SYSTEMS APPROACH FOR HOUSING PROTOTYPE IMPROVEMENT
Case Study: Thailand

by

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ABSTRACT

The urgent need for housing, especially for the low income families in most developing countries, is found to be exacerbated by various factors such as the adaptation of inappropriate policies, construction standards, zoning laws, land tenure policies, and lack of attention to the development of appropriate housing technology and responsive design method to user requirements.

In the light of the above, this study aims at determining comprehensive guidelines for the improvement of housing prototypes in Thailand. To exemplify such guidelines, a housing model is selected, i.e., a typical walk-up apartment of the National Housing Authority.

The improvement is proposed by means of a systems approach to building and the introduction of the building performance concept. The systems concept would allow the problem solver to deal with any set of problems, related to buildings as a whole, within which interactions between various factors in construction industry interact with each other before any resolution is developed. It also provides the problem solver to evaluate more rationally the answer he has developed and enables the process to be repeated over and over again in differing situations by means of transmission of the information. Also applied is the performance concept which would serve as an intermediary between user requirements and hardware solution.

The guidelines are developed in general five steps of the systems approach to building as follows: 1) statement of objectives, 2) problem analysis and base line data gathering, 3) development of performance criteria, 4) the generation of alternative solutions, and 5) evaluation and selection of alternatives. Accordingly, special attention is focused on the feedback from the in-use prototypes which is reflecting in the performance criteria and design proposal (Step 3&4).

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INTRODUCTION

One of the most chronic problems facing developing countries is the shortage of housing which meets minimum levels of permanency, hygiene, and habitability. The rapidly expanding populations of the developing countries, particularly in the already crowded urban areas, coupled with the increasing social expectations of these people, make the provision of sufficient decent housing one of the urgent concerns of developing countries throughout the world.

During the past decade, the housing problems in Thailand are becoming recognized as being both social and economic in nature. Despite the attempt of the Thai government to face the difficult housing task through the establishment of the National Housing Authority (NHA) in 1973, in order to cope with all the housing problem in the country, progress so far seems to suggest that the situation appears to be out of hand because of the facts 1) that:

1) Housing completions are far short of the targets set by the National Plan.

2) Housing costs are above levels which most of the low-income groups can afford.

To provide an opportunity for families in the low-income category to acquire shelter, various
possibilities, namely self-help housing, core house, etc. have been investigated and, to a certain extent, implemented by the NHA. Regarding urban housing, especially near urban centers, such as the Bangkok Metropolitan area, where land prices are exorbitant (and so is the demand of dwelling units), the walk-up apartment type seems to be the only solution attempted so far. None the less, typical walk-up apartments, currently employed by the NHA, are not responsive to the changing context of the construction industry and, at the same time, do not adequately respond to real or actual user requirements. This study is going to examine the potential for improving the prototype of walk-up apartments where immediate improvements needed are:

1) Greater adaptability to changing user needs and requirements.

2) Development of a methodology of design and procurement which makes use of all resources available, and which recognizes the need for tractable (flexible and variable) housing during its life-cycle.

3) Reduction in duration of construction.

4) Higher performance of the unit and facility.

The purpose of the study is formulated as "development guidelines for the improvement of housing prototypes with special reference to the walk-up apartment building type."
The scope of the study is defined as "to utilize the systems method, technologies, and user requirements for a selected project with a walk-up apartment as the selected building type".

The guidelines to be formed are based mainly on:
1) Feed-back from in-use prototypes.
2) The operative transformation factors in the building industry and the various context variables at present.
3) The program, objectives, and resources of the project.

The objectives stated for the study are as follows:
1) To compile available information relevant to the prototype, and form a comprehensive analysis of the possibility of improvement, considering a systems approach.
2) To confirm criteria and standards to be satisfied in the selected project whether it is constructed by conventional methods and/or by any other building systems.
3) To develop specific methods of evaluation and selection of the method with regard to the criteria selected.
CHAPTER 1: BACKGROUND

1.1 REASONS FOR THE STUDY

1.1.1 Proliferation of High Density Housing Types

According to the study of Chih-Chien Wang, "Observations from 181 Surveys of Urban Dwelling Environments in Developing Countries", 1982,

"The walk-up apartment became popular at the present stage, and is projected to proliferate in the future stage" 1)

The study concludes that the popularity of walk-up apartments is due to the fact that they are able to achieve very high densities with the potential of savings on service infrastructure. However, there are many areas in which the housing type does not perform well, i.e., high initial cost, low user participation during the project development process, and under utilized open spaces. With respect to developing countries, where the problems of housing shortage are evergrowing, the study refers to walk-up apartments (despite its drawbacks) that,

"It is important to note that the walk-up type is likely to be the most predominant dwelling type in the future" 1)
1.1.2 Scale of Housing Demand which cannot be met by Convention Methods of Construction

a. Pressing Demand for Public Housing in the Bangkok Metropolis

Although there is no comprehensive data on the housing shortage in Bangkok so far, there are some clues which are helpful to illustrate the problem, i.e., squatter housing. The magnitude of the squatter population in Bangkok, both on government and private land, was estimated to be 1,050,000 or 60% of the low-income group category in 1980 (see Fig.1.1). This figure does not include the number of population in other low-income housing types, such as workers’ housing, boat houses, and tenements. It is noteworthy that only 9% of the so-called low-income group category can get access to institutional housing by the NHA. Thus, squatter housing is considered as 'substandard' and can be taken as a measure of the housing shortage to a certain extent. Assuming that the low-income population of the Bangkok Metropolis will grow at a rate of 5% per annum, which is approximately the same rate as the metropolis as a whole, the figure could reach 1,700,000 in ten years.
As regards the income level, unsatisfied housing demand may as well be comprehended as almost half of the population in Bangkok being in the low-income group, with the percentage constantly increasing. The minimum wage established by the Thai government in 1979 was set at US$ 810 per year while, according to the World Bank, the absolute poverty line was the equivalent of US$ 822 per household, per year. The National Housing Authority classified the income groups as follows: below US$ 900 as very low income (see Fig.1.2); between US$ 900-1800 as low income; between
US$ 1800-3000 as middle income; and the rest was considered as high income. It is estimated that that 10% of Bangkok residents who are below the absolute poverty line, this, at the same time, constitutes about 54% of the total urban poverty population in the country. Moreover, the low-income group, above the absolute poverty line, accounts for 33% of Bangkok residents. Therefore, 43% of the total population in Bangkok may be considered as being in the low-income category by the NHA standard.

Figure 1.2: Income Levels

Due to land scarcity and the high costs for
providing the necessary urban infrastructure, such as water, electricity, and road networks, the Bangkok Metropolis is not only suffering from a lack of decent housing, but -moreover- cannot provide minimum services for new sites, proper planning, and management. Furthermore, there are no housing financial institutions which could provide long term loans and mortgage facilities, aside from encouraging savings. Incorporated with the aforementioned low income levels of almost half the population of Bangkok, a situation has developed where a considerable proportion of housing is of extremely low standards in terms of sanitary and physical conditions. In other words, squatter housing becomes more and more visible, indicating an urgent need for a new approach to providing low-income housing solutions.

b. Problems facing the Production of Low-Cost Housing

Production of low-cost housing in Thailand, limited by existing scarce resources, can hardly meet the pressing demand. The problems facing increased production can be outlined roughly as follows: the inconsistency of the Government’s Housing Policy, the inefficiency of the building teams (the NHA and contractors), technical problems in implementing housing projects, and the constraints on construction inputs.
First of all, the government's housing policy may be considered as basically inconsistent so far. This is caused mainly by the frequent changes of government in the past decade. For instance, during 1975-1977, the NHA witnessed three cabinets and the initial target plan of 170,000 units was raised by each of them successively. Finally, the target reached 270,000 units, which was not at all realistic, since it was clearly beyond the capacity of the NHA and the building industry. This kind of wishful thinking was causing many problems such as uncoordinated land acquisition, finance, personnel management, etc. As a result, a number of programs of construction were delayed or entirely postponed. Nonetheless, this is a problem which should be realized by any government in power: i.e., the need for long term planning which will take into account not only the effective demand of housing, but also the capacity of the industry, coordinated by the NHA, which seems to be the best solution that could be contemplated under given conditions so far.

The second problem is the inefficiency of the building teams which consist mainly of two parties, i.e., the NHA and contractors.

According to the NHA housing policy in Policy
"The National Housing Authority will be the sole agency responsible for the provision of housing for the low income and medium income families"

Despite the careful preplanning of its operations and its organization in the very beginning, the NHA is still faced with an inefficient organizational structure and poor management. The NHA is, in fact, a public enterprise which is more flexible than a public administration as far as organization and management are concerned. The fact is that the NHA is an amalgamation of previous government agencies, such as the Housing Division and the Housing Bureau of the Department of Public Welfare, and the Slum Clearance Office of the Bangkok Municipality. Accordingly, most of its personnel have been transferred from the aforementioned agencies. The situation exemplifies the problems of management resulting from the process of recruitment.

"Many problems of personnel management in public enterprises seem to have arisen from the way in which the managers are recruited and the nature of service conditions under which they operate." 2)

Now let us consider the second party of the building team, the contractors, which are operating in the private realm of the construction industry. Entering the construction industry as a private entrepreneur in Thailand is quite easy, since the
required initial capital is small, with a comparatively high ratio of liquid to fixed capital. Therefore, there are a great number of small and inexperienced contractors of which many are organized to take one project at a time. As a result, a number of firms went out of business in 1976 due to the rising prices of building materials, exacerbated by inept management. Aside from the above, ease of entry has also resulted in a very competitive market for bidding on construction projects. As a result of such high competition, many firms bid on projects at unreasonably low prices, for the sole purpose of getting the job. Later, they try to hold costs down during construction by using substandard materials and unskilled labor.

To cope with the situation, the NHA has set a minimum standard for contractors to be eligible for the NHA bidding. However, some of the contractors who win a bid, often sub-contract their work to other contractors who, most of the time, are not as well qualified. This is another problem, as far as housing production is concerned, which needs to be solved by the NHA.

Regarding the next problem, the technical difficulties in properly implementing housing projects, there are a number of areas which need to be developed, i.e., project planning, project tendering, contracting
and procurement, and project construction.

One of the most critical problems of implementing public housing is the lack of information and inefficient project planning. Despite the biggest pool of professionals working for the NHA, there is still an absence of effective co-ordination and adequate control mechanisms during design, bidding and construction process, coupled with inexperience in the area of low-cost housing which eventually results in an inability to produce efficient end products. The results are cost overruns of projects, poor planning and decision-making, a costly design stage, and the absence of any feedback or evaluation system, etc.

As far as contracting and bidding are concerned, the conditions for allowing any contractor to bid on a project are past experience (only a single contract of amount exceeded one million baht or US$50,000), and reliable legal and financial status. However, qualified contractors, once they manage to get the work, try to sub-contract it to another contractor who may be unqualified but willing to assume a share of the business. Substandard performance of buildings is the general result. At the same time, this also limits new construction firms, which may provide high performance, but lack the minimum qualifications set by the NHA, to
enter into the work pool, leaving the registered (with the NHA) contractors operate in the bidding process the way they want, i.e., bidding without any standard bill of quantity. Thus, it is difficult to set any standard price, as well as, to implement control systems during the construction period.

During the construction stage, the NHA has the important task of controlling and co-ordinating activities all over the country. The contractors, lacking experience on repetitive house building, are causing problems, more or less, on site, since the specifications issued by the NHA control only the quality of materials and end products of the building. As a result, utilization of labor, materials, and machinery depend on ad hoc decisions of the contractor and the sub-contractors. Accordingly, this causes delays of most of the projects, since scheduling and control are poorly managed. To cope with this issue, it will be necessary to co-ordinate fully the work of program, design, and construction.

Last but not least, the constraints on construction inputs, i.e., land acquisition, finance, labor, and building materials, are also some of the more serious problems facing the production of low-cost housing.
Land, especially in Bangkok and other big cities, is available, but at a very high price. Land speculation is further exacerbating the situation. However, there are still some pieces of land within Bangkok available owned by some government agencies, which could be developed for public housing development.

Subsidy is the key word to public housing, but it is not always the case as experienced by the NHA. The NHA used to get heavy financial support from the government in the very beginning of its formation. However, that support lasted for only 2 years, i.e., from 1976 to 1977. As of today, the NHA is supposed to operate with its own resources as much as possible. It is inevitable that most of the current housing projects have to be designed to suit available scarce financial resources.

Thailand has been experiencing a high mobility of workers—skilled, semi-skilled, and unskilled—the like of which she has never experienced before. In 1982 alone, 108,519 workers left the country, among them, 88,271 were heading for Saudi Arabia to join the existing Thai workers' community of 170,000 persons in the Arabian Gulf region. This phenomenon has created
a problem of skilled-labor shortage in the country. Moreover, it has tended to drive up hourly wages and expectations which will cause many workers to leave construction sector. This problem should be seriously considered by responsible government agencies.

Concerning building materials, cement and reinforcing steel are currently 'key' construction materials. Wood, which was once very popular, is losing its popularity due to its scarcity and high price. However, the evergrowing demand of the aforementioned key materials and other related materials for concrete construction, such as aggregates, are causing accelerated price increases. Unfortunately, there are, so far, no alternatives of new and/or inexpensive materials and components so far. Moreover, there is no substantial government support for any solid and long-term building research program at the present.

c. Housing Supply

Despite the establishment of the National Housing Authority in 1973, the supply of public housing still is unable to meet the growing demand. Starting from the first national housing plan to the recent one, the NHA, faced with various problems of housing production, failed to meet the targets it aspired to.

In the first two years of the NHA, it was
following the housing targets set out in the Third National Economic and Social Development Plan and while at the same time trying to set its own course. The first guidelines for its housing program were set up in the Third National Economic and Social Development Plan (1972-1976). The NHA, following these guidelines, planned to provide 17,000 units per annum from 1974-1983. Facing the change of government and political uncertainties between 1973-1975, the NHA carried on its task based on the 1974-1983 plan. During the first two years, the NHA was able to proceed and complete housing projects inherited from the previous agencies, such as community housing and government public housing complexes. Moreover, to formulate urban development and slum improvement plans, the NHA also embarked on conducting socio-economic surveys in various community.

During 1972-1976, the NHA, with limited resources and the attempt to quantify housing need, did not reach the assigned target. Out of 85,000 units of the Third National Development Plan, 31,342 units of housing had been programmed in relation to the land available at that time. By 1976, only 12,275 units were completed. Therefore, the housing construction programs undertaken by the NHA were 72,725 units below the target (see Fig.1.3). During this period, instead of looking at the
constraints on the production of housing, which had fallen far short of the target of 17,000 units per year, the NHA was trying to establish the housing needs in the Bangkok Metropolitan area.

The surveys done in 1975 indicated at that time that some 110,000 families of all income groups in the capital were suffering from a housing shortage, and that 85% of these families' income was less than 5,000 baht (US$250) a month. Besides, the surveys estimated that if the housing need increased by 10% annually, the shortage would be 161,051 units by 1980 (see Table 1.1).

Figure 1.3: The target of the Third Plan and Achieved by the NHA.

Table 1.1: Housing Shortage 1976-1980

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<tbody>
<tr>
<td>Housing Shortage</td>
<td>110,000</td>
<td>121,000</td>
<td>133,100</td>
<td>146,410</td>
<td>161,051</td>
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Without making any causal reference to the potentials and limitations of the construction industry, the government then pledged to Parliament in 1975 that it would raise the target to 20,000 units per year in order to eliminate the housing shortage.

Under the Fourth National Economic and Social Development Plan (1977-1981), the Ministry of Interior through NHA was assigned to implement the government's housing policy and to formulate a plan which would satisfy the demand within five years' time. The focus of the plan was people with incomes less than 5,000 baht (US$250) a month. The NHA set its own target of completing 120,000 units from 160,000 units estimated within five years, leaving the rest to the private sector. Aside from the aforementioned, the Fourth National Plan initiated a provision for basic services, which included the building of housing units throughout the country. The NHA planned to build 5,000 units, out of the planned 120,000 units, rotating supply from province to province each year.
In order to implement such a gigantic housing program within five years, the NHA divided the plan according to income groups as follows.

Table 1.2: Housing Distribution to Income Groups

<table>
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<th>Household income in Baht/month</th>
<th>TargetGroup Type</th>
<th>Percent. Distribution</th>
</tr>
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<tbody>
<tr>
<td>Less than 1,500</td>
<td>A</td>
<td>35</td>
</tr>
<tr>
<td>1,500-3,000</td>
<td>B</td>
<td>40</td>
</tr>
<tr>
<td>3,000-5,000</td>
<td>C</td>
<td>10</td>
</tr>
<tr>
<td>5,000+</td>
<td>D</td>
<td>15</td>
</tr>
</tbody>
</table>


A. 5,000 units for those whose monthly income was less than 1,500 baht (US$75), which accounted for 35% of those who were seeking housing.
B. 5,600 units for those whose monthly income was between 1,500-3,000 baht (US$70-150), which accounted for 40%.
C. 1,400 units for those whose monthly income was between 3,000-5,000 baht (US$150-250), which accounted for 10%.
D. Those whose monthly income was more than 5,000 baht (US$250), which accounted for 15% would seek housing from the private sector under NHA assistance. The private sector was estimated to accomplish about a third of the work done by the NHA with some 10,000 housing units being supplied by the private sector annually.

The five-year plan (1977-1981) of housing
construction was launched in both urban and suburban areas. Accordingly, a study of satellite towns was initiated, responding to the government’s town planning policies which were advocating the establishment of new self-contained communities.

In addition, the NHA made efforts to implement a five-year slum improvement scheme which was considered as a more economical and faster method to deal with substandard and inadequate housing. The scheme aimed at upgrading 200 slums in the Metropolis.

At the end of fiscal year 1977, the NHA was revising the plans and policies. It was found that, it could implement just one new construction project, i.e., Tung Song Hong Project which was funded by the World Bank. The remaining ten projects were dedicated to slum upgrading. Only 2,989 units had been completed in 1978 along with 4,656 units being upgraded.

During 1979-1981, the NHA had planned its own target according to the available budget, i.e., 1,500 million baht (US$75m.). The target consisted of 5,596 units of rental apartments, 19,160 units of site and service core houses, and 26,000 units of slum upgrading. According to the assessment in June 1980, only 7,856 units altogether of every scheme were
completed.

The current five-year plan (1982-1986) has been geared towards distribution of housing construction and investment into different regions of the country. This decentralization is expected to improve the living standards of the people in the provinces, as well as reduce the migration of rural dwellers to the Bangkok Metropolis. Notwithstanding the above, the NHA set its own target of completing 42,500 units in Bangkok and only 7,500 units in the provinces. 30,00 units of slum upgrading is also included in this program.

In conclusion, the NHA has faced many problems both internal and external in the housing production and delivery process, which have prevented the agency from achieving its targets, as set by the government. The question then, to be asked is: Will the NHA manage to reach the new housing targets assigned to it? The actual amount of housing supply in each year is shown in Fig.1.4, compared with the targets set in the National Plan. It is quite obvious that the production of low-cost housing in quantitative terms has consistently fallen far short of the targets, set by the NHA.
Figure 1.4: Housing supply from 1949-1980 compared with the target of the Third National Economic and Social Development Plan 1972-1976, and the target of the Fourth National Economic and Social Development Plan 1977-1981.

The actual amount of housing supply in each year:

- 1949-1972: 500 units per annum
- 1973: 965 units
- 1974: 1,456 units
- 1975: 4,921 units
- 1976: 4,933 units
- 1977: 10,013 units
- 1978: 2,989 units
- 1979-1980: 7,856 units

Source: National Housing Authority, "Annual Report"
1975" and "Annual Report 1976".  
1.1.3 Inabilities to fulfill Users' Requirements

Housing demand does not exist just in quantitative terms, but is also qualitative as Grant Wanzel writes:

".....the demand for building is three dimensional; qualitative, quantitative, and economic. Furthermore, it suggested that a crisis would exist were there a failure to meet any or all of these demands. The housing situation may be easily examined in terms of these criteria." 5)

The quantitative demand, as mentioned earlier, is not difficult to perceive. In contrast, qualitative demand is, by its very nature, difficult to be quantified and explicitly stated. However, housing programs which do not take such demand into consideration are doomed to fail. The Pruitt-Igoe Housing Project in St. Louis exemplifies this fact, more or less, even in the context of a "developed" country - the USA. As a result, in July 1972, three central buildings were blown up by dynamite by the government as conditions deteriorated to a point, where people could not tolerate conditions prevailing in the project any more *. This problem of satisfying qualitative demand is often the case in low-cost housing, and caused more often than not by limited budgets, which translate into poor built environment.

* Note that the project was the winner of a number of architectural awards and was published widely as an example of "excellence" in public housing design.
In short, it is undeniable that both economizing, as well as poor design assumptions about poor people’s housing need led to this sort of disaster. As long as a new approach is not realized, such a mistake will be repeated over and over again, regardless of the context. The fact is, for both developing or developed countries, it is not always the case that economizing is the same as squeezing people in a box. There must be a better, if not the best, way to deal with this difficulty.

As a result of a survey done in 1971 by the NHA, there were specific complaints, concerning the performance of living units of walk-up apartments by the NHA. The dwellers were not satisfied with ventilation, space requirements and configuration (see detail in Chapter 5, 5.3.1 Summary of User Feedback). Moreover, after the first phase of the Klong Toey Housing Project was finished in 1978, it was not uncommon to find users try to convert part of the unit to suit their needs, i.e., change space for various small commercial activities; such as groceries, dress making, beauty salons etc. Some of the dwellers felt that the apartment units were too small. These are some of the messages from the users that have to be taken into account for any future projects to be implemented by the NHA.

Given the preceding discussions, the situation calls for methods of incorporating such messages or qualitative
aspects of the built housing environment into the total housing process. The traditional specification approach, usually employed in low-income housing, is becoming outmoded in terms of fulfilling user requirements (as reflected in user feedback studies discussed above). Thus, instead of using simply "prescriptive" minimum standards, where varying user requirements cannot be easily accommodated, a new possibility of using "qualitative" criteria for building performance should be initiated in housing design and construction.

The performance concept, allowing a performance requirement to be stated qualitatively, without prescribing a specific solution, is such a possibility. The concept, once properly applied, would help mediating real user requirements and construction hardware solutions. However, this does not mean that all prescriptive standards would be eliminated, but only those which prevent positive change or innovation.
1.2 STATE OF THE ART IN BUILDING INDUSTRY IN DEVELOPING COUNTRIES 6)

Regarding the present state of the art of systems in developing countries, the following observations can be made:

1) Most of the dwellings and buildings being erected today are using some open components, manufactured on site or off site in factories.

2) No substantial cost reductions compared to conventional system have been derived so far from systems building in most cases.

3) Technical advances in building technology are probably 10 years ahead of the building industry and technology is capable of producing almost anything the market demands in the consumer goods sector.

4) Out of the large number of systems sponsors, only a few appear to be successful. The key to success seems to be the management linked to superior organizational and marketing capabilities of the company.

5) For the high-rise building sector, systems building is more capable of playing an important role during the building process. This is so because of the relatively high overall construction budgets, the repetitive nature of high-rise construction, and the concentration and density of construction sites for high-rise construction sites which helps facilitating the
concentration of mechanization and control.

6) It is difficult to make a reliable real cost comparison between each building systems since each company appears to include different factors in its cost analysis.

7) A few building systems have originated in developing countries. However, the superiority of systems building has recently been realized by various governments, builders, and contractors. Consequently, some building system have been used with success in low-cost housing projects such as various prefabricated panel systems in Cuba.

8) The housing situation in most developing countries calls for an extensive and continuous program of building activity as part of an overall industrial development plan, or policy, to bring living conditions to a minimum acceptable standard. Such a program, if undertaken, may become a highly important factor in advocating the adoption of systems building as part of an an overall industrial development strategy.

9) Almost, in all developing countries, unskilled labor is abundant and relatively cheap, however, it has nothing to do with the continuous rise in wages of skilled construction workers which may eventually place a premium on conventional construction methods (which require skilled workmanship and hardly make any use of abundant unskilled labor). Also, unskilled rural
migrant labor aspires to higher "status" as permanent industrial labor.

10) The price of conventional building materials continue to increase. Moreover, these materials are being rapidly depleted such as wood. There is need for useful research on newer and cheaper materials, especially from industrial and agricultural waste (rice husk, coir fibre, e.g.), which could replace conventional materials.
1.3 ANALYSIS OF CONTEXT VARIABLES

The main features of context variables in Thai construction industry can be outlined succinctly as follows:

Labor 7)
- Abundance of unskilled and illiterate labor.
- Lack of skilled workers.
- Labor supply is seasonal.
- Carpenters can be easily obtained.
- Masons are available.

Building Materials and Products 8)
- Concrete is available, but suffers the problem of seasonal short supply.
- Reinforcing steel bars are abundantly available.
- Wood is expensive and scarce.
- Ready mixed concrete is available.
- Some open components are gaining more acceptance such as floor components and concrete block.

Land 9)
- Land in the city is scarce and extremely expensive especially in the private market.
- It is still possible to negotiate to utilize idle land for housing purposes from other government agencies.

Transformation Factors in Construction Industry 10)
- The majority of builders have had experience with
reinforced concrete structures.

-More than half of the contracting firms have occasionally employed systems building.

-Most of the system builders employ post & beam systems.

-The majority of system builders have experience in casting components either on site or in the plant.

-A new generation of systems-conscious technicians is readily available.

-Medium weight mechanization is a common practice for most builders.

-Modular coordination has been introduced in the industry, although it is not yet common practice.

-No substantial research program on building systems is discernible.

-Long term planning of housing is inconsistent and stop-go.

-Capital investment in plant and equipment is comparatively low.

-Excessive concentration of authority in management.

-Workers tend to be unfamiliar with new efficiency-oriented productivity processes, and lack proper incentives to increase productivity (and skill).

Transportation 11)

-Road transportation is most economical within a radius of 200 km.
Low-bed trailers for large building components or elements are available.

Finance 12)

The NHA is expected to operate with its own financial resources as much as possible.

The facts above exemplify an obvious dichotomy, characteristic of developing countries, i.e., while there is an abundance of unskilled and illiterate labor seeking employment, the level of technology, potentially and practically, is relatively high. The fact is that, due to the minimum wage policy of the government, labor has become increasingly costly relative to other inputs in construction, there has been a tendency to raise productivity by replacing labor with equipment and by using labor-saving materials and prefabricated components and/or systems. Whether or not this is appropriate for developing countries is highly debatable, especially if one takes into account their severe shortages of available investment capital, labor surpluses, and lack of competent management.

However, in order to avoid any preconception of what ought to be done, we may look at the context variables only in terms of whether they are favorable or not to systems development as such.

The context variables which can be defined as
relatively highly favorable to systems development are: building materials and products, land, and transportation. All of them are potential candidates for any systems building development.

The variables which are obviously unfavorable to systems building are problem of housing finance and investment. Since the NHA is expected to operate without government subsidy, it will have to generate its own sources of financing from savings, fees, etc. There is no substantial amount of money as required in developing systems building in the very beginning of building systems development.

Regarding labor and other transformation factors, these are partially for and partially against the initiation of systems building. Thus while the lack of skilled labor and seasonal supply of labor are in favor of systems building, the abundance of unskilled labor certainly is not. Likewise, most of the transformation factors in the industry are preferrable to systems development while others, e.g., no substantial research program on building systems, inconsistent long term housing development plans, capital shortage for investment in plant and equipment, and personnel’s attitudes towards management, are denying such a development.
Whatever the case may be, insofar as several building systems are concerned, all of the aforementioned issues constitute a variable set of multiple criteria, (see Chapter 5, 5.4) often with unequal values of importance for the selection of the best and most appropriate system. The methodology outlined in Chapter 6 would provide a systematic approach to deal with these diverse issues.
The Systems Approach is a methodology which is concerned with the total process of building, its context, management, and resources. Total process here means every stage from the identification of the need or demand to the completion of the building and its effective life use.

The Systems Approach has two main features: goals are clearly stated in performance rather than the prescriptive terms, and it emphasizes explicitly the inter-relationships of sub-systems within the overall system.

The diagram (see Fig.1.5) is an attempt to illustrate the major aspects and stages that typify the total building system as a process.

At the outset, the Systems Approach is conceived in the context of an assumed "market place" of supply and demand. This market comprises, on the one hand, the consumers or users of the future buildings, whose needs and requirements have to be identified and the resources available to meet them, on the other.
To bring both parts into a satisfactory balance entails that each is expressed in measurable terms. Measurement is a vital consideration in the prediction and control of implementation. Identification of needs requires an understanding of people, their activities, the equipment they use, the spatial configuration necessary to accommodate these, and the environmental conditions to be satisfied. Most of these can be expressed in measurable terms of quantity and quality. 13)

This information can then be translated to describe the range of performances required of the built environment. The descriptions should state how the solution must perform, not what it must be.
The resources available to meet specified needs include manpower skills, finances, materials, land, plant, machinery, organization methodologies, administration, and management.

With data assembled for both perceived needs and available resources, it is then possible to enter the stages of analysis and ultimately synthesis. This is the modelling phase, using the techniques such as cost analysis, structural calculations, and, perhaps, even mathematical models to simulate the performance of alternative solutions before evaluation and one solution or solution range is selected. Thus alternative possibilities are explored and generated.

The alternative which is considered the most accurate assessment of the intended results will be selected under the guidance of the evaluation criteria, followed by the implementation stage. This is the manufacture of the parts of buildings and their assembly at the site. The result at this stage is not necessarily a building system, it can be an acceptable range of building systems to be tested or a process to be implemented, or even the design of a new institutional structure, e.g., financing, or planning, etc.

Thereafter, buildings are occupied, used, and/or tested, and subsequently can be evaluated against the goals,
objectives, and predictions of the conceptual models.
1.5 STUDY METHODOLOGY

In order to make full use of Systems Approach, it is necessary to establish the steps of operations in the study and implementation process. As far as the NHA is concerned, the following steps are suggested:

- After the decision for the study has been made, the Department (Research & Planning Department) will send requests to several bureaus to appoint a representative to serve as members of a "project team".

- The purpose of the team approach is to assemble a group of experts to work closely with each other and provide material concerning the activities and responsibilities of the various offices.

- In order to resolve a given program, these steps are to be undertaken:

  1) Identifying statement of objectives
  2) Problem analysis and base line data gathering
     a) State of the art in construction
     b) All parts of the problem and the relationship between the parts
     c) The variables and constraints which will affect attainment of the objectives
     d) Identification of the needs of the potential users of the building through surveys, interviews etc.
  3) Development of performance criteria based on user need
  4) Translation of performance criteria to performance standards and requirements (technical)
  5) Generation of alternative solutions
  6) Evaluation and selection of alternatives based on previously defined performance criteria
  7) Implementation
  8) Evaluation of the actual performance of the selected alternative against the performance criteria
N.B. Step 6,7 are beyond the scope of this page.

- After the team is formed, a series of meetings will be held to introduce the project and discuss various methods of system building.

- The team then proceeds to discuss advantages and disadvantages of present design and construction methods in order to establish objectives for use facilities.

- A group of experts, preferably the ones who are experienced in performance criteria formulation, will be selected from the team members and then assigned to develop the performance criteria and also the criteria for the selection of the system.

- A series of alternatives is developed for:
  a) Planning aspects
  b) Hardware solutions: construction and materials
  c) Time schedules for construction
  d) Mechanization, work process, and building design relationship
  e) Relationships with industry

- The evaluation and selection of alternatives will eventually take place by means of evaluation procedures by the individual and group.
CHAPTER 2: PROGRAM & OBJECTIVES

2.1 PROGRAM

2.1.1 Background 1)

In mid 1950’s, a community of squatters settled on Port Authority land. Today the settlement constitutes a small city within the Bangkok Metropolis. The community houses 6,000 families giving the total population of 30,374. It has grown through accretive development, independent from any government intervention.

The NHA has considered the three alternatives to the problems caused by this settlement, since the physical condition is considered as sub-standard and hard to upgrade:

1) Relocation: Relocation of the families to another area on the periphery of the city similar to other government housing projects.

2) Rehabilitation: Rehabilitation of the existing area by improving land utilization, infrastructure, environmental conditions, and community facilities.

3) Return: Return the residents to the rural villages. The government would provide land for new self-help settlements.

The determination of desirable possibility is based on the size of the population, the proximity to employment, and other social benefits.
Figure 2.1: Locality Plan of Klong Toey Slum
After the conclusion has been reached, the solution which turns out to be rehabilitation, is to be implemented through providing 7,500-8,000 units of walk-up apartments. The first phase project was finished in 1978 and was considered, more or less, as a model for further development.

The aim of this study is to determine a tentative solution to the problem of design and construction of the prototype by means of the systems approach.
2.1.2 Basic Data of the Site

**Location:**

The site is approximately 10 km. south-east of the Bangkok city center. It is located between a middle/high income residential and an industrial area near the Chaopraya river.

**Area:**

- Total area: 207 Ha.
- Port Authority of Thailand occupies: 104 Ha.
- Squatter community occupies: 64 Ha.
- Available area for project development: 103 Ha.

**Boundaries:**

- To the north: Gloy Num Tai residential area
- To the east: Gloy Num Tai residential area
- To the south: The Port of Thailand and Chaopraya river
- To the west: Klong Toey commercial - residential area

**Ownership:**

The Port Authority of Thailand acquired the land on which the squatter community is located before World War II for international shipping facility development. The Port's rapid growth and the location has attracted many families from different parts of Thailand to build their houses on Port Authority land.
Existing Community:

In mid-1950's a community of squatters established itself on Port Authority land, and now constitutes a small city within Bangkok Metropolis. The community houses 6,000 families adding up to a total population of 30,374. The community grew through accretive development, independent from any government support. It has been and still is a symbol of high concentrations of social, health, education, and housing problems. In 1970 the World Bank approved a loan of US$12.5 million for the expansion of docking facilities, which has brought to public attention the 20 year long occupation of a portion of Port Authority land by the squatters of Klong Toey.

Zoning:

It is proposed that the site be developed into a residential community. The Port will reduce all heavy loading to the new port located near the Gulf of Thailand.

Approaches/Access:

The approach to the site is through Rama IV road which is located about 500 meters north of the site. Arjnarong road is the major street connecting the site with Rama IV which leads to the city center. The traffic volume to the site is limited. Public buses and private mini-buses serve the area along Arjnarong road.
Topography/Natural Features:

The site is flat. Most of the land in the site is marsh land, only the edge of the site along Arjnarong road is dry land.

Soil Condition:

The surface is composed of organic fragments and blue clay with limited bearing capacity. The blue clay has a varying depth from the surface of around 20-25 m. This is the most common type of soil condition in Bangkok.

Flooding:

The marsh area of the site is prone to frequent flooding. Construction in the adjacent area has trapped water in the site.

Infrastructure/ Community Facilities:

Since the settlement is illegal, there are no utility services beyond Arjnarong road. Health and welfare services are available on the site through different social organizations. All commercial activities are located along Arjnarong road. Small corner shops/artison are found throughout the community.
2.1.3 Planning Criteria

Most of the criteria are similar to the criteria used in the first phase development.

Primary Use: Residential community
- The primary use of the site will be a residential community for 5,000 people at full development.
- The following supporting facilities are included:
  - Primary schools
  - Community center
  - Parks, playgrounds
  - Markets
  - Sewage treatment plant

Target Income Groups: Moderately low to upper low income
- The development will focus on moderately low to the upper low income sectors in Bangkok.
- To better illustrate the point, it is important to study the income levels of the target group as categories of income and employment status as follows:
  - Subsistence level 1:
    Unemployed: semi-employed (casual labor)
    no or very little savings; no family stability
  - Subsistence level 2:
    Full-time employment:
some savings: developed family life:
income range less than 1,500 baht/month
-Subsistence level 3:
Same as subsistence level 2,
except income range between 1,500 baht/month to
3,000 baht/month
-Income level 4:
Income range from 3,000 baht/month to 5,000
baht/month
-Income level 5:
Income range from 5,000 baht/month and up

N.B.: G.N.P per capita in 1977: US$410 or 8,200
baht/year. Income per capita of Bangkok
Metropolitan area in 1976: over 10,000 baht/year

The target group is composed of subsistence level
3 and income level 4, which constitutes respectively
42.16% and 8.86% of the total population in the Klong
Toey area.

The aforementioned target groups will be the
target of rehabilitation in the project. The remaining
3,000 units will come from low income people in other
areas of Bangkok.

It is recommended that subsistence level 1 should
be allowed to stay where they are now, or be relocated within the area. Slum upgrading, plus sufficient employment and suitable training programs, should be initiated as complementary policies of upgrading and social improvement. Subsistence level 2 should be relocated in the NHA "site and service" core house project on the periphery of Bangkok. Income level 5 can get access to housing in the private sector without much trouble.

Tenure: Condominium ownership or rental
- The development will offer two options of tenure with primary emphasis on condominium ownership.
- Rental is also possible.

Intensity of Land Use: High Density
- The density planned for the site is the same as in the first phase which is 1,700 persons/Ha.

Financing Mode: Public
- Public financing is needed to carry out the development.
- It is suggested that, though the budget has not been set up yet, the study of the hardware solution should be geared towards a scheme that would ease financial investment difficulties, i.e., provide the most economical feasible solution at optimal
exploitation of innovative design and procurement methods (i.e., application of the systems approach).
2.2 OBJECTIVES

A series of objectives has been set up as follows:

- To increase space adaptability in order for the plan to be reorganized in response to dweller preferences including the possibility for expanding the unit in an orderly way.
- To improve the performance of buildings and building subsystems in response to users' feedback requirements.
- To reduce the costs of ownership: construction, operation, and maintenance.
- To provide equal performance for lower cost or better performance for the same or lower cost, when compared with conventional construction types.
- To improve physical comfort and privacy within the unit.
- To eliminate inadequate ventilation.
CHAPTER 3: PROTOTYPE & PROPOSED CONSTRUCTION SYSTEMS

3.1 DESCRIPTION OF SELECTED PROTOTYPE 1)

The prototype is a five-storey concrete building, each one consists of 100 dwelling units or 20 units on each floor (see Fig.3.1). Each unit is comprised of a bathroom, a kitchen, a balcony, a multipurpose room, which is supposed to be capable of being subdivided into living, dining, and sleeping spaces. Service cores, which consist of staircases, refuse chutes, and water tanks, are generally at both ends of the building. Nevertheless, the positions of the service elements are subject to change from situation to situation, for example, two buildings may share the same staircase.

The following information is the official description of the prototype in terms of function and structure:

Functional Area

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Corridor</td>
<td>5.22 sq.m.</td>
<td></td>
</tr>
<tr>
<td>2. Multipurpose</td>
<td>21.21 sq.m.</td>
<td></td>
</tr>
<tr>
<td>3. Kitchen</td>
<td>6.21 sq.m.</td>
<td></td>
</tr>
<tr>
<td>4. Bathroom</td>
<td>3.51 sq.m.</td>
<td></td>
</tr>
<tr>
<td>5. Balcony</td>
<td>5.22 sq.m.</td>
<td></td>
</tr>
</tbody>
</table>

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Total 36.18 sq.m.
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57
Structure

System of Construction: Conventional post & beam
Foundation (support): R.C. piles, capacity 35 ton/pile

Material

Structure: Cast-in-place reinforced concrete
Ground floor: Precast concrete component; inverted "T" beam with filler blocks
Upper floor: ditto
External wall: Concrete block
Party wall: ditto
3.2 PROPOSED SYSTEMS OF CONSTRUCTION 2)

3.2.1 Conventional System

Figure 3.2: Conventional System

a. Structural System and Enclosure

The conventional structural system is composed of cast-in-situ columns and beams. The floor system is of a precast concrete composite type. The precast floor consists of precast, prestressed concrete inverted "T" beams with floor filler blocks in-between. The filler blocks act as form-work for the concrete topping. The foundation is a pile foundation with cast-in place isolated footings. The internal and external partition walls are hollow concrete blocks. The roof is a timber frame covered by corrugated asbestos cement sheeting.

b. Method of Construction

The construction commences with the driving of piles which are made of precast, prestressed concrete.
Piles are driven by drop hammer. After the excavation and the erection of form-work, footings are cast. Grade beams and columns are then constructed and are subsequently followed by first storey beams. Seven days after the first storey beams have been cast, the first floor begins to take shape, starting by placing inverted "T" beams on the first storey beam. The placing and adjustment of the beams are done by two men at both ends. During construction, the beams have to be temporarily shored at mid span to prevent deflection. The floor filler blocks are then put into place between the two beams. On top of the blocks, floor topping reinforcement is then applied, followed by the pouring of concrete topping and floor finishing respectively. The forming and casting of the second floor supported columns and beams are then executed and are succeeded by the placing and casting of the second floor slab. Similarly, the remaining third to fifth floor are constructed in the same way as the second one. The roof is built after the fifth floor is finished. The wall partitions, carpentry and finishing work can begin at any time as soon as the second floor is finished. This construction method is currently practiced in most housing projects of the NHA.

c. Advantages and Disadvantages

1. Advantages of the system
a) Low investment: The system requires few pieces of mechanical equipment.

b) Labor intensive: The use of labor in the system is favorable to the employment situation in general.

c) High structural stability: Since the system employs a monolithic cast-in-place structure, the structure is very stable.

d) More competitive bidding: Since the system is well known to most of general contractors, there are many potential bidders, and gradual cost reduction is likely to be achieved during the bidding process.

2. Disadvantages of the system

a) Long construction time: It takes approximately 10 months (see Fig.3.3) to complete each building of walk-up apartments, provided that the management is good. Normally, it takes 1 year for a building to be completed.

b) Skilled labor requirement: Skilled carpenters and masons are indispensable for this type of construction.
Figure 3.3: Bar Chart Schedule of Conventional System

d. Notes on Related Issues

1. Contractors:

   The construction of NHA projects is done by general contractors on a competitive bidding basis. The supply and driving of piles are done by suppliers. Also, precast floor components are supplied and erected by their manufacturers.
3.2.2 Small Component System (Partial Prefabrication)

The structural system can be divided into two parts:

1. Service core:

The structure of the service core is cast-in-situ beam, column, and stairs. These elements are constructed in the same way as the conventional method (see p.55) described in the last part.

2. The dwelling area:

Its structure is composed of a reinforced, load-bearing concrete block wall with column-supported corridor and a precast concrete composite floor. The foundation is a cast-in-place continuous beam footing, resting on piles.
Concrete blocks are laid on footings and the precast floor is placed on the block wall when it reaches a full storey height. The roof, external wall, and partitions are similar to the conventional system.

b. Method of Construction

The construction of the foundations is similar to the conventional method, except that dowel bars (vertical reinforcement in concrete blocks) are placed in pre-determined positions when the footings are being cast. The horizontal bars are then put on top of the footings and blocks are laid on the footings with mortar joints. Both horizontal and vertical joints are about one centimeter thick. After the first two rows of blocks have been laid, the grouting mortar will be poured and compacted into its place by steel rods. Horizontal bars are then placed and followed by the laying of bond beam units. After that, bond beam reinforcement is placed and grouted. The construction of the floor slabs is done in the same way as the conventional system. The service core which is also done by conventional methods is installed while the bearing wall blocks are being fabricated.

c. Advantages and Disadvantages

1. Advantages of the system
a) Low investment: Little mechanical equipment is needed.

b) Shorter time in construction: The total construction time for this building type is about six months (see Fig.3.5).

c) More efficient in terms of form-work and scaffolding: The system eliminates the off and on problem of form-work and scaffoldings.

d) High performance of party walls: Concrete blocks provide sound absorption and also possess heavy thermal mass to absorb heat from the outside.

2. Disadvantages of the system

a) Close inspection and supervision are required since most craftsmen are not familiar with the system.

b) Difficult to repair since the wall is subject to the structural load all the time.

c) Rigidity in planning: There is less flexibility in spatial arrangement.

d) Structural safety is not good: There is a risk of progressive structural collapse due to local structural failure.
d. Notes on Related Issues

1. Contractors:

   In order to undertake the construction tasks most efficiently and economically, there is a number of factors which deserve particular attention from masonry contractors in this type of construction.

   a) Work Repetition: Prior to bidding, masonry contractors should realize the repetitive character of the work and minimize the requirements of scaffoldings.

   b) Material Handling: Material handling is a challenging task in multi-storey construction and it is suggested that masonry contractors not only consult with general contractors,
but also with their block suppliers. Experience (from the construction of NHA prototype buildings) indicates that it is helpful to procure the exact amount and number and types of blocks required for each room and correctly estimate contingencies for handling and waste. Thus, accurate material estimating is a must to reduce waste and cost.

c) Pre-assembly of elements: Repetition of work in multi-storey building makes possible the pre-fabrication of some elements, such as lintels.

d) The most important issue that contractors should bear in mind is the provision of qualified site supervisors for the job at all times.
3.2.3 Prefabricated Post & Beam System

Figure 3.6: Post & Beam System

a. Structural System and Enclosure

The structure of the building is comprised of precast concrete beams, columns, and floor panels. The columns are continuous over two storeys and spliced over the third floor level. They are designed that way for the purpose of ease of shipping and handling. The floors are ribbed slabs. The external walls are reinforced concrete precast panels and are prefabricated with carpentry work in a plant (it can be done on site as well), if there is any. Internal walls and partitions are small reinforced concrete panels precast in the plant.

b. Method of Construction

Starting from the foundation, construction is similar to the conventional method (p.59), except that a cavity seat and dowels have to be provided in the
footings in order to connect the columns to the foundation. Columns are then erected by a mobile crane. Guided by the positions of the dowel bars, the columns are put into their proper positions. The columns are then strutted and connected to each other by means of bracing, followed by beam erection. Welding and grouting facilitates the connections between beams and columns. After the connections are finished, floor and wall panels are lifted to their positions. It requires three mobile cranes (capacity 2 t. at working radius 12 m. and height 18 m.) in order to produce six dwelling units a day.

This construction method has never been used in Thailand before. Nevertheless, some buildings were constructed in a similar way by this method with cast-in-place columns instead of precast ones.

c. Advantages and Disadvantages

1. Advantages of the system
   a) Short time of construction: The construction process is simple. Also, building components are light, so they are easy to transport and fabricate (see Fig.3.7)
   b) High quality of end product: Quality control processes can be effectively implemented during production in the component
manufacturing plant.

c) Independent from weather condition:

Construction can take place in almost any kind of weather.

![Figure 3.7: Bar Chart Schedule of Post & Beam System](image)

2. Disadvantages of the system

a) High investment: The investment in plant and equipment is inevitably higher than the two methods mentioned earlier in order to implement this method.

b) Difficulties in transportation: Prefabricated components are more difficult to transport compared to lighter or smaller materials
(especially loading and unloading).

d. Notes on Related Issues

1. Contractors:

Since this construction method requires high capital investment, substantial financial support needs to be given to the contractors (from the clients or government). A prototype building should be constructed and tested prior to regular mass construction. The contract term should be long-term, and the number of units ought to be large enough for a reasonable investment recovery schedule and "breaking-in" of the system (i.e., "learning curve"). Any contractor who plans to undertake this construction method should have some past experience in precast concrete technology. Furthermore, the contractor must provide a decent management system in order to coordinate the component production in the plant and the ongoing construction on site.

2. Manufacturing:

Basically, there are two alternatives: Manufacturing components made in the factory and those made on the construction site. Given a reasonable economy of scale (say 2,000 units/year), production in a permanent factory is more
economical than on-site production and thus would provide justification for the introduction of the system in the long run. In this case, the proposal is focusing only on the manufacturing in a factory.

3. Transportation:

The transportation of the precast components is to be done by low-bed trailers. Small and flat components, such as floor and internal wall units are suggested to be transported in a horizontal position. This also applies to columns and beams. The large external panel walls should be conveyed in an up-right position. This would require four trailer trucks to enable the production of six dwelling units a day.
3.2.4 Prefabricated Panel System

a. Structural System and Enclosure

The system consists of load-bearing cross-walls and floor units. The bearing walls are precast concrete walls of about 4 m. width. The floor slabs are precast ribbed slabs. The external walls are precast reinforced concrete and prefabricated in a plant complete with integral carpentry and finishing. Foundations are pile foundations with cast-in-situ beam footings. The structure of the service cores is similar to that of the dwelling area. The stair flights and landing are also cast in the factory.

b. Method of Construction

The foundation work is done in the same manner as the foundation of the partial prefabrication method (see p.68). The first floor walls, which have to be as
rigid as possible in relation to the foundation, are cast on the footing with assembly bolts placed in position. These assembly bolts will control the center line of walls. The sequence in panel erection is very crucial in this process, since it must enable the fabrication gangs to attain a high rate of work progress per shift. It requires two mobile tower cranes (capacity 4 t. at working radius 20 m.) in order to build eight units a day.

This construction method has never been used in Thailand before.

c. Advantages and Disadvantages

1. Advantages of the system
   a) High speed of erection: The construction procedure involves a small number of components, elements, and construction tasks. Thus, with the help of modern means of mechanization, construction can proceed at a very high speed (see Fig.3.9).
   b) High quality end product: Quality control and supervision can be effectively controlled and implemented in the manufacturing plant.
   c) Independent from weather conditions: Construction can proceed in almost any kind
of weather.

d) High performance product: Thick panels provide excellent sound insulation and possess heavy thermal mass.

![Bar Chart Schedule of Panel System]

Figure 3.9: Bar Chart Schedule of Panel System

2. The disadvantages of the system

a) High investment: High investment capital for panel production plant and equipment, on-site and/or off-site is required.

b) Difficulty of transportation: Large panels are difficult to transport, and especially difficult to load and unload.

pc) Unreliable structural safety: There is a
risk of progressive collapse resulting from local structural failure, due to the structural and joint characteristics of the structure.

d. Notes on Related Issues

1. Contractors:

   The system requires, at the least, the same level of qualification of contractors as for the prefabricated post & beam method.

2. Production:

   It is also, more or less, the same as the prefabricated post & beam method, in terms of the justification of the system's implementation.

3. Transportation:

   The transportation of all precast panels is done by low-bed trailer. The wall units, both internal and external, are to be transported in an upright position. It is suggested that all of the panels be loaded on the vehicle in the same position as manufactured since it is better in position and order to be assembled. Also, the position should correspond to the final position when finally fabricated. This will ensure high efficiency in both transportation and fabrication.
at the same time. It requires five trailers to facilitate the production of 8 dwelling units in a day.
3.3 COMPARATIVE COST ANALYSIS

The determination of cost takes into account all relevant (time-dependent and quantity dependent) cost components as follows:

a. Labor
b. Materials
c. Investment
d. General expense
e. Transportation
f. Overhead
3.3.1 Cost Determination

The cost for each method is estimated on the basis of the cost of a building in a project of 100 standard dwelling units. Land cost, land development expenses, tax, and profit, which are constant for any method, have not been taken into account. The following are the ways in which costs were determined for each method of construction:

a) Conventional Method

The cost estimate is composed of 2 parts; quantity take-off and unit costs. Quantity take-off includes substructure, superstructure, and finishes, it is then multiplied by the unit costs. The price of labor is calculated in relation to units of materials, which is common practice in Thailand. Five percent is added to the total quantity of reinforcing steel for splicing and wastage. Also, 7% is provided for concrete and mortar, and 5% for concrete block, for wastage that may exist in the process. Overhead costs include salaries and fees for engineers, foremen, and staff on site and at headquarters, during construction, etc. General expenses can be broken down into cost of site preparation and power and water consumption. The cost of investment is the cost of form-work, equipment, and tools.

b) Small Component Method

The cost estimate of this method is similar to
conventional cost practice.

c) Prefabricated Methods (Post & Beam and Panel System)

The total cost of these methods is made up of production costs in the factory, construction costs on site, transportation costs, general expenses, and overhead costs. Construction can be broken down into foundation work, fabrication and erection, architectural finishes work, mechanical work, electrical work, and sanitary installations. The main cost items which have been taken into account can be outlined as follows:

1) Plant & production cost analysis: A model of the plant necessary for the construction of a prototype is assumed, and the cost of plant and production can be derived from its analysis. The interest rate assumed is 13%

2) Construction cost on site: The cost of foundations, erection, and fabrication.

3) Transportation cost: The cost of five trucks to facilitate the production of 8 units a day.

iv) Overhead cost: Expenses of salaries and fees for engineers, staff, in plant and on site.
3.3.2 Cost Comparison

In the final analysis, the comparison indicates that the construction by the prefabricated panel method is the cheapest one, followed by prefabricated post & beam, small component (partial prefabrication), and conventional method respectively. Other noteworthy remarks are:

- The total cost per dwelling unit, referred to the one built by conventional method as 100%, is 97.6% for the small component method (see Table.3.1), 94.6% for the prefabricated post & beam method, and 93.6%, for the prefabricated panel method.

- A cost component breakdown shows that, for different methods of construction, labor is about 12-16% of the total cost (see Table.3.2), materials 73-78%, investment 4-6%, general expense 1-3%, overhead 2-3% and transportation in prefabrication methods 1%.

- The total material cost per dwelling unit, if one assumes that conventional method as 100%, is 100.6% for the small component system, 99.5% for the prefabricated post & beam method, and 99.3% for the panel method, and thus are almost the same for each system (not to mention savings due to speeded up erection time).
### Table 3.1: Breakdown of Construction Cost Components

<table>
<thead>
<tr>
<th>Cost Component</th>
<th>Conventional</th>
<th>Small Component</th>
<th>Prefabricated Post&amp;Beam</th>
<th>Prefabricated Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Labor</td>
<td>100.0</td>
<td>101.2</td>
<td>72.0</td>
<td>76.8</td>
</tr>
<tr>
<td>Materials</td>
<td>100.0</td>
<td>100.6</td>
<td>99.5</td>
<td>99.3</td>
</tr>
<tr>
<td>Total Investment</td>
<td>100.0</td>
<td>64.7</td>
<td>129.8</td>
<td>105.6</td>
</tr>
<tr>
<td>Transportation</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>General Expense</td>
<td>100.0</td>
<td>97.6</td>
<td>26.7</td>
<td>20.7</td>
</tr>
<tr>
<td>Overhead</td>
<td>100.0</td>
<td>57.0</td>
<td>59.6</td>
<td>59.6</td>
</tr>
<tr>
<td>Total Cost</td>
<td>100.0</td>
<td>97.6</td>
<td>94.6</td>
<td>93.6</td>
</tr>
</tbody>
</table>

### Table 3.2: Comparison of Cost Components

<table>
<thead>
<tr>
<th>Cost Component</th>
<th>Conventional</th>
<th>Small Component</th>
<th>Prefabricated Post-Beam</th>
<th>Prefabricated Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>14.9</td>
<td>15.5</td>
<td>8.8</td>
<td>2.6</td>
</tr>
<tr>
<td>Materials</td>
<td>73.7</td>
<td>76.0</td>
<td>42.0</td>
<td>35.5</td>
</tr>
<tr>
<td>Investment:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factory</td>
<td>-</td>
<td>-</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Equipment</td>
<td>2.7</td>
<td>2.3</td>
<td>2.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Formwork</td>
<td>2.9</td>
<td>1.4</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Total Investment</td>
<td>5.6</td>
<td>3.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Transportation</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>General Expense</td>
<td>3.4</td>
<td>3.4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Overhead</td>
<td>2.4</td>
<td>1.4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total Cost</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>
CHAPTER 4: DESIGN APPROACH

4.1 General Criteria for Housing Construction Systems

Selection

Different users or the same user at a different point in time have varied needs. In order to satisfy such varied needs or various categories of users, and for the purpose of producing dwellings responding to those needs by various methods of construction, two alternatives exist:

1) A system of construction employing physical elements that can be changed by the user without interfering with the main structure and its integrity.

2) A system of construction with no elements that can be altered by the user. This is the most prevalent approach to housing design at the present, not only in Thailand, but throughout the world.

The NHA is employing the second alternative, which results in the limitation of most users' choices, since the housing stock is not large enough, and thus the users' ability to move from one housing type to another, is also limited. This does not mean that the user is not allowed to rearrange his unit at all (for example, he can change his furniture), but the fact is the extent, to which he is allowed or limited to make needed or desirable modifications to his house, suggests that his varied needs cannot be
accomodated by present solutions. The reason lies in the lack of incorporating ever changing users’ needs in the design process from the beginning. Ideally, to accomodate all needs, original stock of dwellings would have to provide a wide range of selections of many diverse designs, allowing the user to move from one dwelling to another, as his needs and requirements change. In addition, the housing stock offered would have to be larger than effective demand, to allow for such mobility. This, however, is seldom the case or rarely possible, since users generally are unable to move around for a number of reasons, and the housing stock, as earlier mentioned, is not and will hardly be larger than effective demand, in the foreseeable future, particularly in Bangkok.

Due to the existence of an insufficient housing stock and the subsequent severe limitation on users’ mobility, an alternative approach, which allows the user to change or even expand his own unit is more preferable in such a situation. Given the possibility to change his dwelling, the user should be able to change the relationship between different spaces as he wishes; he can open a door, close another, remove or relocate a partition, increase or decrease the dimensions of a space, and so on.
4.2 NOTES ON EXISTING SYSTEM

Insofar as the first alternative is concerned, i.e., allowing the participation of the user in changing the characteristics of his space, the system does not allow any modification on the part of the user, once all elements have been fixed in the design, and during construction. The user is thus confined to a fixed layout in his own unit in terms of territory and, to some extent, space configuration. Consequently, the following impediments to adaptability and extensibility arise in relation to the existing standard prototype (see Fig. 4.1):

- It is difficult and sometimes impossible to remove a wall or partition, even non-structural ones.
- The distribution of structural reinforcement in the floor does not allow for the relocation of any wall or partition (a heavy one).
- The distribution of electrical, water, and sewage outlets does not allow for the relocation of functional spaces, such as kitchens and bathrooms.
Figure 4.1: Existing Prototype of Dwelling Units
4.3 "SUPPORT-DETACHABLE UNITS" APPROACH TO HOUSING 1)

In order to investigate better ways to deal with the problems of the design and construction of mass housing, nine Dutch architects and a representative of the Dutch Architects Association formally founded the SAR (Stichting Architecten Research) in 1964. As a result, a hypothesis was developed on the conviction that large scale industrialization of the housing process can be developed successfully, if production and use are realized as two distinct "spheres".

The collective sphere is represented by the "support structure" which is seen as or referred as a long-term investment and is made, as well as, decided upon by the community to contain a given number of dwellings and thus constitutes a collective infrastructure, i.e., the "support". The support may or may not be the result of using systems building and responds to professional decision making.

The other sphere is represented by the "detachable units" which are the elements for internal layout and servicing of the dwellings in the support structure. These element are industrially made products, durable consumer goods subject to change by decisions of the user.
Each sphere has its own rules of production, planning, and design. The actual individual dwelling is the result of "detachable units" being placed in the "support" structure.

In conclusion, the SAR methodology (as generally known) is a tool to allow for a more open-ended approach to plan, design, and conceive mass housing schemes by assigning those decisions made by the community to the realm of "supports", while decisions made by the individual dweller are satisfied by the "detachable units" or "infill".

The methodology is based on two objectives, i.e., a dwelling can truly reflect personal aspirations only when the dwellers are able to make their own decisions on the level of the plan and equipment of their dwelling, and the participation of the residents is critical in the exploitation of the potential of existing technology to accommodate change. Accordingly, three principles for the design of supports took shape, as follows:

1) Each dwelling unit in a support must allow for a number of different layouts.

2) It must be possible to change the floor area, either by additional construction or by changing the boundaries of the units within the support, or by manipulating the layout as such.

3) Supports or parts of a support have to be adaptable to non-residential functions, such as office space or
shops.

However, it is not necessary that every support will have to satisfy all these criteria.

As regards Thailand, the conventional approach aims at providing a complete, fixed, and finished unit. This has as a result the rigidity of planning, relatively high initial cost, and lack of adaptability to almost all levels of change.

In the outset, the second criterion (i.e., the possibility to change the floor area) mentioned above is an answer to the most critical user requirements, in terms of additional space. The first criterion of support principles, that is flexibility, will help in increasing the choice of planning configurations which were once partially fulfilled by the conventional approach.

Moreover, since the dwelling process is considered-as it should be—as dynamic and changing in the support-infill approach, it also enables the analysis of the dwelling construction not only from the point of view of finished unit cost but from the viewpoint of stages of completion and trade-off possibilities, e.g., between space and finish, or finish and equipment, etc. Cost is then considered a variable and can be assigned to various stages as well as
various levels of completion as the situation may require, which is likely to be a more realistic approach to low-cost housing in developing countries, than what is being implemented at the moment.

Last but not least, the third criterion (i.e., the adaptability to non-residential functions) will provide the answer to problems of urban decay if rehabilitation of any sort is necessary. In brief, the support-infill approach is viable in Thailand context in terms of a design approach, since it responds to the requirements of both individual and community in many respects, which are practically absent in the conventional approach.
4.4 TRANSFORMED SYSTEM

From a survey of user requirements (see Chap. 5, 5.3), and given the assumption that the user will call for, or require additional space for the accommodation of additional people or belongings, the emphasis of the support should be then on the issue of expansion, affordable for the user. Although the dwellers are prepared to invest in the enlargement of the house, either for their own use, or subletting, usually only limited savings are available for this task. It is suggested that the support should be designed in such a way that only a minimum of variable elements, to accommodate expansion, will be provided. If this is done, the user can enlarge his unit with a minimum of construction effort, which means that the initial cost of the provision for expansion, as well as the cost of expansion itself, will be kept to a minimum.

The discussion above exemplifies the design of supports as a matter of optimization. The problem is, how to generate the setting for a desirable greatest variety in lifestyles and personal preferences, by using as few "detachable" units as possible. If we consider the support as elements that cannot be changed, (since it is community product) then the three examples (see Fig.4.2) can be considered as three kinds of support structure.
The first one (a) is a prototype unit provided by the NHA, the second one (b) is the support which optimizes the elements, and the third one (c) is the support which provides an unlimited range of variety in terms of planning configurations and expansion. The first example is clearly too rigid, for there are too few variable elements. It will certainly not accommodate any changes that may be required; the unit cannot be extended in any direction whatsoever. At the other extreme, if too much is made variable (as in the third example), money and effort will be wasted in providing possibilities in excess to what is necessary. The second support, obviously, is the middle path. It also is the most economical solution, for it provides the requisite variable elements that may eventually be adapted, as required by future needs.
4.4.1 Design Proposal

The support as shown below (Fig.4.3) represents the basic minimum elements required to accommodate the plans to be shown in the following pages. It is adapted from the original plan of the prototype (the width of a new proposed plan is the same as the original, but the length of a new unit exceeds the original one by 15 cm).

![Figure 4.3: Proposed Support Structure](image)

It should be noted that the proposal is not the only solution or alternative available, there are several possibilities for the support plan proposal. However, one principle has to be realized, i.e., the design of an actual support for any given income category is a matter of optimization, i.e., to provide the greatest possible range of options to satisfy the basic affordable dwelling needs of a target income group (for further reference of the design of supports, see "Variations: The Systematic Design of
Technically, both the spatial capacity of the support and its modular order should facilitate a good integration between support and infill, either by means of modularly coordinated and industrially produced elements, or by conventional ones. Fortunately, the dimensions employed in the original plan of the prototype are, more or less, based on standard modules, e.g. the width of each unit is 3.60 m. So, it is not so difficult to adapt the prototype dimensions for a new proposed unit and use these dimensions as a viable integrating dimension for both support and infill (see Fig. 4.4) The 90 cm. module coincides with the basic modules currently used in Thailand, namely 10 cm. and 30 cm.

Figure 4.4: Proposed Prototype of Dwelling Units
4.4.2 Combination of Dwelling Sizes & Staging Process

To illustrate the efficacy of the proposal, the combination of floor areas below (Fig.4.5) represent an assessment of the capacity of the support to accommodate the mix of various dwelling sizes for varied user needs and requirements. None the less, this does not mean that all the options listed here will need to be implemented. Normally, 1 to 2 modules of support sectors seem to be the most applicable in this project.

Figure 4.5: Combination of Dwelling sizes

Regarding the objective to increase the possibility for adaptability and expansion, the following example of a simulated staging process will exemplify the capacity vis-a-vis this objective of the new proposed support plan.
Phase 1:
This represents, theoretically, the basic support as a minimum dwelling site to be occupied by users. However, depending on income level or economic capacity, it may include more elements than shown here. It is possible for users to buy or rent just this basic support.

Phase 2:
Since the basic support is not sufficient for immediate occupation, which is likely to be the case for this project, the NHA will provide some infill elements for initial occupation. In general, each basic unit will have a toilet (with bathroom), a kitchen, and a front and back facade. The finishes inside vary depending on income level. However, it is also possible
if a user does not want the infill elements from the NHA, he may wish to add infill elements on his own, from the very beginning.

Phase 3:
Partition for a bedroom with a door has been added. Painting and other finishes (if there were none) have been completed.

Phase 4:
The kitchen is extended to the balcony area, giving more interior space to accommodate a sofa. The family may gain a new born member, the bedroom starts to be a little crowded.
Phase 5:
The user manages to acquire a space from an adjacent unit (either by renting or purchasing). Thus, it enables him to have a big master bedroom. The new bedroom is, clearly, less crowded. The space which was once a bedroom has been changed into a spacious living room.

Phase 6:
This is normally the last stage for a nuclear family in big cities. The unit, now, occupies two modules of the support, accommodates a master bedroom, two bedrooms, a living-dining space, a kitchen, and a bathroom (with toilet).
4.4.3 Support Element Options

The Support Element Options shown below represent four possible alternatives (see Fig. 4.7), and take into account the previously proposed systems of construction (see Chapter 3). Clearly, many other solutions are possible and/or feasible. However, the proposed systems of construction, to a certain extent, are designed in compliance with available technology and also based on available industrialized components in the country.
As a result, in terms of construction, we have the following four support types:

1) Conventional System: The system is composed of cast-in-situ columns and beams. The floor system is of precast concrete composite type. The internal and external partition walls are hollow concrete blocks. The roof is timber frame covered by corrugated asbestos cement sheets.

2) Small Component System: Its structure is composed of concrete block walls with reinforced concrete
lintels. The roof and floor system are similar to the conventional system.

3) Prefabricated (R.C.) Post & Beam System: The structure of the support is comprised of precast concrete beams, columns, and floor panels. The internal walls and partitions are small reinforced concrete panels, precast in plant. The roof is made of modified floor panel slabs. Service cores (staircase, e.g.) are also prefabricated.

4) Prefabricated Panel System: The system consists of load-bearing cross-walls and floor units. The bearing wall panels are prefabricated in plant and transported to the site. The floor and roof slabs are precast ribbed slabs. The stair flights and landings are also cast in the factory.
4.4.4 Infill Elements

Generally speaking, the best and most economical support will be one which provides elements that are most essential for providing basic shelter needs at an affordable price, in the first place. Those which can be added later are "infill" elements finished or made by the dwellers themselves or by means of later stages of building activities.

The so-called "infill" elements represent, by definition, all those items which are to be provided by the user after taking possession of the "support". Nevertheless, in this case, since the public may not be acquainted with this notion and, in most case, users want to occupy the unit as soon as possible, some infill elements will be provided by the NHA in the first place. These elements include bathrooms and the front and back facades (see Fig.4.8). In keeping with the notion of flexibility and extensibility, it is suggested that such elements should be provided in such a way that, if possible, they can be re-used again (see Chapter 5, 5.3).
It should also be noted that, an infill element is not necessarily temporary. It may be as permanent as the support structure. The difference lies in the decision making power, although it is made of reinforced concrete, as long as the user can decide its location, it is definitely an infill element.
4.5 TENURE POLICY

Insofar as flexibility and especially extensibility are concerned, the adaptive design of the layout aspects alone is not enough for implementation. In addition, an appropriate tenure policy is also required to exploit the potentials of flexibility and extensibility of planning. In other words, a planning concept is of little value, if the system of tenure does not allow change to happen. Therefore, the system of tenure should accommodate the expansion of the units, whenever the situation calls for it. Suggestions on this matter are as follows:

- Dwellers can buy one, one and a half, two, or more support "sites", on a hire-purchase basis in the first place.
- Dwellers may occupy all units after purchase, or they can occupy just one unit and "hold back" the rest for future extension. The spare unit may be sublet with the help of the NHA.
- The subletting terms should be bound by signed and legally valid contracts. Dwellers who need more space, can expand the unit by simply not renewing the sublet contract.
- Dwellers who remain on a subletting basis could be relocated in new projects or available spaces within the project, to accommodate expansion or
change for the original owners.

-The NHA could try to locate rental units in-between purchased units in order to allow for the possibility of buying adjacent units, whenever money is available, and needs for expansion arise (in this case, the sublet units are owned by the NHA)

-Dwellers who own the units have the privilege to buy the adjacent units first, if the unit becomes available.

These suggestions are based on the assumption that the NHA will provide standard units (support and some infill elements for initial occupation) in the first place, and that there will be no exclusive modification other than that.
CHAPTER 5: PERFORMANCE & EVALUATION CRITERIA

5.1 PERFORMANCE CONCEPT

Traditionally, the designer's knowledge has been based on his empirical knowledge of the direct material correlation between a given design solution and implicit or explicit user needs. If the designer had to decide that a wall should provide privacy between adjacent bedrooms, he would weight cost against benefit of the wall to determine the best design solution. The aspect of "benefit" was usually acquired through long and direct experience of known alternative solutions and thus he could decide empirically on the particular type of wall construction which should be chosen and which would provide what he wanted, while another did not. Scientific measurement of acoustical separation was unnecessary, since his direct experience of what material (design) could assure what acoustic "quality" he was looking for, not the measured acoustical performance of the wall.

However, such a formulation of design knowledge has its shortcomings, particularly with the introduction of untested new materials and methods. For example, building codes, which express the need for safety in terms of specific design solutions, become rapidly outmoded by new or changing technology. Thus, the application of new products and materials, new forms of tendering, the rationalization of
building and the internationalization of construction, are calling for new approaches, since they are beyond the efficacy of the traditional approach.

The concept of building performance may be compared with the behavior of a person in action. Both respond under the influence of internal and external conditions. The more the needed and/or required responses of buildings can be programmed, the better performance criteria can be stated to achieve these responses. In doing so, the concept of guiding performance allows us to formulate our knowledge of the resources from which the building is assembled and relate it to the value system of the building's user.

In the conventional prescriptive approach, the physical design of the project, buildings are defined in terms of specific types of construction and materials. In contrast,

"The performance concept is an organized procedure or framework within which it is possible to state the desired attributes of a material, component, or system, in order to fulfill the requirements of the intended user without regard to the specific means to be employed in achieving the results." 1)

In more specific terms, J.R. Wright mentions that

"A performance statement, according to the National Bureau of Standards, has three essential parts—Requirements, Criteria and Test...

A requirement is a qualitative statement which identifies a user need..."
When possible, the Requirement, a qualitative statement, is converted to a quantified statement which is called the Criterion. This statement provides specific levels for attaining compliance with the intent of the Requirement.

The Test portion of the performance statement indicates the method of assessing materials, components or systems for compliance with the Criterion...

Criterion levels must be thought of as indeterminately tentative. This is because of two prominent aspects of performance: 1. The final level of the performance required of a material, component or system depends on its inevitable interaction with other materials, components and systems, and 2. Desired performance levels are continually subject to change due to the information feedback mechanism that is part of the performance approach." 2)

In short, the essence of the performance concept is the performance basis for evaluating the suitability of building systems. The approach is an organised procedure within which it is possible to state the desired attributes of materials, components or systems to fulfill the requirements of user without regard to any specific means employed in achieving the results. Therefore, the formulation of a statement of what is expected from components or subsystems in terms of performance is made possible. The statement identifies a requirement, quantifies this in the form of criterion, if feasible, and sets the method of assessing the solution for compliance with the criterion.
5.2 PERFORMANCE CONCEPT vs SYSTEMS CONCEPT

A systems approach to building does not necessarily include the performance concept. The performance concept may be applied independently from a systems concept as John Voilett contents:

"....it is incorrect to say that because the systems approach necessarily involves the identification of objectives and measures of performances, it therefore incorporates the performance concept. The latter term appears applicable only to situations in which it is both desirable and feasible to precisely specify measurable characteristics of physical objects without references to the particular means of producing them. Such situations are by no means invariably present in all building industry problems which could benefit from the systems approach. Conversely, the performance concept can be usefully applied to problems in which the systems approach has no particular relevancy." 3)

Generally speaking, the systems concept is most applicable when the problem is large-scale, complex, with individual values difficult or impossible to quantify. The nature of the problem calls for an emphasis on the whole rather than the part, as well as, on their interactions. The performance concept, however, is more relevant to problems related to individual components, when the emphasis is more on measurable properties. In this case, ends, rather than means, are crucial. It is also obvious that there is a certain area of overlap (see Fig.5.1), in which problems are best addressed by some combination of both approaches which is also the case of this particular project by the NHA.
Figure 5.1: Area of Systems and Performance Concept Overlap
5.3 USER REQUIREMENT & PERFORMANCE CRITERIA

5.3.1 Summary of User Feedback

As a result from a survey done in 1971 by NHA, the key problems associated with user requirements in the walk-up apartment were:

1) The space was too narrow and inadequately ventilated. The units had dimensions of 10.00 m. by 3.50 m. which is proportionally narrow. Moreover, each unit had to be divided into zones, i.e., kitchen and toilet in the back, along with bed rooms and living rooms in the front. The dividing partitions made ventilation even worse.

2) Since extended family life still prevailed, and the number of children was many, the need for more or additional space was a major problem. The units were generally occupied by more people than they were originally planned for. Loft space was sometimes added by the occupants to provide more living accommodation for the family.

3) Due to the way most food were cooked, i.e., most dishes are prepared by frying, it was suggested for the kitchen to be located outside the unit.

4) Another observed but unsatisfied need was the need for additional storage space. The occupants expressed this unfulfilled need. It is very usual for this category of people to save everything that
may prove to be useful in the future. They preserve metal containers, boxes, pieces of wood, etc., etc. This hoarding of miscellaneous items was not supposed to occur and was not expected to take place in the provided spaces. It certainly exacerbates the already over-crowded living conditions.
5.3.2 User Requirements

The following dimensions, according to Tarja Cronberg's "Performance Requirements for Buildings", of user activities were chosen as the basis for formulating user requirements for buildings:

1) Which activities are performed by the user (or which activities should he be able to perform)?
2) Who performs the activity (who is the user)?
3) Which of the consequences caused by the characteristics of these three dimensions (which activities, by whom, and which consequences) have been derived from the model in Figure 5.2.

Figure 5.2: A Conceptual Model User Activities
In relation to the objectives of the project and summary of user responses, there are two main concerns which are: 1) flexibility and 2) extensibility, in planning of the dwelling unit. As a result, user requirements can be formulated as follows (Table 5.1):

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>USER CHARACTERISTIC(S)</th>
<th>CONSEQUENCE(S) FOR THE USER</th>
<th>USER REQUIREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>to expand</td>
<td>- Changing needs</td>
<td>satisfaction of need to</td>
<td>The building should be designed in a way which enables the user to expand his own unit to meet his needs.</td>
</tr>
<tr>
<td></td>
<td>a) Family cycle</td>
<td>have more space</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Social mobility</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Locational mobility</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>d) Change in world view</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>e) Change in dwelling culture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to select</td>
<td>- Differing needs</td>
<td>satisfaction of need to</td>
<td>The building should be designed in a way that the user is able to select any planning arrangement that he desires.</td>
</tr>
<tr>
<td></td>
<td>a) Differing dwelling types</td>
<td>select any planning arrangement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Consumption and production influences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to adapt</td>
<td>c) Income distribution</td>
<td>satisfaction of need to</td>
<td>The building should be designed in a way that the user is able to adapt his dwelling to meet his needs.</td>
</tr>
<tr>
<td></td>
<td>d) Social allocation policies</td>
<td>adapt the unit</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.1: Formulation of User Requirements
5.3.3 Performance Requirement and Criteria

After obtaining the relevant user requirements, performance requirements for parts or subsystems of a building can be derived. Performance requirements, by their nature, are formulated independently of the solution and/or material which is applied to meet the requirements. When formulating the requirements, the solution is left open. A performance requirement does not prescribe a specific solution. Instead, the goals for the end result are given, i.e. what is to be achieved by the end result. At the same time one must, nevertheless, also specify how to evaluate the degree to which alternative solutions fulfill these requirements.

A transformation of user requirements to performance requirement implies:

1) The identification of performance requirements for subsystems, technical solutions and materials on the basis of user requirement.

2) Formulating the performance requirements in a way which will enable the control of the requirements, both in the building process and in the building in use.

Therefore, a performance requirement is formulated with two components:

1) The goal component, identifying what is to be achieved.
It is still debatable whether this component should be stated qualitatively or quantitatively. However, in both cases, one ought to be able to assess whether the goal has been achieved or not. The National Bureau of Standards (Guide Criteria 1971) considered "performance requirement" (goal component) as qualitative, as opposed to the term "criterion", which is quantitative.

2) The criteria component, describing how the goal satisfaction can be controlled. It provides a means for selection of a solution and control of the requirements. Criteria for performance requirements generally consist of a statement of the properties which are required of the solution (Karlen, 1973)

The objective of distinguishing between the two components (goals & criteria) of a performance statement is to facilitate the evaluation of alternative solutions in the design phase and the quality control in the manufacturing phase, while maintaining the links between the different phases of the transformation process. The latter is provided by the goal component, which is stated without regard to the solution to be applied or to the given conditions applicable. Criteria, given in terms of required properties, provide the means for selection and control.

Two underlying assumptions for formulating performance requirements in this way are that the criteria are more
easily evaluated than the satisfaction of the goal itself, and a correlation between the degree of goal satisfaction and the values of the properties stated as criteria can be established.

From the user requirements formulated earlier, performance requirements and criteria for subsystems of a prototype can be formulated as follows:
**Subsystem: Partition**

<table>
<thead>
<tr>
<th>Performance Requirements</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Living unit should be expandable</td>
<td>-Users should be allowed to relocate the partition within the units. Two semi-skilled users should be able to do this task with hand tools.</td>
</tr>
<tr>
<td>-Living unit should be rearrangeable</td>
<td>-Bathroom partition should be dismantled easily by a semi-skilled users with hand tools.</td>
</tr>
</tbody>
</table>

N.B.: The partition, once removed, should be re-usable. It should also be designed in such a way that its basic units could be lifted by 2 healthy adults without any excessive strain. This does not apply to the bathroom partition.
Subsystem: Floor

<table>
<thead>
<tr>
<th>Performance Requirements</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Living unit should be</td>
<td>-The floor should be designed in</td>
</tr>
<tr>
<td>expandable</td>
<td>such a way that the</td>
</tr>
<tr>
<td></td>
<td>reinforcement provided shall</td>
</tr>
<tr>
<td></td>
<td>accommodate the relocation of</td>
</tr>
<tr>
<td></td>
<td>walls or partitions that may be</td>
</tr>
<tr>
<td></td>
<td>changed by the users' decisions.</td>
</tr>
<tr>
<td>-Living unit should be</td>
<td></td>
</tr>
<tr>
<td>rearrangeable</td>
<td></td>
</tr>
</tbody>
</table>
Subsystem: Structure

<table>
<thead>
<tr>
<th>Performance Requirements</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Living unit should be expandable</td>
<td>-The structure should accommodate any expansion (within allowable limits), change, or modification of the space configurations that may happen without the addition of any essential structural elements or parts.</td>
</tr>
<tr>
<td>-Living unit should be rearrangeable</td>
<td>-The structure should accommodate any expansion, change, or modification of the space configuration without any deflection in any structural members.</td>
</tr>
</tbody>
</table>
Subsystem: Wall

<table>
<thead>
<tr>
<th>Performance Requirements</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Living unit should be expandable</td>
<td>-The party wall should be designed in such a way as to allow the users to penetrate it to facilitate horizontal expansion of the units (by occupying the adjacent units).</td>
</tr>
<tr>
<td>-Living unit should be rearrangeable</td>
<td>-The wall would allow the attachment of another wall or partition either by conventional methods or special components without difficulty, even though the work is undertaken by the users themselves (unskilled or semi-skilled).</td>
</tr>
</tbody>
</table>
Subsystem: Sanitary System

<table>
<thead>
<tr>
<th>Performance Requirements</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Living unit should be expandable</td>
<td>-Water supply and sewage taps should be located in a position that facilitates the relocation of the bathroom and kitchen within a certain specified range.</td>
</tr>
<tr>
<td>-Living unit should be rearrangeable</td>
<td>-The connection of the duct system should allow modifications due to the relocation of related facilities. Modifications to the duct system are suggested to be preferrably undertaken by skilled craftsmen.</td>
</tr>
</tbody>
</table>
5.4 SELECTION CRITERIA

Decisions related to the design and construction of any building systems involve many different criteria and/or objectives. Each of which, one way or another, is concerned with different aspects of the construction industry. In order to formulate selection criteria for a decision in our case, there are three areas where special attention should be paid, i.e., the program and its objectives, the context variables, and the performance requirements. Since the aforementioned areas have been investigated and discussed in the previous chapters (Chapter 1, 2, & 5), a set of selection criteria or objectives may be outlined as follows:

0-1 Improve the performance of buildings and subsystems
0-2 Minimize cost of construction & maintenance
0-3 Number of units to be built: 5,000-6,000 units
0-4 Unit height: 5 stories
0-5 Maximize unskilled labor
0-6 Short "learning curve" *
0-7 Minimize use of skilled workers
0-8 Simple on-site assembly
0-9 Minimize finishing on site

* The period of being accepted in the market.
Maximize the use of local craftsmanship

Maximize consumption of locally produced materials or products

Minimize imported materials

Reinforced concrete is desirable

Minimize consumption of wood (includ. formwork, scaffolding)

Maximize interchangeability of components, available in the market

Minimize idle material stock and waste on site

Post & beam method is preferable

Handling on site: manual and medium to light-weight machinery

Maximize use of available technical know-how of technicians

Develop management and technical capacity of existing technicians

Endure discontinuous product line (inconsistent housing policy)

Minimize technical support from other agencies (since it is not yet available)

Minimize highly sophisticated management, but improve to achieve higher attainable level of sophistication

Handling off site: manual and medium to light-weight machinery

Road transportation: medium to light-weight
equipment and vehicles

0-26 Minimize initial capital investment in construction

0-27 Short term returns of investment

0-28 Minimize erection time

0-29 Living units should be expandable

0-30 Living units should be rearrangeable

N.B.: 0-1 through 0-4 are derived from the program and its objectives, 0-5 through 0-28 from the context variables, and 0-29 through 0-30 the performance requirements.

It should also be noted that the listing of selection criteria suggested above were compiled on an individual basis for the purpose of illustration. Principally, it is intended only to exemplify the application of the methodology and thus represents the author's own interpretation of this procedure. It is obvious that a team of experts—say—comprising an economist, a contractor, an architect, a policy-maker, etc., would most likely produce a series of more accurate and explicit objectives for systems selection. Unfortunately, it is beyond the capacity of the author to organize such a team for this study. Nevertheless, for the purpose of illustration, as mentioned earlier, an
attempt was made to keep the selection criteria listed as "generic" as possible, yet not irrelevant.
CHAPTER 6: SYSTEMS EVALUATION & SELECTION

6.1 THE METHODOLOGY

6.1.1 Individual Evaluation

To sum up, the procedure for a decision-support model in decision-making can be outlined, step-by-step as follows:

- **Step One** - Determine the objectives
- **Step Two** - Choose the alternatives to be evaluated
- **Step Three** - Decide upon a scale of Beta values
- **Step Four** - Make a table for each system
- **Step Five** - Give Beta-value judgements for every system with respect to each objective
- **Step Six** - Give Alpha values by applying an objective weighting method, in this place, the aforementioned method of Paired Comparisons (with results normalized to a standard sum)
- **Step Seven** - Decide upon the aggregation function to be used
- **Step Eight** - Aggregate Alpha and Beta value judgements
- **Step Nine** - Derive overall judgement about each alternative system
- **Step Ten** - Compare the overall judgements for all the systems and rank them

To illustrate this procedure in application, we will take a simple example of a low-cost housing project:

**Step 1:** Assuming that the objectives are:

- **01** - ease of assembly
- **02** - short erection time
- **03** - use of medium-weight equipment
- **04** - production made in situ

The choice of only four objectives is obviously an unrealistically short list for
selection, but is used here only as an illustration of the method.

Step 2: Let us assume that the choice is to be made between a large panel system and a small component system.

Step 3: The Beta scale will be 1 to 9, with 9 = most desirable, 5 = neutral, and 1 = most undesirable.

Step 4: Construction a table for each system.

Table 6.1: Alpha-Beta Table for System A & System B

<table>
<thead>
<tr>
<th>System A (large panel)</th>
<th>System B (small component)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta</td>
<td>Alpha</td>
</tr>
<tr>
<td>01</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td></td>
</tr>
<tr>
<td>04</td>
<td></td>
</tr>
</tbody>
</table>

Sum of Alpha’s = Sum of Alpha’s =

Sum of Alpha-Beta = Sum of Alpha-Beta =

Sum of Alpha-Beta = Sum of Alpha-Beta =

Sum of Alpha = Sum of Alpha =

Step 5: Give Beta values for each system with respect to the objective, e.g., that a large panel system is desirable due to ease of assembly.
more desirable in terms of time of erection (8), undesirable for use of medium-weight equipment (4), and most undesirable in terms of production on site (1).

Small components will score (6) for ease of assembly, (4) for time of erection, (9) for use of medium-weight equipment, and (8) for production on site.

Step 6: Give Alpha values to objectives. By means of the method of Paired Comparisons (Fechner, 1860), we construct a matrix of the objectives and compare them, pair by pair,

\[
\begin{array}{cccc}
01 & 02 & 03 & 04 \\
01 & 1?2 & 1?3 & 1?4 \\
02 & 2?1 & 2?3 & 2?4 \\
03 & 3?1 & 3?2 & 3?4 \\
04 & 4?1 & 4?2 & 4?3 \\
\end{array}
\]

Fig. 6.1

It should not be forgotten that the Principal Diagonal will be left blank, since this is where each objective is compared to itself.

Let's assume that (01), i.e., ease of assembly is equally important with (02), short
erection time, and (04), production on site, but both are less important than (03), i.e., use of medium-weight equipment.

Thus, \(1?2 = \text{ties} = 1/2\)

\[
\begin{align*}
1?3 &= \text{no} \quad = 0 \\
1?4 &= \text{no} \quad = 0
\end{align*}
\]

Similarly, for (02) short erection time

\[
\begin{align*}
2?3 &= \text{no} \quad = 0 \\
2?4 &= \text{no} \quad = 0
\end{align*}
\]

Also, (03) use of medium-weight equipment

\[
3?4 = \text{yes} \quad = 1
\]

Subsequently, all these values are entered in the matrix. It should be noted that although the comparisons above fill just one side of the Principal Diagonal, this is sufficient, since the opposite judgement may be simply entered symmetrically in the corresponding cells on the other side of the diagonal. Thus, we obtain the following matrix:

\[
\begin{array}{cccc}
01 & 02 & 03 & 04 \\
01 & & 1/2 & 0 & 0 \\
02 & 1/2 & & 0 & 0 \\
03 & & 1 & 1 & 1 \\
04 & & 1 & 1 & 0
\end{array}
\]

Fig. 6.2
By means of simple calculation, Alpha values can be obtained as follows:

Objectives | Alpha value
---|---
01 | $\frac{1}{2}$
02 | $\frac{1}{2}$
03 | 3
04 | $\frac{4}{2}$

If we normalize Alpha values by assuming the sum to be 100.0, then

Objectives | Alpha value | Rank
---|---|---
01 | 8 | 3
02 | 8 | 3
03 | 50 | 1
04 | 34 | 2

Step 7: The aggregation function will be

$$\frac{\text{Sum of Alpha-Beta product}}{\text{Sum of Alpha's}}$$

Step 8&9: With Beta values from step 5, Alpha values from step 6, and table from step 4, the following tables will take shape:
Table 6.2: Alpha-Beta Table (with assigned values)

<table>
<thead>
<tr>
<th>System A (large panel)</th>
<th>System B (small component)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta value</td>
<td>Alpha value</td>
</tr>
<tr>
<td>01</td>
<td>7</td>
</tr>
<tr>
<td>02</td>
<td>8</td>
</tr>
<tr>
<td>03</td>
<td>4</td>
</tr>
<tr>
<td>04</td>
<td>1</td>
</tr>
</tbody>
</table>

Sum of Alpha’s = 100  
Sum of Alpha-Beta = 354  
Sum of Alpha = 3.54  
Sum of Alpha-Beta = 8.02

Step 10: Compare the overall judgements. Obviously, since 8.02 is greater than 3.54, system B is more desirable, and system A is less desirable. Also, from the Beta scale, we can draw the conclusion that system A is undesirable with respect to the objectives as a whole while system B is preferable.

Notice that system B has emerged as a better solution even though it scores badly in relation to short erection time (02).

Such a decision is quite possible if the objectives have been ranked and weighted accurately enough to represent the
decision-maker’s values. Nevertheless, if the result seems intuitively unacceptable to the decision-maker, it is suggested that the ranks and weights of the objectives should be reexamined, and the process repeated to check original assumptions.
6.1.2 Group Evaluation

As mentioned earlier, no substantial research program on building systems is discernible, so performance prediction on the basis of a sophisticated and complete statistical data base in Thailand has not been yet developed to the point of practicality at the moment. Thus, this lack of systemic performance prediction requires a certain method which can offset this weakness. Such a method ought to have the capacity of bringing past experiences, in any form whatsoever, to facilitate a more effective management of the decision-making process.

Rittel's Evaluation Procedure 2) for Groups is such a method among others. The procedure is described step-by-step, which, hopefully, will become self-explanatory, in terms of application.

Step 1: Each member of the group makes an off-hand, overall judgement.

Step 2: Each member makes a list of the aspects or parameters that are important (objectives).

Step 3: Each member weights the objectives to indicate his judgement concerning relative importance among themselves (Alpha values).

WAIT ONE TO TWO WEEKS, then repeat steps 1 through 3. Discard the first results and keep
Step 4: Assemble a union list of aspects/parameters (objectives) made up of all those submitted by all members of the group. Edit the union list to eliminate repetition.

Step 5: Distribute the edited union list to all members of the group and ask them to weight the objectives in accordance with their judgements concerning relative importance among themselves (Alpha values).

Step 6: Each member of the group scores each alternative (or system) against each objective on the union list (Beta values).

Step 7: Overall deliberated scores are computed (Alpha-Beta values).

ALL THE GROUP’S DELIBERATIONS UP TO THIS POINT MAY HAVE TAKEN PLACE WITHOUT A FACE-TO-FACE MEETING.

Step 8: Compare each individual’s off-hand judgement from step 1 with his deliberated judgement from step 7.

Step 9: The result of the first eight steps is a deliberated, overall judgement.

The role of each individual person in the
process may be anonymous up to this point; this
is desirable, if the participants are of
unequal rank or prestige.
A face-to-face meeting might be considered at
this stage.
One of the functions of such a meeting is to
discuss whether the results of step 8 are to
stand as the group’s decision.

1. A pre-weighting of the aspects can be used
to generate the right arguments, and to
avoid wasting time on trivial matters.
2. People may arrive at similar overall
judgements for quite different reasons.
Causes of extreme disagreement can be
analyzed and discussed by searching for
widely divergent weighting and scoring
judgements from steps 5 and 6.
3. The group may decide to deliberate further
in areas of major disagreement, perhaps
generating research or simulation projects
in the process, or to repeat the entire
cycle, or to break down some important
aspects into sub-aspects and/or to
construct more detailed criterion
functions.

Step 10: Either decide to act upon the deliberated
judgement of step 8 or to recycle or revise, as
described in step 9.
6.2 SYSTEMS SELECTION AND ASSESSMENT

After acquiring all the methods and information that are essential for the application of a systems approach to building, the total process needs to be integrated into a coherent whole. However, in terms of the efficacy of systems approach, the last step, i.e., the selection and evaluation of systems, is, perhaps, the most important part of the approach, since value is what we are aiming at from the very beginning. It is a strategic point, where various factors or components in the process are made to interact with each other.

Once again, it should be noted that it is beyond the capacity of this effort to determine a precise and/or certain answer of all the problems stated earlier, and considering the vast scope of defined or less defined context variables. The selection and evaluation process to be shown is mainly intended for illustration purposes, and it may be useful in a real situation to a certain point. However, it is strongly recommended that attention should be paid mostly to how the procedure can be utilized, rather than to the end result presented here. In other words, process rather than product is of utmost concern, regardless.
6.2.1 Alternatives

According to step 2 of the selection method, alternatives to be evaluated have to be chosen. In our case, we have two dimensions of alternatives, the first one is concerned with systems of construction (Chap.3) and the second one, planning aspects (Chap.4). For the first dimension, alternative systems of construction are comprised of:

1) Conventional System,
2) Small Component System,
3) Prefabricated Post & Beam System, and
4) Prefabricated Panel System.

In terms of planning, a conventional plan of the NHA and a new plan proposed by applying SAR methodology (Chap.4,4.4) are used two plan options.

Therefore, if we want to test all dimensions of the options against the selection criteria, the following eight alternatives (see Fig. 6.3) will be judged in the process:

A-1 Conventional plan, conventional system of construction
A-2 Conventional plan, small component system
A-3 Conventional plan, prefabricated post&beam system
A-4 Conventional plan, prefabricated panel system
A-5  Support plan, conventional system of construction
A-6  Support plan, small component system
A-7  Support plan, prefabricated post&beam system
A-8  Support plan, prefabricated panel system
Fig. 6.3
6.2.2 Weighting Criteria

Weighting the selection criteria or objectives, using the Method of Paired Comparisons (The "ties-allowed" rules will apply, with 1/2 given to both objectives)

<p>| | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>02</td>
<td>03</td>
<td>04</td>
<td>05</td>
<td>06</td>
<td>07</td>
<td>08</td>
<td>09</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>19</td>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>28</td>
<td>29</td>
<td>30</td>
<td>Rank</td>
<td>Score</td>
<td>Alpha Total 100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Score determined by rank of criteria and normal alpha value.
Selection Criteria in Ordinal Scale:

0-29 Living units should be expandable
0-30 Living units should be rearrangeable
0-2 Minimize cost of construction & maintenance
0-19 Maximize use of available technical know-how and technicians
0-20 Develop management and technical capacity of existing technicians
0-27 Short term returns of investment
0-12 Minimize imported materials
0-28 Minimize erection time
0-11 Maximize consumption of locally produced materials or products
0-26 Minimize initial capital investment in construction
0-10 Maximize the use of local craftsmanship
0-15 Maximize interchangeability of components, available in the market
0-1 Improve the performance of buildings and subsystems
0-8 Simple on-site assembly
0-14 Minimize consumption of wood (includ. formwork, scaffolding)
0-7 Minimize use of skilled workers
0-6 Short "learning curve"
0-22 Minimize technical support from other agencies
Maximize unskilled labor

Reinforced concrete is desirable

Minimize highly sophisticated management, but improve to achieve higher attainable level of sophistication

Post & beam method is preferrable

Minimize finishing on site

Road transportation: medium to light-weight equipment and vehicles

Handling off site: manual and medium to light-weight machinery

Minimize idle material stock and waste on site

Handling on site: manual and medium to light-weight machinery

Number of units to be built: 5,000-6,000 units

Endure discontinuous product line (inconsistent housing policy)

Unit height: 5 stories
6.2.3 Systems Judgement

By means of the Alpha-Beta Model, with

Beta scales:

9 = Excellent satisfaction  4 = Poor satisfaction
8 = Good satisfaction    3 = No satisfaction
7 = Average satisfaction  2 = Very unsatisfactory
6 = Moderate satisfaction 1 = Totally incompatible
5 = Indifferent satisfaction

The aggregation form = \frac{\text{Sum of Alpha-Beta}}{\text{Sum of Alpha}}
Table 6.4: The Alpha-Beta Model

<table>
<thead>
<tr>
<th>Objectives</th>
<th>a-value</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
<th>A7</th>
<th>A8</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-29</td>
<td>5.5</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>0-30</td>
<td>5.5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>0-2</td>
<td>4.8</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>0-19</td>
<td>4.8</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>0-20</td>
<td>4.8</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>0-27</td>
<td>4.7</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>0-12</td>
<td>4.6</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>0-28</td>
<td>4.6</td>
<td>6</td>
<td>8</td>
<td>9</td>
<td>7</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>0-11</td>
<td>4.4</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>7</td>
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Sum: 100.0

Sum of Alpha-Beta Product:

- A1 = 612.3
- A2 = 671.8
- A3 = 732.4
- A4 = 576.4
- A5 = 625.7
- A6 = 708.8
- A7 = 757.2
- A8 = 613.4

By using the aggregate form = \( \frac{\text{Sum of Alpha-Beta Product}}{\text{Sum of Alpha}} \)
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7.3.5 Systems Assessment

In terms of construction, the evaluation is clearly in favor of the prefabricated post & beam system, followed consecutively by the small component system, the conventional system, and the prefabricated panel system. The prefabricated post & beam system is the most desirable vis-à-vis the defined context, since it scores relatively high in almost every objective. The areas where the system performs outstandingly are the use of available technical know-how, the interchangeability of components available in the market, the minimization of erection time and finishes on-site. Moreover, the post & beam method of construction is generally acceptable to local craftsmen. Another important fact is that the sizes of the components within the system present no difficulties in transportation, handling on-site, as well as, off-site. Considering the evaluation score, the system is on the scale of average to good satisfaction.

The small component or partial prefabricated system also scores relatively high, in general. However, it is very much inferior in certain areas such as the minimization of skilled labor, on-site assembly, and improvement of technicians’ capacity. The system, since it is a wall-bearing type, is less desirable, compared to any post & beam system. As a whole, it scores moderate to average satisfaction on the beta scales.
The conventional system has turned out not to be the least desirable system, since most of its score is around moderate satisfaction. Nevertheless, it does not respond well in many areas, especially the areas of changing context, such as the potential of existing technical know-how, the improvement of existing standard of technicians' capacity, the consumption of wood, and the scarcity of skilled workers. The problems on-site, i.e., the handling of materials, the assembly process (long erection time), and the problem of finishes, are also weak points of the system. On the beta scales, moderate satisfaction is where the system performs.

On the average, the overall performance of prefabricated panel method is approximately the same as that of conventional systems, which should not be the case. The point is, while the system responds quite well in a certain area, it performs very badly in another; while it is very good in terms of construction and maintainance cost, building performance, simple assembly, skilled labor requirement, wood consumption, and on-site finishes, it performs badly in the areas of capital investment and investment return, the utilization of local craftsmen, component interchangeability, and unskilled labor maximization. Furthermore, the implementation of the system entails better management and solid technical research
background which are both not available at the moment. Transportation and material handling, which require heavy equipment are also not in compliance with the current situation in Thailand.

As regards planning, it should be noted that the support plan is always more desirable when one system of construction is considered at a time. In the evaluation process, the support plan definitely outperforms the conventional one in terms of flexibility and extensibility as stated in the objectives.
CONCLUSIONS & RECOMMENDATIONS

In recent decades, one of the most important tasks of developing countries is to provide decent housing for the increasing number of people with their dwindling resources. Accordingly, various building systems have been invented and introduced (initially in the western hemisphere and later transferred to developing countries) for the sake of systematizing the design, planning and production processes of construction industry. Each building system is responding to a certain set of pressing demands for the optimization of various aspects of quality, cost, time, and available resources. Therefore, building system as such is not a panacea that can be applied wherever regardless of the environment.

In the light of the above, there is an urgent need for a method to justify various building systems vis-a-vis differing context. A method is needed to rank the alternate building schemes by evaluating their overall desirability as regards their anticipated performance under the context variables and environmental factors to which they would be subjected in real use.

In order to evaluate and select any desirable building system in a given context in a systemic way, certain guidelines are necessary. First of all, the objectives of
the project have to be made clear, followed by base line data gathering and analysis which mainly involve the context variables such as land, labor, management, etc. Performance criteria of the desired building system or scheme has to be developed. From the aforementioned procedures, criteria or objectives can be established for the selection of a desirable scheme. The next step is the generation of alternative schemes or systems. Finally, the stage of evaluation and selection of alternatives can take place, this phase consists of three basic components, i.e., value component which aims to articulate the objectives of the decision-maker and the priorities attached to those objectives, performance component which represents a process which helps to predict the building performance, and decision component which represents a process which help to determine the desirable building schemes.

However, the area where most technicians always fail to address is the real user needs and requirements. The housing demand cannot be viewed just in terms of quantity and economy, quality should be taken into consideration as well. A new possibility of using qualitative criteria for building performance should also be initiated in housing design and construction. With the help of building performance concept, user feedback can be formalized into performance criteria which would mediate user requirements and the built environment.
In the final analysis, this study has, above all, pointed out the need for further work towards:

1) Development of a comprehensive set of performance prediction models along with supporting data banks for the evaluation of building performance.

2) Evaluation of the performance of building in use and making its comparison with the evaluation of anticipated performance of a scheme during the design development phase.

3) Development of extensively acceptable criteria, measures and performance requirements in other dimensions such as the perceptual aesthetic and sociological contexts to a comparable degree of refinement as in the technological and economic contexts.

4) Development of more specific bases for the establishment of context, criteria, and measure weightages.

5) Investigation into the time characteristics of the value system as represented by the relative weightages of various selection criteria (If the designer has some rational basis for predicting the value system under which his building will function in future, he will be best served in the decision process).
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INTRODUCTION


Chapter 1.


8) Ibid. p.29-31.


Moavenzadeh, F., "Choice of Appropriate Technologies in the Housing Sector for Conditions Prevailing in Developing Countries," presented to The International Conference on Housing Planning, Financing in Construction, December 2-7, 1979, Miami Beach, Florida.


Chapter 2.


Chapter 3.


Chapter 4.

1) N.J.Habraken, "Three R for Housing," Scheltema &
Holkema, Amsterdam, 1970.


Chapter 5.


5) Ibid. p.46.

Chapter 6.


2) Ibid.
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