. The final waste product is heat. Heat is both a source of energy to man and a waste product. Thus, a proper heat environment must be maintained that will allow man to obtain heat from external sources if he requires it, or to exhaust heat to the external surroundings if he has produced too much. Ventilation, humidity, and mechanical sources of heating or cooling are among the mechanisms available.

ENVIRONMENTAL CLIMATIC CONCERNS

Man's environment can both sustain him and destroy him. Man manipulates his environment so as to make it acceptable for survival. He uses artificial means such as clothing, shelter, and machinery to adapt. Human comfort is affected by four primary climatic environmental elements: air temperature, radiation, air movement, and humidity.

Air Temperature: Man can survive a moderate range of temperatures. At the upper level of man's existence is sunstroke; at the lower level is freezing. In the continental United States, there are three principal climatic zones. Zone #1 (North) is primarily cool and suffers the extremes of winter with temperatures frequently as cold as -10°F to -15°F, and the number of degree days per year exceeding 6,000. Zone #2 (Central) is a temperate zone with intermediate weather conditions. Temperatures in winter are as low as -5°F to +5°F, and the number of degree days ranges from 3,000 to 6,000. Zone #3 (South) comprises a hot climate and includes both arid and humid areas. These areas experience less than 3,000 degree days per year. (P&D:18,pp.3-4) Since disaster may strike within any one of these regional zones, temporary shelter must be capable of maintaining temperature levels adequate for comfort. The body exchanges heat with its surroundings through four main processes: radiation, conduction, convention, and evaporation. Estimates show that radiation accounts for about 2/5 of the body's heat loss, conduction for about 2/5, evaporation for 1/5, and convection is negligible. These proportions are variant with changing activities and climatic thermal conditions. (B&R:55,p.16)

Radiation: Nature radiates heat in the form of solar energy. Man must have the option both of receiving this heat and of blocking it out, in order to maintain a proper comfort level. Provisions for shade and insulation are important in this respect.

Air Movement: Air movement is essential to prevent stagnation of air which can cause conditions which are unhealthy and uncomfortable, such as insufficient oxygen content of air for breathing and the build up of germs, odors, and smoke within closed areas. Air movement is also an important resource for cooling and heating, and for regulating relative humidity. Natural air movements are called winds and breezes. Provision must be made within temporary shelter to allow the occupant to regulate the rate of air movement so as to maintain a proper comfort level. Air movements can cause noises which can be either masking or bothersome. The latter should be discouraged as much as possible through proper design.

Moisture: The moisture content of the air is important to comfort and survival. Extreme moisture levels cause conditions of mildew and rot which are not conducive to living. Disease and sickness are more prevalent in a humid environment. On the other hand, a certain minimum level of moisture is required for comfort. Breathing and sweating are influenced by the moisture content of the air.

ENVIRONMENTAL HEALTH AND SAFETY CONCERNS

In addition to these climatic elements, there are also influences of another environmental aspect. These are the potentially dangerous areas of contagion and accident.

Contagion: The environmental factors of disease and vermin must also be controlled. Conditions that are conducive to such maladies must be avoided. Temporary housing must be of such a nature that it prevents sources of contagion both from spreading and from occurring. Vermin must be prevented access to the shelter. Proper control of sanitation techniques and the provision of adequate ventilation and volume within the structure will help prevent the contraction of contagious disease. Proper sanitation techniques and construction details will prevent access to vermin.

Accidents: In sustaining life, proper emphasis on safety is essential -- safety in construction and in operation. Construction practices should insure the structural integrity against live and dead loads, both internally and externally applied; and also should insure the use of materials that will provide a sufficient level of fire protection. Systems such as electrical and gas should be correctly installed and maintained, and should be provided with adequate safety devices.

The provision of means for maintaining the bodily functions and for dealing with environmental factors is vital not only to the life-sustaining period following natural disaster, but to all periods. These provisions, basic to life itself, are necessary to satisfy the initial post-disaster physiological needs of the victims. The post-disaster user needs change with time, that is, they expand.

3.2.2 Life Stabilization and Recovery

In addition to the basic life-sustaining needs, further physical needs arise during the situation stabilization period. These are physiological needs that are necessary for stabilization and recovery. They arise out of the victim's desire to restore some of his normal activities and to regain a certain measure of the capacity for self-care and independence which he possessed prior to the disaster impact. These desires become dominant after the victim has been provided with the basic life-sustaining resources and after he has been able to both integrate the disaster experience somewhat within his mind and to recover from the mental and physical exhaustion of the recent events. Such desires usually begin to emerge by the end of the first post-disaster week. It is at this time that the transition from life-sustaining to situation stabilization begins and it is at this time that physiological needs require the switch from rudimentary emergency shelter to a more normal family-oriented form of temporary shelter.

DESIRE FOR RESUMPTION OF NORMAL ACTIVITIES

During this period, it becomes harder to differentiate the physiological from the psychological user needs. Some needs are in fact, both. The desire to resume some normal physical activities in a more comfortable and family-oriented environment necessitates the change from large open mass shelters to housing more on the family scale. Among the activities that become vital are:

Sleeping: in a bed in a room, not in a cot in a hall; at hours which one prefers, not at hours dictated by the desires of the crowd; with the light on or off as one so pleases; with someone else, or alone; with or without clothing or blankets; with the heat turned way up, or the windows wide open; with absolutely no noise, or the radio playing; eating in bed; with the dog at your feet; up at dawn, or asleep past noon; whatever is normal and comfortable.

Relaxing: alone or with others, daytime or nighttime; lights on or off; music or none; on a chair or a couch; with a drink, or with none; fully dressed, or not.

Eating: at times which are normal and convenient; at a table with family; in an area just for eating; food which is familiar; uninhibited discussion;

joking and arguing.

Exercise/play: alone or with family; in areas where young children can be watched while mother is busy; games which are private, adult, or childish; noisy and uninhibited, or quiet and refrained.

The key word here is choice -- allowing the family the option of behaving in a manner which is normal for them. Conflicting value systems soon become apparent in mass living situations. People are not completely free to act as they are accustomed. Parent-child and husband-wife communication becomes difficult and restrained. The real need is for sufficient privacy for the family unit. The desire is to resume normal physical activities.

DESIRE FOR SELF-SUFFICIENCY

Cleanliness: In addition to resuming normal physical activities, victims also desire a greater degree of physical self-sufficiency. Resources for bathing and cleaning are essential. In disaster areas, where personal possessions have been destroyed and damaged, cleaning takes on a real importance. What clothing or household items that can be salvaged will need to be cleaned in order to use them or just to store them away until semi-permanent living accommodations become available. The dirty conditions following disaster will necessitate frequent cleaning of clothes and personal bathing. Keeping oneself and one's environment clean is essential both in terms of sanitation and mental attitude. One of the first things that disaster victims seek is the means to clean themselves and their remaining possessions.

Housekeeping: Facilities for cooking and food storage become increasingly important. Self-sufficiency requires that the family provide for its own meals. Resuming the responsibilities of a normal household are essential to stabilization and recovery. Not only do the victims seek to assume these responsibilities, but they should be encouraged to do so at the earliest opportunity. The transition from physiological dependence to physiological independence marks the real beginning of the recovery period. It is only after this endeavor that man can really begin to straighten his affairs and anticipate the future.

Hence, a number of physical needs have been identified for the post-disaster period of situation stabilization. These needs are of two basic types: those necessary for sustaining life, and those necessary for situation stabilization. An attempt will now be made to place quantitative meanings to some of these. These will then form the basis for the subsequent development of performance guidelines.

3.2.3 Summary: Physiological Shelter Implications for Performance Guidelines for Use in the Period of Situation Stabilization

LIFE-SUSTAINING REQUIREMENTS

A.) Maintenance of Bodily Functions: Minimum Needs Per Person.

Provision of:

Oxygen -- 700 liters/day (25 cu. ft./day)
(see illustration #7)
Drinking Water -- 2 liters/day (1/2 gal./day)
(see illustration #7)
Food -- 2,000 to 4,000 kcal./day (2 to 4 lbs.)
(see illustration #7)
Heat -- sufficient to insure 70°F temperature within surrounding environment.

Disposal of:

Carbon Dioxide -- 600 liters/day (22 cu. ft./day)
(see illustration #7)
Heat -- 300 to 400 Btu/hr. (B&R:55,p.17)
Urine -- 1.4 liters/day (1/3 gal.)
(see illustration #7)
Fecal Matter -- 1/10 liter/day (3 oz./day)
(see illustration #7)

B.) Provision of Means for Dealing with Environment.

1.) Protection from the Elements.

Temperature:

Indoor design temperature: Maintenance of an indoor design temperature of 68°F to 70°F summer and winter.
(B&R:45,p.101)

Outside design temperature extremes for continental United States:
winter -- -40°F
summer -- 115°F (B&R:45,pp.142-146)

Heat Loss:

The total heat loss of the living unit shall not exceed 50 Btuh per sq. ft. of the total floor area to be heated.
(B&R:47,p.69)

Radiation:

Moderate comfort standards: Insulation U-value of:
.07 Btuh/sq. ft./°F for ceiling
.09 Btuh/sq. ft./°F for walls and floors
(P&D:18,p.2)

Air Movement:

Proper means, artificial or natural, to control the flow of fresh air and to guarantee the following recommended ventilation rates:
general: 20 cfm/person (2 air changes/hr.)
kitchen: 2 cfm/sq. ft. (8 air changes/hr.)
bathroom: 2 cfm/sq. ft. (20 air changes/hr.)
(B&R:50,p.743)

Moisture:

Exclusion of direct moisture in the form of rain, hail, sleet, or snow.

Exclusion of water vapor -- use of vapor barrier with a 1 perm rating. (P&D:18,p.4)

Indoor relative humidity:
50% -- summer
30% -- winter (B&R:45,p.101)

2.) Protection from Disease and Vermin.

Sanitation:

Elimination of solid and liquid bodily wastes of 1/2 gallon per person per day.

Elimination of waste water: In normal applications, the average daily water usage is 30 to 50 gallons per person.
(B&R:45,p.30)

3.) Safety.

Structural Integrity:

Live loads:
Wind -- 45 mph (maximum wind load for U. S. applicable to structures under 20 ft. in height)
(B&R:47,p.36)
Earthquake -- lateral force equal to 10% of dead load for structures less than 35 ft. in height. (B&R:47,p.248)
Snow -- 40 lbs./sq. ft. (maximum snow load for U. S.)
(B&R:50,p.31)

Fire Protection:

Walls should be constructed such that in the event of fire, the average temperature of unexposed surfaces does not exceed 250°F in order to stop flame or hot gases capable of igniting cotton.

LIFE STABILIZATION AND RECOVERY REQUIREMENTS

A.) Provisions for Resuming Normal Physical Activities.

Sleeping:

Separate sleeping areas, beds, and bedding.
Minimum bedroom size: 80 sq. ft. (B&R:47,p.32)
Sound isolation: NC 25-35 (equiv. to 35-45 dB) (B&R:50,p.615)

Relaxing:

Furniture such as chair and couch.

Eating:

Table and chairs.
Sink, range, refrigerator, work surfaces, and storage spaces.

B.) Provision for Self-Care.

Bathing:

Provision of fixtures, including sink and shower, and a supply of water adequate for bathing and grooming.

Cleaning:

Provision of fixtures, including sink and wash-tub, and a sufficient water supply for cleaning operations.

3.3 PSYCHOLOGICAL NEEDS

3.3.1 Description of the Neurotic Process

In attempting to understand the mechanisms of psychological disturbances following natural disaster, some insight into the 'neurotic process' is essential. While mental illness is not yet known to be a real threat in natural disaster, certain psychological processes occur which place the victim in a more vulnerable mental position. Post-disaster relief should begin with the idea of relieving the stresses that have placed the victim in this heightened position of vulnerability. One description of the 'neurotic process' and the balance between the states of mental health and illness is given by Dr. Lawrence Kubie, who recognizes:

> ". . . a universal neurotic potential in all human beings. This neurotic tendency, when aggravated by events and environmental situations throughout any individual's life, may evolve into an active 'neurotic process,' which in turn may plunge the individual into a serious 'neurotic state'." (B&R:52,p.36)

Thus, in the framework of this 'neurotic tendency', the psychological problems that result from the stress of natural disaster can be understood. Realization that such a tendency exists in all persons, and that under stress, these tendencies lead to disorders which can become serious if such aggravations are not dealt with effectively is the jumping-off point then for considering the psychological implications of natural disaster.

Disaster produces psychological stresses and perplexities that initially can overwhelm the victim. The post-disaster period then is not only one of picking-up-the-pieces and reconstructing the physical environment, but also one of integrating the disaster experience with previous experiences. In discussing the relation of physical environment and experiences, W. R. G. Hiller makes the following case:

> "There are some interesting differences between the 'physical system' and the 'experience system'. In the first place, the physical system is subject to normal process of entropy (the tendency towards disorder or formlessness), in that it decays if it is not subjected to a programme of action aimed to prevent this.
>
> The experience system does nothing of the kind. Often its tendency seems to be in the opposite direction. Once basic stresses are removed, a given physical system partly through action on it, and partly through adaptation in experience itself, becomes an increasing source of life enhancement by becoming a framework for associations, social relationships, memories, and perhaps also a very fundamental kind of stability. In other words, human experience of environment in itself tends to move towards life enhancement on its own. This realization may help us to understand the apparently very high degree of human adaptability to environment.
>
> We could hypotehsize from this that a natural tension exists between the physical system and the experience system in that they run normally in opposite directions (you stay in the East End because you like it in spite of decay) until a critical point is passed and the entropy of the physical system gets the upper hand, or another environment holds more promise of life enhancement (you move)." (B&R:56,p.28)

While Mr. Hiller was not speaking about natural disaster, some of the points which he makes about the experience system and the physical system are important in understanding the relationships between these systems. The fact that through the removal of certain 'basic stresses' and through 'adaptation in experience itself', the physical environment, even though in a disordered and formless state can become a source of life enhancement is an encouraging revelation. The idea that man's environmental experience moves towards life enhancement is an interesting concept when considering the disaster situation.

Disaster can also present new and exciting relationships, challenges, and experiences that do much to shape the victim's views of the future.

> "Devastating as a catastrophe may be, the very needs it creates can be an asset to psychological first aid. Unlike ordinary life, disaster engenders more urgent jobs than there are people to do them. Opportunities to regain self-respect and self-confidence are correspondingly greater. Psychological first aid can help many emotionally disturbed victims to take advantage of these opportunities, and thereby get back into their stride." (P&D:17,p.15)

Disaster then creates psychological needs, but at the same time presents the opportunities for resolving these needs and in the process, strengthens the psychological state of the victim through these new relationships, challenges, and experiences which it fosters. This is not to say that disaster heals its own wounds. Rather it presents a framework in which they can be tended. This is the important realization to keep sight of in discussing the psychological needs of disaster victims and ways in which to deal with them.

In discussing the psychological implications of disaster, it must be kept in mind that psychological needs change with time, just as physiological needs do, and that in satisfying these needs, both human relationships and physical shelter play a role. There appear to be essentially three phases of psychological need: the first involves the relief of psychological bewilderment and suffering that follows on the heels of disaster impact; the second concerns the recovery of mental attitude and balance; and the third deals with stimulating motivation and hope for the future. Each of these periods of need will be investigated with the aim of identifying the psychological needs and pointing out the ways in which both human aspects of relationships and aspects of shelter might attend to them. In determining shelter guidelines for situation stabilization, it will be necessary to recognize and respond to each of these needs.

3.3.2 Relief of Psychological Bewilderment and Suffering

Following disaster impact, everyone goes through a period of psychological despair. For some, this period is fleeting and the disaster experience is quickly come to terms with mentally, but for many the psychological needs which arise will take days and weeks to sort themselves out. The real psychological problems which arise at this time are based on the trauma of the event itself and the deprivation of the victim from his ordered, familiar environment.

> "The objects with which he has identification, and to which his behavior is normally tuned have been removed. He has been suddenly shorn of much of the support and assistance of a culture and a society upon which he depends and from which he draws sustenance . . .
>
> The response to the assault of this realization is withdrawal from perceptual contact with this grim reality and regression to an almost infantile level of adaptive human behavior characterized by random movement, relative incapacity to concentrate attention, to remember, or to follow instructions. Such individuals appear to be 'dazed,' 'shocked,' 'stunned,' 'apathetic'. Actually they are far from being indifferent; it is the intensity of the previously-felt anxiety which has prompted this blocking of perception and regression." (B&R:3, pp.127-128)

Psychological needs which arise during this time are essentially involved with re-establishing contact with reality. So many things have happened so quickly and in such an upsetting manner that the brain needs time to sort them out and make some judgements. This is true of all four types of natural disaster with which we are concerned here, but especially with those forms of disaster, such as tornado and earthquake, which strike with no real warning. In floods and hurricanes, there is generally some prior warning period during which the victims frame of mind has been at least somewhat prepared for impact. But even in these cases of advanced warning, the actual event is often far different than that which one is prepared to expect. The real immediate post-disaster psychological problems include: the trauma of the disaster event itself; the confusion that accompanies this trauma; anxiety over the welfare of family and friends; suffering caused by personal injury, or the injury or death of a loved one; and certain religious or doomsday feelings that perhaps this is some form of punishment, or the beginning of the end. Many of these problems sort themselves out over time. Certain defensive mechanisms come into play in enabling the victim to begin to re-establish the fabrics of life. Certain normal activities, performed almost by rote give the victim the chance to let the events settle:

> "Indeed, even in the area of total impact, there was a tendency for dazed persons to putter about, sweeping, mopping, and sorting out belongings from the wreckage, even though such activities were so trivial in comparison with the task to be done that their significance lay evidently in their symbolic meaning rather than their practical utility." (B&R:3,p.98)

This is not to say that the best course of action is to put people to work immediately after disaster. Rather they should be encouraged to work in a way which will allow them the opportunity to digest the disaster experience in their own mind and at their own pace. Physical and mental exhaustion will limit the scope of their attempts.

> "That is, after a disaster, one's energies on a conscious and an unconscious level are much in use in the service of somehow integrating the disaster experience. It is more important that one's energies be relatively free for this task than that one try to live up to all the workaday expectations that one is quite able to live up to in ordinary circumstances." (B&R:24,p.54)

In the wake of disaster, the victim needs to know that he is not alone, that many others have been left in the same predicament and that he can help others through this difficult period just as they can help him. Human contact becomes essential in calming disturbed victims and in pulling them into the workings of the recovery process.

> "To sum up, the basic principles of psychological first aid concern ways of establishing effective human contacts with disturbed overwhelmed persons who have lost touch to some degree with the world as it is. Once such contacts are made, it becomes reasonably easy to help many of these people to take an active, contributory part in the simpler phases of emergency activities." (P&D:17,p.15)

The community assumes a real importance in the immediate post-disaster period. For disaster is not an experience that hits just individual people, it is also an experience that is common to groups of victims:

> "The socially-disorganizing effects of a disaster are not merely the additive effects of many individual traumas, there is something more which can be considered the group or community trauma." (B&R:24,p.5)

This is perhaps the redeeming feature of disaster. It fosters a realization of community and its importance in the life of the individual. The sense of community becomes a resource for recovery and a source of strength and encouragement. In our mobile, fast-moving society, a real sense of community becomes increasingly hard to find. Disaster slows down the pace of life and forces people to take a second look. It refocuses one's attention on his neighbors and on the larger context in which they live together. This awareness and rediscovery is perhaps the most important source of comfort and support during the first critical week following disaster. Wonderful things can happen:

> "Culturally derived discriminations and social distinctions tend to be eliminated in disaster because all groups and statuses in the society are indiscriminately affected: danger, loss, and suffering become public rather than private phenomena.
>
> Disasters provide a temporary liberation from the worries, inhibitions, and anxieties associated with the past and the future because they force people to concentrate their full attention on immediate moment-to-moment and day-to-day needs.
>
> The widespread sharing of danger, loss, and deprivation produces an intimate, primary group solidarity among the survivors, which overcomes social isolation and provides a channel for intimate communication and expression and a major source of physical and emotional support and reassurance." (B&R:26,p.206)

In this first phase of psychological relief then, two strategies are apparent: an environment should be provided in which the victim's natural defensive mechanisms are allowed to operate in integrating the disaster experience; and suffering should be transformed from a strictly private phenomena to the more open public realm in which it can be dealt with more effectively. The first is accomplished by letting the victim react initially in his own way to exorcise the trauma. The second is accomplished by encouraging the development of a spirit of community. The physical environment will play a major role in determining whether these strategies can develop successfully.

> "The human personality does not merely bud and bloom spontaneously and gravitate towards an environment in which its natural propensities can 'find expression'. The physical (though more particularly the social) environment in which it finds itself serves to shape and mould the developing personality." (B&R:56,p.20)

People must be sheltered following disaster. What is desired then, is a means of initially housing victims that will allow them not only the physical amenities necessary for sustaining life, but also an atmosphere in which the individual will be able to sort the disaster in his own mind and to form groups to discuss common experiences and problems. What this means is that immediately following disaster, shelter is needed that is of such a scale that the opportunity for individual reflection and group formation presents itself. This suggests a mass public shelter arrangement in which one is able to lose oneself in the crowd so to speak, so that his inner restorative mechanisms can operate (privacy of thought is possible even where visual and acoustical isolation are not), and in which group formation can begin to occur both on the family and on the community scale.

> ". . . mass shelters tend to foster group formation more than do hotels and motels. Public shelters afford less privacy and bring people together in mass feeding and sleeping quarters. For this reason, they probably promote the formation of groups which cross over family lines." (B&R:6,p.104)

> "In most situations the architectural environment is only a small segment of a person's total environment. However at a specific time, it can be the critical environment." (P&J:38,p.10)

Such shelter should, if possible, be situated within a large community identified building. Disaster studies have shown that following impact, landmarks such as churches, schools, town halls, etc. that are well-known and that have survived undamaged are often viewed by the victims as a beacon of strength and inspiration. The feeling is that by the survival of these buildings, the community has somehow thwarted the forces of destruction. This feeling is somewhat analogous to being held-up and robbed of one's wallet and afterwards realizing that somehow that twenty dollar bill that you've been keeping in your vest pocket was overlooked, and so you have not been left totally destitute after all. It's sort of a 'who gets the last laugh' situation. Such situations are extremely important in psychological recovery.

But isn't this mass shelter strategy exactly the same as that which is traditionally enacted following natural disaster? Well, not quite. There are several considerations which traditional responses have tended to neglect. In the first place, the choice of buildings for mass shelter purposes is often made without a real consideration for their psychological 'landmark value', or their centrally located positions that would enable them to become community rallying points not only in the immediate situation, but for some time afterwards. Also, conditions within the shelters themselves are sometimes artificially manipulated to discourage group formation because such gathering normally precipitates a great deal of discussion, argument, and emotionalism which authorities and organized relief groups often view with apprehension and alarm. In reality, these group formations are not really potentially explosive, rather they are a form of therapy and psychological relief. But the most important feature which traditional mass shelter responses often overlook is the fact that there is a time limit to the effectiveness of such a form of shelter. Since physiological and psychological needs change with time, the shelter response must also change if it is to be effective. The transition from emergency mass shelter to family-scale temporary housing is often delayed because such temporary housing forms do not become available in time for a variety of reasons, necessitating a longer period of mass shelter habitation. The real desire should be to vacate these mass shelters once the spirit of community cooperation has been developed and has reached a high pitch. Then this community influence will accompany the victims when they move into the temporary housing situation. The danger is that in delaying this move, human nature will get the best of the situation and things like personal discomforts and dissatisfactions will begin to snowball and destroy the positive community feelings that have been developed. And that then, people will either leave the shelter in disgust before temporary housing becomes available, or when it does arrive, will no longer carry such healthy views of community effort.

In summary then, immediately following disaster impact, psychological difficulties arise from trauma and deprivation. The immediate psychological needs can be cared for in mass shelter situations. Such situations can be conducive to community group formation which is important not only to the immediate crisis, but to the following period of situation stabilization as well.

3.3.3 Recovery of Mental Attitude and Balance

The preceding discussion dealt with psychological needs pertaining to the bewilderment and suffering that follow on the heals of natural disaster impact. These needs are essentially short lived if they are given proper attention and consideration. Usually by the end of the first post-disaster week, a period is begun in which the recovery of attitude and balance on the family scale becomes the dominant concern. It is during this period that the changeover from mass shelter to temporary family-oriented forms is essential. This is the period during which the victim strives to regain a measure of the life he knew prior to impact. During this period, a number of positive measures should be taken:

> "The minimization of exposure to secondary traumatic stimuli, the rapid uniting of families, the restoration of familial and occupational routines, rapid and efficient efforts at reconstruction and rehabilitation, and measures designed to protect the populace from future danger are positive measures that can be taken to prevent and ameliorate negative emotional and psychosomatic after-effects."
> (P&J:7,p.48)

Of primary importance is the re-establishment of normal family functions: father working, mother taking care of small children and the household, older children returning to school, activities such as eating, sleeping, and relaxing in a family atmosphere. In such a way, family life-styles can re-emerge. This is essential to the recovery of attitude and balance necessary if the family is to face up to the future which may require certain adjustments and inconveniences for a year or more while the rebuilding process is under way. It is necessary to resume normal man-wife, parent-child, and sibling behavioral relationships. Concern for the development of the child is especially important.

> "In ordinary day-to-day life, the child takes from the parents' behavior the cues as to how he himself should behave with them. The situation is no different in a time of stress or trauma." (B&R:24, p.29)

Here, the message is simply to attempt to return conditions to a sufficient normalcy so that parents will be able to behave in a manner that will be an encouragement for that of their children. In other words, if the parents are upset and ill-at-ease, their children will be also, and their behavior will evidence this fact. This in turn will serve to upset and disturb the already shaky parents to an even greater degree. They have enough problems to deal with in trying to piece back together their physical resources without having to be exposed to domestic ills. These sorts of secondary stresses which do not arise directly by disaster implication must be avoided.

In order to resume normal family functions, it will be necessary to provide the family with a measure of self-sufficiency. Certain facilities and equipment will be required. Thus, for this reason, and for the need for a degree of family privacy, a temporary housing form is essential at this time. Such a shelter should strive to provide basic spaces and equipment that will allow a measure of family living and independence. This shelter form is meant as an intermediate solution to span the time element between the mass shelter living situation and the semipermanent living situation. Self-sufficiency is important to man psychologically. It allows him to resume a life-style which is comfortable for him. It allows him to regain the confidence in his ability to control his own destiny. And it restores a feeling of dignity, a feeling that he and his family are no longer a burden to others.

Another need which man feels at this time is the need to return to familiar surroundings -- namely, the house and lot where he lived previously.

> "It is axiomatic that most disaster victims who have had to flee head straight back once danger has abated. Even if they have no homes to come back to. And usually they rebuild on exactly the same sites. They want life to be the way it was before the catastrophe. 'The pull of the familiar' is the psychologists' phrase." (B&R:9,p.196)

> "Evidently there are strong attachments to a place which has been one's home. It is easier to break such bonds by a voluntary decision then to have them brusquely severed by circumstances beyond one's control. A woman speaks of her home which has been rebuilt on the spot where the previous one had been destroyed by a tornado: "We had friends that tried to get us not to rebuild on this lot. I said, 'Yes, sir, that's home to me and I'm going to build right here.'" Moreover, the need for restitution following a disaster, for undoing the harm done, for restoring the status quo ante so that one can feel (almost) as almost it had never happened finds satisfaction in re-establishing life in the same place.
>
> The impulse to master a trauma by repetition is also operative in the return to the disaster locale. If one can go back into the same situation and experience it in a favorable way, the fears aroused by the catastrophe may be exorcised." (B&R:10,p.168)

Thus, the motivation for returning to one's original home-site derives from two sources; the pull of the familiar, and the desire to return and conquer the situation that caused one so much hardship and anguish. In the United States, I feel that it is this second source which probably influences the return to original surroundings more than the first. Economics also plays a role in that some housing which was damaged can be repaired and brought up to standards quickly and for a reasonable cost. Many people choose to move elsewhere within the area, or to leave entirely. Relocation is sometimes a desirable course of action in terms of safety from future disaster occurrences or in terms of restructuring the community. There has developed in recent years a certain attitude in America that is both good in that it enables victims to start anew more easily, and unfortunate in that it makes it more difficult to develop the type of lasting roots in any single locale that a real sense of community requires. This development is along the following lines:

> "There is a very general American feeling that belongings are replaceable. There is no sense of loss at parting with last year's car which is replaced by a better model. The same often applies to one's house, one's neighborhood, the city where one lives, one's job, and even one's circle of friends. All may be changed, with the prevailing feeling that one will find just as good or better as one moves along. American mobility is closely involved with this sense of easy replaceability.
>
> For Americans, to a marked degree, property, physical appearance, even personality can be changed without a sense of self being altered.
>
> In a more traditional culture, the loss of an hereditary estate may make an individual feel that he is no longer the same person. For Americans, who in each generation acquire on their own their major possessions, and, as has been remarked, continue to replace them repeatedly, there is no such involvement of particular belongings with the sense of self.
>
> There is a measure of protection against the possibility of feeling damaged in defining the self in

> this spare way. The more belongings are included in the definition of the self the more vulnerable one is to losing parts of oneself. To the extent that belongings are replaceable appertenances which do enter into the composition of the essential self, one is more insured against the feeling of being damaged or depleted in losing them." (B&R:10,pp.178-180)

Nevertheless, the need to return to one's homesite as quickly as possible following natural disaster is a very real psychological need. The previous account of new developments in American feelings is somewhat of an over-statement of the case in my estimation. Mention was made of it because it does exist and because that does seem to be a trend presently. But this research deals with the present situation and in that situation, a return to one's homesite can be very beneficial in attitude recovery and mental balance.

The final need in this phase of recovering mental attitude and balance is for the victim to be able to appraise his real situation. Again, this requires a family atmosphere in which stock can be taken of the situation in forming a basis for future planning. Honest and accurate appraisal requires a realistic viewpoint which can only be attained when some conditions of normalcy have returned.

> "However, when households begin to be reconstituted, people expect to find ready to hand all their usual equipment. They then feel the loss of each thing which is missing. As one man says, 'Until you start setting up housekeeping again you really don't know what you've lost.'" (B&R:10,pp.176-177)

During this second phase of psychological need, family and shelter play dominant roles. The family provides the reason and motivation for this recovery. By resuming aspects of normal family life, the victim re-discovers the love and peace of mind that are essential aspects of balance and attitude. The pleasures and responsibilities of family living encourage down-to-earth thinking and action. This sort of normal family life cannot occur in mass shelter situations. This is why temporary shelter forms are essential. The success of temporary shelter in providing for man's physiological and psychological needs depends both on the actual design of this shelter itself and on his state of mind when he moves in.

> "An important aspect of this interaction which we are stressing between man and structured space lies in the area of perception; the impact which a space has upon an individual experiencing it will be conditioned in many different ways by that individual's psychological states and his prior experience." (B&R:52,p.26)

Prior experiences will include those of normal family living prior to disaster impact, those during impact, and finally those of living in the mass shelter situation. The strongest memories should be those of life before disaster. Yet the just-completed experience of life in a mass shelter situation will be particularly fresh in one's mind. Thus happy memories of both of these will greatly influence the victim's satisfaction in the temporary housing phase. Some mention should also be made of the victim's shelter experience during the actual impact. This might have some bearing on his ability to adapt to temporary housing and suggest concerns which might not be apparent.

> "Also in certain kinds of catastrophe belongings may assume an inimical quality. The meaning of a roof over one's head becomes radically changed when one fears that the roof will fall in on oneself and one's children. This was one of the most frequent fears of tornado victims in the moment of impact. Bright, shiny window panes are transformed into dangerous splinters of glass, cherished pieces of furniture may topple and crush their owners . . . . In normal times a house gives a sense of comfort and protection; in the feelings that it evokes, it may be compared to a good mother. In a disaster the house may turn into

a bad mother who threatens to crush her children."
(B&R:10,p.176)

This suggests that such housing should be designed and constructed so that it contains no features that might appear unsafe or threatening, or evoke bad memories similar to those in the just quoted passage. Possibilities should be looked into of actual victim assistance in providing this shelter. By participating in some measure of its assembly or erection, the user would not only feel that he is performing a useful function, but that he also might be better able to appreciate the design and soundness of the shelter system and might feel better in entrusting the welfare of his family to such a structure. Another reason for victim involvement might be the real possibility that such shelter could be moved from some initial site to his backyard when conditions allow. Then his familiarity with erection could be called upon for this operation. It might be possible that he could enlist a couple of neighbors to give a hand in moving his shelter and then reciprocate in helping to move theirs.

Finally, the following factors concerning emotional well-being should be considered in determining the types of architectural spaces that might be provided in temporary housing schemes. These include:

"1.) continuous reaction of individual to the enclosed spaces in which he finds himself.
2.) role played by structured space in conditioning interpersonal and family relationships.
3.) conditioning of extra-familial contacts, community interaction and group association patterns.
4.) status determination." (B&R:52,pp.15-18)

3.3.4 Stimulation of Motivation and Hope for the Future

The final phase of psychological needs deals with the stimulation of motivation and hope for the future. Once the victim has recovered a mental attitude and balance similar to that which he possessed prior to the stress of disaster, he must be motivated to a heightened state of mind in which hope for the future and desire to begin the rebuilding process are stimulated. In large part, this will occur through the process of re-establishing a measure of the self-sufficiency and family life that he knew prior to impact. Also, as the disaster experience grows farther away in time and as some aspects of the physical environment are restored, motivation and hope come more easily.

> "Let the dead be interred, let electricity come back on, let the sun rise, and hope resumes. People start thinking of the future. Soon is heard the most reassuring sound possible in a disaster area; saws and hammers at work.
>
> Soon is seen one of the most reassuring sights possible; clean wash hanging on the line." (B&R:9, p.196)

Finally, man needs the example of recovery operations commencing and proceeding on the community scale. The clearing of roads, cleaning of debris, and the general hustle-bustle of large-scale rehabilitation operations does much to put man in the proper frame of mind about the future. The return of services and reopening of businesses and other signs of resuming normalcy promote a real feeling of optimism.

It is in this final phase of psychological recovery that the importance of the community becomes once again apparent. Just as in the first phase of psychological recovery, where the development of a spirit of community provided a real emotional uplift, so now a re-emergence of community activity acts in the same way in stimulating real hope. As always, the family remains a stabilizing factor. In involving the family members in planning for their future and in evaluating the options which are available to them, a stronger sense of purpose results. The prospects of moving back to their homesite while they rebuild or renovate are important factors in motivation. Being able to participate in, or just watch the workmen and contractors at work, is an important stimulation. Finally, the prospects of the arrival of semi-permanent housing, such as mobile homes, or the completion of necessary repairs to make their homes livable again makes the future that much brighter and that much closer to reality.

3.3.5 Summary: Psychological Shelter Implications for Performance Guidelines for Use in the Period of Situation Stabilization

Nature of Shelter: This shelter shall be of a family type which is suitable for a number of activities and which allows for a measure of self-sufficiency.

Purpose of Shelter: This shelter is to provide a framework for re-establishing a normal family routine, and for restoring a sense of dignity and self-sufficiency to the victim.

Timing of Delivery: This shelter is to be delivered within a 2-week time frame following disaster impact. Studies show that initially mass shelter can be an effective means of shelter in the immediate post-impact period when emergency facilities are required. The opportunity for group formation and the development of a spirit of community are characteristic of such shelter. This group formation is important not only in the relief of psychological suffering, but also in motivating the recovery process. Studies also show that this development peaks eventually and that prolonging the stay in mass shelters leads to a disintegration of the community feeling. It is most desirable to implement the transition from mass shelter to temporary family-oriented shelter at the peak of community spirit. This usually occurs in the first 7 to 10 days following impact. Therefore, it is essential that temporary housing be provided sometime in the period between one and two weeks following impact.

Siting: This shelter should be placed in cluster arrangements with other similar shelters in the vicinity of large buildings and open spaces where activities can be encouraged such as day-care, sports and games, group meetings, information exchange, entertainment, and medical services and counseling. Alternately, shelter should be moved to original homesites when this becomes possible.

Community: This shelter should be designed and set-up so as to encourage visiting and contact between neighbors.

Shelter Activities: This shelter should provide for the activities of sleeping, eating, cooking, relaxing, playing, cleaning, grooming and bathing.

Self-sufficiency: This shelter should provide basic facilities and resources for maintaining the physiological requirements of the family, including food preparation and storage, bathing, cleaning, and waste elimination.

Nature of Spaces: This shelter should provide flexible spaces that are adequate for their intended use. Spaces should be light, airy, and uncluttered. Provision should be made for varying degrees of visual and acoustical privacy. The immediate outdoors should become an extension of indoor space.

Feelings: This shelter should evoke the user's confidence through adequate detail of strength, durability, safety, and security: and by involving him in some aspects of erection and placement.

Psychological considerations include the areas of design, construction, social and personal relationships, siting, and logistics. Thus it is not enough to simply specify design and construction criteria. In providing for psychological needs, the concern for logistics, siting, and relationships are equally important. It is these last areas in which psychological influence will affect performance guidelines.

4. TRANSLATION OF NEEDS INTO SPECIFICATIONS FOR TEMPORARY HOUSING

4.1 TEMPORARY HOUSING: ALTERNATIVE APPROACHES

4.1.1 BRAB Recommendations

There are basically two alternatives for providing temporary housing -- use of housing resources within the immediate area or importing shelter units from outside the area. In the recently completed BRAB study, Housing Technology Alternatives For Use In Planning Post-Disaster Housing Assistance Programs, three recommendations were put forth:

> "1.) limiting as far as possible the importation of structures.
> 2.) providing structures when they must be imported that offer a standard of livability no greater than that demanded . . .
> 3.) involving a broad spectrum of the building industry." (B&R:31)

These recommendations are well-founded and should be observed. Several comments are in order however. First, in limiting the importation of structures, the concern should be for timing. If by such limitation, the victim's stay in the mass shelter situation will be prolonged beyond two weeks, then such limitations should be dispensed with. This means that if sufficient alternative forms of in-area family-type housing cannot be found or utilized within the first two post-disaster weeks and if repair and rehabilitation is expected to be a prolonged affair, then structures should be imported without question. The second recommendation is logical provided that the 'standard of livability' desired is defined. That is one of the objectives of this research. The last recommendation is both an economic and political argument. In principle, it is a wise course to follow. But, if it is found that one particular building industry offers the greatest potential, or has developed the only real viable shelter solutions, then that industry should be encouraged even if it means neglecting the others.

4.1.2 Use of In-Area Housing Resources

Consideration must now be given to the question of utilizing housing resources within the area versus importing structures from outside. We must identify what types of 'housing resources' exist, and what exactly 'within the area' means.

In the situation stabilization period 'housing resources' means housing suitable for resumption of the normal family routine for a period that may last up to two months in duration and that will begin within one or two weeks following the date of disaster impact. Such in-area resources include single-family housing of the house of mobile home form, multi-family apartment buildings, and commercial hotels, motels, and boarding houses. Such housing forms possess the framework and facilities necessary for family living. The real problems however, concern their cost, their condition following disaster, their availability and readiness for the period intended, and their location. Certain accommodations such as hotels and motels may be prohibitively costly, yet some workable plan might be instituted. Many housing resources that have escaped serious damage within the area might not be suitable because of disruptions of services and utilities caused by disaster which may require a long period before they can be restored. There is the possibility in this regard of developing a service/utility package that might be delivered to the unit to make it livable. Such a package might contain equipment for providing drinking water, bathing and cleaning facilities, cooking, heating, and power. Many housing resources may not be ready or available within the first two post-disaster weeks. Or they might be available for only part of the period during which they are needed. Either of these cases is unacceptable. It is essential that the victims be transferred from mass shelter situations within the first two weeks and it is important that they not be shuffled around during their stay in the temporary housing situation. Finally, there is the question of location. It has already been shown in this research that there are strong psychological implications for keeping the victims within an atmosphere of community and neighborhood (though living in family quarters) and for allowing the victim to return to his homesite. He needs the comradeship of others and he needs the feelings of familiarity, security, and mastering one's fears that a return to the homesite can provide. His physical presence during the rebuilding process is also an important consideration. This drive is so strong that there are many documented cases of families returning to the homesite when there were no services or utilities, and even when the house itself was in a severely damaged state. Thus, it is essential that housing resources utilized be within a reasonable proximity of the victims' homesites. In today's mobile society, nearly every family possesses at least one automobile. Temporary housing should probably not be more than 30 minutes drive at most from the homesite. This would place a distance limit of 15 to 20 miles at the maximum, in most instances, probably less. So, in the use of existing housing resources within the immediate area, the whole picture must be surveyed and the aforementioned restraints imposed. Both the scope of the disaster impact and the scale of surviving housing resources will determine the feasibility of this approach.

4.1.3 Use of Imported Shelter Resources

On the other end of the spectrum is the possibility of importing temporary shelter units into the area. There are three principal types within this option. Their basic difference lies in their intended recoverability. By this, I mean whether they are designed to be used once and thrown away; to be reuseable a number of times; or to be used once, but instead of being disposed of, be expandable in-whole-or-in-part to become a part of the permanent house. All three options will be considered.

ONE-USE, DISPOSABLE

This form of shelter is attractive from both an economical and a logistics viewpoint. Since durability is only a two-month concern at most, materials and techniques could be used that would not be suitable in a conventional structure. Savings in materials and labor costs are possible. Such shelter can be constructed using today's technology and can be made livable for the period intended. One drawback is the service and utility equipment which is often quite a sizable investment for a one-use situation. This could be overcome by segregating all such equipment within a basic core unit that could be hooked-up to the disposable shelter unit during its two-month use period, and then unhooked and reused any number of times in later disasters. Such a service/utility package could also be used in conjunction with existing housing resources that would be suitable except for lack of such services and utilities. The concept of using space either in the form of imported structure, or in the form of existing housing is an extremely promising one and bears further research. The fact that it has the capability of employing both alternative approaches is significant.

The other encouraging feature of a one-use disposable system is that of logistics. Such a system is essentially only handled once. After it has been used, it does not have to be repackaged or reshipped. It is simply disposed of. Thus, problems such as maintenance, restocking, wear, repackaging, and clean-up are avoided entirely. These operations take labor and cost money -- money which is really depreciation and gets the user nothing. In addition, in-field construction techniques might be utilized, eliminating transport problems. Thus, it would appear that one-use disposable systems are potentially attractive. Additional information is necessary before making a final judgement, especially in the areas of fabrication and materials. One further concern is that of ecology. Some such systems employ synthetic materials which are either non-biodegradeable, or chemically objectionable. In the wake of natural disaster, there is enough rubble and debris to be disposed of, without adding to it with large numbers of shelter carcasses. The key word then is disposable. This means that the unit must be either capable of being consumed by natural processes, or it must be capable of being 'shredded' and its materials used as resources for other desirable purposes.

REUSEABLE

This form of shelter is attractive because it can be used in a number of disaster experiences. Thus, the results of one manufacturing effort can be used for a number of years in a number of disaster situations. Economically, there are several costs which must be considered. First, there is the initial unit construction cost. Since this unit must be durable both in terms of weatherability and user abuse, such a first cost can be substantial. Then there are the inventory costs. Such units must be stored in some central locations between periods of disaster use. Also, there is the cost of delivery, setting-up, taking down, and returning the unit every time it is utilized. Finally, there is the cost of maintaining the unit: general maintenance and repair, restocking, and repackaging for shipment. Such cost accompanies every use. Thus cost is an important consideration, not only the first cost, but operating cost as well. Involved statistical evaluation is really needed in arriving at a true cost picture over time. Such an evaluation is not possible in the context of this paper.

A reuseable system could be quite livable in the temporary housing period. One concern would be that shipping and reshipping requires that such a unit be as small as possible. This has many user implications. If the accommodations are too small, the unit could be unacceptable as temporary housing in that it would present a stressful environment to the user. This implies then that such a unit should occupy as minimal a volume as possible during shipping operations, and as large a volume as possible upon erection. There are several ways of accomplishing this. Various folding schemes could be used. Also, the packaging system could become a part of the unit during erection. Or, the service/utility package could be separated from the unit during delivery so that the shelter part could be compacted in some manner and then expanded on-site and hooked-up to the core package. This latter is a promising possibility.

EXPANDABLE IN-WHOLE-OR-IN-PART TO PERMANENCY

A form of shelter that would be expandable in-part-or-in-whole to become part of the permanent house is a very exciting architectural possibility. Certain technical and cultural problems must be considered, however. The problems of integrating such a unit with an already existing housing form presents questions of differing construction practices, differing materials, and aesthetics. On the other hand, using such a unit as the starting influence for a whole new house might be more appropriate. Designs would be needed that would allow for a great deal of lay-out variation, flexibility, style-range, siting alternatives, and cost-range. Such a comprehensive design package is certainly a possibility. Other problems such as the selection of which parts of the unit to incorporate into the permanent scheme would have to be resolved. Such units would have to be constructed with standards similar to that for conventional housing if a successful transition is to occur from the temporary to the permanent situation. One advantage of this scheme is that the user can really begin to get back to normal living since his temporary environment will become a part of his permanent environment. The process of growth would be especially evident and could become a real source of satisfaction to the victim.

Certain cultural questions arise. Is this a culturally acceptable solution in this country? In other, less-developed countries, the process of incorporating temporary structures into the permanent home is a common practice following disaster. (P&D:12,p.18) But their permanent homes are usually quite deficient in many aspects. In this country, people expand their existing homes by means of an 'addition'. Thus, the problem of growing a house is not completely alien. It would seem that the real concern would be that the temporary unit be of a sufficient quality and of a sufficiently traditional appearance that it would not stand out when the permanent house is complete, or if it did, that it would not be objectionable, but rather, an enhancement.

4.1.4 Additional Considerations

The considerations of cost, livability, and some technical aspects have been discussed in the area of imported temporary housing systems. Two final concerns are also important -- mobility and acceptability. Alternate siting arrangements are desirable. Initially, these units might be clustered together near some large resource centers. But, when possible, the victim will often desire to be relocated close to his damaged homesite. When conditions permit, it would be advantageous if he were able to move his temporary housing facilities to his backyard, or near his property. Thus, such imported shelters should have the capability of being uprooted, moved short distances, and set-up again all within the same day. Since most victims will have a car of their own, or access to one, it would seem logical that this be used as a means for transporting the unit. Some sort of hitching mechanism should be developed to allow for this operation. Then some means for either directly placing wheels on the shelter or placing it on some form of trailer bed should be possible. Restating the case: this operation should be capable of being performed by the victim or by a group of victims and should not require a great deal of accessory equipment; and this operation should be capable of being completed within the time frame of one day.

The final consideration is that of acceptability. Will the victims accept imported shelter as temporary housing. First, they have in the past. Second, this may in some ways be preferable to living in other available housing during the period of temporary housing. Such shelters could conceivably be a fun experience -- sort of like getting a new car. The American way of living is geared to this practice of trading-in and renewing.

Such a practice might also have the further psychological advantage in that the appearance of large numbers of such shelter units can be a real encouragement that the situation is being met and better things are to come.

4.2 SUMMARY: PRELIMINARY SPECIFICATIONS FOR TEMPORARY SHELTER TO BE USED IN THE PERIOD OF SITUATION STABILIZATION

The following specifications are meant to act as preliminary guidelines for temporary shelter units. These guidelines are meant to augment normal housing performance guidelines so that the disaster requirements can be provided for in a framework that is physiologically and psychologically attuned to particular user needs. These guidelines will be expanded and possibly modified during the next phase of study in which technological implications will be investigated.

4.2.1 Shelter Aspects

PHYSICAL CHARACTERISTIC

Occupancy: Single-family situation. The design should accommodate 4 persons. Provisions should be made for the addition of space to accommodate larger families. Minimum occupancy will be 3 persons.

Self-sufficiency: Units shall possess the capabilities of complete self-sufficiency with the exception of electric power which will be assumed either operative by the end of the first post-disaster week, or provided on a temporary basis from large portable generators, or from selected trunk lines diverted from other locales.

Spaces: A number of interior spaces are necessary. In addition, the design and layout should encourage the use of immediate exterior spaces as much as possible as an extension of the shelter itself. Areas surrounding the structure, as well as above and below, should be investigated as possible activities areas.

Physiological and psychological considerations suggest that the following spaces be provided:

2 sleeping areas, one of which must be totally private; the other must possess the capabilities of semi-privacy and of alternate use for other activities such as play.

1 food preparation area (kitchen), which should include areas for cooking, cleaning, storage, and working; as well as necessary equipment.

1 living room/dining space in which the eating area can be either a separate area, or used only at meal times for that purpose.

1 wash area with space for a minimal tub/shower unit and space for drying. This area is to be capable of total privacy when used for bathing. This area is to double as a laundry, during which use, the tub shall be used as a wash tub. Some storage area and work surface should be immediately available.

1 private bathroom area with space for toilet and sink.

1 service area for storage tanks, holding tanks, service equipment, and fuel storage.

2 closet spaces, one of which must be accessible to the bedroom areas.

The following areas are suggested as suitable standards. These sizes were arrived at through an attempted synthesis of area sizes suggested in the following sources: 1.) F.H.A. Minimum Property Standards (B&R:47,p.32); 2.) Architectural Graphic Standards (B&R:51,p.13); 3.) Time Saver Standards (B&R:50,pp.1038-1040); and typical spaces in mobile home applications (P&D:29,p.2).

1 private sleeping area	90 sq. ft.
1 semi-private sleeping area	80 sq. ft.
1 kitchen area	50 sq. ft.
1 living room/dining area	180 sq. ft.
1 wash area	25 sq. ft.
1 bathroom area	20 sq. ft.

1 service area		15 sq. ft.
2 closet areas, @ 7-1/2 sq. ft.		15 sq. ft.
	TOTAL:	475 sq. ft.

These spaces are referred to as areas. Only three such areas must be considered as rooms in the true sense of the word -- the private sleeping area, the wash area, and the bathroom. In the remainder of the shelter, open space type planning would seem most logical, both in the nature of the multi-use character of many areas and the need to minimize feelings of tightness that a constrained area evokes. Each space, with the exception of the service area and the closets, should have at least one operable window, both for daylight illumination and ventilation. In addition, sources of artificial lighting shall be provided, which are to insure an illumination level of 30 to 70 foot candles. (B&R:50,p.869)

Unit Size: A total unit area of 475 sq. ft. is suggested by a summation of spaces previously articulated. This figure should be adhered to within a 5% (25 sq. ft.) limit.

Dimensional Implications: Units should be kept to a basic height of one story. Interior stairs take up space which is too valuable to lose. However, telescoping roof sections that might increase interior ceiling heights are permitted and desirable as a means of enhancing and varying interior space. In such cases, lofts attainable through the use of vertical ladders would be permissible. Exterior stairs or ladders may be used to make the roof area accessible for various activities. In such cases, adequate handrails and roof railings are to be provided.

Ceiling heights of a minimum of 7 feet should be permissible. A 7-1/2 foot high ceiling would seem to be the most desirable. Since space will be tight within, a ceiling somewhat lower than the customary 8 feet will give a slightly enhanced feeling for area, despite the decrease in volume.

Total length, width, and height limitations will be imposed by both the nature of the delivery process, and by the desire to maximize the number of units deliverable by each transport operation.

Safety: Normal housing concerns and standards relating to fire protection, accident prevention, and equipment safety should be rigidly followed. In addition, the structure should be capable of withstanding the following loadings:

Snow -- 20 lbs./sq. ft. (provides for adequate safety in over 90% of the country. The maximum snow loading level is 40 lbs./sq. ft. and affects less than 5% of the country. Since these figures are based on seasonal snowpack, it should be possible to remove some of the snow from the roof during the course of the winter to allow for this reduced loading capability of 20 lbs./sq. ft. in even the snowiest regions) (B&R:50,p.131)

Wind -- 45 mph. (provides adequate protection throughout the United States for a unit of this size) (B&R:50,p.132)

Earthquake -- lateral loading equal to 10% of the dead load of the structure

Dead -- the weight of the structure itself.

LOGISTICS

Siting: More than one site may be used during the period in which the temporary shelter is to be in use. For this reason, and for the fact that optimum site conditions cannot be anticipated, two concerns must be realized: 1.) the normal architectural practices of site planning so as to take full advantage of the natural environment, cannot be depended upon in this situation; and 2.) the system of foundation must be amenable to the moving process and to various ground conditions.

Mobility: The possibility that the unit might be moved from some initial site (in some larger community context) to a different site (backyard or neighborhood area) requires that it be provided with some means to permit this relocation. Such movement should be accomplishable without extensive equipment and labor requirements. Since nearly everyone has access to a car, this should be considered as a principal mode of movement. The shelter should be provided with some means of affixing wheels to it, or of placing it upon a suitable trailer-bed. An adaptive hitching system should be provided for connecting the unit to the car for movement. Such movement should be restricted to the immediate area, and to slow speeds. Complete resituational efforts should be accomplishable within the time frame of one day.

4.2.2 Service Aspects

HEATING, COOLING, AND VENTILATION

Heating and Cooling: Each unit shall have a heating unit capable of maintaining a 70°F indoor design temperature with an outdoor design temperature of -15°F. This provides for a heating capacity capable of meeting winter conditions in over 90% of the country. (B&R:50,p.742) Provision should be made for secondary heating units to be added in meeting winter disaster emergencies in the colder regions.

A summer indoor design temperature of 70°F is also desirable, yet a higher temperature can be tolerated under certain conditions. Over 90% of the continental United States has a summer design temperature in the 90°-100°F range, or lower. (B&R:50,p.745) In many instances, the occupant can provide fans or small unit air conditioners which he has salvaged from his home. Adequate insulation, shading, and ventilation should make summer living conditions tolerable in most instances. In disaster situation which arise in the hotter regions of the country, small room air conditioners should be provided as additions to the basic shelter package.

Ventilation: Each enclosed living space within the shelter shall have at least one operable window to insure a means of natural ventilation. Attic spaces (if any) shall be provided with adequate vents. Recommended ventilation rates of 20 cfm per person (in the case of the shelter unit which serves 4 people: 4 X 20 = 80 cfm total) shall be attainable within the unit. In addition, the kitchen area shall be mechanically vented by means of an exhaust fan so as to eliminate smoke and cooking odors effectively. A ventilation rate of 2 cfm per sq. ft. is recommended. (B&R:50,p.743)

PLUMBING

Water: Fresh water shall be contained in holding tanks which shall be periodically replenished from some outside source. All water-related systems shall be designed so as to minimize the use of potable water. In the United States, the average daily consumption of 30-80 gallons per capata is excessive and wasteful. Much of this is needlessly wasted in carrying bodily waste products from the home. Such forms of waste are not permissible in this form of shelter.

Self-sufficiency requires that the unit carry its own potable water storage facilities, since the resumption of municipal water service cannot be assured during the temporary housing period. If people are taught to be careful in their use of potable water, if systems are provided which minimize water usage, and if efforts are made to recycle non-sewage waste water, then a per capita daily consumption of potable water on the order of 10 gallons should be sufficient for normal activities of drinking, cooking, cleaning, bathing, and grooming, without making the occupants feel as if they are rationing water. Considering a family of 4, this means a daily usage of 40 gallons total, and a weekly usage of 280 gallons. A storage system with a 280 gallon capacity would necessitate replenishing operations only once a week, which should impose hardship upon the family. A cylindrical tank, 2 ft. in diameter and 6 ft. tall, has a storage capacity of 141 gallons. (B&R:50,p.591) Two such tanks together would provide a storage capacity slightly in excess of the 280 gallons required, and would be about the limit size-wise that would be desirable. Refilling could be obtained once a week from water tank trucks that could make regular visits around the area.

Waste Disposal: There are two principal forms of waste: excremental and water. In conventional systems, all wastes, both excrement and water, are carried out of the unit by means of water. In the temporary shelter period, sewage systems may be inoperative. Therefore, an alternative approach to the elimination of wastes must be implemented. Excrement in the form of fecal matter and urine must be disposed of carefully in order to guarantee against disease and odor. Sanitary toilet systems exist which require as little as 1 quart of water to flush after each use. (B&R:46,p.32) Such systems employ holding tanks in which chemicals attack the wastes. These holding tanks must be periodically flushed and their contents disposed of. There are other self-contained recirculating chemical systems which allow as many as 80 flushes between emptying operations of the holding tank. Whichever system is utilized, it will require a periodic emptying of the holding tank and disposal of its contents. This should be done about once a week at most so as to be as slight an inconvenience as possible. Some sort of municipal operation run similarly to that of garbage collection should be instituted.

The other type of waste disposal problem is that of waste water -- from sinks, washtub, and shower. This water could be collected in a holding tank where chemicals would be added to purify and clean it. This water then could be reused for cleaning, washing, and bathing, but not for drinking. Excess water could be drained to the ground without worry of pollution or contamination.

POWER

Electricity should be solely relied upon for power. It should be possible within the first two post-disaster weeks to restore the electric utility to a serviceable condition in at least a few selected areas. The reasoning behind this statement is that electricity in the suburban or town situation is normally carried by wires which are strung above ground, and hence easy to get to for repair operations, unlike water, sewage, and gas lines which are buried beneath the ground and must be dug up in order to repair. In the case where electrical generators and transformers were severely damaged, it should be possible to divert power from other areas to the disaster zone, or to truck in auxiliary equipment. Electricity has the advantage of no storage requirements and easy hook-up for shelter applications.
All efforts should be aimed at restoring this utility first following disaster.

5. TECHNOLOGY: INFLUENCE AND IMPACT ON PERFORMANCE GUIDELINES

It is the intent of this section of research to: 1) identify technological areas of concern; 2) develop an understanding of the significance of each area; 3) analyze the pertinent data of concern; 4) suggest refinements for those guidelines previously outlined; and 5) make recommendations for further performance standards. These standards, or guidelines, shall then present a total picture of temporary housing potential. By coordinating this investigation of both user needs and technological realities, a meaningful guide for use in the disaster period of situation stabilization should result. Then, with such a guide in hand, a more meaningful avenue will be created for the evaluation of available alternative shelter systems, and for the initiation of new design.

Shelter is really a combination of several elements -- services, furnishings, enclosure, and foundation. Services include the mechanical and utilities systems and equipment that make the shelter comfortable, convenient, and healthy. Furniture provides the equipment of a non-mechanical nature that is necessary for various activities. Enclosure provides the framework in which these activities take place, and the envelope necessary to protect man, services, and furnishings from the elements. Enclosure includes; structure, roof, floor, walls, skin, ceiling, and openings. The foundation forms both the base on which the enclosure rests, and the means for stabilizing it against the forces of nature. A complete shelter package then combines all of the elements just described. Technologies which play an important role in the field of shelter include the following:

Materials
Structural Systems
Services: Electrical, Plumbing, and Mechanical
Fabrication
Delivery
Erection/Placement/Securement

5.1 MATERIALS

5.1.1 Significance

A shelter is built from a variety of materials which provide the enclosure, space definition, and texture that compose the immediate living environment. It is essential that they be chosen wisely. The practical considerations of economy and construction techniques further influence material selection. In determining materials for temporary disaster shelter, the normal material concerns are operative, but, in addition, special concerns arise.

5.1.2 Types

Three functional types of materials are required in shelter construction: structural, skinning, and insulating. Structural materials must be strong and capable of withstanding the various forms of stress which are applicable. Skinning materials must be strong, durable, and watertight. Insulating materials must have low coefficients of heat transfer. In all material considerations, attempts must be made to minimize weight without sacrificing the functional requirements. Various materials can be used for each of these functions. Certain materials possess properties that make them suitable for fulfilling two or more functions simultaneously. In surveying the field of available materials, certain classes appear promising for temporary shelter use. These include: metals, wood products, plasterboard, plastics, and fabrics. An attempt will now be made to explore and evaluate each of these classes.

METALS

Steel

Structurally, steel is an excellent choice because of its physical and mechanical properties, and because of its availability in a wide number of structural shapes. Its mechanical properties include a yield strength of the order of 25,000-50,000 psi., a tensile strength on the order of 40,000-60,000 psi., and a modulus of elasticity on the order of $1x10^7$ psi. It is available in the following structural shapes: equal angles, unequal angles, channels, H-beams, I-beams, wide-flange beams, tees, zees, bars, pipes, and rods. (B&R:33,MET1-Uni:pp.3-13)

As a skinning element, steel is usually used in the form of thin sheets. Because steel is susceptible to rusting, it must be protected if it is to be used as an exterior skin. There are two basic methods of providing this protection. The first involves the process of galvanizing. This involves coating carbon steel sheets with zinc in a hot-dip process. United States Steel provides galvanized steel sheets in a number of variations: regular galvanized, minimized spangle, paintbond, galvannealed, and specialty. These involve varying degrees of galvanizing and varying surface finishes. Such steel is available in both sheet and coil form. Thicknesses from .0157 to .168 inches are available. Widths from 3 to 60 inches, and cut lengths from 18 to 218 inches are also available. The second protective process entails the coating of carbon steel with aluminum containing 5% to 10% silicon. This combines the corrosion resistance, heat resistance, and heat reflective properties of aluminum with the strength of steel. Such steel is also available in sheet or coil form. Thicknesses, widths, and lengths are in a range similar to galvanized. (B&R:33:MET1-Uni:pp.3-13)

Aluminum

Its properties and availability in various structural shapes make aluminum a desirable material for structural uses. Its mechanical properties include an ultimate tensile strength of 25,000-88,000 psi., a yield strength (tension) of 6,000-78,000 psi., a shear strength of 11,000-52,000 psi., and a modulus of elasticity on the order of $1x10^7$ psi.. It comes in the same structural shapes as steel. (B&R:33,MET2-Alu:p.15)

Aluminum is also available in thin sheets suitable for skinning functions. Its inherent weatherability is a real asset in this form of application. Alcoa produces a number of different types of aluminum sheets, including: enameled, patterned, stainless steel clad, and vinyl-coated. It also is available in sheet and coil form in thinknesses of .015 to .051 inches, and widths up to 48 inches. (B&R:33,MET2-Alu:pp.2-5)

Some observations can be made about metals. First, they are relatively heavy: steel -- 490 lbs./cu. ft., and aluminum -- 165 lbs./cu. ft.. This implies that they must be utilized as efficiently as possible so as to minimize the amount of material used. This is possible structurally since these metals come in a number of sizes and structural shapes. This is also possible in skinning applications because of the extremely small thicknesses available in the sheet form. Secondly, durability will normally require special finish treatments for steel, but not necessarily for aluminum. Thirdly, both metals have extremely high strengths as has been shown, and this can allow a reduction in the cross-sectional area of material used. Fourthly, neither steel nor aluminum possess insulative value. However, the use of reflective finishes can be of value in maintaining a level of thermal comfort. Finally, metal does not burn, but melts at sufficiently high temperatures on the order of 1,000°F (B&R:37,p.4.5) When metal melts, it loses its strength and shape.

WOOD

Wood comes in a number of useable forms -- boards, beams, planking, and sheets. It has possible applications for both structural and skinning purposes. The mechanical properties of wood vary with type. In general, wood has a modulus of $1.2\text{-}1.6 \times 10^6$ psi., and an allowable bending stress on the order of 1,200-2,000 psi.. (B&R:51,pp.214-215) Wood comes in rectangular cross section in a variety of thicknesses, widths, and lengths. Its widespread availability and use in traditional housing construction make it attractive for shelter application.

Plywood, masonite, and composite fiber board are all possible skinning elements. These generally come in 4 ft. x 8 ft. sizes and larger; and in thicknesses varying from 1/8 inch to 5/16 inch for masonite and from 1/4 inch to 1-1/8 inches for plywood. Both plywood and masonite can be used for exterior purposes, but must be protected from the elements by painting or covering. Plywood, because of its alternate criss-crossing of plies is quite strong in all directions, as opposed to lumber which is strong only in the direction parallel to the grain.

Wood then is a viable material for structural and skinning uses. Its relatively light weight -- 20-40 lbs./cu. ft. -- makes it even more attractive. However, its susceptibility to fire makes it dangerous in shelter application. It therefore must be protected from heat and flame. Its use must be restricted to areas in which it can be protected -- for example, as studs within plaster-sided walls. Its susceptibility to deterioration from moisture and termites requires that it be protected from direct exposure to such threats. Finally, wood, while better than metal in terms of insulating properties, falls far short of that necessary for real thermal protection.

PLASTERBOARD

Gypsum plasterboard has applications as an interior skinning element. It is available in 4 ft. x 8 ft. panels and larger, and comes in a standard 1/2 inch thickness. It is composed of calcinated gypsum which has a great affinity for water and becomes rock hard through the process of setting. Gypsum plasterboard is mentioned here because of its great fire resistance and ability to protect structural elements from both flame and heat.

> "When gypsum-protected structural members are exposed to a fire, the chemically-combined water being released as steam acts as a fire barrier until the slow process of calcination is completed. The temperature directly behind the plane of calcination is only slightly higher than that of boiling water (212°F), and that is considerably below the temperature at which steel begins to lose its strength, or lumber ignites." (P&D:19,p.6)

One advantage with gypsum plasterboard is its relatively low weight -- 53 lbs./cu. ft. (2.2 lbs./sq. ft. for 1/2 inch thick panels). This is comparable to plywood which weighs 36 lbs./cu. ft. (1.5 lbs./sq. ft. for 1/2 inch thick panels). (B&R:51,pp.672-673) Furthermore, gypsum plasterboard is durable as an interior skinning material and possesses excellent sound characteristics. Its thermal conductivity is slightly higher than wood, which means that it is not a very good insulator.

PLASTICS

Plastics are synthetically produced chemical compounds. In the fast-growing field of plastics, there are two principal types that have real application to shelter construction -- cellular and glass fiber reinforced. The two are so different that they must be considered separately in nearly every respect.

Cellular

These include polystyrene, polyethylene, and polyurethane. In general, their properties are similar. Of primary interest in housing applications are the polyurethane products commonly known as urethane foams.

> "Urethane polymers are produced by reaction of isocyanates with hydroxyl-bearing compounds (primarily polyether, or polyester compounds). A gas generated within the reaction mixture produces the cellular or foamed structure." (B&R:36,p.89)

Urethane foams have a wide range of material applications: structure, skinning, and insulative. This unique ability to combine all three material functions within one material makes urethane foams extremely inviting as a building material. Urethane foam possesses unique physical characteristics. Due to its cellular nature, low thermal conductivity levels on the order of .11 Btu-in./hr. °F ft.^{2} are possible, with densities of 1 to 3 lbs./cu. ft.. (B&R:36,p.89) Structural foams with densities as high as 14 lbs./cu. ft. are available. These possess a compressive strength of 8,000 psi. and a tensile strength of 5,800 psi. (P&D:23,p.2) These are special-use foams however and are much more expensive. Common urethane foams of 1 to 3 lbs./cu. ft. density generally have much lower strengths (compressive -- 35 psi., tensile -- 30-45 psi.). (P&D:20,p.2) With urethane foam there is a trade-off between strength and insulative value. Higher strength requires greater density; greater density means less trapped air pockets within the foam, and hence lower insulating efficiency. In general, foams around the 6 lbs./cu. ft. range are capable of structural application while retaining a sufficiently high insulating characteristic.

Urethane foam can be utilized in two forms: sheets and liquid. Urethane foam sheets, which are available in a variety of thicknesses, widths, and lengths, can be used as insulation or in structural panel applications. In addition, since urethane is self-foaming, it can be utilized in operations such as pouring-in-place, and spraying. No heat is required to trigger the foaming operation in which two chemicals are mixed and expand to thirty times their original liquid volume. Thus, urethane is an extremely flexible material to work with. It can be used to fill cavities, since it expands to fill any shape which encloses it. It can also be sprayed on surfaces to provide insulation and sound deadening properties, or it can be sprayed on a formwork covered with layers of wire mesh, allowed to harden (setting occurs within several minutes, full curing takes only several hours), and the formwork can be removed, leaving a structural shell. Such techniques have been used in experimental housing forms.

There are a number of drawbacks to the use of urethane foams, however. They are very expensive when compared to other materials on a pound-for-pound basis. Furthermore, foam products are combustible. They can be compounded to be self-extinguishing, or in some cases non-burning. This costs extra money though. It is generally best to protect urethane foam from direct flame contact. Finally, when used as a skinning agent, care must be taken since foam disintegrates in the presence of the sun's ultraviolet rays at the rate of about 1/16 of an inch per year. Special paint-on sealers are available to combat this.

Urethane foams are extremely efficient insulation materials. This is probably their most valuable attribute. The alternative methods of foam application make it desirable from a building process standpoint. One of the most successful applications of urethane foam technology thus far has been its use in sandwich panel construction. Sandwich panels are an extremely efficient way of taking full advantage of the attributes of urethane foam while at the same time overcoming its limiting aspects. Such panels feature thin faces of metal or fiberglas separated by several inches of urethane foam. These panels can then become structural by taking advantage of the fact that the faces, which are extremely strong in tension, are separated by a substantial distance. In this way, nearly all of the stresses are concentrated in the faces. The foam core simply acts to keep the faces separated, and does not need to be structural itself. This means that the foam can be a low-density type, and hence, a very good insulator. In addition, the face materials protect the foam core from moisture absorption, the ultraviolet rays of the sun, and from direct flame contact in the event of fire. These sandwich panels can be economically competitive and should be seriously considered for possible shelter applications.

Glass Fiber Reinforced

This form of plastic product is generally known by the name of fiberglas. It is produced by a combination of plastic resins and fiber reinforcing. These resins are of the polyester and epoxy variety, and the reinforcing is glass in the form of fabric, mat, yarn, or roving. This product possesses high mechanical strength comparable to that of aluminum (B&R:60,pp.322,324),

a high level of impact resistance, and an exceptional degree of dimensional stability. It is stronger than steel (lb. for lb.), and lighter than aluminum (per cu. in.). Fiberglas (30% glass) weighs on the order of 80 lbs./cu. ft.. (B&R:37,p.4.5)

Fiberglas is suitable for both structural and skinning purposes. In addition, it possesses a low thermal conductivity. It is combustible, however, but may be made quite fire-resistant through the use of flame retardant additives. Fiberglas is also immune to insect and vermin attack and does not nourish mold growth that could cause deterioration. It has a long life expectancy. It can be made resistant to sunlight, but its colors tend to fade after prolonged exposure.

Furthermore, fiberglas is a nice material to work with. It may be molded, drilled, tapped, sawed, or punched. Decorative and translucent effects may be achieved by accentuating fibers, graining, or by coloring the resins. Fiberglas is available in rectangular sheets, or it may be molded into any desired shape.

Thus fiberglas is an extremely versatile material and can be used alone, or in conjunction with other materials. Fiberglas faced sandwich panels with urethane foam cores appear to be an extremely desirable form of building product, taking full advantage of the plastics family.

FABRICS

The last material type which shall be discussed is that of fabrics. Fabrics bring to mind tent structures, air structures, and domes. These are the most common shelter forms which employ fabric. Fabrics are suitable primarily as skinning elements. They have no structural rigidity on their own. However, fabrics can be quite strong in tension, and when advantage is taken of this fact, they can have structural application. In addition, fabrics themselves are poor insulators.

Fabric strength is a function of the base material, whose size and strength, and type and closeness of weave are major concerns.

> "In general, fiber, weight, strength, weave, count, denier of yarn, coating compound, thickness of coating, and method of seaming are the variables which determine the size and support, durability, and weatherability capabilities." (P&D:24,p.1)

The fabrics most commonly used today in shelter applications are of a vinyl nature. Special coatings are used to impart various properties, including the resistance to abrasion, weathering, ultraviolet rays of the sun, flame mildew, and fungi. Fabrics provided for use in climates characteristic of the continental United States (temperature range of -20 °F to +120 °F) have been developed by Birdair Structures Inc.. (P&D:24,p.1)

Problems with insulation can be corrected through the use of an additional fabric liner which traps air between itself and the skin, thus reducing heat transfer significantly.

Vinyl fabrics are available in both clear translucent and multicolor form. Translucent skins permit light to penetrate into the space from outside. And, because of their reflective nature, make interior lighting sources operate more efficiently.

Fabrics then can have application in shelter situations, either in total or in part. One possibility is using fabric covered spaces as additions to more conventionally covered areas. This could be especially important in adding spaces to account for larger family situations, or for special use. Fabric systems are especially promising because they occupy very little space when disassembled and folded up.

5.1.3 Summary: Implications for Guideline Development and Refinement

CONSIDERATIONS

In analyzing various classes of materials, a number of factors have been identified which have an important influence on their suitability for use. These include strength, weight, durability, fire resistance, workability, finishes/textures, and cost. Thorough considerations of each of these areas is essential in material evaluation and selection. At this time, certain comments can be made in each of these areas.

<u>Strength</u>: Strength is important in structural and skinning operations. It is not a factor in insulation selection. High strength is essential for structural elements. Lower levels of strength are needed for skinning materials.

Strength is a misleading word. There are a number of types of strength -- tensile, compressive, flexural, and shear. The type of strength called for is determined by the types of stresses which the selected structural system produces. Materials capable of dealing with these imposed stresses are sufficient for the purpose.

Strength is not a property of material alone. It is also a result of the geometric way in which that material is used. In designing temporary housing units, great emphasis should be placed on geometry. This can reduce the level of required strength and enable the use of alternate materials, or the reduction of material cross section.

Weight: Weight is a special concern when transportation and handling operations are required. In such cases, material alternatives should be selected which are capable of the same functions at reduced weight. Temporary shelter is one such case. Geometry should be advantageously employed to reduce cross-sectional areas of materials, and hence their weight.

Durability: Two factors determine the life of a material -- the user and the environment. Durability is a measure of a material's ability to withstand abuse from both sources.

User inflicted wear is primarily due to impact and abrasion. There are various ways of measuring the hardness and resistance to impact of a given material. Such information is always included in material descriptions.

There are a number of environmental sources which are potentially damaging. Moisture, in the form of rain or vapor can lead to mildew, rot, and fungus attack. Temperature extremes such as freezing and superheating can lead to cracking, tearing, ageing, disintegration, and fatigue. Large variations in temperature can produce similar results. The ultraviolet rays of the sun can cause discoloration and disintegration of exposed surfaces. Finally, vermin can attack and destroy susceptible and exposed materials.

Fire Resistance: Fire resistance, in a sense, is a measure of durability, but it is important enough to be placed in a classification by itself. Added emphasis is needed in calling attention to this area. In any sort of habitable environment, man must be protected from fire. Materials are not the source of fire, but are the principal fuel and conveyor. Correct selection of fire resistive materials can prevent the spread of fire sufficiently to allow man time to react and save himself and possibly his environment. Fire resistance is both a feature of the material itself, and the way in which it is used. Proper construction details can greatly enhance fire protection. In the temporary shelter situation following disaster, a damaging fire in one unit can cause a great deal of fear and alarm in the others. Such a fire, following on the heals of the terrible event of disaster can be especially harmful to the psychological recovery of the victim populace.

Workability: The workability of the material chosen is important for a number of reasons. Most basically, it is important to the selection of a manufacturing process. It is also vital in the maintenance operation, in determining the level of skill and equipment necessary to effect repairs. Finally, it is important to the user himself, in that it will either allow him the option of making changes in certain areas, or prevent his tampering in those areas. In a sense, both are essential. There are certain things which should be left to the user to ultimately decide and modify, and there are things which he is best to leave alone. Thus workability includes both the areas of construction and user participation.

Finishes/Textures: Finish and texture are material attributes which can do much for the user in the areas of aesthetics, atmosphere, comfort, and information. Certain finishes and textures evoke certain moods and emotional responses, and are more conducive and comfortable for certain activities. Man also receives certain cues from these attributes as to how to react to his environment. In the confines of a minimal shelter situation, it is especially important that these attributes of finish and texture be utilized. A varied use of texture and finish will greatly enhance the temporary environment.

Cost: This is the final area in material evaluation. It is unfortunate that economics must play such a major role in material selection. Working within this constraint, materials should be selected which satisfy all of the aforementioned considerations satisfactorily for the use intended, and then cost should influence the final choice from among the applicable alternatives. There is the danger in economic cost concerns to 'put the cart before the horse' and let these considerations dominate throughout. Low-cost should be used as a check, not as a motivation. Costs have not been dealt with in this research because that is not its prime concern. What this research hopes to do is to lead one to the point where a firm understanding of the problems, needs, and alternatives have been dealt with, and where cost can then be utilized as a final resource for selection.

RECOMMENDATIONS

Most recommendations have already been made in the process of investigation and evaluation. Three comes to mind:

First, systems which combine the aspects of structure, skin, and insulation seem especially promising. One such material is urethane foam, but certain problems inhibit its effective use. The best solution seems to lie with the sandwich panel concept. This system utilizes materials effectively and efficiently. Such panels could have metal or fiberglas skins and urethane foam cores.

Second, effective consideration and utilization of geometry can do much to reduce stresses and minimize cross-sectional areas and material weight.

Third, in shelter situations, it is senseless to transport space. Areas of such shelter, which consist principally of space should be constructed of materials that can be compacted during periods of storage, transport, and non-use. Fabric-type materials could play a key role in this operation. Their ability to be folded into a small volume and re-erected when needed, is an important one which must be utilized in the planning of temporary shelter units.

Furthermore, two additional suggestions can now be made. In materials evaluation, a realistic selection is impossible without an in-depth study of the aspects of strength, weight, durability, fire resistance, workability, texture/finish, and cost. Therefore such a process is invaluable. Also, a number of promising materials have been identified and studied. Of these, those in the fields of plastics and fabrics give the greatest indication of potential application in temporary shelter construction. Metals (steel and aluminum), wood (studs and sheets: plywood, masonite, and composite), and gypsum plasterboard have possible application as well, but do not appear as advantageous.

5.2 STRUCTURAL SYSTEMS.

5.2.1 Significance

Structure is that element of shelter which provides the framework for space enclosure, and the means by which loads and their resulting stresses are channeled to the earth. Structural development is integral to the total design process. The selection of an optimal structural system is based on two principal factors - knowledge of the physical properties of materials and a determination of forces and stresses. This research has already established a background of material properties in the preceding section. The following is a list and description of forces which may be found applicable in planning shelter design:

Compression -- tends to condense a material.
Tension -- tends to stretch a material.
Shear -- tends to divide an object along a plane parallel with the opposing external forces.
Torque -- the result of forces which tend to twist an object.
Bending -- the result of forces which tend to deflect a member by inducing tension, compression, and shear.
(B&R:54,pp.1-3)

The key to structural design is the resolution of such forces which may be acting so that the structure will remain in a state of equilibrium. "In architecture, applied loads and forces must be resolved within an immovable structure." (B&R:54,p.3) In other words, we are talking about a static system which must resolve forces through internal mechanisms.

Finally, two types of loads must be contended with -- live and dead. Live loads are those which may be externally applied or removed, such as wind, snow, earthquake, and people furnishings. Dead loads are those loads which are a permanent part of the building, i.e. the weight of the shelter itself.

This research then shall deal with an investigation of the structural system types available, and the way in which they respond to forces, as well as an evaluation of their applicability to temporary shelter design.

5.2.2 Types

This section intends to examine the whole spectrum of structural systems. Many will emerge as being clearly unacceptable, or inapplicable to the case at hand. Such types will then be merely glossed over. Those types which do appear pertinent and promising will be expanded upon in sufficient detail. The following is a listing of the various alternatives within the realm of structure:

Bearing Wall
Post and Beam
Arch
Truss
Vault
Dome
Cantilever
Slab
Shell
Space Frame
Geodesic Frame
Suspension
Pneumatic (B&R:54)

In investigating each of these systems, I shall rely heavily upon the text of Structure and Architectural Design by Philip A. Corkill, Homer L. Puderbaugh, and H. Deith Sawyer, as this book is one of the clearest and most complete sources of structural systems' information available. This reference is denoted by the designation B&R:54.

Bearing Wall

"A bearing wall is a structural system that distributes loads which spread gradually through a vertical or near vertical continuous mass to supports. The

> loads create internal compressive forces and stresses in the wall." (B&R;54,p.36)

Most conventional single-family housing is based on the bearing wall principle. In these structures, parallel bearing walls of either brick or wood stud-frame construction are used to collect loads and channel them to the foundation. In a temporary shelter system, the bearing wall has application in the wood stud-frame form. Such a form minimizes material and weight, and has been proven effective in resolving loads of the nature most common in small-scale buildings of the single-family house type. Lightweight steel and aluminum stud alternatives are also available. This stud system is one which people are already familiar with and would certainly find acceptable in temporary shelter use. In addition, this familiarity has the desirable feature of user involvement, in that the occupant is more likely to modify or manipulate a structural system which he understands. Such a system would have special significance in the imported shelter alternative which would be expandable in-whole-or-in-part to become a part of the permanent dwelling.

Post and Beam

> "The post and beam is a structural system which distributes loads to supports through a linear arrangement of horizontal and vertical members. The vertical members are posts which primarily resist compressive forces and the horizontal members, beams, resist bending forces and shear." (B&R:54,p.66)

Such a structural system does not appear promising for use in temporary shelter applications. Geometrically, lateral stability is not inherent, and the inclusion of another structural system such as bearing walls would be necessary for stabilization. In addition, space enclosure is not attained until secondary non-structural elements are provided. The relative advantages of a post and beam system are not those that would be in principle, the type sought in temporary housing applications.

ARCH

> "The arch is a structural system that distributes loads to supports through a curvilinear form within a single plane. The forces developed within an arch are primarily compressive and the arch must be designed to resist these forces with a minimum of bending." (B&R:54,p.116)

The significance of the arch is that it is a planer design element. As such, its application to shelter construction would not be of a systems nature, but rather as an element of a system, such as in the cases of the vault or the dome. Several comments can be made however. In collecting forces, the arch produces a thrust at its base which must be resisted. A system which utilizes arch action should be provided with some sort of inherent mechanism to do just that. The arch is an efficient structural form because it utilizes materials in an almost exclusively compressive manner.

TRUSS

> "The truss is a structural system which distributes loads to supports through a linear arrangement of various sized members placed within a single plane. These members, each shorter than the total span, resist either direct tensile or direct compressive forces." (B&R:54,p.94)

The truss is also a planar design element, and thus its application to shelter construction would not be of a systems nature, either, but rather as an element of a system, such as in the case of the space frame or geodesic. By its very nature, the truss is a long span element. Such spans do not arise in the single-family temporary shelter situation, and therefore its application does not seem feasible. Its paramount advantage is that it utilizes materials in their most efficient manner -- either in pure tension, or in pure compression. This allows for material, and consequently, weight reduction, which is essential in the temporary shelter scheme. However, other structural systems also exist which accomplish this same purpose, and which might be better suited for the purpose at hand.

VAULT

> "The vault is a structural system which distributes loads by arch action through a single curved plane to continuous supports. The stresses within the vault are primarily compressive." (B&R:54,p.144)

The vault is a glorified arch. It has the advantage of being laterally stable and of enclosing space. It acts like a curved bearing wall, but instead of transmitting compressive forces vertically, it does so axially, and produces a thrust which must be countered at its base. One means of accomplishing this is by intersecting vaults at right angles so that they act to restrain one-another. One limitation of the standard vault is that it is an axial geometric form. However, the mobile home is also an axial form, and it has been successfully employed as a shelter resource for many years. The fact that the vault works not only as a supporting framework, but also as a space enclosure makes it promising as a temporary shelter form. Contemporary thin shell systems appear the most promising. Armand G. Winfield Inc., Plastics Consultants have designed, developed, and constructed an "Emergency Structure" which is based on the vault form and is constructed of PVC (polyvinyl chloride) extrusions. The total raw material cost for this insulated 8'x14' prototype was under $400.

DOME

> "The dome is a structural system which distributes loads to supports through a doubly curved plane. It is a continuous geometric form, without corners or abrupt changes in surface direction, and encloses the maximum volume with a minimum of surface area. The dome must be designed to resist compressive stresses along the meridean lines (arch action) and to resolve circumferential forces in the lower portion of hemispherical domes." (B&R:54,p.158)

The dome possesses a number of characteristics which are desirable in temporary shelter applications. Since the dome provides maximum volume with minimum surface area, it is truly efficient. In shelter situations, the desire is to attain maximum useable interior space for the investment in materials made. The problem with the dome though is that much of this interior space is difficult to use because of the nature of the curvature and the variation of interior heights involved. This is a problem for design which will determine whether or not the volume can be used efficiently. The variation in height within the interior is a nice feature at any rate, especially in the temporary shelter situation where the area is to be at a minimum. Also, since the dome encloses this maximum space with a minimum surface area, considerable savings in materials are attainable, both in terms of cost and weight reduction. Heat losses are also minimized since there is less surface area for heat exchange. Domes can be cutoff at any point, that is 3/8, 1/2, and 5/8 spheres are often used in shelter situations. Provision must be made for resolving the stresses at the plane of such a cut, however. This is a fairly simple matter.

Contemporary domes are of the thin-shell, or geodesic frame variety. The major constraint to the use of the dome in temporary housing cases, is its awkwardness in transportation and storage. In order for the dome to be utilized as a housing resource for disaster situations, it must be either subdividable into panelized elements that can be erected and disassembled quickly and easily (such a system exists (P&D:15,p.30)); or it must be a disposable form that can be built in place cheaply through some method of reuseable formwork and material spraying operation (Such systems have been used in meeting disaster emergencies in other countries, including Peru and Israel, according to information supplied by the American National Red Cross).

CANTILEVER

> "A cantilever is a structural system which distributes loads through a projecting member to supports at one end. Frequently, a cantilever is an extension of another structural system. The forces developed within a cantilever are primarily bending and shear, and it must be designed to resist these forces." (B&R:54,p.174)

The cantilever is not really a system at all. It has no real application in temporary shelter use. There is the possibility that part of the shelter unit might be cantilevered on its foundation so as to create a useable space below, or that certain roof sections might cantilever to provide covered outdoor space. These are the only real applications of the cantilever principle that might have some significance.

SLAB

> "A slab is a structural system which distributes loads to supports in one or more directions within a single plane. The forces developed are primarily bending and shear, and the slab must be designed to resist these forces. . . .The structural slab may also be oriented vertically. The vertical reinforced concrete slab may be supported on columns. Loads are transferred through the wall to the supports in a

manner similar to a tall thin beam." (B&R:54,p.198)

Slabs may be one-way or two-way, flat or folded. A slab may comprise the entire structural system and enclose space, or it may be a part of another system, such as a bearing wall type. This flexibility makes the slab extremely inviting. The aim in a slab system should be to utilize geometry as effectively as possible. A flat slab such as the sandwich panel with metal or fiberglas faces and a urethane foam core is one such example of an efficient system. This sandwich panel-slab system could also be of the folded plate variety, which would be quite a strong and efficient system for shelter applications. In any use of a slab system, the principle of the sandwich panel is probably the wisest to follow. Folded-plate slab structures, which are themselves foldable into small packages have been developed for use in shelter applications of both a military (P&D:25,pp.4-5) and of a civilian (B&R:37,p.6.32) nature.

In slab utilization, then, efforts should be directed towards the efficient use of geometry and of lightweight materials. In this respect, the folded plate form appears most promising in conjunction with sandwich panel technology.

SHELL

> "A shell is a structural system which distributes loads to supports in a number of directions within a singly or doubly curved plane. Applied loads induce compressive, tensile, and shearing forces within the plane of the shell, and it must be designed to resist these forces with minimum bending, the internal stresses resulting from these forces are referred to as membrane stresses." (B&R:54,p.228)

Two types of structural shells exist -- singly curved and doubly curved.

Singly curved shells are called barrel vaults. Doubly curved shells include the inverted hyperbolic, paraboloid, the curved cylindrical, the conoid, and shells of revolution. Of these types, only the singly curved, and the shell of revolution seem to exhibit possibilities for temporary shelter use. The other shells are geometrically too complex, it would appear, for serious consideration.

For temporary shelter applications, a shell structure would have to be designed with one of two approaches in mind -- either that of being capable of assembly and disassembly for transport and storage, or that of being a disposable unit which would be cast in place through some reuseable framework-spraying type operation. The use of plastics appears to be the best choice of materials in shell applications for shelter use.

SPACE FRAME

> "A space frame is a structural system which distributes loads to supports through linear arrangements of members placed in more than one plane. It is designed to transmit load through its members by direct tension or compression without bending. The space frame is a three-dimensional truss."
> (B&R:54,p.258)

Space frame technology is really intended for large-span applications. In general, the number and complexity of its members would appear to be prohibitive for temporary shelter use. The labor involved in erection and dismantling could also be a prohibitive factor. The advantages of efficient material use seem to be offset by the complications of erection and the additional necessity of utilizing some skinning system in order to realize space enclosure. There does however exist the possibility of utilizing some simplified space frame system, such as a geodesic with a fabric skinning technique. This appears to be the only feasible space frame application.

GEODESIC FRAME

> "A geodesic frame is a structural system which distributes loads to supports through a linear arrangement of members placed in a spherical plane. These loads cause either direct tension or compression in the members. The geodesic dome is a twentieth century development of mathematics and geometry. . . .The geodesic is a spherical space frame." (B&R:54,p.274)

As stated, this form of space frame system appears to have the greatest potential application in the area of temporary shelter. It can be constructed from a number of linear elements (of which only several different lengths are required) used in conjunction with a special hardware connection. Thus the inventory of required materials is quite small. Since there are only two basic frame components, and since these components are all convenient for one-man handling, such a framework can be assembled and disassembled in a number of hours by the occupant himself with only cursory instruction. This is a real advantage in the temporary shelter situation following disaster. User participation in the construction process is extremely desirable psychologically. Once this framework has been assembled, the enclosing skin can simply be a prefabricated fabric unit which is unpacked, draped over the frame, and secured. This development is in a sense characteristic of one of the first temporary shelter systems developed in North America long ago -- that of the Indian tipi. The tipi consisted of a frame composed of linear elements (poles) lashed together at their tops and covered with a pre-made fabric (skins) covering. Such tipis were used extensively by the plains Indians, whose life style necessitated frequent movings in following migrating animal herds. These tipis were used in all sorts of climates, hot, cold, dry, and moist. They were adaptable to any situation by manipulating various features of the shelter package itself, and by utilizing add-on features (such as interior liners in cold weather). In my estimation, this historical development gives an added interest to the principle of the geodesic frame and fabric skin approach. An excellent account of tipi construction and life can be found in The Indian Tipi by Reginald and Gladys Laubin (B&R:25).

One interesting variation of the geodesic frame concept which has been experimentally produced is a complete geodesic frame which is constructed of a network of vinyl tubes that are air-inflated on site to complete an entire geodesic superstructure in a matter of minutes. (P&J:34,p.21) Such a framing system that combines the principles of both the geodesic space frame and the pneumatic structure seems especially promising. This system could be employed very quickly, and very successfully in disaster shelter systems as a space enclosure.

One further application of the geodesic frame is that of incorporating both the skin and frame elements within triangular sandwich panels which could be assembled into the geodesic form and secured to one-another with special butt-joint fasteners which have been developed for this type of purpose by the Simmons Fastener Corporation. (P&D:15,p.28) These fasteners would be built into the panels themselves and would require only an allen wrench for the panel joining operation. This is a real advantage in terms of user participation. Furthermore, this operation is completely reversible for disassembly purposes. A rectangular version of this application has been developed for providing housing for use on the DEW line. In this system, an entire house assembled from a number of large rectangular sandwich panels constructed of plywood-covered plastic foam can be put up in less than a day, and dismantled in half that time. This unit is called the "Eskimo House" and was built by Arctic Units Inc.. (P&D:15,p.29)

SUSPENSION

> "A suspension structure is a structural system which distributes loads through cables or membranes to supports. This sytem must be designed to transmit tension forces. Cables and thin membranes are capable of resisting tension only. The material used in this system must be strong in tension."
> (B&R:54,p.288)

A suspension structure is essentially a tent structure. Such a structural system has the advantages of lightweight, efficient material utilization, easy compaction for transport and storage, and simple erection and dismantling procedures. Problems of heat loss because of the low insulative value of the membrane skin could be handled through the use of interior liners.

Such a structural system appears well-suited for applications of space provision. When used in conjunction with a more substantial core element, it could be a feasible shelter system. The primary objection to such a shelter form might be its "flimsy" nature (at least in the minds of the victims) which might cause the user to approach its use with reservations for an extended two month application. For this reason, such a tent system should only be used together with a more substantial element which could house those activities that require more conventional enclosure.

PNEUMATIC

> "A pneumatic structure is a structural system which distributes loads to supports through pressure supported membranes. The membrane transmits tensile forces through the plane of its surface in many directions to supports. These supports are generally designed to anchor the structural system." (B&R:54,p.312)

The commercial application of pneumatic architecture has probably been advanced the farthest in this country by Birdair Structures Inc., whose president and founder Walter Bird described air structures as such:

> "I refer to the 'pneumatic structures' as any of the wide variety of structures using pressurized air to stiffen or stabilize flexible material to form a structural shape." (B&R:36,p.249)

> "The air structure is the most efficient structural form available to date. It combines the inherent strength and reliability of materials used in tension with the structural efficiency of the shell. There are no problems of bending or buckling. All material is placed at the extreme fiber, where it is utilized to maximum advantage. There is no need for columns, beams, or other supports. The structural envelope is simply supported by air." (B&R:36,p.254)

Before beginning a more detailed investigation of the principles and applications of pneumatic structures, one more source should be heard from. In the Principles of Pneumatic Architecture, Roger Dent speaks of the architectural aspects of pneumatics:

> "To correct the environmental deficiencies of rigid traditional structural envelopes, energy must be supplied to heat and ventilate them, bringing them up to the comfort standards that are determined by the building's function; the amount of this applied energy depends on the insulation characteristics of the structural envelope . . . .It is now possible to create a fully conditioned environment without a structure of the kind usually associated with architecture; all that is required is a bag to contain the manufactured environment. This is the

> architectural essence of pneumatic structure; a membrane or bag stabilized by small pressure differentials created by the application of environmental energy." (B&R:53,pp.13-14)

Thus, we see that pneumatic structures result in efficient utilization of materials and environmental energy. There are basically two types of pneumatic structures -- the air inflated structure and the air supported structure. Both utilize air as a supporting mechanism, but in different manners.

Air Inflated

An air inflated structure is one in which air under pressure is sealed within a double walled membrane. This is a compartmentalized affair that relies on pressurized 'pillows' to form the enclosure support mechanism. Failure of one section will usually not collapse the entire structure. Doors and windows are possible in this pneumatic form. The geodesic pneumatic frame previously described is one variation of this air inflated type, which depends on inflated rib action. In general, air inflated rib structures are pressurized to about 700,000 N/m^3 and this air pressure needs to be adjusted just once every 3 months. (B&R:53,p.140) Furthermore, an air inflated structure may also utilize the principles of an air supported structure as a secondary means of support. Air inflated structures, by nature of their double membrane air compartments have an inherent insulation.

Air Supported

Air supported structures are slightly different. They enclose space by means of a single membrane. The entire interior space is formed when this membrane is pumped with air to a pressure slightly above ambient. This creates three unique structural problems:

> "1.) The need to maintain the pressure differential across the membrane with a constant air supply.
> 2.) The need to minimize air leakages.
> 3.) The need to counteract the up-lift forces with some means of anchorage." (B&R:53,p.19)

The first problem is handled with low pressure fans which operate intermittently throughout the life of the structure. "As a rough guide the fan capacity should be such that the air changes are between one and two per hour..." (B&R:53,p.101) To determine the capacity in m^3/sec., the following formula is applicable:

Capacity in m^3/sec. = K/3600 x (Building volume in m^3)

where K lies between 1 and 2 (air changes)
(B&R:53,p.101)

Such air supported structures need only pressures slightly above the normal atmospheric for support. This increase is on the order of .036 lbs./in^2 (or, 1 inch of water static pressure). For comparison, if you close your mouth and puff your checks, a pressure of about 30 inches of water static pressure is developed. Automobile tires develop 600 inches of water static pressure. (B&R:49,p.12).

One drawback to air supported structures is the necessity for airlocks. Operable windows are not possible. Doorways must be specially designed so as to minimize air loss in the entry/exit operation. These do not seem very well-suited to family style living situations in which small children are constantly coming and going.

The skin fabrics most commonly used in military and civilian operation include neoprene or Hypalon coated nylon, Dacron, glass, or vinyl-coated materials. There are designed to insure high strip tensile strength, high tear resistance, good coating adhesion, maximum weathering resistance, maximum joint strength, good flex resistance, and good flame resistance. (B&R:36,pp.257-258) Varying degrees of translucency and opacity are possible. For a light source within a translucently skinned membrane, the light loss is 5-10% through the skin and 20-25% through absorption and heat conversion, but nearly 70% bounces off the skin to light other surfaces and objects. A 70% reflectance is high compared to most sources. (B&R:49,p.16) Thus, interior lighting is an enhancing feature of air supported structures.

The final consideration must be that of safety. There are two areas of concern -- puncture and fire. Bubbles can survive a number of small punctures, or tears, and patching is a simple operation. Such patches are made of the identical skin material and are applied interiorly while the bubble is inflated. A heavy coat of vinyl cement is used. The patch is mated by ironing it on with a conventional home iron set to 300°F. (B&R:49,p.12) Such repairs could be done by the occupants of such a shelter with little trouble.

A bubble skin will not catch fire. However, long-term exposure is intense heat sources can cause the fabric to melt and a hole to form. Pressurized air inside would then rush to escape and in the process snuff out the flame. (B&R:49,p.12) Even if the hole were substantial, the deflation would take several minutes at least, even in a small shelter. Furthermore, Birdair Structures Inc. has stated that the collapse of a bubble has hever injured anyone. (B&R:49,p.12)

In summary, then, pneumatic structures offer tremendous potential in the area of temporary shelter. The most appropriate pneumatic systems seem to be those of the air inflated variety -- either the inflated pillow, or the inflated rib. The problems of air locking systems in air supported structures on the single family temporary shelter scale seem prohibitive and, in a sense unnecessary in that air structures are possible that don't rely on one trapped air space being maintained for stability.

5.2.3 Summary: Implications for Guideline Development and Refinement

CONSIDERATIONS

Through this process of looking at a variety of structural system alternatives, a number of considerations have emerged as being important in their evaluation. These include loads and forces, materials, level of complexity, space enclosure, and economics.

Loads and Forces: In choosing a structural system, loads and forces are the key words. A shelter envelope is used as a framework for environmental control and protection. Certain loads and forces emerge through the actions of the environment and through the structure itself. The manner in which the structural system channels these loads to the earth is of prime concern. The stresses which result must be of a type and of a magnitude that are within the capabilities of the desired materials. A structural system should be chosen that handles such loadings and forces most advantageously in view of the nature of the activity that is to function within its environment. This is the key to structural success.

Materials: The structural system determines the type and magnitude of stresses that will be operative. Alternative structural systems can produce greatly differing stresses, both in type and intensity. Thus, in determining material selection, one eye must always be focused on the options allowed by alternative structural systems. Material choice must operate within the framework dictated by the structural system. Structural system selection and material selection are locked in an elemntal cause and effect relationship. If you choose to use such and such a structural system, then only such and such types of materials are suitable, and vice-versa.

Level of Complexity: Structural systems vary greatly in their complexity. The degree of difference between a flat slab and a space frame is one example of this level of complexity consideration. In general, the simpler a system is, the more desirable it becomes. However, in the event that the selection of a more complex structural system can substantially reduce internal stresses, or quantities of materials used, then it might be chosen over the simpler. Structure should be a search for the simple. Never use a complex system when a simple one will suffice. In temporary shelter situations, the needs for quick erection, often by the victims themselves, demand that a level of simplicity to which they can relate be maintained.

Space Enclosure: Structure encloses space. Such space is to be utilized for various activities. The way in which the structural system operates on space is critical to the success or hindrance of these activities. It is therefore essential that the influence that the structural framework will have upon the activities which it surrounds be thoroughly understood. Also, the relation between indoor and outdoor space is determined by the structural framework to a great extent. This relationship between space enclosure and structure is especially important in the area of housing.

Economics: Questions of structural systems' cost, materials' cost, and environmental energy costs arise from the selection of the structural system. There are ways of minimizing costs. The real judgment however should be considered only when a number of structural system alternative have been determined to meet the prior considerations of loads and forces, materials, complexity, and space enclosure. Cost-effectiveness can then be used as a mechanism for final decision.

RECOMMENDATIONS

Two types of recommendations can be made -- one relating to structure and one relating to materials. The following structural recommendations are made:

Structural systems applicable for all or part of the shelter package are:

> BEARING WALL: stud wall or sandwich panel systems.
> SLAB: sandwich panel: flat or folded-plate.
> SHELL: vault and shell of revolution: assemble/disasemble panel system.

Structural systems applicable for space enclosure when used in conjunction with a more conventional core area are:

> DOME: on site constructable, disposable.
> GEODESTIC FRAME: assemble/disassemble frame with fabric skin
> SUSPENSION: fabric tent-type.
> PNEUMATIC: air inflated type utilizing air inflated compartments or ribs.

In viewing structural system alternatives, certain materials emerge as the most potentially useful. These are the plastics and the fabrics. Furthermore, composite sandwich panels are seen to have possible structural application in a number of different systems.

In considering the potential of plastics for various structural systems, the following recommendations were put forward by the Architectural Research Laboratory of Ann Arbor Michigan in its study Structural Potential of Foam Plastics for Housing in Underdeveloped Countries:

> "It is apparent that structural forms which offer the largest potential for cellular plastic construction are those in which stress levels can be kept low by the distribution of loads throughout the structure and where load and stress concentrations are avoided as much as possible. Therefore, solutions the project has sought have been within the family of surface structures, especially shells and folded plates, which have such characteristics.
>
> By contrast, it is evident that post and beam structural systems would be undesirable since this type of construction collects the loads and transfers them to linear structural elements of relatively small but highly stressed cross sections.
>
> In general, there are three basic groups of surface structures which can utilize cellular plastics: 1.) shells, both singly and doubly curved; 2.) folded plates, linear and composite; 3.) slab and panel systems." (B&R:37,p.r.7)

5.3 SERVICE SYSTEMS: ELECTRICAL, PLUMBING, AND MECHANICAL

5.3.1 Significance

A number of services are essential in the on-going operations of environmental control. These service systems provide an atmosphere of comfort, health, and convenience in which the family can function effectively. These systems are of an electrical, plumbing, and mechanical nature. In the disaster situation, many of these service systems upon which man depends are disrupted, some for long periods of time. In the temporary shelter period, man will have to adjust to this fact. This does not mean, however, that he must suffer. Rather it implies that he must learn to coservatively and judiciously utilize these services during this time. Essential service functions must be provided. Alternative approaches and practices may be required.

Services provide the resources for power, lighting, cooking, food storage, clean water for drinking, bathing and cleaning, sewage disposal, heating, and ventilation. These services must be provided in some form to the temporary shelter during the period of occupancy. There shall only be one assumption of resumed service -- that of electricity. With temporary housing sited either in clusters, or scattered throughout homesites, a flexible, easily tapped energy source is a necessity for operation. Electricity is the only utility system that possesses these attributes, and whose service is selectively restorable on a scale, and with a speed capable of meeting the needs of temporary shelter within two weeks following disaster impact.

5.3.2 Types

A number of types of service systems are required. These include: power and lighting, water-related services, heating, and ventilation. Temporary shelter conditions shall provide these services, but on a reduced scale, sometimes utilizing non-conventional approaches if necessary.

ELECTRICAL

Power

Electricity shall be the source of power and the means for lighting. Its selection is based on: its level of availability; its ease of restoration following disaster; its ease of hook-up; its compact transmission of energy through cables; its elimination of fuel storage problems within the shelter units; its applicability to many varied uses; and its familiarity to the user. Electricity then, will form the lifeline that will enable the temporary shelter to function as autonomously and flexibly as possible.

Normal electric service shall be contemplated in the physical planning of the shelter. For small residence situations, occupying less than 1,000 sq. ft., a nominal 100 amp, single phase 120/240 volt, 3 wire electric package is suggested. (B&R:45,p.514) This shall be the package provided in the temporary shelter.

Lighting

Lighting should be provided by normal incandescent and flouresent fixtures which derive their power from electric current. While it is true that lighting could alternately be provided by gas fixtures, this approach would be both dangerous and unnecessary. The average family today is not accustomed to having an open flame within the house, except possibly in the stove and furnace. These are only utilized by responsible individuals, i.e. parents and older family members. The requirements that artificial lighting be available in every room and that it be operable by persons of all ages restricts it to conventional **electric** illumination. The risks of fire are too great with an open flame system. Therefore, for this reason, and because electric power should be available, lighting shall be of the traditional electric type. Sufficient lighting fixtures should be provided so as to maintain a 50 foot-candle illumination level throughout the shelter in the absence of natural illumination. This is the level suggested for living-type activities. (B&R:51,p.639)

Cooking and Refrigeration

Similarly, cooking and perishable food storage operations shall derive their energy from electrcity. The feeling is that if there is a source of power available, it is best to take full advantage of it rather than depend for some functions upon power sources (i.e. gas) which are liable not to be generally restored to an acceptable level and which therefore would require their storage in some form within the shelter. An electric range with burners and no oven and an electric refrigerator should therefore be provided. These fixtures are sufficient for the purpose and for the projected length of occupancy.

PLUMBING

Many normal residential activities are dependent upon water-related services. These require resources for water supply, systems operation, and sewage disposal. The shelter occupants cannot expect that the conventional water utilities of supply and disposal will be functioning normally during the first month or so following disaster. These utilities depend upon underground delivery systems in the case of municipal service. They also depend upon pumping stations, reservoirs, water towers, and disposal treatment plants; any of which may have been damaged. These facilities take time to repair, often a great deal of time. In the case of wells and septic tanks, they may be contaminated, damaged, or access to them might be difficult. In the course of this research, no hard statistics were found concerning the average length of time required for utilities restoration following disaster. However, the evidence gained through researching a number of actual large-scale disasters give a feeling for such questions. One such case study is that found in reference (B&R:9).

The essence of these revlations is that the temporary shelter shall have to provide for its own potable water supply storage and sewage disposal system. The aim should be to provide the shelter unit with the facilities necessary to make it self-sufficient in this respect for a week at a time, with some weekly city operated water re-supply and sewage pick-up service run along the lines of conventional garbage collection operations. Such a service would be instituted for the duration of the temporary shelter period. Also, such temporary shelter units should come equipped with an alternate hook-up system similar to that provided in travel trailers that would allow for conversion of the water-related systems once the water utility has been re-established. This seems like the best approach, and one that the occupants could adapt to quite easily.

Potable Water Supply

Previously, in the section on user needs, it was established that if a family of four were allowed 40 gallons of potable water a day, they would require a water storage capacity of 280 gallons for a 7 day operation period between refills, and that such a storage requirement could be handled in a couple of conventionally-sized water tanks. A 2 tank system is probably wise as a precaution against contamination. It also would give the occupant a very real evaluation of his water usage rate. If he uses one tank in less than a half a week, he will know that he must be more conservative.

Hot water should be produced through the use of electric coils operating upon a separate smaller tank of perhaps a 20 gallon capacity. This should be more than adequate.

Systems Operation

One interesting feature found in many small sailing ships is the use of hand pumping operations to pressurize the water system. The reasoning is that if people must periodically pump their own water, they tend to realize its value and consequently are less inclined to be wasteful. This principle might find application in the temporary shelter system where water must be used conservatively. Alternately, electric water pumps could provide the means of pressurization. Fixtures should include one small kitchen sink, one small bathroom sink, one toilet, and one tub/shower unit that could double as a wash tub.

Waste Disposal

There are two forms of waste classified as sewage -- excrement and waste water. In a minimum water use situation, water cannot be used as a means of carrying excremental wastes from the shelter. Such wastes amount to less than 1/2 gallon per occupant per day. The need is to provide a toilet system that will accommodate these disposal needs with a minimum utilization of water for flushing purposes. A number of such systems are commercially available. One minimum flush-water toilet, mounted directly over a holding tank needs only 1 quart of water to flush the bowl at the push of a button. After flushing, a small quantity of the flush water is retained in the bottom to provide a water-type seal which will prevent ordors from escaping the holding tank. (B&R:46,p.32) If one estimates that each person produces 1/2 gallon of liquid waste per day and flushes the toilet an average of 4 times, then each person produces 1-1/2 gallons of sewage daily. A family of 4 would then produce 6 gallons daily, or 42 gallons weekly, which gives a rough idea of the holding tank capacity required. Such a toilet system has the added feature of being hooked up to normal sewage lines if service should be restored. In addition, self-contained chemical toilet systems exist which require much smaller holding tanks, yet provide a similar period of use.

Disposal of waste water from sinks, bath, and wash tub is another problem. Such water does not contain excrement, yet is biologically dangerous. The solution to this problem, as mentioned previously in this paper might be to provide a holding tank in which chlorination and purification processes could return this water to a clean enough state for bathing and cleaning purposes, or to be drained to the ground safely. A recyclable system would require two holding tanks, one for water in the process of being cleaned, and one for already cleaned water.

In the case of larger family size, provisions would have to be made to increase storage tank and holding tank capacities. Add-on packages to augment these systems are one possibility. Increased frequency of replenishment and disposal operations are another.

On the municipal scale, Aerojet General Corporation produces units for both water purification and sewage treatment. Such units could be used as sources for replenishing the potable water supply and for treatment of the excremental sewage which would be collected weekly. The water purification unit is run on a single-pass, reverse osmosis process that provides high quality drinking water. It is available in sizes ranging from 1,000 to 50,000 gallon daily capacities. Such a unit could service the requirements of a large number of shelter units. The transportable sewage treatment plant is capable of processing 10,000 gallons of raw sewage daily in both a primary and secondary sewage treatment based on modification and adaption of the trickling filter principle. (B&R:34,pp.82-84)

Thus, the intent is to provide the shelter units with the capabilities of meeting their own water-related needs on a weekly cycle. A city-run service of potable water supply and sewage pick-up would take place once weekly in the same manner as garbage collection. Potable water could be trucked in from outside the area or it could be obtained from portable purification units similar to that previously described. Sewage treatment would be similarly handled. This operation would continue until the water utilities were restored to their normal operation, at which time the shelter units would switch from their self-sufficient operations to the municipal utilities.

MECHANICAL

Heating

Heating is only needed during cold periods, but when it is needed, large amounts of energy are required. Since electricity is the only source which can be relied upon, electric heat shall be the system selected. Electric heat has the advantage of: cleanliness, silence, individual room control, fire safety, no water, no chimney, no fuel storage, compactness, less initial equipment cost, and little or no maintenance. (B&R:45,p.258) Electric heating systems are also available in a number of different forms, including baseboard, wall units, heat pumps, duct and furnace, and cable.

The question of costs arise. Isn't electric heat much more expensive than gas or oil? Statistics show that in general the cost of electricity has stabilized and in some instances is being reduced slightly, while the costs of fossil-derived fuels is increasing. (B&R:34,p.26) In terms of heating value, electricity provides 3,413 Btu/kilowatt (except for heat pump applications). As a comparison, propane and butane provide 2,300 Btu/cu.ft. of gas. (B&R:44,p.87)

Ventilation

Ventilation requirements have been discussed in previous sections. The shelter shall be designed so as to include a minimum of one operable window within every enclosed living area. This should provide adequate means for natural ventilation. The kitchen range should be provided with an exhaust fan. Any attic or closed-off spaces should be provided with vents.

5.3.3 Summary: Implications for Guideline Development and Refinement

CONSIDERATIONS

In the selection of electrical, plumbing, and mechanical systems for use within the temporary shelter unit, five main concerns emerge: size, degree of self-sufficiency, reliability and maintainability, safety, and economy.

Size: There are two sizes which must be evaluated -- the quantity size of needs and the physical size of equipment systems. Numerical estimates of capacity and demand are vital in determining the range of equipment options that are suitable to the purpose. In addition, the physical size of the equipment selected is important in the confines of the small temporary shelter unit. It is possible that alternative equipment systems or alternative approaches to the service needs can result in the reduction of equipment volume necessary for the task.

Degree of Self-Sufficiency: In the temporary shelter situation, the term "self-sufficiency' is slightly misleading. Self-sufficiency here is a matter of degree, rather than of absolutes. Electricity is considered to be available, though initially, perhaps only at a reduced level. In this way, then, the unit is totally dependent upon the electric utility service for its source of operational energy. This, however, is an acceptable form of dependence. All functions that depend on electricity such as cooking, refrigeration, lighting, and heating are thus automatically supplied with a power source. The remaining concerns are the water-related functions. These are to be self-sufficient in a weekly cycle, which provides for an external service input once-weekly. This then is a limited dependence, but at a tolerable level that gives the user a measure, and most importantly, a feeling of self-sufficiency. In other respects, such as enclosure, the shelter is to be completely self-sufficient.

Reliability and Maintainability: Service systems selected must have a high degree of reliability and a low level of required maintenance. This is essential for a number of reasons. First, the occupant who may be capable of numerous repair and maintenance operations in his own home may have difficulty in similar attempts with unfamiliar equipment, or may be unwilling to perform even simple forms of equipment maintenance in a shelter which he does not own, and which he will not occupy for more than a couple of months. Second, should breakdowns occur, there might be long delays before repairmen or parts become available. Such breakdowns could result in health and comfort problems to the occupant family.

Safety: The heightened requirement for safety within such small temporary shelters has already been discussed. The primary concerns are for electrical safety and fire protection. Due to the necessary extensiveness of electrically powered equipment, the standards set forth in nationally recognized electrical codes must be stringently adhered to in order to prevent shock or fire. The possibilities of equipment shorting out and of receptacles being overloaded must be anticipated and measures taken to prevent such occurrences.

Economy: There are three economic considerations -- equipment costs, equipment maintenance, and fuel costs. The first two can be affected to some degree. The last is already determined by the initial assumption of complete electric service. The trade-offs between the situation of high initial equipment costs with a low level of anticipated future maintenance, and the situation of lower initial equipment costs with the possibility of greater future maintenance must be studied. It is my feeling that high initial cost equipment with a good level of future reliability will be the most economical alternative in view of the service problems which might arise while the unit is in use.

RECOMMENDATIONS

Three recommendations emerge -- one in the area of power, another in the area of water-related services, and the final in terms of equipment provision. It is recommended that all equipment derive its power from electricity. This is advised: 1.) on the basis of the reasonable potential availability of electricity quickly following disaster; 2.) on the basis of the high degree of reliability of electrical equipment, especially in the area of heating; and 3.) on the premise that mixing power disciplines is unwise in view of the uncertainty as to the condition of other utilities and the desire to avoid large-scale fuel storage, especially when the alternate form of electric power can be available which requires no such storage facilities within the unit.

It is also recommended that water-related systems be capable of self-sufficiency on a weekly basis as this seems to be the maximum that can be negotiated with reasonably sized storage and holding tank facilities.

Finally, it is advised that all service-oriented equipment be placed in a central core unit. Such a core unit could also include the spaces necessary for kitchen, bathroom, and washroom activities.

5.4 FABRICATION

5.4.1 Significance

Industralization is the only real fabrication process which makes sense for the production of shelter units on a mass scale. A high degree of technological efficiency is required in assembling a shelter package which is both user-responsive and cost-effective. In addition, the method of fabrication desired will play a role in determining the unit type: reuseable, disposable, or expandable-to-permanency. The implications of on-site or off-site production must be weighed in the selection of the fabrication process. These implications include: logistics, materials choice, technologies, unit-type possibilities, and user participation possibilities.

5.4.2 Types

In an industrialized fabrication scheme, there are two real possibilities for production -- on-site and off-site. In the disaster situation, on-site production means the setting up of an in-field plant capable of producing shelter units to meet the temporary housing needs within the immediate area. Such a plant would be set up in one location and would manufacture units that would then be moved a short distance to scattered site within the area. An off-site production plant would be one which is of a permanent nature and has been designed and erected to produce shelter units for use in any disaster situations which might arise. Such an operation includes the manufacture and inventory of shelter units and necessitates the development of a delivery system.

ON-SITE

A disaster situation creates a captive audience. It creates a large temporary shelter demand within a limited geographical area. In supplying such a demand, transportation costs can be sizeable. An alternative approach would be to eliminate transportation costs by moving the factory into the area. An in-field operation would require only that a supplyline for raw materials be established. Large quantities of such materials can easily and economically be transported. In this way, it is only the materials, and not the spaces which they are to enclose which must be moved. In eliminating the need for long distance transportation, the requirements imposed by volume limitations and highway constraints are eliminated. This gives an added measure of flexibility to the design of the shelter units themselves. Such an on-site operation makes sense only in the production of shelter units which are either of the one-use disposable type, or of the expandable-to-permanency type. It doesn't make sense in such an operation to produce units which are meant for reuse in other disasters, since such shelter forms would have to be made transportable for these future situations, which defeats the original intent.

Further complications arise with on-site production. There are the logistics problems of assembling skilled labor and necessary equipment within a very short period and establishing supplylines. Then, there is a question of what to do with this manpower and equipment between disasters. Disaster is a whim of nature and does not occur on a predetermined schedule. It is entirely possible that long periods of time may elapse between emergencies that would require this on-site production team. It is also entirely likely that several disaster situations occurring simultaneously or in quick succession in a number of scattered locations will produce a shelter demand that will far exceed the capabilities of on-site production crews. Such varying posibilities are real and their occurrences are authenticated in historical disaster statistics. It is my feeling then, that this approach cannot assure that the temporary shelter demands arising from natural disaster will be met within the desirable two-week time frame. Before leaving this approach entirely, one more deficiency can be pointed out. Such an on-site operation cannot have the capabilities of producing service core units in the field. Such unit assemblies require a high degree of labor and numerous individual parts. These cores would have to be produced elsewhere and be delivered to the on-site plant for inclusion within the shelter unit. Such cores will be rather substantial in volume since they will require storage and holding tanks and equipment necessary for self-sufficiency. So, in a sense, transportation does re-enter the picture after all, and the real advantages of in-field manufacture diminish.

OFF-SITE

Off-site production of shelter units is the alternative. In such operations, the advantages of assembly-line production and automation technology can be derived. Such an effort argues well for shelters of the reuseable, or expandable-to-permanency type, but not for the one-use disposable. The real feeling is that if a unit is going to be designed and built so that it can be transported, it might just as well be of a more permanent nature so that its real potential can be better utilized through either a reuse capability, or an expandable-to-permanency application.

In-factory production also offers the capabilities for better quality control and for the combination of a greater number of technological disciplines in the manufacturing process. If effect, a product of higher quality and of greater sophistication is possible. The constraints imposed by the necessity for storage, transportation, and assembly and disassembly operations, are then really of a design nature more than of a fabrication nature.

Certain comments can be made concerning the implications for reuse and for expandable-to-permanancy applications. A reuseable option argues for a shelter package that will occupy a minimum volume during transportation, since this operation is to be a repeated one throughout its life. Inventory requirements further support this notion. There are basically two ways of achieving such a volume minimization. The first involves the development of a package in which those areas of a primarily space nature within the unit possess the capabilities of being folded-up, placed within one another, or broken-down into panelized sections. The second involves the notion of making these space-type areas out of flexible fabric-type materials that allow for folding into a very small package. Both options are based on the provision of a basic core area that would be a permanent feature of the unit. This core would contain service equipment and could also contain those areas which rely heavily on such equipment. This core would then be used in conjunction with the two systems of space provision that have been outlined. This first package would be of a more permanent type and could be expandable to permanent housing. The second type would be more flexible, and would be more suited to a reuse function because of the compactness capabilities of its fabric space envelopes. Both packages would allow the option of extra space provision for larger families.

Thus, an in-factory approach would seem the best. It allows the flexibility and option necessary for a wide range of manufacturing applications. Through inventory maintenance, a large stockpile of shelter units can be developed for meeting disaster contingencies on almost any scale. The units will be available. There is no worry that shelter cannot be provided. Once housing needs are assessed following disaster impact, the operation of supply can begin. There is only the process of transportation and erection to be contended with. The sizes and locations of shelter inventories will be known. There will be no rounding-up process. Delivery operations can begin immediately and the shelter packages can be obtained quickly.

5.4.3 Summary: Implications for Guideline Development and Refinement

CONSIDERATIONS

In determining the suitability of various fabrication processes, a number of factors must be considered. These include; design, materials, capabilities, operation, and economy.

<u>Design</u>: The shelter package design must be amenable to the fabrication process desired. The choice of on-site or off-site manufacture has many design implications. Such implications must be understood and evaluated before design initiation.

<u>Materials</u>: Material selection and fabrication choice are interdependent. In arriving at a manufacturing decision, material desires must be realistically appraised. The possibilities and wisdom of material substitution must be balanced with similar fabrication considerations.

Capabilities: The fabrication must be capable of dealing with the fluctuating demands reflected by the inconsistency of disaster occurrence and severity. The process must be adaptable to the logistics developed to meet disaster contingency needs.

Operation: Essential operational questions include: the scale of production desired, the location and number of production facilities, the level of technical sophistication, and the type of management approach desired.

Economy: The criteria for evaluating alternative means of manufacture should be based on their cost-effectiveness as well as upon their ability to operate successfully within the framework of inconsistency which characterizes disaster, and within the pressing time constraints which are essential to an effective user responsiveness.

RECOMMENDATIONS

Off-site, in-factory fabrication is seen as the only process which lends itself to the vagaries of disaster demand. The need for the development of sufficient shelter inventories to insure disaster preparedness precludes the use of on-site manufacturing methods.

Two types of shelter packages emerge as being the most applicable -- those which are reuseable, and those which are expandable-to-permanency. The disposable alternative is best suited to the on-site production process which has been found to be unmanageable in light of the uncertainties of disaster. Thus, it is recommended that in-factory fabrication be pursued as the most suitable process, and that provision be made for the manufacture and inventory of both reuseable and expandable-to-permancy shelter types.

It is further recommended that both packages be based on the same equipment core use, but that the means for providing the additional spaces be of a more flexible, fabric nature in the resueable case, and of a more rigid, traditional nature in the expandable-to-permanency case.

5.5 DELIVERY

5.5.1 Significance

In developing an understanding of the real physiological and psychological needs of the victims following disaster impact, it was shown that the timing of the transition from the mass shelter situation to the temporary family-oriented shelter situation was critical and that such a switch must be accomplishable within the second post-disaster week. This timing is most essential to the psychological well-being and recovery of the victims and to the perpetuation of the positive spirit of community that the brief mass shelter residency can evoke. This critical housing switch can only be accomplished if the temporary shelter packages have been made available for occupancy within the specified two-week time period. The delivery system plays the key role in this process, assuming that the shelter packages are stockpiled in some location and are ready for immediate use. A transport system is required that possesses: 1.) the physical resources necessary to move large numbers of shelter units; 2.) the wide range of route alternatives necessary to negotiate disaster-torn areas; 3.) the capacity to accomplish complete delivery within the critical two-week time frame; and, 4.) the ability of accomplishing such movements in a cost-effective manner.

Furthermore, the possibilities of both civilian and military involvement in this transport function requires some careful consideration. It is essential that a conflict in roles and a duplication of tasks not develop. In addition to being wasteful of the resources at hand, such problems could conceivably affect the scheduling of delivery. It is essential that this does not occur. The wisest plan would seem to be one in which civilian resources were organized sufficiently to guarantee that transport vehicles would be available when they were needed. This could involve some disaster contingency agreements between the transportation industries and the federal government, whereby industry would be paid some pre-determined yearly rate in return for guaranteeing that shelter transport operations would be given priority over their normal customer obligations in the event of disaster. This would be sort of an open first-option that the government could demand in return for paying some yearly rate. It would be a 'leased option' so to speak. This sort of argument will not be pursued any further since it lies outside the intent of this research. It is only suggested as one possible approach.

My feelings are that the shelter package delivery operation should be handled by private industry and that measures to insure its feasibility should be studied.

5.5.2 Types

Many transport services are available in this country, by water, air, and land routes. Water can be eliminated because of the restrictive nature of its routes. Air has the problem of cost and of requiring additional land-based transport resources for the entire delivery operation. While air may be the speediest form of delivery, it may not be the most desirable in terms of returning the shelter packages to their storage location once their services are no longer required, mainly because of the costs involved. It would make little sense it would seem to develop a shelter package that would require adaptability to more than one mode of long-distance transport. For these reasons, air transport shall also be excluded from further consideration. That leaves land-based transport as the last alternative.

Two forms exist: rail and truck. Both possess large vehicle resources and extensive routing alternatives.

RAIL

The railroad industry possesses tremendous freight potentials, both in terms of the number of cars which it possesses and in the capabilities which they can carry. The most suitable car for conveying shelter units is the flat-car. A large number of such cars are available with a wide variety of lengths and load carrying capabilities. The standard flat-car has a bed length of 87-1/2 feet and a base width of 10-1/2 feet, and rides on two sets of four-wheeled trucks. Such a car can accommodate a load package that is 85 feet in length, 12 feet in width, and up to 12 feet in height with sufficient clearances to negotiate most routes. (B&R:51,p.43) Weight is not a factor since these cars possess a far greater loading capacity than could conceivably be utilized by shelter packages. (B&R;41,p.44.11)

As a means of illustration, if a shelter package were to be compactable to a configuration of 12 ft. x 12 ft. x 8-1/2 ft. high, then such a flat-car could conceivably transport 10 such packages laid on their sides. This would mean the delivery of housing for 40 people (4 people/shelter x 10 shelters/flat-car). These flat-cars would be grouped together to form a train. Such trains often are 100 to 200 cars long. Taking an intermediate number of 150 cars, this would mean the delivery of 1500 shelter packages (10 packages/car x 150 cars/train), or shelter for 6,000 people (4 people/shelter x 1500 shelters/train). This is a sizeable payload. It would only take a few such trains to service most shelter requirements following disaster.

Railroad transport possesses the disadvantage of requiring the use of supplemental trucking operations to deliver the shelter package from the closest rail line siding to the exact site location. This requires an additional transfer operation in the delivery process from storage depot to site. It is assumed that storage depots will be located near rail lines so that the loading operation at least will not require this intermediate trucking operation. Also, some shelter forms, such as recreational vehicles, possess integral wheel systems which would allow them to be towed by car from the rail siding, eliminating the necessity of trucks entirely.

Rail transport has the further disadvantage of slow speed. Total daily trip distances of several hundred miles are the normal limit for freight transport. This is due to the fixed rail concept of railroading that requires the adherence to a set of tracks which must be shared with other trains traveling in both directions. This necessitates frequent stopovers and switching operations that cause significant delays. In a disaster emergency it may be possible to give trains carrying shelter packages first preference just as military trains were given preference in wartime. This could significantly reduce transport times and make rail delivery more competitive speed-wise with that of trucking.

One final drawback exists in the use of railroad cars. When the need arises, they must be assembled from far and wide. The process of rounding up sufficient numbers to initiate trainloads may take a number of days. This problem could be circumvented by keeping on hand a number of flat cars just for the event of disaster use. Then, a train could be put together quickly and the shelter units sent on their way. Such a train could probably make a couple of trips during the allowable two-week period, even if the distance was fairly great. But keeping flat-cars on hand is an expensive proposition and not very efficient. It might be more advantageous to work out some 'leased option' agreement with the railroad in which it would guarantee to keep a number of flat-cars in operation within a certain area of the shelter stockpile depot such that they could be diverted from their normal operations to this depot in a short period of time if the need were to arise.

Rail transport is feasible as a shelter package delivery system only if the problems such as those outlined can be negotiated. The capability certainly exists, but not in the present state of affairs. It is essentially a timing and logistics problem that must be worked out.

TRUCK

The trucking industry possesses the physical resources and flexible mobility necessary for delivery operations in natural disaster emergencies. Nearly 1.5 million truck and diesel tractors are currently in service in the United States. (B&R:42,p.18) These rigs, when mated with flatbed trailers, are suitable for the transport of the shelter package. Such trailers generally have a payload capacity of at least 30 tons. (B&R:63,p.93) However, since the shelter package is a lighter-density form of cargo, the process of 'cubing out' -- utilizing full cargo space without achieving the maximum gross weight allowable -- will occur before maximum gross weight loadings are attained. The average flatbed trailer is typically 45 feet in length, with a standard bed width of 8 feet. (B&R:51,p.40) Most states impose width limitations of 12 feet (with permit) on truck loads and limit the total height of the truck plus payload to 13-1/2 feet. Truck bed height is about 4-1/2 feet, which leaves 9 feet for the payload. These payload limitations of 45 foot length, 12 foot width, and 9 foot height should be adhered to in planning the shelter package. Variations in size limitations exist from state to state. In an emergency situation, it has been possible to wave these restrictions on a temporary basis, as for example in the recent case (1972) of Hurricane Agnes, when width restrictions were lifted by 35 states to allow mobile homes to be delivered to the disaster area quickly. (P&D:11,p.47) But, in the planning of shelter units, it is advisable to stay within the generally recognized limitations. There is also the growing possibility of utilizing 'doubles' -- tractor rigs that pull both a semi-trailer and a trailer simultaneously. Currently, nearly 70% of the states allow the operation of 65 foot long doubles (B&R:39,p.31) These usually utilize 27 foot long trailers. Such combinations are possible for shelter transport.

As a means of illustration, if an average 45 foot long flatbed truck trailer were utilized, with a height limitation of 9 feet and a width limitation of 12 feet, then it could conceivably transport 5 units, each 9 ft. x 12 ft. x 9 ft. high. A 9 ft. x 12 ft. floor area would be adequate for housing the kitchen, bathroom, washroom, and service area. The remaining parts of the shelter package could be of some flexible or foldable nature that could be contained within the core during transport. Each truckload then could deliver shelter for 20 people (4 persons/shelter x 5 shelters/truck).

In surveying the picture, trucking appears to be the optimum means for shelter transport purposes. Trucks can travel on highways at fast speeds. They can even negotiate smaller back roads if disaster has cut the main arteries. The vast highway network which exists in this country makes delivery a speedy operation, even from great distances. Daily trip distances of 1,000 miles or more are possible. Large fleets can be assembled in even a few days time from far and wide. Furthermore, the possibilities of many trips by the same rig during the delivery period reduces the number of rigs required. And trucks possess the capability of delivery from depot to doorstep with only one loading and unloading operation.

One disadvantage to a truck system of delivery is the cost involved if the distances are great. Most common literature establishes an operating range of 300 miles as the maximum that is financially attractive for the transport of housing modules. (B&R:39,p.20) These figures are based on the transport of only a single housing unit. If 5 shelters were deliverable with each trailer, then perhaps this limiting distance could be extended by quite a bit. The implication is to establish a system of regional shelter depots that would each service a certain area, whose size would be determined by the maximum delivery distances that were found to be economically feasible.

5.5.3 Summary: Implications for Guideline Development and Refinement

CONSIDERATIONS

The determination of desirable transport attributes is essential in evaluating the alternatives available. The following aspects should be a part of this evaluation: payload, flexibility of routing, logistics of operation, completeness of delivery, speed, and economics.

<u>Payload Size</u>: Payload limitations are a question of size rather than of weight in the transport of temporary shelter units. Volume will be filled long before weights are exceeded. However, weight limitation is advisable in terms of handling convenience, and in terms of secondary movements in the event of possible future resituation. The nature of the transport process

imposes certain limitations on the length, width, and height of payload. Legislative regulations impose further restrictions. It is best to plan ahead and design shelter systems that are transportable under the framework imposed by these restraints.

Flexibility of Routing: Alternative route selection is often essential in the disaster struck area where many transport routes will often be impassable because of damage to the road surface itself, or to bridges, tunnels, or other supporting intermediaries.

Logistics of Operation: The problems of quickly amassing large quantities of specific types of vehicles in central locations must be solvable in order that such transport will be effective in delivering sufficient shelter units within the desired time frame. The vehicles provided must be utilized as many times as feasible in the delivery operation.

Completeness of Delivery: In the transport of shelter units from the stockpile depot to the disaster site, the number of changeovers in transit must be minimized. Such transfers require labor, equipment, and time; and increase the prospects of damage or delay. Delivery systems which involve only one vehicle throughout the process are the most desirable.

Speed: Previous consideration of the psychological needs of victims indicates that the delivery of all temporary shelter units is essential within a two-week time frame following disaster. To meet this demanding schedule, a speedy transport system is essential. Speed allows both quick delivery and the possibility of multiple trips by the same vehicle. Speed is determined not only by the quickness of the delivery vehicle itself, but by the additional consideration of handling, transfer, and routing delays. Thus, speed is an operational efficiency measure in addition to the normal distance per unit time definition.

Economics: Transport cost can be a sizeable addition to the costs of the physical shelter package. Efforts must be made to reduce both required trip distances and loading inefficiencies. Statistics show that transport costs skyrocket after the initial 100 miles (P&J:37,p.44) Regional shelter stockpiling depots are one answer to reducing these delivery distances. However, these regional depots cost money to operate, so that in reality, the savings in distances are somewhat offset. The best answer appears to be geared towards increasing the number of shelter units deliverable per vehicle trip. This argues strongly for reducing the shelter package provided to a minimal core area and supplementing this on site with expandable space enclosure systems.

RECOMMENDATIONS

In considering the feasibility of various delivery processes, a number of recommendations can be made. It appears that the land-based systems of rail and truck are the most viable in this type of application. Of these, rail transport appears to be the most economical, but the slowest. Truck transport is highly advantageous because of its flexibility, completeness of delivery, and speed; yet it is more costly. At any rate, efficiency will be augmented if the number of shelter units deliverable per unit trip can be increased. This is more of a design problem than a delivery problem, since certain natural and legislative forces act to limit payload dimensions. Finally, the feasibility of setting up regional shelter stockpiling centers should be investigated to establish the number needed, and the sizes of the areas which they should cover.

5.6 ERECTION/PLACEMENT/SECUREMENT

5.6.1 Significance

When the shelter finally arrives at the site, a number of operations remain before it is ready for occupancy. These operations are broadly described as erection, placement, and securement. In reality, these activities were begun long before this stage. They were initiated in the planning and fabrication process. The complete shelter package should contain the necessary elements for set-up and securement of the unit. It is essential that the unit itself contain the mechanisms and resources for these tasks, for this is the beginning of the stage of self-sufficiency. It is desirable that the occupant be allowed to play a role in this work. The psychological benefits accrued through participation and accomplishment will be invaluable in effecting a successful transition from the mass living situation to that of the single-family temporary form.

Because of the possibility of moving to a different site during the occupancy period, the erection and placement operations must be reversible. Yet, because of the actions of the environmental forces, especially wind, the unit must be sufficiently secured at the end of these operations so as to be safe and comfortable for the occupant family. Thus, the planning of these processes is an extremely important one. Also, since this capability for movement and resituation will exist, it would seem even more convincing that these units be of the reuseable or expandable-to-permanency type.

5.6.2 Operations

FOUNDATION

The foundation has two principal roles in this situation: 1.) to raise the dwelling off of the bare earth in order to separate it from the domain of moisture, cold, and vermin; and 2.) to transmit the dead load of the structure, and the live loads of the furnishings, occupants, and nature to the ground in such a way as to prevent settling and maintain stability.

The first requirement is the result of health and comfort considerations. It is necessary to prevent direct contact of the floor with the ground for several reasons. The ground is cold and moist, and water collects after rainfall. In order to reduce heat losses, and to prevent moisture infiltration that can lead to rotting and mildew, some form of barrier must be provided between shelter and ground. Air is one such barrier. Furthermore, vermin inhabit the ground and will attempt to infiltrate any environment which promises warmth and food. Again, a barrier is needed. The simplest approach to both problems is to elevate the shelter slightly from the ground. Such elevation can be accomplished by the use of mechanical jacks or stilts positioned strategically around the perimeter of the structure. In order to completely eliminate the possibility of vermin infestation, each jack should be provided with a special designed bonnet to prevent any means of their access to the shelter.

The second requirement is the result of safety and comfort considerations. The forces acting upon the shelter system must be channeled to the earth. Jacks or stilts are an efficient method for this transmission providing that they have flat plate bottoms of about one or two square feet area each.

The forces are then channeled through the structure and into the stilts which distribute the load evenly to the ground through their substantial web-like bases. This not only spreads the forces and prevents later settling, but also stabilizes the system somewhat by providing a wider base than the stilts alone could provide. Many military-type structures utilize systems in which these jacks are housed within sleeves which are welded at regular intervals around the dwelling's perimeter. These jacks have a number of setting positions so that the height of separation between the ground and the unit can be incrementally adjusted. (P&D:25) This is important in setting-up on rough ground or on inclined sites so that the unit can be leveled. Levelness is essential for comfort. Means should be provided by which the occupant can judge the levelness of his shelter. This can be done quite easily by the inclusion of small glass tubes filled with colored water and an air bubble, similar to those used in a standard carpenter's level. These should be located at several strategic locations around the shelter. In this way, the occupant can judge the levelness and then adjust the appropriate jack settings if adjustment is called for. Slight settlement might require that this operation be repeated at a later date also.

Shelter systems such as inflatables, tents, and domes provide special problems in foundation. Since these systems usually do not possess an integral floor system capable of being raised off the ground. However, the same foundation requirements should be adhered to in order that the environment within the shelter be safe, comfortable, and healthy for an extended living period. Dirt or fabric floors are unacceptable.

ERECTION

This phase involves the setting up of the unit as it was conceived. Various types of erection methods are possible; assembly of panels, assembly of framework and coverage with fabric, inflation, unfolding and securing, joining of modules, and others. These processes should be straightforward and accomplishable within a short period of time. No major equipment should be required. This is an operation that the intended occupant should participate in so that he can gain confidence in the dwelling's design and so that he can be able to duplicate it later on if need be, such as if the unit is resituated.

Once this operation is completed, electricity hook-up and the filling of water storage tanks should follow. From this time on, the unit will be habitable and self-sufficient. However, it will not be completely safe and stable until the tie-down operation is completed.

TIE-DOWN

The final operation is that of tie-down. This procedure is necessary to provide for stabilization in high winds. There are two means of tie-down which might have application in this situation, where the possibility of a later resituation of the dwelling might occur. The first method is derived from the mobile home industry. (P&B:28,pp.5-11) It consists of running several cables across the top of the shelter and tieing these on each side to ground anchors. Ground anchors are disk-like pieces of metal with an integral rod which is 5 to 6 ft. in length running through their centers. These anchors are buried to a depth of about 4 ft. in a pattern surrounding the unit. Several ground anchor variations exist, including screw augers and expanding anchors. The anchor system used should have a holding power of at least 4,000 lbs. -- that required for withstanding hurricane-force winds. (P&D:28,p.10)

Another tie-down possibility might be that of surrounding the shelter at its base with a large water-filled vinyl collar, and tieing it to this. The weight of the water-filled collar could stabilize the structure in windy situations. While not as good as the ground anchor system, this method is well-suited to the possibility of resituation of the shelter to some different site. The water can simply be drained from the collar, and the empty collar rolled up. When the shelter is in its new location, the collar can be reattached and refilled. Possible use of this collar as the water storage area for potable water could eliminate the need for storage tanks within the unit. There is some problem with this type of a collar arrangement in sub-freezing applications since the water inside could freeze. But it should have application in warmer situations.

In all foundation and tie-down planning, the use of systems such as concrete slabs and footings should be avoided. These systems require resources and equipment which are unnecessary. In addition, they are not adaptable to the resituation possibility. Flexibility is the desire. Shelter set up for a two-month occupancy does not require the permanency of concrete foundation and securement systems.

5.6.3 Summary: Implications for Guideline Development and Refinement

CONSIDERATIONS

The erection/placement/securement process is the final step in the provision of temporary shelter. It is also a very important one in terms of safety and comfort. Considerations which emerge include: speed, simplicity, flexibility, equipment and labor, and economics.

Speed: Erection must be capable of completion within a time span of a few hours. Placement and securement should have similar time efficiencies. The desire is to complete the entire erection/placement/securement operation in less than a day. Such speed requires that the erection method be straightforward and that the placement capabilities be built in to the shelter package itself.

Simplicity: The possibility of user participation in the erection/placement/securement operation requires that it be a simple process and that it be based on simple and easily understood principles. In the event of resituation, the occupant will have to repeat the process largely on his own.

Flexibility: This pertains primarily to the placement process. It must be both adaptable to various ground conditions and amenable to the process of resituation. The means must be provided by which the user can make adjustments when they are required in maintaining the structure.

Equipment and Labor: No heavy equipment should be required other than that necessary to deposit the shelter unit on its site. Any tools necessary to erection/placement/securement should be included with the shelter package if the victim is to be responsible for the setting-up operation. A minimum amount of labor should be required. Such labor should require a low level of skill and should be easily learned. The victims should be involved in the operation to as great an extent as possible.

Economics: The erection/placement/securement operation should be strictly low-cost. Money is better spent on the shelter package itself. Crude methods of placement and securement should suffice for a two-month occupancy.

RECOMMENDATIONS

It is advised that the victims take part in the erection/placement/securement operations for both psychological and practical reasons. In order that this might occur, the shelter package should be planned and structured in such a way that it can be easily understood and manipulated.

It is further advised that the placement operation of foundation, and the securement operation of tie-down, be extremely simplistic and not rely on concrete-based systems. The most applicable sources of inspiration seem to be those methods utilized in the mobile home and military shelter fields. Foundation and tie-down should be reversible and all equipment utilized should be reuseable.

Finally, the entire erection/placement/securement operation should be accomplishable within the 8 hour time frame of one working day.

6. SUMMARY OF PERFORMANCE GUIDELINES

This listing of guidelines is an initial attempt to combine the preceding evaluation of physiological and psychological victim needs with the technological implications suggested in the just-completed research. These performance guidelines for temporary shelter design are meant to be a compilation of all research completed thus far. These specifications are divided into two major sections. The first section is a summary of the scope and applicability of these guides. The second is a listing of actual requirements and specifications. This latter includes: shelter type, spaces, materials, structural systems, service systems, fabrication, delivery, and erection/placement/securement.

In Section IV of this research paper, these guidelines will be evaluated and modified through a process of testing and use. This process will give a more reliable base to these specifications.

6.1 PREFATORY REMARKS

6.1.1 Statement of Intended Use, User, and Period of Use

USE:	As temporary single-family housing during the second post-disaster period, situation stabilization.
USER:	Single family of 4 members. *Maximum occupancy is to be limited to 7 members; for which add-on supplementary space and service packages will be available. *Minimum occupancy is to be 3 members; for which no change from the basic package will be necessary.
PERIOD:	Until semipermanent housing becomes available, or until a sufficient level of repair operation has been completed upon the occupants' home to restore it to livability condition. *Beginning of use: within the first 2 weeks following disaster impact. *Maximum use period: 2 months

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6.1.2 Statement of Needs Provided for

PHYSIOLOGICAL:	Maintenance of bodily functions. Protection from environmental forces. Resumption of normal physical routine. Provision for self-care.
PSYCHOLOGICAL:	Resumption of self-dependency. Resumption of normal family routine. Provision of a comfortable atmosphere for recovery of mental attitude and balance. Provision of a framework for rational assessment of the future and for consideration of available options.
SOCIAL:	Provision of a framework from which to resume normal roles.

6.1.3 Statement of Shelter Scenario

PROVISION:	The shelter package is to be delivered to the family during the second post-disaster week. It is to contain all elements necessary for operation, erection,

placement, and securement.

SITING: The shelter package shall be sitable in a location of the occupants' choice; or, in the event that is impossible, then in clusters with other such shelters in open areas near relief or community centers. Re-situation of the unit shall be possible in the event that the occupants' choice should later become available.

OPERATION: The shelter package is to contain the resources and spaces necessary for the resumption of normal family routine. These activities include: sleeping, relaxing, cooking, eating, cleaning, and grooming. The unit is to be self-sufficient on a weekly-renewable basis. Once-weekly resupply and discharge services shall be instituted by the local government and shall continue through the duration of shelter occupancy.

6.2 REQUIREMENTS AND SPECIFICATIONS

6.2.1 Shelter Type

Two types of shelter packages are to be applicable: the reuseable, and the expandable in-part-or-in-whole to permanency. Both should include a service core unit and a supplementary package of area enclosures. The core unit may be identical in both applications. The area enclosures will not be.

REUSEABLE: This option should include a well-constructed service core unit. Such a unit should contain essential service equipment and may include areas of a service-oriented nature.

The supplemental area packages shall be either of a flexible, periodically-renewable type capable of being folded into a small volume during storage and transport, or of a rigid panel nature capable of assembly/disassembly and similarly reducible.

EXPANDABLE: This option should include a core unit similar to that provided for the reuseable. This unit can be retained as part of the permanent structure, or removed when it is no longer necessary.

The supplemental area packages shall be of a rigid panel nature capable of assembly/disassembly and permanent application. Such panels shall produce traditional rectangular spaces suitable for use in the permanent situation.

6.2.2 Spaces

DESCRIPTION:

The following spaces are suggested as suitable to the nature and planned scope of the activities planned:

- 2 sleeping areas, one of which must be a totally private space meant for no other activity; the other must possess the capabilities of semi-privacy and may be used for secondary activities such as child play when not in use for sleeping.

- 1 kitchen area which should include the essentials for cooking, washing, storage, and working.

- 1 living room area that either contains a specific dining space, or possesses the capability of being used for that purpose during meals.

- 1 private wash area containing space for a minimal tub-shower fixture and a drying area. This area is to double as a laundry wash area when not in use for bathing, with the tub being used as a wash tub. A small shelf area should be included for storage.

- 1 private bathroom space containing toilet and sink with mirror and medicine cabinet.

- 1 enclosed service area to contain mechanical equipment and storage holding tanks.

- 2 closet spaces, one of which must be easily accessible to the bedroom areas.

SIZES:

The following square-foot areas are suggested as suitable to the functions that they serve. It is further suggested that these area sizes be adhered to within 10% of that stated.

1 private sleeping area	90 sq. ft.
1 semi-private sleep/play area	80 sq. ft.
1 kitchen area	50 sq. ft.
1 living room/dining area	180 sq. ft.
1 wash area	25 sq. ft.
1 bathroom area	20 sq. ft.
1 service space	15 sq. ft.
2 closet areas, ea. @ 7-1/2 sq. ft.	15 sq. ft.
Total:	475 sq. ft.

NATURE: These spaces are referred to as areas. Only three such areas must be considered as rooms in the true sense of the word -- the private bedroom, the bathroom, and the wash area. In the remainder of the unit, open space planning would seem most logical, both in the nature of the multi-use character of many areas and in the need to dispel feelings of crampedness that a unit constrained in size can evoke. Planning in these areas should provide manipulatable means for attaining various degrees of openness and privacy. In addition, the design and layout should encourage the use of immediate exterior spaces as much as possible as an extension of the shelter itself. Areas surrounding the unit, as well as those above and below, should be utilized as potential activities spaces whenever possible.

DIMENSIONAL IMPLICATIONS:

Units should be kept to a height of one story. Multiple stories require interior stairs which occupy space that is too valuable in an already constrained living situation. However, features such as telescoping roof sections that might increase interior ceiling heights are permissible and desirable as a means of enhancing and varying interior space. In such cases, lofts attainable through use of vertical ladders would be permitted.

Minimum permissible ceiling height is 7 feet. A ceiling height of 7-1/2 feet is recommended.

Overall height, width, and length limitations are outlined in the section on delivery guidelines.

6.2.3 Materials

1.) Material systems such as the sandwich panel which combine the aspects of structure, skin, and insulation are suggested. One particular sandwich panel application which seems especially well-suited combines faces of metal (galvanized steel or aluminum sheets) or fiberglas with a core of urethane foam.

2.) The most promising materials for temporary shelter application appear to be: plastics of the glass fiber reinforced (fiberglas) or the cellular (urethane foam) variety, and fabrics of the synthetic type (neoprene or Hypalon coated nylon, Dacron, glass, and vinyl coated, such as p. v. c.-coated nylon). It is suggested that these be primarily used in shelter construction.

3.) Areas of shelter that consist primarily of space should be constructed of materials that can be compacted into small volumes during periods of storage and transport. Fabric-type materials and assemble/disassemble panel systems are recommended for these applications.

4.) To facilitate ease of handling, it is essential that lightweight materials be used.

5.) All materials used in construction shall possess non-combustible or sufficient fire resistant properties, or shall be protected in some manner from direct flame and from heat exceeding 250°F in the event of fire.

6.) Thermal heat loss of the living unit shall not exceed 50 Btuh per square foot of the total floor area of spaces to be heated. This requires an insulation with a U value of .07 Btuh/sq. ft./°F for ceilings and .09 Btuh/sq. ft./°F for walls and floors.

6.2.4 Structural System

1.) The structural system chosen shall be capable of withstanding the loads and stresses applied. The following loading levels shall apply:
DEAD: The weight of the unit itself.
LIVE: Occupants and furnishings - 30 lbs./ft.^{2}
Snow - 20 lbs./ft.^{2}
Wind - 45 mph
Earthquake - lateral loading equal to 10% of the dead weight.

2.) Systems applicable for all or part of the shelter package are:
BEARING WALL: stud or sandwich panel system.
SLAB: sandwich panel: flat or folded-plate.
SHELL: assemble/disassemble panel system.

3.) Systems applicable for space enclosure when used in adjunct with a core unit are:
DOME: assemble/disassemble panel system.
GEODESIC FRAME: assemble/disassemble frame with fabric skin.
SUSPENSION: fabric tent-type.

PNEUMATIC: air inflated type utilizing air inflated compartments or inflatable ribs.

4.) Structural systems which efficiently utilize geometry so as to reduce required material cross sections and allow the use of lighter weight alternatives are suggested.

6.2.5 Service Systems

ELECTRICAL

POWER: Power shall be obtained solely from electricity. It is assumed that the electrical utility will be operational during the period of temporary housing. Each shelter unit shall be provided with a 100 amp. single phase 120/240 volt, 3 wire electric package for hookup by cable to a power line within the area.

LIGHTING: Lighting shall be provided by standard electric fixtures of the incandescent and flourescent variety. These fixtures shall be supplied in sufficient number and positioned in such strategic locations as to assure an illumination level of 50 foot candles throughout the shelter in the absence of natural light.

COOKING: Cooking shall be done on a 4 burner electric range (no oven). Perishable food storage shall be maintainable through use of an electric refrigerator. This equipment is to be minimal in size.

PLUMBING

WATER SUPPLY: A supply of potable water shall be held in storage tanks within the shelter. This supply shall be based on a 40 gallon daily use rate (10 gal. each for 4 people) and shall be sufficient to last for a one week period between resupply operations. A hot water storage tank of 15 gallon capacity shall also be provided.

SYSTEM OPERATION: Pressurization of the water system shall be by means of electric water pump. Plumbing fixtures to be provided are: 1 kitchen sink, 1 bathroom sink, 1 toilet, and 1 tub/shower. These are to be of a one-piece fiberglas construction and are to be minimal in size.

SEWAGE DISPOSAL: In the sewage disposal system, excremental wastes and waste water are to be handled separately. A minimum flush-water type toilet is to deposit excremental wastes in a sealed holding tank, which is to be of sufficient capacity to service 4 persons (at 1/2 gal. of waste per person per day) for a period of one week between tank discharge operations.

Waste water is to be collected from the tub/shower and sink fixtures into a holding tank in which chlorination and purification operations are to take place. This cleaned water should then be available for bathing and cleaning purposes, but not for drinking. Excess cleaned waste water can be drained to the ground if the holding tank overflows.

MECHANICAL

HEATING: Heating is to be provided by an all-electric system. This system is to be capable of maintaining an indoor design temperature of 70°F at an extreme outdoor temperature of -15°F. A secondary supplemental heating system shall be available as an add-on package for use in areas experiencing colder conditions.

COOLING: A unit air-conditioning system shall be available as an add-on package for use in areas experiencing temperatures greater than 100°F.

VENTILATION: Air change shall occur through the heating system and through windows. An air change twice-hourly shall be guaranteed. Vent screens shall be placed in sealed areas. The kitchen range shall be provided with a mechanical exhaust fan capable of 8 air changes per hour. The bathroom and wash room shall be provided with operable windows, or in the event that is impossible, with exhaust fans capable of 20 air changes per hour.

Furthermore, an indoor relative humidity of 50% in summer and 30% in winter applications shall be maintained.

6.2.6 Fabrication

1.) Fabrication shall be of an industrialized off-site, in-factory type.

2.) Fabrication shall consist primarily of developing a core unit and a supporting package of area enclosure. The means for erection, placement, and securement shall be provided in the fabrication operation.

6.2.7 Delivery

1.) Delivery of shelter units shall be accomplishable within the two-week period following disaster.

2.) Delivery shall be an entirely land-based operation relying on rail and truck transport.

3.) Delivery shall be a civilian operation, undertaken by private transport contractors.

4.) A disaster contingency preparedness plan should be worked out between the federal government and the railroad and trucking industries to assure the availability of sufficient vehicle resources for shelter delivery operations in the two-week period following disaster impact.

5.) Rail transport shall be by standard 87-1/2 foot long flat-bed cars. Payload dimensions shall be limited to 85 foot length, 12 foot width, and 12 foot height. Truck transport shall be by 55 foot long flat-bed trailers. Payload dimensions shall be limited to 55 foot length, 12 foot width, and 9-1/2 foot height. (In some states, a variance will be required to permit the transport of 12 foot wide payloads.)

6.) Shelter units shall be compactable for shipping to such extent that at least 10 such units can be accommodated per rail car, and 5 such units per truck bed.

7.) A system of regional shelter unit stock-piles shall be set up throughout the country to minimize trip distance and to insure the meeting of time schedules.

6.2.8 Erection/Placement/Securement

1.) The erection/placement/securement operation shall be accomplishable within 4 to 8 hours following delivery to site.

2.) The erection/placement/securement operation shall involve the potential occupants to a significant degree.

3.) The erection/placement/securement system shall be an integral feature of the complete shelter package.

4.) The foundation system should:

a.) be capable of maintaining stability and of preventing settlement under varying ground conditions of roughness, inclination, and bearing capacity.

b.) provide the means for leveling of the structure.

c.) elevate the structure at least 1 foot off the ground.

d.) prevent the infiltration of insects and vermin from the ground into the structure.

e.) be reuseable.

5.) The erection process should:

a.) require only minimal equipment to complete.

b.) be reversible.

6.) The securement procedure should:

a.) be simple, quick, and reversible.

b.) utilize components in the anchoring system that have a holding power of at least 4800 lbs. each (necessary for hurricane wind requirements of 100 mph).

SECTION IV

TESTING, USE, AND REFINEMENT OF PERFORMANCE GUIDELINES

1. PROLOGUE

This process is meant to evaluate and strengthen the guidelines which have just been formulated. The intent is to demonstrate the suitability and applicability of these standards, and to bring this research into a firm contact with reality in order to provide a more substantial base to the thusfar theoretical formulations. Two approaches shall be attempted. First, feedback is to be solicited from various officials with whom I have come into contact in the course of guideline preparation. These persons will be approached for their evaluations because they represent agencies or disciplines that have an established disaster experience. The second method of consideration will involve the investigation and determination of viable shelter alternatives. The purpose of this action will be three-fold: to judge such alternatives; to attempt to demonstrate the process of working within the guideline context; and to utilize this working process to amend or expand the listed guideline criteria based on this experience.

Upon completion of this three pronged thrust, the guidelines which have been formulated and listed in Section III will be reworked and updated, and the resulting revised guideline standards will then be detailed in Section V. This shall be the final version of these specifications and shall represent the completion of the major objective of this research.

2. FEEDBACK FROM QUALIFIED OFFICIALS

2.1 SIGNIFICANCE AND PROCESS

This first stage of testing and refinement deals with the evaluation of the performance guidelines listed at the conclusion of Section III. Originally, a Delphi-type consultation of many experts was considered. Ultimately, however, I decided to send copies of these guidelines plus a cover page of instructions to only four officials in Washington, D.C. whom I had previously contacted at the outset of my work, because they represent key agencies with disaster-related missions. These officials included:

1.) Mr. William Cosby, Program Manager of the Building Research Advisory Board, National Academy of science, whose office had recently completed a three month study for the Office of Emergency Preparedness which dealt with disaster/shelter alternatives.
2.) Mr. Roy S. Popkin, Assistant National Director, Disaster Services, the American National Red Cross.
3.) Mr. Ugo Morelli, Office of Emergency Preparedness, Division of Disaster Preparedness.
4.) Mr. Robert Berne, AIA, Chief Architect, Defense Civil Preparedness Agency.

The performance guidelines which I sent were identical to those listed in (6.) of Section III, with the exception that the system of numbering used in headings and subheadings has since been changed so as to better correspond to the system adopted throughout this text. There were no substantive differences, however. A copy of the cover page of instructions can be found in Appendix #3, on page 334. I shall not dwell upon these instructions but shall simply summarize by saying that they presented a background of my work and a request for comments and criticisms which were to be written in provided spaces corresponding to each section of the specifications.

The intended outcome of this process was to be 4 copies of the performance guidelines, each evaluated and criticized by a different official knowledgeable in the field. These 4 varied evaluations were then to be analyzed section by section, comparing the listed comments and attempting to establish trends or common concerns that could be used in refinement and reformulation. Unfortunately, this did not materialize with quite the detail expected. In actuality, I received only one reply in the exact form which I had requested. That response was from Mr. Popkin of the Red Cross. A second response was received over the phone on April 30, 1973 from Mr. Morelli of the OEP in which he verbally related his comments concerning each section. So these two replies were in the basic form which I had desired. However, the two remaining officials, Mr. Cosby and Mr. Berne were both involved in important work which precluded a detailed evaluation. Thus, they were only able to convey a general impression of their reaction to a cursory reading of the guideline material. Mr. Cosby's reply was by phone, Mr. Berne's by letter. A complete listing of all comments made by these 4 officials can be found on pages 337-341 in Appendix #4.

Even considering the alternative nature of this response, I feel that there is adequate feedback to institute an evaluation process, though on a somewhat different scale. Significant issues were raised, and a number of specific points were questioned. It is now my intention to present a synopsis of this feedback, both that of a general, and that of a specific nature, and to consider and evaluate this response in an effort to determine how the guidelines can be improved to reflect this added input.

2.2 RESPONSES AND COMMENTS RECEIVED

This section shall summarize the responses and comments received from the previously mentioned officials. Subsequently, in section 2.3, these responses will be evaluated and assessed. Finally, section 2.4 shall list the guideline refinements suggested in this process.

2.2.1 General Comments

In terms of general comment, all sources expressed the feeling that the guidelines seemed fairly reasonable. According to my advisor, Assistant Professor Arthur Bernhardt, it has been his experience in surveys of this sort, that the absence of the mention of any serious objections in the general summary of the reply is a positive indication that the material presented was judged to be basically sound. In addition, there were 2 further comments of this nature which dealt with more substantive issues. Mr. Berne expressed the feelings that ". . . the units you have in mind are perhaps more elaborate than necessary under emergency conditions. You might want to keep this in mind as you develop the project further." Additionally, Mr. Morelli was concerned that the area of cost-effectiveness was not dealt with in the guidelines themselves.

> "Design conditions are paramount at the outset, but at the end of the process, costs are going to play a dominant role. . . You need to have some sort of cost criteria to make your selection of alternatives acceptable, to bring it down to earth. Otherwise, this excellent effort (performance guideline development) could be wasted."

2.2.2 Specific Comments

In this section I intend to go through the performance guidelines section by section and present a synopsis of the specific comments which were applied to each. This listing is based totally on the comments made by

Mr. Morelli and Mr. Popkin, as they were the only two who were able to respond in a detailed manner.

Statement of Intended Use, User, and Period of Use: There was a concern on Mr. Morelli's part that it was difficult to justify a two month occupancy on the basis of cost-effectiveness. Mr. Popkin asked whether the occupancy period could be extended to up to one year to conform to a HUD temporary housing program which shall be discussed later in section VI. He was also concerned about the possible occupancy by two persons, especially elderly couples on pensions, which he described as an urgent need and which these guidelines do not address.

Statement of Needs Provided for: Mr. Popkin commented that the considerations listed were good.

Statement of Shelter Scenario: Mr. Morelli questioned the wisdom of relying upon, or encouraging the victims to participate in the erection process. His objections were mainly based on the premise that for a large cross section of people, especially senior citizens, such participation did not seem realistic. Mr. Popkin was confused about who exactly was responsible for erection and what the nature of the utilities services was to be.

Shelter Type: Mr. Popkin felt that the guidelines listed were good in this respect.

Spaces: Mr. Morelli was concerned that the square foot arear specified might be a little tight, but when he learned of their comparability to those offered in the mobile home situation, he was somewhat assured. Mr. Popkin was confused as to the nature of equipment and appliances, but these misunderstandings were clarified to his satisfaction in the later section dealing with service systems.

Materials: Mr. Popkin initialed an OK.

Structural Systems: Mr. Morelli was concerned that both the suggested wind design loadings and earthquake design loadings were perhaps not stringent enough. However, he admitted to having no real facts that influenced this concern, just a general feeling.

Service Systems: Mr. Morelli wondered whether it was advisable to omit an oven as suggested. He also questioned the relative humidity specifications as being somewhat of a luxury that many normal housing units do not even possess. Mr. Popkin asked about the possibilities of the need for portable generators. He also was unclear as to how the potable water was to be supplied, and how sewage was to be disposed of. These latter questions were supposed to be dealt with in the previous "Statement of Shelter Scenario".

Fabrication: No Comments.

Delivery: Mr. Morelli was concerned by the omission of air transport. He maintained that this was a viable delivery system, especially in terms of the speed and ability to land in most airport situations which many cargo transports possess. He also felt that it was unwise to exclude the military from participation in this operation, since it can mobilize an immediate response and since it possesses large personnel and equipment resources which have a capability for disaster transport operations. Furthermore, he felt that the mention of a federal disaster contingency plan was out of place in a listing of design guidelines. He pointed out that in regards to stockpiling , there are now 10 federal stockpile regions for disaster inventory and that these could possibly be the main storage depots for shelter inventories. Mr. Popkin was concerned that the trailer trucks couldn't negotiate some disaster areas from his experience, and that possibly some smaller transport vehicles such as pick-up trucks and helicopters should be mentioned as possible short-haul intermediaries.

Erection/Placement/Securement: Mr. Morelli again expressed his "serious doubts" about occupant erection. He was also unclear as to what was meant by "minimal equipment" in the erection process. He was satisfied when he learned that this meant small hand tools. Mr. Popkin was unclear as to whether the foundation was a part of the shelter package.

2.3 EVALUATION AND INTERPRETATION OF RESPONSES

An attempt will now be made to address each of those areas in which objections or confusions were evidenced. The relevant responses previously summarized will be interpreted and evaluated, and an attempt will be made to deal with these within the framework of the performance guidelines. At the conclusion of this process, section 2.4 will summarize the guideline refinements considered necessary.

General Comments: Mr. Berne's comment that the shelter units appeared more elaborate than necessary is very vague. Does he mean that the victim is being given more than he needs in terms of services and facilities, or that the services and facilities provided should be included, but that they should be more rudimentary in nature, or is he speaking of possible costs? There is no real way of answering this comment without additional clarification.

I can only reiterate my original feelings that the activities provided for are necessary to the resumption of family living and that the services provided are those required to support these activities. I see no luxury involved.

Mr. Morelli brings up the concern for cost and its necessary inclusion in the performance guidelines. I have acknowledged this concern throughout this paper, and have attempted to comment upon it whenever possible. Cost is, of course, a very real and important factor in design, but it lies in a field of study which is beyond the concentration which I have selected and which is outside the scope of this endeavor. However, I have mentioned cost considerations as much as possible throughout the course of this study, and I feel that an attempt should be made to include their mention in the performance guidelines, primarily as an illustration of relevant areas of concern in the total design picture.

Statement of Intended Use, User, and Period of Use: Regarding the two-month maximum occupancy period outlined in this section, I feel that the concerns which Mr. Morelli voices regarding how this can be justified on a cost-effective basis are relevant. The difficulty lies in the necessity under the scheme outlined in the guidelines of providing 3 different shelters, one following the other. It is difficult to justify this three-fold expenditure. There appear to be 2 options. These were suggested by Mr. Morelli and Mr. Popkin. The first is to provide a shelter system that is deliverable within a number of hours following disaster and which will be livable for a two month period. This eliminates the need for mass shelter accommodations. The second option involves the upgrading of the two month shelter package so that it can also be utilized in the semipermanent housing situation. My feeling is that the first suggestion is both unworkable and unwise. There is no really accurate way of judging the quantity of shelter units needed immediately following impact. This requires time for proper evaluation. Also, the capabilities for such "instant transport" have not been developed or demonstrated sufficiently. There are certain requirements of a two month occupancy which necessitate at least a minimum shelter bulk. This entails handling and transport operations which are not physically possible, even in the time frame of one day. Of equal importance in this consideration is that in this contemplated alternative the mass shelter experience is eliminated completely. My research has shown conclusively, I feel, that an initial mass shelter response is psychologically advantageous to both the immediate and recovery periods. The second approach of expanding the occupancy by updating the temporary shelter to semipermanency after the first month or two seems much more reasonable. It allows for the initial mass shelter experience and it provides sufficient time for a reasoned estimate of needs to be assessed and for the delivery operation to be completed. Furthermore, the very nature of the temporary shelter being either reuseable, or expandable-to-permanency, as I have outlined in the guidelines lends itself easily to a process of updating. This would tend to make the temporary shelter package more realistic on a cost-effective basis.

In terms of the user, these guidelines were developed with the family in mind. At an early stage of this study, the family was destined to comprise three or more persons. It would seem that in the area of single persons, or couples, an alternate response might be necessary, possibly in the nature of a motel or part set-up. This research has not concentrated on this aspect of occupancy, and I feel that it would be unwise at this time to attempt to incorporate this additional concern within the guidelines.

Statement of Shelter Scenario: Victim participation can play a very vital role in the restoration of feelings of self-sufficiency and self-confidence. Mr. Morelli's objections seem to be based on two premises: the first being that it is unworkable, and the second being that certain types of people such as the elderly are incapable of such operations. In regard to the first, it has not been proven to be unworkable. In various accounts which have been published detailing disaster case studies, the victim populace is often eager to assume tasks, even those with which they are unfamiliar, especially when it causes them to feel that they are contributing. In light of this, I feel that it is important to allow this option. In the second case, dealing with groups of people who are physically incapable of such operations, I can only point out that this shelter is meant for families, and that in the context defined, elderly couples do not constitute a family. Within the family structure, there should be persons capable of simple erection tasks. Perhaps it should be made clearer that erection is not to be done entirely by the victim populace, but rather is to be augmented by their input, no matter how minimal in nature. They are not expected to do the job alone, nor even necessarily the major part of it. Instead, the intent is that they become involved in aspects which are of a scale and level of skill that they can cope with. There is the possibility that in some efficient designs, the erection process will be so simplified as to in fact allow the occupants to really assume the major burden. One such scheme that immediately comes to mind is the example of the camping trailer which requires only the operation of an integrally constructed winch to complete the entire erection procedure. The overriding point to be made is that some form of victim participation is desirable, even if on a very restricted or minimal scale. In addition, Mr. Popkin's concern for erection responsibility has also been dealt with in this discussion. His further concern for the nature of the utilities services can be easily satisfied by a simple rewording of the accompanying section which deals with operation.

Spaces: Mr. Morelli's hesitancy concerning square foot areas was partially alleviated by our discussion on the phone in which their comparison to conventional mobile home situations was pointed out. His concerns were not of a specific nature, but rather, a general feeling. The area sizes listed in the guidelines have a basis of fact. They were arrived at by considering existing housing standards. I feel that no revision is necessary, and that though somewhat "tight", these areas are functional and offer the degree of livability which is demanded in the period of occupancy. These areas must be kept to a minimum, but I feel that in so doing, functionality and suitability have not been sacrificed.

Structural Systems: Re-investigation serves only to reconfirm the wind and earthquake design loads which are specified in the guidelines. These are the extreme values regularly specified in building designs of this type and size. The wind specifications do not cover tornadoes, but are applicable in a hurricane situation. Realistically, tornado protection is impossible. Conventionally built housing crumbles under such an extreme lashing. It would seem difficult to give temporary shelter a quality which even normal housing cannot guarantee. The earthquake design loading is that recommended in F.H.A. housing standards. In this respect, then, I feel that the guidelines are sufficient as stated.

Service Systems: The question of the provision of ovens can be answered in this way. Cooking does not require the use of an oven for many types of items. If anything, ovens are being used less today than ever before, especially with the large variety of frozen food items which are available. Therefore, an oven can be dispensed with as probably being a more elaborate feature than that required for simple food preparation.

In regards to the question of humidity control, the phrasing of the guidelines is not quite that which was intended. It should rather recommend that these humidity levels are desirable design goals.

The possibility of portable generators should be mentioned, as this is an operation which might be necessary for a time, especially if the disaster is extremely widespread in its impact area. In this case, it will be necessary to organize the shelter units in cluster arrangements such that each grouping can be serviced by a single generator. The electrical system within the unit should be capable of this alternate hook-up, and should possess the means for such a temporary linking. In the majority of cases, it should be possible to re-establish a number of major trunk lines however, so that generators will not be necessary, especially when this shelter form is not contemplated for use any sooner than a week following impact.

Mr. Popkin was also confused as to the water-related delivery and disposal operation and responsibility. This is a question of clarification that can be resolved by a rewording of the "Statement of Shelter Scenario" and by including a statement to this effect in the actual service section which deals with water supply and waste disposal.

Delivery: I feel that perhaps this is the area in which the guidelines will require a close scrutiny to determine if they are realistic or if they fail in analysis. Considering first the question of air transport, I find that my original reasoning for limiting the transport operation to the land-based types was hasty and requires a second evaluation. My original thinking was based on two facts: the presumed high cost of air transport; and the necessity to develop a shelter package that would conform to both the size limitations imposed by highway legislation and by allowable air transport cargo sizes. The question of cost is unclear. I have no real means of comparison between land-based and air transport. In reviewing information concerning the sizes of the cargo spaces on many conventional air cargo planes, there does seem to exist the opportunity to fit a number of shelter units within such an area. Also, in many conventional cargo transport planes such as the "Boeing Stratofreighter", the "Douglas Globemaster", the "Lockheed Constellation" and others, the cargo compartment's height and width limitations are comparable to, and sometimes even less restraining than those of the truck and railroad. And lengths, if anything, are often larger than that available in the truck trailer unit. On the basis of this further information, it would appear that air transport could be a viable alternative when used in conjunction with rail and truck operation. It is possible that parts of the shelter package, or even the entire package could be flown into the area to a nearby airport. From there, trucks assembled from within the area could be utilized for the short-haul transport to site. I feel that the guidelines should be revised to reflect this new thinking and information.

Mr. Morelli's second concern dealt with the exclusion of the military in the shelter delivery operation as outlined in the guidelines. His feelings were that the military is often the first presence felt following disaster, and that it was a limitation on the design to omit their possible participation. My feelings had been to make the shelter provision operation independent, relaying solely upon private contractors. My hope was to eliminate the military presence entirely from the disaster operations work. On reflection, this desire no longer seems valid, as the disaster relief operation is one for which the military is especially well-equipped in terms of manpower and equipment. Also, this is a positive form of involvement as opposed to war which I consider to be a negative use of the resources of the military. It would seem unwise in this light to exclude the military from this beneficial and important work. Large quantities of military vehicles including trucks, planes, and helicopters are stockpiled at various bases throughout this country. These vehicles are maintained and kept in an ever-ready condition for training and emergency uses. Thus, these transport mediums could be put into immediate operation. The Air National Guard, Corps of Engineers, and various Army reserve units have sizeable manpower resources to operate these vehicles at several hours notice. This ever-present preparedness could probably begin the shelter transport operations before private industry could possibly mobilize its resources. As I have stated previously, the overriding goal in the disaster situation should be to effect the transition to temporary housing within the two-week period previously defined. As the military possesses the capabilities and resources to assure that this transition will be brought about in a timely manner, I must yield to this realization and revise the guideline specifications in this area.

Mr. Morelli also pointed out that there are now 10 federal stockpiling regions throughout the country that have been set-up as disaster inventory locations. The guidelines point out the need for such regional inventories. Perhaps then, the specification in this particular area should be modified to reflect this new information and take advantage of these regional locations which have been set-up to service various sections of the country based on such information as trip distances and the likelihood and types of disaster conceivable within their boundaries.

As to Mr. Popkin's concern for trailer truck maneuverability in certain areas of disaster impact, it would seem that the inclusion of the military in the delivery operation will mean that various types of heavy-duty equipment can be made available that could traverse almost any type of terrian, or that could repair a route sufficiently to allow conventional truck operation to resume within a short time. The possibility of using military helicopters for short-haul transfer to the site is also a possibility. It seems that the wind-down of the Viet Nam war may make large numbers of such transport helicopters available in this country. These could be easily modified for this type of payload conveyance.

<u>Erection/Placement/Securement</u>: Mr. Morelli's concern for victim participation has already been discussed, and the guidelines in this area should be re-worded so as to make the intent perfectly clear in this respect.

In addition, Mr. Morelli's concern over the wording of "minimal equipment" can be easily rectified by a simple rewording that would specify hand tools.

Mr. Popkin's comments on the foundation system seemed for the most part to be based on a misinterpretation of the stated guidelines covering this point.

I think that this situation can be clarified by dividing this section into three parts "Foundation", "Erection", and "Tie-Down". Mr. Morelli also expressed some confusion, especially regarding securement which was cleared up when he realized that securement meant tie-down.

2.4 IMPLICATIONS FOR GUIDELINE REFINEMENT

Cost: An additional section shall be added to deal with the question of cost. This section shall emphasize the necessity of cost-effectiveness and enumerate the areas in which this concern should affect design.

Statement of Intended Use, User, and Period of Use: This section shall be amended so that: 1.) USE will include the mention of the possibility of occupancy during the recovery period as well; 2.) USER will specify that these guidelines are not applicable for the single person and couple situation; and 3.) PERIOD will state the possible extension of the occupancy period in the event that the need extends beyond two months, in which case the temporary shelter package is to be updated to a semipermanent livability.

Statement of Shelter Scenario: This section shall be amended so that: 1.) PROVISION states the secondary role of the victim in the set-up process; and 2.) OPERATION is clarified so as to better explain the nature of the provision and operation of the utilities services.

Service Systems: The POWER section shall be amended to include the possible use of electric generators in the event that electric service is not restored when occupancy begins. In this case, a group of shelters are to be serviced by the same generator.

The WATER SUPPLY section shall be amended to include an explanation of how the water requirements shall be met. This explanation shall deal with the refilling of storage tanks in the event that normal water supply systems are unworkable, and with the further provision for an alternate hook-up capability in the event of such service resumption or availability. A similar explanation shall be included to deal with the SEWAGE DISPOSAL section.

The VENTILATION section shall be amended so as to suggest the stated indoor relative humidity levels as design objectives, rather than as specification requirements that must be met.

Delivery: The delivery section shall be revised on six specific points:

1.) Delivery shall be amended so as to include air transport.
2.) Delivery shall be amended so as to include the military.
3.) The section dealing with a disaster contingency preparedness plan shall be omitted.
4.) The cargo plane shall be mentioned as the vehicle of air transport. Dimensional limitations shall be explained as dependent upon the actual type of plane utilized.
5.) The section dealing with regional shelter stockpiles shall be amended to suggest the utilization of the ten federal disaster inventory stockpiles which have been set-up.
6.) Military helicopters shall be mentioned as a possible intermediary short-haul transport vehicle in the event that trailer trucks cannot negotiate the immediate disaster area.

Erection/Placement/Securement: Erection shall specify that this operation is to be capable of completion by unskilled labor, and that the posibility of including the potential occupants in some phase of this process should be recognized, and if possible, designed into the procedure in such a way as to allow for this flexibility.

The item describing the requirement of only minimal equipment in the erection process shall be amended so as to specify hand tools. This section shall be divided into three major subheadings: "Foundation", "Erection", and "Tie-Down", so as to make the intent clearer and avoid the confusion and misunderstandings which seem to have arisen.

3. FEEDBACK FROM THE EVALUATION OF ALTERNATIVE SHELTER SYSTEMS

3.1 SIGNIFICANCE AND PROCESS

This second stage of testing and refinement involves the consideration of alternative shelter systems. It is hoped that the feedback from this analysis will not only further the development of effective and relevant guidelines, but also that it will begin to identify those alternatives and concepts which might be effective in disaster relief shelter response. In this way, we will be able to combine the experiences of both the human responses from the previous process and the systems responses from the present effort, to arrive at a finalized version of performance guidelines, and a summary of meaningful comments and recommendations.

This analysis first involves the establishment of general categories of shelter alternatives. These categories will tie together shelter system alternatives of both real and conceptual, as well as civilian and military type which have some form of underlying relationship. Then, typical and illustrative examples from each such category will be cited and expanded upon in more detail. This shall require a fairly lengthy, but necessary account in the following text, section 3.2. Finally, a two-fold attempt will be made to first list all of these examples in an evaluation matrix for purposes of drawing comparisons and insights, and second, to determine how these inputs affect the performance guidelines, and what implications can be discerned that would recommend certain system alternatives over others.

3.2 ALTERNATIVE SHELTER SYSTEMS: DATA

In reviewing the alternative shelter responses which this research has discovered, five major categories emerge that dominate these examples. These are: 1.) mobile units; 2.) inflatables; 3.) tent structures; 4.) panelized assemble/disassemble structures; and 5.) shell structures. An effort will now be made to fully explore these categories by means of considering illustrative examples from each. The level of descriptive information is extremely variant from one example to the next. For some, a great deal was obtained, while for others, it was only possible to collect little detail. However, in the latter case, sufficient qualitative data, as well as some of a quantitative nature could often be derived from even the scant text and illustrations provided. The following is a brief investigation of each of the broad categories along with a number of illustrative examples for each.

3.2.1 Mobile Units

GENERAL CHARACTERISTICS

This category includes those types of shelters which were developed specifically with the concept of mobility and the concern for a measure of self-sufficiency in mind. Their most obvious identifying trait is their common concern for transportability. These units have been provided with wheeled systems which allow for easy and efficient land-based transport. Their designs involve the combining of the features of movement and living activities. Examples include the full spectrum of real and conceptual, military and civilian.

PRESENTLY AVAILABLE EXAMPLES

Mobile Homes

In some respects, mobile homes can be considered as large-scale versions of travel trailers. The real differences lie in size and self-sufficiency. Mobile homes require supportive services for operation. Travel trailers possess self-sufficient capabilities and will be investigated when the recreational vehicle field is studied. For this reason, and for the additional reason that mobile homes are considered to be more of a semi-permanent form of housing that might follow the temporary shelter use, these units will not be considered any further. Their suitability really lies in the later period of recovery when prolonged occupancy periods of a year or more are indicated, and when there is less of a critical time restraint imposed upon their acquisition and delivery. Furthermore, only a prolonged period of occupancy can justify the $5,000 or more expenditure for these units.

Recreational Vehicles

Recreational vehicles include a number of types: motor homes, vans, camping trailers, slide-in campers, and travel trailers. Currently, there are 4.5 million of these 'on the road'. In addition, present production (1972) is at the rate of 700,000 units per year. (P&J:43,p.95) Motor homes and vans will not be discussed because a large portion of their package is devoted to self-mobility. This is a feature which is unnecessary for the temporary shelter situation. The money spent on this feature as well as the space which it requires in the unit are prohibitive. Thus, only recreational vehicles of the camping trailer, slide-in camper, and travel trailer type will be discussed. In general, these units provide sleeping space, living space, food storage, clothing storage, and adequate appliances. Many units are self-contained and have provisions for both self-sufficiency and the option of alternate hook-up to existing services when they are available. The approach to this analysis will basically be to identify various characteristics and options found in each type generally, as well as to investigate one specific example which is thought to be typical of the field.

A.) Camping Trailers

These units are basically small low-slung retangular boxes, encased in baked-enameled steel or aluminum, and mounted on two wheels which make them suitable for easy towing by the family automobile. Their in-transit configuration allows for better handling and visibility for the driver. Their low-slung configuration allows for increased stability because of the lowered center of gravity. Once situated in a desired location, these trailers are expanded to full living shape by means of a winch system which elevates the roof an addition 4 to 5 feet, and allows the deployment of fabric walls and extensions. This erection operation requires only minutes to complete. The final ereration is the deployment of stabilizing jacks at each of the four corners. The unit is then habitable. The completed unit looks like a combination of a rectangular tent and a house, with a number of cantilevering projections protruding from its sides. These projections are sleeping spaces. Most campers sleep 4 to 6 people and provide sleeping spaces, clothes storage areas, minimal food preparation and food storage areas, a small living area that also functions as a dining and sleeping area, and a minimal bathroom area. All travel trailers expand in size when erected, increasing in height, and projecting cantilevered extensions. However, rather than increasing in floor area, these extensions serve as sleeping or sitting spaces. This leaves the original floor area much freer for other activities. In its in-transit configuration, the smallest available camping trailer (meant to be towed by even sub-compact automobiles) measures only 6'9" long, 5'7" wide, and 25" high. When opened, the width increases to 13'7" by means of fabric projections. (P&D:30,p.1) The larger units reach sizes on the order of 20-1/2' x 7-1/2' when fully extended. (P&D:31,p.2)

Finally, as an illustrative example, the specifics concerning a typical camping trailer will be enumerated. One such unit is the "Executive 6" by Starcraft. Its total cost is in the neighborhood of $2,000. Dimensions include:

> "Closed for Traveling: length 16'8"/width 6'11" /height 4'8".
> Living Area Erected: length 20'/width 6'4"/height 6'6".
> Bunk Sizes -- Extended Ends: 48" x 72".
> Convertible Dinette: 44" x 76".
> Total Weight (Systems Dry): 1985 lbs.
> Hitch Weight: 220 lbs.
> Load Capacity: 600 lbs." (P&D:32,p.3)

Provisions include space for sleeping, cooking and food storage, dining/living, clothes and other storage, and shower/tub and toilet. It is designed to accommodate 6 persons in 2 double beds and 2 singles. The double beds are located at opposite ends of the unit to afford a measure of privacy. In addition, there are curtains which can be drawn for visual privacy. There is also a wardrobe, chest of drawers, and trunk for clothes and other storage. The living/dining area includes a convertible dinette and convertible seating/bed units. The kitchen area includes a 3 burner gas range with oven, an under the counter gas/electric refrigerator, a sink, and work surfaces and storage areas. The molded fiberglass tub/shower unit is enclosed within a vinyl curtained area which provides for visual privacy. Within the same area is a "Porta Potti" which can be stored during bathing. (P&D:30,pp.3,11)

Mechanical and electrical equipment includes a 110/12V converter lighting system, a 20 gallon pressure water tank, a 3 gallon water heater, a 20 lb. LP gas bottle, and an optional fresh air vented heater. All services have alternate hook-up receptacles for outside services when available. (P&D:32,p.11) All mechanical and electrical equipment meets or exceeds State and Federal standards.

Physically, the unit has an insulated fiberglas roof; an insulated vinyl covered floor, and insulated 4-ply structural sandwich panel lower wall sections, and fiber upper wall sections. Windows are screened with zippered clear vinyl covers. There is a single conventional-type doorway. The interior is carpeted. In addition, the optional features include: a 12' canopy, a 12' add-a-room, and a 12' screen enclosure to augment the useful enclosed space. (P&D:32,p.11)

Total erection is accomplished by one person in 5 minutes. A built-in winch is all that is used in this erection. Stabilizing jacks are an integral feature of the unit. The cantilevering sleeping areas are stabilized by means of elastic cords. (P&D:32,p.10)

Thus, the camping trailers are extremely well-designed and complete living units. Their use for an extended period would necessitate the inclusion of additional space enclosures such as those mentioned. In addition, the limited capacities of storage and fuel tanks in these campers would require the inclusion of extra capacity storage tanks. These trailers afford a condition of living that is not very different from the conventional, just more cramped. The potential has been developed to a marked degree, but further development could really make these campers a viable alternative for disaster use.

B.) Slide-In Campers

These campers are meant for use with a pick-up truck. They are mounted on the bed during both travel and operation. However, they can also be removed from the truck and used separately. These units usually include a permanent projection which is cantilevered over the cab and which serves as a sleeping area. These campers are completely insulated with cellular structural foam which is seated between faces of plywood or metal. Their construction is typical trailer-coach type with stud framing and exteriors of baked enamel steel or heavy gauge aluminum. Erection basically entails only the positioning of stabilizing outrigger jacks. However, in the case of separation of camper from vehicle, additional stabilization and support is required.

One typical example is the "Ventura" by Open Road Industries. Open Road is the leading manufacturer and distributor of slide-in campers in this country. The "Ventura" is 11' long by 7' wide. The overhead sleeper adds an additional 5 feet to the overall length. But this is sleeping area, rather than floor area. This model can sleep 6 persons; 4 in bunks, and 2 in a double bed over the cab. The double bed can be made private through the use of provided curtains. The other beds either fold out of the way during the day, or are used as sitting equipment. The "Ventura" includes: the over-cab sleeping area; a molded fiberglas bathroom with toilet and shower; a complete galley with gas-electric refrigerator, oven-range, sink, and work and storage spaces; and a living/dining/sleeping area which is adaptable to all of these activities. There is a single rear door and a number of operable glass windows.
(P&D:32,p.11)

Mechanical and electrical provisions include a separate 110 volt and 12 volt lighting and electrical system with ample outlets, a "Monogram Clasic" sanitation system, dual 5 LPG tanks with regulators, a 50 gallon fresh water capacity, and an optional 10,000 Btu wall furnace and 6-10,000 Btu air conditioner. All utilities are provided with alternate hook-up capabilities for use when these services are available. All mechanical and electrical equipment meets or exceeds applicable standards. (P&D:33,p.20)

This slide-in camper unit also offers some promise. However, its principal drawbacks are its limited space and unsuitability for compaction. Extra spaces could be added. But this shelter form is incompatible by its very very nature. Its price is in the range of $2,000 to $3,000. Its self-contained and self-sufficient nature, as well as its suitability to American family lifestyle are its principal attributes.

C.) Travel Trailers

This last class of recreational vehicles is in reality simply a smaller self-sufficient version of the mobile home. Trailer sizes range from as small as 13-1/2' to upwards of 30' or more. One variation is a telescoping trailer whose height can be reduced during transport. However, this reduction is only on the order of one to two feet and therefore does not appear to be of really significant advantage. Travel trailers are constructed in much the same fashion as mobile homes and are built of much the same materials. Their bodies are of frame-type construction of either wood stud or tubular steel. These units rest on a reinforced chasis with 2 to 4 wheels and 1 to 2 axles depending on the size. These trailers tend to subdivide the interior into more formal room-type areas than do the other recreational vehicle forms.

Also, the bathroom and kitchen areas are larger and more complete than in the other noted forms. These trailers generally are priced in the $2,000 to $5,000 range.

As an illustrative example, we shalll consider the "Skylark Model 22 Front Door, Rear Gaucho" which is manufactured by Skylark Industries Incorporated. The "Model 22" is 22' long, 7-1/2' wide, and 8-1/2' high. It has a dry weight of about 3,500 lbs.. It is capable of sleeping 6. There are 2 sleeping areas located at opposite ends of the trailer. These can be partitioned for privacy by means of curtains. The kitchen includes a gas-electric refrigerator, range with oven, sink, and work and storage spaces. The living/dining/sleeping area adapts to these multiple uses. Walls are panelled and floors are carpeted. The bathroom includes a molded fiberglas shower, lavatory, and toilet which are all contained within a conventional wall-enclosed space. (P&D:34,pp.3-4)

Mechanical and electrical provisions include a 30 gallon pressurized water supply, a 6 gallon water heater capacity, a 110 volt lighting and electrical system, and two 20 lb. gas bottles. All systems have alternate hook-up capabilities and meet or exceed applicable codes. (P&D:34,p.4)

The principal difficulty with travel trailers is their large transport size, incompactibility, and prohibitive cost. In all other respects, they appear extremely suitable. However, some additional space enclosure would be required for extended periods of occupancy. This is no great difficulty as some trailer systems offer additional compatible space packages for providing play space or other activities spaces. Also, the storage capacities would have to be augmented to enable greater periods of self-sufficiency.

CONCEPTUAL EXAMPLES

Two examples will be discussed that have been suggested for temporary living situations. They have not been actually produced on a commercial scale, but they have interesting concepts that bear exploration. The two forms to be discussed are the "Travel House" and the "Tilted Box".

"Travel House"

The Travel House is an experimental form of camping trailer devised by two Frenchmen, Jean Louis Lotiron and Pernette Martin-Perrland. It is extremely unique in the sense that it compacts to a minimal volume for transport, yet expands to a maximum volume during use.

> "When travelling, the house is reduced to the mere volume of the facilities cell (kitchen and bath), mounted on a wheeled trailer, a volume of 5.98 cu. metres. On reaching the site chosen for the stopover, the house 'develops' in less than half an hour into a dome covering an area of 24.80 sq. metres. The side walls of the facilities cell are lowered horizontally, becoming a hexagonal floor, and the translucid lid of the cell rises (by means of a pneumatic winch) releasing the tent which is blown up to form the dome (a compressor connected to the car engine is used). The dome contains six pneumatic beds and six revolving clothes supports."
> (P&J:36,p.16)

This is an extremely viable concept. It depends on a very well-planned minimal core for services, and upon a pneumatic structure for the space enclosure and for some of the furnishings. In addition, the central location of the core facilities, and the circular nature of the shelter help to create a feeling of many different types of areas within the structure. This unit sleeps 6 and makes use of the available space extremely wisely and flexibly. This space is approximately 19 feet in diameter and 268 sq. ft. in area. (P&J:36,p.16) Another advantage is the integral and compactible floor system which provides an insulated and elevated platform which is highly desirable. The only limiting reature is the lack of space for adequate holding and storage tank capacities. This could be incorporated as an add-on feature.

"Tilted Box"

This is a form of camping trailer developed in Japan by Kiyohiko Kurokawa and Tateo Kagaya.

> "'Tilted boxes' are an idea for a new architecture for a new market, which in Japan will be looking increasingly for 'individual spaces' for living. So this 'containerized architecture' has come into being. In the outer shell of the home is an industrially manufactured container which, when tilted, expands its volume and offers various possibilities of interior arrangement." (P&J:28,p.12)

This unit appears much like a conventional camping trailer in its in-transit configuration. However, when it is opened up, radical changes take place. Rather than rise straight up so as to enlarge the rectangular configuration already present, it tilts, with one whole side hinged at the base. It thus appears similar to the conventional milk-crate traps that little boys make by lifting one edge of the crate and propping it open with a stick. Size-wise, this unit is roughly 23-1/2' long and 7 to 8' wide in its folded in-transit configuration. When erected, it is still roughly these dimensions in plan, but it rises from an original height of about 4' to a new height of 14' at its top. This unit then has two different interior floor levels and offers approximately 300 sq. ft. of floor area. The bottom level contains the service core which includes bathroom and kitchen facilities, and an area for living/dining/sleeping. The upper level contains two areas for sleeping. The unit appears suited to an occupany of four people. Its rigid-wall construction allows for permanency and good insulation. It has the capability of easy and rapid erection. An interior collapsable stair system is also an integral feature.

It seems entirely possible that in addition to being reuseable, this unit could also be expandable-to-permanency when the wheels are removed and it is placed on a suitable foundation. Indeed, the designers have enlarged upon this concept in other schemes for providing quick-erection building components. (P&J:28,p.12)

MILITARY-USE EXAMPLES

Gichner Electrical Equipment Shelter

These rectangular box shelter are roughly 12' long, 6-1/2' wide, and 7' high. They are designed to house equipment and are not compactible. A bonded sandwich panel provides a high strength to weight ratio. These boxes are mentioned not because of the form of shelter which they provide, but rather because of the adaptability for transport that they possess. An interesting wheeled transport system has been devised whereby a 2-wheeled, 1-axle dolly assembly clips on at both the front and rear of the unit, enabling it to be pulled by a transport vehicle. When the unit is at the desired site, it simply drops integrally mounted adjustable jacks at each corner and lifts itself. The dolleys can then be removed for use in transporting another unit and so forth. (P&D:35,p.1) This application has real potential in the disaster situation for providing the capability for resiting without necessitating an integral wheel assembly in the unit, or the use of a large bulky trailer. Nor would a crane-type set-up be necessary to lift the unit onto the transport vehicle. It could jack itself up and the dolleys could be positioned under it. This is an extremely attractive way of handling the problem of transport and resituation. In addition, the jacking feature becomes the supporting foundation for the unit.

Expandable Shelter/Container

These units were designed and built by the Goodyear Aerospace Corporation for providing the military with transportable climate-controlled work areas. They are adaptable to land transport in the same way as that previously mentioned in the Gichner example. "These ... unfold from a packaged center structure (container mode) to a deployed shelter mode." (P&D:25,p.10) Basically, the panels swing out on 2 sides to enable the structure to expand in size. The transport size is about 10' in length, 7' in width, and 8' in height. Its plan area triples in size when fully deployed. All panels are rigid resin-impregnated paper honeycomb bonded between parallel faces of aluminum. Structural framing is of cast and extruded aluminum. There are integral windows and a single door. Complete erection requires only 30 minutes by 4 men. The unit itself contains no power source, but has a hook-up capability designed into it for use with a power pack. Furthermore, this unit is supported on 8 leveling jacks that raise it from the ground and allow a great deal of terrain adaptability. "The ES/C can be erected on terrain that varies a maximum of 18 "over the projected area." (P&D:25,p.11) This structure is extremely stable in severe winds and is capable of large interior loadings. It is applicable to the reuseable, as well as the expandable-to-permanency situation.

This systemis mentioned because of the interesting compactibility concept that it exhibits. The principle of constructing space from the actual packaging panels could be effectively utilized in disaster shelter relief applications. In this way, a core could be provided with surrounding panels that would swing open on all four sides to provide additional space enclosure.

Goodyear Aerospace Corporation also makes a similar, slightly larger unit for the Air Force, called the "WS-430 Expandable Laboratory" for use as a photographic processing workshop. (P&D:25,p.14) Another system was also developed called the "MUST Expandable Shelter" (Medical Unit Self-Contained, Transportable) for hospital use in Viet Nam. It is similar to the two previously cited. This expandable unit measures 12' in length, 7-1/2' in width, and 8' in height and weighs less than 4,000 lbs.. (P&D:27,p.3)

3.2.2 Inflatable Structures

GENERAL CHARACTERISTICS

Inflatable structures are systems which depend upon the principles of pneumatics for structural as well as envelope maintenance. Two variations are possible, the air supported and the air inflated. The air supported depends upon the maintenance of an internal air pressure slightly above ambient, while the air inflated depends on higher pressures. Both systems are characterized by fabric-type materials which possess an extremely high degree of compactibility and lightweight. Both also depend upon the use of a compressor. The air supported requires continuous or intermittent fan operation, while the air inflated requires only initial pressurization followed by infrequent supplemental pressurizations.

PRESENTLY AVAILABLE EXAMPLE

Numax Low-Pressure Air Inflated Rib Structure

This is a hybrid pneumatic-tent structure, which depends upon air for its strength. It utilizes a tent structure in combination with an air-inflated rib structure. A number of clear vinyl portholes are incorporated into the fabric for windows. This structure requires a guy-wire anchoring system around the perimeter. The floor system is a built-in one-piece fabric type. This shelter appears to be approximately 25' long, 12' wide, and 8' to 10' high. This would mean an enclosed floor area on the order of 300 sq. ft. is provided. The advantage of this system is its freedom from relying upon compressors for support. Naturally, it is extremely lightweight and easily compactible. (B&R:53,p.139)

CONCEPTUAL EXAMPLES

Pneumatic Tube Geodesic Space Frame

This system was mentioned previously in this research. It combines the attributes of the geodesic frame and pneumatic air support. This system could be an extremely desirable one in terms of weight, compactibility, strength, and speed of erection. When covered with a fabric skin it can provide a suitable means for space enclosure. A fairly sizeable dome could be erected at a minimal cost. Service systems would have to be provided in another package. This experimentally produced frame was designed by P. Frankenstein and Sons Ltd.. Their sample structure was approximately a 20' diameter half-sphere. This would have a floor area of about 300 square feet. (P&J:34,p.21)

Inflatable Dome

This system is largely experimental. Its simplicity of form and ease of erection are its outstanding features. When inflated, it resembles a large pumpkin. Due to its completely fabric construction, this system is extremely lightweight and compactible. Another disadvantage is that it requires a compressor to maintain its shape. This experimental prototype appears to be about a 5/8 sphere of 16' diameter. This would enclose a floor area of roughly 130 sq. ft.. An occupancy of two seems to be a reasonable limit for a shelter of this limited size. (P&J:39,p.48) However, larger versions, suitable for family occupancy could be manufactured.

"Small Holiday House"

This inflatable shelter has the fortune of being air inflated rather than air supported. It is basically hexagonal in shape with 6 rectangular inflated PVC pillows forming its walls, and 6 triangular inflated PVC pillows forming its roof. The pillows are joined by zippers. The completed structure resembles an igloo. Thus, assembly/disassembly is very quick and easy. The air within the walls and roof provides an extremely efficient insulation. This system provides no floor or service equipment however. The prototype is about 15' in diameter and encloses a floor area of about 150 sq. ft. in plan, which is hexagonal. This system is extremely lightweight and compactible. (P&J:32,p.34)

MILITARY-USE EXAMPLES

"MUST Inflatable"

This inflatable system was developed by the Garret Corporation for the U.S. Army Medical Service and was first utilized in April, 1967 in Viet Nam as a surigical hospital. It is designed of inflatable rib sections which are joined side-by-side to one another. It is both an air inflated and an air supported structure. Thus, problems with air leakage, etc. are minimized.

It is designed for use with a service core package.

> "The inflatable element is constructed of rubberized fabric and made up of four inflatable units to provide an area 20 feet wide, 10 feet high, and 52 feet long. This element is packed in a skid-mounted container which also contains two end walls and an airlock. All equipment required for the erection and operation of the element is also packed within the container.
>
> The inflatable element is attached to the utility element which can fill it with air within five minutes. The air manifold is connected to the compressed air line of the utility element and the sections are inflated. The sections are then joined by zipper and buckle connections. This element also contains a floor which is anchored by hold down stakes and similarly made up of ruberized fabric. Anchor cables are staked to stabilize the unit.
>
> Interior air conditioning ducts are connected, lighting fixtures are attached, external air conditioning and electrical connection to the utility area are made and the interior equipment is set up. Erection or disassembly can be accomplished by six men in approximately 30 minutes." (P&J:39,p.44)

This alternative is mentioned because it involves an already perfected system of utilizing 13' long by 20' wide inflatable sections which can be connected to make shelters as large as desired. This concept could be important in terms of providing larger shelters for larger families.

"STEM Lunar Shelter"

The STEM (Stay Time Extension Module) system was developed by the Goodyear Aerospace Corporation for use by NASA in lunar living situations. It was designed to be easily compactible and inflatable. It is cylindrical in shape and is about 7 feet in diameter and 13 feet in length. It is meant for use by two astronauts for periods of up to 8 days. The reason for its mention is its judicious choice of materials. It is fabricated from flexible high strength stainless steel filaments in a composite with other flexible materials. The advantage of this skin is its highly reflective nature which enables it to maintain a comfortable interior temperature even in extremely hot or cold environments. Similar fabric-type materials might be quite well-suited to providing protection against heat loss and heat gain in fabric-based relief shelters. (B&R:53,p.179)

3.2.3 Tent Structures

GENERAL CHARACTERISTICS

Tent structures depend upon cables, poles, and thin membranes for structure and space enclosure. Erection is usually a simple matter, but requires a level ground terrain that is suitable for driving stakes and setting posts. Tents utilize fabric membranes in their most efficient manner -- tension. Thus, these structures possess lightweight and compactible attributes that are equivalent to that found in inflatable structures. Lack of adequate floor systems and built-in insulation are the principal disadvantages in the use of tents.

PRESENTLY AVAILABLE EXAMPLE

Sears Tent

This is mentioned because it is sort of a standard shelter response following disaster. Piles upon piles of boxes marked "Sears Tent" are frequently seen in pictures of disaster relief operations. Many such tents were pressed into service in the recent Managua earthquake. One such tent is the 10' x 14' "Continental" which sleeps 6 and weighs less than 65 lbs. complete. It has no real insulative protection. It contains an integral fabric floor and several screened windows plus a single zippered door. (P&J:44,p.61) This is an example of a really minimal shelter type, but one that is nevertheless frequently pressed into service during disaster periods. These tents should be applicable only as space enclosures when used in conjunction with a more viable core area.

CONCEPTUAL EXAMPLE

Tipi

This tent form has been mentioned previously in this paper. It is considered again because of the efficiency of its construction and the compactibility of its scant materials. The tipi is based on the use of long poles and a fabric skin. One problem that the Indians had with long poles was their awkwardness in transport. This is no longer a problem today, since posts can be broken down into a number of manageable lengths and screwed back together when needed in the assembly operation. Its great stability even in windy conditions is extremely favorable factor when comparing it to other conventional tent forms. Tipis with a diameter of 20' are not uncommon or unmanageagle. This would provide an interior floor area of about 315 sq. ft. in a circular plan. Such tipis have been utilized for occupancy of 4 or more persons in the past. The addition of an interior liner can make the tipi more resistant to heat loss. One serious disadvantage to the tipi system is the absence of a suitable integral floor system.

3.2.4 Panelized Assemble/Disassemble Structures

GENERAL CHARACTERISTICS

Panelized assemble/disassemble structures are those which are based on a system of easily assemblable and disassemblable component panels. These panels are rigid in nature and are joined to one another through various fastening systems to become space enclosures. These panels incorporate structural, skinning, and oftentimes insulation functions. Such panel systems usually produce either rectangular or shell-type structures.

PRESENTLY AVAILABLE EXAMPLES

"Eskimo House"

This alternative was also referred to earlier in this text. It was developed by Arctic Units Inc. for use along the DEW line. It is constructed of large panels (about 4' x 8') which provide the walls and roof. These panels are of sandwich construction with plywood faces and foam cores. They are designed to insulate against the Arctic cold. When assembled, this shelter looks very much like a conventional house with a crowned roof and standard doors and windows. These openings are built into the panels themselves. The whole assembly operation requires less than a day. It capitalizes on the use of a fastener called the "Roto-Lock" which was developed by the Simmons Fastener Corporation. Its operation is reversible in the disassembly process. These fasteners are built into the panels themselves. When assembly is complete, the joints are weathertight. The entire house comprises around 500 sq. ft. of floor area according to an illustration which showed the house under construction. The panels can be palletized for easy shipping. This house could conceivably house 4 to 6 people comfortably. This unit does not provide for interior subdivision or services. (P&D:15,p.29)

"O'Dome

This shelter system was designed by William Moss. It consists of 18 pieshaped plastic panels that are joined together in the erection process to form a dome. This operation takes 2 people less than 3 hours. This package comes complete with a large bubble skylight and a door. Diameters vary, and the most optimum for the temporary relief shelter case appears to be a 25' diameter. This yields a floor area of about 450 sq. ft.. This is ample for 4 people. This interior ceiling height is about 10 feet throughout, since this dome is not a hemisphere, but rather a truncated version. Total panel weight for this dome is 1,600 lbs.. A floor system and services are not included. This dome seems satisfactory for the family living situation. (P&J:41,p.435)

"Emergency Structure"

This shelter unit was specifically developed for disaster shelter operations. It was developed by Armand G. Winfield Inc., and a prototype has been constructed. This structure is made of lightweight PVC (polyvinyl chloride) extrusion panels. These panels are capable of being palletized for shipment. When assembled, the shelter looks like a large barrel vault. The prototype measures 8' x 14' when erected. The raw materials for this insulated structure cost under $400 (1972). This shelter includes the entire exterior enclosure, but not a floor system. The structure has the added advantage of not requiring the use of skilled labor. It would appear that the complete assembly operation should only require a few hours at most. This shelter system has no provision for mechanical and electrical services.

MILITARY-USE EXAMPLE

Military Radome

The radome is a dome shelter designed to house military radar units. It is impractical itself as an emergency shelter, yet the application of its principles might be beneficial. It is composed of a number of curved rectangular fiberglas panels. These panels are locked together with a fastener similar to that used in the "Eskimo House". Here again, the assemble /disassemble operation can be completed quickly and easily. Thus, this type of panel joining system can be effectively utilized both with flat rectangular and curved panels. The military radome is about 50' in diameter which is much too large for family shelter applications; however, a scaled-down version might be suitable. Assembly involves a significant number of panels, yet these all appear to be the same, which makes the operation fairly straightforward. (P&D:15,p.30)

3.2.5 Shell Structures

GENERALLY CHARACTERISTICS

Shell structures distribute loads to supports through a singly or doubly curved plane. These structures are generally either cast-in-place, expanded from a basic core, or assembled from a number of component panels. The difference between these latter panelized types and those mentioned in the previous panelized assemble/disassemble section is that these shells are not designed to be disassemblable. Shells to be considered include both the curved and the folded plate variety. The advantage with shell systems is found in their efficient use of geometry, which enables the use of lightweight materials in their construction.

PRESENTLY AVAILABLE EXAMPLES

Rigidized Foam Structure

This shelter system was devised by a British firm, Frankenstein Ltd.. In this system, a liquid is sprayed on both sides of a pneumatic form, expanding to become urethane foam. This is an in-field construction process. A single unit typically requires 3 to 4 hours of work for completion. Once the foam has hardened, windows and doorways can be cut out. This system has been used in Israel to construct dome-shaped houses. (B&R:53,p.150)

Bayer, a German firm has utilized this same method in providing homes for earthquake victims of the 1970 Turkey disaster. Their technique is slightly different from Frankenstein's. An inflatable form was rotated on a turntable and sprayed with polyurethane. A total of 400 of these domes, each housing 8 to 10 people were erected. Each dome was about 16-1/2 feet in diameter and 10 feet in height. That provided a total floor area of roughly 210 sq. ft.. (B&R:53,p.151)

Both of these systems involve in-field techniques that yield one-use, disposable shelter. These shelters are well insulated and appear adequate for their purpose. The flexibility of cutting doors and windows could give the victims some real choice and individuality in their immediate living environment. The real problem with this shelter form, however, is the necessity to provide services from some alternate source.

"Geodomes"

These are paper geodesic domes designed by Buckminster Fuller. They are manufactured by the Monsanto Corporation and have been used in relief operations in Chile. This is a panelized structure, but once constructed, it is not capable of disassembly. Therefore, it is a one-use, disposable form.

The "Geodome" obtains its strength through the transfer of stresses along its rigid folds. Waterproofing is provided by painting following erection. These paper domes have a limited life span, yet are certainly durable for the duration of the temporary housing period. Upon completion, the dome is a hemisphere of about 20' diameter. This provides a useful floor area of about 315 sq. ft.. This system is noted because of its judicious use of inexpensive lightweight paper materials and its suitability for victim participation in the erection process. (B&R:12,p.37)

Papertech Structure

This structure is marketed by U. S. Papertech Corporation. It is a folded plate shell. Its form is a prismatic one, similar in appearance to a truncated A-frame. This shelter is assembled from paperboard which is stapled together and sprayed with glass and a resin sealer. This paperboard comes in the form of a number of channel-shaped pieces. When completed, the shelter is 21'4" long, 20' wide, and 6'8" high. The useful floor area is about 420 sq. ft.. The entire shelter weighs only 1,000 lbs.. This structure is notable because it has the option of being expandable-to-permanency. The fiberglas protects the paper from the weather. (P&J:42,p. 501)

"Plydom"

The "Plydom" was initially designed by Hirshen and van der Ryn to shelter migrant farm workers in Southern California. This shelter is a folded plate structure, similar in appearance to a barrel vault.

> "The Plydom consists of a 3/8-inch thick prefolded structural shell of kraft paper with a polyurethane core and factory applied polyethylene finish. The total cost of the unit in 1966, including heating, evaporative cooling, cooking, washing and complete

furnishings of beds, chairs, and tables was $1,000."
(P&J:42,p.501)

A similar structure was built by another group using the same exact plans, but a 1/4" thickness instead. This structure was completely foldable into two 12" thick packages in an accordian fashion. These components were then joined on site to form a unit which messured 17' x 19' and enclosed a floor area of 323 sq. ft., while weighing a total of only 105 lbs.. The price was set at $450. That does not include end walls, floor, or services. This unit is reuseable, and shows no signs of failure even though there have occurred repeates saturations of the paper near the ground. (B&R:37,p.6.33)

CONCEPTUAL EXAMPLE

"Flexible House"

This is an experimental shelter form that was developed by a group of students in Japan under the direction of Masayakio Kurokawa. These living units consist of twin rigid boxes, each measuring about 4' long, 8' wide, and 8' tall. They are connected by an accordian-like ribbed fabric material. In shipment, these boxes are closed together to form one large box that is approximately 8' x 8' x 8'. On-site, they are opened and spread some distance apart. These boxes can conceivably be separated by 12' to 16' or even more, and can be situated in a straight line, or at right angles to one-another, or at any intermediate angle. The accordian shell simply conforms to these situations. Also, a number of these units can be joined end to end to create larger units. This has real potential for providing suitable space for larger family situations. The boxes contain the service equipment and the means of access and egress. The accordian shell contains space for activities and for furniture that can be housed in the rigid boxes during transport. Thus, a system is provided that can contain all of the elements necessary for living, yet be easily transportable in a minimal box configuration. The only real problem is the floor system which appears to be fabric with periodic ribs. This structure then is an extremely flexible and innovative approach to disaster shelter. (P&J:27,pp.14-15)

MILITARY-USE EXAMPLE

Military Personnel Shelter

These shelters are used for troop dormitories. They consist of a small rectangular core which is expandable to enclose a large area within a flexible folded plate type shell. The center core structure is constructed of extruded aluminum beams and a sandwich panel system which has faces of aluminum and a core of paper honeycomb. (P&D:25,p.3)

> "Each 32-foot-long shelter packages in a center structure approximately 2'8" long, 13' wide, and 8' high. All components that form the shelter and all tools required to assemble it are packaged inside the center structure." (P&D:25,p.2)

This shelter rests on scissor-type jacks which are used for support and leveling. They are an integral part of the unit. The floor and endwall sections are composed of sandwich panels which have aluminum faces and honeycomb cores. These sections hinge out from the center section on both sides. The end walls have windows and a door in each. The roof is formed by first suspending support beams between the center section and the end walls, and then by pulling out the folded shell structure in an accordian fashion from both sides of the center section to their corresponding endwalls using the roof beams as tracks. The edges of the shell structure have fabric flashing that attaches to the floor and endwalls along their edges of contact.

A flysheet is finally stretched over each expanded section and secured along its edges. This provides for added stability, weathertightness, and insulation. With a floor area of 416 sq. ft., this 32' x 13' shelter weighs only 2,875 lbs.. Erection time is 1 hour by 4 men. The completed shelter serves as a barracks for 24 men. (P&D:25,pp.3-5)

This system has tremendous potential. Not only is it lightweight, compactible, and easily erectible, but it also incorporates the means for foundation and stability, as well as space for the possible inclusion of mechanical and electrical equipment within the rigid center section. Such a unit could be suitable for temporary housing in the post-disaster situation. It appears to have most of the requisite advantages.

3.3 EVALUATION OF RESPONSIVENESS AND SUITABILITY OF ALTERNATIVE SYSTEMS

This section shall deal with the effort to consider all of the system alternatives previously described in an attempt to ellicit some broad forms of judgment as to responsiveness and effectiveness. An evaluation matrix shall be set up in which all of the alternatives will be rated against a number of pertinent criteria. Then, from this data, an effort will be made to identify trends or enlightening aspects and to interpret their significance.

3.3.1 Evaluation Matrix

The evaluation matrix which I have set up is found in table #5, page 263. In this matrix, the 25 systems previously identified are rated against a number of criteria which I have selected as indicative of the many areas of concern in temporary shelter. I take full responsibility for all ratings.

These are my estimations of suitability. In the limited time frame available, this was the only approach possible. A more meaningful rating could have been obtained if a number of other persons -- officials, designers, dealers, manufacturers, and victims -- could have been polled (e.g. Delphi) for their evaluations concerning each categorized index.

Vital indices include: occupancy, area, social/family suitability, spaces, shelter type, nature of spaces, materials, structural system, mechanical and electrical system, fabrication, delivery, erection/placement/securement, cost, and disaster potential. These concerns are largely taken from the performance guidelines. It is hoped that these concerns will enable significant observations and judgments. This should serve the dual purpose of developing a feel for the potential applicability of various alternate shelter systems, and also of involving the guidelines experimentally in a process of analysis which will hopefully demonstrate their usefulness and identify areas which require revision or refinement.

Three methods of identification are used in the evaluation matrix. The first involves the use of actual numbers which are descriptive of their respective evaluative indices. The second involves the use of checks in selecting from a number of alternative listings for each evaluative category. The third involves the use of the symbols '-', '0', or '+' in describing the degree of responsiveness of each system alternative to a set of listed attributes or indices. These symbols have the following meanings:

+ highly advantageous.
0 minimally or neutrally advantageous.
- undesirable or non-existant.

TABLE #5

EVALUATION MATRIX

SHELTER ALTERNATIVES	OCCUPANCY	AREA	SOCIO/FAMILY SUIT.	SPACES: space enclosure	SPACES: service core	SPACES: both	SHELTER TYPE: one-use, dispos.	SHELTER TYPE: reuseable	SHELTER TYPE: expand.-to-perm.	NATURE OF SPACES: single area	NATURE OF SPACES: subdivided area	MATERIALS: heat-loss protec.	MATERIALS: light-weight	MATERIALS: compactibility	STRUCTURAL SYST.: strength	STRUCTURAL SYST.: efficiency	SERVICE SYSTEMS: self-sufficiency	SERVICE SYSTEMS: complete. of prov.	FABRICATION: on-site	FABRICATION: off-site	DELIVERY: transport mobil.	DELIVERY: transport size	ERECT/PLACE/SEC.: simpl. of proc.	ERECT/PLACE/SEC.: compl. of proc.	COST	DISAST. POTENTIAL: present form	DISAST. POTENTIAL: conceptual form
Camping Trailers	6	130	+			x		x			x	o	+	+	o	+	+	+		x	+	+	+	o	o	o	+
Slide-In Campers	6	122	+			x		x			x	+	-	-	+	o	+	+		x	o	o	+	o	o	o	o
Travel Trailers	6	165	+			x		x			x	+	-	-	+	o	+	+		x	+	-	+	o	-	-	o
Travel House	6	268	+			x		x			x	o	+	+	o	+	+	+		x	+	+	+	o	o	+	+
Tilted Box	4	300	+			x		x	x		x	+	o	o	+	+	+	+		x	+	o	o	o	o	+	+
Gichner E. E. S.		78	-		x			x	x	x		+	o	-	+	o	-	-		x	+	o	+	+	-	-	o
Expandable S/C		210	-	x				x	x	x		+	o	o	+	0	-	-		x	o	o	+	+	-	o	+
Numax Rib Structure		300	o	x				x		x		-	+	+	o	+	-	-		x	+	+	o	o	o	o	o
Pneum. Geodesic		300	o	x				x		x		-	+	+	o	+	-	-		x	+	+	+	o	+	o	+
Inflatable Dome	2	130	o	x				x		x		-	+	+	o	+	-	-		x	+	+	+	o	+	o	o
S. Holiday House		150	o	x				x		x		+	+	+	o	+	-	-		x	+	+	+	o	+	o	+
MUST Inflatable		260	o	x				x		x		+	+	+	+	+	-	-		x	+	+	o	o	o	o	o
STEM Lunar Shelter	2	100	o	x				x		x		+	+	+	0	+	-	-		x	+	+	o	-	-	+	-
Sears Tent	6	140	o	x				x		x		-	+	+	-	o	-	-		x	+	+	o	-	+	-	-
Tipi		315	o	x				x		x		-	+	+	o	o	-	-		x	+	+	o	-	+	-	o
Eskimo House	4	500	o	x				x	x	x		+	O	+	+	o	-	-		x	+	+	+	o	-	o	+
O'Dome	4	450	o	x				x		x		o	+	+	+	+	-	-		x	+	+	+	o	o	o	+
Emergency Shelter		112	o	x				x		x		+	+	+	o	o	-	-		x	+	+	o	o	+	o	o
Military Radome			-	x				x		x		o	o	+	+	+	-	-		x	+	+	o	o	-	-	o
Rigid Foam Struc.	8	210	o	x			x			x		+	+	+	+	+	-	-	x		+	+	o	o	o	o	o
Geodome		315	o	x			x			x		o	+	+	o	+	-	-		x	+	+	o	o	o	o	o
Papertech Struc.		420	0	x			x		x	x		o	+	+	o	o	-	-		x	+	+	-	o	+	o	o
Plydom		323	o	x				x		x		o	+	+	+	+	-	-		x	+	+	+	o	+	o	+
Flexible House	4	190	+			x		x			x	-	+	+	-	o	+	+		x	+	+	+	o	o	+	+
Mil. Per. Shelter	24	416	o			x		x		x		+	+	+	o	+	-	-		x	+	+	+	+	o	+	+

3.3.2 Discovery and Interpretation of Trends

OCCUPANCY AND AREA

In terms of numbers, some interesting facts emerge concerning occupancy level and shelter area. Considering just those 9 shelter alternatives with a listed occupancy of 4 to 6 persons, the floor areas provided ranged from a low of 122 sq. ft. to a high of 500 sq. ft., with an average of 252 sq. ft.. Of these cases, more than half were shelters designed for short-term occupancy or vacation use. Of those remaining systems which had a more extended period of occupancy in mind, the areas varied from a low of 300 sq. ft. to a high of 500 sq. ft. It is in this category that temporary disaster relief shelter would fall. The guidelines developed list 475 sq. ft. as a desirable area for a family of 4 for a 2 month occupancy. It would seem then, that perhaps the occupancy of the 475 sq. ft. temporary shelter could be increased to as much as 6 without necessitating the provision of additional space enclosure.

SOCIOLOGICAL/FAMILY SUITABILITY AND SPACES

It appears that the most desirable shelters in terms of their suitability to family and social life are those of the recreational vehicle or of the conceptual type that provide for services as an integral part of their construction. Single large spaces which would require the addition of a core area did not appear especially advantageous, although they did not appear completely unsuitable either. A dominant factor in this consideration seems to be how the services are integrated into the activities that are to occur within the shelter. That is, if these service systems really seemed to help to subdivide the space so as to create definite feelings of activity 'domains', then they were successful, whether contained within a central core, or scattered throughout the shelter unit. There were definite examples of both which seemed to work well, as in the cases of the "Travel House" and the travel trailer. This point should be raised in the design guidelines.

SHELTER TYPE

Of the 25 shelter alternatives listed, 22 were of the reuseable type, and of these, 4 units were also expandable-to-permanency. The remaining cases were primarily of the one-use, disposable type. These latter cases did not appear especially promising in terms of social and family suitability or disaster potential. This information seems to support the view found in the performance guidelines which does not recommend the disposal option.

MATERIALS

One thing that does become apparent is that paper products should be included in the listing of recommended materials. There is strong evidence that lightweight paper building materials are especially well-suited to the temporary housing situation not only in terms of their weight, strength, and workability, but also in terms of their weatherability when properly treated.

In terms of the three attributes -- heat-loss protection, lightweight, and compactibility -- 19 out of 25 shelter alternatives were able to achieve at least 2 of these objectives, yet only 6 out of these 19 were able to achieve all 3 attributes. Inflatable systems accounted for 3 of the 6, and 2 involved the use of foam core sandwich panels, while the last incorporated PVC plastic. This reinforces the guideline recommendations of fabric, sandwich panel, and plastic materials as desirable for temporary shelter use.

STRUCTURAL SYSTEM

Superior structural strength and efficiency was only found in 5 cases. These were all domes or shell configurations. Both of these are highly recommended in the guidelines.

SERVICE SYSTEMS

Only 6 out of 25 alternatives came with both adequate and self-sufficient service systems. These were primarily of the recreational vehicle type, with several being of a conceptual nature. No shelter alternative contained large enough storage and holding reserves for self-sufficiency on a weekly basis. Most were extremely conservative in terms of water and fuel supply. This was because they were principally intended for use in areas where auxiliary hook-up to existing services was available. When used in remote areas, these shelters were only intended for a duration of several days, or if for a longer stay, rationing was required in order to extend reserves. In the temporary shelter situation of up to two months occupancy, either greater storage reserves will have to be provided, or more frequent replenishing operations will have to be instituted. The guideline recommendations in this paper seem sufficient.

FABRICATION

In only one case was fabrication performed on-site. In all of the others, either the entire shelter, or its component parts were manufactured in a factory environment off-site. This highly reinforces the performance specifications in this respect.

DELIVERY

A very high proportion (20 out of 25) of the shelter alternatives considered were deemed advantageous in terms both of transport mobility and transport size. This appears to be an area in which many manufacturers have been successful. Indeed, many designs have so concentrated on these attributes, that they seem to have neglected many of the other vital areas of shelter suitability. There are three primary types of transport configurations that seem most successful -- those that are collapsable into a smaller shipping module, those that are panelized and palletable, and those that fold into a small package which completely excludes air space. A recommendation to this effect should be added to the delivery section of the performance guidelines.

ERECTION/PLACEMENT/SECUREMENT

In terms of both simplicity and completeness of process, only 2 systems were found to be highly satisfactory. Both were military systems. Military-use shelters seemed to be much more concerned with the completeness of this three-fold operation. Other alternatives fell far short, especially in terms of placement and securement. The guidelines are explicit as to the necessity and scope of these three operations. Without the provision for each operation, the shelter system cannot be deemed satisfactory or entirely safe. One specific addition can be made to the placement section of the guidelines, however. Military specifications call for a level of terrain adaptability that will provide for suitable erection on terrain that varies a maximum of 18 inches over the projected area. This seems advisable for the disaster situation also.

COST

In terms of low-cost, the inflatables, tent, and paper structures seemed most desirable. Yet, in the more important area of cost-effectiveness, a clear judgment cannot be made at this time.

DISASTER POTENTIAL

Based on my research experience, I found that in 11 of the 25 cases evaluated, a high level of disaster use potentiality seemed to exist in either the real or conceptual form. These comprised an extremely broad spectrum of shelter alternatives, including: mobile units, inflatables, panelized structures, and shell structures. Only tents did not exhibit a clear potential. Yet, only 2 examples from this category were investigated, while many more were considered in each of the other categories, so this is enlightening, but inconclusive.

OVERVIEW

Finally, in order to make some broad judgments as to the real suitability of the various alternatives considered, the following process was attempted. Those evaluative categories that elicited a '-', '0', or '+' response were counted, which revealed a total of 15. Next, in each of the 25 shelter alternatives evaluated, the number of +'s recorded were counted. The maximum possible score was 15. Then, in an effort to ellicit some crude form of ranking, these alternatives were grouped in terms of their scores. The following ranking resulted. The highest scoring system alternatives are at the top of the list, the lowest scoring are at the bottom. Their respective '+' scores are listed in parentheses in front. Those systems which have the same score must be considered essentially equal. Systems which scored 9 or 10 are graphically depicted in illustrations #8-#16 on pages 271-279.

(10) Camping Trailers
(10) Travel House
(10) Flexible House
(10) Military Personnel Shelter
----
(9) Tilted Box
(9) Small Holiday House
(9) Plydom
----
(8) Pneumatic Geodesic Space Frame
(8) O'Dome
----
(7) Travel Trailers
(7) Inflatable Dome
(7) MUST Inflatable
(7) Eskimo House
(7) Rigid Foam Shelter
----
(6) Slide-In Campers
(6) STEM Lunar Shelter
(6) Emergency Shelter
----
(5) Expandable Shelter/Container
(5) Gichner Electrical Equipment Shelter
(5) Numax Air-Inflated Rib Structure
(5) Tipi
(5) Sears Tent
(5) Radome
(5) Geodomes
(5) Papertech Structure

This listing provides only a summary judgment. Some of the units which rate highly do not include all of the features and equipment essential for temporary disaster shelter. Yet all of those which had a score of 8 or higher also rated a '+' in terms of conceptual disaster potential, and only one attribute with a score of 5 rated a similar '+'. This appears to give some credibility to the crude process which was utilized to arrive at these ratings. Furthermore, the fact that all alternatives fell in the middle range of 5 to 10 '+' 's out of a possible high score of 15 and low score of 0 gives further evidence that these alternatives were all evaluated in much the same way, i.e. there were no favorites or non-favorites.

3.4 IMPLICATIONS FOR GUIDELINE REFINEMENT

In the preceding discussion and evaluation, a number of specific guideline refinements were suggested. These are now listed together.

1.) Occupancy of the 475 sq. ft. temporary shelter should be changed from 4 persons, to 4 to 6 persons without the necessity of supplementary add-on space enclosures.

2.) The service equipment, whether in a single core, or distributed throughout the shelter, should be integrated into the erected unit in such a way as to create a real sense for activity domains, either physically, or in an illusionary sense.

3.) A level of terrain adaptability shall be provided that will allow for suitable erection on terrain that varies a maximum of 18 inches over the projected area.

4.) Paper products should be added to the listing of desirable materials.

5.) Three primary types of transport configuration are most desirable: 1.) those that are collapsable into a smaller shipping module; 2.) those that are panelized and palletable; and 3.) those that fold into a small package which completely excludes air space.

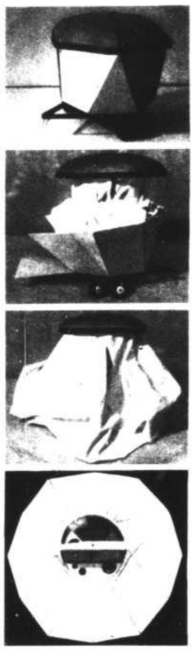
ILLUSTRATION #8

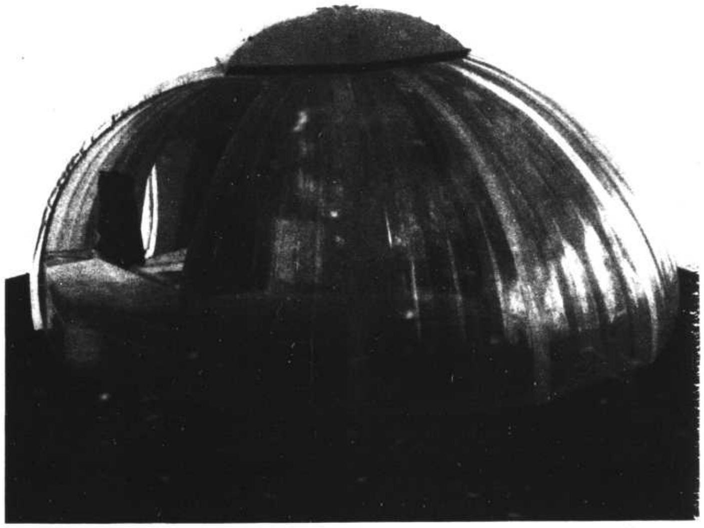
CAMPING TRAILER

(P&D:32,p.1)

ILLUSTRATION #9

TRAVEL HOUSE



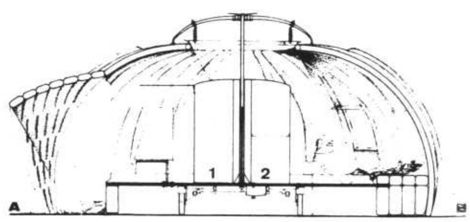


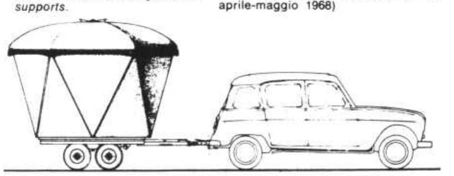
LA CASA IN VIAGGIO

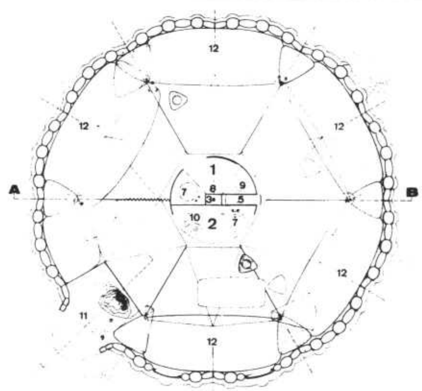
When travelling, the house is reduced to the mere volume of the facilities cell (kitchen and bath), mounted on a wheeled trailer, a volume of 5.98 cu. metres. On reaching the site chosen for the stop-over, the house "develops" in less than half-an-hour into a dome covering an area of 24.80 sq. metres. The side walls of the facilities cell are lowered horizontally becoming a hexagonal floor, and the translucid lid of the cell rises (by means of a pneumatic winch) releasing the tent which is blown up to form the dome (a compressor connected to the car engine is used). The dome contains six pneumatic beds and six revolving clothes supports.

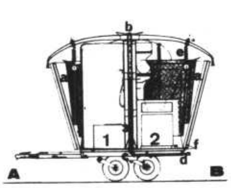
Quando è in viaggio, la casa è ridotta al puro volume della cellula dei servizi (cucina e bagno), montata su ruote e trainata, un volume di mc. 5,98. Quando si arriva al posto prescelto per la sosta, in meno di mezz'ora la casa si « sviluppa » in una cupola abitabile, che copre una superficie di mq. 24,80. Le pareti laterali della cellula dei servizi si abbattono orizzontalmente formando un pavimento esagonale; e il coperchio traslucido della cellula si solleva (per mezzo di argano pneumatico) liberando la tenda gonfiabile che crea la cupola (la si gonfia con un semplice compressore, collegato al motore della macchina); la cupola contiene sei letti pneumatici, e sei supporti girevoli per gli abiti. (Da « Architecture d'Aujourd'hui », aprile-maggio 1968)

proposta di Jean Louis Lotiron e Pernette Martin-Perriand









1 bagno
2 cucina
3 riserva d'acqua
4 frigorifero
5 ripostiglio
6 gas liquido
7 lavabo
8 doccia
9 w.c.
10 fornello
11 ingresso
12 letti gonfiabili
a tenda pneumatica ripiegata
b coperchio in poliestere traslucido
c cerniera
d manovella per la manovra dell'argano
e molla di sospensione del coperchio
f pannelli del pavimento in poliestere, imbottiti di poliuretano espanso

(P&J:36,p.16)

ILLUSTRATION #10

FLEXIBLE HOUSE

MOBILE HOME LA CASA FLESSIBILE

Dato che nella architettura giapponese non esistono spazii « individuali » si è pensato a queste unità architettoniche, indipendenti, destinate a scapoli o a studenti.
Ogni unità è costituita da due « scatole » rigide e da un elemento flessibile di raccordo, a fisarmonica.

Le due scatole, che si possono chiudere l'una sull'altra, contengono tutti gli elementi, tutte le attrezzature, necessari alla abitazione. Richiuse, le scatole diventano un container adatto ad un facile trasporto. Nei tre esempi qui riprodotti, tre possibilità di attrezzatura interna.

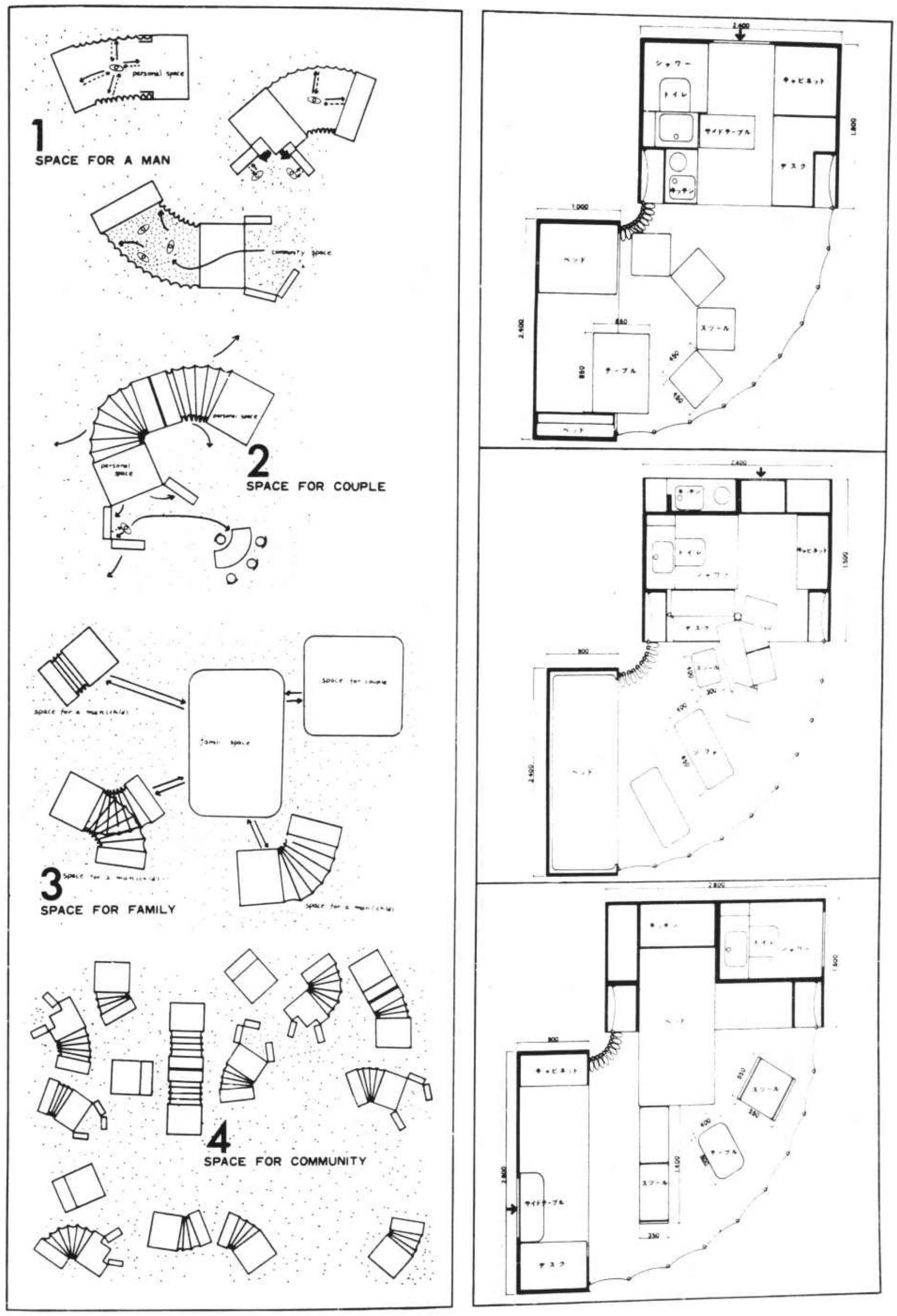
Living units. Each unit comprises two rigid « boxes » and a flexible, concertina-like connecting part. The two boxes can be closed together. They contain all the facilities and equipment necessary for living. When closed they become a container suitable for easy transportation.

progetto del gruppo di studenti Ogasawa, Shibuya, Tanimoto, Nagaike, Hayashi della Nihon University, gruppo diretto da Masayuki Kurokawa, architetto

(P&J:27,p.14)

ILLUSTRATION #11

FLEXIBLE HOUSE (cont.)



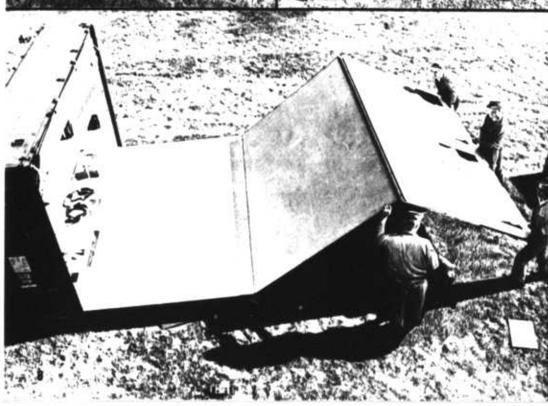
15 domus 514, settembre 1972

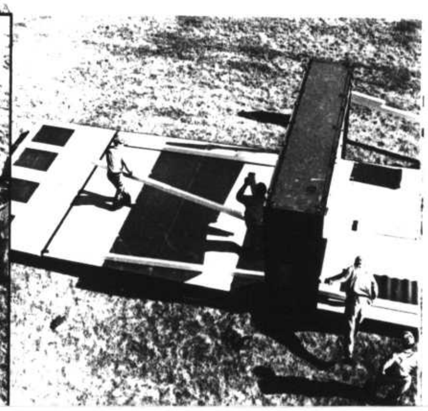
(P&J:27,p.15)

ILLUSTRATION #12

MILITARY PERSONNEL SHELTER

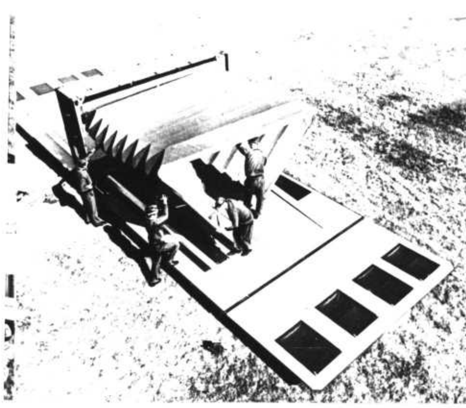
4 MEN 1 HOUR





In less than an hour, four men can transform the packaged Goodyear Aerospace personnel shelter into

- a barracks for up to 24 men
- a station for aircrew alert
- an administrative office
- a field hospital
- an emergency housing unit for disaster victims
- living quarters for oil drilling crews or for groups engaged in exploration, conservation, or missionary work anywhere in the world.



(P&D:25,pp.8-9)

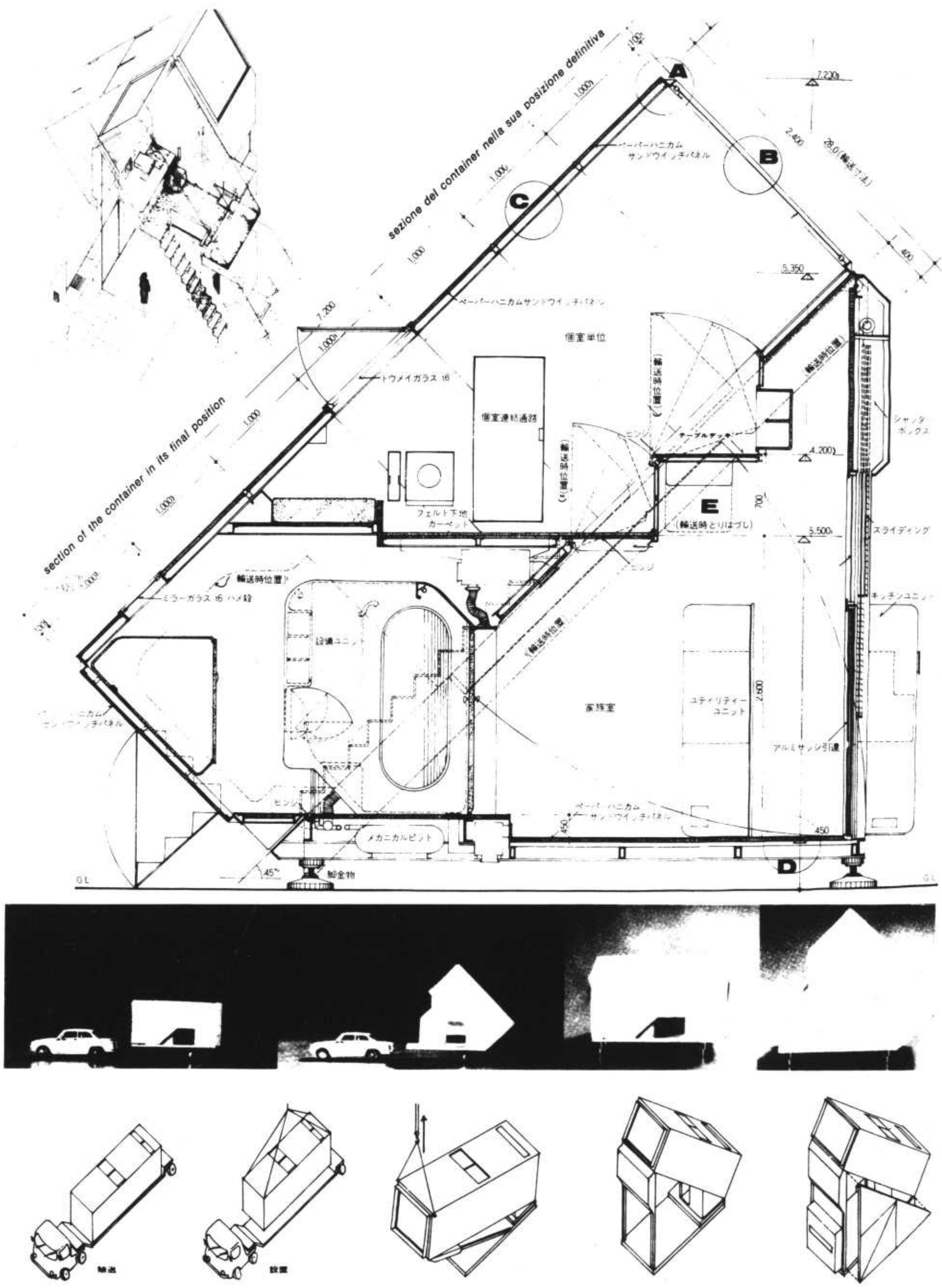
ILLUSTRATION #13

TILTED BOX

(P&J:28,p.11)

ILLUSTRATION #14

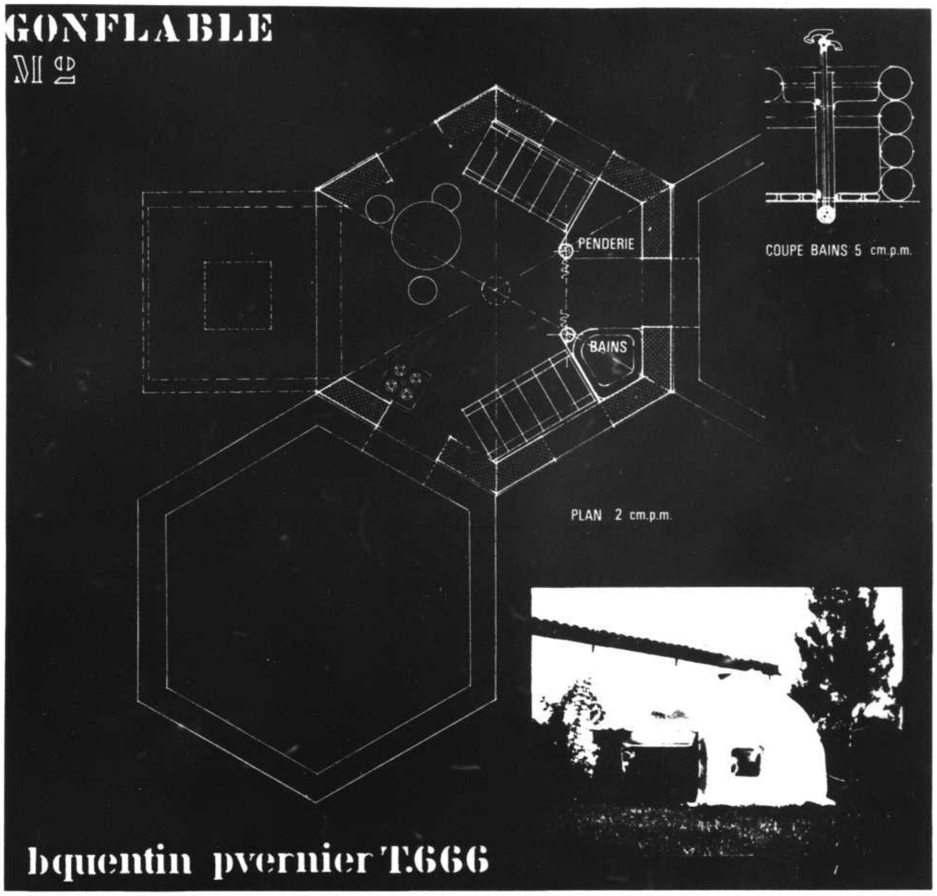
TILTED BOX (cont.)

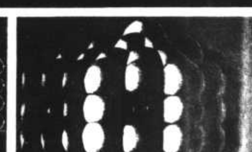


(P&J:28,p.12)

ILLUSTRATION #15

SMALL HOLIDAY HOUSE





six rectangular and six triangular inflated PVC panels joined by zippers make up the walls and the roof of the small holiday house

CASA MINIMA

progetto: Bernard Quentin e Patrick Vernier, Parigi

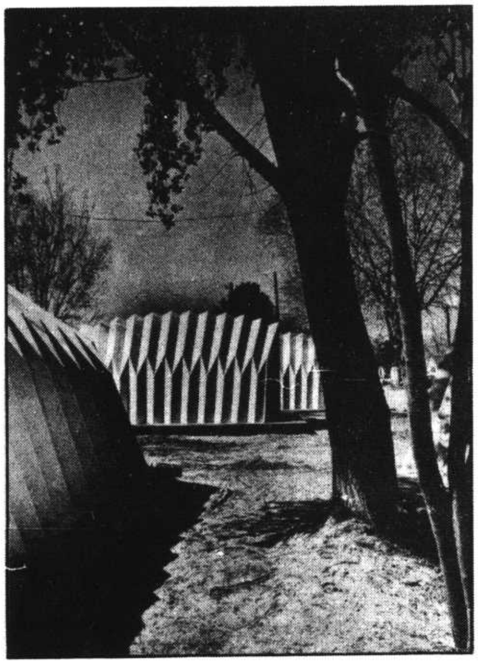
Già realizzata, la casa T.666, prodotta in Francia da SIEM, Pantin: casa pneumatica in PVC, con pianta esagonale (altezza m. 3,50, larghezza m. 6,00, superficie abitabile mq 20; cinque finestre di m. 1 x 1, una porta, una pensilina abbattibile): è composta da sei pannelli rettangolari, a doppia parete, intercambiabili, che formano la struttura verticale autoportante, e da sei pannelli di copertura, triangolari, a doppia parete; tutti i pannelli vengono gonfiati separatamente e poi uniti l'uno all'altro con chiusure-lampo.
In progetto, la casa T.999, di uguali misure e di uguale pianta, e con pareti pneumatiche «molecolari».

PNEU

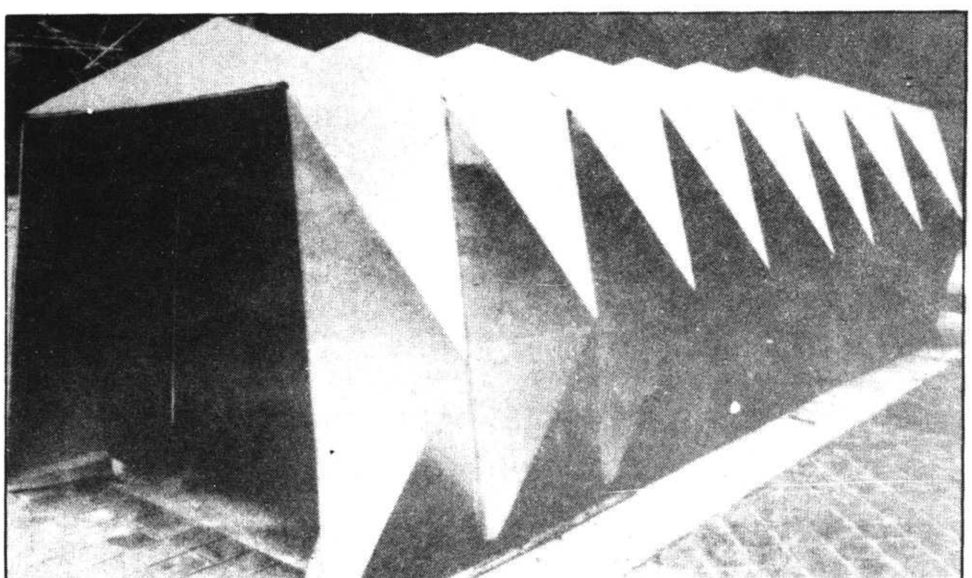
(P&J:32,p.34)

ILLUSTRATION #16

PLYDOM



About the most successful paper shelter so far is the Plydom, designed by Hirshen and van der Ryn to house migrant agricultural workers in California. The Plydom consists of a 3/8" thick prefolded structural shell of kraft paper with a polyurethane core and factory applied polyethylene finish. The total cost of the unit in 1966, including heating, evaporative cooling, cooking, washing and complete furnishings of beds, chairs and tables was $1000.



Folded plate barrel vault in card designed by Collin, Père and Père, students in Paris of DG Emmerich.

(P&J:42,p.501)

4. ADDENDUM: FURTHER REFINEMENTS

Several additional minor points must be dealt with before presenting a finalized version of the guidelines. These deal with the original preliminary guidelines listed in section III. In my haste to assemble these specifications and to get them in the mail to the various officials contacted, several omissions and mistakes were inadvertantly made in that initial version. These shall be enumerated and clarified, and their corrections shall appear in the finalized version.

4.1 OMISSIONS

In the prefatory remarks, there was no mention of the 4 primary types of disaster that these guidelines address, or of the suburban/town context of their applicability. Therefore, in the finalized version, there shall be an addition to the preface which shall be titled "Statement of Situational Applicability", and which shall deal with the questions of disaster type and locational context.

Also, in the section which deals with services, there was no mention of the alternative hook-up capabilities which all service equipment is to possess in order that conversion to conventional service utilities might occur once these services have been restored within the impact area. Therefore, this addition shall be incorporated into the service section of the revised specifications.

4.2 CORRECTIONS

The wording in the materials section which deals with the limitation of heat transmission through walls in the event of fire was not formulated into a clear and concise statement as it was intended. This shall be corrected.

The listing of an allowable truck trailer package length of 55 feet was a typographical error. It should be corrected to read "45" feet.

Finally, in the discussion of acceptable structural systems, the descriptions of the shell and dome options were not presented as originally intended. They should be amended so as to read: "SHELL: vault and shell of revolution: assemblable panel systems."; and "DOME: assemblable panel systems.".

SECTION V

FINAL VERSION OF PERFORMANCE GUIDELINES

1. PREFATORY REMARKS

1.1 STATEMENT OF SITUATIONAL APPLICABILITY

DISASTER TYPE: This shelter is to be applicable for use in 4 principal types of disaster: tornado, hurricane, earthquake, and flood.

IMPACT LOCATION: This shelter is to be designed for use in disaster relief in suburban/town situations. These guidelines do not specifically address disaster in the urban or rural context.

1.2 STATEMENT OF INTENDED USE, USER, AND PERIOD OF USE

USE: This shelter is not conceived for use in the initial post-disaster emergency period of life sustainment. Rather, it is primarily intended as single family housing for use during the second post-disaster period of situation stabilization. In the event of protracted need, it is also to be capable of being updated to a condition of semipermanent livability, for occupancy during the third post-disaster period of recovery.

USER: This shelter is intended for occupancy by single family groups. In its basic form, this shelter is to accommodate 4 to 6 persons. These guidelines do not specifically address the needs of the single person or couple.

*Maximum occupancy is to be unlimited. For each additional 2-person occupancy, added space enclosure and service storage capacity shall be provided in the form of supplementary packages.

*Minimum occupancy is to be limited to 3 persons, for which no change from the basic shelter package is to be necessary.

PERIOD OF USE: Immediate post-disaster shelter needs are to be provided for through mass shelter accommodations. Occupancy in temporary family-oriented shelter is to begin 1 to 2 weeks following impact and is to continue for a period of up to 2 months. If, at the end of this period, a protracted occupancy is deemed necessary, then the basic shelter package shall be updated to a semipermanent condition of livability. Such revised shelter packages are to be capable of an occupancy of 1 year.

1.3 STATEMENT OF NEEDS PROVIDED FOR

PHYSIOLOGICAL: Maintenance of bodily functions.
Protection from environmental forces.
Resumption of normal physical routine.
Provision for self-care.

PSYCHOLOGICAL: Resumption of self-sufficiency.
Resumption of normal family routine.
Provision of a comfortable atmosphere for the recovery of mental attitude and balance.
Provision of a framework for rational assessment of the future and for consideration of available options.

SOCIAL: Provision of a framework from which to resume normal social roles.

1.4 STATEMENT OF SHELTER SCENARIO

PROVISION: The basic shelter package is to be delivered to the desired site within 1 to 2 weeks following disaster impact. It is to contain all elements necessary for set-up: erection, foundation, and tie-down. Set-up is to be accomplished by an unskilled labor force. The potential for a possible secondary role of the victims in some phase of this operation should be recognized in the package design.

SITING: The shelter package shall be sitable in a location of the occupant's choice; or, in the event that is impossible, then in clusters with other such units in open areas near relief or community centers. Re-situation of the unit shall be possible in the event that the occupant's choice should later become available.

OPERATION: The shelter unit shall contain the resources and spaces necessary for the resumption of a normal family routine. This includes provision for the activities of sleeping, relaxing, cooking, eating, cleaning, and bathing. Service equipment requisite to these functions shall be an integral part of the shelter package, and interfaces for hook-up to conventional service utilities (electric, water, and sewage) shall be provided. In addition, water storage and sewage holding tanks shall be provided within the basic package for use in the event that the water utilities are not restored. In this case, a weekly or semi-weekly operation of potable water supply and sewage pick-up shall be instituted by the local government on a temporary basis and shall continue until normal service is restored. Electric power is to be obtained from trunk lines, or portable generators, depending on the condition of service. In the case of generators, a number of shelter units are to be clustered so as to share a single generator.

2. REQUIREMENTS AND SPECIFICATIONS

2.1 SHELTER TYPE

Two types of shelter packages are to be applicable: the reuseable, and the expandable in-part-or-in-whole to permanency. Both should include a service core unit and a supplementary package of area enclosures. It is possible that the basic shelter package may be initially identical in both options. However, the methods of updating for a prolonged occupancy will be different.

REUSEABLE: This option should include a well-constructed service core unit. Such a unit should contain essential service equipment and may include areas of a service-oriented nature.

The supplemental area packages shall be either of a flexible, periodically-renewable type capable of being folded into a small volume during storage and transport, or of a rigid panel nature capable of assembly/disassembly and similarly compactable.

EXPANDABLE: This option should include a core unit similar to that provided for the reuseable. This unit can be retained as part of the permanent structure, or removed when it is no longer necessary.

The supplemental area packages shall be of a rigid panel nature capable of assembly/disassembly and permanent application. Such panels shall produce traditional rectangular spaces suitable for use in the permanent situation.

2.2 SPACES

DESCRIPTION: The following spaces are suggested as suitable to the nature and planned scope of the activities planned:

- 2 sleeping areas, one of which must be a totally private space meant for no other activity; the other must possess the capabilities of semi-privacy and may be used for secondary activities such as child play when not in use for sleeping.

- 1 kitchen area which should include the essentials for cooking, washing, storage, and working.

- 1 living room area that either contains a specific dining space, or possesses the capability of being used for that purpose during meals.

- 1 private wash area containing space for a minimal tub-shower fixture and a drying area. This area is to double as a laundry wash area when not in use for bathing, with the tub being used as a wash tub. A small shelf area should be included for storage.

- 1 private bathroom space containing toilet and sink with mirror and medicine cabinet.

- 1 enclosed service area to contain mechanical equipment and storage holding tanks.

- 2 closet spaces, one of which must be easily accessible to the bedroom areas.

SIZES: The following square-foot areas are suggested as suitable to the functions that they serve. It is further suggested that these area sizes be adhered to within 10% of that stated.

1 private sleeping area	90 sq. ft.
1 semi-private sleep/play area	80 sq. ft.
1 kitchen area	50 sq. ft.
1 living room/dining area	180 sq. ft.
1 wash area	25 sq. ft.
1 bathroom area	20 sq. ft.
1 service space	15 sq. ft.
2 closet areas, ea. @ 7-1/2 sq. ft.	15 sq. ft.
Total:	475 sq. ft.

NATURE: These spaces are referred to as areas. Only three such areas must be considered as rooms in the true sense of the word -- the private bedroom, the bathroom, and the wash area. In the reaminder of the unit, open space planning would seem most logical, both in the nature of the multi-use character of many areas and in the need to dispel feelings of crampedness that a unit constrained in size can evoke. Planning in these areas should provide manipulatable means for attaining various degrees of openness and privacy. In addition, the design and layout should encourage the use of immediate exterior spaces as much as possible as an extension of the shelter itself. Areas surrounding the unit, as well as those above and below, should be utilized as potential activities spaces whenever possible.

DIMENSIONAL SIZES: Units should be kept to a height of one story. Multiple stories require interior stairs which occupy space that is too valuable in an already constrained living situation. However, features such as telescoping roof sections that might increase interior ceiling heights are permissible and desirable as a means of enhancing and varying interior space. In such cases, lofts attainable through use of vertical ladders would be permitted.

Minimum permissible ceiling height is 7 feet. A ceiling height of 7-1/2 feet is recommended.

Overall height, width, and length limitations are outlined in the section on delivery guidelines.

2.3 MATERIALS

1.) Material systems such as the sandwich panel which combine the aspects of structure, skin, and insulation are suggested. One particular sandwich panel application which seems especially well-suited combines faces of metal (galvanized steel or aluminum sheets) or fiberglas with a core of urethane foam.

2.) The most promising materials for temporary shelter application appear to be: plastics of the glass fiber reinforced (fiberglas) or the cellular (urethane foam) variety, fabrics of the synthetic type (neoprene or Hypalon coated nylon, Dacron, glass, and vinyl coated, such as p. v. c.-coated nylon), and suitably weather-treated paper products. It is suggested that these be primarily utilized in shelter construction.

3.) Areas of shelter that consist primarily of space should be constructed of materials that can be compacted into small volumes during periods of storage and transport. Fabric-type materials and assemble/disassemble panel systems are recommended for these applications.

4.) To facilitate ease of handling, it is essential that lightweight materials be used.

5.) All materials used in construction shall possess non-combustible or sufficient fire resistant properties, or shall be protected in some manner from direct flame. Walls should be constructed of materials that will prevent the transmission of heat exceeding 250°F in the event of fire.

6.) Thermal heat loss of the living unit shall not exceed 50 Btuh per square foot of the total floor area of spaces to be heated. This requires an insulation with a U value of .07 Btuh/sq. ft./°F for ceilings and .09 Btuh/sq. ft./°F for walls and floors.

2.4 STRUCTURAL SYSTEMS

1.) The structural system chosen shall be capable of withstanding the loads and stresses applied. The following loading levels shall apply:

DEAD: The weight of the unit itself.
LIVE: Occupants and furnishings - 30 $lbs./ft.^2$
Snow - 20 $lbs./ft.^2$
Wind - 45 mph
Earthquake - lateral loading equal to 10% of the dead weight.

2.) Systems applicable for all or part of the shelter package are:

BEARING WALL: stud or sandwich panel system.
SLAB: sandwich panel: flat or folded-plate.
SHELL: shell of revolution or vault: assemblable panel systems.

3.) Systems applicable for space enclosure when used in adjunct with a core unit are:

DOME: assemblable panel systems.
GEODESIC FRAME: assemble/disassemble frame with fabric skin.
SUSPENSION: fabric tent-type
PNEUMATIC: air inflated type utilizing air inflated compartments or inflatable ribs.

4.) Structural systems which efficiently utilize geometry so as to reduce required material cross sections and allow the use of lighter weight alternatives are suggested.

2.5 SERVICE SYSTEMS

DESIGN: The service equipment, whether in a single core, or distributed throughout the shelter unit, should be integrated into the erected configuration in such a way as to create a real sense for activity domains, either physically, or in an illusionary sense.

ELECTRICAL

POWER: Power shall be obtained solely from electricity. It is assumed that the electrical utility will be operational during the period of temporary housing. Each shelter unit shall be provided with a 100 amp. single phase 120/240 volt, 3 wire electric package for hook-up by cable to a power line within the area, or alternately, to a portable generator in the event that this utility has not been restored.

LIGHTING: Lighting shall be provided by standard electric fixtures of the incandescent and flourescent variety. These fixtures shall be supplied in sufficient number and positioned in such strategic locations as to assure an illumination level of 50 foot candles throughout the shelter in the absence of natural light.

COOKING: Cooking shall be done on a 4 burner electric range (no oven). Perishable food storage shall be maintainable through use of an electric refrigerator. This equipment is to be minimal in size.

PLUMBING

WATER SUPPLY: The shelter package is to have a conventional hook-up capability to the existing water utility. In the event that this utility is not functionable, the shelter shall depend upon included storage tanks to meet daily potable water needs. In this case, resupply operations shall be instituted on a weekly or semi-weekly basis by the local government. A per capita water usage of 10 gallons/day is sufficient for normal living functions if wastage is avoided. Basic storage capacities should be large enough to service a family of 4 for a one-week period between resupply actions.

SYSTEM OPERATION: Pressurization of the water system shall be by means of electric water pump. Plumbing fixtures to be provided are: 1 kitchen sink, 1 bathroom sink, 1 toilet, and 1 tub-shower. These are to be of a one-piece fiberglas construction and are to be minimal in size. A hot water storage tank of 15 gallons capacity shall also be provided.

SEWAGE DISPOSAL: In the sewage disposal system, excremental wastes and waste water are to be handled separately. A minimum flush-water type toilet is to deposit excremental wastes in a sealed holding tank, which is to be of sufficient capacity to service 4 persons (at 1/2 gal. of waste per person per day) for a period of one week between tank discharge operations.

Waste water is to be collected from the tub-shower and sink fixtures into a holding tank in which chlorination and purification operations are to take place. This cleaned water should then be available for bathing and cleaning purposes, but not for drinking. Excess cleaned waste water can be drained to the ground if the holding tank overflows.

Both systems are to have hook-up capabilities to conventional sewage disposable systems, in the event that this utility becomes available.

MECHANICAL

HEATING: Heating is to be provided by an all-electric system. This system is to be capable of maintaining an indoor design temperature of -15°F. A secondary supplemental heating system shall be available as an add-on package for use in areas experiencing colder conditions.

COOLING: A unit air-conditioning system shall be available as an add-on package for use in areas experiencing temperatures greater than 100°F.

VENTILATION: Air change shall occur through the heating system and through windows. An air change twice-hourly shall be guaranteed. Vent screens shall be placed in sealed areas. The kitchen range shall be provided with a mechanical exhaust fan capable of 8 air changes per hour. The bathroom and wash room shall be provided with operable windows, or in the event that is impossible, with exhaust fans capable of 20 air changes per hour.

An indoor relative humidity of 50% in summer and 30% in winter applications shall be a design goal.

2.6 FABRICATION

1.) Fabrication shall be of an industrialized off-site, in-factory type.

2.) Fabrication shall consist primarily of developing a core unit and a supporting package of area enclosure. The means for erection, placement, and securement shall be provided in the fabrication operation.

2.7 DELIVERY

1.) Delivery of shelter units shall be accomplishable within a two-week period following disaster impact.

2.) Delivery shall rely on the land-based operations of rail and truck transport, as well as on the air-based operation of cargo plane transport. Helicopters may be utilized as intermediary transport vehicles for short-haul movement in the event that truck or rail cannot negotiate the immediate disaster area.

3.) Delivery shall be a civilian operation, undertaken by private transport contractors, as well as a military operation, undertaken by mobile service divisions.

4.) Rail transport shall be by standard 87-1/2 foot long flatcars. Payload dimensions shall be limited to an 85 foot length, 12 foot width, and 12 foot height. Truck transport shall be by 45 foot long flatbed trailers. Payload dimensions shall be limited to a 45 foot length, 12 foot width, and 9-1/2 foot height. (In some states, a variance will be required to permit the transport of 12 foot wide loads.) Air transport shall be by large cargo planes, most of which have width and height capabilities at least comparable to that of trucks, and generally longer lengths.

5.) Shelter units shall be compactable for shipping to such extent that at least 10 such packages could be accommodated per rail car; 5 per truck; and 15 - 20 per cargo plane. Three primary types of shelter transport configurations are the most desirable: 1.) those that are collapsable into a smaller shipping module; 2.) those that are panelized and palletable; and 3.) those that fold into a small package that completely excludes air space.

6.) To minimize trip distances, save on costs, and insure the meeting of time schedules, the 10 regional federal stockpile depots set up for disaster inventories shall be utilized for shelter inventory as well.

2.8 ERECTION/PLACEMENT/SECUREMENT

1.) The complete set-up procedure shall be accomplishable within 4 to 8 hours following delivery to site. Systems designed for such an operation shall be an integral feature of the complete shelter package. Set-up is to be undertaken by unskilled labor, with the potential of victim assistance in some secondary aspects; or if the designed set-up system is extremely simplistic, then greater reliance could be placed on victim participation.

2.) The foundation system should be capable of maintaining stability and of preventing settlement under varying ground conditions of roughness, inclination, and bearing capacity. A level of terrain adaptability shall be provided that will allow for suitable erection on terrain that varies a maximum of 18 inches over the projected shelter area.

3.) The foundation system should provide the means for leveling of the structure.

4.) The foundation system should prevent the infiltration of insects and vermin from the ground into the structure.

5.) The foundation system should be reuseable.

ERECTION: 1.) The erection procedure should require only minimal equipment of a hand tool nature.

2.) The erection procedure should be reversible.

TIE-DOWN: 1.) The securement procedure should be quick, simple, and reversible.

2.) The securement procedure should utilize components that have a holding power of at least 4800 lbs. each (necessary for hurricane wind requirements of 100 mph.).

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3. COST-EFFECTIVENESS

Economic considerations will play a major role in design development and application. Efforts should be made not to compromise design standards due to cost impositions. The guidelines should provide a measure of flexibility suitable to enable the development of a number of alternative design scenarios. The ultimate choice should be a synthesis of those aspects which combine the features of user-effectiveness and cost-effectiveness. In designing relief shelter of this nature, there are a number of costs which must be dealt with. These can be condensed into three main categories:

1.) CONSTRUCTION COSTS
2.) LIFE-CYCLE COSTS
3.) SOCIAL COSTS

3.1 CONSTRUCTION COSTS

Construction costs include those of design, materials, labor, and plant facilities and equipment. These are once-only costs, whose impact can be reduced by reuse of the shelter package in a number of disaster applications.

3.2 LIFE-CYCLE COSTS

Life-cycle costs include those of transport, handling, maintenance, provisioning, assembly/disassembly, site preparation, inventory, operation, and management. These costs are continuing costs that remain present throughout the life of the shelter unit.

3.3 SOCIAL COSTS

Social costs are hard to define, and even harder to place a price tag on.

Disaster breeds deprivation and trauma-based psychological problems that can manifest themselves in the social context. In order that the provided shelter be truly cost-effective, it must be responsive to the real victim needs. If the shelter system provided fails in this respect, then in the long run, the real costs will be higher. Beginning the recovery period on the right foot can greatly accelerate the return to normalcy. This rapid return will hasten the re-establishment of a proper mental attitude within the afflicted community, and in the process, motivate the desire for self-sufficiency and financial stability.

SECTION VI

CONCLUDING STATEMENTS

1. COMMENTS CONCERNING PERFORMANCE GUIDELINES

1.1 SUMMARY: PROCESS, SIGNIFICANCE AND VALIDITY

The finalized performance guidelines presented in Section V represent the culmination of the efforts of this research, formulation, and testing process. The major objective, as well as the numerous sub-objectibes as set forth at the beginning of this study have been accomplished. Furthermore, this process has been pursued with an architectural base and a strong sociological concern. I feel that these have been vital in dealing with the discovery and evaluation of shelter needs, as well as with the translation of such needs into viable standards of suggested approach. In this summary I intend to discuss both the significance and validity of the process which has been developed and utilized, and to point out the important lessons which I feel should be emphasized as a result of this work.

This study has attempted to maintain a firm contact with reality. Rather than simply developing performance standards and presenting them as theoretically applicable, I have tried to demonstrate their relevancy and accuracy through a process of testing and use. As a result of this approach, considerable refinements were effected in transforming the preliminary guidelines to the finalized version. Real-life methodologies were instituted in this reformulation endeavor. Consultants in the form of key officials were approached through survey techniques for their knowledgeable criticisms and suggestions. In addition, the guidelines were put to actual use in evaluating both real and conceptual alternative shelter systems to determine their suitability and potentiality for disaster applications. In this manner, a number of facts and points were discovered which might otherwise have remained obscure. I feel that both of these attempts at refinement have been extremely successful and enlightening, and that these lend an important aspect to this thesis.

There remains one final process to be further attempted in the ultimate determination of guideline effectiveness. That is the institution of these guidelines in an actual design endeavor. Unfortunately, this attempt cannot be realized at this time because of the limiting time constraint imposed upon this work. However, I do feel that valuable experiences could be derived from this additional step that could further influence the guideline statement. This might be attempted in the context of an architectural studio.

1.2 SUMMARY: IMPORTANT LESSONS

This intensive approach to the problem of providing responsive and effective disaster relief shelter has pointed out a number of significant lessons. These are both of a general process nature, and of a specific factual type. I shall identify these both as a summarizing influence and as a personal attempt to alert the reader to the emphasis which I feel is important.

1.2.1 General Process

This study has been conducted from the outset with a firm grasp of organization and intent. By establishing these early in the work, the subsequent expansion into the actual working phase was effected in a meaningful and efficient manner. This was extremely important to the development of a consistent and ambitious approach to a problem which has been found to be broad in its scope, and significant in its impact. Any number of issues discovered in this work could have been greatly expanded upon into studies in their own rights. However, I feel that only by attacking the paramount problem was it possible to reveal the complexity and vitality of these issues; and that only by attempting to deal with the large overall picture was it possible to develop meaningful responses in the limited time frame of this thesis context. Furthermore, I feel that the real merit and meaning has been obtained through both the clarity of organization and the attempt to criticize and re-evaluate the formulated guidelines, rather than by stopping short and contending my self with their preliminary developments. I feel that the goals of this work have been met and that they have been dealt with in a rigorous and convincing maner. Naturally, with this scope, shortcomings are inevitable in the guidelines. But I hope that these will serve as a catalyst to encourage other people and agencies concerned with this vital issue of disaster shelter relief to attempt further refinements.

1.2.2 Specific Lessons

This study of natural disaster and its impact on the shelter environment has shown the importance of the twin concerns of logistics and hardware. Both play vital roles in effective shelter response; and neither can approach its true potential without the other. An efficient, responsive disaster shelter management program cannot be implemented without the availability of the types of shelter hardware which are necessary in satisfying victim needs. And, shelter hardware packages are ineffective unless coupled with a logistics program that is capable of utilizing these to their full and intended advantage. In both of these areas, a realization of user needs, technological capabilities, and cost-effectiveness is the overriding criterion for success. The first two are critical to the development of the response. The third determines their utility. Together they provide the framework of the shelter approach.

In developing an effective shelter approach, I have found timing to be the key element. Physiological and psychological analysis have shown the changing nature of shelter needs in the time period following disaster impact, and the necessity of reacting to these changes in planning the relief shelter response. I once again wish to restate this most important issue which has been hammered home in this study. The family living situation must be re-instated at an early date following impact. This can best be accomplished by developing the spirit of community immediately following disaster within the framework of the mass shelter context, and by capitalizing upon its potential by effecting a transition to the family living situation at the peak of such development. This requires a shelter program that is capable of both the family living activity and of timely implementation. Cost-effectivenesses dictates that this should involve shelter which is either expandable-to-permanency at a later date, or that is capable of being updated to a semipermanent living condition in the event of protracted need.

The performance guidelines outline these important considerations. They provide a framework which is flexible enough to encourage a variety of shelter responses. This variability of possible response is an extremely encouraging factor in determining that needs can be met in a user-effective and cost-effective manner. By outlining the applicable standards within a comprehensive collection, the real impact which alternative avenues of design approach can evoke can be more readily seen. In other words, not only should the guidelines serve as a reference for checking design applicability, but also they should act to stimulate the development of effective design approaches to this problem. In many ways this is the most important lesson of this research because it takes into account the need for effective logistics-hardware development and interaction as well as the important timing aspects of shelter provision and change, and places them all together in a framework that is both accessible and useable.

2. COMMENTS CONCERNING A REALISTIC SHELTER APPROACH

2.1 BASIS

It is impossible to conclude this work without some mention as to what my exposure to this area of concern has shown might be realistic shelter approach. I intend to briefly outline such an alternative. This shall require statements of both logistics scenario and hardware detail. I base my analysis on the critical family needs following disaster and upon the ways in which these needs change in the subsequent weeks. I also base this analysis on the technological implications that seem most appropriate in this regard. Finally, I base this alternative synopsis on criteria of cost-effectiveness that play a dominant role in the selection and application of shelter alternatives.

2.2 SCENARIO

2.2.1 Logistics

The prime concern is to provide housing which is suitable to the family living situation and which can be deliverable in a timely and cost-effective manner. Following disaster, the first efforts should be directed towards the emergency care of the victims, and towards the assessment of projected shelter needs and the evaluation of the availability and suitability of surviving in-area housing stock. In the event that in-area resources are insufficient, imported shelter alternatives should be requested. These are to be stockpiled in the 10 regional federal disaster inventory stockpiles, and are to possess the rudimentary space enclosure and service systems necessary for temporary family housing. They are to be adequate for the type of climatic environment found within their designed region. Once the request had been received at the inventory depot, the delivery process would commence. Sufficient transport vehicle resources, rail, truck, or air cargo -- depending on which appear most effective to the case at hand -- are to be obtained from both the private and military sectors. The transport operation is to deliver the shelter package from depot to site destination. Initial siting is to be either at actual homesites, or at large clustering areas, depending upon the scope of impact and the condition of the utilities services. Once delivered, erection/placement/securement is to proceed and be completed the same day. In this operation, an unskilled labor force with the possible assistance of the victims themselves in some aspects, is to effect the conversion from the transport mode to the living mode. This entire provisionary process is to be accomplished by the end of the second post-disaster week. The families are then to move into these accommodations for a period that is not to exceed two months, unless further modification is made at a later date to the initial shelter environment. Power is to be obtained from electricity, either from hook-up to trunk lines, or to portable generators if necessary. In the latter case, clusters of units will be serviced by a single large generator. Additionally, the local government shall enact operations of potable water supply and sewage collection on a weekly or semi-weekly basis until these water-related service utilities have been restored, at which time alternate hook-up shall be possible.

If, during the following two-month period, the occupant's housing is restored to a livable condition, then he is to be allowed to move back to his home. If, on the other hand, at the end of this time, it is apparent that his housing cannot be returned to a suitable condition for a prolonged period, then he is to be given the option of utilizing the shelter package as the basis for the development of a new home, or of continuing his occupancy on a temporary basis in the same shelter. In both cases, additional systems of rigid space enclosure shall be provided. The expandable-to-permanency option shall involve rectangular panelized systems that are meant for permanent use. The second option shall involve a panel system that is of an assemble/disassemble or of a disposable nature to replace the original flexible space enclosure. In the assemble/disassemble case, these panels are to be reuseable in subsequent disaster situations. Both shelter options shall involve the resituation of the shelter package to the occupant's homesite if this has not been accomplished previously. Thus, the shelter package which I have outlined shall possess the characteristics necessary for protracted occupancy through the semipermanent living situation of a year's duration, once they have been updated for such a use.

2.2.2 Hardware

The shelter package which I see, based on my analysis and guidelines, as having great potential is somewhat similar in principle to the "Travel House" which has been discussed previously in Section IV. The basic package would consist of a rectangular 8' x 12' service core, four 8' x 12' lightweight rectangular sandwich floor panels, and a supporting system of fabric-based space enclosure. In its transport mode, the core would be compacted to a 4' height. This height would be increased to 8' on-site by means of a telescoping roof section. In transport, the four rigid floor panels would be placed on the roof of the core. This would increase the total package transport height by about 2' (6" thick panels) so that the total transport configuration would be 8' x 12' x 6'. This is an extremely advantageous delivery size in terms of rail, truck, and air cargo transport, as it allows for a number of units to be transported by each delivery vehicle (20 units/flatbed railcar, 7 units/flatbed truck trailer, 18 by a Douglas C-124A "Globemaster") within the limitations imposed by dimensional and legislative considerations.

On-site, the core would be maneuvered into its desired location by means of a dolly system similar to that utilized in the military examples cited in Section IV. Once in position, integrally mounted corner jacks would be dropped from the core and the dolly would be removed for use in situating another such unit. These jacks would form a part of the supporting base for the unit. At this time, the four lightweight 8' x 12' floor panels would be removed from the roof (a two-man operation) and joined together around the perimeter of the core unit to serve as a floor platform. These would be supported by the core at one edge, and would be supported by additional jacks positioned at their corners. The total floor area would then be increased to 480 sq. ft. (counting the core unit). The transition would appear as shown in plan in Illustration #17 on page 307. In this way, there would be provided a rigid, sealed floor system with a core area that was approachable along three of its sides from the inside, and along one side from the outside. In the event of larger family situations, additional floor panels could be easily provided to augment the useable floor area. Also, in the case of reduced family size, or possibly even for couples, fewer floor panels, say 2 or 3 could be used. The advantage of this modular system is that it offers a wide variation of possibile floor plans since the panels could be positioned in a number of different orientations. It is also efficient in its use of the core as a means for subdiving the interior space into various activities areas.

Walls and roof are to be provided in the following way. The roof of the core is to telescope so as to increase the interior ceiling height to at least 7'. Small hinged panels contained within the core are to be used to extend the core walls by this additional height. Also contained within the core will be a compacted fabric "enclosure bundle". There are a number of alternative ways of utilizing this fabric system. In one case, an assemblable system of aluminum tubing could be erected to form a rectangular framework for a tent-type application. In this way, the fabric system would enclose the entire floor area, including the core within a structure that would look like a large tent with a crowned roof. (see Illustration #18 on page 307) In this situation, the tube elements could be broken down into short assemblable sections and stored in the core along with the fabric envelope during transport. The floor panels and core unit could have molded inserts to accommodate these structural elements in the erection mode. Rigid windows and a door should be sewn into the fabric cover. In an alternate system, a pneumatic approach could be utilized, in which a large vinyl envelope would be attached at the perimeter edges of the floor panels so as to enclose the entire floor area, including the core within a single envelope when inflated. This would require the use of a small fan system for erection and for enclosure maintenance. This system should also incorporate a number of air-inflated ribs to assume part of the support responsibility, so that problems of air leakage in the entry/exit operation will not require special air locks. A rigid door would be integral in the fabric construction. Translucent skylights should be provided to insure adequate illumination during the day. Both of the alternate

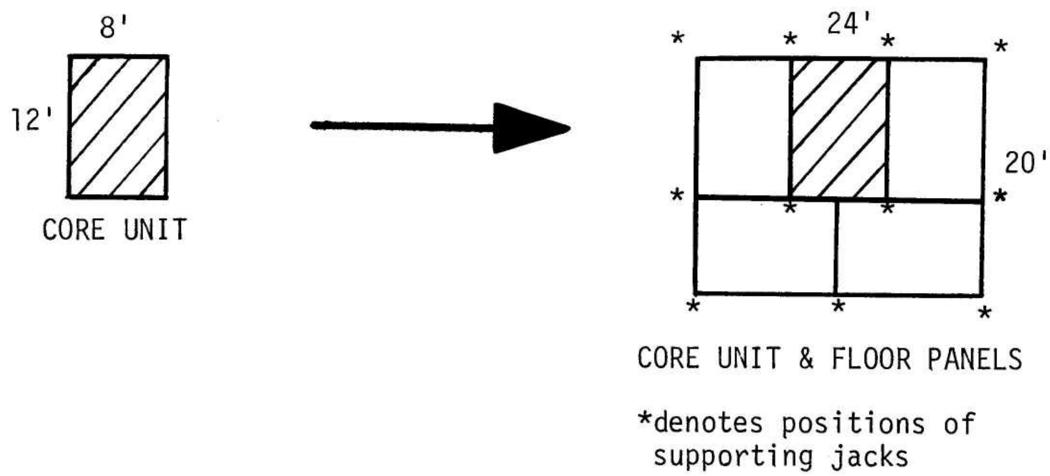


ILLUSTRATION #17

EXPANSION OF FLOOR AREA

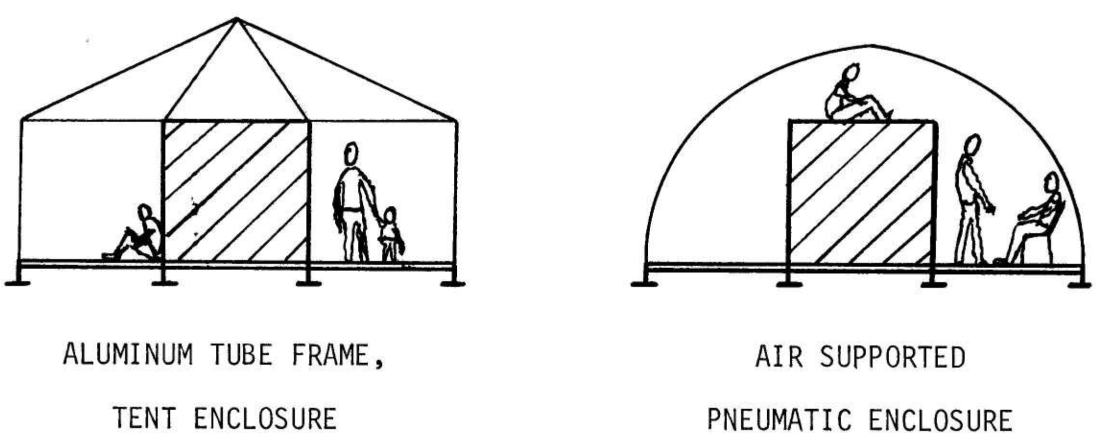


ILLUSTRATION #18

ALTERNATIVE SPACE ENCLOSURES

systems require tie-down by a series of cables and ground anchors. One nice feature of these schemes is that they completely enclose the core unit, and offer the possibility of using its rigid roof as a sleeping, play, or storage area. This adds roughly an additional 100 sq. ft. of useable floor area at no extra cost, except in terms of a larger heating requirement.

This alternative which I am proposing shall be habitable for up to two months occupancy. In the event of protracted occupation, rigid panel systems would be provided to replace the fabric space enclosure at this time. In the expandable-to-permanency application, these panels would be of a durable, permanent rectangular nature suitable for "traditionally-styled" housing. In the case where the unit was to be returned at the end of the semipermanent occupancy period, the panel systems could be made of lightweight disposable paper construction treated with a weather protective agent, or of fiberglas-type construction that would have an assemble/ disassemble, reuse character.

This concludes the brief description which I wished to make in suggesting a possible optimal shelter scenario. Many options exists. This is simply one example. I feel that the guidelines offer a great deal of flexibility in initiating such design.

3. COMMENTS CONCERNING HUD REQUEST FOR PROPOSALS

3.1 DESCRIPTION OF RFP: OBJECTIVES, SCOPE, AND CONTENT

In the middle of March, 1973, several months following the commencement of my thesis work, the Department of Housing and Urban Development issued Request for Porposal No. H-22-73. This RFP called for the submission of proposals for the "Determination of the Most Cost Effective Housing System(s) That Can Be Used for Temporary Housing for Families Displaced by Disasters and for Transient Persons". In light of my then in-progress thesis work, this was a most informative and reassuring circumstance. This RFP confirmed my feelings that the problems of emergency disaster relief shelter provisions were an extremely current and vital concern. Furthermore, much of the stated scope and concentration of this proposed study was in basic agreement with the work I had carried on up to that point. A copy of the relevant sections of text from this RFP can be found in Appendix #5, on pages 343-348.

In the statement of the scope of the proposed work, HUD outlined 8 main criteria. In general, my work at that point had confirmed and established similar thrusts of intent. The basic considerations which HUD judged relevant to the study are outlined on pages 345 and 346. Summarizing these points, HUD called for a study that aimed ultimately at a cost-effective disaster shelter response. This shelter was to be primarily designed for use in meeting the needs arising from four types of natural disaster -- tornadoes, earthquakes, hurricanes, and floods. This shelter was to be useable for a period of one month to 12 months after disaster impact. The shelter provided was to be suitable for family occupancy. Transient housing was also requested, but from the tone of the proposal, this was clearly an afterthought, or a secondary objective. The housing system developed was to be "expeditiously and simply" transportable by the land based operations of rail and road. It was to be storable, easily maintainable, easily and quickly erectable, and competitively priced in terms of manufacture, transport, and storage. It was also to be suitable for mass production utilizing current technology, HUD outlined three options for the shelter type: one-use, disposable; reuseable; and expandable in-part-or-in-total to a permanent home.

3.2 DESCRIPTION OF TASKS

Pursuant to these objectives, four tasks were outlined. The first involves a literature search of past disaster situations and shelter responses: an investigation of other forms of housing technology that might be applicable; and an investigation and assessment of applicable codes and transportation standards in disaster susceptible regions of the country. From this last consideration, HUD plans to determine applicable standards and codes for disaster housing systems. The second task concerns the evaluation of the cost-effectiveness of the housing systems studied in task #1. This is to result in a ranking. From this ordering, HUD is to make a selection as to the system(s) which it considers most advantageous for subsequent development. The third task involves the preparation of plans and specifications for the selected system(s), such that construction of a demonstration unit could be undertaken if later desired. In addition, the contractor is to develop a scenario showing the hypothetical use of such shelter in a disaster situation. This is to go into complete detail on all aspects of shelter manufacture, provision, and operation. Finally, the last task involves the development of a similar shelter product and scenario for housing transient persons. This calls for the additional design of an illustrative 100 unit park. This entire study is to be completed within a time frame of 6 months at a funding level of $175,000 to $200,000.

3.3 MOTIVATING FORCE BEHIND THIS STUDY

Thus, in its basic nature, this RFP was exceptionally similar to the work which I had undertaken. Considering both this striking similiarity and the timing of the RFP, a great deal of fortuitous coincidence seems to have transpired. However, I maintain that this is not the case. My meetings in January, 1973 with various officials in Washington, D.C. made me aware of the timeliness and relevancy of my work. I am convinced that the recent experience of Agnes in 1972 has prompted this RFP. While meeting with Mr. Ugo Morelli in the Office of Emergency Preparedness, I was alerted to the fact that HUD was in the process of attempting to determine the course of action to pursue in this area. I had no knowledge however, as to what their plans would be.

3.4 MAJOR AREAS OF DISAGREEMENT AND CONCERN

While the HUD RFP and my work seem to be in fair agreement in a number of areas, there are nevertheless, 3 issues which I feel that I cannot stress enough, and which the RFP has skirted in its statement of the problem.

3.4.1 Timing Concerns

First, my work has convinced me of the existence of 3 periods following disaster in which the needs of the victims change, especially with regards to shelter provision. Of these, the period of situation stabilization and its attendant need for temporary housing is the most overlooked, underestimated, and ill-responded to. The transition from emergency mass shelter accommodations to temporary family living situations must take place within the first two weeks following impact. I cannot overemphasize this fact. Yet, HUD has called for emergency non-family type care during the first post-disaster month, with the shelter product which it intends to produce to be brought on the scene one month after disaster. They skirt the period of situation stabilization and rather jump from the life-sustaining to the recovery period without this vital intermediary. I feel that this is a wrong course of action, and that if pursued, it will not provide the optimum potential response.

3.4.2 Importance of Performance Guidelines

My second concern is for the manner in which HUD intends to initiate this research. It calls for a study of disaster background and alternative systems. This is fine. But HUD does not make a real issue of the importance of developing performance guidelines at this early stage. Rather, it only gives this development a cursory mention, and speaks of it as something which will hopefully transpire after this study is completed. By that time, it may be too late to implement such guidelines. Furthermore, the RFP speaks more in terms of codes and transport restrictions, rather than concentrating on victim needs. I feel that the initial establishment of such guidelines is vital, and that these guidelines should be at least as concerned with user needs as with the problems of codes, transport limitations, legislative restrictions, and technology.

3.4.3 Cost Concerns

Finally, the very nature of their proposed study seems to be in direct opposition to the course which I have pursued. It concentrates on cost-effectiveness as the prime concern and determinant of applicability. I maintain that such an economics consideration should only be brought into use as a final means of judgment. I am concerned that cost analysis will over-shadow the more important aspects of suitability and responsiveness to victim needs.

4. COMMENTS CONCERNING OSTI PROPOSAL

4.1 BACKGROUND OF MY INVOLVEMENT

When I became aware of the existence of the HUD RFP, there remained only about 3 weeks before the proposal submission deadline. I had the interest, but not the experience or the time necessary to attempt a response. However, Assistant Professor I. Donald Terner of the Department of Urban Studies and Planning at M. I. T. had heard of my work in this area and contacted me. He was then preparing a response in conjunction with MASSDESIGN, of which he is a founding principal, and with the Arthur D. Little Research Corporation of Cambridge. His interest in the need for such a study, and his reservations concerning the course which HUD had outlined were similar to my own. I therefore agreed to offer my advice and thesis work at that stage to aid in the initiation of a proposal. This alliance was short lived however, when, less than a week before the deadline, and after considerable work had been undertaken, Arthur D. Little Inc. decided to withdraw its backing. This left the proposal without a sponsor or the resources for completion. Professor Terner finally succeed in acquiring the sponsorship of OSTI (Organization for Social and Technical Innovation, Inc.), a large research firm based in Newton which has done work under HUD contracts previously. This left only 3 days in which to publish a formal proposal. (This proposal is referenced in (B&R:65) in the bibliography.) I take no credit for this final push. However, the proposal which was submitted contained much of the background work and substance which I had established in my research.

4.2 OSTI APPROACH

The OSTI proposal pointed out the lessons learned from Hurricane Agnes and described the main approach which they would endeavor to follow. This approach is significant in that it attempted to reformulate the basic HUD RFP and give it a more relevant direction.

> "Recent federal experiences following Hurricane Agnes illustrated the substantial risks involved in relying on the availability of a single housing technology -- such as mobile homes -- to satisfy post-disaster needs, and the importance of considering a variety of alternative housing systems in mobilizing an effective response. Although the RFP validly reflects these concerns, our approach goes beyond its overriding emphasis on housing systems performance -- the 'hardware' component of disaster response -- and takes into consideration the options for improved disaster management planning on the part of the federal government which in turn affect both the availability of housing resources and the cost-effectiveness of disaster response." (B&R:65,p.11)

> "As a result of these considerations, our proposal is based on a dual approach to the problem of disaster housing:
>
> 1.) The development of performance evaluations and specifications (as required by the RFP)
> 2.) The design of a disaster housing management system." (B&R:65,p.15)

This points out many of the things which I have commented upon throughout my work. The need for a manageable plan for coordination and implementation is essential if the shelter forms decided upon are to be utilized to their full potential. Many of these concerns are stated in the performance guidelines which I have developed, especially in the areas of logistics, timing, and delivery. HUD requested only a shelter package with a hypothetical scenario. This proposal seeks to redirect HUD to the additional concern for disaster management. A complete flow chart of the overall research design which OSTI plans to implement in the event of its selection is illustrated in Appendix #6, on page 350. This diagram is taken directly from the OSTI proposal.

4.3 OSTI STATEMENT OF PROBLEM

I now wish to bring attention to one further aspect of the OSTI proposal -- the general intent. This intent is described in the summary found at the end of their statement of the problem.

> "It is clear that local or state resources are inadequate to meet the emergencies generated by disasters. The federal government recognizes this by its efforts to provide immediate financial and manpower assistance when disasters occur. But this assistance has been stop-gap in nature and concentrates more on the survival aspects of shelter than on the return to normal possibilities that such shelters might represent. On the other hand, local and state jurisdictions frequently present obstacles to viable solutions in the form of zoning and code regulations which cannot be easily contravened. Thus, in addition to the development of technological solutions to housing destruction, coordination and planning at the federal level is essential if relief shelter is to be more responsive to user needs, both physical and spiritual.
>
> Our approach, therefore is two-fold. We are concerned not only with technological solutions, but with ways to <u>expedite</u> the delivery of housing in a cost-effective manner while meeting human needs. (B&R:65, p.10)

4.4 SUMMARY CONCLUSION

I am sure that the reader will recognize much of the substance of the just-quoted passages as being taken from my own statement of the problem in this thesis -- a statement which was conceived long before the issuance of the HUD RFP or the OSTI reply. In general, the OSTI statement conveys what I have intended in this research. Thus, the fruits of my work have been incorporated in planning which may conceivably have a real impact on the problems of meeting the future shelter needs of the victims of natural disasters. On this positive note, I wish to conclude this thesis.

APPENDICES

APPENDIX #1

RESEARCH SOURCES

A) Field Research:

1) Personal discussion with Mr. William Cosby, Program Manager of the Building Research Advisory Board, National Adademy of Sciences, whose office has just recently completed a 3 month study of emergency shelter/housing alternatives for the Office of Emergency Preparedness in Washington DC.

2) Brief discussion with Mr. Ugo Morelli of the Office of Emergency Preparedness concerning the BRAB report which I read in his office.

3) Attendance of the Fifth Annual Camping and Travel Show in Chicago Illinois, where the latest innovations in the field of recreational camping vehicles were displayed.

B) Correspondence:

1) Organizations and agencies which specifically deal with the effects of natural disaster:

- The American Institute of Architects
- The American National Red Cross
- The Defense Civil Preparedness Agency
- The Department of The Army, Office of The Surgeon General
- The Disaster Coordination Unit, United Nations
- The Disaster Research Center, Ohio State University
- The Office of Emergency Preparedness, Division of Disaster Preparedness
- The Office of the Disaster Coordinator, Agency for International Development
- The United Nations, Reports and Documentation Section

2) Companies which produce innovative forms of shelter, or have developed products which might have applications in this area of interest:

- Armand G. Winfield Inc.
- Birdair Structures Inc.
- Gichner Mobile Systems Inc.
- Simmons Fastener Corp.

C) Library Research:

1) Boston Public Library
2) Harvard Library System
3) MIT Library System

APPENDIX #2

WORKING OUTLINE

I.) INTRODUCTION

A.) Statement of Problem.
1.) Disaster: Consequences and Responses.
2.) Physiological and Psychological Problems of Mass Shelter Response.
a.) Overcrowding and Lack of Privacy.
b.) Institutional Character of Mass Shelter.
c.) Separation of Friends and Relatives.
d.) Disruption of Buildings Normal Routine
e.) Tendency to Rely on Such Shelter Arrangements for Protracted Periods.
3.) Thesis of Research
a.) Re-evaluation of Traditional Responses.
b.) Involvement of the Architect.
4.) Limitations on Research.
B.) Statement of Objectives.
1.) Primary Objective: Develop and Test Performance Guidelines for the Design of Emergency Relief Shelter.
2.) Sub-Objectives.
a.) Disaster Background Study.
b.) Evaluation of User Needs.
c.) Evaluation of Technology.
d.) Development of Preliminary Guidelines.
e.) Testing and Feedback from Officials.
f.) Investigation of Shelter Alternatives Available.
g.) Final Performance Guideline Formulation.
3.) Limitations on the Scope of Research.
a.) Geographic Area.
b.) Disaster Types.
c.) Location.
d.) Disaster Period.
e.) User Selection.
f.) Fields of Study.
C.) Statement of Methodology.
1.) Collection of Pertinent Information.
a.) Field Research.
b.) Correspondence.
c.) Library Research.
2.) Development of Performance Guidelines.
3.) Testing and Refinement of Performance Guidelines.

II.) BACKGROUND MATERIAL: DISASTER IN THE UNITED STATES.

A.) Prologue.
B.) Definition of Disaster.

1.) By J. W. Powell.
2.) By A. F. C. Wallace.

C.) Three Periods of Disaster.
1.) Warning.
2.) Impact.
3.) Recovery.

D.) Disaster Types.
1.) Motive Forces.
a.) Nature.
b.) Man.
2.) Physical Characteristics.
a.) Identification of Primary Disaster Threats.
1) Hurricances.
2) Tornadoes.
3) Earthquakes.
4) Floods.
b.) Physical Effects.
1) Nature of Occurrence.
2) Frequency of Occurrence.
3) Severity of Occurrence.
4) Effects of Occurrence.
a) Death or Injury.
b) Damage To Housing Stock.
c) Damage to Commercial/Industrial Facilities.
d) Interference with Communications, Transportation, and Utilities Services.
e) Damage to Ecology.

E.) Impact of Natural Disaster on Man.
1.) Physiological Suffering.
a.) Death and Injury.
b.) Loss of Life-Sustaining Systems.
1) Protection from the Elements.
2) Maintenance of Body Temperature.
3) Protection from Epidemic and Disease.
4) Provision of Nourishment.
2.) Material Loss.
a.) Possessions.
b.) Shelter.
c.) Income.
3.) Psychological Suffering.
a.) Three Hypotheses.
b.) Disaster: Popular Image vs. Real Image.
c.) Disaster Syndrome.
d.) Factors Determining Psychological Outcome.
1) No Warning vs. Warning.
2) Duration of Threat.
3) Nature of Damage.
4) Causal Agent.
e.) Types of Suffering.
1) Trauma of Disaster Itself.
2) Anxiety for Lost Relations and Friends.
3) Suffering Due To Injury/Death of Loved One.

4) Confusion Resulting from Unfamiliar Predicament.
5) Despair for the Future.
6) Feelings of Helplessness.
7) Religious-Based Fears.
f.) Psysiological-Psychosomatic Effects.
g.) Disaster-Induced Mental Illness.
F.) Factors Influencing the Scope of Damage and Destruction.
1.) Type of Disaster.
a.) Instantaneous-Focalized.
1) Tornadoes.
a) Description
b) Motive force.
c) Frequency.
d) Severity.
e) Duration.
f) Area of Impact.
2) Earthquakes.
a) Description.
b) Motive force.
c) Frequency.
d) Severity.
e) Duration.
f) Area of Impact.
b.) Progressive-Diffuse.
1) Hurricanes.
a) Description.
b) Motive force.
c) Frequency.
d) Severity.
e) Duration.
f) Area of Impact.
2) Floods.
a) Description.
b) Motive force.
c) Frequency.
d) Severity.
e) Duration.
f) Area of Impact.
2.) Type of Impact Area.
a.) Rural.
b.) Suburban/Town.
c.) Urban.
G.) Organizational Response to Natural Disaster.
1.) Listing of Organizations Involved.
2.) Types of Response.
3.) Special Problems.
H.) Basic Conclusions.
1.) Need for Further Study.
2.) Preventitive Practices.
3.) Methodology and Resources.
a.) Organizational Approach.

b.) Systems Approach.
 1) Software.
 2) Hardware.

III.) DEVELOPMENT OF PERFORMANCE GUIDELINES FOR RELIEF SHELTER DESIGN.

- A.) Prologue.
- B.) Application.
  - 1.) Determination of Period of Occupancy.
    - a.) Three Post-Disaster Periods.
      - 1) Life-Sustaining: Emergency Type Housing.
      - 2) Situation Stabilization: Temporary Type Housing
      - 3) Recovery: Semipermanent Housing.
  - 2.) Determination of User.
  - 3.) Summary of Scope.
- C.) Determination of User Needs.
  - 1.) Background.
  - 2.) Basic Principles of Heathful Housing.
    - a.) Fundamental Physiological Needs.
    - b.) Fundamental Psychological Needs.
    - c.) Protection from Contagion.
    - d.) Protection Against Accident.
  - 3.) Specific Needs Arising from the Disaster Situation.
    - a.) Physiological Needs.
      - 1) Basis of Needs.
      - 2) Description of Needs.
        - a) Life-Sustaining.
          - 1. Provision for Maintenance of Bodily Functions: Metabolism.
            - a. Energy Intake.
            - b. First Aid.
            - c. Rest.
            - d. Waste Elimination.
          - 2. Provision for Dealing with Environmental Factors.
            - a. Climatic Influences.
              - 1 Air Temperature.
              - 2 Radiation.
              - 3 Air Movement
              - 4 Moisture.
            - b. Contagion.
            - c. Accidents.
        - b) Life-Stabilization and Recovery.
          - 1. Provision for Resumption of Normal Physical Activities.
            - a. Sleeping/Relaxing.
            - b. Eating.
            - c. Exercise/Play.
          - 2. Provision for Self-Care.
            - a. Bathing/Cleaning.
            - b. Cooking/Food Storage.

3) Quantification of Physiological Needs.
   a) Life-Sustaining.
   b) Life-Stabilization and Recovery.

b.) Psychological Needs.
1) Basis of Needs.
   a) Neurotic Potential.
   b) Experiential Integration.
2) Description of Three Phases of Needs.
   a) Relief of Psychological Bewilderment and Suffering.
      1. Types of Needs.
         a. Those Arising from Trauma.
         b. Those Arising from Deprivation.
      2. Means of Fulfilling Needs.
         a. Role of Victim Himself.
         b. Role of Community.
         c. Role of Shelter.
   b) Recovery of Mental Attitude and Balance.
      1. Types of Needs.
         a. Reinstatement of Normal Family Functions.
         b. Reinstatement of a Measure of Self-Sufficiency.
         c. Return to Familiar Surroundings.
         d. Appraisal of Real Situation.
      2. Means of Fulfilling Needs.
         a. Role of Family.
         b. Role of Shelter.
   c) Stimulation of Motivation and Hope for the Future.
      1. Types of Needs.
         a. Prior Recovery of Mental Attitude and Balance.
         b. Time Separation from Disaster Event.
         c. Example of Recovery on the Larger Community Scale.
      2. Means of Fulfilling Needs.
         a. Role of Family Environment.
         b. Role of Community Environment.
3) Shelter Implications.
   a) Nature of Shelter.
   b) Purpose of Shelter.
   c) Timing of Delivery.
   d) Siting.
   e) Community.
   f) Nature of Activities.
   g) Nature of Self-Sufficiency.
   h) Nature of Spaces.
   i) Feelings.

D.) Translation of Needs into Specifications.
1.) Alternative Approaches for Temporary Housing.
   a.) BRAB Recommendations.

b.) Use of Housing Resources Within the Area.
1) Types.
2) Considerations.
c.) Importation of Temporary Shelter Units.
1) Types.
a) One-Use, Disposable Form.
b) Reuseable Form
c) Expandable in-Part or in-Whole to Become a Part of the Permanent House.
2) Considerations.
d.) Conclusions.
2.) Basic Shelter Aspects.
a.) Single Family Occupancy.
b.) Degree of Self-Sufficiency.
c.) Spaces.
1) Types and Characteristics.
2) Sizes.
3) Recommendations.
d.) Overall Size.
e.) Dimensional Implications.
f.) Safety.
g.) Mobility.
h.) Siting.
3.) Basic Service Aspects.
a.) Heating and Cooling.
b.) Ventilation.
c.) Power.
d.) Water.
e.) Waste Disposal.
E.) Technology: Research and Recommendations for Performance Guidelines.
1.) Materials.
a.) Significance.
b.) Types.
1) General Classes.
a) Structural.
b) Skinning.
c) Insulating.
2) Specific Kinds.
a) Metals.
1. Steel.
2. Aluminum.
b) Wood.
c) Gypsum Plasterboard.
d) Plastics.
1. Cellular.
2. Glass Fiber Reinforced.
e) Fabrics.
c.) Considerations.
1) Strength.
2) Weight.
3) Durability.

4) Fire Resistance.
5) Workability.
6) Finishes/Textures.
7) Cost.

d.) Recommendations.

2.) Structural Systems.
- a.) Significance
- b.) Types.
  - 1) Bearing Wall.
  - 2) Post and Beam.
  - 3) Frame.
  - 4) Arch.
  - 5) Truss.
  - 6) Vault.
  - 7) Dome.
  - 8) Cantilever.
  - 9) Slab.
  - 10) Shell.
  - 11) Space Frame.
  - 12) Geodesic Frame.
  - 13) Suspension.
  - 14) Pneumatic.
- c.) Considerations.
  - 1) Loads and Forces.
  - 2) Materials.
  - 3) Simplicity.
  - 4) Space Enclosure.
  - 5) Economics.
- d.) Recommendations.
  - 1) Structural Implications.
  - 2) Materials Implications.
  - 3) Suggestions from Ann Arbor Research Group.

3.) Services: Electrical, Plumbing, and Mechanical
- a.) Significance.
- b.) Types.
  - 1) Electrical.
    - a) Power.
    - b) Lighting.
    - c) Cooking and Refrigeration.
  - 2) Plumbing.
    - a) Potable Water Supply.
    - b) Systems Operation.
    - c) Waste Disposal.
  - 3) Mechanical.
    - a) Heating.
    - b) Ventilation.
- c.) Considerations.
  - 1) Size.
  - 2) Degree of Self-Sufficiency.
  - 3) Reliability and Maintainability.
  - 4) Safety.
  - 5) Economy.
- d.) Recommendations.

4.) Fabrication.
    a.) Significance.
    b.) Types.
        1) On-Site, Industrialized.
        2) Off-Site, in-Factory, Industrialized.
    c.) Considerations.
        1) Design.
        2) Materials.
        3) Capabilities.
        4) Operation.
        5) Economy.
    d.) Recommendations.
5.) Delivery.
    a.) Significance.
    b.) Options.
        1) Air and Water.
        2) Rail.
        3) Truck.
    c.) Considerations.
        1) Payload Size.
        2) Flexibility of Routing.
        3) Logistics of Operation.
        4) Completeness of Delivery Process.
        5) Speed.
        6) Economics.
    d.) Recommendations.
6.) Erection/Placement/Securement.
    a.) Significance.
    b.) Operations.
        1) Foundation.
        2) Erection.
        3) Tie-Down.
    c.) Considerations.
        1) Speed.
        2) Simplicity.
        3) Flexibility.
        4) Equipment and Labor.
        5) Economics.

F.) Summary of Performance Guidelines.
1.) Prefatory Remarks.
    a.) Statement of Use, User, and Period of Use.
        1) Use.
        2) User.
        3) Period.
    b.) Statement of Needs Provided for.
        1) Physiological.
        2) Psychological.
        3) Social.
    c.) Statement of Shelter Scenario.
        1) Provision.
        2) Siting.
        3) Operation.

2.) Requirements and Specifications.
    a.) Shelter Type.
        1) Reuseable.
        2) Expandable-to-Permanency.
    b.) Spaces.
        1) Description.
        2) Sizes.
        3) Nature.
        4) Dimensional Implications.
    c.) Materials.
    d.) Structural Systems.
    e.) Services.
        1) Electrical.
            a) Power.
            b) Lighting.
            c) Cooking.
        2) Plumbing.
            a) Water Supply.
            b) Systems Operation.
            c) Sewage Disposal.
        3) Mechanical.
            a) Heating.
            b) Cooling.
            c) Ventilation.
    f.) Fabrication.
    g.) Delivery.
    h.) Erection/Placement/Securement.

IV.) TESTING, USE, AND REFINEMENT OF PERFORMANCE GUIDELINES.

A.) Prologue.
B.) Feedback from Qualified Officials.
    1.) Significance and Process.
    2.) Responses and Comments Received.
        a.) General Comments.
        b.) Specific Comments.
    3.) Evaluation and Interpretation of Responses.
    4.) Implications for Guideline Refinement.
C.) Feedback from the Evaluation of Alternative Shelter Systems.
    1.) Significance and Process.
    2.) Alternative Shelter Systems: Data.
        a.) Mobile Units.
            1) General Characteristics.
            2) Presently Available Examples.
            3) Conceptual Examples.
            4) Military-Use Examples.
        b.) Inflatable Structures.
            1) General Characteristics.
            2) Presently Available Example.
            3) Conceptual Examples.
            4) Military-Use Examples.

c.) Tent Structures.
1) General Characteristics.
2) Presently Available Example.
3) Conceptual Example.
d.) Panelized Assemble/Disassemble Structures.
1) General Characteristics.
2) Presently Available Examples.
3) Conceptual Examples.
4) Military-Use Example.
e.) Shell Structures.
1) General Characteristics.
2) Presently Available Examples.
3) Conceptual Example.
4) Military-Use Example.
3.) Evaluation of Responsiveness and Suitability of Alternative Systems.
a.) Evaluation Matrix.
b.) Discovery and Interpretation of Trends.
4.) Implications for Guideline Refinement.
D.) Addendum: Further Refinements.
1.) Omissions.
2.) Corrections.

V.) Final Version of Performance Guidelines.
A.) Prefatory Remarks.
1.) Statement of Situational Applicability.
a.) Disaster Types.
b.) Locational Context.
2.) Statement of Use, User, and Period of Use.
a.) Use.
b.) User.
c.) Period.
3.) Statement of Needs Provided for.
a.) Physiological.
b.) Psychological.
c.) Social.
4.) Statement of Shelter Scenario.
a.) Provision.
b.) Siting.
c.) Operation.
B.) Requirements and Specifications.
1.) Shelter Type.
a.) Reuseable.
b.) Expandable-to-Permanency.
2.) Spaces.
a.) Description.
b.) Sizes.
c.) Nature.
d.) Dimensional Implications.
3.) Materials.
4.) Structural Systems.

5.) Services.
   a.) Electrical.
      1) Power.
      2) Lighting.
      3) Cooking.
   b.) Plumbing.
      1) Water Supply.
      2) Systems Operation.
      3) Sewage Disposal.
   c,) Mechanical.
      1) Heating.
      2) Cooling.
      3) Ventilation.
6.) Fabrication.
7.) Delivery.
8.) Erection/Securement/Placement.
   a.) Foundation.
   b.) Erection.
   c.) Tie-Down.

C.) Cost-Effectiveness.

VI.) Concluding Statements.
   A.) Comments Concerning Performance Guidelines.
      1.) Summary: Process, Significance and Validity.
      2.) Summary: Important Lessons.
         a.) General Process.
         b.) Specific Lessons.
   B.) Comments Concerning A Realistic Shelter Approach.
      1.) Basis.
      2.) Scenario.
         a.) Logistics.
         b.) Hardware.
   C.) Comments Concerning H.U.D. Request for Proposal.
      1.) Description of RFP: Objective, Scope, and Context.
      2.) Description of Tasks.
      3.) Motivating Force Behind This Study.
      4.) Major Areas of Disagreement and Concern.
         a.) Timing Concerns.
         b.) Importance of Performance Guidelines.
         c.) Cost Concern.
   D.) Comments Concerning O.S.T.I. Proposal.
      1.) Background of My Involvement.
      2.) O.S.T.I. Approach.
      3.) O.S.T.I. Statement of Problem.
      4.) Summary Conclusion.

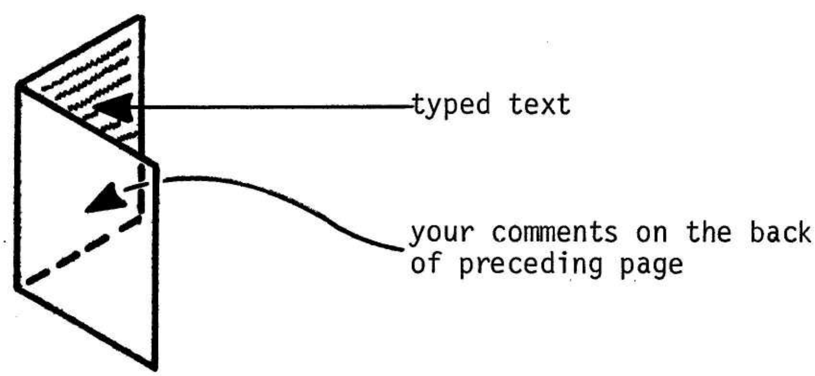
APPENDIX #3

INSTRUCTIONS

The following pages contain a compilation of performance guidelines which I have suggested as applicable to the design of temporary shelter packages for use by the victims of natural disaster in this country. Both the real needs of the victims and the potentialities of present-day technology were researched in arriving at this listing. These guidelines are to cover the disaster situations of tornado, hurricane, earthquake and flood. These guidelines are the result of research which I have conducted in the last months in pursuit of a Master of Architecture degree at the Massachusetts Institute of Technology.

Having composed such a listing, I am now in the position of needing some constructive feedback so that I might refine or alter these performance specifications. I have sent copies of this material to a number of responsible people in private and governmental positions whom I have had some contact with in the course of my investigation, in an effort to obtain their comments. I hope that through this process of consulting people who have some valuable insight into disaster-related affairs, I might arrive at a set of performance guidelines that are more meaningful and that reflect all areas of concern.

I would appreciate it then, if you could find the time to read through this material and write down any comments which you might have on the back of each preceding page which is marked for such purposes.



It would be very helpful if you could note agreements, disagreements, or misunderstandings which arise as you read through these pages. I regret that I am unable to send the supportive material which I have written thus-far, but its rough first-draft form and considerable length prevent this.

It is urgent that I receive your comments as quickly as possible as my thesis deadline is fast-approaching and I intend to use these guidelines in their revised form to attempt an evaluation of the suitability of various existing alternatives. Thank you so much for your kind consideration.

APPENDIX #4

LISTING OF COMMENTS BY CONTACTED OFFICIALS

Mr. William Cosby, BRAB Program Manager: phone conversation, April 27, 1973.

Mr. Robert Berne, AIA, Chief Architect, Defense Civil Preparedness Agency: letter, April 20, 1973.

Mr. Ugo Morelli, Office of Emergency Preparedness, Division of Disaster Preparedness: phone conversation, April 30, 1973.

Mr. Roy S. Popkin, Assistant National Director, Disaster Services, The American National Red Cross: letter, April 18, 1973.

GENERAL COMMENTS:

Mr. Cosby: "I have glanced through the material which you sent me, and it appears to be an interesting and reasonable piece of work . . . I do not have time, however, to give an in-depth response as you have outlined."

Mr. Berne: "Thank you for your letter of April 11 and the Performance-Guidelines section of your thesis.

The material arrived while I was away, and I haven't been able to look at it until now. I note that you are anxious for an early reply to meet an urgent deadline.

I have reviewed it and see nothing to comment on that would affect your development of the project. My one general impression is that the units you have in mind are perhaps more elaborate than necessary under emergency conditions. You might want to keep this in mind as you develop the project further."

Mr. Morelli: "Your results look pretty good, however, I do have some comments . . .

You should add something about costs. Otherwise, you are going to be unrestrained by cost . . . Design conditions are paramount at the outset, but at the end of the process, costs are going to play a dominant role. . . Compare it to a common alternative like the mobile home. . . You need to have some sort of cost criteria to make your selection of alternatives acceptable, to bring it down to earth . . . Otherwise, this excellent effort (performance guidelines) could be wasted . . . Also, you should mention the cost of site preparation. The cost of site preparation is substantial in most current operations."

Mr. Popkin: "Looks good to us. Note comments. ABT Associates in Cambridge is bidding on a HUD R&D Contract for the kind of thing you have done. You might contact them."

Statement of Intended Use, User, and Period of Use

Morelli: "Your time period of 2 months gives me some problem . . . It is a question of cost-effectiveness --- how much are you willing to spend for something which is going to be used for only 2 months . . . You are going to have trouble justifying the expenditure of a large sum of money for such a limited use period . . . If this sort of shelter package is necessary, then perhaps you should make it avaiable within hours. . ."

Popkin: "What about occupancy by two people, especially elderly couples on pensions? This is an urgent need.

Could it be used for up to one year? This would conform to HUD Temporary Housing Program."

Statement of Needs Provided For

Popkin: "Good!"

Statement of Shelter Scenario

Morelli: "Do you mean that the people are to erect their own shelters? . . . Assuming that the person who gets the shelter package will be expected to do this, I don't know how valid this is for a large cross-section of people, especially, say senior citizens. . . In asking myself the question, would I do it? . . . No, I'd probably go to a motel. It is alright to require that an unskilled person put it up, but I wouldn't require disaster victims to do this . . . It takes people awhile to adjust following disaster."

Popkin: "Who erects it? What about utility hook-ups? What about availability of utilities?"

Shelter Type

No Comments.

Spaces

Morelli: "I don't have a very good grasp on area size myself. It seems like an awfully crowded space. . . Perhaps a little larger square footage should be provided . . . I am concerned that all of the types of spaces which you include do not have enough area . . .

(At this point I told him of the comparable relation to the mobile home situation --- 40-45' long by 12' wide)

Well then, maybe they are not too far off then."

Popkin: "Are appliances included? Sinks, refrigerator, stove, toilets, washing machines --- if so, how do they function if no water and/or power lines? Will a well and septic tank have to be dug --- by whom?"

Materials

Popkin: "OK"

Structural Systems

Morelli: "I question the 45 mph design wind conditions. Is this really enough? It seems that perhaps you are sowing the seeds of another disaster. Shouldn't you provide for at least a moderate hurricane of 75 mph. I think your figure is a little low.

Also, concerning an earthquake design loading of 10% of the dead load of the structure, isn't that about .1G? I seem to recall having read recently that some earthquakes produce lateral loadings of as much as 1G. Think about it. We don't want to breed another disaster."

Service Systems

Morelli: "What about an oven? I don't know too much about cooking myself, but how do women feel about this?

Humidity control requires more than most homes come with. I am in favor of it, but this seems to be a little bit too much of a luxury item."

Popkin: "What if power has to be from a portable generator?

This answers previous questions, but where does the 40 gallons come from? Does it have to be hauled, trucked, or what --- if no water lines available?"

Delivery

Morelli: "If you've gone to that extent why not make them fit into the envelope of an existing cargo plane such as a C-141, especially if they are compactable or palletized. Cargo planes can get into most areas very quickly . . . The units could still be trucked back to the storage depots. I don't think this duality of transport vehicles is a real concern. Since you are proposing new design standards, you should include air transport so that its capabilities can be utilized by new products.

Your #3 is not really relevant. They (the military) are there and will always be called upon. Such groups as the Air National Guard, the Corps of Engineers, and Coast Guard are geared for this type of work . . . The military is often the first federal presence felt in disaster. The first reports of disaster usually go to the military district commander. He has the power to automatically respond in many ways without needing approval from higher sources . . . I feel that you are unnecessarily limiting the usefulness of your product if you leave out the military.

A disaster contingency plan has no design impact. It has no relevancy in a listing of design guides. You have to assume that the federal, local, and state governments have some plans for dealing with disasters.

There are 10 federal stockpile regions for disaster inventory presently. These have been developed in the last few years."

Popkin: "Trailer trucks can't get into some areas --- can smaller trucks be used? Pick-ups? Helicopters? Top of a station wagon?"

Erection/Placement/Securement

Morelli: "I have serious doubts about occupant erection.

By minimal equipment do you mean hand tools? I needed that clarification."

Popkin: "Is foundation part of package? If not, who prepares site and puts in foundation? What about small cement piers, cement blocks (like for a mobile home).

APPENDIX #5

H.U.D. REQUEST FOR PROPOSAL

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
WASHINGTON, D.C. 20410

MAR 9 1973

OFFICE OF THE ASSISTANT SECRETARY
FOR ADMINISTRATION

IN REPLY REFER TO:
ASA-1
RFP H-22-73

REQUEST FOR PROPOSAL NO. H-22-73

Gentlemen:

Subject : Request for Proposal No. H-22-73, for the Determination of the Most Cost Effective Housing System(s) that can be Used for Temporary Housing for Families Displaced by Disasters and for Transient Persons

You are invited to submit a proposal to be received not later than 2:00 P.M., local time, April 9, 1973, to the Department of Housing and Urban Development in accordance with this Request for Proposal and the following attachments which are incorporated herein and made a part hereof:

Attachment A:	Proposal Instructions and Conditions (including Addendum 1)
Attachment B:	Factors for Award
Attachment C:	Statement of Work
Attachment D:	Special Provisions
Attachment E:	General Provisions, HUD-747 (1-71)
Attachment F:	Additional General Provisions, HUD-747.1 (4-71)
Attachment G:	Alterations to General Provisions, HUD-747.2 (8-72)
Attachment H:	Price Certification
Attachment I:	Cost and Price Analysis, HUD-745 (9-71)
Attachment J:	Certifications and Representations, HUD-777 (4-71)
Attachment K:	Disclosure Statement - Cost Accounting Practices and Certification
Attachment L:	Additional Certification of Compliance with the Provisions of the Clean Air Act
Attachment M:	Notice of Maximum Permissible Escalation in Wage and Price Standards
Attachment N:	Listing of Employment Openings
Attachment O:	Certificate of Current Cost: Pricing Data

All work called for under any contract resulting from this Request for Proposal shall be completed not later than six (6) months after the effective date of the contract.

It is anticipated that a cost-plus-a-fixed-fee type contract will result from this Request for Proposal. The Department of Housing and Urban Development considers a level of effort in a range of $175,000 - $200,000 to be appropriate for this requirement; however, you are requested to submit a proposal on a basis which is considered to be realistic for the approach you propose. The contract will be awarded to the responsible offeror whose proposal is within the competitive range and determined to be to the best advantage of the Government. The factors to be considered in the evaluation of proposals and selection of a contractor are set forth in Attachment B, herein.

Inquiries regarding this Request for Proposal shall be in writing and be directed to the Contracting Officer:

T. J. Charney
Contracts & Agreements Division
Department of HUD
Room 2140
Washington, D. C. 20410
(202) 755-5450

Attention is directed to Clause 35 of the General Provisions entitled, "Utilization of Minority Business Enterprises" which is contained in Attachment G.

To prevent opening by unauthorized individuals, your proposal should be identified on the envelope, or the wrapper, as follows:

Proposal submitted in response to RFP H-22-73
Due Date: April 9, 1973, 2:00 P.M. local time

LATE PROPOSAL WARNING. The conditions applicable to late proposals in paragraph 7, Attachment A, will be strictly applied.

Address Proposal to:

U. S. Department of Housing and Urban Development
Contracts and Agreements Division, Room 2140
Washington, D. C. 20410

Sincerely,

Nathan Blacker
Chief
Contract Branch

This RFP consists of 49 pages.

ATTACHMENT C
TO RFP H-22-73

STATEMENT OF WORK

I. OBJECTIVES

The objective of this contract is to determine the most cost-effective housing system(s) that can be used for temporary housing for families displaced by disasters and for transient persons.

II. SCOPE OF WORK

General - the housing system(s) shall be evaluated for cost-effectiveness on the basis of the following criteria:

a. Livability - the shelter is to provide an acceptable private living environment for one family with provisions for two and three bedrooms, one bathroom, kitchen and eating area and a living room area.

b. Transportable - the housing system(s) is to be expeditiously and simply transportable by either road or railroad.

c. Storable - the housing system (s) is to be adaptable to conventional storage techniques. Requirements for preparing the system(s) for storage and use are to be minimal.

d. Site Erection - the housing system(s) is to have the capability of being quickly and easily erected on site, with minimum requirements for site preparation and skilled workmen. Utility hookup is to be simplified and adaptable to varying site conditions.

e. Maintenance - the housing system(s) is to require minimal maintenance by the occupants and to be durable for the use intended.

f. Economics - the units shall be competitively priced and will be adaptable for low cost transportation and storage methods. Consideration is to be given to the cost of site preparation, maintenance and rework for reuse.

g. Delivery Time - the housing system(s) should be immediately available for mass production or easily adaptable to mass production methods as used in most sections of the country.

h. Special Consideration - there are three options which are to be considered by the contractor. One is that the shelter is disposable after being used once. The other is to have the shelter either in part or in total be expandable to a permanent home in the area but not necessarily on the same site. That portion that is expandable to a permanent structure must conform

ATTACHMENT C
TO RFP H-22-73

to the HUD directed codes and standards as determined in Task I. The third is that the housing system(s) is capable of being reused and stored several times for either the same disaster area or in other disaster areas.

The housing system(s) will be used at the disaster sites for a period of one month to twelve (12) months after the disaster occurs. The housing for the immediate emergency period will be provided from local facilities and by other non-family type living quarters. This emergency housing is not to be considered in this study.

Disasters to be considered are to include tornados, earthquakes, hurricanes, and floods. These will produce varying conditions which can have an effect on the site preparation and should, therefore, be considered in the design selection.

The (s) on housing system(s) is used to indicate that one or more systems may be selected for a follow on demonstration test and evaluation project.

SPECIFIC TASKS

Task I:

The contractor shall perform a literature search, and investigation of types of temporary housing systems that have been utilized in past disasters, and other types of temporary housing in use or being considered, for example, by the Department of Defense. The contractor shall consult with the HUD, Office of Emergency Preparedness and the Corp of Engineers to get a full understanding of disaster situations, particularly in regard to problems associated with the types of housing systems that have been used in the past.

The contractor shall investigate other forms of housing technology that could be utilized. Sub-system technologies which are not developed are not to be considered. Neither this project nor the subsequent demonstratior project will fund any technology development. It is possible that the subsequent project will demonstrate new developed technology as a part of the housing system.

The applicable codes for the selected system(s) and transportation standards in the disaster susceptible regions of the country are to be investigated and assessed. From this assessment HUD intends within a reasonable period of time to determine the applicable standards and codes to be utilized for disaster housing systems.

ATTACHMENT C
TO RFP H-22-73

Mobile water, waste treatment, and equipment is to be investigated, to determine its applicability.

Task II:

The contractor shall evaluate the cost-effectiveness of the housing systems investigated in Task I on the basis of the criteria given under (Article II a through h) above. This evaluation should result in a ranking of the systems investigated. Those which are highest ranked shall be analyzed on the basis of the cost-effectiveness criteria in greater detail. For example, production start up time, production rate, handling and transportation methods and ancillary equipment and work crew, re-use maintenance, acceptability by and into mobile and modular production facilities, storage and deployment methods, and climatic and disaster conditions. The results of the final evaluation for these systems are then to be ranked and presented to HUD with recommendations and substantiating data for final system(s) selection. HUD will make the selection within ten (10) working days.

Task III:

For the system(s) selected by the GTR, the contractor shall prepare plans and specifications for the housing structure or whatever material, such as working drawings, is necessary for fabrication which might possibly be used to construct a demonstration unit.

The contractor shall present a scenario on the system for a hypothetical disaster, including disposition after use by the disaster victims. All equipment, manpower facilities and time periods shall be identified for the scenario. Costs for the housing system as related to the scenario shall be provided; leasing vs purchase of the system by HUD shall be explored.

In the event that water and sewage are not readily available it may be advisable to use a portable plant. Accordingly, costs, storage and operating characteristics, size, etc., shall be provided on the mobile water and waste treatment plant. Connection method and housing unit capacity for this plant for both single and multi unit use shall be given as well as maintenance requirements. It should be assumed that electric power is available and serious consideration shall be given to using electric heat in order to reduce site and logistic requirements.

In addition to the plans and specifications the contractor shall specify the equipment that will be required to demonstrate the housing system(s). Costs for constructing the demonstration housing system(s) shall be estimated.

ATTACHMENT C
TO RFP H-22-73

Task IV:

The investigation performed in Task I shall be used to enable Task II to be performed on temporary housing for transient families. The units developed through this program could be used to ease the severe housing shortage.

While criteria under Article II (b) thru (g) above still apply, criteria (a) and (h) do not for this type of temporary housing. The units are to be designed with typical hotel/motel accomodations, one bath and one bedroom units. The units are anticipated to have up to two years of service and will be erected in groups on tracks of available land perhaps similar to mobile home parks. Two options shall be considered; one is that the units are disposable after being used once, the other is that the units can be resued, transported and stored several times.

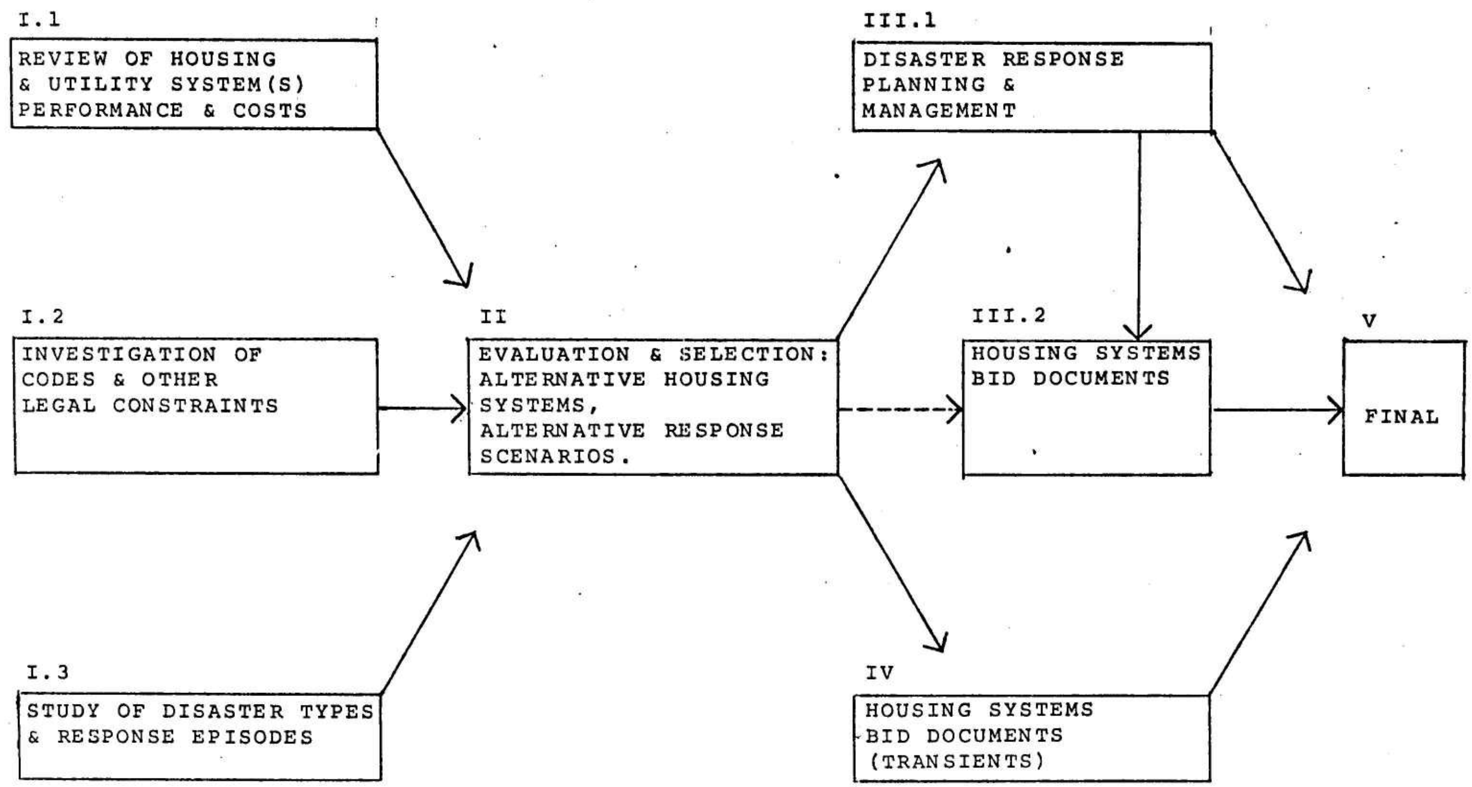
The contractor shall perform the work specified in the first paragraph of Task III for the temporary transient housing. Emphasis in the selection of a system shall be placed on the ability to start on production as soon as possible. A demonstration unit for this system is not contemplated. The contractor shall perform a cost study on the system selected. This study is to estimate the cost of production, transportation, storage and erection. The production rate and erection time shall also be determined, as well as the time to start production of the system and any required support equipment. If any special equipment is required in the factory to fabricate the housing system or subsystem, the cost of this equipment and its availability shall be provided.

The contractor shall also provide a site plan for a 100 unit park, showing utility lines, unit location and vehicular areas. A mobile waste treatment plan and conventional sewage system are to be considered in preparing the site plan. Costs for, except for the mobile waste treatment plant, the site shall not be determined.

APPENDIX #6

OVERALL RESEARCH DESIGN

CHART I



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This bibliography contains not only a listing of the sources directly referred to in this paper, but also a selected listing of additional references that were found to have a bearing on this topic. All of these works cited were investigated in the course of this research. Those directly referred to in the text are denoted by an asterisk (*).

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