

INDUSTRIALIZATION WITHIN THE ISRAELI HOUSING  
CONTEXT: SOME SPECIFIC PROPOSALS

BY

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ABSTRACT

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Israel's housing problems started upon the declaration of her statehood in 1948. At that time, severe overcrowding existed; since then, the population has quadrupled. Valiant efforts have pushed construction to impressive levels, but at great cost to the national economy and the individual purchasers. Architectural quality, too, has suffered seriously from the constant pressure for numerical achievement.

Although the conditions necessary for successful industrialization are present in Israel, past governmental efforts to improve the situation using foreign bought building systems have had limited success. Using a systems approach based upon a comprehensive analysis of the factors effecting housing production, a strategy for an improved building method is herein developed. Hardware, too, is designed, utilizing increased industrialization and non-sophisticated technologies. Along with the creation of a much

improved product, the process yields side benefits to other sectors.

With the realization that economic factors are critical, analyses are made comparing the proposed system with conventional construction methods. These indicate that cost and time savings can be achieved with the proposed system.

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## SUMMARY

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The State of Israel inherited, upon its declaration of Statehood in 1948, severe housing problems. A quadrupling of the original population of 870,000, mostly due to immigration during the next twenty-five years, has greatly aggravated the problem.

Housing achieved priority second only to defense. Through a tremendous effort and at great cost, unprecedented numerical success was achieved. No inhabitant of the state lacked shelter for a single night. The housing itself, although filling the need, was lacking in quality.

With Israel's rapid development, increasing Westernization of tastes and standards has focused new housing efforts toward higher quality.

Investigation of the specific states of the factors of production (i.e. land, finance, labor, management, materials, and design) indicate that blatant weaknesses in these area policies is often responsible for the inadequacy and great cost of this housing, both to the families, and to the nation as a whole. Changes in these policies are aimed not only at improvement of housing conditions; strong side effects are likely to positively influence the labor market, capital market, and technological and managerial potential in other sectors. Specific policy recommendations involve

government intervention, but this is the norm in Israel and other developing countries.

Government sale of some of the 92% of its land and steps to limit speculation on potential housing properties would directly lower prices. A subsidized savings and loan industry would provide alternatives to land speculation making this money available almost exclusively to builders.

Improvements in Development Towns might decrease the demand for the main cities, while perpetuating the policy of dispersion of population.

Increased technological input to the housing sector could significantly increase its performance as well as positively effect other sectors. Steps such as development of national performance specifications and increased dimensional and modular coordination would encourage this. A systems approach here would cut costs, increase flexibility and speed, and improve performance. It would also free workers in an extremely tight labor market and release capital for other pressing needs. Management capacity and technological knowhow, applicable to other sectors, would be developed.

Although many different approaches to the problems of hardware design may be appropriate, it is clear that the

national context is of utmost importance in determining the nature of the new technologies and the specific hardware designs.

Land costs, shortage of skilled labor and management, general non-reliability of service industries, high interest rates and the increasing expectations of the population, are just a few of the factors influencing designers' decisions. These, of course, are in addition to the more classical architectural form determinations such as climate, materials available, life styles, aesthetics and tradition.

One system is proposed; although it is specifically designed around utilizing economic and environmental assets of sloped sites, it can be used in most low-rise situations. It is an attempt to produce a set of parts which work well together or in combination with conventional construction techniques. This will enable the innovations to effect large and small builders alike, encouraging reduced costs through economies of scale. It will also reduce financial risk by allowing breakdowns to be easily sidestepped through using conventional means. The existing industry infrastructure is used, further simplifying the intergration of the system.

The system reduces labor, particularly skilled labor, and optimizes the short management resources. Units can be built in under four months and have tremendous flexi-

bility both initially and overtime.

The aesthetic chosen is a respectful emulation of Mediterranean village architecture. This not only makes good use of sloped, otherwise often unused land, it also allows the user to benefit as did his predecessors from the micro-climates, and the rich natural variety of slope, landscape and panorama.

An improved physical housing product alone is not enough. In order to realistically expect any product to replace another on an appreciable scale, the consumer must be able to satisfy more needs and aspirations for each dollar.

An analysis of manpower requirements, construction durations, materials costs, and capital investment needs indicate that although more processed, more expensive materials are called for, the orderly assembly line-like manageability of the total process, and reduced site labor required, can result in approximately 10% savings in direct construction costs. Effects of the sharply decreased construction duration and resultant decreased construction financing costs, in addition to the generally lower land costs for sloped sites, should result in total savings of 19-31%.

For implementation purposes, easy divisibility of the system into manufacturing and construction concerns, and the ability to operate these concerns at several scales allows for varied investment approaches. Several generic organizational approaches

are described. Two hypothetical scenarios illustrate the attractiveness of the time and cost savings possible to the producers of both high and low income housing using the proposed method at two production scales.

# I. CONTEXT

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HISTORICAL BACKGROUND  
AND  
PERSPECTIVE

When Israel was founded as a state in 1948, she had 870,000 inhabitants. The main principles upon which her Declaration of Independence was based included the concept of Israel as a homeland for Jews throughout the world. Jews, particularly persecuted Jews, could come or be brought to Israel, where they would be guaranteed citizenship and a new life, free of persecution. This charter fulfilled a substantial need.

In the twenty-two years between the U.N. Charter and 1970, the population of Israel had grown tremendously. The total population increased to 2,911,000 (not including "Israeli Administered Areas"). More complete data shows that of the 2,841,000 people in Israel in 1969, 2,434,000 were Jews; 300,000 Moslems; 92,000 Christians; and 33,000 Druse and others. Of the quadrupled Jewish population, two-thirds of the increase was due to immigration. The non-Jewish population tripled during the same period. The main factors of rapid growth included natural increase at an extremely high rate, a government family reunification program, and the 1967 annexation of Jerusalem (pop. 70,000).

Among other factors effected by so large a population growth rate on so small an original population, we would expect the impact on housing to be tremendous. Evaluation of housing situation and policy in Israel must always take

this growth factor into account. Planning literature of the 1950's and 60's is largely concerned with the efforts on behalf of the destitute immigrants. It should not be, however, assumed that the population in Israel was adequately housed prior to 1948. Since the population in Palestine between 1922 and 1946 had more than doubled, overcrowding in 1946 reached 4.6 persons per room in Tel Aviv and 6.8 per room in Jerusalem. (Jewish Agency Economic Research Institute survey, "Housing Conditions among Urban Jewish Population")

Housing policy-makers in Israel have had to cope with not only the massive population increases; a need for spacial dispersion too was crucial. In 1948, 7,993 square miles were unevenly populated. The goals of planners, even in the earliest years, were to "provide housing and employment for large numbers of new immigrants; to settle sparsely-populated regions in order to overcome regional imbalance of development; to occupy frontier regions to assure security and sovereignty within them; to open up 'resource frontiers', especially the natural resources of the desert; to provide a choice of settlement types; and to integrate the regions of the country to achieve efficient systems of distribution of services." (A. Baumgart, Industrialized Housing in Two Developing Countries, p. 6) These goals were to be accomplished by Israel's primary spacial policy: "dispersion of

population":, which is still considered a major objective in the national debate.

For the most part this policy of dispersion was and is implemented through two programs: development towns and planned rural settlements. The "development" or "new" town program by 1970 had accounted for over 21% of the population in 34 towns, each less than 20 years old. They had target sizes of between 6,000 and 60,000 persons each, according to their heierarchical area location.

The second program was to encourage dispersion through smaller groups. Four hundred and fifty rural settlements were established between 1948 and 1968. These were mostly "moshavim" (semi-collective settlements), Kibbutzim (collective settlements), and many degrees of everything in-between. These vary greatly in size from 60 to 2,000 members.

The inducements given to immigrants, who made up most of development-town populations, were in the form of housing and employment. Master planners determined the amount of housing in development towns. Since the financial terms of these units were far superior to all other housing opportunities, and there was little else which would draw settlers the number of government financed units ultimately became the development town size. 81% of this housing went to immigrants. Industry is generally subsidized for three years, at which time they are expected to be viable on their own.

The manpower for the construction industry in the development towns has traditionally been done by the earlier settlers in the town. When rapid expansion subsides, they transfer to the factories.

The following is a chart of Population by Habitation-Type, 1969, from: Facts on Israel: 1970:

table 1

Settlement type	Population (thousands)	Percent	Localities
<u>TOTAL</u>	2,841.1	100.0	882
<u>Urban</u>	2,334.8	82.2	77
Towns	1,884.9	66.4	27
Urban Areas	449.9	15.8	50
<u>Rural</u>	506.3	17.8	805
Large Villages	167.0	5.9	46
Small Villages	76.1	2.7	112
Moshavim	122.5	4.3	344
Collective moshavim	5.1	.2	22
Kibbutzim	84.2	3.0	235
Bedouin tribes	35.2	1.2	
Institutions, Farms	18.2	.4	46
Living outside villages	3.9	.1	

The overall role of government, beyond the "planning" level is another extremely important factor in providing a background on the housing sector. During the period between

1949 and 1964, 556,670 units were built and of these less than 40% were privately contracted. Of the 1.67 billion dollars spent during this time, 44% was initiated either directly by the government, or by a public company. 58% of the units were of this type. The apparent discrepancy in the last two figures here is caused by the significantly smaller size and therefore lesser price of the public-sector units. The ratio of units built by government and public companies to the overall total changes from year to year. Of the units under construction in 1966, 51% were public; in 1968, 48%; in 1970, 51%, and in 1972, 39%. The first quarter of 1973 showed 63% public-initiated housing. (The Israel Economist, July, 1973)

A sample of types of government programs gives an indication of the size of program areas and priorities. Dwellings completed in all public sector programs, by type, from: Facts About Israel, 1970, p. 129:

table 2

<u>Program</u>	<u>1967</u>	<u>1968</u>
Housing for new immigrants	4,530	4,031
Clearing of ma'abarot (temporary quarters built in the early 50's)	150	70
Housing schemes for settled population	3,770	2,124
Slum clearance	1,740	1,568
Housing for young couples	800	600

<u>Program</u>	<u>1967</u>	<u>1968</u>
Miscellaneous	<u>1,580</u>	<u>1,027</u>
<u>Total public building</u>	12,570	9,420
Private building	<u>15,130</u>	<u>12,800</u>
TOTAL	<u>27,700</u>	<u>22,200</u>

As shall be seen in a later chapter, the total number of units started in 1973 is approximately double that of 1967.

A look at the individual housing units in Israel is rather disappointing. Quality took a secondary role in the system which has satisfied so well the country's goals in terms of sheer quantity and national dispersion policy. Creative architecture was evidently scorned, and very minimally-sized units became the standard. Design was for the general rather than the specific. Eight-story apartment types, which are predominant in the cool and windy hilly areas are found in an identical form at the middle of the sparsely-populated arid desert regions. Undersized units, lack of sufficient site considerations, poor and few interior layout types, wasteful detailing and lack of environmental control systems: these are all common. One wonders whether the potential homes were not considered merely numbers in the eyes of the planners and architects. Was the insufficient and inadequate design a necessary evil in achieving the larger-scale housing policy

goals?

In summary, Israel inherited a poor housing situation. Although the population almost quadrupled in 25 years, through tremendous efforts and at great cost, both financially and in terms of quality, housing has progressively improved and is continuing to do so. This is particularly in terms of quantity and location within the framework of national dispersion goals. Ann Strong has observed that "Starting with independence and a population of 870,000... The fact that no arriving immigrant lacked shelter for a single night is fantastic in itself." This was confirmed by A. Baumgart in 1973 (p. 46), "No inhabitant of the state who was willing to avail himself of services offered has been left homeless."

PRESENT SITUATION  
AND POLICIES

One may assume from the above background that the housing situation in Israel has been through its toughest period. Although quantities of immigration are uncertain, as compared to total population it will probably never approximate the earlier levels. The quantity and location of housing stock is dramatically improved. The main question in housing analysis now should cease to be, "Is there shelter for every family?" We should begin to ask, "Is there adequate shelter for every family?" The standard of adequacy itself is rising and will continue to do so in the future.

While it is true that no one in Israel is homeless, let us take now a better look at what a family there typically must "pay" for his housing, and what he is likely to receive. The hardships, financial and otherwise, may sound trivial in comparison to other developing countries. One cannot allow oneself to forget that Israel has experienced almost unique growth and performance increase in all sectors. The 25 year old developing country has developed, for right or for wrong, Western tastes, standards and expectations.

The most direct measure of cost to the consumer of anything, housing included, is the monetary one. Based on personal information and checked by Israeli professionals, it seems that the "typical" Israeli white collar worker in

a major city (not Jerusalem or Tel Aviv) with 2-3 children is likely to live in a 70 square meter apartment. This, in 1974, will cost 110,000 IL or \$26,000. The generally low standard, in size and quality of the unit is discussed in another section of this paper, however, it is important to note the lack of any personality or "frills" such as fireplaces, landscaping, built-in closets, heating, or the like. In 1974 it takes our typical family approximately nine years of the main bread-winner's total regular salary after taxes to pay for this home. This necessitates moonlighting, children working, etc., for 20 years, to pay for this most basic house. The same unit in Jerusalem or Tel Aviv would be 20-30% higher.

Typical financing in the non-government encouraged areas is for only 20-40% of cost. The free market interest rates, due to inflation (in 1948 1 IL = \$2.80; 1975 1 IL = 16.7¢) are in the 18% range. If the family does not have, and cannot raise the remaining 60-80% cash from a previous home, they are forced to live in an extremely small old unit, or move from the major seven or eight urban centers to a government signified development area. Disruptive ten to fifteen year detour periods in development towns are not unusual, especially in the lives of Jerusalemites and those from Tel Aviv, in order to finance downpayments on reasonable housing in their cities. Although this is not Siberia, it

is often very far from the desired life style.

A look at the factors of production of housing will help in understanding more specifically the elements making up the high cost of housing to the consumer.

Land

Land costs in Israel have been increasing steadily. In large towns and cities, the recent years have seen the portion of typical housing cost devoted to land reach 30-40%. This seems to hold for rich and poor alike, as the luxuries of a patch of grass and garden at the entrance of an apartment building are often limited to the wealthy. "Villot" and cottages, as one and two-story single family residences are called, make up only a small percentage of housing, and are found almost exclusively in the suburbs where land is reasonable. This often means only \$15,000-20,000 per lot which also amounts to one third of the typical cost of a 150 square meter home.

The Israeli government and its various public agencies (i.e., The Keren Hakayamet) own 92% of all land in Israel. Most of this land is not in major cities. "The meagre 8% of privately-owned land in Israel is almost entirely concentrated in the cities, and at the base of rapidly rising housing costs in these cities." (Baumgart, p. 47). The declining value of the Israeli pound and the illegality of purchasing the more steady dollars or German

Marks have led to speculation and steep increases in the value of this 8% of urban land. "Land, presenting the most common stable opportunity for capital investment has been treated very much like a popular stock issue."

(Baumgart, p. 49) It can be seen from a comparison of change in land prices, cost of living, and national income index, that this increase of land prices is drastic even in comparison with the large rise of the other two.

table 3

	<u>1953</u>	<u>1963</u>
<u>Land Price:</u>	100	1,500
<u>Cost of Living:</u>	100	280
<u>National Income Index:</u>	100	455

(Source: Darin-Drabkin, Nature of the Urban Market, p. 20)

The land price index increased fifteen fold in a ten year period while the cost-of-living rose 280% and income-average 455%. Land prices in the Tel Aviv area went up over twenty fold in ten years!

Until 1969, the government had done little outside of the development towns to counter the expensive land situation.

Finance

The home finance situation, as mentioned in the previous example, instills a very major hardship on most housing buyers. Housing is typically financed 20-40%. This is usually by a combination of subsidized employment savings

plans, and bank loans. Certain people, by occupation, age group, and locations are given improved finance conditions. This is because their happy existence in a given area, as a group is considered essential to proper functioning of the state. Private and public mortgages range from 8% to 20% interest per year, and are usually for 10-12 years. Special incentive loans often are given with the understanding that if the dweller lives in the unit for over 5 (or 10) years, repayment is unnecessary. Construction loans are for approximately 18-20% per year.

Capital shortage in Israel is not limited to housing. All investment ventures are faced with this problem. Housing is actually responsible for 70-80% of the total borrowing in Israel. This for individual households is 90% of their marketable assets, as compared with 41% in the United States. Ninety percent of Israeli households own their dwellings, or have control over them under key money arrangements. Although there is much room for improvement in the housing finance situation, actual shortages of capital itself makes straight-forward solutions impractical.

Labor

Israel's high proportion of children and low proportion of working-age people makes for a comparatively low ratio of work-force to population. This is heightened by the traditionally low work participation of Asian and

African women, and high rate of long school attendance. The present ratio of labor force to total population is almost ten percentage points lower than that of Europe. (Bruno, Economic Development Problems of Israel, 1970-80)

The unemployment rate in Israel is down to about 3.0%. Much of this is the structural unemployment which Bruno says is to be expected even during a boom period in an immigration country. He also predicts a 1968-80 increase of employment by 3.5% per year, while population increases only 2.5% per year. This increase largely reflects the coming of age of the large under 14 population, which will be more educated on the whole than the existing labor force. The overall situation is that the state lacks the necessary manpower to cope with existing and growing needs.

Construction labor as presently used in Israel is largely skilled to semi-skilled. Workers such as floor layers, tilers, plasterers and painters make up about 65-75% of the group. "Poalim" or unskilled workers make up the remainder. A general look at trends over the past years shows that (based on U.N. 1969 Statistical Yearbook, p. 269) a major shift has occurred from low-skilled workers toward more skilled, higher productivity and higher paid workers in both construction and other industries. In construction, from 1964-1968 the total workers dropped 20%, but salaries increased 25%.

Earnings during this period for industrial workers increased 42%. Average wages according to government sources in 1971 were:

All sectors	781 IL (\$186.)	per month
Industry	756 IL (\$180.)	per month
Construction	705 IL (\$168.)	per month

It is common knowledge, however, that due to the shortage of skilled construction labor the traditional cash payment and high taxes, the recorded salaries for construction workers are not representative. More recent information

(July, 1974) indicates that unskilled workers in Jerusalem and Rishon Litzion, (pop. 52,000), between Jerusalem and Tel Aviv earn about 12 dollars per day; approximately what industrial factory workers get. The skilled workers (i.e. plasterers and painters), much in demand by builders, often get three to four times this amount, although no statistics exist as only approximately \$170. per month are recorded. The rest is "under the table." (U. Rosen, Manager, Halpern Construction Corporation)

The shortage of labor too is a problem. When in 1972 the government increased its housing starts by 50%, the lack of enough skilled finish-trade workers caused the completion time to increase by approximately the same percentage to 19 months.

Materials

Materials for building have frequently been a source of aggravation to Israeli builders. Cement and concrete block are the materials used in 99% of buildings. Wood is used only for concrete formwork and trim, and metals for reinforcing. Bad planning probably accounts for the shortage of Portland cement. Large plants were built which satisfied the demand for a few years, but it is now in very short supply. Months of waiting, and black market dealing at 300% of price are not unusual, even on government projects.

The plastics industry is well-developed in Israel. A.B.S., P.V.C., styrofoam, polyurethane and fiberglass are all used and often exported. Many products which are wood, steel or porcelain in the U.S. and Europe are generally plastic in Israel. This transfer, however, is rare in building products. Many personal conversations on this subject indicated that the root of the problem was a conservative attitude on the part of the builders, who themselves claim that the buyers are too conservative.

Sheetrock panels are not heavily used in Israel and the notoriously sloppy job of plastering often holds up the building process. Floors are virtually always 9" or 12" square cement and marble chip terazzo tiles. They are about 1" thick and are laid on a 4" bed of sand for leveling. The combination is extremely heavy per square meter of floor.

The entire building structures are thus always more massive than need-be, had other flooring been used.

Inaccuracy associated with some of those processes, including flooring, plastering and block walls, adversely effect other areas. Kitchen cabinets and even doors for blocks of hundreds of identical flats are often separately measured and singly built to fit. These interface areas, however, are improving.

### Management

Trained professional managers are almost non-existent in Israel. Larger government companies are almost universally headed by ex-officers. It is assumed that the skills necessary to control a platoon are identical to those necessary to manage a large business. These people generally know other ex-officer heads of industry and government, and poor management is often compensated for by ability to continue to land large contracts. Hundreds of millions of dollars per year, however, are probably lost due to inefficiency and lack of the basic management techniques. The large firms of the construction industry are managed just this way. These firms do over 50% of all construction in Israel; a large percentage of this is government initiated.

Smaller firms, construction or other, are typically family owned and run. These are generally still in the first generation. In construction, it is not unusual for the manager-owner of a 50-100 unit per year construction

company to be an ex-electrician or painter.

One such firm with which I have had contact has no concept of the cost breakdown per unit per building. "Management technique" consists of getting as much down-payment as can be squeezed before construction or very early; paying workers as little as possible; cutting corners only where it doesn't show; and knowing when to yell at the workers. They have never heard of double entry bookkeeping, let alone C.P.M. or P.E.R.T. Programming!

In the existing seller's market, however, even firms with this lack of sophistication can't help but make good profits. Ten to twelve percent of selling price per unit is said to be typical. The high, 50% downpayments before construction starts often enable most of the construction to continue without high builders' cash input. This often results in \$100,000 + annual profit for a 60 unit per year concern. This is heavily taxed, but one must remember that this is approximately forty times the workers' and twenty times the architects' salaries. With this in mind, it is only natural that builders are hesitant to innovate.

### Design

For the sake of simplicity, a separation of design concerns into design of the physical forms and design of the building process is helpful. Neither of these are easily quantifiable. However, even an untrained eye can

marvel at the ugliness of the typical rows of boxy structures. With few exceptions, mostly in universities, museums, commercial complexes, and memorials, recent Israeli buildings are unpleasing aesthetically; housing more so.

This poor architecture is not limited to aesthetics. Not only don't the buildings look good; they often do not work well. Overhangings are curiously seen on the wrong side for good sun control, living rooms face away from the view, etc.

The inside of many units is no better than the outside. In the seller's market even poor floor plans are quickly bought up. Not only are extras not typically offered (i.e. closets), but they are often not planned for (by a simple jog in the wall). A low usable/gross area ratio often results from awkward circulation.

All of these are common, not universal. However, they are the grossest of architectural considerations; the finer points are more neglected. "Good spaces" are very rare indeed. Flexibility, exploitation of non-built space, continuation of community areas between rows, and aesthetic fit are among the things which seemingly have received little or no consideration.

Ministry of Housing specifications are few. These relate mostly to square meters per room and apartment. They also give the minimum amount of wall outlets and a few other material specifications. Performance specifications

are not used and it was not until 1973 that the government issued a modular coordination scheme.

The building process, too, has evidently been of little concern to the architect in Israel, and the Housing Ministry also. Most plans assume typical block construction and details are often not specified. Architects act as clerks. They simply fit the number of required rooms into the prescribed number of floors with the desired level of luxury.

POLICY GOALS

Before describing various goals and policies, it might be useful to note that the following pertains to the more general Jewish and Arab populations in Israel. Numerous specific cases exist; i.e. Beduin, specific Development Towns, new immigrant groups, refugee camps, etc., which warrant individual consideration. These are specific problems and will not be dealt with in this paper.

A first step in proposing a policy should be the formation and clarification of goals.

In terms of housing itself, increased quantity, quality, and choice are clearly what the consumer wants. Significant cost decreases, direct and through financial tools, will give an increasing number of consumers greater choice in general and differing degrees of size and luxury corresponding to particular willingness and need to trade one for another. The user, it should be remembered, varies greatly in income, need, taste and aspirations.

The location of housing is an especially complex problem in the case of Israel. Long range development, economic, and defense needs of the country as a whole are involved. These must be delicately balanced with the individual family's willing or unvolunteered sacrifices for the fulfillment of this nationally desirable, perhaps essential policy of dispersion.

Housing, having the importance that it does, will, with altered policies, effect employment, capital availability, balance of payments, and income distribution.

Specific goals regarding labor are unusual, especially for developing countries. Israel's naturally low labor to total population ratio, resultant in overemployment, has created a pressing need to free-up labor.

The capital situation, however, is typical of developing countries in being very tight. An increase of housing standards without further tightening of capital would be desirable and impressive. The same goes for balance of payments, although according to a recent Rand Study (Economic Development Problems of Israel, 1970-1980, Bruno), balance of trade will be favorable by 1980; this making slight increases in housing materials imports tolerable.

The general egalitarian income distribution in Israel finds little salary differential between machinists and professors, architects, etc. One rather sore spot in this has been the incredibly high income of many builders. Government policies have not attempted to curb this for fear of adversely effecting housing quantity. A move to limit this income without decreasing production would be another desirable goal.

The uncertain levels of Russian and Anglo-Saxon immigration are likely to produce unpredictable variance between high and low years of up to 70,000 people. It is important to create an infrastructure which will allow high peak load production capacity to meet this potential problem.

Lastly, the "fit" between user and housing product should be improved. This is a direct function of sensitivity and the relative freedom of the architect, coupled with the ability of the user to choose between products and further modify them to best suit his changing needs and aspirations.

It is useful to bear in mind that in Israel, as in most developing countries, the role of the government in all facets of life has been considerable. For the most part this goes without objection. Government actions will be suggested in the following pages which would be considered unpallatable in the United States, but which fall well within the range of the type of involvement which the Israeli government has traditionally played.

## **II. PROPOSALS**

PROPOSED POLICY

The most direct consideration in housing policy is quantity. The numbers to which new housing policy should aim seem to have been well-studied by the Ministry of Housing. Target dates to eliminate substandard housing within four years afford a buffer to be used in the case of large, now unpredictable immigration. The government target figures (as quoted by M. Avnielli, 1973) follow:

table 4	Immigrant Housing	18,000 units
	Young peoples' Housing	6,000 "
	Replacement of substandard housing below 3.5 people/room, 44,000/4 years	11,000 "
	Replacement of low standard housing below 2 people/room, 60,000/4 years	15,000 "
	Middle and Upper Income Housing	<u>10,000 "</u>
	Goal for total private and public housing starts:	<u>60,000 units</u>

The desired numbers of units is being constructed. Figures of the Central Bureau of Statistics, as quoted by Amiram Harlap (A Survey of the Building Construction Industry in Israel) indicate 60,000 units were started in 1972. This is 19.1 dwelling units per 1000 inhabitants, the highest rate in the world. (At the end of 1972, 82,000 units were under construction!)

Land costs, presently 30-40% of total housing prices, make this area a reasonable starting point for variance with existing housing policy. The government has considerable influence on land prices, both directly and indirectly, which is not being used effectively. Land costs are continuing to increase.

State and public agency ownership of 92% of total land in Israel enables very direct manipulation of the land supply. Although little of this property is in the major cities, it does exist in close enough proximity to sharply effect housing price. Increased cheap supply of land with services in the suburbs would significantly drop inner-city prices. It would also produce revenue and future taxes. Since the largest cities in Israel are only approximately 500,000 population (Tel Aviv), and 300,000 population (Jerusalem and Haifa), the likelihood that the immense suburban sprawl images which are associated with really large cities of the world will occur in Israel is small.

East Jerusalem after 1968 provided an experiment in just such a practice. In an effort to quickly settle the newly annexed areas of the city, large quantities of land were sold cheaply to builders and large developments were built. The prices of these were cheaper than the West Jerusalem counterparts, which themselves fell in price, leaving the consumer a choice. Quantity and degree of luxury

could be traded-off against location.

Another direct government action involving land would consist of offers for builders to construct housing on public land. This would encourage increased activity into the construction business as less capital would be needed for entry. Land speculation would be discouraged, as less private land would be needed. The government could couple this with defrayed or long term loans on the land to buyers. Since no actual cost except utilities accrues to it, the government capital situation is not depleted. Whatever low interest they would charge would be income. To the consumer it would be equivalent to another 30 + percent of his housing costs mortgaged. As stressed earlier, this is of major import.

Government actions could restrict speculation on land. Use of properties as common stock to hedge inflation is openly acknowledged. Heavier taxing on the excess profits of this speculation over the existing bank interest rates would reduce this now lucrative trade.

An alternative investment source with high after tax and low risk returns, perhaps linked to the dollar, would also lessen land speculation. In this country the savings and loan institutions have done just that, and 80% of all savings and loan investments must by law go into

housing. Government action enabling savings institutions to link funds to the dollar or tax reductions on the return on these investments would aid housing production in two ways. The availability of mortgage capital would increase, and the value of land as stock would decrease with the introduction of a low-risk alternative.

Another government action which would effect demand for housing in major urban areas involves the Development Towns. The prevailing strong preference by most people, including immigrants from small towns in other countries, is toward the larger cities. Currently, the major factor encouraging the settlement in most of the Development Towns, despite the general knowledge of the importance of national dispersion, is the poor mortgage terms available elsewhere.

In-depth studies should be carried out as to why these towns are relatively undesirable. Perhaps the answer is as simple and solvable as the lack of a bowling alley and discotheques. Perhaps they are too small at the outset to function and fewer should be built. Maybe the cultural or socioeconomic mix is insufficient. What are the advantages in the most desired Development Towns? Whatever the causes, improvements could probably be made which would increase the desirability of these towns. This would make life there more tolerable; even desirable, while at the same time decreasing

demand for land and existing housing in the major cities.

This simplistic view towards improvement of Development Towns sounds fraught with naivete. However, the ugliness and absurdity of one such New Town remains in this author's mind. Sixteen identical eight-story towers, densely packed, sixty miles from anything; a sole cafe for diversion, a factory, and an unopened drug store were all it had to offer.

Industrialization of the construction industry is another step which would have profound positive effect upon the total housing picture in Israel. All the prerequisites which experts seem to agree upon as necessary for this industrialization are exploitable.

A survey of the literature shows that most critical factors include the following:

Quantities of required housing, both at present and in the foreseeable future are sufficient to sustain even large scale industrial processes.

A large percentage of government initiated housing is available to counteract initial consumer reluctance toward a new product, and to smooth cyclical tendencies in private purchasing.

A healthy natural housing budget exists;  
housing priority is high.

A trained professional labor force exists.  
(The assumption here is that industrial-  
ized building will use less labor.)

Centralized population and general small  
size of the country reduce transportation  
problems for even large housing components,  
and allow centralization of plants.

Organized overall linkages are maintained  
between installations of utilities, commun-  
ications and traffic, and new housing in  
development areas.

Qualified professionals in the following skills  
and disciplines are available: economy,  
planning, engineering design, materials,  
sociology, geography, information, adminis-  
tration, and law. (Klaus Blach, Prerequisites  
of Industrialized Housing)

Precedents at high and low levels of technology

and mechanization, when applied to other than housing uses (i.e. electronics, aviation, plastics, diamond cutting) indicate potential for success.

Getting specific about the actual types of industrialization requires thorough study. This will be dealt with in a later chapter. Let it suffice here, however, to say that careful consideration must be paid in a specific way to materials available and their costs, labor cost and availability, climactic conditions, transportation costs, availability of vehicle types, and road restrictions, existing zoning restrictions, tax structures, consumer, union and architect receptivity.

Hardware must be designed specifically for Israel, although not necessarily by an Israeli. Experience has shown that imported finished building systems almost universally fail, yet there are few Israeli firms competent in systems design.

An early step in encouraging and assuring quality in this new type of housing process would be governmental development of a detailed set of performance specifications. Performance requirements must replace existing code requirements calling for specific materials and methods. Areas which should be covered are structural resistance, fire

retardency, electrical safety, water-proofing, acoustic separation, ventilation and perhaps ability to change with time.

It is on accepted levels of performance in these areas that the government should take bids on the annual 36,000 or so units they initiate, and it is in this arena that industrialized housing must out-perform per dollar conventional construction methods.

The Ministry of Housing may want to further encourage industrialization by offering long term, large contracts based on meeting these performance criteria. On the basis of these (and perhaps a prototype unit) firms could approach financial institutions to obtain the funds necessary for capital intensive technologies.

Factories probably should not be subsidized and although valuable spin-off benefits will undoubtedly occur, cost comparisons of industrialized products should always take into account amortization of the plant and equipment.

Industrialization need not be an all-or-none proposition. The recently developed "modular coordination specifications", although shortsightedly detailed specifically toward large, concrete panel builders will aggregate markets for small element manufacturers. The same elements, not only can serve more than one system; wise conventional builders can incorporate into their buildings these parts

when advantageous. Parts may range from those as small and simple as windows and fuseboxes, to whole bathroom-kitchen modules. In addition to encouraging a mix of conventional and pre-fabricated building techniques, dimensional coordination will provide easy phasing-in of industrialization on different levels. With time, increased numbers of firms will be producing parts. Whether any firm can produce a total building is not of great import if the coordination is sufficient. Ultimately complete "catalogue building" may be possible. This would bring with it tremendous flexibility for architect, builder, contractor, and most important, user; both during initial construction and throughout the life of the home.

Although pictures of Eastern European closed building systems bring to mind cold unchangeable repeated forms, there is little reason to believe that coordinated systems building will not increase the vocabulary of built form, particularly for limited budget buildings.

What can industrialization do aside from improving the physical product and decreasing labor content? It is very likely that the price per square meter (of improved performance building) would decrease. A survey of twenty-one countries by Jay Howenstine (Prefabricated Construction: Developments Abroad) indicates that the countries using the large heavy panel systems typical of Eastern Europe

average 10-20% savings on construction costs and 33-75% savings on completion time. The more attractive Scandinavian and West European systems, generally of high quality, average 5-15% cheaper with a site time decrease of 35-58%. "The long term prospect is that industrialized building eventually will demonstrate clear cost superiority over conventional building" (Jay Howenstine, Ibid.).

A major advantage which the Israeli context has, even over most of these other countries experiencing gains, is the high cost per traditional building of construction loan (whether this is done in the formal framework or not is not crucial). Construction loans typically go for 18% per year. Four story housing generally takes 16-20 months and elevator buildings even longer. It would not be unreasonable to assume that industrialization will cut the construction time 40-80%. This would result in corresponding savings in interest alone at 6-10% of total construction costs!

With the particularly tight construction labor market in Israel, there is reason to believe that a decrease in demand for skilled workers of a few percent would allow the prices in this area to drop significantly. If the actual numerical need for construction workers decreased very significantly, many or all other sectors would benefit from the added, much needed manpower. Construction now occupies over 8 1/2% of the total labor force.

The shortage in managers would be less severe with more industrialization. This does not eliminate the need to train people in management for all fields. A large governmental program, such as the one which resulted in a high per capita engineer rate, is necessary. If not done, it will ultimately prove blatantly urgent as international trade tariffs are lifted. Whatever the supply of good top management, however, increased finished products make site assembly easier and far quicker, needing less supervision. Any move toward sub-assemblies in more controlled conditions is likely to necessitate less management per worker hour.

The general move toward factory sub-assembly of building elements, each with a larger market (due to the dimensional coordination) is likely to result in other changes. Competition between the element manufacturers is likely to result in improved quality, lowered costs, and greater incentive for research and development.

New technology will transfer into the housing industry; equally important, the new methods will help the country in developing a new industrial capacity. It is fortunate that an opportunity exists for all of the necessary learning to occur not on the international market but in an inefficient home industry, heavily influenced by the government ministries and public companies.

Although some of the equipment and materials necessary for this new, more rational building industry will need to be imported, the quantities will probably decrease after several years. The government's traditional rationing of imported materials to protect Israeli substitutes should here be applied with special caution. Import decisions must be made after analysis of benefits of the whole "system", considering as many of the side effects as possible.

The indigenous architecture of the Middle East is very exciting. Domed rooms step down hillsides, cool wind is channeled through spaces, cooling them even on the hottest days; terraced roofs and courtyards allow varied outside activities. All dwellings are individualized, yet they fit each other and gain from joint use of walls. A beautiful texture results. The conglomerate works at all scales.

This, unfortunately, is very much in contrast with the previously described rows of a four story boxy flats which characterize the architecture of Israel during the last thirty years. A future of higher technology and lower prices one would hope will enable architectural forms once again to be dealt with aesthetically. The new vocabulary should take precedent from the old. The units should fit the

site, and future changeability should be designed in. If necessary, "soft" zoning regulation should be required; courtyards, planted roofs, natural ventilation, and views can be part of the typical home.

The road to improved housing in any country is not easy. The Israeli government's unique voluntary involvement and commitment to this area and her healthy housing budget could, with more creative policy, bring future qualitative achievements more in line with the quantitative successes of the past.



A HARDWARE  
DESIGN STRATEGY

In earlier chapters housing policy goals were enumerated. Various policy alternatives were then suggested; one of these being increased industrialization of the building industry. The role of this industrialization in the total scheme was generally outlined.

The design process can begin here based on the established framework, constraints, and national goals. At this point, the author will change roles, from that traditionally played by planner, to one of systems designer. The problems to be solved are not limited to the building forms, or how well the buildings work in terms of circulation and space efficiency. Although the output must ultimately be aesthetically pleasing and functionally efficient, the nature of the system must be formed with strong input from other sectors. Clearly, no two designers placed in this context will produce the same results. Different approaches can be rationally applied to achieve similar ends.

Getting down to specifics, an early form determinate in this particular approach was the high cost of land. Sloped sites exist unused around or within all of the major cities. This land is useless for agriculture; and, perhaps due to the traditions formed when land was cheap, few builders construct on these areas without the very costly job of completely leveling every site and constructing retaining walls.

If an inexpensive foundation system could be developed, not only could land costs be reduced, but other benefits of the slopes could be gained. High densities can be achieved, since units can be placed very close together without restricted views, light and ventilation. Roofs can be used as gardens or terraces. Slopes lend themselves to good environmental design and beautiful community spaces, characteristic of Mediterranean village architecture, can be easily and naturally created.

Land costs for sloped sites seem to be approximately one half to three quarters of flat lot costs. (Presumably this might reflect the premium typically paid for the levelling.) Using these figures and the usual land cost of approximately 36% of total cost, the new system can cost 9-18% more and still be competitive.

Another of the major weaknesses in the housing sector is a marked shortage in skilled labor, and the resultant high wages demanded. Two alternatives seem available to decrease reliance on these workers. One approach is to use highly mechanized, high capital-outlay equipment to replace as many skilled jobs as possible. The other approach is to redesign their tasks in order to increase their productivity, and enable lesser, or semi-skilled labor to, in some instances, replace them. Both of these

approaches to reduce skilled labor per unit are used in the proposed system.

It is characteristic of countries undergoing rapid development that things often "don't work." Although complex tasks do eventually get accomplished, it is critical not to interconnect too many processes. The chance of one failure holding up the whole system simply becomes too great.

Industrialized building is characterized by just such linkages. In the U.S., mobile home plants with hundreds of men working and hundreds of thousands of dollars in semi-finished products on the line can rely on truck deliveries scheduled to the hour. In the Middle East, and in Latin America, factory managers often consider themselves lucky if shipments arrive only days late. Furthermore, the location of the plant itself compounds this issue. When machines break down, parts often must be ordered from overseas. Attempts must be made to provide alternatives to each of the steps in a system, and to have few steps or processes interdependent.

Another factor making up a significant part of construction costs is the high cost of a construction loan. 18% to 20% interest on principal, 1/2 of which is in use on the average, coupled with a construction period of 18 months adds 15% to construction costs. Without significant

changes in the economy, certainly not the systems designer's role, the way to best combat this is to drastically reduce construction time. International precedents indicate that a cut to 40 to 80% of present construction time is not unrealistic. The savings here are obviously substantial.

Shortage of trained management too, is a serious problem. Although professional managers must be trained, the existing shortage can be minimized by creating situations in which those managing can most effectively work. The organization of the construction process such that the trades do not interfere with each other, and need rely as little as possible on each other, can produce efficiencies in this area. Choice of optimum project sizes as opposed to scattered sites, and repetitive tasks in which workers or teams can do the specific jobs through rows of houses, will also lessen the burden on these managers or allow poorly trained managers to better control. The role of factory production of elements and sub-assemblies is a significant factor, too. Clearly, in these situations, the management required per unit, and per worker hour is decreased.

Balance of trades problems is another important factor effecting the system. Because it is a substantial part of the budget, housing should be designed to make use

almost entirely of local materials. Also, the vacation and retirement home market in Israel is slowly growing, despite the poor environmental and architectural design. Improvement in quality of aesthetics in environmental and architectural design can make this source of foreign currency more significant. Although total housing is generally not shipped great distances, well-designed compact parts can be exported.

A related priority is Israel's desire to be an exporter of technology. Slow, phased involvement in different aspects of technologies related to building systems can improve this potential. Lessons can now be learned slowly in competition with inefficient conventional builders, rather than later in international market.

The problem of an increasing Westernized culture, progressively and predictably expecting and demanding a higher standard of living, must be provided for with a flexible architecture in order to prevent future outmoded substandard housing. Buildings should be expandable. Interior partitions should be flexible with time, allowing small roomed apartments to later have fewer, larger rooms, as the user, or users' lives change. This obviously has implications on the structure of the system.

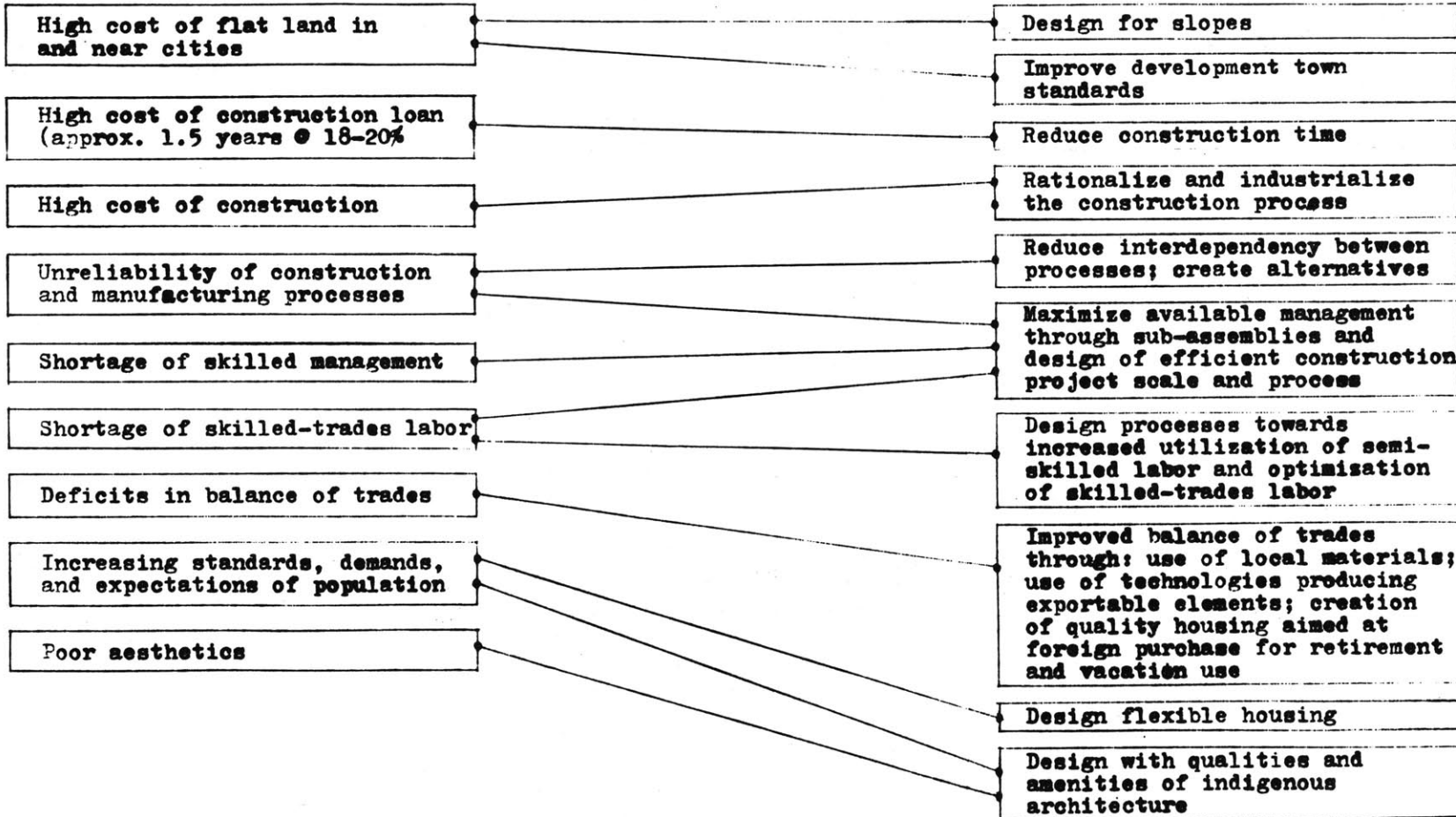
The question of aesthetics, too, must be dealt with. The short history of Israeli Architecture has produced few notable buildings. The architects have attempted to be

little more than modern, and have failed even at that. In the very attempt, however, the necessities of Mediterranean climate and lifestyle have been put aside. The landscape and skyline too suffer from a mismatch. The architect operating in the Mediterranean countries should not attempt to imitate the indigenous architecture. He should, rather, understand it and strive to incorporate into his new architecture (necessarily of different building methods and materials) the qualities, amenities and sensitivity to nature achieved in these indigenous buildings.

The following chart summarizes the major problems in the Israeli Housing Context and their respective input to the designer.

# current problems

# design implications



THE PROPOSED SYSTEM

Although the design process is not linear, the written word is. Strategy and hardware decisions have been made in light of the interdependency of consequences of each decision on the others. It appears most coherent to first state a few of the preliminary considerations and then to examine the system elements in the order in which they would be used in the construction process. It should be noted here that the last section contains illustrations which may be referred to in order to simplify the understanding of this text.

One of the problems listed in the section above dealt with the general unreliability characteristic of industry in developing countries, and the resultant incentives not to link processes. Another very related factor is the fragmentation of the construction industry in almost all

countries. Most of the buildings are not built by large builders. How can a system be designed such that even the small contractors and builders can be positively effected, too?

One solution to this can be to design the system with most tasks parallel to those in the conventional construction process. This will allow large users or builders using the system to plug gaps or problem areas with conventional means. Technical, labor union, economic or production problems can thus be easily sidestepped while construction process continues. Smaller builders can use one or two innovations where this will increase their efficiency without the need for expensive tool-up or new trades.

By creating the system framework in this way, the cost of elements can benefit enormously from economies of scale. Although Israel builds 60,000 units per year, the largest of the pre-fab factories produces only approximately 1,200 units per year or 2% of the market. 10-25% of the market for many of the newly designed part types, however, does not seem unreasonable. At this scale the most efficient mass production manufacturing techniques are well within reach. Yet an over-abundance of similar or identical housing on the landscape need not result.

By the above description the system may be rightfully

put into the category of "open system." Open systems, however viable conceptually, traditionally have become only incomplete systems. Complex high-technology parts make up the structures of units; the open part is the messy time-consuming job in finishing. In two open systems used in Israel known to this author, the time was cut approximately two months at the expense of initial and lifetime flexibility, aesthetics, and, in one case, price.

The module chosen for the proposed system is within the framework of the new governmental modular coordination scheme to which all government initiated projects must adhere. The actual modules, may of course be a multiple of the government suggested "common denominator" module.

In the case of the proposed system, the vertical planning module is 20 cm. This is two government vertical modules. Need for more level changes than that are not necessary and the 20 cm dimension works well both as step and concrete block. For horizontal planning modules, 10 is recommended; where possible, 30 is to be used. The proposed system makes use of 60 in one direction; the other direction has total flexibility. Consistant with one of the recommended examples in the Ministry of Housing handbook, dimensions are taken from the interior edge of bearing walls.

An assumption used throughout is that although system parts could be used in any size project, for use of the total system as described, optimal project size is 100 units or more. This would keep teams of workers constantly busy and progressing systematically through the process. Project size of 150-400 seems to have the best scale environmentally and will support social and economic conveniences as day-care centers, nursery schools, neighborhood stores, bus stops and cafes.

Although the system is designed to meet the special problems of slopes, it can be used to create 3 to 4 story high density, urban, low-rise housing on flat sites, too, even in its most complete system form. The decision to try to build for sloped sites had its obvious benefits enumerated earlier. The problems include access for heavy equipment, high cost of driving deep piles, difficulties in site utilities, movement of large building elements over the rough terrain, and the high cost of roads. If these problems (however formidable) could be satisfactorily and economically dealt with, we would be past a most difficult phase, and able to make use of the savings gained from the less expensive land.

After much contemplation, and consultation with structural engineer and building technologists, a very simple foundation system illustrated was arrived at.

Through the use of a concrete pump and hose for the foundation (and later for most other phases) it was possible to eliminate the need for access to heavy equipment and reduce drastically the carrying of all mass within the construction site. By using grade beams with footings, no deep drilling is necessary and by arranging the units as row housing, the need for these foundations is nearly halved.

The densities attainable due to lack of visual barriers on slopes, and the related perception of lot size, allow for reasonable distances when parking at the main roads without expensive private automobile access to each unit. This may be seen as a weak point, but the current one car per 4.5 families and the governmental emphasis on mass transit puts this into a different context. Coupling this with the very reasonable attainable maximum distances of house-to-parking-spot of approximately 70 meters along developed, often protected pedestrian streets, may make this decision an environmental asset.

High densities, and ~~row~~ house construction make distribution of site utilities to each unit efficient. Pipe lengths along the rows service many apartments, and the necessary drainage slope of sewage pipe is of course not the problem often encountered on flat sites. Since the units

are mostly off the ground, permanent access to pipes is available. The constraint of stacking wet spaces is also diminished by the ability to make horizontal runs easily, under the units.

The actual construction of this foundation is remarkably simple. Narrow trenches are cut by unskilled labor, or if accessible and desirable, by trencher or back-hoe. These are parallel 3, 4.5, or 6 meters apart. Within these trenches, modular steel-edged plywood reuseable forms are placed with burlap gaskets to the soil. The final positioning of these forms sets the building tolerances. This is the most critical dimensional job in the process, and must be inspected or supervised by a foreman, engineer or surveyor. However, the modular nature of the formwork joints enables a whole linear section of foundation to be checked at once. In row housing, this involves only one or two forms per dwelling. Standard reinforcing bars are placed within this formwork

If the system is used to its fullest the foundation forms are filled by using the concrete pump. If this has a very modest three cubic foot per minute capacity, foundation pouring speed can be slightly under one linear foot per minute. The hose need be no more than 2 1/2 or 3 inches in diameter and will weigh when full approximately 6 pounds per linear foot. As the sections are of different

heights, levels must be allowed to cure slightly between pours at different levels to prevent overflow. This presents no slowdown in projects larger than six or seven units.

After the foundation walls are completed, the bearing walls must go up. These must be of small elements in order to change levels to best utilize the slope. In the total system, these are of mortarless self-aligning foamed concrete block. Several clever designs for these blocks exist. Three have been adapted to the government module and illustrated. Most simply work on the principal of edge keys which enable the laborer to feel when the block is in securely and perfectly in place. When it is, there is no need to level or mortar the joints, which constitute the time-consuming aspects of laying masonry. These walls have been tested by Christopher Alexander, Peter Land, Educational Design Inc. and others, and have proven to be accurate, strong and waterproof. The fact that mortar is not required also enables the professionally supervised dimensions to be unaffected by different mortar joint thicknesses. Lessening the density of the concrete by foaming serves several purposes: the insulation value is increased, and the weight is decreased, allowing for easier manipulation on the site and larger blocks with fewer joints. Textured block will save lifetime maintenance

problems and also provide increased surface area for heat dissipation.

The masonry process would probably involve a mortar bed to finalize and cap the foundation tops. Upon this would be the very carefully laid first course of block. From that course on, blocks could be laid extremely quickly by unskilled workers. As the walls are generally bearing party walls, few interruptions will occur between floors. At each floor or floor line, steel rods are placed in appropriate cavities (the frequency depending largely upon the load above) and these cavities are then pumped or poured full of concrete to unify the structure and increase bearing capacity.

Slabs are pumped or poured in place. The innovation brought to this process is the use of reusable fiberglass formwork designed specifically for the three bearing wall span dimensions. The formwork is of the one directional joist type. This produces a coffered, undulating smooth finished ceiling which need not be plastered or even painted. It may, of course, be tiled over if desired. It can also carry duct work in one direction within floor depth; direct or indirect lighting too can be placed in these cavities. The real benefit of the one way slab system is the 55% savings of materials possible by reducing the amount of heavy unstressed concrete between the joists.

This further allows savings in other parts of the structure as the whole building weight is significantly decreased.

The use of this type of formwork is not efficient in small spans with constantly changing dimensions. Modular bearing wall construction, however, is ideal for this; the forms can even be ganged and reused in groups. Forms will weigh between 100 and 200 pounds each depending on length.

The forms are bolted together and reinforced at the bottom with steel channels. These are supported by jacks as necessary. Tolerances at the edge are allowed for by use of temporary filler supports. Steel reinforcements are placed in the forms as needed. The longer spans take larger sections, but the slab width stays constant and on the module. Framing for stairs, balconies, galleries and skylights is done by modular sectional forms; only two types are needed. Vertical plumbing runs involve only a simple removable filler plug in the thin part of the slab when poured.

Slabs key into bearing wall cavities, and concrete goes down one layer to a special lentil block. This increases the structural continuity of the buildings. The vertical continuous reinforced cavities also tie in with the slabs.

Floor treatment is optional. The quickest method,

gaining particular efficiencies with standard spaced bearing wall construction is a rolled out finished floor of carpet, or foam-backed tile. These can be applied after the troweled-smooth concrete slabs are cured, but before the interior partitions are installed. These may come from the factory with a temporary polyethylene covering on the roll. A thin poured surface could also be used.

The conventional terrazzo tiles, laid over sand on rough concrete has traditionally been a bottleneck in the construction process. Its use, however, does have some redeeming qualities and strong consumer approval. Its virtues may outweigh the added time necessary.

The wet cores can be placed before or after the floor is laid. These units are easily lifted by four men. The kitchen unit is put in place, and the simple plumbing hook-ups are done in the back of the lower cabinets. The units are complete, and need only to be sheetrocked in on the exterior during that phase of construction.

Bathroom units are much the same. Shortened "1/2 bathroom" and "mechanical" module types allow aligned fronts, while leaving good access to pipe chase during construction. Later access is through a panel behind water closet.

Dry modules, consisting of kitchen and bedroom cab-

inets, are placed in much the same way, as are stairways which are man liftable steel or wood prefabricated elements. After the placement of these, the unit is ready for end walls.

These walls, too, are of mortarless self-aligning block. A variety of "pizzaz" attachments may be integrated to provide various amenities. These include skylights and a solar water heater on the roof, window seats, arched facade elements for window and door framing, shade elements and even a small cantilever-balcony. All of these are modular and lightweight, and many use the same set of parts. They can be easily integrated within the blockwork with wet or dry flat joints. The next stage is mounting of doors and windows. The building is then closable and finish work can be started.

At least two types of quick interior partitions can be used. Mortarless concrete block similar but thinner than that used for bearing walls can provide excellent user-controlled flexibility if post tensioning rods are used to replace the poured cavities. These, like the structural bearing walls, can be textured and may need no finish at all. Special blocks must be produced to fit the undulating ceiling line when walls run parallel to the bearing walls.

Another possibility would be to use stud walls not unlike those used in the United States. Studs are now available in wood, aluminum, sheet-metal, and gypsum. Perhaps the economics of these or other materials now will enable non-structural, studded partitions to be built and covered with standard sheetrock, pressboard, or plywood. These could all be 2.40 meters high and attached with .22 caliber cartridge-fired fasteners into the slabs. Standard filler frames could be sealed with neoprene gasgets into the trapezoidal ceiling coffer spaces.

When all walls are in place, sheetrocking, (if necessary plastering) taping and spackeling should be completed; and painting and correcting of flaws and inaccuracies started.

The electrical wiring is the last step of the building process. It is accomplished by first gluing a continuous waterproof hollow rubber extruded coving along the wall-floor joint. Splice technique is simple, and the job need not be done by an electrician. In addition to providing a place for the wiring and providing a durable easily cleanable molding plate, the coving eliminates the need for a perfect joint and allows for easy dimensional tolerances on the flooring and wall surfaces. Wall panels, if used, can be perfectly placed at the top with knowledge that poor align-

ment at the bottom will not show.

When this coving is completely installed, an electrician is called in. He drills undersized holes where outlets are required and inserts the self-locking waterproof fitting within the holes. He then runs wiring from the fuse-box in the kitchen out both sides and around the house. This is placed in the permanently accessible, screw-closable channels. The wiring in the top channel is for "local" wiring which is attached to the outlet leads in the same room or nearby. The lower channel is for wiring connected to other fuses for rooms further along the coving and perhaps telephone lines and television antennae.

The same system could further be modified; pre-wired, pre-outletted; however, this would probably reduce flexibility and necessitate that the whole process, not just the wiring, be done by an electrician.

Vertical travel is through the chase, at which point it is accessed from the corners of the bathroom. All doors are pre-wired and have provisions for a switch. If door controlled wall outlets alone are not deemed satisfactory for lighting, the interior partition types described are easily wirable. As an alternative to this, wiring could travel from the door frame to the ceiling, and then unobtrusively across it as needed. When the system is

completely wired and checked by the electric company, the man-power line is pulled from under the unit and connected to the kitchen fusebox.

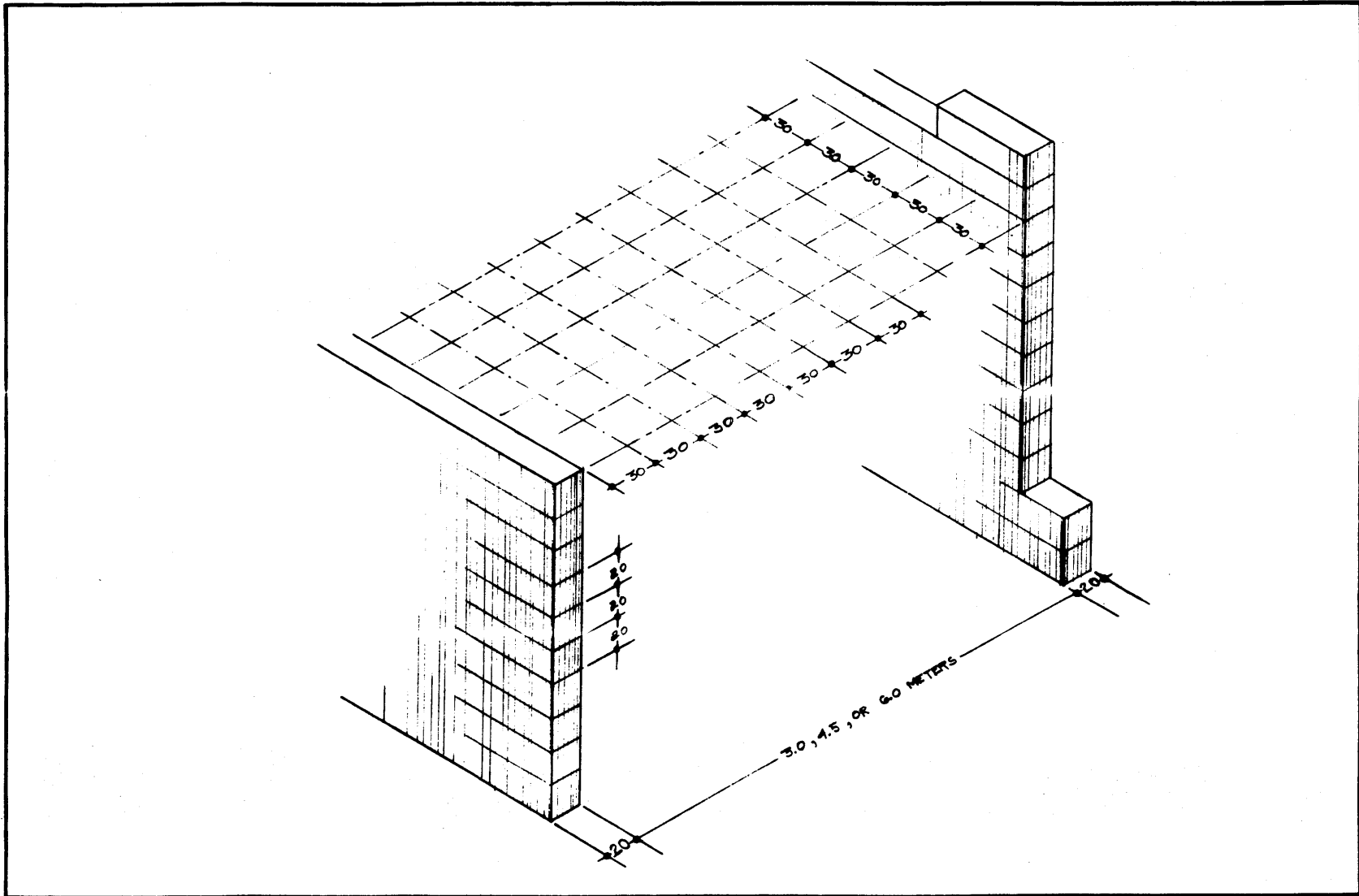
As the unit is undergoing the last one half or so of the construction, sitework and landscaping can be done. Much of this is traditionally done by semi-skilled workers using local stone at very reasonable rates. Although this method with guidelines from the site planner or landscape architect would probably be most advisable, quicker more technological elements as alternatives would be easy to design.

It is also worth noting that the unit vocabulary described above can be utilized to develop exciting outdoor public and private spaces. Public paths may wander under houses; either between bearing walls or under supporting arches or half arches. Public stepped terraces of various widths can be created using the standard floor elements. "Perforated" arched walls define space, yet are easily penetrated.

On the more steeply inclined slopes, those over about 40% grade, as in the indigenous architecture, property lines are less easily defined; air rights become an issue. This is due to the natural ease by which roofs of neighbors' become terraces. At higher slopes, even public paths must

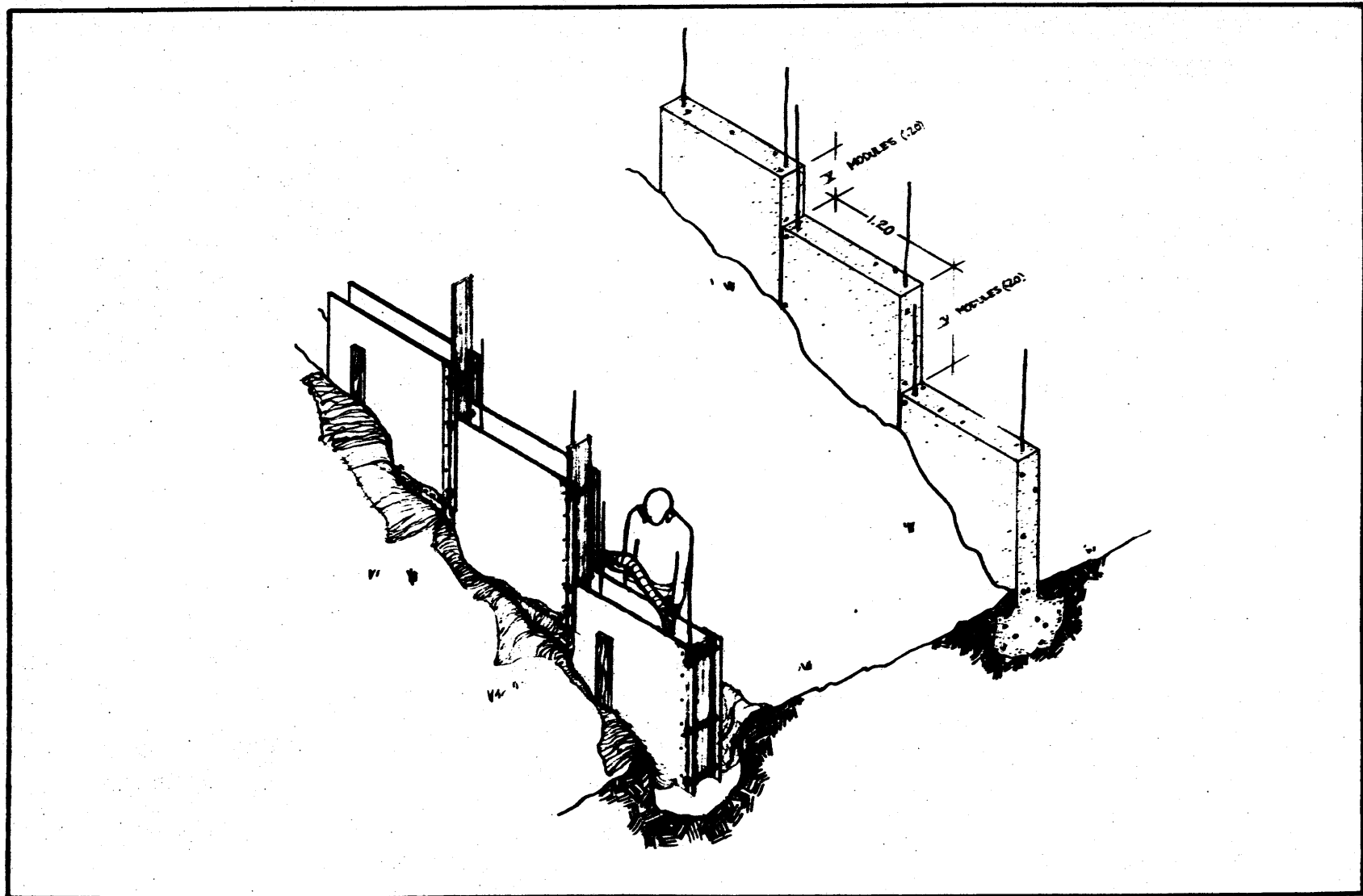
go over or under otherwise private property. Privacy can, however, be maintained through thoughtful design. Whatever problems this may bring the lawyer, it will undoubtedly increase land utilization efficiencies and bring varied and exciting spacial experiences to the future users.

An attempt has been made here to present a system which will be financially and technologically sound, based on user needs and environmental factors, while aesthetically pleasing and which can be flexibly translated to meet various and changing user needs. The following illustrations will allow for a more clear and coherent understanding of the system's parts and their relationships to one another.



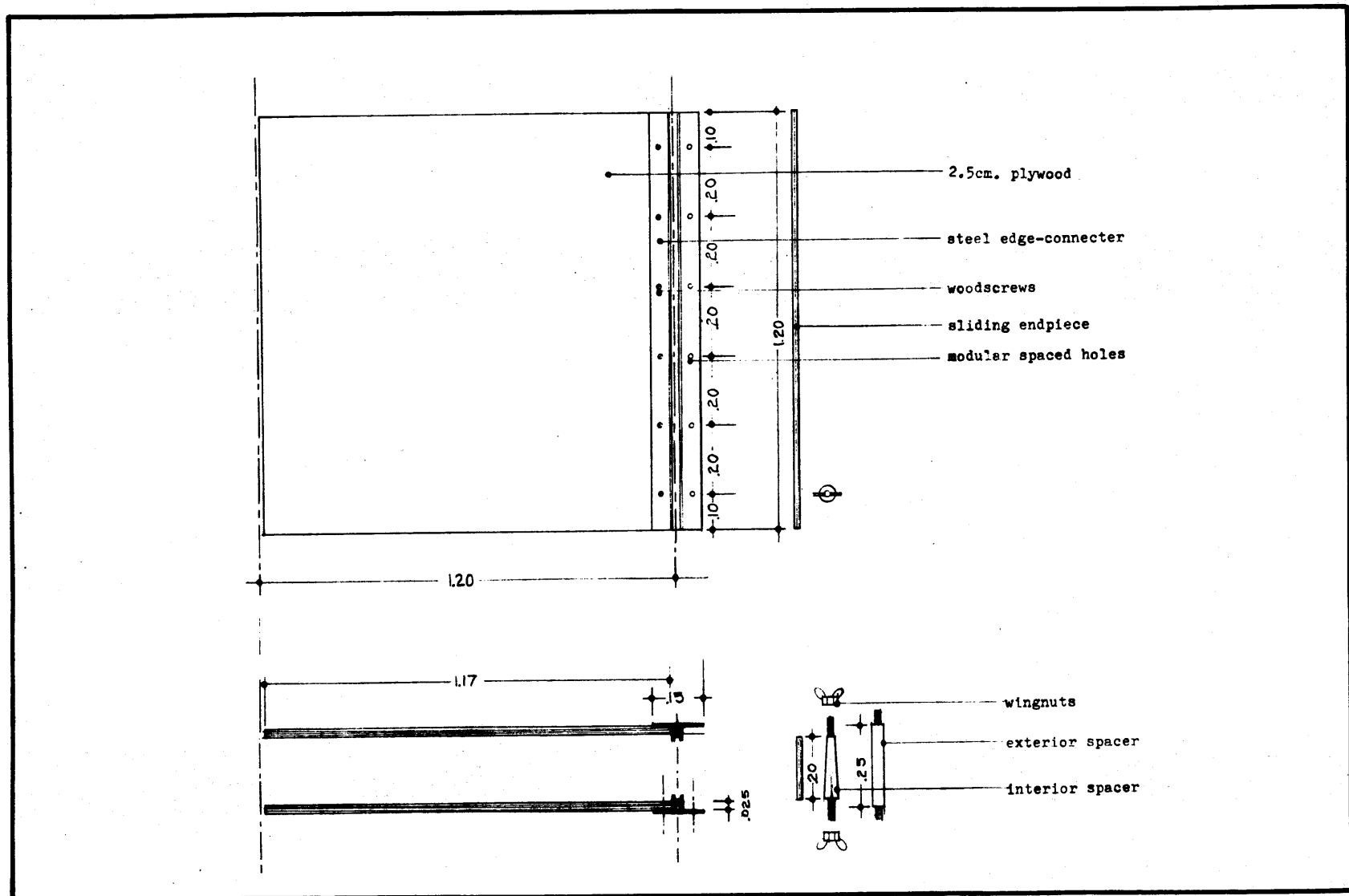
Note: The modular coordination scheme used is compatible both with the Israel Ministry of Housing and United Nations Recommendations.

## THE MODULE



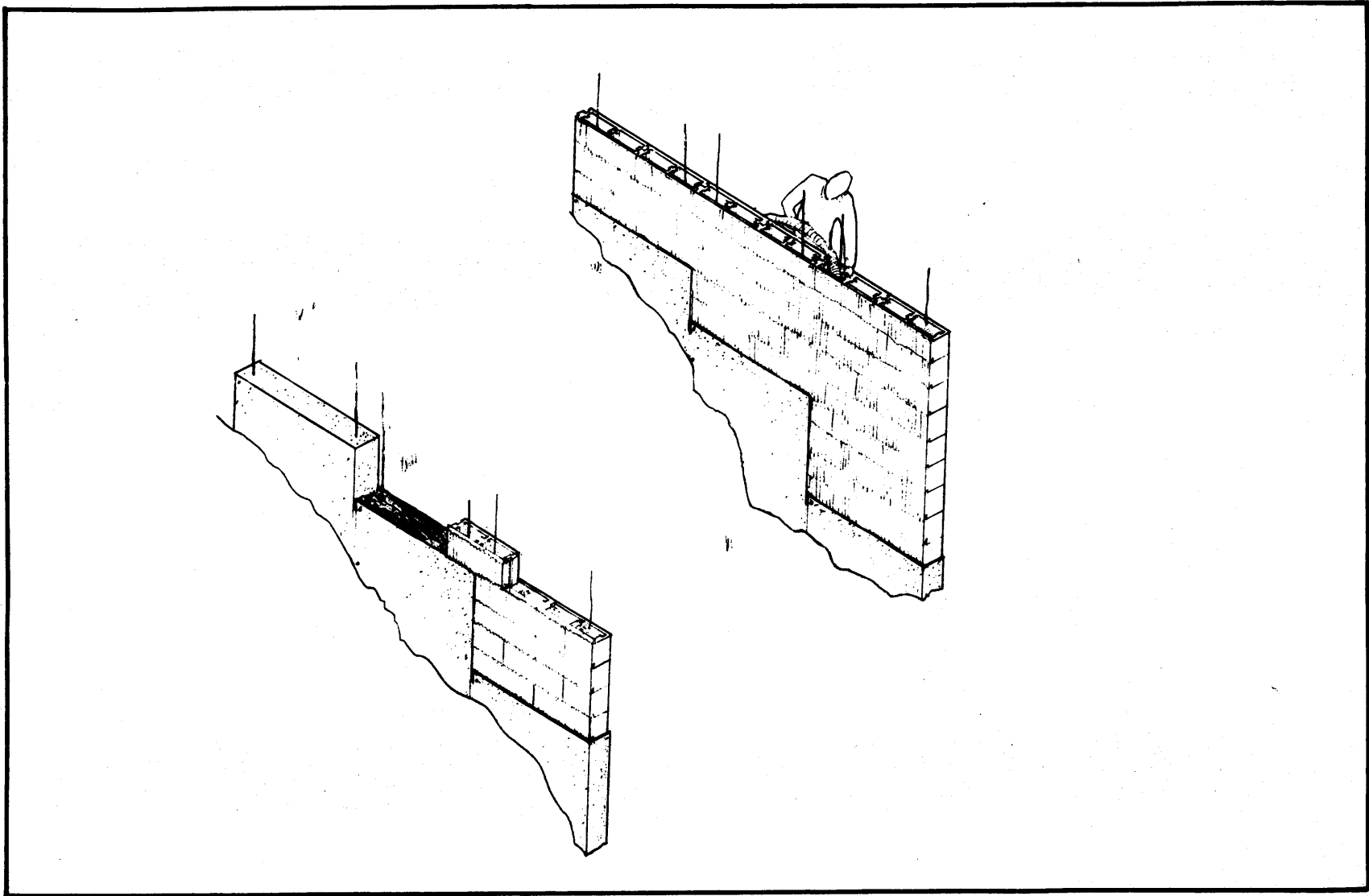
The Process: Modular metal-edged plywood forms are assembled to fit the slope contours. They are then placed in the trenches, carefully leveled, reinforced, and pumped full of concrete.

**STRUCTURAL SYSTEM**  
**foundations I**



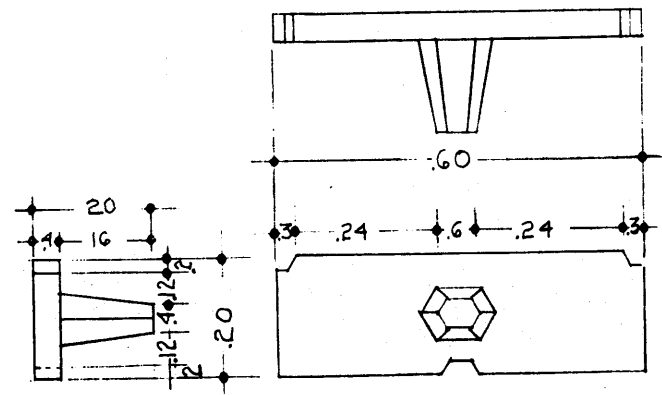
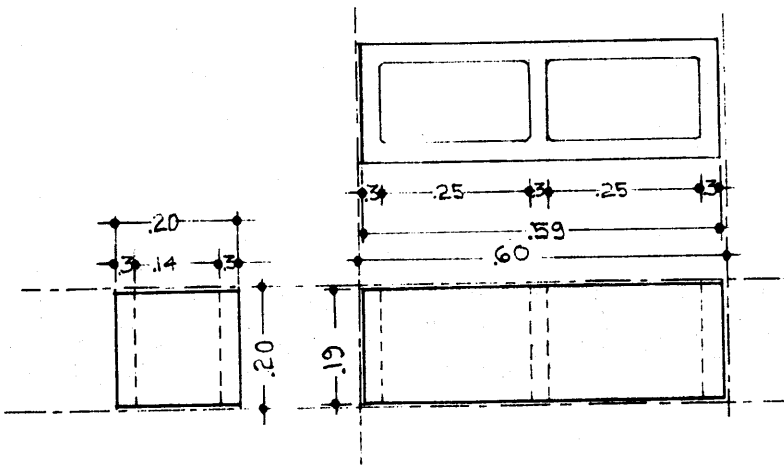
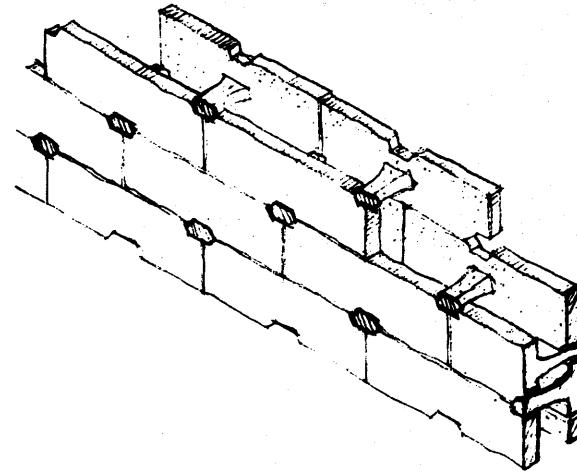
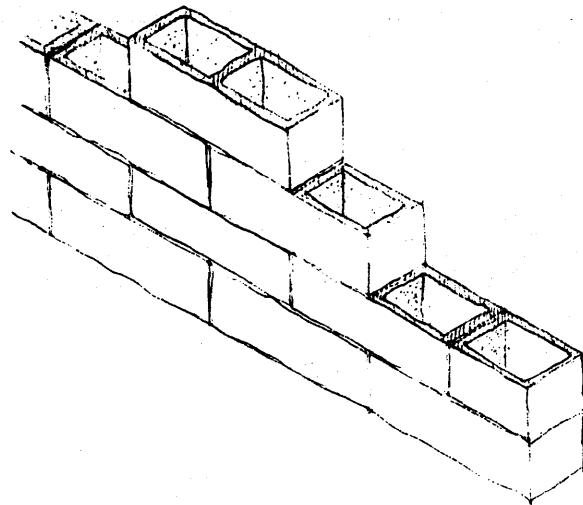
The Parts: The Major part of the formwork consists plywood and a metal edge-connector. These are slightly modified "off-the-shelf" items as are the spacers, wingnuts and reinforcing.

## STRUCTURAL SYSTEM foundations 2



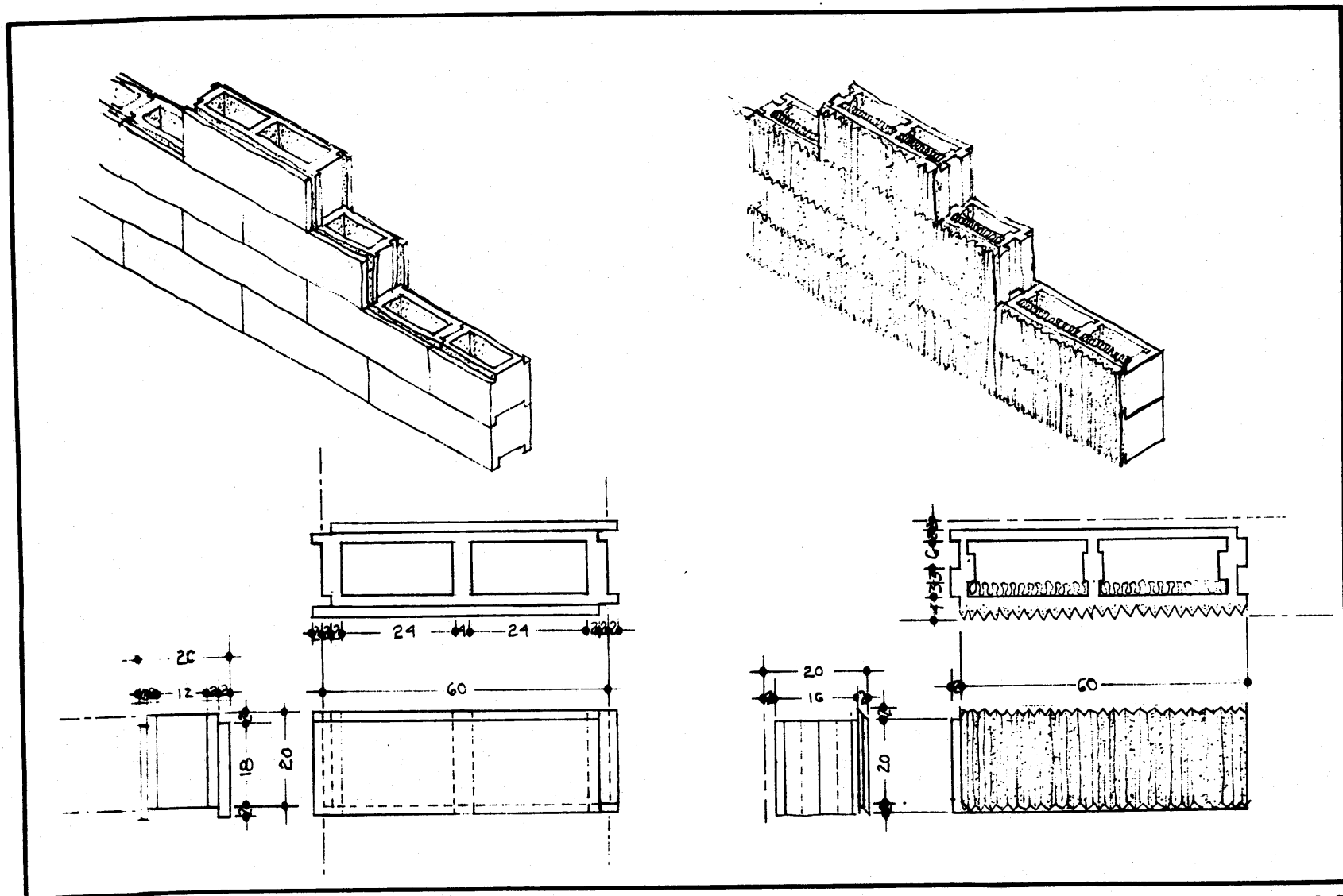
The Process: Mortarless, self-aligning concrete block is laid on a mortar capped foundation. At slab levels, where necessary structurally, cavities are reinforced and filled with concrete.

**STRUCTURAL SYSTEM**  
**bearing walls | I**



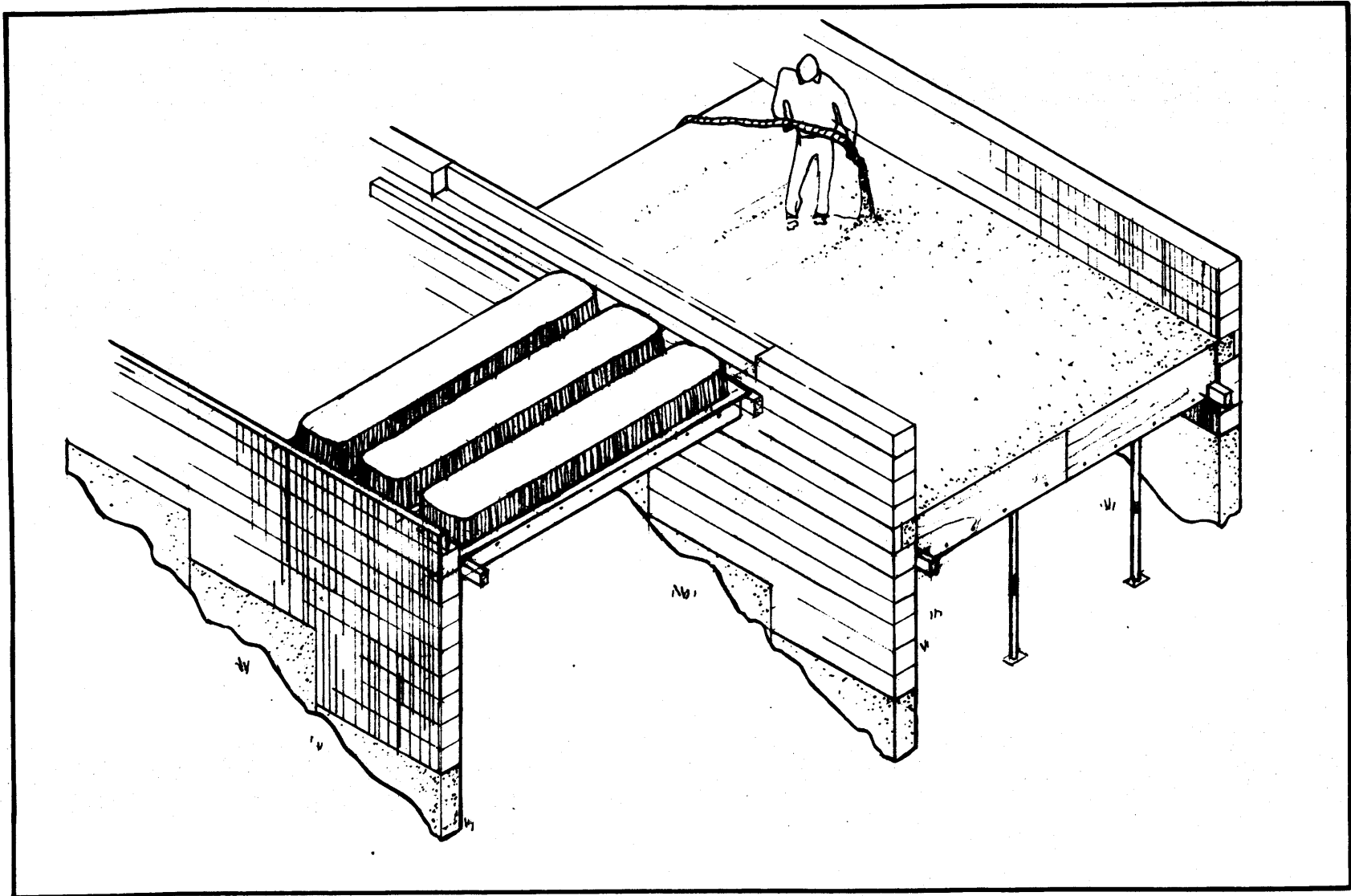
The Parts: Left block is a traditional concrete block made to conform to the module. Right block is a modularised version of the E.D.I. patented block.

## STRUCTURAL SYSTEM bearing walls 2



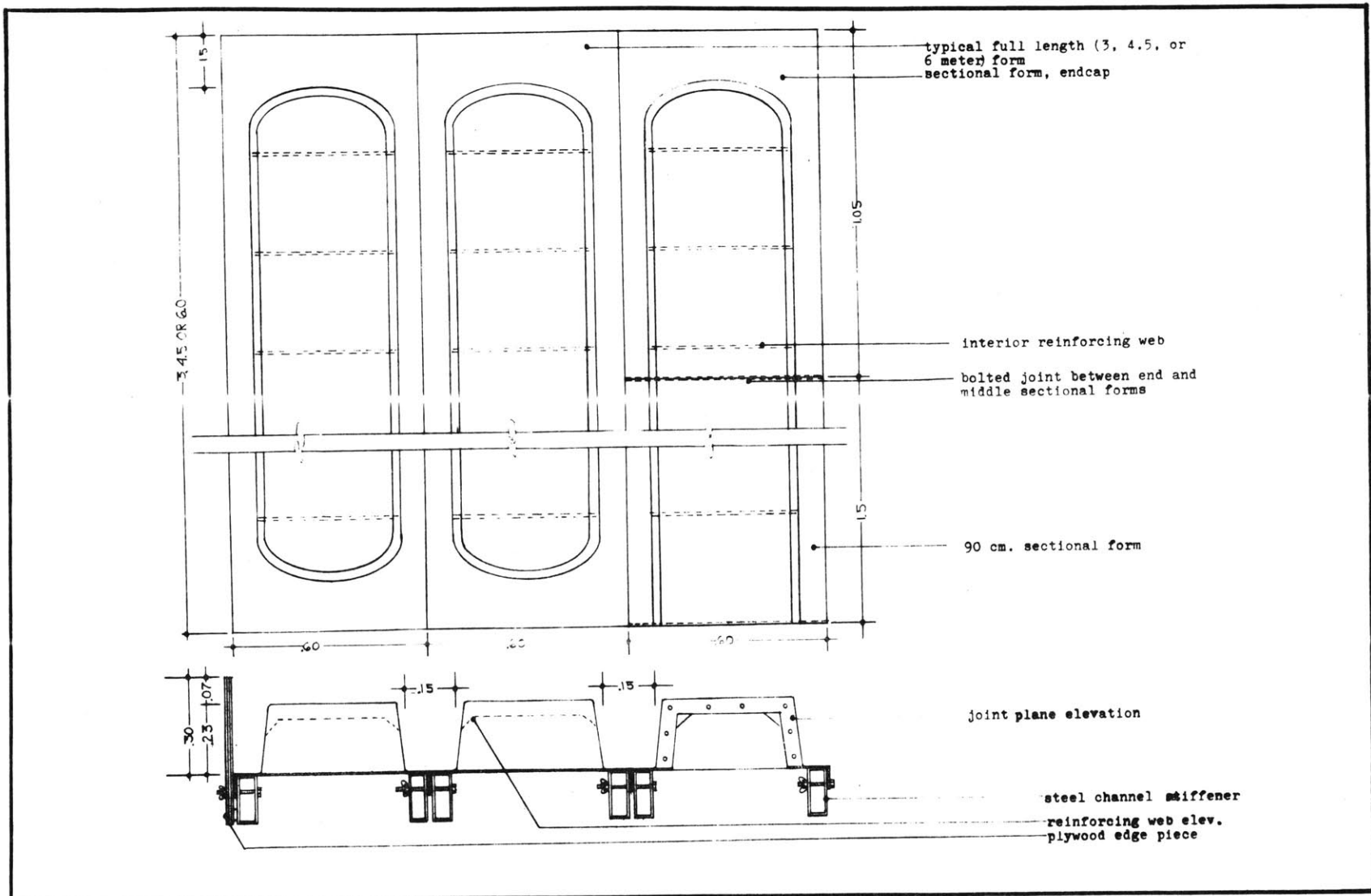
The Parts: Left is a modularized version of a block P. Land developed for use in Previ, Peru. Right block has a finished texture yielding additional heat dissipation area.

**STRUCTURAL SYSTEM**  
**bearing walls 3**



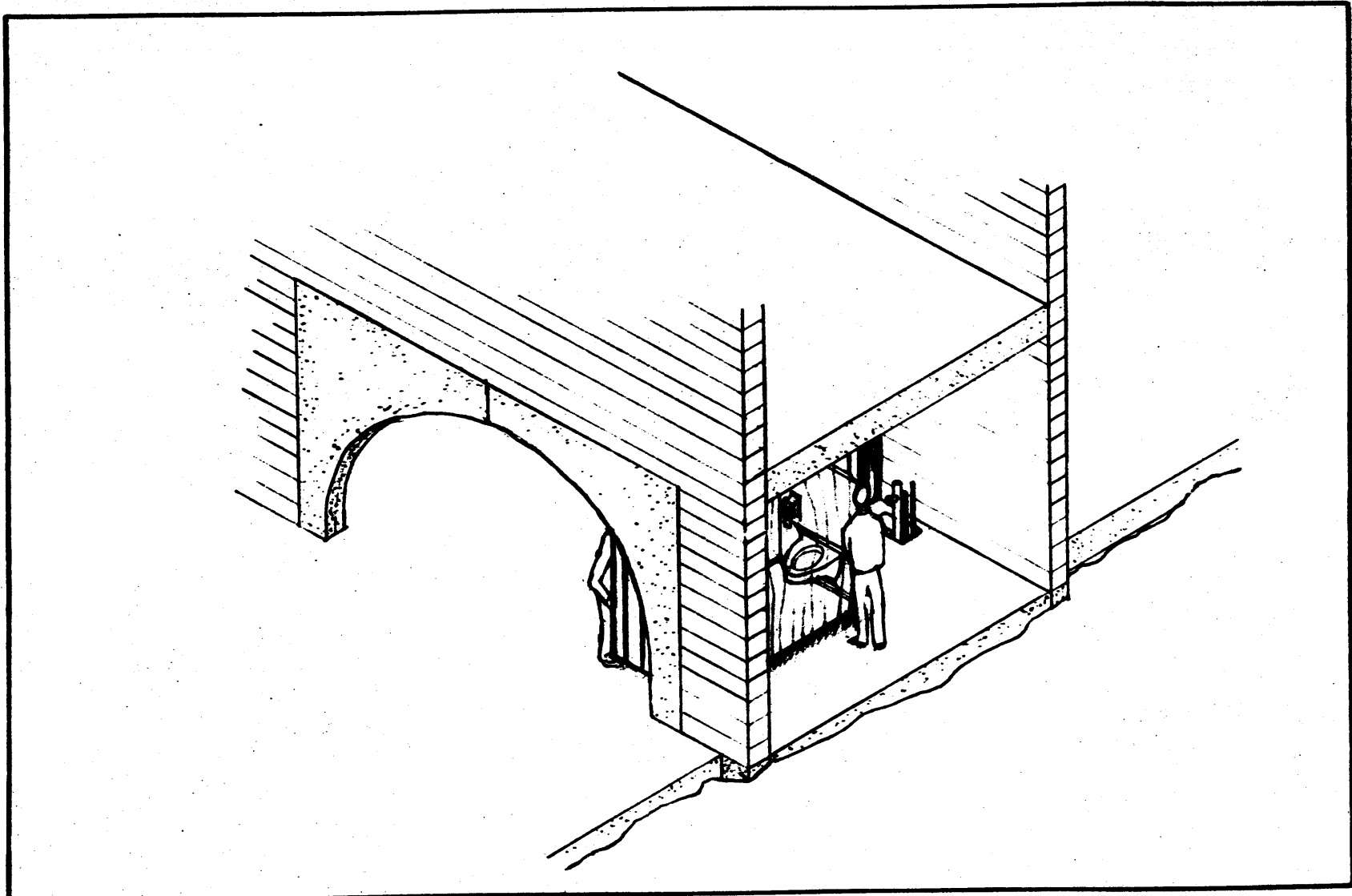
The Process: Modular fiberglass formwork is placed between the bearing walls, supported by jacks, bolted together and leveled. It is then reinforced and pumped full of concrete.

## **STRUCTURAL SYSTEM** **joist-slabs I**



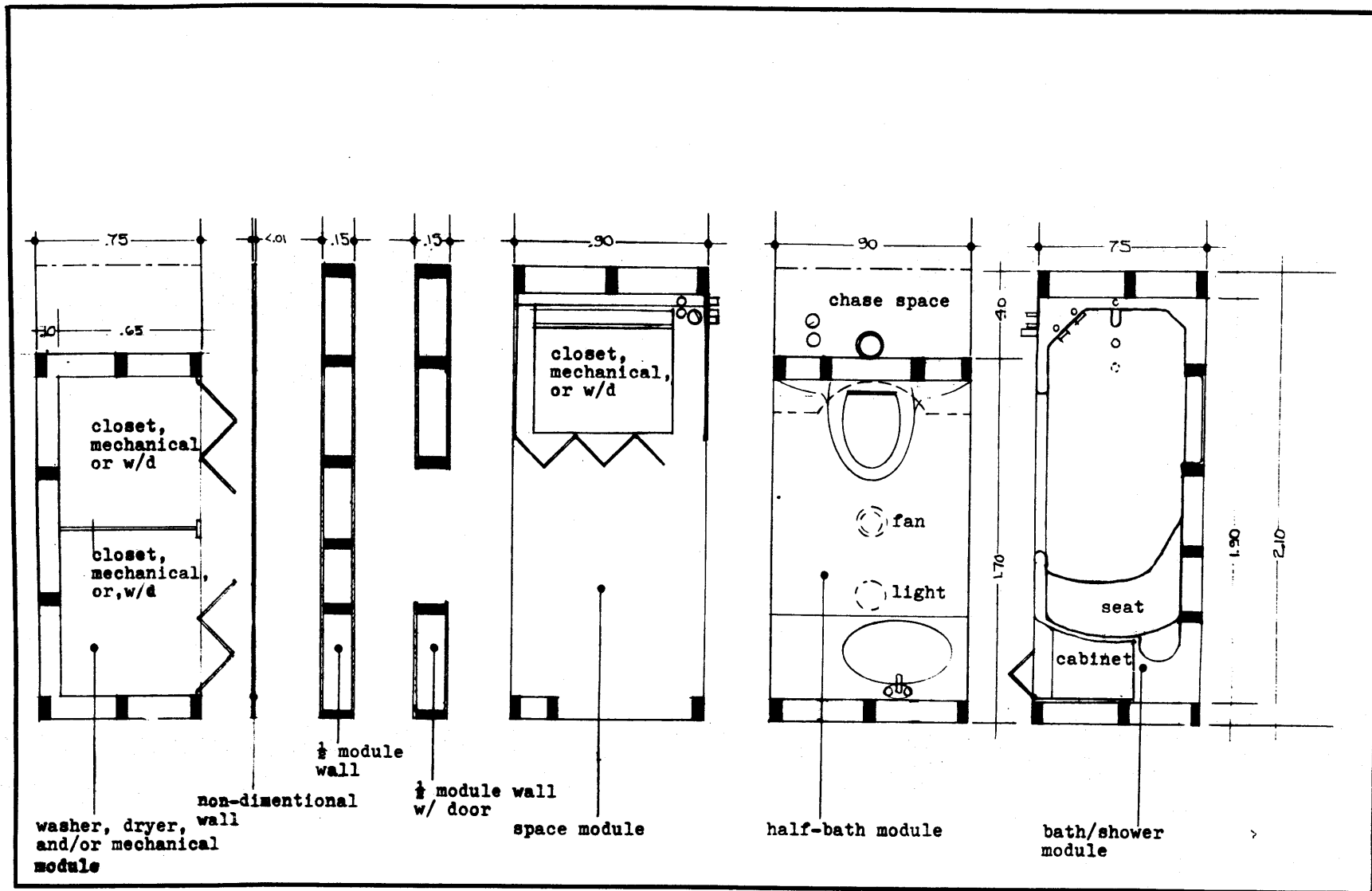
The Parts: Full forms come in 3, 4.5, and 6 meter lengths as do steel channels which support the weight of the concrete until set. Holes (for stairs, skylights, etc.) are framed using sectional forms.

## STRUCTURAL SYSTEM joist-slabs 2



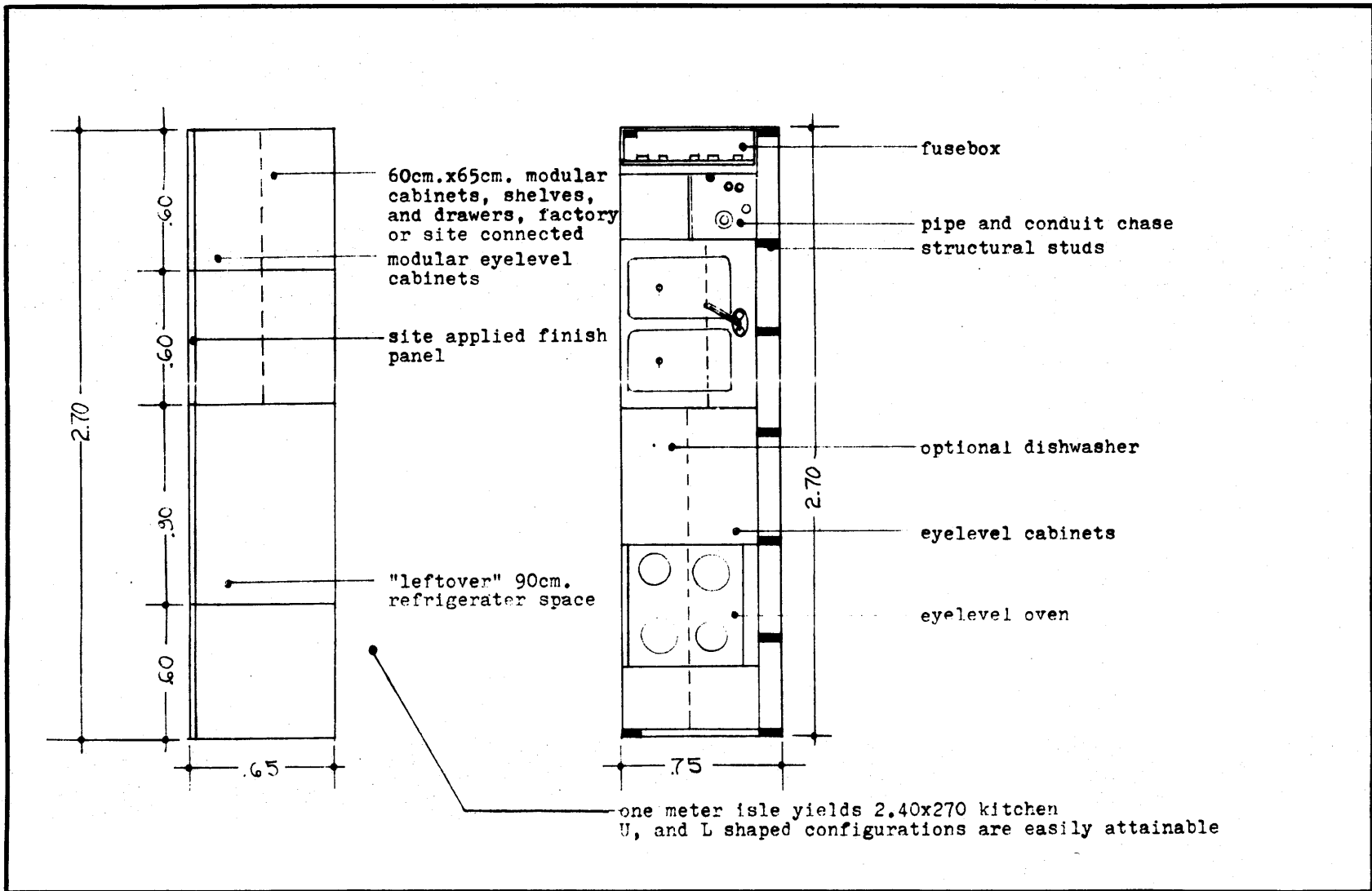
The Process: Sectional "Wet Modules" are carried by four men and placed in position near utility slots. Hook-ups are made, the modules are bolted together. At a later stage module exteriors are covered.

**SERVICES**  
**module placement**



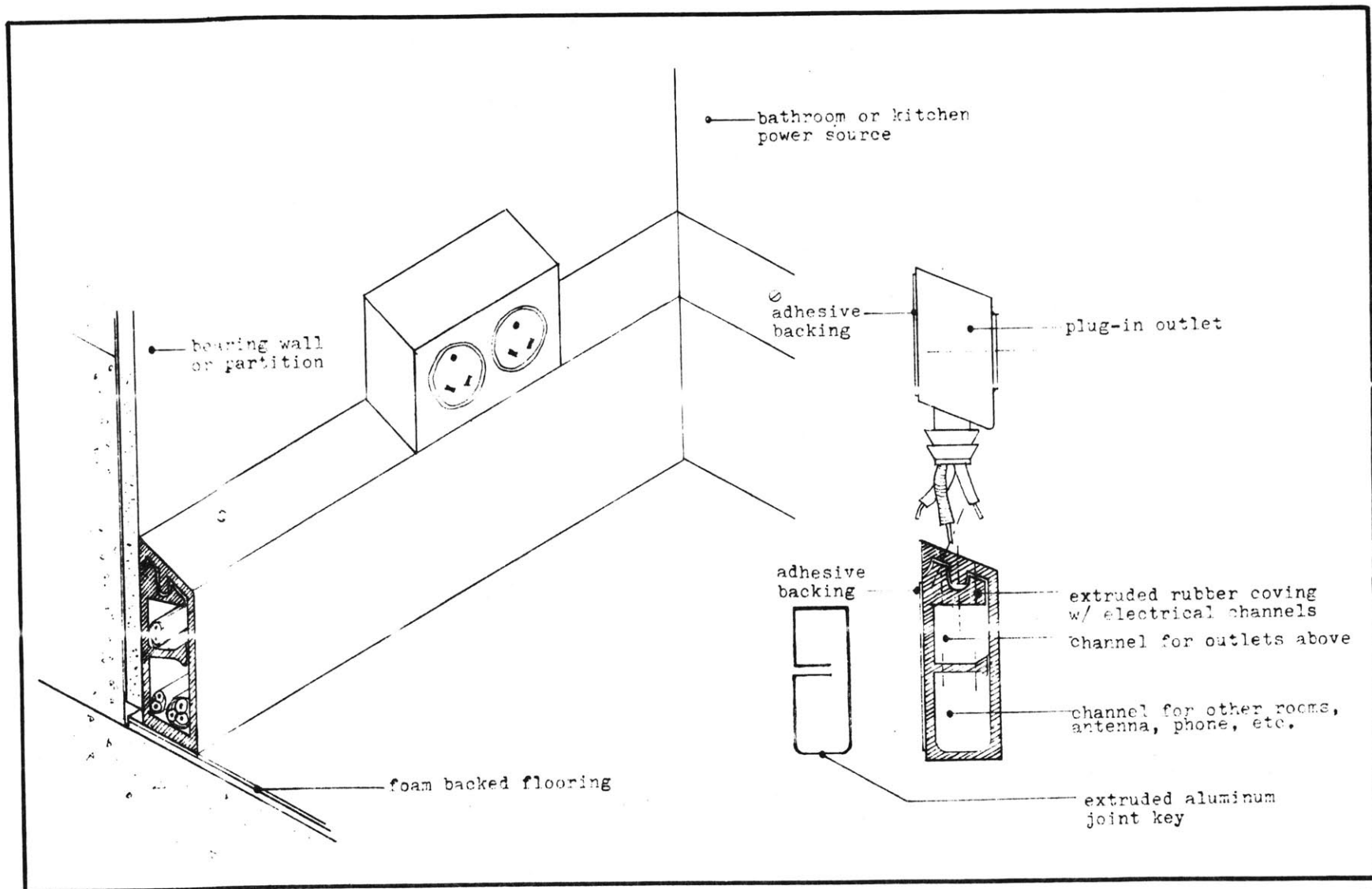
The Parts: Bathroom modules are glass-reinforced polyester  
 Exterior steel studs are for attaching finish surfaces  
 and for added rigidity. The modules can be combined as  
 needed for small, large and seperated bathrooms.

**SERVICES**  
**modules: bathroom**



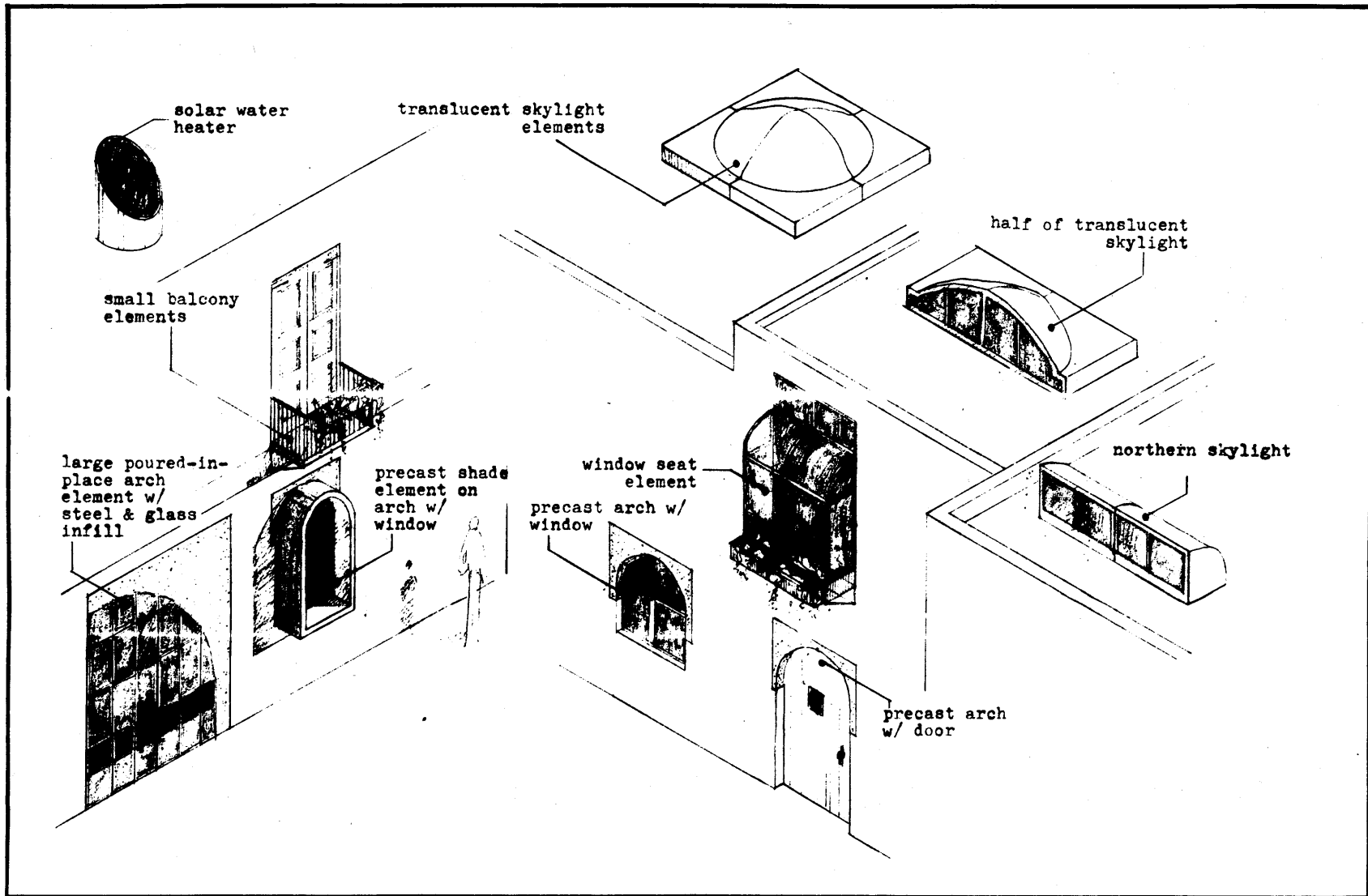
The Parts: The "Kitchen Wet Module", right is composed of the basic cabinetry and appliances on a metal stud frame. The modular wooden cabinet system, left, is site or factory combinable for forming larger kitchens.

**SERVICES**  
**modules: kitchen**



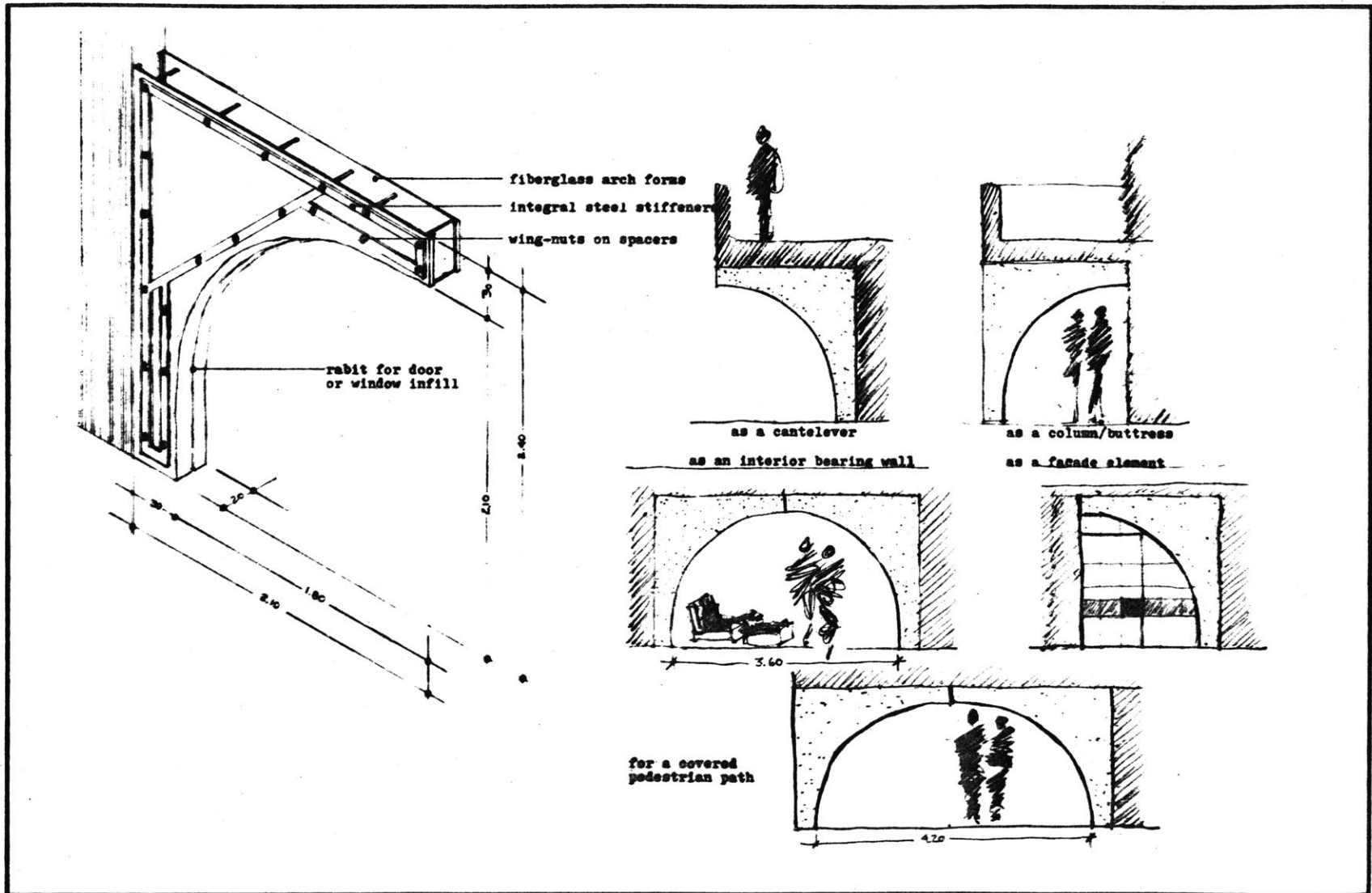
Notes: Coving which allows easy tolerances on both wall and floor finishes can be installed by semi-skilled labor, and later wired by an electrician. Wires are permanently accessible.

**SERVICES**  
**electrical coving**



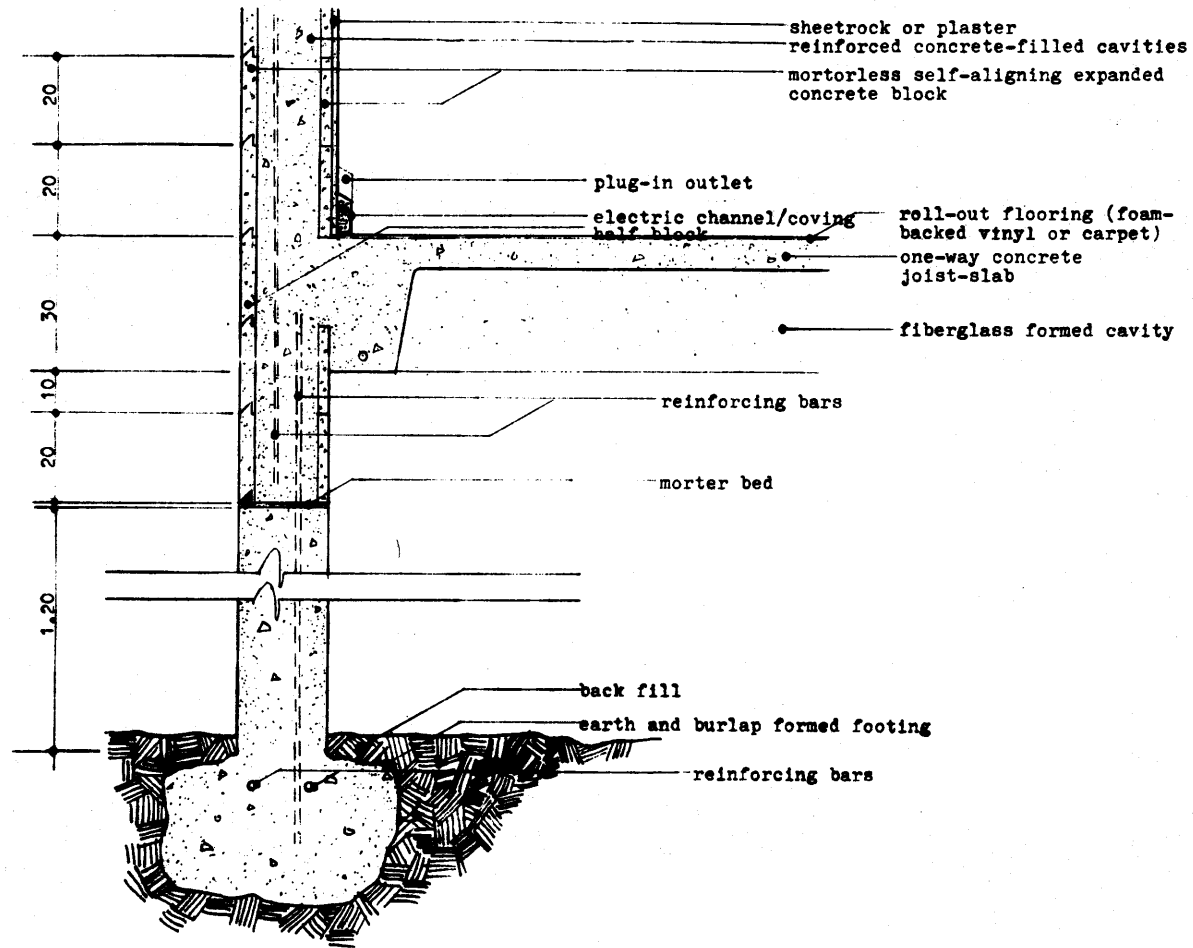
Notes: Pizzaz elements share sub-elements, are modular and attach with epoxy mortar to the blocks. They repeat the forms and amenities found in the indigenous, Mediterranean village architecture.

**PIZZAZ**  
**vocabulary**

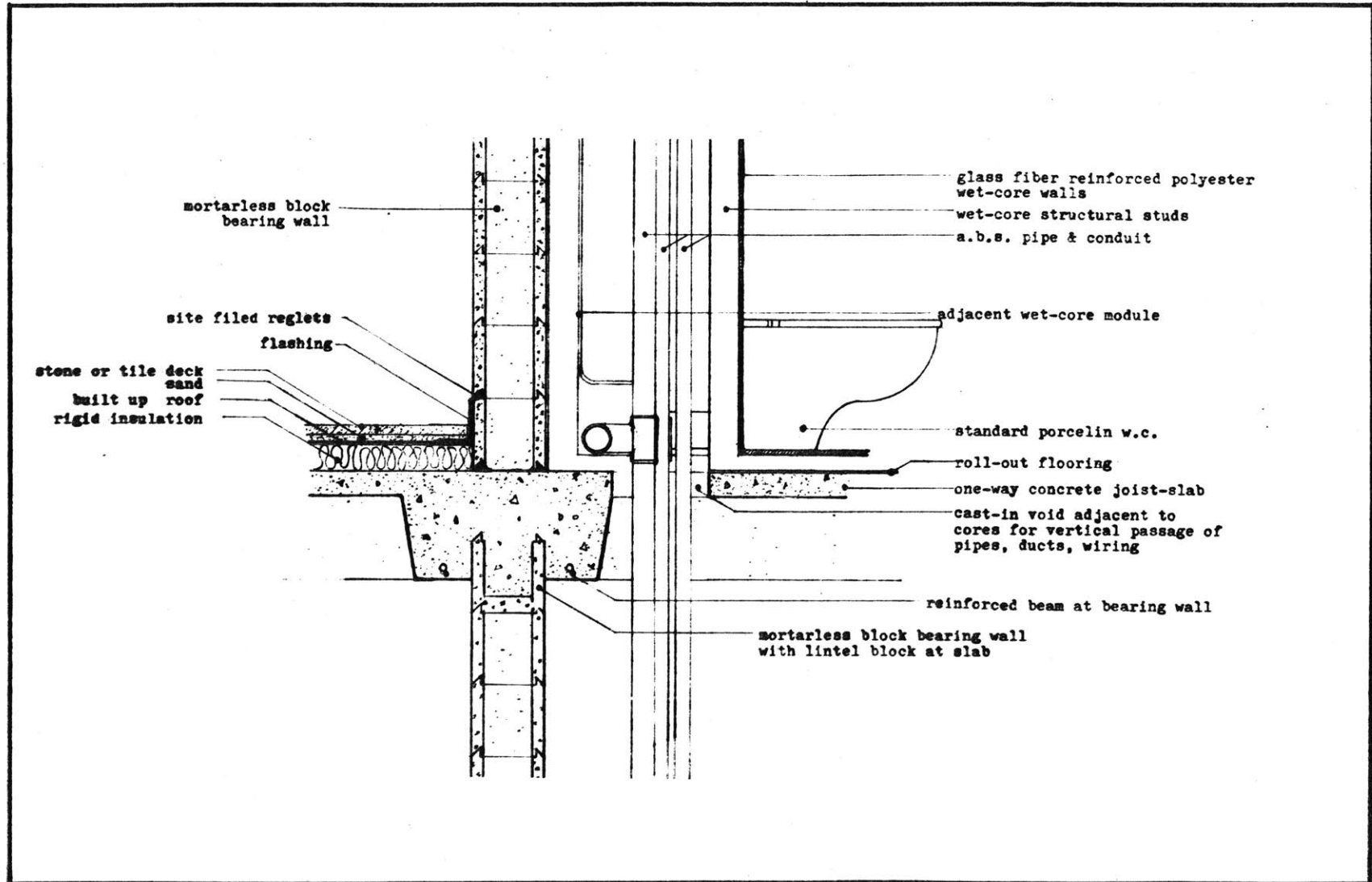


Notes: The half-arch element serves many purposes. It is poured-in-place concrete using reinforced fiberglass forms.

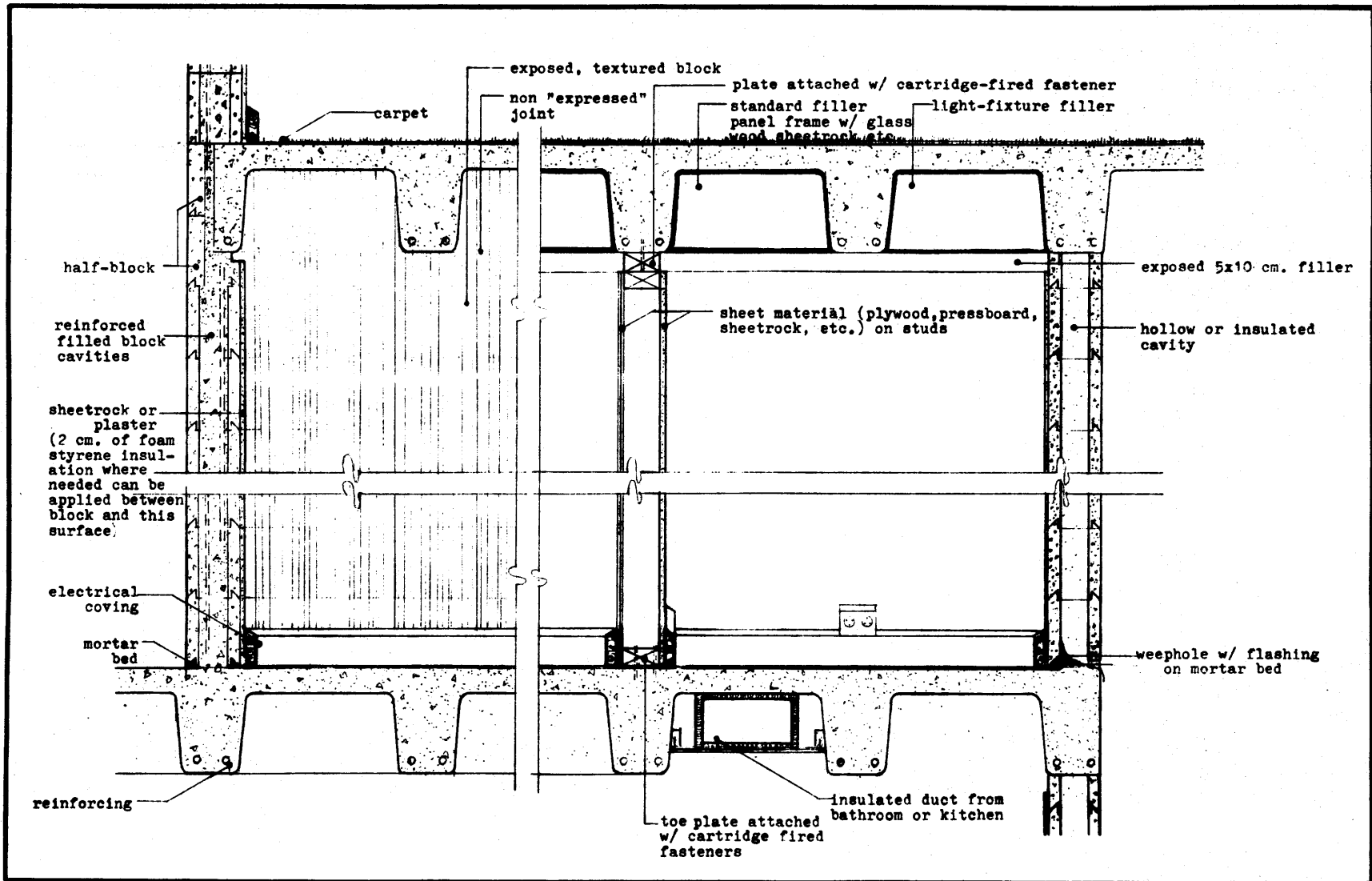
**PIZZAZ**  
**half-arch element**



**CONSTRUCTION DETAILS**  
**section through bearing wall I**

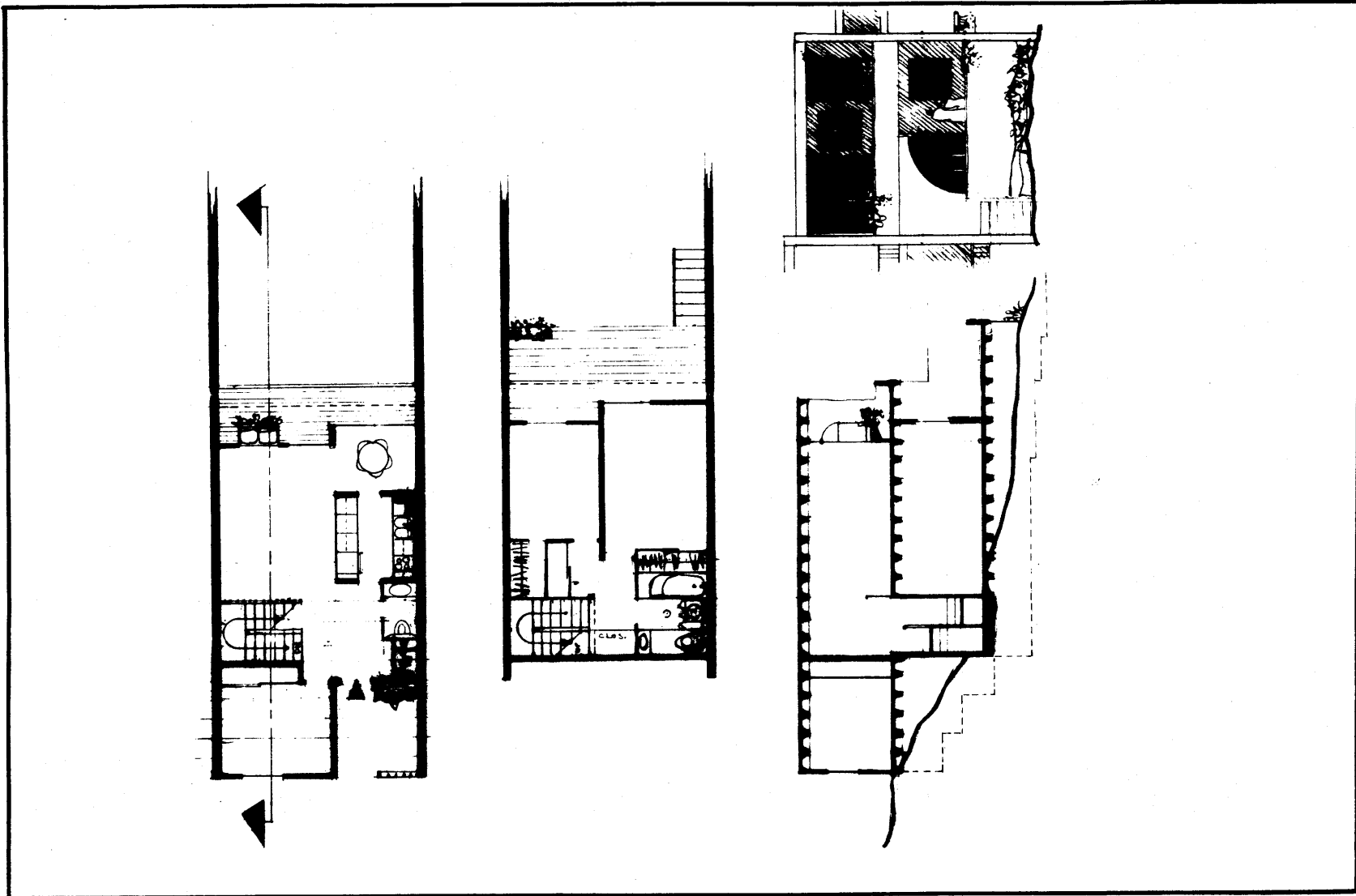


**CONSTRUCTION DETAILS**  
**section through bearing wall 2**



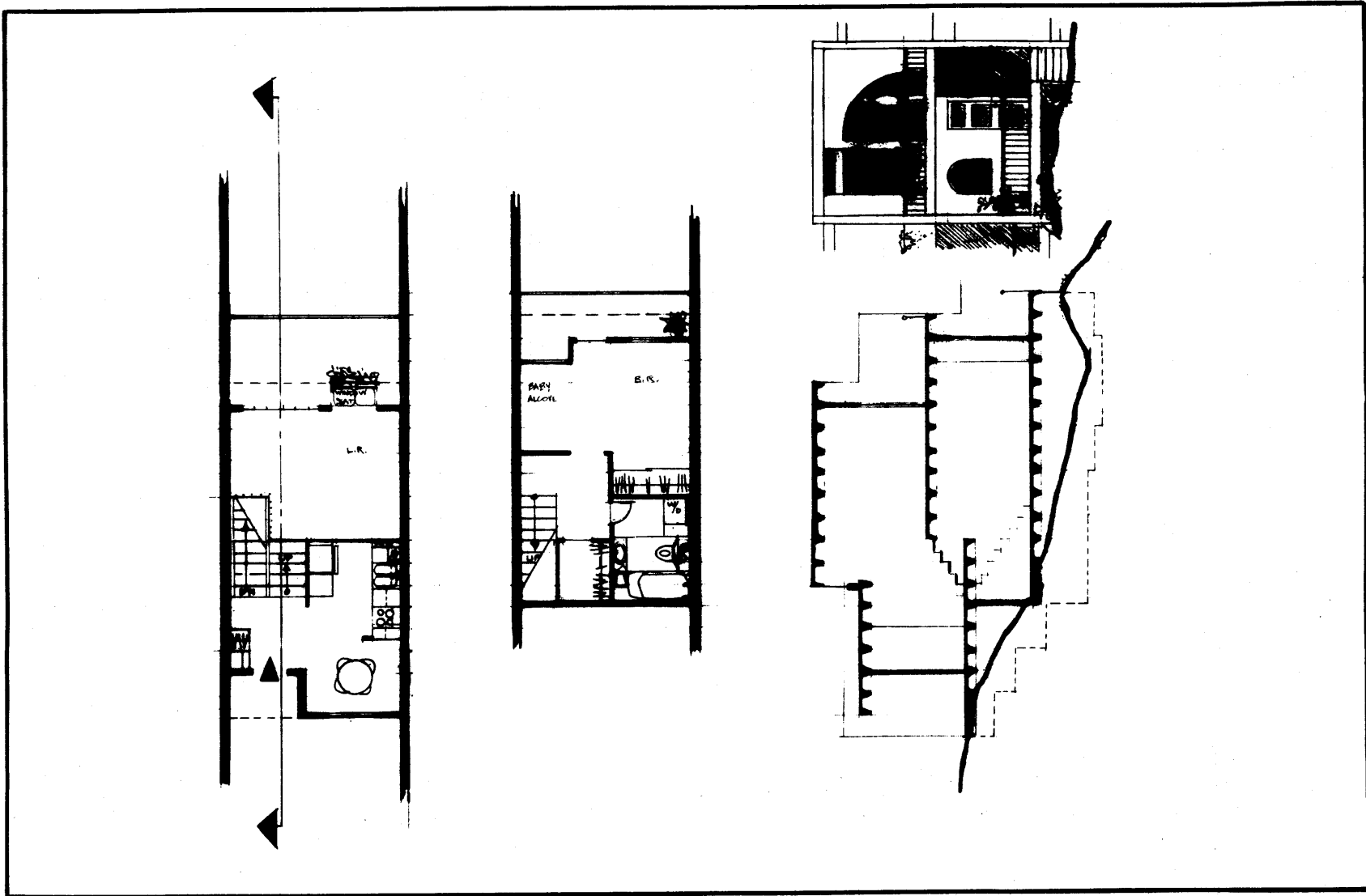
Notes; The details at left are more traditional using block. On the right lighter, larger elements are used and the structure is expressed.

## CONSTRUCTION DETAILS section parallel to bearing walls



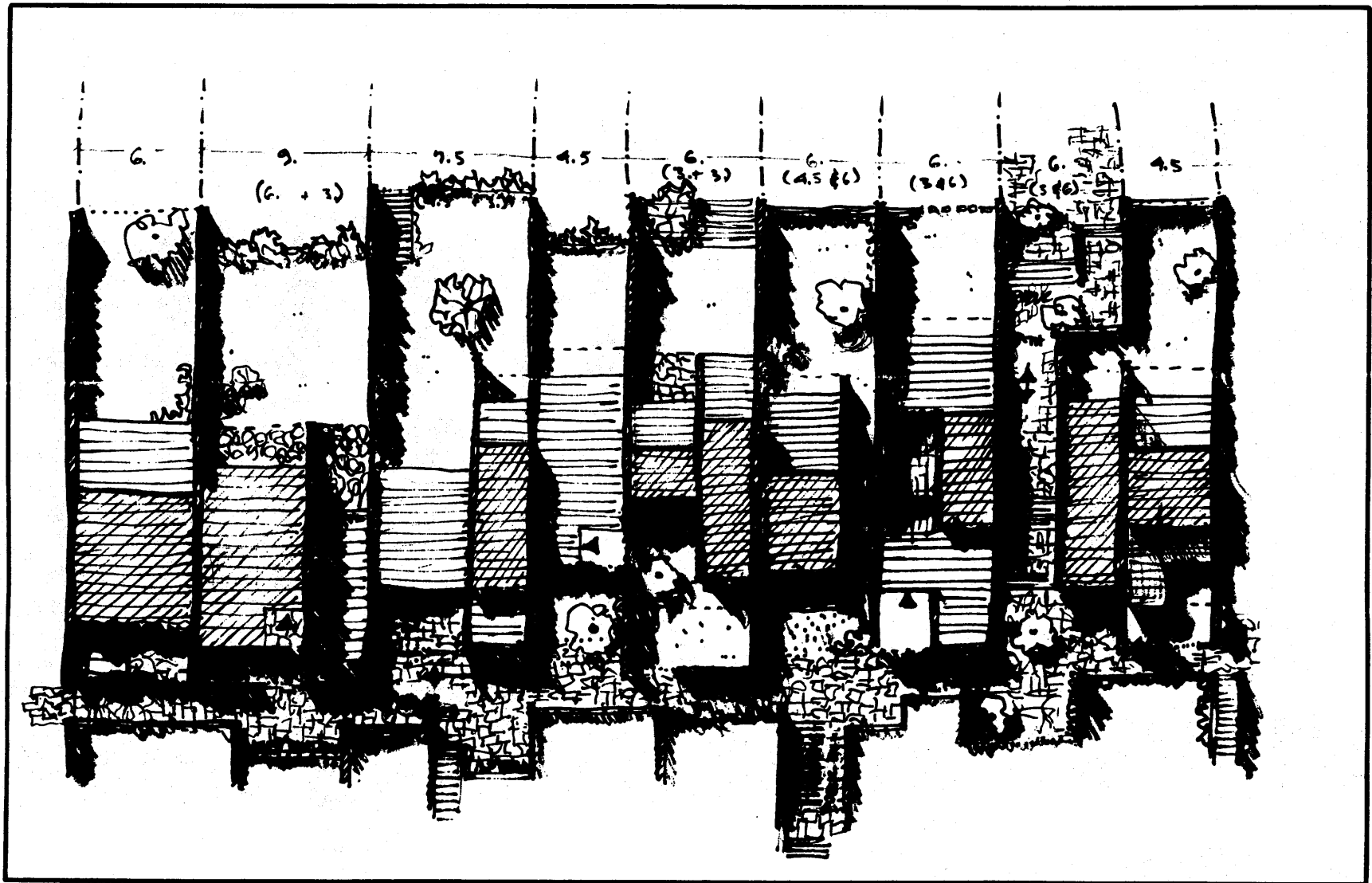
Notes: The unit is 93 square meters.  
Bedroom at top is easily used as  
den or office. Distance between  
bearing walls is 6.0 meters.

**TYPICAL UNITS**  
**3 bedroom**



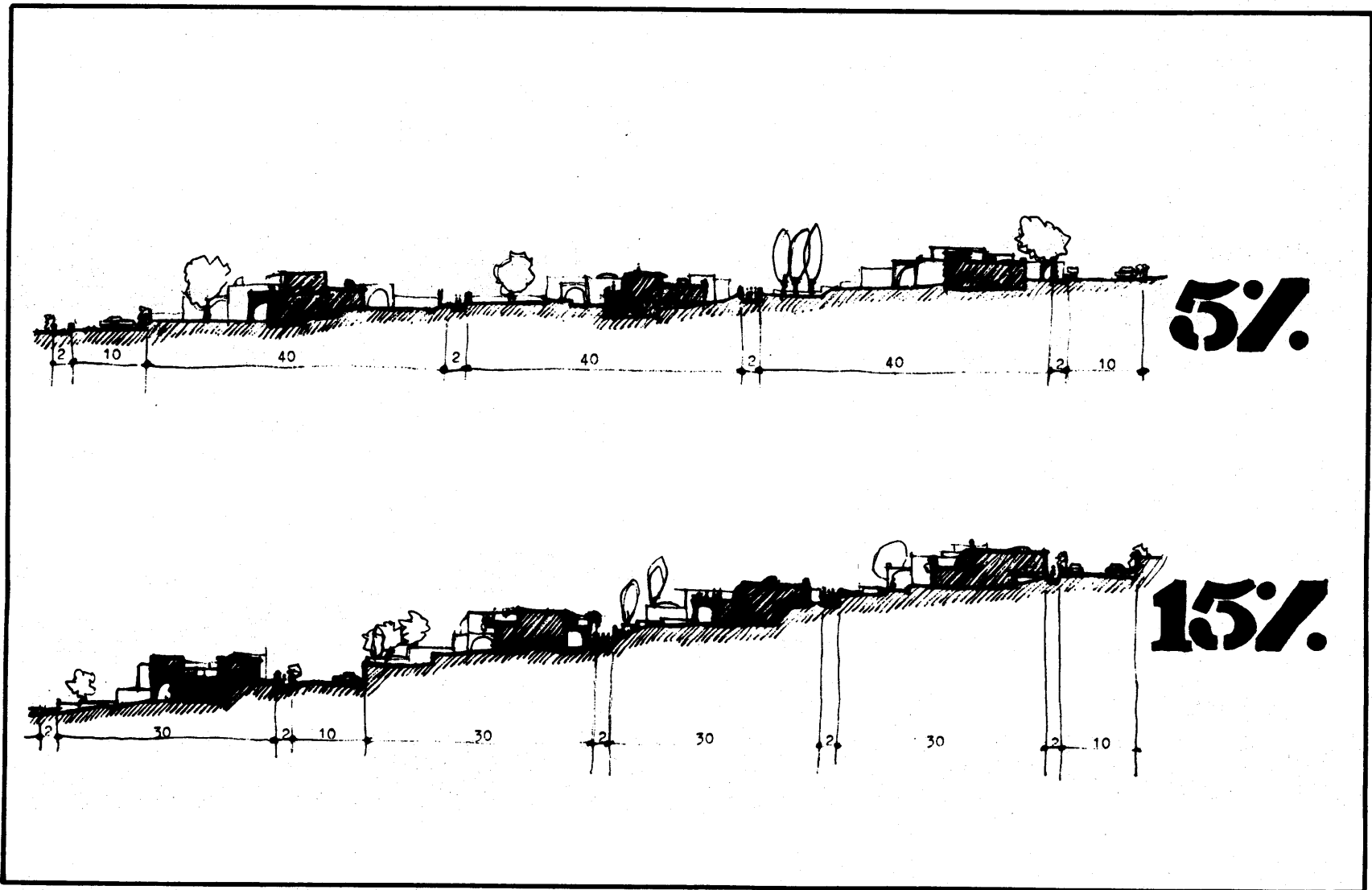
Notes: The unit is 62 square meters and is designed for young couples. The large bedroom has a partitionable alcove for study, or baby. Unit width is 4.5 meters.

**TYPICAL UNITS**  
**1 bedroom**



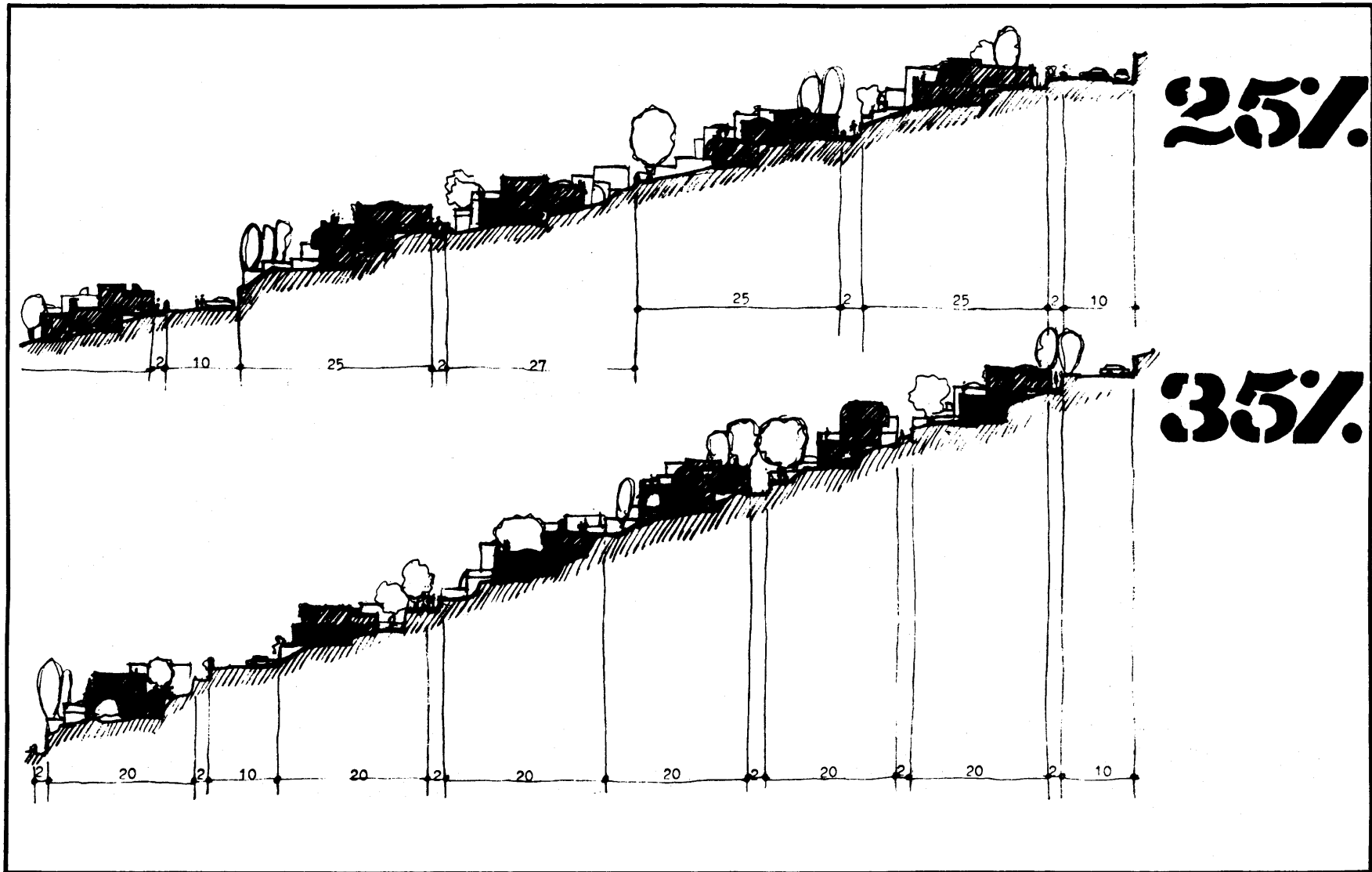
Notes: A rich variety of public and private spaces result from random use of bay sizes and placement of the units within these. Crossed-hatching indicates a second story.

**SITE STUDIES**  
**spacial diversity**



Notes: Distances between units must be large if unhampered view is to be obtained. Services, roads and parking must serve fewer units. Plot lines are clear; no overlap occurs. 10-25 units/acre.

**SITE STUDIES**  
slopes 1 & 2

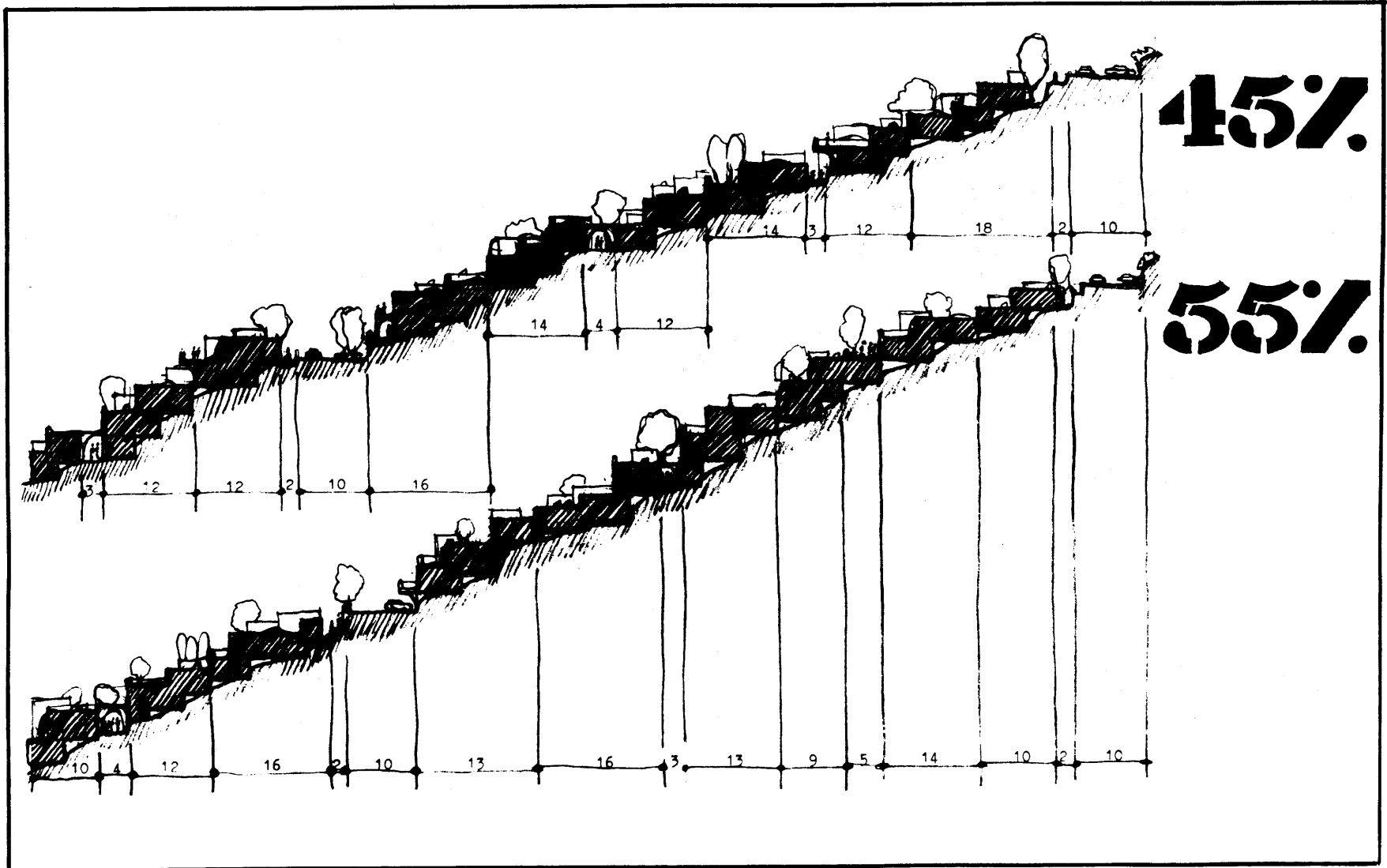


**25%**

**35%**

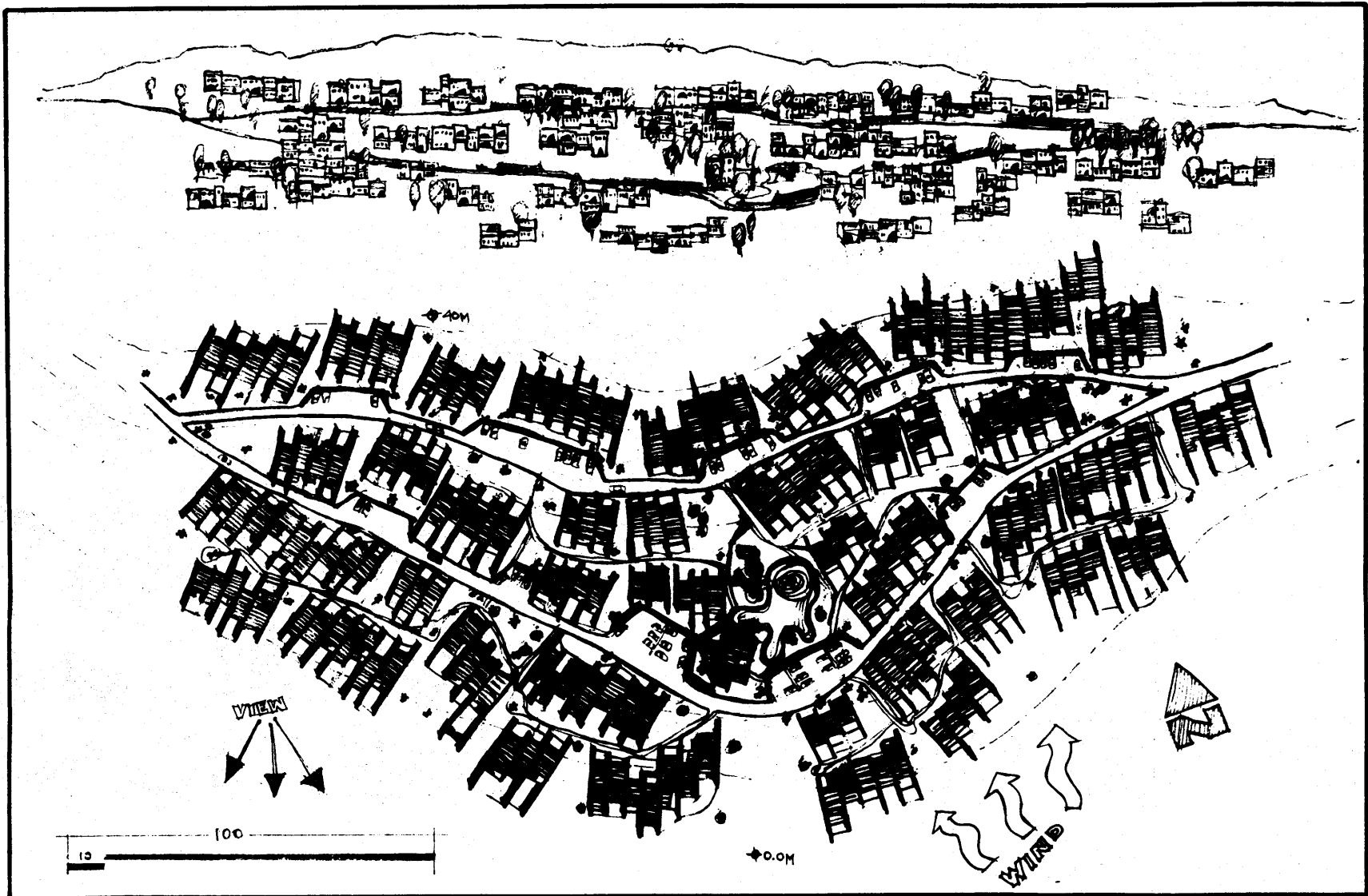
Notes: Distances between units remains comfortable while service and road utilization increases in efficiency. Paths are easily travelled ;site is environmentally exciting. Roofs are acessable. Density is 20-36 units/acre.

**SITE STUDIES**  
**slopes 3 & 4**



Notes: Distances between units becomes very small yet the slope allows light and view. Services are efficiently utilized. Site is exciting, but perhaps perilous and difficult to plan. Property overlaps. 30-50 units/acre.

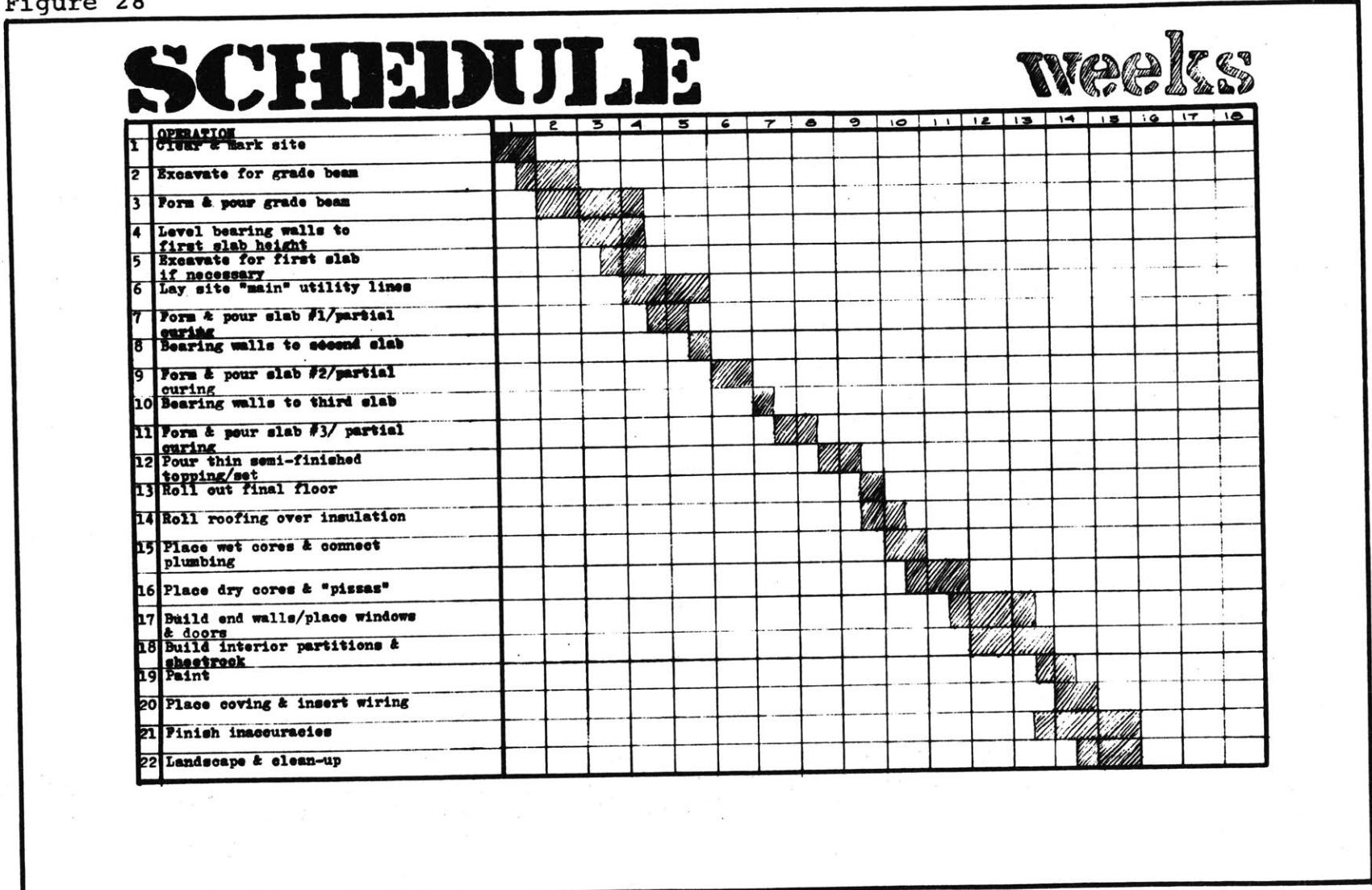
**SITE STUDIES**  
**slopes 5 & 6**



Notes: Site length is 300 meters, width is 125 meters, and the drop in elevation is 40 meters. A parking spot is provided for each unit and a multi-service community area is central.

## SITE STUDIES 180 unit cluster

Figure 28



Notes: Schedule assumes two story building in construction cluster of 100. Roads and utility mains are assumed to be existant.

## CONSTRUCTION SCHEDULE

ECONOMICS CONSIDERATIONS

1. Introduction and Note on Reliability of Data

In order to realistically expect any product to replace another on an appreciable scale, the consumer must be able to satisfy more needs and aspirations for each dollar. The case of housing is no different. Users of a new building construction process and elements are both the builder and the dweller; each of these groups must come out economically ahead if the product is to be successful.

In the following pages, the various components of housing costs will be explored. This will be done first for the existing housing product and process. In a later section, analysis of the proposed system will be presented and areas of potential savings will be examined.

Various methods of implementation of the system at several scales will be discussed. Two development scenarios depicting firms with different organizational structures and with varying access to capital are then presented with their relevant economic data.

In order to be able to best assess the conclusiveness of subjects as quantitative as those to be discussed in this chapter, the validity of data used should be reviewed. Since 1972, in response to prodding by a largely foreign Technical Advisory Committee on Housing, quantitative analyses of the input into the Israeli housing sector have been published by several sources. Various obstacles have prevented these analyses from being as detailed or all-encompassing as the Dodge or Means construction

cost guidelines familiar in North America. Primary among these are the tremendous effect of inflation and increased demand which have, for example, increased costs for public housing from 220 IL/sq. m. in 1967, to 410 IL/ sq. m. in 1971, and 1020 II/sq. m. in 1974. These increased 40% faster than the already inflationary cost of living index.

Other factors too, tend to destroy the construction cost breakdown, particularly during 1974. The non-qualifiable after-effects of the Yom Kippur War, a July moratorium on certain building types, and a 43% currency devaluation in November, 1974, all must be considered when interpreting the data and analyses.

In developing the cost models in this chapter, as many sources as possible were used in order to derive a firm data base, rather than attempting to decide which cost analysis is most correct. Although occasionally a significant discrepancy does occur, for the most part, differences were small, or resultant from different methods of dividing the whole of housing inputs.

Most of the analyses are done using percentage and not actual costs; however, the data is corrected to one time frame: July - August, 1974. This choice eliminated the current temporary post-devaluation distortions. It also enabled the author to make use of unpublished Ministry of Housing and private sector data relevant to this period, which was acquired through interviews in Israel during August and September, 1974. The ratios for this particular time seem unlikely to be permanently and significantly altered

during the next few years.

In summation, it can be said regarding building cost data that no one reliable, all encompassing index exists. However, through combination of many disjointed, incomplete studies and analyses, coupled with first hand interviews with officials and builders, a reasonable assessment of the elements of housing costs have been achieved.

2. The Competition:  
Existing Housing  
Prototypes

i. The Product and  
Process

Before getting into the costs of conventional housing, a look at the product itself is in order. The wide variety of housing types which are available in the United States cannot be found in Israel. Although it would be absurd to assert that all or most housing in Israel is identical, the vast majority of apartments are modeled after very few prototypes. Aside from the single family suburban and rural residences, which house less than 5% of the population, generally in the highest income levels, very little variation occurs. The streets of most cities are lined with boxy four story apartment blocks, generally with two or four apartments per floor. Half or all of the ground floor is generally unbuilt and is used for parking cars, and garbage and storage rooms. These structures are usually 6-12 meters apart reflecting minimum local zoning ordinances. The average apartment size in 1972 was

93 square meters. This includes wall thickness, and balconies which virtually all apartments contain. Publicly initiated apartments were smaller on the average, 76.8 square meters; and private sector housing, 105 square meters. The difference here is usually the addition of a dining corner, a third bedroom, and an additional water closet in the bathroom. (A. Harlap, Israel Builds, 1973, p. 244). The exterior walls of these buildings are generally covered with stucco, unless they are in Jerusalem, in which case they must, by law, be faced with stone.

Recently, due to increased land costs, elevators have become economical and buildings similar to those described are built to 6 or 8 stories. Another variation is the joining of two such buildings, eliminating the land in between, but using two entrances and stairways. Apartments along a hallway have not been accepted by the public.

Building materials and methods used in Israel have even less variety than the housing's physical form. Virtually all buildings in Israel are largely of the same material; concrete. This is used in two main forms in building; concrete block, and reinforced, cast concrete.

Approximately 85% of housing units started in 1973 are of concrete block. This is referred to in Israel as "conventional construction". In this method, concrete piles are poured in situ on a three to four meter grid in each direction. Slabs and columns are also poured in situ. 20 cm hollow concrete block with large

aggregate is used for exterior and party walls, and 7 cm hollow block is used for interior walls. These walls are plastered, as are ceilings.

Of the 15% of housing not conventionally built, two-thirds are made of heavy pre-fabricated concrete bearing panels. These panels, some with windows and wiring, are brought from one of eleven factories in Israel and assembled on conventionally built foundation walls. The product is generally even more boxy and sterile than conventional construction, and is totally inflexible for the life of the building. The remaining 5% of housing is built of non-prefabricated concrete walls. These are often poured using table or tunnel formwork.

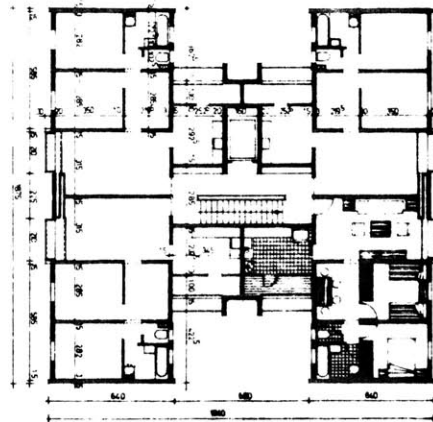
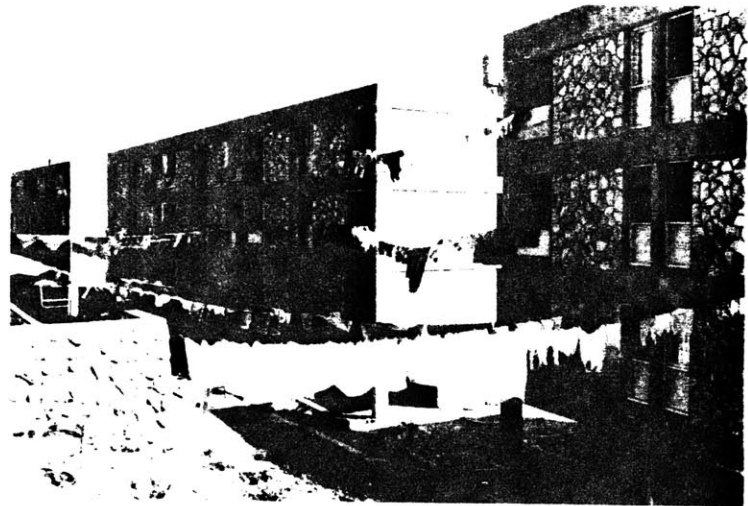
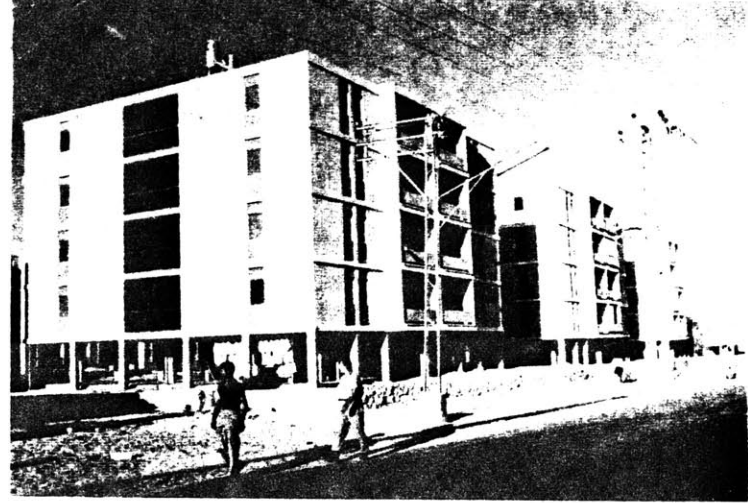
The interior finish work of these three types of construction is identical. Floors, as mentioned in an earlier chapter, are marble specked terazzo tiles, 20-30 cm square, laid in mortar on a thick sand bed. A 5 cm high coving of similar tile is cemented to the bottom of the walls. Two electrical outlets are provided in living rooms and one in each bedroom. Each room has one light fitting, and in the living room this is double switched. Two separately fused power lines run to the kitchen for appliances. All electrical wiring is for 220 volts.

Central heating is included only in the coldest mountain parts of Jerusalem and the Galilee. Cooling systems are not provided. Bathroom facilities are separated in the European tradition; a bathtub with a hand shower and sink in one room,

the water closet in another. Built-ins in the kitchen consist of a porcelain sink and a 1.8 meter marble top with a shelf and doors below. Each apartment comes with its own 120 litre water heater. (A. Harlap, A Survey of the Building Construction Industry in Israel, p. 40-50)

Figure 29-31 shows plans and photographs of typical conventional and pre-fabricated housing in Israel.

Figure 29-31 Plans and appearance of typical apartment buildings in Israel



It is useful to note here that conventional construction is now being done at varying levels of sophistication. In the most advanced level, as described by the Israel Institute of Productivity, a mobile crane is used during the early stages of construction, concrete is brought to the site in ready-mix trucks, and reinforcing bars are ordered pre-bent. A lift is used to transport materials to higher floors, windows are of aluminum, and doors and frames are pre-fabricated.

In the non-advanced method no crane or lift is used, and materials handling is done by unskilled labor. Forms, windows, and doors are all wooden, often individually made for the spot. Concrete is mixed in a 100 gallon mixer on the site. Most conventional buildings are built using various combinations of these labor saving techniques, and must be classified somewhere between "Advanced" and "Non-Advanced" construction.

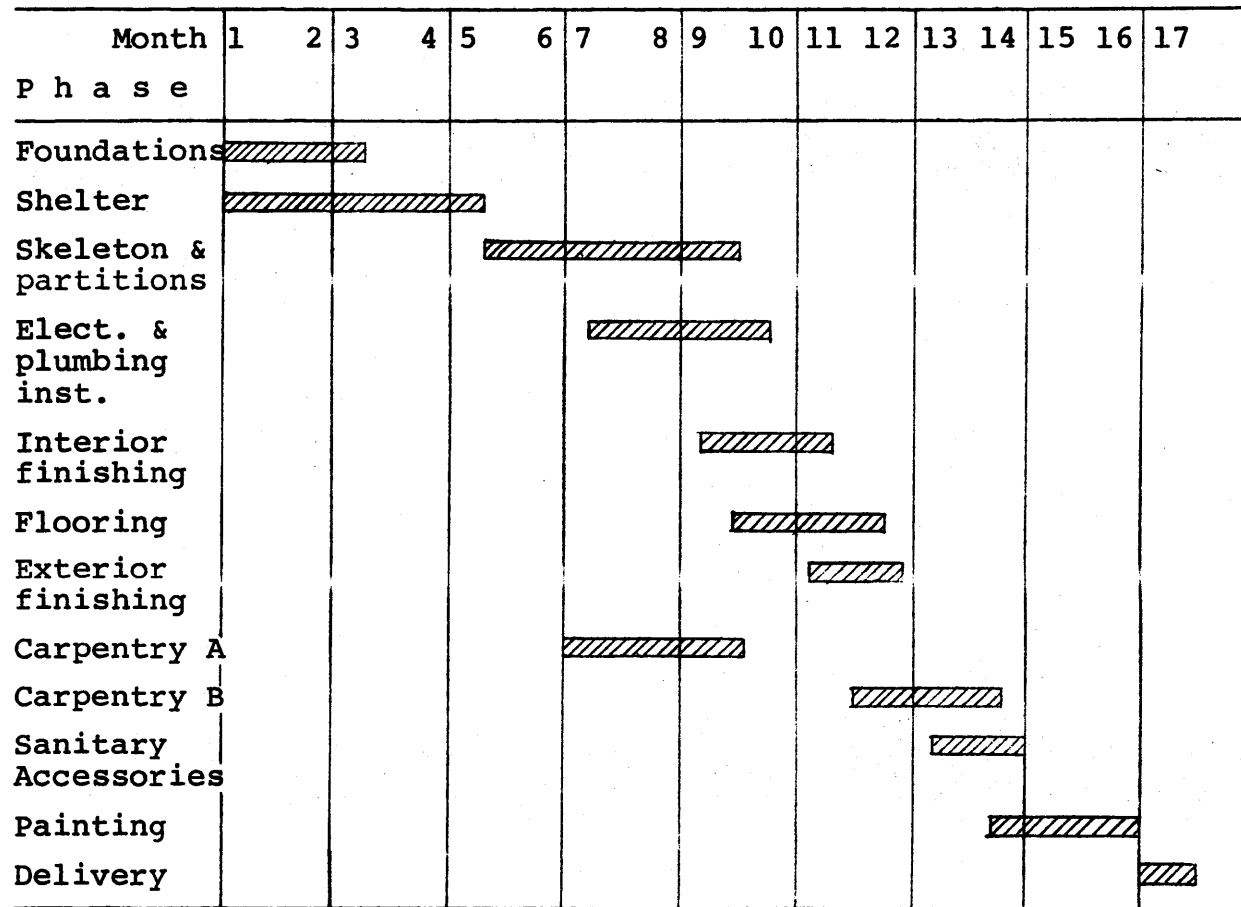
Inherent in the conventional construction process at any level are several obstacles to quick completion of the buildings. The high level of labor required, particularly skilled labor, coupled with Israeli shortages of this commodity, is a major cause of the 16-20 month construction period required even in pre-war 1973 to build a four story apartment house. Other factors include many wet and messy, sequential and interdependent processes. Among these are several coats of plaster, poured concrete lintels, and floor tiles laid in mortar. Other

problem areas involve inconvenient overlapping of trades, or the need for trades to return at several stages of construction.

Figure 32 is a bar chart indicating a typical construction schedule for a four story apartment block built with mid-level conventional construction.

Figure 32

Typical time schedule for the construction of a single, four story apartment building, using conventional construction.



Source: Ministry of Housing, State of Israel, Summary of Publications and Reports on Construction and Housing in Israel, p. 25, (from "The Lavitt Report").

Although there is a shortage of building electricians in Israel, an example of the problem can be seen in following their involvement in the process. During the early forming stages, the electrician must lay conduit for lights into the formwork for each slab. He must return when the walls are in place to chisel a channel into the block for the conduit and boxes which pass along the walls. After cementing in these conduits and boxes, he returns a third time to pull the wires and attach switches and outlets, a fourth for the electrical inspection, and a fifth to connect the main line to the fusebox. In each of these phases he must wait for another process, and in turn, another stage awaits his completion. Plasterers, floor layers, tilers, carpenters, and plumbers all must return after other trades have intervened.

ii Economic data

After this overview of the housing product and process, the subject of cost can be approached. Evaluations of any method of construction must be done in the context of total housing cost rather than construction costs alone. This is important in any country, however it is essential in Israel where, as seen in Table 5, construction generally makes up less than one half of total housing costs.

Table 5

Breakdown of Basic Housing Costs in ten largest cities in Israel, July, 1974

	Land	Land Costs	32.0%
	32%		
	Development	Finance Costs	14.0%
	20%	Legal and Administrative costs	3.5%
		Design costs	2.5%
100%			
Total Housing Cost	Construction	Materials cost	28.0%
	48%	Labor cost	16.0%
		Profit	4.0%

Source: Interviews with authorities in private and public housing during July and August, 1974.

The reasons for high land costs were previously discussed and include lack of alternative anti-inflationary investment opportunities, and state ownership of 92% of the lands. During the last years this portion of housing cost is up to approximately one third.

Development costs in Israel, too, are high. This is largely due to the high interest rates caused by constant devaluation of the Lira with respect to the dollar. This results in interest rates on short term loans of 18-20% annually. When 75% of land costs are financed and the construction costs are drawn down in a symmetrical fashion for the typical building period (for four story structures) of 18 months, the result is that 14% of every housing dollar goes to the intangible construction loan. Although various alternative financing arrangements do exist, notably discounts to buyers who pay during the early stages of construction, the decrease in price reflects the value of money over time, and is therefore tantamount to a finance payment.

Construction costs themselves can be divided several ways. Table 5 indicates the average percentages which labor, materials, and overhead and profit constitute out of the total housing costs. As percentages of construction costs alone, labor (including overhead labor) is approximately 34%,

materials 58%, and profit 8%. Table 6 indicates the actual manpower hours required in two extreme levels of conventional construction used in Israel. It can be seen that between two thirds and three quarters of labor used is skilled. Although total site manpower hours are significantly reduced using the advanced techniques, there is no evidence of difference in total construction costs.

In Figure 33 manpower requirements of three main Israeli building technologies are placed in the context of various building methods used in other countries.

Table 6

Manhour requirements per square meter in two levels of conventional construction in Israel

Activity	Non-Advanced	Advanced
	Conv. Const.	Conv. Const.
<u>Foundations, Structure, Enclosure</u>		
Excavation	.12	.12
Formwork	3.87	3.05
Reinforcement	.79	.42
Pouring Concrete	1.05	.65
Walls	1.87	1.68
Total, foundation, frame, walls	7.71	5.92
% of total building	41.5%	39.5%
% of "non-advanced" construction	100%	86.2%
% of skilled labor/total	68.3%	73.3%
<u>Mechanical System</u>		
Plumbing & Fixture Install.	1.74	.7
Electrical System	.49	.39
Total, Mechanical System	2.23	1.09
% of total Building	12%	7.2%
% of "non-advanced" construction	100%	48.9%
% of skilled labor/total	58%	88%
<u>Finish Work</u>		
Floors and coving	1.27	1.12
Plaster & wall decorations	3.14	2.6
Carpentry (including plastic)	.55	.55
Metalwork (including aluminum)	.18	.18
Glazing, Insulation, Flashing	.52	.52
Painting	.95	.84
Total, Finish Work	6.62	
% of total building	35.6%	38.7%
% of "non-advanced" construction	100%	87%
% of skilled labor/total	79.9%	80.6%

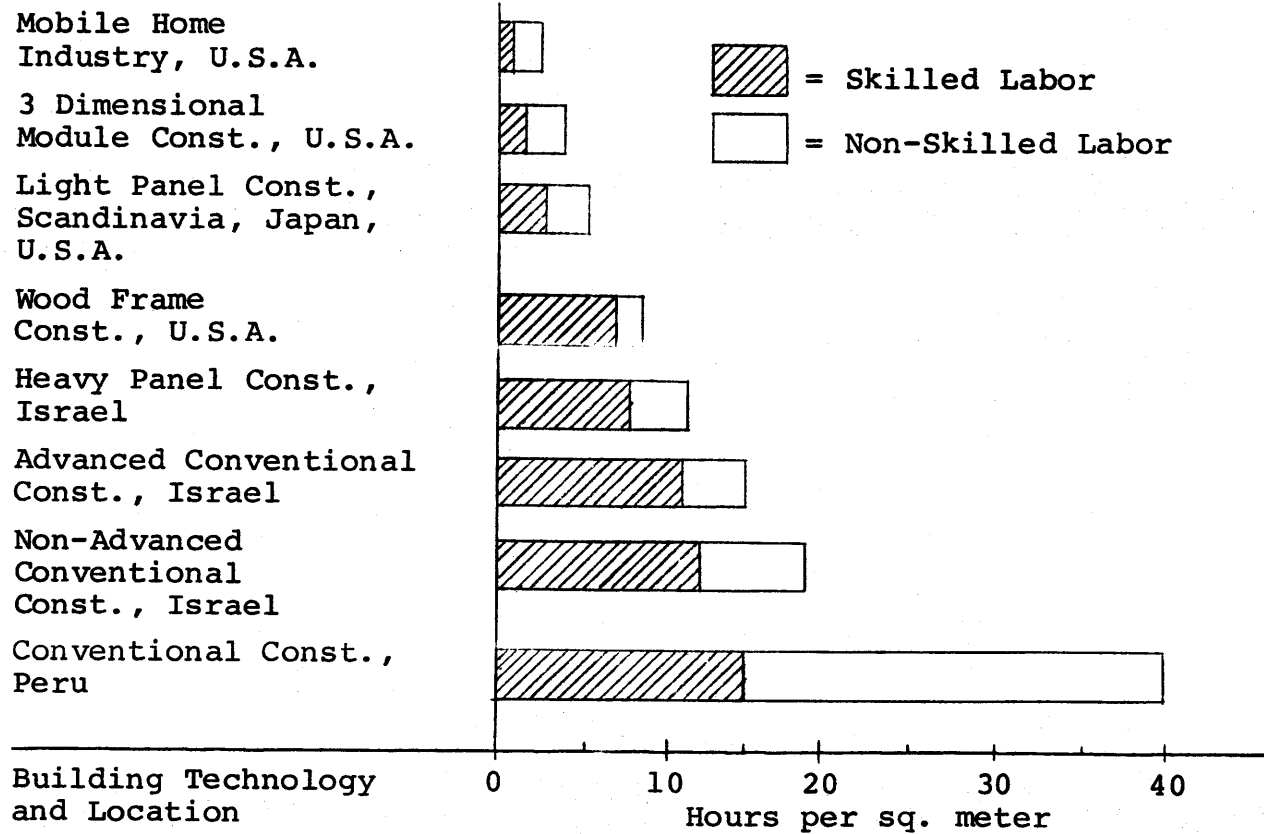
Table 6 contd.

Activity	Non-Advanced		Advanced	
	Conv. Constr.		Conv.Constr.	
<u>General Work</u>				
Paths & utility connection	.04		.04	
Site clean-up	.24		.24	
Equipment maintenance	.06		.2	
Management, storage, watchman	1.66		1.66	
Total, General Work	2.00		2.14	
% of total building		10.7%		14.2%
% of "non-advanced" construction		100%		107%
% of skilled labor/total		48%		47%
Total manhours/square meter	18.56		15.0	
% of "non-advanced" construction		100%		80.8%
% of skilled labor/total		67%		72%

Source: Israel Institute of Productivity, Skilled and Unskilled Manpower Requirements in Conventional Construction, 1974.

Figure 33

Manpower Requirements per sq. Meter Using  
Various Building Technologies



Sources: A. Bernhardt, MIT: Program on the Industrialization of Housing Sector, H.U.D. Israel Institute of Productivity: Skilled and Unskilled Manpower Requirements in Conventional Construction; and Manpower Requirements in the Erection of Residential Building with Comprehensive Pre-fabrication Construction Method.

In Table 7 construction costs for July, 1974 in most areas are analyzed along the lines of the physical product itself. At that time, according to Ministry of Housing data, total construction cost for public housing averaged 1020 IL per square meter, or \$242.85 U.S. per square meter, and \$22.98 U.S. per square foot.

The Ministry of Housing uses a multiplier in several areas to counteract regional cost disparities. In Eilat and Jerusalem, for example, the costs are often multiplied by 1.25 and 1.30 respectively, to cover the high transportation and labor costs in the sweltering climate of Eilat, and the required stone facing in Jerusalem.

Table 7

Construction cost breakdown for 93 m<sup>2</sup> conventional\* housing unit in Israel, July, 1974

Aspect of Construction	Labor Costs IL	Material Costs IL	Total IL	Costs \$	Approx. % of Total
<u>FOUNDATIONS, STRUCTURE, ENCLOSURE</u>					
Excav. & Sitework	900	200	1100	262	1%
Foundations	2000	5750	7750	1845	8%
Structure, Slabs, Enclosure	8500	15450	23950	5702	26%
<b>Total: Shell and Structure</b>	<b>11400</b>	<b>21400</b>	<b>32800</b>	<b>7809</b>	<b>35%</b>
<u>MECHANICAL SYSTEM</u>					
Plumbing, bath & Kitchen fixtures	2700	3000	5700	1357	6%
Electrical system	1100	900	2000	476	2%
<b>Total: Mechanical System</b>	<b>3800</b>	<b>3900</b>	<b>7700</b>	<b>1833</b>	<b>8%</b>
<u>FINISH</u>					
Floors & coving	1700	2200	3900	929	4%
Int. walls, ceiling	4000	9450	13450	3202	14%
Carpentry	800	3750	4550	1083	5%
Metalwork	350	750	1100	262	1%
Painting	1600	1300	2900	690	3%
Glazing, insulation, flashing, cleanup	1400	500	1900	452	2%
<b>Total: Finish</b>	<b>9850</b>	<b>17950</b>	<b>27800</b>	<b>6619</b>	<b>29%</b>

Table 7 cont.

Aspect of Construction	Labor Costs IL	Material Costs IL	Total IL	Costs \$	Approx. % of Total
<u>PUBLIC SPACES</u>					
Entrance, stairways	3200	8350	11550	2750	12%
Elevator**	0	0	0	0	0%
Paths & utility connections	200	800	1000	238	1%
<b>Total: Public Spaces</b>	<b>3400</b>	<b>9150</b>	<b>12550</b>	<b>2988</b>	<b>13%</b>
<u>INDIRECT COSTS &amp; PROFIT</u>					
Site cleanup & Landscape	400	420	820	195	1%
Equipment Maintenance	200	600	800	191	1%
Mgt., Watchman, Storage	2800	2000	4800	1143	5%
Profit			7590	1807	8%
<b>Total: Indirect Costs</b>	<b>3400</b>	<b>3020</b>	<b>14010</b>	<b>3336</b>	<b>15%</b>
<b>Total Housing Costs</b>	<b>31850</b>	<b>55420</b>	<b>94860</b>	<b>22585</b>	<b>100%</b>

Note: Wage rates average 17.75 IL per hour: 21 IL per hour for skilled workers, and 10 IL per hour for unskilled. Approximately 32% is withheld for taxes and social benefits. In addition to the hours specified in Table 6, 12% was added to allow for public spaces such as entrance, stairway, and approaches.

\* The ratios of labor and materials rates change with the level of construction method. Advanced methods yield lower labor costs. These figures are for "mid-level" construction.

Table 7 cont.

\*\* Elevators cost approximately 150,000 IL for a six story building. Decision is made largely on basis of land cost. As this analysis is on four story buildings, no elevator cost is included.

Source: A compilation of data received from:

A. Levin, Head, Department of Pre-fabricated and Industrial Construction, Ministry of Housing, Israel.

E. Nir, Director, Udwin Nir Construction Co.

U. Rosen, Halpern Construction Co.

A. Safiah, Construction Department, Israel Institute of Productivity.

The reader is again reminded that construction costs make up less than half of total housing costs. The total cost of the 93 square meter house analyzed in Table 7, when for sale unsubsidized, is likely to be about 198,000 IL, or \$47,000 U.S.

In both public and private client/builder contracts, when purchasing housing not yet built, prices are often linked to a building-cost-index. This frees the builder from the responsibility for rise in material and labor costs likely to occur during the long construction duration. It does, however, leave the purchaser uncertain as to the price he will pay for his home. A 15% rise in construction costs is not unusual.

### 3. The Proposed System

Earlier sections of this paper have included various shortcomings in Israeli housing which led to the strategy by which the proposed building system was designed. Perhaps the most central of these problems to which most of this chapter is devoted is the high cost of housing. Although it is the contention of the author that costs per square meter of housing can be significantly lowered using the proposed method of construction, it is worthwhile first to briefly discuss the improvements in the end product.

#### i. The Product

In simplest terms, the product is high density low-rise row housing. Although the methods can be used on flat ground for four story housing, adaptability to sloped sites allows the use of less expensive land which is often otherwise unused. Sloped sites also afford the users panoramic views even when housing is built as densely as 30 to 50 units per acre. This is equal to the densities usually achieved in the rows of four story buildings typical of Israeli cities.

In addition to these views, sloped sites enable the users to benefit from breezy micro-climates generally caused by sloped terrain. Equally important, each dwelling can generally be associated with private and public outdoor spaces, in front and back of the units. Roofs, too, are useful as outdoor space and take on character. They are plantable and their easy access makes them part of the usable landscape. Skylights and solar

water heater elements reflect indigenous forms.

Although much of the construction process is rational and systematic, individuality is inherent from the varied slopes, as well as the interior and exterior of the units. Only the modular crosswalls are bearing. Interior walls are lightweight and non-structural, allowing the architect and client total flexibility in the layout of the home. This flexibility remains over time allowing the users to move walls relatively inexpensively throughout the lifetime of the building. Most of the exterior walls too are non-loadbearing. Interspersed in these at the designer's will can be various modular windows and "pizzaz" elements, each offering amenities. Among these are window seats, balconies, and shade elements.

More esoteric than these qualities, and undoubtedly less important to most Israelis contemplating spending many years' income on a home, is the aesthetic fit. His home is the proper shape and scale to fit the natural landscape and traditional built environment of the region.

## ii Economic Data

As with existing housing types, cost analyses for the system being proposed must be done on total housing costs, and not construction costs alone. Since the building system was designed using a comprehensive systems approach after study of the entire context, it is not surprising that potential savings

can occur on all three of the major factors making up housing costs (see Table 5).

In this initial evaluation of the economic savings of the proposed building system, the direction to which any benefits could accrue will not be discussed. Many options exist for the total process, which results in housing, to be divided amongst several firms and users in a multiplicity of ways. The question of profitability to any one group or part, will be considered in section 4 following and only overall free market efficiencies of the total land-development-construction system will be discussed here.

Table 8, repeating the basic cost breakdown used in Table 5, indicates the potential reduction in costs of the various components of total housing input. As can be seen, the savings potential of the proposed system comes largely from the non-construction costs.

Table 8

Potential Savings of Proposed Building System on  
Total Housing Costs

	Percentage of Conventional Housing Costs	Potential Reduction	% of total Cost Saved
<u>Land Costs</u>	32.0%	25-50%	*8 - 16%
<u>Development Costs</u>	Finance 14.0%	50-80%	7 - 11%
	Arch. & Eng. 2.5%	_____	**0
	Legal & Admin. 3.5%	_____	0
<u>Const. Costs</u>	Mater-ials 28.0%	(10-20%)	(3 - 6%)
	Labor 16.0%	40-50%	6 - 9%
	Profit 4.0%	20-30%	1%
Total Potential Cost Reduction:			19 - 31%

\* on flat ground land savings which are due to substantially lower cost of sloped land would not occur. However, due to lower foundation and excavation costs, construction would be slightly less expensive.

\*\* architectural fees are in most cases presently very low, since these services now usually consist of simply re-drawing existing plans for new sites, making few changes. Where buildings are actually designed specifically, client could save approximately 2%.

Through the use of the proposed building type and simple foundation system which can be constructed efficiently on less expensive sloped sites, substantial savings on land costs can be achieved. The ability of the system to be fit to various slope ratios gives the developer flexibility as to choice of location, yet sites which previously involved very expensive levelling now require only increased excavation costs. Since excavation in the conventional case typically constitutes less than 2% of total construction costs, even with radical increase in this cost, the combined land-excavation-foundation savings is considerable.

Through drastically shortening the duration of construction, a large portion of the construction mortgage costs can be eliminated. Although a 50-75% reduction in time sounds revolutionary if not impossible, precedents in Scandinavia and Eastern Europe indicate that 58 and 75% savings respectively have been attained through increased industrialization. (Howenstine, "Prefabricated Construction: Developments Abroad", Monthly Labor Review, May, 1972). In Israel, too, heavy panel construction, although generally neglecting the time-consuming finish work, has been done in less than one half the conventional time. A 70% reduction in the 16-20 month construction period and therefore construction finance costs would have the effect of reducing total cost 9 to 10%. This would still allow five and one half months

for construction of housing units; considerably longer than that indicated on the bar schedule in Figure 28, and certainly well within reason.

Decreased construction time leads to savings in addition to reduced construction financing costs. Builders' overhead and expected profit are both related to time, as well as other factors. Most overhead employees, regardless of how quickly units are completed, receive wages on a weekly or monthly basis. The builder able to double or triple the quantity of units completed each year will not undergo a proportional increase in overhead. It is not unlikely, too, that with this sharp increase in yearly output, he will be willing to reduce his profit per unit and still show a high annual profit increase.

The other significant reduction in cost is that of construction labor. The 40-50% estimated decrease from the non-advanced conventional construction method in Israel can be viewed as realistic when considered in the light of the tremendous variance of manpower per square meter required for various construction methods. As was seen from Figure 33 different levels of building technology and availability of material types result in manpower requirements ranging from forty hours per square meter for non-mechanized labor-intensive construction in Peru, to less than two hours per square meter in the mobile home factories in the United States. Industrialized

construction in Israel too, using heavy panels, has been done with less manpower than the later detailed 10.1 hours estimated for the proposed method.

Ability to cut site manpower requirements in this system stems from several factors. Formwork requires over 20% of the total conventional construction manpower hours. Repetition and standard sizes achievable using the bearing wall system has enabled formwork to be standardized. Initially more expensive, but reusable, lightweight fiberglas forms can cover a much larger area than the traditional wood formwork, and it need not be disassembled at every pouring. Floor covering and certain wall parts can be pre-cut or fabricated to size due to the frequent repetition of the three standard bay widths between bearing walls, and the installation of flooring before non-structural walls.

Although materials cost for concrete is saved due to the cavities in the joist-slab formwork, significantly more expensive materials are used for floor coverings, bathroom and kitchen modules, the electrical system, and wall finishes. Manpower savings, however, on these items are over 60% of non-advanced conventional construction, and most of the new tasks require largely unskilled labor.

The cost reduction in labor itself may only pay for the increased cost of the materials. Elimination of bottlenecks, simplification of the coordination of trades, and predictability of costs will allow for other efficiencies in permitting the previously mentioned savings on interest, overhead, and profit.

It is important to note here again that unlike most industrialized systems, if for some reason a bottleneck in any one of the time and labor saving processes does occur, construction is not brought to a halt. Rather, conventional methods can be substituted to fill gaps.

Another factor effecting hours of manpower input is the productivity of labor while on the site. Dr. S. Peer, and S. Selinger of the Department of Construction Management and Economics at the Israel Building Research Station studied factors effecting housing construction time at 130 construction sites. It was their conclusion that increased labor motivation, wage incentive, and more rationalized organization of the construction process can improve labor productivity 30-35%, and decrease duration 40% even without new building techniques. (S. Peer, S. Selinger; Factors Effecting Housing-Construction Time, Ministry of Housing).

The linearity and few wet processes in the proposed system permit construction to proceed in an orderly assembly-line-like progression of events. The erection process illustrated in the bar chart schedule in Figure 28 can be divided into tasks requiring work teams of two to six men as suggested in Table 9. These have been arranged so that the men can do the same limited but not insignificant activities on approximately two units per week. The responsibilities can be tuned so that it is unnecessary to hire and fire members of the site labor force when specific tasks arise or are completed. This is extremely important in Israel where the subcontractor system is just starting and no union hiring halls exist. It also enables linkage of individuals' pay incentives to quality and productivity and will encourage camaraderie and teamwork. The proportion of labor which must be skilled can be decreased to 50%, and the repetitive nature of the process will itself provide training for unskilled labor.

Table 9

Organization of Site Labor Force Into Job Teams  
For the Construction of 100 Dwelling Units per Year.

Team	Number of Men Total	Skilled	Non-Skilled	Job Description	Activity No. in Figure 28
#1	3	1	2	Clear & mark site; excavate for grade beam & where necessary 1st floor, assemble foundation formwork	1,2,5
#2	6	4	2	Adjust foundation formwork & pour grade beam; level walls to 1st slab height; lay main site utilities	3,4,6
#3	6	3	3	Form slabs & pour; build block walls to next level-repeat for each floor	7,8,9,10,11
#4	3	2	1	Pour floor topping; screed; insulate & waterproof roof	12,14
#5	4	2	2	Roll-out final flooring; install wet & dry cores & connect; place pizzaz elements	13,15,16

Table 9 cont.

Team	Number of Men Total	Skilled	Non-Skilled	Job Description	Activity No. in Figure 28
# 6	10 (2x5)	6	4	Build endwalls; hang doors & windows; build interior partitions & sheetrock	17,18
#7	5	2	3	Repair inaccuracies; paint; place coving & wiring, clean up apts.	19,20,21
#8	2	1	1	Pave paths, landscape & cleanup	22
#9	5	2	3	Operate 2 concrete pumps and hoist for supply of concrete & block to teams 2,3,6.	
#10	6	2	4	Superintendent's general staff	
	<hr/> 50	<hr/> 25	<hr/> 25		

Table 10 shows a comparison of estimated manpower requirements of the proposed building system with the documented needs of non-advanced and advanced conventional construction previously presented in Table 6. Manhour requirements for the proposed system were arrived at by estimating the relationship of the hours needed to do each process by the new method, in teams, with the documented hours required by each of the conventional

means. Combining the estimated 10.1 manhours required per square meter of construction from Table 6 and the 93 square meter average unit size, yields a labor requirement of 940 hours per unit. This is slightly under 24 man weeks, consistent with Table 9 above.

Table 10

Manhour requirements per square meter using conventional construction and the proposed building system

<u>Activity</u>	<u>Conv. Const.</u> <u>"Non-Adv." Adv.</u>	<u>Proposed System</u> <u>Hours Work Teams</u>
<u>Foundations, Structure, Enclosure</u>		
Excavation	.12 .12	.25 1
Formwork	3.87 3.05	1.6 1,2,3
Reinforcement	.79 .42	.42 2,3
Pouring Concrete	1.05 .65	.50 2,3,9
Walls	1.87 1.68	1.0 2,3,6,9
Total, foundation, frame, walls	7.71 5.92	3.77
% of total building	41.5% 39.5%	36.0%
% of "non-advanced" construction	100% 86.2%	48.9%
% of skilled labor/total	68.3% 73.3%	52.0%
<u>Mechanical System</u>		
Plumbing & Fixture Install.	1.74 .7	.45 5
Electrical System	.49 .39	.3 7
Total, Mechanical System	2.23 1.09	.75
% of total building	12% 7.2%	7.4%
% of "non-advanced" construction	100% 48.9%	33.6%
% of skilled labor/total	58% 88.0%	47.0%
<u>Finish Work</u>		
Floors and coving	1.27 1.12	.4 4,5,7
Plaster & wall decorations	3.14 2.6	1.4 6
Carpentry (inc. plastic)	.55 .55	.55 5,6
Metalwork (inc. aluminum)	.18 .18	.18 6
Painting	.95 .84	.7 7
Glazing, Insulation, flashing	.52 .52	.52 4,6,7
Total, Finish Work	6.62 5.81	3.75
% of total building	35.6% 38.7%	37.2%
% of "non-advanced" construction	100% 87.0%	56.6%
% of skilled labor/total	79.9% 80.6%	55.0%

Table 10 contd.

Activity	Conv. Const. "Non-Adv."	Adv.	Proposed System	
			Hours	Work Teams
<u>General Work</u>				
Paths & utility conn.	.04	.04	.2	2,8
Site clean-up	.24	.24	.2	8
Equipment maintenance	.06	.2	.2	9
Mgmt., storage, watchman	1.66	1.66	1.2	10
<b>Total, General Work</b>	<b>2.00</b>	<b>2.14</b>	<b>1.8</b>	
% of total building	10.7%	14.2%	17.9%	
% of "non-advanced" construction	100%	107%	90.0%	
% of skilled labor/total	48.0%	47.0%	40.0%	
<b>Total manhours/square meter</b>	<b>18.56</b>	<b>15.0</b>	<b>10.07</b>	
% of "non-advanced" construction	100%	80.8%	54.3%	
% of skilled labor/total	67.0%	72.0%	50.0%	

Source: Israel Institute of Productivity, Skilled and Unskilled Manpower Requirements in Conventional Construction, 1974.

In Table 11, using the basic data from Tables 7 and 10, the results of changes in materials and labor costs, and potential savings through use of the proposed system are indicated.

Table 11

Potential Construction Cost Savings of the Proposed System Over Conventional Methods

Aspect of Construction	Approx % of Total	Labor Cost IL	% Saved on	Materials Cost IL	% Saved on Materials	Approx Saving on Aspect IL	% of Total
<u>Foundation, Structure, Enclosure</u>							
Excav. & Sitework,	1%	900	(100)	200	-----	(900)	(.9%)
Foundations	8%	2000	40%	5750	-----	800	.8%
Structure, Slabs, Enclosure	26%	8500	60%	15450	10%	6600	7.0%
<b>Total: Shell and Structure</b>	<b>35%</b>	<b>11400</b>	<b>45%</b>	<b>21400</b>	<b>5%</b>	<b>6500</b>	<b>6.9%</b>
<u>Mechanical System</u>							
Plumbing, Bath & Kitchen fixtures	6%	2700	70%	3000	(100%)	(1100)	(1.2%)
Electrical system	2%	1100	45%	900	(30%)	200	.2%
<b>Total: Mech. System</b>	<b>8%</b>	<b>3800</b>	<b>65%</b>	<b>3900</b>	<b>(85%)</b>	<b>(900)</b>	<b>(1.0%)</b>
<u>Finish</u>							
Floors & coving	4%	1700	75%	2200	(75%)	(400)	(.4%)
Int. walls, ceiling	14%	4000	55%	9450	(25%)	(200)	(.2%)
Carpentry	5%	800	---	3750	(15%)	(600)	(.6%)
Metalwork	1%	350	---	750	---	---	---
Painting	3%	1600	25%	1300	20%	700	.7%

Table 11 (contd.)

Aspect of Construction	Approx % of Total	Labor Cost IL	Saved on Labor	Materials Cost	Saved on Mat.	Approx. % of Saving IL	% of Total
Glazing, insulation, flashing, cleanup	2%	1400	---	500	---	---	---
<b>Total: Finish</b>	<b>29%</b>	<b>9850</b>	<b>40%</b>	<b>17950</b>	<b>(25%)</b>	<b>(500)</b>	<b>(.5%)</b>
<u>Public Spaces</u>							
Entrance, stairways	12%	3200	35%	8350	15%	2400	2.5%
Elevator	0	0	0	---	---	---	---
Paths & utility connections	1%	200	(150%)	800	(150%)	(1500)	(1.6)
<b>Total: Public Spaces</b>	<b>13%</b>	<b>3400</b>	<b>25%</b>	<b>9150</b>	<b>---</b>	<b>900</b>	<b>.9%</b>
<u>Indirect Costs &amp; Profit</u>							
Site Cleanup & Landscape	1%	400	---	420	---	---	---
Equipment Maintenance	1%	200	(50%)	600	(50%)	(400)	(.4)
Management, Watchman, Storage	5%	2800	60%	2000	---	1700	1.8%
Profit	8%	---	---	---	---	1900	2.0%
<b>Total: Indirect Costs</b>	<b>15%</b>	<b>3400</b>	<b>45%</b>	<b>3020</b>	<b>(10%)</b>	<b>3200</b>	<b>3.4%</b>
<b>Total Housing Costs</b>	<b>100%</b>	<b>31850</b>	<b>45%</b>	<b>55420</b>	<b>(15%)</b>	<b>9200</b>	<b>9.7%</b>

Note: Wage rates average 17.75 IL per hour: 21 IL per hour for skilled workers, and 10 IL per hour for unskilled. (Approximately 32% of this is withheld for taxes and social benefits.) In addition to the hours specified in Table 2, 12% was added to allow for public spaces such as entrance and stairways. These figures are for "mid-level" construction.

iii. Available  
Technology,  
Precedents,  
and  
Capital  
Requirements

The previous section dealt with the various areas of savings possible through the use of the proposed open building system. Little has been said about the precedents on and off the site and the availability and reliability of the equipment necessary. Nor has the discussion dealt in detail with the costs of the producing and erecting equipment.

In designing the system, care was taken not to use exotic technologies, or even techniques not previously used successfully in a related form in Israel, or in countries of similar levels of development. This will eliminate much of the risk often associated with new building systems.

Five groups of processes make up the element manufacturing portion of the housing production: fiberglas forming, plastic and rubber extrusions, carpentry, metal, and concrete. Although it would be economically feasible to set up a plant or plants for a market of approximately 500 dwelling units per year, it is reassuring to know that facilities exist for each of the five groups which produce similar or related products for the housing or other industry sectors. In considering production scales of less than a few hundred dwelling units, the existence of similar manufacturing capacity may be essential.

Most complex and expensive among these processes is the manufacture of the fiberglas components. Precise models of wood must

be produced from which several negative master forms of fiberglass are made. These are then lubricated and sprayed up with glass fiber reinforced polyester from a rather sophisticated pressurized gun which mixes the components in the air. Hours later, when set, the products are removed from their molds. This process has been used in the United States and Europe for many years. More importantly, it is currently being used in Israel to produce truck cabins, airplane parts, small sail boats, and, most recently, in two plants (Modulplast and C.B.L.) bathroom units.

Along with the bathroom units, the equipment could be used to produce the formwork for the joist-slab floor system, and the arch element. Fiberglass components are also used in much of the "pizzaz" vocabulary; northern and translucent skylight elements, window seat element, and solar water heater.

Another piece of relatively advanced technology is plastic or rubber extruding equipment for the electrical coving. Extrusion equipment, too, is common in Israel. Almost every home in Israel comes equipped with rolling shutters made of extruded plastic. Since extrusion dies are cheap and easily changed, both coving and shutters could be produced by one machine owned by the company itself, or ordered from one of many extrusion plants.

Carpentry and metal shops make the majority of the other

significant components. These facilities, of course, exist at all levels of sophistication in Israel. Here too, depending upon anticipated quantity and availability of capital, a large, mechanized or automated facility or a small shop could be created; or, the products could be ordered from existing firms. Products to be fabricated of metals include reinforcing steel, frames for wet modules, window and door frames, pizzaz details, railings, and stiffeners for fiberglas formwork. Elements to be manufactured of wood include foundation formwork, kitchen modules and dry cores, cabinetry, windows, doors, and frames.

A process which has no direct parallel in Israel is the manufacture of self-aligning, foamed concrete block. Self-aligning blocks are produced in Europe and South America by both simple and automated block-making machines. Costs of these machines range from \$500 to \$100,000 U.S.. The equivalent block-making machinery is used to make standard concrete blocks in Israel. Only the addition of keyed metal molds is necessary to create the self-aligning characteristic. With additional simple injection equipment, foaming or air entraining agents can be mixed into the concrete immediately prior to insertion into the molds. This will enable larger size blocks within the same weight restrictions, fewer joints, and improved insulation characteristics.

Table 12 indicates the capital required for plants and equip-

ment, with a capacity to produce components for 500 dwelling units per year. The location of the block-making facility can vary depending upon quantities, distances, anticipated transport cost, and breakage. Advantages of a large centralized fully-automated block plant must be weighed against the convenience and economies of a smaller, less sophisticated machine on the site.

Table 12

Capital Requirements for Facilities to Produce  
Elements for 500 Dwelling Units per Year

1. Fiberglas production facilities for:**		
	Bathroom modules, Pizzaz parts, Floor formwork	\$275,000*
2. Extrusion equipment for:**		
	Electrical coving, Window shutters	35,000
3. Metal shop for:		
	Reinforcing steel, Module frames, Pizzaz, Window, door frames, Railings	50,000
4. Carpentry shop for:		
	Doors, Window frames, Cabinetry, Kitchen parts Closet modules	50,000

TABLE 12 (continued)

5. Block-making equipment (optional)**	40,000
6. Trucks for delivery (optional)	30,000
<hr/>	
Total for equipment.....	\$480,000
Raw materials and inventory.....	<u>500,000</u>
Total capital required for element production	\$980,000

\* This is the cost for an optimal production size fiberglas facility. It will produce three to four times the production required for 500 units yearly. However equipment for one-third this capacity would cost only 20% less.

\*\*Source: Professor F. McGarry, Department of Civil Engineering, Massachusetts Institute of Technology.

The crew on the site, too, must have some special equipment, some of which is not ordinarily maintained by traditional builders. Most of this is as unexotic as a compressor, transits, a hoist, custom dollies for transport on the sloped site, and supplies of system formwork. Small concrete pumps can eliminate a major materials handling problem and readily supply the necessary concrete regardless of the floor level or terrain. It will also enable ready mix trucks to deposit in very major spots, allowing easy access and reducing the need for temporary roads on the site.

A trencher could be used to increase excavation speed and save labor on some sites. Simple, small communications equipment, too, may save time in communicating between various areas on a large site. Following is a list and approximate prices of construction equipment recommended for a sloped site, based on the team process described in Table 9.

Table 13

Capital Requirements for Equipment for One Site  
Employing 50 men, Producing 100 Dwelling Units Annually

<u>Team # &amp; Main Tasks</u>	<u>Equipment Type</u>	<u>Approx. costs</u>
#1 Mark and excavate site	Transit, Compressor, Jackhammer	800 6000
#2 Foundations	Tripod level Modular foundation formwork*	600 1600
#3 Slabs and Bearing Walls	Formwork for joist slabs* and arch	4800
#4 Screed Floors, Waterproff Roof	Tarring equipment Screeds	600 100
#5 Place Finish Flooring and Cores	Custom dollies*	400
#6 Build Infill, Sheetrock	Arch formwork*	400
#7 Paint, Electricity		
#8 Landscape & Cleanup	Landscape tools	500
#9 Pump concrete, Supply block	2 Small concrete pumps Hoist & Custom dollies*	12,000 1400
#10 Superintendent and his General Staff	Office & Storage area Walkie-Talkies (Optional Block-making)	5,000 600 (12,000)
		\$34,800

\* Indicates equipment custom produced for system users.

Source: Abbot Construction and Industrial Equipment Company, INC.  
Boston; January, 1975.

iv. Overall Economic Considerations

A very simplified look at the potential profitability of the element production and erection process as a whole may be useful here. For simplicity, it will again be assumed that a central plant produces parts for 500 dwelling units per year which are erected on five 100 unit sites. The direction to which profits or savings may accrue will not be discussed; if the sum of the total process is profitable, it is likely that organizational parts, too, can be arranged each receiving a proportional part of the benefits.

In simplest terms, based on the data in Tables 12 and 13, investment in element producing facilities to produce parts for the 500 dwelling units per year is approximately \$980,000 in equipment and materials stock. Each of five sites will require about \$35,000 invested in equipment and about \$40,000 in working capital (5% of the value of the units under construction at any one time; approximately one third of annual starts). The total cash investment in the plants, equipment for five sites, working capital, and inventory would be about \$1,350,000.

On five hundred 93 square meter units, construction value alone, using conventional processes at the Ministry of Housing July, 1974 cost of \$243 per square meter, is 11.3 million dollars. In implementing the above described building system, material costs, traditionally making up 58% of construction costs, will

increase 10-20%. Labor costs, however, (due to a decrease in total men and percentage of skilled men), can drop 40-50% of conventional construction, and profit per unit can be decreased by 20-30%. The effect of these basic factors on construction costs, as can be seen from Table 11, is a 9.7% savings of \$1,110,000 per year.

A two thirds reduction on the 14% construction financing possible even with a conservative six month construction period, would reduce development costs from about \$4,000,000 to \$2,270,000. The net yearly savings on the \$15.3 million construction and development costs are over 2.8 million dollars; before taxes over 200% of the capital investment is saved annually. It should be noted that the effect of lower land costs have not here been calculated. Although these could result in another 8-16% (or \$3600-7200) saved per unit, the variance is considerable, and the financing options complex.

Although not directly profit-related, two other factors have a considerable economic value to the government. One of these is the positive effect that any saving of manpower, particularly skilled manpower, has on the total economy. The easing up of the current labor shortage in almost all sectors of the economy is now of utmost importance. Building techniques such as the ones here described have a proportionately impressive effect. Whether governmental subsidy, tax incen-

tives, or use of shadow pricing in competitive bidding should be used to promote more of this type of activity will not be discussed here. Suffice it to say that side benefits of increased availability of less expensive, skilled labor could accrue to the building industry as a whole from the widespread use of the proposed types of building elements and techniques.

The second factor valuable to the government and the country as a whole is the increased peak-load capacity that such a system is likely to have. With unpredictable Russian and American immigration likely to vary up to 70,000 per year, the need for thousands of homes almost instantly may occur. Conventional construction is not able to cope with such a demand, as was evidenced by the tremendous increase in housing starts, but insignificant increase in completions in 1972-73. This system, which reduces the need for skilled manpower, and shortens construction time can, in the event of emergency, using extra shifts, provide significantly more output than during typical production periods.

#### 4. Implementation

In the previous pages, without dealing with any particular organization or structure, the efficiencies and possible savings on the land-development-construction "system" using the proposed building elements and techniques were enumerated. In this section, various ways of organizing a production framework to exploit these savings will be discussed.

i. Background  
Variables

There is no one universal best way to structure a production organization. Motives of the participants may vary: with them, willingness to take various levels of risk, length of investment, and altruistic commitment to producing good low cost housing. Assuming a healthy balance of profit and growth coupled with a desire to produce a good product as the investor's main motivation for involvement in this area, two primary factors strongly influence the design of the organization. These are the involvement of the government, and the level of capital which is to be invested.

Although the government policy towards industrialization since 1971 has been positive, and actual incentives when offered have been significant, the programs are constantly changing. The roles the government has played in past industrial building plants have varied. Grants of 50% of the value of initial investment have been used by firms willing to place their factories in development areas. Long term low interest loans and tax exemptions are given to special companies with "approved enterprise" status in any field which is considered important to the state infrastructural development of balance of trade. No precise definition of these are given; it is the responsibility of the borrower to negotiate this status. In a discussion with the author, A. Levin, head of the housing ministry's Department of Prefabricated and Industrial Construction, said

that over 70% of the capital for existing industrialized housing firms is provided by the government through grants and subsidized, low interest loans.

Most commonly, the Ministry of Housing gives orders in large quantities to build housing on government land generally in development towns. These come with unit and site plans, and sometimes subsidized financing.

Another program now being phased out, gave industrialized builders a 2-5% premium per unit during the first years of operation in order to amortize the plant.

A government program of design-build competitions was started in 1973. In this, the government issues two or three year contracts for 200 dwelling units per year. The results of the 1973 competition indicated a project cost savings, but only one usable, innovative building or process design in 16 entries. Government incentives in addition to the large scale multi-year nature of the contract include an interest-free loan of 10% of the contract price. A 2% premium for each of the first two months the project is finished prior to schedule is offered, as is a 1% premium for total site labor under 9 manhours/m<sup>2</sup>. Most government contracts are linked to a building cost index.

Inability to predict with any reasonable degree of certainty the availability, size, and possible locations of any of

these programs without extensive negotiations, and in some cases a competition, makes more discussion on this subject somewhat useless. It is important to stress, however, that programs do exist and the scale of incentives is such that they could play a major role in determining an organizational direction.

The other major factor influencing organizational structure even more than governmental involvement is availability of capital. Needless to say, certain options which are available, and perhaps desirable to the investor with access to one or several million dollars are not open to those less fortunate. Still, due to the potential profitability of the total entity, opportunity exists for large returns on smaller investment in various parts of the whole.

ii. Alternative  
Options

In forming an organization implementing the proposed building system, several basic approaches can be taken, each with variations. Starting from high capital investment and working toward lower levels, some basic organizational possibilities include:

A large integrated firm could be formed to produce all elements and construct on five or more sites for private and/or public markets. Plant capacity could also be used to produce elements for sale to other builders.

A large element production plant or plants could be developed to produce all of the housing elements to be sold to builders, perhaps specially franchised.

A few, one, or even no elements could be produced by a construction oriented organization which would contract the manufacture of the other parts from existing firms involved with similar products or materials. Since only dies would need to be purchased, construction of significantly fewer units would be necessary for economic feasibility while maintaining construction and development costs below conventional methods.

In a variation of the above, the element-producing/ordering company would sell elements, perhaps packaged with plans, knowhow and rental of equipment to builders of various sizes.

Assuming no element producer evolves, a smaller scale construction organization (perhaps 50 units/year) could still produce housing slightly slower using most of the system. Parts would be more expensive, ordered from small less-mechanized producers in lower quantities; where necessary conventional construction would be substituted. Naturally, with this alternative one would not expect to obtain the full measure of potential cost or time savings.

Very small investors could produce alone, or in groups, one system part. These could be used in conventional construction or, with others, to produce housing using most of the system. Several of the elements, including the electrical coving, window seats, solar water heater, and bath and kitchen cores are applicable by themselves to conventional construction.

If regular production of elements does come into being in one of the various methods, a one site construction operation of even a few units/year would gain from some of the system's efficiencies.

Given the attractive cost and time savings possible with the total system, the wide variety of possible directions of involvement, and the various governmental incentives, it is likely that an investor interested in the basic field could match his needs to one of these roles.

iii. Two Development  
Scenarios

The process by which developers choose to become involved in, and invest in, various projects is complex. A tremendous amount of detail work must go into negotiating the right financing with banks. Desirability of location to the target market and availability and cost of labor in the area must be studied. Government incentives, tax benefits, and loop-holes must be investigated. Possible partnerships or associations with firms or individuals possessing land, capital, equipment, or experience in the area too must be considered. All of these factors are manipulated in an effort to increase profitability and decrease risk.

Projects are often started when an interested individual notices a better than average opportunity in one or a few of the multiplicity of variables and the "package" begins to come together.

It is difficult, if not impossible, to simulate these conditions. Not only are the variables themselves complex, but the real value of each specific condition is peculiar to the needs of

the particular investor.

In attempting to describe the investment potential of the system two scenarios will be presented. They are not to be perceived as models; rather they could be thought of as a successful group of "matches" arrived at through untiring open-minded searching and convincing salesmanship, which together make up the successful whole.

In both scenarios one factor provides a necessary break. In the first one, it is assumed that a government design/build competition is won. In the second, units are traded for property. These will not always occur. What can be said, however, is that the flexibility of approaches available with this system will make opportunities easier to find. These, coupled with the inherent economic efficiencies of the system itself can prove to be very profitable.

#### Scenario A

The Ministry of Housing calls for bids on a design/build basis for the construction of low-income housing on government land in Akko. Bids on 200 units per year for three years are due three months from publication of the conditions. Housing is to be started six months from the decision date and completion of the first phase of 100 units is due eleven months later. Non-binding apartment and site layout suggestions are provided.

As per usual, competition winners are eligible for a loan of 10% of the contract price, interest free for the duration of the project. The entire contract is linked to the building-cost index. Early completion bonuses of 2% per month for the first two months are part of the contract, as is a 1% bonus for completion with under nine site-labor hours per square meter. Site development costs for the sloped area are to be included in the bid.

The bid calls for a team with \$1.2 million in annual production under construction. The potential developer feels that in associating with a builder only slightly over this minimum size, he would have something to offer; rapid growth. He also feels that association with someone who is knowledgeable regarding local conditions and who can provide some loyal manpower is essential. A local builder is found and sold on the system and the potential return. A team is formed and an "approved enterprise" status is negotiated.

In preparing a bid price the team did careful cost analyses and took several additional factors into account. Although the project land is government owned, its slight slope allows the team to use it to their advantage. It will cost their competitors, concrete panel and conventional builders, a premium of several percent to level the site. Past competition winners have had bids between 5 and 10% below market rate. The team feels

that they can bid 7% below the market rate for flat sites (from Table 7) and still be low-bidder. Since quality of product, too, is judged, they feel that even if a competitor does manage to bid slightly lower, they will win. An impressive brochure is prepared.

The effort is successful and the competition is won. The bid price for 600 eighty square meter units is \$10,840,824 (based on a price of 93% of \$242.85 per square meter). A 1,084,000 dollar interest free loan is taken out and equipment and materials for the element producing facilities are ordered and assembled. Where possible, existing shops will be bought and personnel retained. Production is to be geared to 500 units/year; the excess output will first be sold to builders, and later used for expansion. This 60% of plant facilities would operate as a separate profit center returning 10% of its cost annually. As in Table 12, the plant and equipment costs are \$480,000 and raw materials and unsold inventory are another \$500,000.

The remaining \$100,000 can be used for site equipment and for working capital when the first units are complete, approximately five months after the start of construction. By the end of the first year, units should require only four months from start to finish, and should be completed at the rate of 10 units per month by each of two parallel teams with competing superin-

tendents.

The likely yearly income and expenses from this scenario after the basic learning period are:

Annual Income:

On site: Bid = 93% of conventional construction @ \$242.85/meter <sup>2</sup> or \$19,428/unit = 0.93x200x\$19,428 =	\$3,613,608
Premium = 0.04x\$3,613,608 =	144,544
	<hr/>
	\$3,758,152

Annual Expenses:

On site: Construction costs (from Tables 7, 11) Labor + Materials = (.903-.06)x total conventional cost =.843x\$19,428x200 units =	\$3,275,560
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Annual Pre-Tax Profits

On site: From sale of 200 units =	482,592
At production facilities: from use of excess production capacity @ 10% 0.1x\$980,000x0.6 =	<hr/> 58,800

Total Annual Pre-Tax Profit: \$ 541,392

After Tax Profit: Minus tax on approved  
enterprise @ 28%  
.72x\$541,392 = \$ 389,802

Although the first year would probably not be as profitable, the three year total is quite impressive. The team could have most of the 1.1 million dollar loan paid off and be involved in other private and public sector contracts by the time their contract is completed.

Scenario B

A builder with approximately \$100,000 available is interested in initiating a high profit development. He thinks he has the capacity to manage the men and equipment to construct 50 dwelling units annually, but realizes that the (flat) land alone necessary for a 50-unit development will cost approximately \$800,000.

The builder comes across the proposed building system and sets out to find a property owner with inexpensive sloped land. He finds several with land that would not currently be profitable to build on with conventional construction methods, yet is useless for agriculture. Due to high tax on real estate profits, one land owner with a site capable of accommodating 150 dwelling units is willing to trade land for completed units to be furnished one year later. The builder feels that with the decreased manpower requirements, he can produce 150 large (120 sq.m.) units in two years. In exchange for the land he agrees to turn over to the property owner forty units, twenty at the end of each year. Banks are willing to lend short term construction

money based upon the value of the property, eliminating cash flow problems.

The market value of 120 sq.m. split level units in the chosen location is in excess of \$54,000. However, in order to insure quick sale, a \$52,000 price will be asked. The view that the slope affords each home is a strong selling point when compared with comparable "hedged in" units placed on equal sized flat plots.

A large fiberglas firm will produce bathrooms and other fiberglas parts and forms only with a \$25,000 fee for molds, and a minimum order. This is agreed upon. Small shops are contracted to produce the wooden and metal parts. Concrete block, too, is produced by a nearby supplier to specifications.

The builder feels that inefficiencies necessary due to smaller than optimal operation size can easily be covered in higher income housing. He expects his costs to be 5% below those of conventional construction.

The total investment in the project is \$100,000; \$30,000 in site equipment, \$25,000 in molds and \$45,000 in working capital. The builder himself will act as project manager.

The anticipated annual income and expenses in this scenario are:

Annual Income:

From sale of 55, (75-20),  
120 m<sup>2</sup> dwelling units,  
55 x \$52,000 = \$2,860,000

Annual Expenses:

Construction costs: 75x120 m<sup>2</sup>x  
(\$243-8% profit)x.95 = 1,703,673  
Site development to attract  
high income residents = 150,000  
\$1,853,673

Development: Finance costs on con-  
struction; (18%x6/12x.5  
=4.5%)  
.045x\$1,853,673 = 83,415  
Arch. & Eng. fees @6.5%  
.065x\$1,853,673 = 120,488  
Legal & admin. @ 3.5%  
.035 x \$2,860,000 = 100,100  
\$ 304,003

Total annual expenses: 2,157,676

Annual Pre-Tax Profit: 702,324

Annual After-Tax Profit: Minus tax @ app-  
roximately 62%  
.38x\$702,324 = 266,883

In this case, too, the first months would probably not run as smoothly as hoped. However, the two year project produces impressive results. Furthermore, once the site crews have been working with the system, transfer to another location can be easily done.

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