LOW COST HOUSING DEVELOPMENT
WITH AIDED SELF-HELP METHOD
IN BAYAMON, COMMONWEALTH OF PUERTO RICO

BY
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Y.Muh. Mim. - 1956 - Technical University, Istanbul, Turkey

Submitted in the partial fulfillment of the requirements for
the degree of Master in Architecture at the Massachusetts
Institute of Technology.
August 1958

Signature of Author: __________________

Certified by: __________________
Thesis Supervisor

Accepted by: __________________
Chairman Departmental
Committee on Graduate Students
To my Father and Mother
320 Commonwealth Avenue
Boston, Massachusetts
August 11, 1958

Dean Pietro Belluschi
School of Architecture and Planning
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

Dear Dean Belluschi:

In partial fulfillment of the requirements for the degree of Master in Architecture, I submit the following thesis entitled "Low Cost Housing Development with Aided Self-Help Method in Bayamon, Commonwealth of Puerto Rico."

Respectfully yours,

Bulent Kastarlak
Acknowledgment

The author is grateful for the aid and support, his enterprises received from many quarters, among which the following are explicitly acknowledged:

Dean Pietro Belluschi

and

Professor Bechwith

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Mr. Calserrada

Mr. W. Chester Browne

In the name of the Advisory Thesis Committee for their guidance, and for the M.I.T. Scholarship which made my trip to Puerto Rico possible.

For his deep understanding and guidance during my residence in M.I.T.

For his close interest and guidance in my studies.

For their close interest and hospitality during my visit to San Juan, Puerto Rico.

For his deep understanding.

Bulent Kastarlak
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Introduction

Throughout the world millions of people live under poor conditions of housing, and in some places even without the simplest means of sheltering. The severe consequences of such situations, being seriously understood by all countries, the government in charge, as well as international organizations, such as the United Nations, undertakes extensive studies over special and common problems of housing.

It is generally agreed that there is no magic formula for the accomplishment of decent housing for all people in need, the circumstances showing various differences and in the meantime, the success of the plans, depending mostly on the careful and flexible execution of the details. However, it is also believed that, among varied solutions, one particular method shows a fairly wide range of adaptability, with special emphasis given to the particular conditions of the area concerned. This method is called "Aided Self-Help Housing." Even though it does not constitute a final and ideal solution, it provides, in many circumstances, a satisfactory answer to the housing needs all around the world.

The success of the method depends widely on the advance preparation of a comprehensive, but flexible, administrative and technical procedure, good public relations, as well as the design aspect of the project.

For this reason, within the thesis, a special and important consideration has been given to the survey and study of the method, together with the architectural characteristics, derived from climatic, social and economic conditions of the project area of Puerto Rico.
The first part of the thesis is devoted to the analysis of these items, aforementioned, and the second part treats the characteristics of the chosen project in particular.
1. **Location and Area**

Puerto Rico is the smallest and easternmost of the four islands, Cuba, Jamaica, Hispaniola, Puerto Rico, which forms the greater Antilles in the Caribbean Sea. It is located between the latitudes of $17^\circ 55' - 18^\circ 30'$ North, and the longitudes of $65^\circ 34' - 67^\circ 17'$ West. It has a shape of a rectangle, measuring 100 miles by 35 - 40 miles in east west direction, covering an area of 3,435 square miles, together with the satellite islands (Vieques, Culebra, Mona).

2. **Topography**

Mountains extend from east to west, broken with alleys. They take almost 3/4 of island's area. They slope down to a flat coastal plain which varies from 8 - 13 miles in width in the north, and from 2 - 8 miles in the south. The highest peak is Cerro de Punto, rising to 4,398 feet of altitude, located on the south west of the chain. The Atlantic Ocean reaches its greatest depth about 45 miles north of Puerto Rico in the Milwaukee depth 27,922 feet.

3. **Geological Formation**

Mountains are of the same period composed of Hornblende gneiss and tuff, in high altitudes blue limestone. Silver, copper, lead, oil, iron are found in adequate quantities for exploitation. However, marble of high quality, granite for buildings, limestone, gypsum, clay for bricks, tiles and rough ceramics are abundant. Kaolin for porcelain is also found. Mountains are covered by erosion deposits, forming a soil of deep reddish clay, loams and tenacious red clay suitable for construction.
4. Fauna and Flora

Rich soil suitable for agriculture provided a rich wooden area, before the occupation of the island by the Spanish, now some remains. The common useful trees are: bamboo, palm, cedar, ebony, calabash, white wood, lancewood, boxwood, logwood. However, they can not be exploited as a major construction material. The plantations of sugar cane along the plains, tobacco in the valley and coffee on the slopes, provides a source of exploitation of the surplus as a construction materials.

5. Climate

Puerto Rico is within the torrid zone, but its climate is hardly tropical.

<table>
<thead>
<tr>
<th>January temperature</th>
<th>73 Degrees Fahrenheit</th>
</tr>
</thead>
<tbody>
<tr>
<td>July temperature</td>
<td>79 &quot; &quot;</td>
</tr>
<tr>
<td>Highest afternoon</td>
<td>86 &quot; &quot;</td>
</tr>
<tr>
<td>Lowest night</td>
<td>68 &quot; &quot;</td>
</tr>
<tr>
<td>Annual temperature</td>
<td>76.5 &quot; &quot;</td>
</tr>
<tr>
<td>Higher interior regions</td>
<td>70 - 76&quot; &quot;</td>
</tr>
</tbody>
</table>

The temperature changes from day to night 6 - 7 " "

Average rainfall is 70 inches. For north coast it is 60 inches. South 30 inches. Central mountain 100 inches. The rainfall is heaviest from September to November. The rains are sometimes heavy, but of short duration.

The average humidity during the day is 70%, and during the night about 85%. 
CLASSIFICATION of CLIMATES

ARCTIC

TEMPERATE

TROPIC

TEMPERATE

ANTARCTIC
5. Climate (cont'd)

Trade winds play an important role on the conditioning of the climate in Puerto Rico. During the day and throughout the year the breeze blows constantly from the north, each direction, and during the night a cool land breeze usually blows from the mountains. During the months of November through April, trade winds reach their maximum intensity and humidity becomes much lower comparing with the summer months. However, there is almost no marked difference between the seasons of the year. At no time heavy clothes are required. Southern parts of the island, however, irrigation is required because comparatively dry climate is prevalent. There are only few days when the sun does not shine. There the climate affords an ideal year round growing season for tropical crops. Hurricanes are occasional, but occurs mostly between July and October.

6. Population

The total population, according to 1950 census, is 2,205,398, with an overall density of 650 square miles, 40% of the population is concentrated in seven urban areas, and 60% in 70 small centers and rural areas.

The population of major municipalities is:

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Total</th>
<th>Per Square Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Juan</td>
<td>223,949</td>
<td>37,461.2</td>
</tr>
<tr>
<td>Rio Piedras</td>
<td>143,897</td>
<td>3,511.9</td>
</tr>
<tr>
<td>Ponce</td>
<td>126,451</td>
<td>1,093.2</td>
</tr>
<tr>
<td>Mayaguez</td>
<td>87,038</td>
<td>1,148.9</td>
</tr>
<tr>
<td>Cagnas</td>
<td>60,132</td>
<td>1,019.2</td>
</tr>
<tr>
<td>Bayamon</td>
<td>43,000</td>
<td>1,0901.9</td>
</tr>
</tbody>
</table>
TEMPERATURES - Monthly Averages, 1955
San Juan City - Degrees Fahrenheit
Annual Average: 78.5

Note: The averages of Bayamon were not available

RAINFALL - Monthly Amount, 1955
Bayamon - Inches of rainfall
Annual Rainfall: 71.72
6. **Population (cont'd)**

The increase of population is one of the highest in the world, if not the highest. It is estimated that with the same rate, the population will double in 25 years.

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth rate</td>
<td>40 per 1,000</td>
</tr>
<tr>
<td>Death rate</td>
<td>10 per 1,000</td>
</tr>
<tr>
<td>Labor force</td>
<td>786,000</td>
</tr>
<tr>
<td>Employed</td>
<td>686,000</td>
</tr>
<tr>
<td>Unemployed</td>
<td>100,000</td>
</tr>
<tr>
<td>Labor in agriculture</td>
<td>39%</td>
</tr>
<tr>
<td>Labor in manufacture</td>
<td></td>
</tr>
<tr>
<td>Labor in trade and transport</td>
<td>18%</td>
</tr>
<tr>
<td>Other, mostly service</td>
<td>19%</td>
</tr>
<tr>
<td>School age children in school</td>
<td>63%</td>
</tr>
<tr>
<td>Literacy</td>
<td>78%</td>
</tr>
</tbody>
</table>

The people of Puerto Rico are descendants of the Spaniards, who conquered and settled the island of the Indians. They found there of the negroes they imported and to minor extent of Portuguese, Syrians, Corsicans, French, Dutch and other immigrants from Europe. However, a particular interest is the lack of tension surrounding racial problems in Puerto Rico. There is little discrimination against the negro, because of color or race. Aside from marriage, such discrimination, as exists racially is chiefly on a basis of class or economic standing.
Figure 4(a).—Winds of the World, January. (Ocean data after W. F. McDonald.)

Figure 4(b).—Winds of the World, July. (Ocean data after W. F. McDonald.)
7. **Way of Living - Customs and Traditions**

Although Spanish customs have been modified considerably, especially in the cities, Puerto Rico today is more Spanish than American. Food, houses, music, literature, family organization, social relationships, training of children, all remain predominantly Spanish. The family is very closely united, and, to a great extent, social life is confined to the family group which is usually very large. (The average family has about 5.5 members). Visiting, talking, celebrating birthdays are recreation times spent at home. The principal amusement, outside the house, are movies and dances. Organized games are not part of the life of the people, although basketball, boxing, and baseball have become popular. Catholicism is the religion of the people, but there are also a number of Protestant churches.

The high and medium income group is brought up by American standards and methods. The native-rural citizen clings to soil tenaciously. He is not very ambitious, but a good and obedient worker. He is rarely a landowner for the most part, either a tenant or a farm hand.

8. **Living Conditions**

At present, a vast majority of Puerto Ricans live not far above the starvation level. Of the islands' 400,000 odd families, some 340,000 (85%) have an income of less than $400.00 a year. There is a small wealthy class and a growing, but still relatively unimportant "middle" class.

Housing, generally, is reduced to a minimum. The most typical house, urban or rural, is a small, wooden, unpainted cabin, built rather high above the ground and roofed with tin or zinc.
8. Living Conditions (cont'd)

It usually has only one room or two with a lean-to, kitchen where charcoal or wood is burned on a high earthen platform, between stones which support the pots or kettles over the fire. Because of the mild equitable climate, Puerto Rico homes are not heated. The chief fault of houses is not that they are unsubstantial with the local standards, but that they are too small.

The diet of the majority of Puerto Ricans, dating from slave days, consists of rice, beans, cod fish, bread and black coffee, supplemented sparingly with fresh fruits and vegetables, principally potato substitutes. There are few storage and no refrigeration facilities available in the rural areas. This, together with the poverty, has led to the custom of buying in very small quantities for day to day, almost meal to meal, use. Even the most primitive sanitary facilities are lacking for more than half the population. Water is scarce and impure, and in rural areas, must be carried from a distant spring, stream or well. However, the irrigation problem is seriously undertaken by the Government as a part of the economical development under way.

Puerto Rico has developed one new type of school which is unique. This is the vocational rural school, known as the second unit school, which provides a combination of academic and vocational training for rural children, through the 9th grade. In addition, it serves as an education and cultural center for both parents and children. These schools direct their programs chiefly toward the community and its particular
8. **Living Conditions (cont'd)**

problems and resources. They emphasize training in agriculture, in simple carpentry and repair work, in cooking, care of children, and in health education. A social worker is attached to each school to work with the families in the community.

9. **Survey of Materials and Construction Methods Commonly used in Puerto Rico**

Generally speaking, the standards of living and the advantages provided by the climate does not require highly technical and luxurious materials and methods of construction for Puerto Rico. For this reason, from a realistic point of view, the prevailing construction materials and skills can be accepted as a base for such activities. However, it is the author's belief that, all existing materials and skills should be subject to an intensive and scientific research as to determine their full use and future potentialities, adaptable to the needs and the conditions of the island.

As to the architectural tren in Puerto Rico, it is true to say that an amalgam of modern, spanish and insipid architecture dominates the field. The spanish influence is more common among the lower-middle income groups and in old sections of the cities. Climatic influence can be seen in wooden structured verandah type houses tilted on piles as a protection against termites. Generally speaking, the traditional spanish style seems to be loosing its importance. But on the other hand, new examples can be qualified as a poor utilization of the contemporary means of architecture.

The primary materials most commonly used are: wood, stone, clay
9. **Survey of Materials and Construction Methods Commonly used (cont'd)**

Products and concrete.

Wood, because of its scarcity and vulnerability against termite actions is generally excluded as a structural material. Stone, as a structural element tends to leave its place to concrete, which presently constitutes the major material for this use. The production of Fonce Cement Corporation has reached 4,093,759 barriles (1 barrile = 376 lbs) during the year of 1956. Thus a significant stimulus is given to construction activities in Puerto Rico. The existing and the future trend in the use of a structural material seems to be the concrete, which is also favored for its resistance against the termite attack and hurricanes, together with the cheapness of its handling.

Clay products, despite the availability of high quality clay, does not have a wide use. It is possible that a better architecture can be achieved with the combination of these two local products of Puerto Rico: clay and concrete.

Glass has no major role in the design of houses. The climatic conditions requires constantly free openings for the circulation of air. Thus the enclosures of the openings should be suitable for such ventilation, together with the provision of privacy and light. For their durability aluminum louvres are mostly used for this purpose. The manufacture of these louvres are also made on the island.

Finally, as to the construction methods, the hand labor constitutes the major element of building construction. Mechanized means are generally rudimentary and rather used in the field. Thus prefabrication of suitable scale remains to be explored.
B. WHAT IS AIDED SELF-HELP HOUSING?

1. What is Aided Self-Help Housing?

Self-help is the oldest and most widely used of all methods of shelter production. Taking the form of aided self-help, it provides in many circumstances a satisfactory answer, if not ideal, to housing needs all around the world. Though it does not represent a magic and final solution to housing problems, it is an important transition from houses built by families with no outside aide, which are usually inadequate, unhealthy and subject to deterioration, to houses provided wholly by building industry which is beyond the reach in cost, for most families.

We might define it as:

Joint and voluntary action of a group of persons who come together to study their problems of housing, to formulate plans for solving them through self-help and community aid and to organize themselves for purposes of mutual assistance and direct action, with minimum outside assistance, and under the technical direction of agencies specially equipped for this purpose.

Because people have not been able to afford houses built on a commercial basis, this technique of group work has brought together the needed knowledge and organization to help individuals build their own houses, working together in their own community. It is usually combined with an educational program which covers, on the community level, a variety of activities, designed to facilitate the participation of the population in improving living conditions and adapting themselves to new and more complex ways.

While self-built housing may appear, theoretically, to mean a
1. **What is Aided Self-Help Housing?** (cont'd)

Lowering of certain standards, in fact, group achievement through aided-self-help has, in most cases, made possible far more adequate shelter than could otherwise be available to the lowest income groups.

Group work enables the provision of many needed community facilities. House building, sanitation, road construction, organization of community services and the means of obtaining a better living and education, can be attacked simultaneously.

Aided self-help is considered the most suitable for assisting persons in low-income groups, who are often unable to make a contribution in cash. The contribution of such persons is made in the form of personal labor, which compensates for their lack of savings or ability to save. The investment of personal labor instead of cash also means that the amount of amortization and interest is reduced, so that in practice, the payments even on a relatively more adequate dwelling, can be more easily met on the percentage of the family budget that must be set aside for such payments, can be reduced. This results in both cases in an improvement in the purchasing power of the worker's wages.

Aided self-help also has merits in guiding the people which are involved, toward a more organized and democratic way of life. It teaches and develops the spirit of solidarity and responsibility which is necessary for orderly progress. It encourages private ownership of property. It provides constructive opportunity for the use of spare time. It gives the family the opportunity to improve its economic position and its social status in the community. It gives each participating family a stronger interest in the economic and political stability of the country. It adds
1. **What is Aided Self-Help Housing?** (cont'd)

hope for a better future for many, even though their government has comparatively few resources. It enables people to solve their own housing needs rather than depend on others. It is obvious that two prerequisites are necessary for the successful accomplishment of the aided self-help program.

1) The active and direct participation of the persons concerned.

2) The technical and financial assistance of agencies capable of directing popular action for adequate housing construction.

It should be also noted that programs of aided self-help can be carried out independently of outside assistance, as in the case where countries with a high level of education and a wide range experience with co-operatives and similar undertakings. Governments can bring to realization the surge toward economic and social progress by making the initial step toward better housing and communities, a part of their immediate development programs. The objective would be to formulate basic standards for community services, house types and construction methods corresponding to each country's potential. This means assigning a high priority to the utilization of readily available resources and exercising ingenuity in using the skills and materials at hand. In these circumstances aided self-help can become a lever for continuous betterment of living conditions in general.

Aided self-help is a kind of co-operative institution. The co-operative house building group usually acquires a property from different sources and gives title or full ownership to individual members or families for either the land and/or buildings after completing one or several of the following items:
1. What is Aided Self-Help Housing? (cont'd)

1) Bulk purchase of land and subdivision into individual parcels, with or without provision for community ownership and maintenance of some portions, such as parks and other facilities.

2) Joint architectural and planning services, legal work, etc.

3) Communal installation of streets, water supply, power utilities, etc. in areas where this is not clearly a municipal responsibility.

4) Mass purchase and supplies of materials.

5) Construction of houses or apartments on one building contract.

6) Provision of services such as co-operative buying, maintenance, and operation of nursery school, recreation center, etc.

7) Safeguards against speculation in the sale of property and/or dwellings whose value may have been changed as a result of co-operative activity.

Land Tenure - Control over the ownership of land may be exercised in the sale of immovable property and in the subdivision and partition of land. Some countries give land freehold, others prefer to lease it or to grant it in usufruct, for long terms, ranging from 60 to 99 years at a low annual rental. The advantages of the latter system are obvious. It prevents land speculation by controlling land over a long period of time. This control is exercised by preventing the sale or the transfer of the property by the owner without taking the approval of the committee in charge. In Sweden another alternative is in use. The speculation rendered difficult by the ruling that anyone who has once sold his dwelling cannot erect a new one. However, this matter of controlling land is not favored by all the countries for the reason that, especially in developing areas, people build
1. What is Aided Self-Help Housing? (cont'd)

houses merely to satisfy their needs and not, as in the case of more developed areas, for benefit and speculation. For this reason, wherever it is possible, the land would have to be given in freehold.

Financing - This should be adjusted according to the financial capacity of the groups for which the program is intended. In some cases the central or local government authorities provide the land as well as the water supply, sewage system, road and other utilities. In others, the persons participating the program, have to install part of these utilities on their own account, such as in Norway, where they are responsible for the construction of the roads and of the water and sewage systems as far as the main lines. However, it should be noted that when the authorities provide the utilities, the cost is not always charged against the beneficiaries.

In addition to their contribution of personal labor, the participants must, as a rule, pay all or part of the cost of the building materials, as well as the cost of supervision and technical assistance. In places where the land is granted freehold, non repayable, interest free loans are granted to serve as a guarantee for the fulfillment of certain obligations. If these obligations are not fulfilled, the land, plus interest, may become payable in full.

The initial payment of the dwelling by the occupant usually varies between 7 and 10%, which is generally considered equivalent to the labor that has been put into the construction of the dwelling. However, this 7 - 10% does not reflect the correct value put by the participant as a labor within the total cost of dwelling.
1. What is Aided Self-Help Housing? (cont'd)

Possibly as much as 40% or more of the total cost is represented by the cost of labor. Where there is a mass purchasing of materials, simplification of design, mass production of a number of the parts and a substantial reduction in land costs, the share of the labor in the total cost may be larger. Consequently the possibilities for capital formation through self-help in housing appear very great. Moreover, the expenditure is more capable of being placed on a self-finance basis. With the increase in the cost expenditure required, it becomes possible for the individual to repay all, or part, of it from his current income. It may even permit him, directly or indirectly, to take advantage of financial institutions set up for this purpose, since he can offer security, having a cash value far in excess of the actual cash cost. A further advantage is that government funds to supplement self-help can affect more housing improvement than when they have to employed for the entire cost of construction.

The hourly rates of the participants are determined by one of two criteria. It is either less or more than the average wage paid locally to construction workers. The first of these alternatives is the more usual, where interest in the program is so apparent that there is no danger of the participants failing to perform the work which they have undertaken to contribute. The second alternative is used where an inducement is needed to ensure that the work contribution will be fulfilled. The purpose here is to fix a wage rate that will provide compensation for house of work which elsewhere would have been paid for in cash. The result is that the financial investment is increased.
1. **What is Aided Self-Help Housing?** (cont'd)

It is also customary to require a small cash contribution when a project is carried out by a housing association based on the principle of aided-self-help, because such an association is always required to have some initial capital before it can obtain permission to function. This practice is most common in countries where the land must be bought or must at least be paid for in part, while the necessary loans are being negotiated. Government loans are granted on the basis of the number of square meters of building area, subject to prescribed minimum and maximum limits. Subsidies are granted on the same basis. However, the methods of payment differs. In Scandinavian countries, the loans are paid out piece-meal as the work progresses. In other places, the loans are paid upon the completion of specific stages of work and in accordance with initial budgets approved by the government financial agency. If the cost of a specific stage of the work proves greater than the sum provided for in the budget, the loan is not paid until the difference has been made up in cash.

**Organization** - It generally involves two stages:

1) **Preparatory stage.**

2) **Development stage.**

The first stage is an important one and consists of preliminary meetings designed to arouse the interest of a specific locality or group of persons in housing as a community problem. In some cases, the group must undergo an extended period of preliminary training, not only in housing problems and the methods of solving them, but also in the philosophy of co-operation, advantages, methods of co-operation. It is considered indispensable that the participants be completely familiar with the program, the by-laws,
the relevant legal provisions as well as technical knowledge, so that they will be thoroughly aware of their responsibilities and prepared to accept them freely. Experience has also shown that a fairly long period of preparation tends to eliminate the persons who are not genuinely interested in the program and leaves only those who by their perseverance in the initial stage, which is the least attractive is a true guarantee of the success of the project. The education of the citizen cannot be limited to the traditional formal schooling. All agencies affecting the individual such as school, press, radio, television, religious center, must be mobilized so that the undesirable social habits may be eliminated and good habit of responsible citizenship instilled which will arouse interest toward better housing. The degree and extent of this education depends rather to the cultural level of the people concerned. There is a difference of method and period in the educations of an Scandinavian and African people.

The work of guidance and training preceding group organization, should be directed by persons who are well qualified with respect to both technical ability and their understanding of human relations. The person in charge should be able to give explanations over the administrative details of the project as well. Because a complete understanding of the problems involved, is indispensable, and will to a large extent, determine the success of the program.

In connection with the education or training required for the construction work, it is of interest to note that the principles underlying the construction of single family houses are very simple and can be mastered with surprising rapidity by even the most poorly educated farm worker. Once a group spirit has been created and a definite desire and determination to secure
adequate housing has been instilled, it is an easy task to
teach the necessary simple process of construction. The
instructions should be very clear, the tasks to be performed
by each group or person should be clearly defined. In
addition, the participants in the program must have a com-
mittee that will properly represent them as their sole
spokesman before the agency in charge. As order and
discipline are of paramount importance, agreements are often
signed before hand among the members setting forth their rights
and duties.
The key man in this stage of the program is the master builder,
his duty is to teach the workmen how to build and to ensure that
the construction work is well done, but it is not his duty to
build the house himself. It is very important that there should
be complete agreement on the building plans before work is begun
and that they should be in perfect harmony with local requirements,
and so far as possible, with the personal wishes of the future
occupants. The plan of the house may be designed to be construc-
ted by steps. It can be so arranged that the construction starts
from the nuclear unit to be expanded later as long as the owner
can afford. Any change during the process of construction might
cause an increase in the cost and occur undesirable delays.
Especially the last factor should be taken into consideration
as regards of its effects over the participants. It might
produce discouragement and weakening of interest to the
project.
After building their own homes, many of the workers will become
semi-skilled. The family will benefit, because the man of the
1. **What is Aided Self-Help Housing?** (cont'd)

The house will have learned how to keep up and improve his home; the construction industry will benefit, because a new source of skilled and semi-skilled labor will have been created; and the government will benefit, because effective "vocational schools" will have been established at an insignificant cost for persons who never had the opportunity to attend such a school.

The preliminary stage is also important as a means of selecting a group that will be as homogeneous as possible. This will be helpful not only in establishing mutual understanding and a sense of solidarity, but also in such practical matters as the time of meetings and the performance of the work. Projects of this kind are the most successful when carried out by persons employed in the same factory or business concern or engaged in the same trade or profession.

This preliminary stage is usually under the direction of a government agency with a highly specialized staff or of an organization for example a university doing extension work, or an association especially established for the purpose.

**Forms of Organization** - In case of aided self-help, a housing construction program is generally carried out by one of two types of organizations.

1) **Duly organized association.**

2) **Group of persons who jointogether for the purpose of constructing housing, but not bound to each other by legal ties.**

The legally organized association is usually either a co-operative association or a non-profit housing association of the joint stock type. The form of organization adopted is generally determined
by the legislation of the country concerned and by the particular advantages which the members wish to obtain. The form of organization adopted is generally dependent upon the type of administration desired, for in the co-operative association the members themselves are the managers, but in the joint stock type of association, they do not always exercise control, even though they may possibly be represented on the board of directors. It is important to note, that, associations based on the principle of aided self-help, the very nature of the contribution of personal labor gives a member a right of co-ownership and he can never be a mere tenant as in the case of other non-profit associations. However, this does not mean that every member is necessarily the owner of all the immovable property and the members are required to sign leases in its favor. Only when a member has paid off his debt, may he become an individual owner.

The second form of organization requires greater care and attention on the part of the authorities, because the legal obligation here is a personal one between each member and the financing agency. The members in this case are usually more interested in obtaining private ownership of their homes than in merely satisfying their housing needs, or they must, on the other hand, be provided with the incentive of private ownership, so that they can be persuaded to take part in the common effort which is needed to carry out the program. In practice, however, certain restrictions on such private ownership have been found necessary in order to prevent speculation, the improper subdivision of land or other undesirable features inherent in this system. For this reason the land is not usually given freehold, but is granted in usufruct or under
1. What is Aided Self-Help Housing? (cont'd)

A long term lease. The responsible agency, however, after considering the circumstances, permits property to be transferred without revocation of the subsidy. It should be noted that this form of organization through temporary groups is very common in rural areas, but then in urban areas the legally constituted association is more usual.

In case of the temporary groups, there is the problem that a fresh start must be made with each one, because once a project is completed the members are no longer joined by any mutual ties, except those which may have been established through personal friendship or community of interests. This obviously makes a difficulty to preserve the continuity of efforts for future projects. The matter of keeping the interest alive depends merely to successful organization. Wherever this interest tends to fade out, for the sake of the project, it is necessary to prefer legally enforced associations and not groupings.

Aided self-help projects are usually so organized that people will have to work together in smaller groups. This means that there is better control of workmanship and instruction with decrease in the cost of supervision. There is less opportunity for the individual to become discouraged and there is more flexibility in allocating an individual worker's time. As for the size of these groups, there is no set figure, but the suggested desirable figure seems to be from six to eighteen families. The group size should be such as to avoid having idle hands during a working period, but also to ensure having enough men available to do a continuing job, as all members of the group may not be able (because of other employment) to work at the same time. Another rule of thumb is that the
1. What is Aided Self-Help Housing? (cont'd)

The group should contain sufficient members to provide enough money to build one house between them. In countries where self-help housing is undertaken for the first time, it is advisable to build demonstration projects. In this case the current experience should be systematically examined, recorded and made available for wide distribution. Each demonstration project should be formulated and developed in the light of specific objectives of cost, livability and further application.

Types of Assistance - Type of assistance required depends on whether the farmer owns his land and a building tradition still flourishes, the problem is mainly village development. Some of the richer communities can pay for most of the developments themselves, but all require technical assistance. Many communities needs loans as well. The landless peasant needs, first of all, security of tenure, then financial or material assistance, to obtain manufacturing material and advise. The town dweller requires other forms of assistance. The more sophisticated may only need a building loan. The wealthier town dweller may be able to purchase or lease the site for cash, but most families will require financial help in the form of long term loans. Except for families recently came from countries and workers in the building trade, few town dwellers possess any building skill. Most town dwellers will, therefore, need materials as well as technical help.

Programming the Aided Self-Help Housing - The successful development and application of aided self-help methods requires the preparation of a program realistically conceived from the economic, social, technical, administrative and financial points of view. This requires:
1. What is Aided Self-Help Housing (cont'd)

1) Planning.

2) Execution of the plans on a test demonstration basis.

3) Initiation of a large scale activities based on experience derived from the test demonstrations.

4) Continuing analysis and revision to improve the program.

From an economic point of view, an aided self-help program should be based on the following principles:

1) It should be adapted to the financial resources of people and government.

2) It should provide security of tenure on building sites, so that the family will have the incentive to invest its labor and savings in home improvement; this incentive is essential to the success of the aided self-help approach.

3) It should be integrated with a national program of economic development. Otherwise, it may either be in conflict with other urgent projects, or fall short of utilizing available manpower and other resources.

4) It should be component part of a larger aided self-help program designed to provide basic needs: water, food, fuel and clothing as well as housing social services, such as education and health care; and local public works, such as roads, drainage and public buildings.

5) It should be an integral part of the country's over-all community development and housing program, which may include various housing measures in addition to aided self-help.

From a sociological point of view, an aided self-help housing program must take into account the customs, social organizations and desires of the people concerned.
1. What is Aided Self-Help Housing? (cont'd)

The technological aspects of the program should include effective and economical use of native natural resources for building materials. Production methods, design and construction techniques should be adapted to the aided self-help approach, but should result in structures that are safe, sanitary, healthful and suited to the climate.

The administration of the program should comprise simple, practical methods that can be widely duplicated and can utilize available personnel. A scheme that can only be operated by a genius is of little practical value.

The financial arrangements also should be practical and economically sound.

The program should be flexible enough to be adapted to the differences that exist between communities and to their eventual development. The application of a stereotyped and standarized plan of aided self-help housing to a community may have certain advantages of efficiency at the start, but to be enduring and meet widespread needs it should be flexible within the broadest practical limits. This applies not only to house design, but also to land planning and development and to methods of organization and finance.

Role and Limitations - It has been shown that there are a number of different groups of people who could be helped. Most require assistance in the form of sites and loans of money or materials; nearly all want technical advice, some want far more help than others. The wealthier groups can build to the standards set by ordinary building regulations, but for many, if aided self-help
1. What is Aided Self-Help Housing (cont'd)

schemes are to be practical, building must be simple and some of
the standards must be relaxed. This probably means that less fire
resistant and durable materials might be permitted, sanitation
should be simpler and possibly there should be fewer and smaller
rooms. The risk of creating new slums is therefore greater. To
overcome this danger, it is necessary to increase the space
between buildings and to strengthen public health and building
inspection.

The layout of aided self-help housing in towns creates special
problems, because the density of such housing needs to be ap-
preciably less than, for example, urban rental housing built in
terraces by a public authority. Except in a few special cases,
this type of housing has to be detached because of the lower
building standards. Although the cost of the separate houses in
and aided self-help scheme is likely to be appreciably less than
in a model housing rental scheme, the community may have to bear
an additional cost for transport, and if the housing is not to
become new slums, an increased public health load.

There are other limitations with respect to utilizing aided
self-help methods in larger towns. These methods are particularly
useful when there is a seasonal unemployment, under employment or
unemployment. If a worker is regularly employed, however, has
little time and even less inclination to devote his limited free
hours to the building of his own home. This is especially the
case in a developing country where he may be suffering from
malnutrition and have little surplus energy. Other limiting
factors are the long journey many workers would have to take from
1. What is Aided Self-Help Housing? (cont'd)

their place of work to the construction site, and the desire on the part of many city dwellers for more durable construction than may be possible under aided self-help conditions. It is also a fact that the savings involved in using aided self-help housing in larger towns are not so great as may seem at first sight. There may be a tendency for individuals to add to their own house during the progress of the work, thus increasing group costs, problems and complications. This can be countered several ways. The materials that are delivered to each site should be just enough to erect the minimum house core. There should be complete understanding that all houses in any one group are to be built simultaneously, building must be finished within a reasonable length of time, six months to a year, at most.

In many countries there is a group of people, the lawless, the permanently unemployed, the aged or sick, who will not or cannot house themselves or who, even if given substantial assistance, would be unable to maintain a decent home. Theirs is a social problem and not a housing problem, and it would be not wise for governments to place the responsibility for accommodating them on a housing organization. To do so might jeopardize the success of housing as a whole. There are, perhaps, exceptions; for example, it should be possible to house small numbers of aged, poor as a part of a general scheme for improving the housing of a community. This is particularly so in villages.

The expansion of self-help in housing is primarily technical and social. Among the technical obstacles is the fact there is a limit to the amount of technical supervision that is worth while, and the possibilities of wasted efforts and materials
1. **What is Aided Self-Help Housing? (cont'd)**

exist, especially if there are no appropriate skills or guidance, among the social obstacles to self-help, are the prejudices against such type of manual and unskilled work which sometimes occur. Another is the difficulty of securing co-operative voluntary effort for extended period of time. Moreover, there may be opposition in urban areas, to workers in the building trades.

The difficulty of providing the necessary man-hours of work can be overcome by using the seasonal spare time, holiday time, by introducing labor saving devices like seed drills or by making available a shorter working hours in the industry, also by the introduction of new methods, which are the results of an accompanying research work, requiring less time for the erection of a house.

Aided self-help on a large scale is very difficult as it requires great organizing ability, the most skillful human engineering, the greatest ingenuity, much patience and understanding.

**Conclusion** - Experience indicates that the success of aided self-help housing schemes depends to a considerable extent on the following:

1. Advance preparation of a comprehensive, but flexible administrative and technical procedure.

2. Good public relations to ensure that,
   a) Families understand and accept a scheme and that objection is discussed and overcome.
   b) The local community approves and co-operates.
1. What is Aided Self-Help Housing? (cont'd)

3) The careful selection of families, so that special help can be given to those who need it; those who are unable or unwilling to help themselves should be eliminated from the start.

4) Technical and administrative leadership to ensure co-operation, continuous interest and a reasonable standard of building and particularly to ensure the completion of building and subsequent maintenance and improvement.

Aided self-help housing is not a stop-gap measure, nor is it in any way a magic solution to all housing problems. It is, however, a very important and useful way of providing better housing so long as it is related to a continuing housing policy, and particularly in and around towns, to a well-thought out plan for land use and development. It provides more and better houses and communities than any other method and at far less money cost. It rewards in terms of greater fulfillment of the spirit of co-operation and achievements are very great.
Rural aided self-help in Puerto Rico is part of the Department of Agriculture's Social Programs Administration which attempts by a variety of means to improve the life of the villager. These means include providing plots of land to the squatter and the landless peasant (agregado), providing farms up to 20 acres to share-coppers and tenant farmers; they include the design of rural villages, establishing services and facilities such as schools, health centers, cooperatives, etc. Naturally, these accomplishments, in the face of Puerto Rico's intense density of population and limited resources, is slow. The Social Programs Administration also included "The Minimum Urbanization Program", which provides lots adjacent to urban areas so as to take care of the natural expansion of the towns. Community services and facilities are expected to be provided following aided self-help methods after the families have moved to these new lots.

In 1949, the idea of aided self-help was first tried. Twelve peasants of the rural community "San Jose" of Toa Baja, after a year of study sessions, discussion and planning, tore down their shacks and built, out of concrete blocks and reinforced concrete, new homes at a cost of about $300.00. The market value of these houses is estimated at $1,000.00.

This program was continued. It provided for life tenure of the land. The financing included a subsidy of fifty per cent to be repaid in 10 years at no interest. The later projects require a $30.00 down payment in cash. The house, which is 18' x 18', includes a living-dining room, two bedrooms and a porch. The
kitchen must be built from the salvageable material of the shack previously lived in. This eliminates the possibility of two structures on one plot. Electricity is provided, as in an outdoor privy.

As the program continued, changes in design have taken place very fast. First, the use of prefabricated slab was successfully introduced; it simplified roof construction. Also a set of forms have been introduced which reduces the construction period to four months. In this case, the kitchen is included in the reinforced concrete house. Costs have been kept down to the original $300.00.

The original house of reinforced concrete, concrete blocks, and a reinforced, concrete slab, is still used. The necessary equipment is simple, and inexpensive. And although construction takes from eight to ten months, projects of an extended size can be accomplished.

In these projects, choice of location and candidate is closely considered. The location must not only need housing, it must have interested families, adequate roads, water, sand and gravel, and show a generally cooperative spirit. Meetings are held to inform communities how they may qualify. Then, when a community qualifies, another meeting is held where possible candidates are told how they may qualify, as only a restricted number may be chosen, usually a group of twelve, fifteen or eighteen. In general, for a man to qualify he must be the head of a family, in need of a house, and be cooperative, reliable, trusted and trustworthy.
2. Survey of Aided Self-Help Housing in Puerto Rico (cont'd)

He must be a man of his word, as he is not bound by a written contract. Prospective candidates are thoroughly investigated, and each family is visited in their home.

When the candidates are approved, three men teams are made up, a board of directors is chosen, the date of commencement is decided upon, and the work begins.

The actual construction work is closely supervised for quality; a foreman, occasionally a man who has gained experience building his own home, supervises the pouring of the foundation and floor slabs. All the houses proceed at closely the same time - no house is finished before the others. The completion of the houses is an occasion for both community and family celebration. Through their cooperative work, plus some help from the Government, they have strong, verminproof, well-ventilated, weatherproof houses built at a money cost of $300 but work at least $1,500.

Puerto Rico's "Land and Utilities" project is an attempt started after the war to ameliorate conditions in urban slums. Basically, it provides plots of regulated size and proper utilities, so that those slum dwellers who have houses worth preserving, and at least 25 per cent do, can relocate them in a decent environment. As most of these families do not qualify for orthodox low-rent projects, and as they are leath to give up ownership of their houses, this program was developed. Through experience in Ponce and Mayaguez, more practicable standards have been developed.

All lots in San Jose in Rio Piedras, are provided with water and sewer lines. Generally, a concrete sanitary unit, divided
2. **Survey of Aided Self-Help Housing in Puerto Rico.** (cont'd)

into four compartments, is constructed at the rear intersection of every four lots. The present cost of lots of this type range from $900. - $1,000. per unit. The main elements making up this cost are: lot (250 sq. meters), paved streets, sanitary sewer, drainage system, electrical distribution system, street lighting, fire hydrants and sanitary units. Transportation of a house from slum to the project costs $35.00 which is paid by the Housing Authority. An additional amount is invested by the Authority for foundations and improvements. The total cost ranges from $92.00 to $900.00, depending on the type of house moved; the average is $300.00.

Both the secure tenure and the improved lot and environment stimulates many families to improve their houses. Statistics of the Insular Bureau of Permits show that during the fiscal year 1950-1951 about 10 per cent of the houses were improved through major repairs or expansions, about 50 per cent had minor repairs.

Rents range from $1.00 to $4.50 per month, depending on family income. Families can also elect to buy their lots on a twenty year payment plan. Also the Housing Authority provides for unemployment and sickness; and all hardship cases are thoroughly investigated by the Authority's social workers. About 12 per cent of the occupants fail to pay their rentals on time. And about 15 per cent have sold their homes at a substantial profit, and in some cases real estate agents have taken advantage of this. The Housing Authority, however, is seeking to eliminate this evil by providing for regulated sale, the profits to be
2. Survey of Aided Self-Help Housing in Puerto Rico. (cont'd)

shared with the Housing Authority.
3. A Study on Attitudes - El Embalse Rehabilitation Project, San Jose, Puerto Rico.

The Area of Embalse. - Over the past ten years, as a result of a slum clearance program initiated by the Puerto Rico Housing Authority, the government has relocated approximately 104 families in El Embalse, an area near the San Jose Housing Project. Most of the present residents of El Embalse are people who had been evicted from slum areas such as El Fanguito, Hoare and Tras Talleres, but approximately one out of four families came from non-slum areas.

The Embalse Project Area, composed of six blocks of small households, in an undeveloped community that lacks sewage, paved streets, sidewalks, adequate lighting system and other minor municipal services. Because of the deteriorated appearance of the dwellings, this area was chosen as a suitable location for the Self-Help Demonstration Project.

One major purpose of the Embalse Project is to study and determine both the human and technical problems, possibilities and methods that arise in rehabilitating low income houses through a self-help cooperative project. To aid in accomplishing these aims an Attitude Survey was undertaken in the community. This survey provides answers to several important questions that are basic to the development of the Self-Help Demonstration Project. The questions are as follows:

1) Motivation for Improvement: Do the residents of the Embalse Area want to improve their homes and neighborhood? Are they willing to sacrifice to do it?
3. A Study on Attitudes - El Embalse Rehabilitation Project (cont'd)

2) **Needs:** What are the types of improvements they say they need and want? What are their orders of priority?

3) **Work Solutions:** What are their preferences as to the most economical means for improving their houses? How many propose cooperative means and how many prefer to do the work themselves?

4) **Construction Skills and Experience:** What are the available skills and experience in building construction among the potential work group of men?

5) **Friendship Patterns:** What are the existing friendship patterns within the area? Can they be exploited as work groups?

6) **Identification of Leaders:** Whom do they consider to be the leaders in El Embalse?

The attitude survey helps to answer several basic questions pertaining to El Embalse Demonstration Project.

1) **Motivation for Home Improvement.** - In terms of the various indices used to measure motivation, it seems clear that, with the exception of a group of approximately 25 persons, the residents are highly motivated to improve their homes in El Embalse. In general, they have a positive attitude toward the Housing Authority, based on previous experience, and are happier with their present location than with their former slum residence. Nine out of ten of the families own homes in El Embalse, and fifty per cent of them built their present house with their own labor, proof of past interest in home improvement.

Seven out of ten persons said they were satisfied with their
3. A Study on Attitudes - El Embalse Rehabilitation Project (cont'd)

homes - for the reasons of pleasant location, the lot, or the fact of home ownership. Very few were satisfied because they felt their house needed no repairs or further improvements.

The survey found that the people took pride in home ownership and that they shared the dream of a painted attractive cement house, with modern plumbing, a neat yard and a fence. Their housing ideals approximated those of any middle-class urbanite.

In terms of the location of their homes, three out of four residents of El Embalse took pride in their neighborhood, emphasizing its peacefulness, good neighbors, and progressive spirit. In brief, they were content to live in that area, although they had specific complaints about lack of sewerage, condition of streets and poor transportation.

More than nine out of ten informants had specific plans for improving their house and yards. These repairs ranged from a job such as plastering to rebuilding the house of reinforced concrete. Furthermore, over 61% of the people stated that they planned to repair or build a fence, that hallmark of pride in home ownership.

In response to the question of the type of sacrifice they would be willing to make in order to improve their homes, more than one-third suggested a plan of donating their own labor, and another third suggested economizing on the household budget or depriving themselves of various items in order to accomplish the housing rehabilitation. A small group of 25 persons were
3. A Study on Attitudes - El Embalse Rehabilitation Project (cont'd)
not willing to make any sacrifice. From these results, it seems evident that if willingness to sacrifice is the acid test of motivation most of the El Embalse residents were well motivated to improve their homes.

2) Level of Needs -

A) In the home installation of a toilet led the list of improvements most urgently needed, followed by various repair jobs on the house, such as plastering, painting, repairing walls, windows, doors, roof, garage, fence, etc. However, only one-third of the people felt they could afford to make those improvements with their present income. Two out of three said they lacked the wherewithal to do the job.

B) In the Neighborhood: The residents of El Embalse agreed that sewerage system, paved streets and sidewalks, services of police, fire and postal delivery were the three basic improvements most needed in El Embalse.

3) Work Solutions: What are their preferences as to the most economical way to repair their homes? According to their suggested solution the residents fell into four groups.

Group A - all those who suggested a cooperative work plan (22 persons); Group B - those who suggested asking the help of friends and relatives (80 persons); Group C - those who said they wanted to do the work themselves and who did not suggest asking the help of friends (45 persons); and Group D - those who did not mention any other alternative, cooperative friends aid or self-help, but rather referred to economy plans such as getting a loan, obtaining the cheapest material, etc. (33 persons).
3. **A Study on Attitudes - El Embalse Rehabilitation Project (cont'd)**

Group A and B were shown to be most similar in attitude and in education and income, but were distinguished from each other by the fact that the cooperative were older and had previous experience in cooperative organization.

Group C and D were the most negative in their attitude toward relocation and the Housing Authority. Furthermore, they registered the highest satisfaction with their homes; and had the lowest educational attainment, and family annual income.

It is suggested that Group D - the economy group would pose the most problems for a housing rehabilitation program, mainly because they revealed the lowest motivation for home improvements and for willingness to sacrifice to accomplish the job.

However, Group C, comprised of those who wanted to do the work themselves, without aid of friends, seems highly motivated to improve their dwellings. And, as evidenced by their present housing condition, their houses have already been improved by their own efforts. Furthermore, this group indicates considerable willingness to sacrifice themselves or their money to improve their homes. Their main negative characteristic is their attitude toward working with other people.

4) **Construction Skills and Experience:** Almost three out of four men in El Embalse have had some type of construction experience; carpentry and masonry being the most frequent skills cited. There were also several persons who were familiar with the more technical construction skills required in building houses.

Both the available skills and experience in building construction
3. A Study on Attitudes - El Embalse Rehabilitation Project (cont'd) among the El Embalse residents and their eagerness to learn new skill constitute evidence that the Demonstration Project could mobilize this potential work group into an effective construction crew.
El Embalse
3rd Phase

El Embalse
3rd Phase completed

El Embalse
4th Phase
C. HOUSING AS CLIMATIC PROTECTION IN WARM HUMID ENVIRONMENTS

1. Housing as Climatic Protection in Warm Humid Environment:

Nature of Warm Humid Environments. — In contrast with hot dry environments, these are characterized by only moderately high temperatures (seldom exceeding skin temperature), moist air, and damp ground. Cloud and moisture vapor frequently filter our portions of the solar radiation; the damp ground and free water have a high heat capacity and so heat up less readily; and vapor readily condenses and falls as precipitation; so that here, too, a cycle of events tends to perpetuate itself. In fact, near the equator, variation is minimal unless local topography, such as the relation of mountains to winds, introduces seasonal variation. Further away from the equator, of course, the annual march of the sun and seasonal winds introduce variation, so that the typically warm humid conditions are limited to one period of the year. The moisture, combined with moderate heat, is favorable to the growth of vegetation, which still further reduces radiation by its low reflectivity. It will be seen, therefore, that the radiation load is usually not great, and that there is usually some opportunity for heat loss by conduction, so that the amount of heat that the human body has to eliminate by evaporation does not greatly exceed that produced by metabolic processes. Evaporation, however, is usually difficult. To establish a vapor pressure sufficiently higher than that of the ambient air, the skin has to develop an extensive water film. Sometimes, indeed, even complete wetness is barely sufficient to maintain the necessary difference, and a set skin is distinctly uncomfortable as well as susceptible to certain disorders. Air movement
Figure 13.—Heat exchange in warm humid environments.—Note the intermittent incidence of direct solar radiation, and the absence of reflection from the ground. Reflection from clouds, however, may be considerable. Note also absence of long infrared exchange with ground or “sky.” There is virtually no heat exchange by conduction. Heat loss by evaporation is difficult, but very much accelerated by air movement.
<table>
<thead>
<tr>
<th>Item</th>
<th>Magnitude</th>
<th>Effect on human heat balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct solar radiation</td>
<td>Moderate to high but shade abundant</td>
<td>Moderate to fairly marked addition to heat gains.</td>
</tr>
<tr>
<td>Solar radiation reflected from clouds, etc.</td>
<td>Moderate</td>
<td>Some addition to heat gains.</td>
</tr>
<tr>
<td>Solar radiation reflected from ground, etc.</td>
<td>Little</td>
<td>Little effect.</td>
</tr>
<tr>
<td>Thermal radiation, exchange with ground, etc.</td>
<td>Little</td>
<td>Unimportant.</td>
</tr>
<tr>
<td>Air temperature</td>
<td>Slightly below skin temperature. Slight addition to heat loss.</td>
<td></td>
</tr>
<tr>
<td>Air vapor pressure</td>
<td>High</td>
<td>Restricts opportunity for the heat loss essential to restore balance.</td>
</tr>
<tr>
<td>Air movement</td>
<td>Variable</td>
<td>Promotes heat loss.</td>
</tr>
</tbody>
</table>
facilitates the evaporation, but jungle growth is often an effective screen against air movement.

**Principles Directed to Reducing Human Heat Production.** - It is at least as important to eliminate unnecessary heat production in warm humid as in hot dry environments. Some would maintain that it is even more necessary, since many persons have a greater dislike for the discomfort induced by "sticky" conditions, and particular difficulties are introduced into housekeeping by the prevalence of molds, insects, and general dampness. Accessibility of stores to the point of use, accessibility of waste receptacles, easily cleaned surfaces and utensils, avoidance of step climbing, and conservation of floor space are all important and applicable to low cost housing.

Since floor cleanliness is an important item and one in which an important amount of daily labor may be expended in humid climates, the general matter of floor construction might be mentioned here. To be satisfactory, floors should meet certain minimum standards: (1) they should be comfortable to walk on and strong enough to support the occupants of the house and any necessary equipment and furniture; (2) they should be easily cleaned; (3) they should not be wet or noticeably damp; (4) they should be reasonably durable; and (5) they should be designed to exclude insects, rodents, and other pests. In humid tropical regions it is not easy to meet these requirements as in temperature areas, particularly where high cost is a factor.

An earthen floor maintains a fairly constant temperature, somewhat below the mean air temperature, but is likely to be damp.
or even most of the time and thus produce a layer of humid air near it. It is difficult to keep clean, harbors many pests, and easily becomes infected if sanitations is faulty. The chief asset is negligible cost. Some of the objections to earthen floors can be reduced by stabilizing the earth with cement, bituminous materials, or other suitable chemicals to render them less absorbent and make them easier to clean.

Semiabsorbent material resting on earth (e.g. wood) tends to follow air temperature a bit more closely, and to be somewhat less wet than the earth itself; but of course, it will share in any surface flooding. It is generally easier to clean, though dirt will readily accumulate in cracks between structural units, which are difficult to clean out. Deterioration from fungus and termite action is likely to be great and must be matched against the cost of construction.

Impervious material resting on earth (e.g. concrete or tile) will preserve a fairly constant temperature about the mean of air temperature, and it will be relatively dry unless its temperature happens to fall below the dew point of the air in the house. It can be easily cleaned and even washed thoroughly without harm; continuity of structure will help in this. It will eliminate the penetration of pests from the earth and contamination of the earth from the house. It should be durable.

If the floor is constructed off the earth, many considerations are altered. In general, the floor will be drier and a little cooler. Cheaper semiabsorbent materials can be used, and continuity of structure is not so important. Crevices can provide some increased perflation for the floor region, which usually has a
Figure 2.—This and the succeeding chart may be used in two ways: (1) To determine the warmest conditions at which a given activity can be carried out without exceeding given tolerances—select the box which comes closest to describing the activity and tolerance in mind, and then see what combinations of temperature and humidity correspond to this limiting line. (2) To determine what activity can be carried out under given atmospheric conditions—locate the point corresponding to the conditions and then see what activities describe the lines passing near that point.
Housing as Climatic Protection in Warm Humid Environment (cont'd)
layer of stagnant air, and also a drain for wash water. If
access is provided to the under surface, crevices and the earth
beneath can be cleaned. Pests and vermin can usually be
excluded by continuing the outer walls from floor to ground as
a sheathing. Deterioration of floor materials is not likely to
be rapid. Where the termites are a threat, metal shield should
be placed between the floor and wall structure and the supporting
posts, piers, or foundation walls. The supports themselves
should be resistant to termites and should preferably be of
masonry or concrete. In some areas hardwood posts treated with
creosote, pentachlorophenol, or other preservatives may prove
satisfactory. In any case, walls or supports should be accessible
for periodic inspection. If the supports are high, the space
beneath can be utilized for many purposes, such as the drying of
laundry or recreation.

Principles Directed to Reducing Gains and Promoting Losses from
the Body by Radiation. — Although the average intensity of
direct solar radiation is less under warm humid conditions, it is
still fairly considerable on the roof, and at times rises to
intensities close to those characteristic of hot, dry regions.
Walls, on the other hand, are subjected to much less reflected
and thermal radiation from the ground.

External shade
Since trees are usually abundant, they can be utilized to shade
the roof and walls and the surrounding ground, but account has
to be taken of falling branches, the harborage given to pests
such as sandflies and bats, and the access they provide for
unwelcome visitors, whether animal or human.
The bungalow type structure can take advantage of spreading shade
1. Housing as Climatic Protection in Warm Humid Environment (cont'd)

trees and thus offset its greater roof projection. Mutual shading of houses is much less desirable here, since proximity would restrict the highly desirable air movement between and through houses. The same objection applies to bushes or other screening growth too densely planted. The lack of privacy brought about by open walls also makes separation of households desirable. Apartment-type buildings are open to this objection.

Reduced ground reflection

Vegetation normally covers the ground under warm humid conditions, and full advantage should be taken of the reduction in reflection and thermal emission given by it. The moisture content of the ambient air is little affected by substituting cement or other quick-drying surfaces for grass-covered earth, but both the reflection and the thermal emission may be increased, so that such surfaces are not desirable close to the building.

Attached shade

The proper use of attached shades combined with the screening effect of trees and bushes, can eliminate dependence upon continuous wall structure for radiation protection, and this is often an advantage where, as will be pointed out below, maximum perfusion by the ambient air currents is desired. In spite of the reduced average intensity of radiation, therefore, wall shades retain a marked importance in warm humid environments since they may substitute for the walls proper. They may be provided simply as continuations of a sloping roof, as attachments to vertical supporting members, combined with rain protection over wall openings, or incorporated in other
Figure 8—Radiation loads on roof and walls.—Maximum intensity of radiation falling on horizontal roof and walls at different hours of the day. Solid line above white area, total radiation from sun, sky, and terrain; broken line above gray area, direct radiation from sun; solid line above lightly striped area, radiation cut off by horizontal projection at top of wall equal to three-tenths of the wall height; solid line above heavily striped area, radiation cut off by horizontal projection at top of wall equal to one-tenth wall height. (Courtesy: American Geographical Society of New York.)
1. Housing as Climatic Protection in Warm Humid Environment (cont'd)

architectural devices. The verandah is simply the logical development of attached shade. All shades should be provided with vents for the escape of trapped hot air.

**Minimal solar projection**

If the vertical faces of the building are adequately protected by vegetation or attached shades against direct solar radiation, they do not enter into questions of solar heat load on the house. Such heat as is absorbed by those shades is returned to the ambient air and not added to the house itself. Under these circumstances, it is the solar projection of the roof alone which should be minimized.

With a high altitude sun, this is proportional to the horizontal area covered by the roof, the shape of the roof entering into the determination only where its pitch exceeds the solar altitude. Under these conditions the roof of a multi-stored house would have a smaller solar projection than that of a single storied house with the same floor space, but effective wall shading becomes more difficult as the wall height increases, so that a compromise may be necessary. Height increases convection by natural air movement, but also puts greater mechanical strain on the relatively flimsy construction frequently employed in these regions.

**High reflectivity and high reemission**

High reflectivity towards incoming solar radiation is still important, but high reemission is less so than under dry conditions, since the water vapor content of the air largely filters our thermal radiation loss to the "sky" sky temperatures approaching more closely to those of the ambient air. (That this
1. **Housing as Climatic Protection in Warm Humid Environment** (cont'd)

is so indicated by the fact that one is much less impressed by a sense of coolness on stepping out at night from beneath a canopy in a warm humid than in a hot dry environment). The superiority of a white painted roof surface as compared with a polished metal surface might be expected, therefore, to be less under warm humid conditions.

**Convection over surfaces exposed to radiation**

This is still desirable, especially as surfaces will often be damp, and air movement will tend to promote cooling by evaporation. In dry periods spraying may be used on the roof to supplement this effect. The higher the roof above the ground level, the greater will the air movement tend to be over it. This is one effect of the practice common in Latin America, Siam, and Australia of placing dwellings on piles. Buildings placed upon an elevation will similarly tend to enjoy greater air movement. The mechanical hazards of wind must be borne in mind, however. Obstructing parapets should be avoided in roof design.

**Insulation**

Inasmuch as the roof is exposed to periodic heating by solar radiation, capacity type insulation is that which is more effective for that structure; but since the average load is somewhat less than in the hot dry environment, the insulation requirements may be somewhat less. For walls which are adequately shaded there will be no requirements for insulation against radiation loads. (This does not mean that concrete, or other capacity insulation, should not be used for walls if it is readily available, but simply that it is not necessary.)
1. **Housing as Climatic Protection in Warm Humid Environment (cont'd)**

So unimportant are walls, as long as the weather is kind, that provision should be made wherever possible in warm humid environments for outdoor living. With shade provided by trees, and sufficient privacy given by shrubs and hedges, eminently liveable conditions can be obtained for a large proportion of at least the daylight hours. The space beneath houses raised on piles can be very well utilized in this connection.

**Convection over inner surfaces and ventilation of roof space**

This may be used to offset inadequacies in insulation, but in warm humid environments there is no reason for localizing the intake to the ceiling region, and the flow may well be made a part of the general perflation, which will be discussed later.

**Ceiling height**

There is even less advantage to be gained from high ceilings here than under hot dry conditions since the ceiling temperatures are apt to be less. In fact, it is highly desirable that ceilings be kept sufficiently low for window openings to reach to the ceiling line, permitting hot humid air to be swept out by ventilation.

**Principles Directed to Promoting Losses from the Body by Evaporation.** — In hot dry environments evaporation takes place so readily that skin evaporation seldom requires special encouragement as long as the skin can supply sufficient water; but under warm humid conditions difficulty of evaporation into the moisture laden air is the critical process. Heat exchange by conduction, on the other hand, fades into comparative unimportance. Basements and other devices for heat exchange with the ground are generally not effective in these environments,
1. Housing as Climatic Protection in Warm Humid Environment (cont'd)

and may involve trouble from the usually high water table.

**Ventilation** (Volume flow)

Unless some method of dehumidification is used, vapor pressures inside a house will tend to be raised above those outside by sweating, washing, and cooking. Under these conditions it is desirable to have external air replace the internal; and the more frequently this is done, the more easily will internal vapor pressures be kept from rising. This replacement of internal by external air is properly termed ventilation, and is best expressed as the number of air changes per hour, or, for a given structure, as cubic feet per minute. It is essentially a rate of volume change. Natural air currents will help to secure this through openings suitably placed in relation to the wind direction, one set facing the wind for entry and one away from the wind for exit. Contours, the orientation of the house, and position of surrounding structures may all markedly affect the efficiency of this natural ventilation. It may be supplemented by fans where power is available.

**Air movement** (Velocity of flow)

The more rapidly air moves over the skin, the more readily will evaporation occur. It is important, therefore, in warm humid environments where evaporation is difficult, not only to keep the average vapor pressure of the air in the room down by ventilation, but also to speed up the rate at which that air moves over the skin. The natural air currents can be used to promote this as well as to promote the ventilation, but some type of fan is generally desirable as well.
1. **Housing as Climatic Protection in Warm Humid Environment** (cont'd)

Where major dependence is placed upon natural air currents, the external conditions which were mentioned as promoting ventilation, contours, orientation, position of neighboring structures, location of openings, must be supplemented by structural provisions. The velocity of the incoming air can be kept up if it is channeled by partitions through occupied areas instead of being dissipated by eddies in unoccupied backwaters. Partitions should not run athwart the direction of air flow, but if some thwartwise structure cannot be avoided, it should have several openings and be separated by a space from both floor and ceiling.

Wall openings should not only be of maximum extent, but also be free of obstruction, and this point should be borne in mind when the provision of insect screening is considered. In those tropical areas free from the organisms of insect-borne disease and not possessing power for fans, inhabitants often prefer to put up with the nuisance of insects rather than to restrict the breezes. There is some evidence that the airflow is promoted if the extent of openings on the lee side is greater than that on the windward.

Exclusion of rain from wall openings, is fairly easily obtained by overhangs in the equatorial zone, where winds are seldom of driving force; but in other regions this may present quite a problem. Open verandahs represent areas that can be abandoned to the rain when necessary; louvres and jalousies provide controllable openings as long as they fit well and someone is there to operate them. Blinds which can be rolled, made of rattan or other material, constitute a compromise, but are only partially efficient and are best used on verandahs.
Manpower (e.g. the "Punkah wallah") is no longer generally available for operating fanning devices, so that electric power is usually necessary before mechanical reinforcement of natural air currents can be contemplated. High-speed fans blowing in a fixed direction are not very suitable for domestic use, since the high velocities disturb objects and are unpleasant to the skin. Eddying air currents are in some ways ever more effective than linear air currents in cooling the body, so that fans which set up a general turbulence, though a lower average velocity, are desirable. Large, low-speed overhead fans do this quite well. (These overhead fans are sometimes regarded as "old-fashioned"; but they do the desired job better than many "modern" substitutes.) Smaller, medium-speed, oscillating, wall fans give a useful compromise. A design which has become popular in the United States recently consists of a medium-speed fan blowing upwards on to a cone, which deflects the air stream outwards and upwards. The unit is portable, and can be placed on or near the floor in the position the individual finds most acceptable. It has the great virtue that it does not blow papers and other light objects off the table or desk.

Dehumidification

 Whereas for hot dry conditions the stress in air conditioning is on reducing air temperature, with little consideration for its humidity, the emphasis under warm humid conditions is on reducing the vapor pressure, with only minor consideration for temperature. The more commonly used method of dehumidification is probably that of cooling the air below the dew point so that an appreciable proportion of the contained vapor is condensed. An alternative
1. **Housing as Climatic Protection in Warm Humid Environment (cont'd)**

Method is to remove the vapor by absorption on silica gel, which is subsequently regenerated by heat. It is unlikely for a long time to come that either of these methods can be extensively used in what are commonly regarded as under-developed countries.

To the extent that partial use may be possible, sleeping quarters, critical work rooms, indoor recreational facilities, and hospitals call for prior attention.

**Principles Directed to Reducing Heat Liberation in the Building.**

Since wood is usually fairly abundant, the low capital cost of a wood-burning stove has much to recommend it in a warm humid region, but the problem of avoiding the effects of "wild" heat upon the operator is still very important. The various comments made on this matter in the previous chapter are just as cogent under warm humid as under hot dry conditions. Capacity type insulation, an air space in the over wall lined with reflective foil, low emissivity of the outer surface, and removal of heated and humidified air by directed air flow are very desirable.

**SUMMARY**

Table 14 sets out the principles and more important applications which have been advocated in the design of buildings for warm humid environments, insofar as man's physiological requirements are concerned.
<table>
<thead>
<tr>
<th>Principles</th>
<th>Important Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reducing human heat production</td>
<td>Convenient storage space.</td>
</tr>
<tr>
<td>Convenience of arrangement.</td>
<td>Convenient plan and conservation of floor space.</td>
</tr>
<tr>
<td>Ease of cleaning</td>
<td>Convenient facilities.</td>
</tr>
<tr>
<td>Reducing gain and promoting losses from body by radiation</td>
<td>Easily cleaned surfaces, especially floor.</td>
</tr>
<tr>
<td>External shade</td>
<td>Shade trees, especially roof.</td>
</tr>
<tr>
<td>Reduced ground reflection.</td>
<td>Shade bushes, etc. especially to E. and W. exposures, but without obstructing wind.</td>
</tr>
<tr>
<td>Attached shade</td>
<td>Separation of buildings.</td>
</tr>
<tr>
<td>Water cooling of exterior</td>
<td>Vegetation over ground.</td>
</tr>
<tr>
<td>Minimal solar projection.</td>
<td>Eaves and other horizontal projections on equatorial exposures.</td>
</tr>
<tr>
<td>High reflectivity of exterior.</td>
<td>Awnings, verandahs, etc., especially on equatorial exposures.</td>
</tr>
<tr>
<td>Convexion over surfaces exposed to radiation.</td>
<td>Vertical projections beside window openings on equatorial exposure.</td>
</tr>
<tr>
<td>Insulation (capacity type) to roof.</td>
<td>Water spraying or water layer on roof in dry weather.</td>
</tr>
<tr>
<td>Convexion over inner surfaces</td>
<td>Minimum solar projection of roof.</td>
</tr>
<tr>
<td>Low emissivity of inner surfaces</td>
<td>Light color or polished metal for surfaces exposed to solar radiation.</td>
</tr>
<tr>
<td>Moderate ceiling height</td>
<td>Avoid parapets and mutual interference of roof structures to wind.</td>
</tr>
<tr>
<td>Promoting losses from body by evaporation</td>
<td>Wood, stone, or other material of low diffusivity for roof.</td>
</tr>
<tr>
<td>Ventilation (volume flow).</td>
<td>Ceiling height generally not over eight feet.</td>
</tr>
<tr>
<td>Air movement (velocity of flow).</td>
<td>Maximum wall openings for breeze, with blinds, louvres, etc. against rain.</td>
</tr>
<tr>
<td>Dehumidification.</td>
<td>Cross ventilation directed without obstruction.</td>
</tr>
</tbody>
</table>
Table 14 (cont'd)  
Summary of Principals for Warm Humid Environments and Applications

<table>
<thead>
<tr>
<th>Principles</th>
<th>Important Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reducing heat liberation in building</td>
<td>Ventilation of roof space and spaces between successive roofing layers.</td>
</tr>
<tr>
<td>Minimize heat and vapor liberation.</td>
<td>Turbulence-producing fans.</td>
</tr>
<tr>
<td>Remove liberated heat and vapor.</td>
<td>Dehumidification by refrigeration or absorption.</td>
</tr>
<tr>
<td></td>
<td>Capacity insulation around oven and firebox.</td>
</tr>
<tr>
<td></td>
<td>Narrow air space lined with aluminum foil in oven wall.</td>
</tr>
<tr>
<td></td>
<td>Liquid or gas fuel, or power, where economically feasible.</td>
</tr>
<tr>
<td></td>
<td>Vent to outside over stove.</td>
</tr>
<tr>
<td></td>
<td>Vents and infrared screens for lamps.</td>
</tr>
</tbody>
</table>
C. HOUSING AS CLIMATIC PROTECTION IN WARM HUMID ENVIRONMENTS

2. Functional Considerations

Sleeping quarters

On warm humid nights, and sometimes on exceptionally hot dry nights, many people find difficulty in sleeping. As medical attendants well know, statements of "not being able to sleep all night" must be heavily discounted; but the fact that the person feels that way about it indicates that all is not well, and that a full measure of efficiency, especially in unsupervised mental pursuits, cannot be expected on the following day. It would appear only reasonable, therefore, that special attention should be given to the sleeping quarters in selection of site, design, and equipment. In hot dry areas, full advantages should be taken at night of radiation to the relatively cool sky, as well as the cooler air, by sleeping in the open. Rain, insects and other undesirable bedfellows, privacy, and early morning sun, are items to be taken into consideration; but these are regarded by a large number of accustomed inhabitants as minor difficulties to be fairly easily overcome. In warm humid weather, or when sleeping in the open is not possible for other reasons, quarters on the northern aspects (southeastern in the southern hemisphere), with ample opportunity for entry of cooler night air, boosted if possible by a fan, is to be recommended. Openings should come to floor level. Where insect screening or mosquito netting is used, a fan inside the screen or net is very desirable; but it is generally considered important that the actual rate of air movement over the sleeper should not exceed 50 ft./min., and that it should be of intermittent, fluctuating or turbulent nature.
2. **Functional Considerations**

Where air conditioning is available, its use is most justified in the sleeping quarters, but the objective should be simply to remove the disturbing degree of heat, not to produce a really temperature atmosphere.

One of the biggest impediments to restful sleep on a hot night is the standard western bed. Derived from countries with cold winters, it manages to present a minimum area of skin to the air, even if the sleeper lies naked. The thermally most suitable sleeping device under hot and humid conditions is the string hammock, especially if it is kept spread by crossbars at head and foot. Those accustomed to soft sleeping will demand something between them and the string, but this should be thin, porous, and absorbent. Sponge rubber and all but the most open-work plastics are definitely not admissible. Individual ingenuity will furnish suitable modifications of the hammock design for those who desire stability or space not provided by the standard article.

**Verandah**

The verandah is simply attached shade carried sufficiently far to give space for outdoor activities in a climate in which natural air movement is something to be desired. It is much more functional in warm humid than in hot dry weather. Kept free from all but weatherproof chairs and blinds, it can be abandoned to the elements whenever these are inclement. To the extent that insect screening is considered a necessity, that electric fans are available for forced convection, and that insulating walls can be substituted for attached shade in a
2. **Functional Considerations**

seasonal climate, the verandah loses some of its usefulness. But the main objection to the verandah stems from man's ability to misuse it. Bit by bit, with one "justifiable" excuse after the other, the typical verandah-user turns it into a totally enclosed room. In addition to affording less protection than a properly designed room this also converts the main rooms of the house into dismal dark dungeons, redeemable only by full air conditioning and fluorescent lighting.

**Kitchen**

One obvious solution to the kitchen problem in hot climates is to separate the kitchen from the house proper, so that the heat and odors will not permeate the living space. This is a solution, however, which can work satisfactorily only when cooking is done by outside help. The housewife who has to take care of all the domestic work wants the kitchen as close to the dining space as she can get it, in fact, for the less formal occasions, she may prefer to have the dining space right in the kitchen. Furthermore, merely removing the problem to a distance does not necessarily solve it, at least for those who work in the kitchen. For low cost housing, and for servantless families, the kitchen must be considered as an integral part of the dwelling. In such housing, the location of the kitchen is too often dictated by a standardized house plan, location of street, or access to services; but where any selection is possible, the shady side of the dwelling is obviously the position of choice, with a second thought to the direction of the prevailing breeze. At least as much consideration should be given to protecting the
2. **Functional Considerations**

kitchen from the hot environment as is given to the rest of the house. The state of affairs too often seen in Australia, of a low, unceiled, galvanized iron, skillion roof over the kitchen of an otherwise well constructed and ceiled house, is inexcusable. In hot dry climates, special ventilation may be restricted to the outward carriage of heat from the cooking area, but without first taking it over the cook. In warm humid climates, free ventilation, but again directed outwards from the stove, is highly desirable. Evaporative cooling in hot dry climates or refrigeration in warm humid climates, may be used to give added comfort, but should be considered only as supplementary to proper ventilation of the stove area and construction of the heating units in such a way that "wild" heat is minimized.

Convenience of layout, with easy access to storage space, disposal facilities, and serving area have been mentioned previously as important to conservation of effort. Where separate kitchen facilities are acceptable, advantage can usually be taken of their isolation to secure better ventilation; but, of course, a greater solar projection is provided by the same isolation. The best approach is to treat such isolated facilities as a building in itself and to apply the principles already set out for the appropriate climatic conditions. It will also be necessary in these circumstances to provide some protection against sun and rain for the communicating passageway to the house.

**Laundry space**

To people acculturated to washing their clothes by the river bank, laundry space must seem a veritable abstraction. But as they
2. **Functional Considerations**

Congregate in towns the need for this must become more apparent. The actual process of washing takes little space, but that of drying may be more demanding. The demand is small under hot dry conditions where thin clothes dry almost as fast as they are hung; but on warm humid days the process is much slower, and more space, preferably protected from rain, is required. This requirement may pose an important problem with small dwellings closely placed or combined into an apartment-type structure, and constitutes one more reason for not recommending the apartment-type house for warm humid climates. It can be solved, however, by the provision of a communal covered drying space, portion of which may be convertible to recreational purposes at other times.

**Security and storage**

There are few communities in which the social conscience is so developed that security measures by the individual household are unnecessary. The steps that are felt to be required vary all the way from simple closing of gates to the creation of walled fortresses; but as one ascend the scale of felt requirements one finds building practices more and more dominated by this theme. In some instances the provisions for security blend happily with those for environmental protection. Thus the thick walls and small shuttered openings of the Arab type house eminently meet both desires. In warm humid environments, on the other hand, enclosure of the living space must inevitably interfere with air movement unless the community is one in which power is readily available for fans or air conditioning. The tree house is an admirable way of effecting reconciliation of requirements, but is hardly compatible with progressive
2. **Functional Considerations**

development. The raising of the house on piles, so commonly seen in Siam, Australia, and tropical America, provides a happy compromise, to which bars and other deterrents to intruders can be added as necessary. Since this design provides other desirable features at the same time, such as improved ventilation, and shaded laundry and recreation space, its widespread adoption is not surprising.

To store things, it is not sufficient merely to have a secure storage place. Biblical authority places moths and rust on an equal footing with thieves. Deterioration is particularly frequent in warm humid climates, since such atmospheres are eminently suitable for the growth of fungi which destroy, discolor, or etch a wide variety of materials with abandon. A relatively small fall in temperature may bring goods below the dew point, and the resultant condensation of atmospheric moisture will add to the ruin of prized possessions. This may easily occur even inside a closed container, if it were last opened in a particularly warm moist atmosphere. It is essential, therefore, that storage spaces in such climates be dry and clean. One simple device which is extensively employed where power is available, is to keep an electric light bulb burning inside any closet. By raising the temperature it minimizes the chance of the dew point being reached at night or during a cool spell, and thus prevents condensation. The individual articles should be kept separated, so that any moisture which does condense can reevaporate easily. More elaborate apparatus, such as a silica gel dehumidifier can be used, of course, where resources permit.
PART II - Explanation of the Characteristics of the Housing Development for Bayamon, P.R.

1. Location of the project Area
   The project area is located on the south-east of the downtown Bayamon within 20 minutes walking distance from it. It is surrounded by future residential neighborhoods and will contain mostly families working in the new industrial section of the city located on the south east of the project area within 15 minutes of walking distance. A secondary highway connecting the industrial area to downtown pass from the east of the project area.

2. Schools
   One primary, one secondary and one high school will be located within a 1 mile radius according to the future development plans of Bayamon made by Puerto Rico Planning Board.

3. Commercial areas
   They are located on three spots within the same 1 mile radius.

4. Recreational areas
   Major recreational areas are located as a group in one long green area serving three neighborhoods including the project. It is also within one mile radius and directly at the east of the project.

5. Topography
   A slope ranging from 6 to 18% is found at the west of the project area.

6. Fauna and Flora
   The land is sparcely covered with palm thees and tropical shrubs.
7. Assumptions

The development of the area will be undertaken under the light of the special requirements of Aided Self-Help Method which is discussed in the first part of the thesis. Thus it has been assumed that the houses will be provided in privately owned lots as one floor with special consideration given to the climatic, social and economic requirements of Puerto Rico. The ownership of cars in the future by the families will also be considered. Only small playgrounds and open areas will be provided due to easy access of the major recreational areas. The built up area will be provided at fairly flat portion of the project area (Slope 0-6%) due to the necessity of economy from the excavation costs and speed in construction. House plans will be as similar as possible even though their layout might provide variety in elevations and arrangement of units within the lots in order to break the monotony and achieve a pleasant atmosphere. The possibility of future expansion of houses will be given a primary importance due to the rapid growth in family sizes.

8. Site Plan

Project area: 15.6 acres
Number of dwelling units: 66 Density: 4.3 Fam./Acre
Population: 528 (8 person per family)
Lots: 3200 sq.ft. with min. of 20 ft street frontage
Built up area: 35%
Green area: 50%
Street area: 15%
Street layout: In order to provide minimum through traffic within the project area, loop and dead end streets has been considered. One collector street together with a green strip along the high-
way provides the necessary distance of isolation from noise and
dust.
Clustering of Houses: Due to our assumption of standard plan
with one story, the variety in climax has been tried to be achieved
by free arrangement of clusters. Lots have been put together for-
making rows leaving green open space between and providing easy
access for the fresh north-east breeze. Pedestrian walks give
access to both sides of the lots and visually the surprise effect
has been created by passing from narrow to open places.

9. Types of Houses
Keeping the same lot size of 32,000 sq. ft and basically the same
plan, two types of house plan has been designed.
Type (A) has a lot of L shape and with 20 and 60 ft of street fron-
tage respectively on each side of the row. The living and utility
quarters of the house has been considered as a separate unit from
the sleeping quarters. The private family life has been converted
toward inside of the house. The patio surrounded by living and
sleeping quarters forms the focusing point of the family life. Due
to the mildness of the climate, the living room expands to the patio
and is mainly used for lunch and as a shelter during the short
tropical rains. The front approach is used for gardening. In order
to provide free circulation of the air, the units are designed with
a single room depth and spaced from each other by garden and patio.
4 ft. wide overhangs provides shades along the exterior walls. Heat
control is also provided by using double-roof concept. It is based
on 2 ft. x 4 ft. precast concrete blocks put on the top of the rein-
forced concrete roof without binding them together. Rain infiltra-
ting between the joints together with the breeze passing through
the double roof, produce a cooling effect.
Concrete has been selected as a basic material for construction, because of the abundance and cheapness of cement and sand in Puerto Rico. All forms will be prefabricated and specially designed for this purpose. Window openings will be provided by glass louvres in order to have proper light and ventilation. The structure of the house will consist of cast in place monolithic reinforced concrete walls erected in three phases. During the first phase, foundations and the floor slab will be poured. In the second phase walls and finally in the third phase roof slab will be poured and connected to each other. Concrete mixture will contain light weight aggregate for its insulation property and also for its abundance as volcanic puzzolane. Houses will be started to be built from the nucleus which will be the living quarters and one bedroom. Then as long as the family size will grow, future bedrooms will be added to the house.

Type (B) is a variation of the type (A). In this type the basic plan will be kept but only the living and sleeping quarters will be shifted from each other within a rectangular 40' x 80' lot. The cost and the area of the lot being the same, a different space arrangement and elevations will be achieved.

As to the utilities: There will be kerosene range, running water, refrigerator, electric lighting and wood heated water boiler. In case of emergency and for gardening, rain water will be collected in the underground cistern.

The garden will be enclosed by concrete block 6' high walls which will be built in the future as optional item.
### Applicability of Design Objectives for "Warm Humid" to Other Seasonal Conditions

<table>
<thead>
<tr>
<th>Item</th>
<th>Applicability to Temperate</th>
<th>Applicability to Cold Temperate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced heat production by man</td>
<td>Immaterial</td>
<td>Encouragement to heat production occasionally desirable.</td>
</tr>
<tr>
<td>External shade</td>
<td>Immaterial</td>
<td>Not desirable.</td>
</tr>
<tr>
<td>Reduced ground reflection</td>
<td>Immaterial</td>
<td>Immaterial.</td>
</tr>
<tr>
<td>Attached shade</td>
<td>Immaterial</td>
<td>Minimum effect desired.</td>
</tr>
<tr>
<td>High reflectivity</td>
<td>Immaterial</td>
<td>Resultant poor emission may counterbalance.</td>
</tr>
<tr>
<td>External convection</td>
<td>Immaterial</td>
<td>Not desirable.</td>
</tr>
<tr>
<td>Roof insulation</td>
<td>Immaterial</td>
<td>Desirable against reverse heat flow.</td>
</tr>
<tr>
<td>Unimportance of wall insulation</td>
<td>Some insulation desirable</td>
<td>High insulation desirable against reverse heat flow.</td>
</tr>
<tr>
<td>Internal convection</td>
<td>Not desirable</td>
<td>High insulation desirable against reverse heat flow.</td>
</tr>
<tr>
<td>Low internal emissivity</td>
<td>Immaterial</td>
<td>Resultant poor absorption desirable.</td>
</tr>
<tr>
<td>High ventilation</td>
<td>Immaterial</td>
<td>Not desirable.</td>
</tr>
<tr>
<td>High air movement</td>
<td>Not desirable</td>
<td>Not desirable.</td>
</tr>
<tr>
<td>Roof space ventilation</td>
<td>Immaterial</td>
<td>Not desirable.</td>
</tr>
<tr>
<td>Dehumidification</td>
<td>Not wanted</td>
<td>Not desired.</td>
</tr>
<tr>
<td>Control of heat liberation</td>
<td>Not necessary</td>
<td>Heat may be required.</td>
</tr>
</tbody>
</table>
BIBLIOGRAPHY FOR THESIS

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SELF-HELP HOUSING DEVELOPMENT

BAYAMON - PUERTO RICO

SCALE: 1/40" = 1'-00"

BULENT KASTARLAK
HOUSE - ELEVATION
TYPE - A

SCALE: 1/4" = 1'-00"
HOUSE - ELEVATION
TYPE - A

SCALE: 1/4" = 1'-00"
HOUSE - PERSPECTIVE
TYPE - A
HOUSE - ELEVATION
TYPE - B

SCALE: 1/4" = 1' 00"
HOUSE - SECTION

SCALE . 1" = 1'-00"

1/7 3 RD STAGE
PRECAST CONCRETE DOUBLE-ROOF
BRAVEL INSULATION REINFORCEMENT BAR CONCRETE ROOF 5"

PRESSED SAND STONE BASE INSULATION CONCRETE FLOOR 8"-1/2 CEMENT PASTE MOSAIC TILES MOSAIC CORNER TILE MESH REINFORCEMENT
JOINT FOR 2 ND STAGE MONOLITHIC CONCRETE WALL 4"

SCRUBBED SURFACE

CONCRETE FOOTING

DULCHT RASTAMO 

CONCRETE BLOCKS BRICK RAW WATER DRAINAGE SOIL

MONOLITHIC CONCRETE PARTITION REINFORCEMENT BAR

FLUSH DOOR

2 ND STAGE

0'-8"

1 ST STAGE

1'-08"