A RATIONALIZED BUILDING SYSTEM FOR LOW-INCOME HOUSING AS A RESPONSE TO THE ISSUES OF FLEXIBILITY AND PARTICIPATION

by

Aida Spinazzola

Arquitecta
Facultad de Arquitectura y Urbanismo
Universidad de Buenos Aires, Argentina
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Signature of the author ______________________
Aida Spinazzola
Department of Architecture
May 3, 1988

Certified by ______________________
Eric Dluhosch
Associate Professor of Building Technology
Thesis Supervisor

Accepted by ______________________
Julian Beinart
Chairman
Department Committee for Graduate Students

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ABSTRACT

This thesis will focus on the design of a building system intending to approach the problem of low-income housing provision in developing countries.Two concepts will be proposed as a base for the development of the building system, as follows:

1) The concept of housing as an evolutionary and dynamic process that evolves over time, rather than a static view of housing as a finished product. Thus, housing will be considered as a verb rather than as a noun.

2) The recognition of the dweller as an active power, who inevitably affects and changes the dwelling environment through his/her physical intervention.

The building system designed, by virtue of its generic characteristics (shape, lightness etc.), will facilitate change and variability of the dwelling in response to users´ requirements. The designed system will be applied to two different housing schemes--low density single units and middle density apartment buildings-- in order to test the system´s performance and encourage further research and implementation.

Thesis Supervisor: Eric Dluhosch, Ph.D.
Title: Associate Professor of Building Technology.

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INTRODUCTION

APPLICATION OF RATIONALIZED BUILDING SYSTEMS IN THE CONTEXT OF DEVELOPING COUNTRIES.

The origin, gradual change and improvement of low- income communities are the consequences of a complex dynamic which basically entails technical, economical, social and environmental factors. Among them, some of the most important to mention are:

- The innovations and changes experienced in social living standards and their impact on peoples´ attitudes and expectations towards their living environment

- The difficulty of low-income groups of increasing their saving capacity

- The improvement of productivity in the building industry

- The high cost of traditional methods of construction to satisfy the high demand for shelter.

Any transformation occurring in the built environment has different rationales as a result of specific circumstances affecting the actual situation in any one of the so-called developing countries. To exacerbate an already difficult problem, the current loan payment crisis has amplified and dramatized problems already existing in the field of housing and urban development, by reducing available financial resources from both national budgets and international aid.

The economic recession, caused by this shortage of capital investment funds, is compounded further by fast demographic growth, which leaves large groups of the population without access to job opportunities, thus making it impossible for governments to subsidize housing on any significant scale. The question of how existing capital resources, land, job opportunities, and skills, can best be combined so as to overcome the current problems of unemployment and to provide a stable base for future economic growth, is a complex but crucial one. Nevertheless, it must be considered beyond the scope of the work presented here.

In the case of Argentina, as in most developing countries, fundamental changes in the policy of economic growth, development, and production have been accompanied by the rapid urban growth that resulted from the migration of rural population to urban areas.

Moreover, the country-wide tendency to concentrate industrial activities in and around the main cities,in general has produced the desired overall economic growth, but, this process, has also distorted the labor market by attracting to the urban and suburban areas large masses of population without providing full employment opportunities for the migrants.

Thus, national policy goals such as adequate living standards for the low-income population, better use of the available material resources, and effectiveness in the organization of the technical capabilities, remain a precondition for any realistic housing policy.

> Within an integrated development strategy, the application of appropriate technical approach must complement other social means on the line of thinking that advocates decentralization policies, conservation of socially acceptable environments and reasurement of healthy living conditions for the economically weaker sector.[1]

An "appropriate" technical approach does not necessarily mean a specific package of highly industrialized construction techniques. Neither does it mean the application of traditional construction methods pursuing an itellectualy-bound conservatism.

It means, instead, the consideration of both tradition and innovation as possible complementary strategies.

An appropriate technical approach also means responsiveness to the mobilization of all existing resources, including respect and recognition of the country´s cultural heritage. It also suggests that technology does not evolve along a single path and that a good solution in one circumstance is not necessarily good in another, since every society has different means to fulfill its needs and the technical approach has to respond to those special circumstances.

What is important is how industrialization is promoted and applied. We cannot say that industrialization should not be promoted by means of specialized labor, high mechanization or standardized production since industrialization by its very nature is mechanized and capital-intensive. Neither can we say that industrialization can be promoted, transferred and implemented without the understanding of local construction procedures, available materials and existing or evolving new social living patterns.

Thus, industrialization and rationalization of the building process, "should be seen as the dynamic process which makes possible the optimization of the human resources and materials, together with the financial and organizational programs according to the socio-economic circumstances of each country." [2]

OVERVIEW OF THE EUROPEAN EXPERIENCE.

In order to understand the evolution and consequences of industrialization in housing it is useful to review some aspects of the European experience.

Industrialized production, based on the use of large reinforced concrete panel technology for increasing housing provision, has its origins in European countries after the massive destruction of W.W.II. and as a result of general policies of governmental support for the construction of public housing.

In applying industrialized housing systems which originated as a result of the European experience to a different context, it is important to consider to what extent these systems, once transferred to the new context, will contribute to solve the housing problem of the recipient country, and whether systems transferred from one context to the other are suitable to respect the life styles, urban patterns, and environmental constrains of the host situation (aside from solving the problem of quantity production), without serious modifications.

If we briefly review the European experience, we will see that, after W.W.II, governments had good reasons to provide financial subsidies for large scale projects. In fact, the provision of mass-housing by prefabricated means was a matter of necessity stemming from a post-war situation which involved almost all the European countries. (fig.1)
The necessity to respond to severe weather conditions (i.e. the need to continue producing houses during the winter), the large

FIG.1 EUROPEAN MASS-HOUSING APARTMENT BUILDINGS(BUCAREST)

numbers of homeless people, the lack of skilled workers killed in the war, the labor needed in other production sectors to keep the economy in motion, the necessity of providing year-around employment, etc., were extreme factors which brought the European countries to a situation of general emergency. Considering these atypical, simultaneous circumstances, it is difficult to imagine how European governments could have accomplished the real improvements in housing which have been evolving and taking place over the last 40 years without the decisive application of mass-produced techniques.

Basically, the authorities aimed at producing large numbers of units as fast as possible (sometimes not even necessarily at low cost); maximizing efficiency, promoting continuity and quality in production and minimizing labor input.

Governments tried to solve the housing shortage by transferring to the production factory traditional means of construction. This is proved by the fact that, even today, many of the modular and measurement patterns used in prefabricated systems are not generic to the system as such, but originally came from adaptations of dimensions and norms of traditional ways of building. These were adapted to the design of diverse prefabricated components, often without much coordination between "proprietory" systems (generally referred as "closed"systems), (fig.2), and "open"systems (i.e., "kit-of-parts" systems, made up of catalog components), thus creating difficulties in component compatibility. (fig.3)

Currently, both in Europe and the U.S.A., techniques of prefabrication are applied not necessarily as a response to a massive demand of housing, but to generate profit from the output of a highly industrialized and mechanized production system, to avoid the high costs of specialized labor input, and, furthermore, due to the speed of industrial production, to minimize high interests rates on construction loans. Considering these factors, the application of industrialization to building construction became convenient and applicable in both Europe and the U.S.A., primarily as a matter of economic optimization, and not as a result of social policy.

However, the benefits obtained by the application of industrialized systems to construction were more often than not

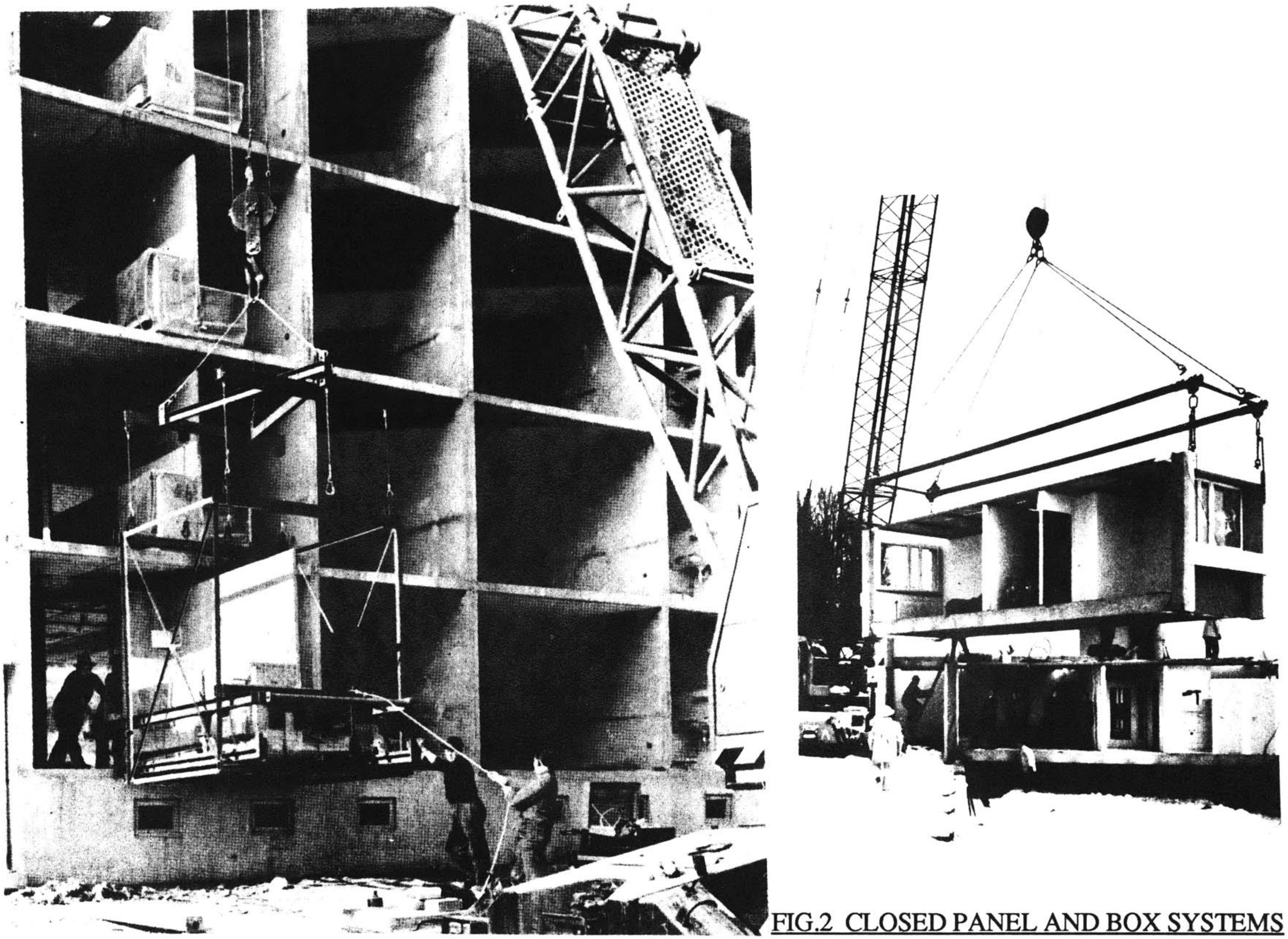
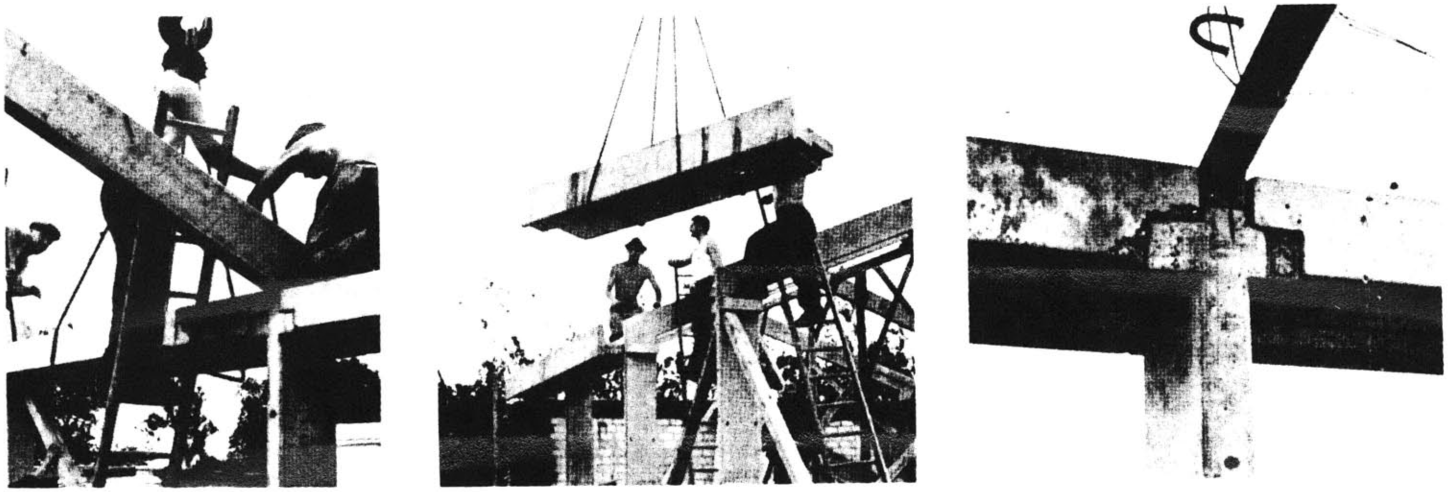


FIG.2 CLOSED PANEL AND BOX SYSTEMS



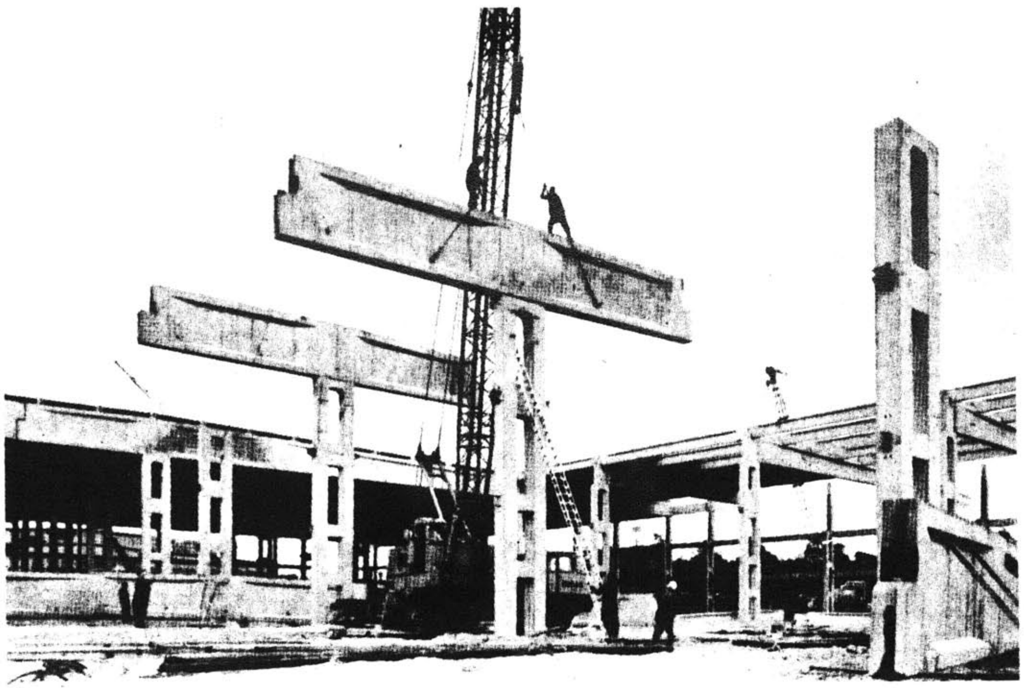


FIG.3 KIT OF PARTS SYSTEM
(W. GERMANY)

achieved at the expense of their adaptability to change according to varying user´s requirements over time, mainly because modifications were difficult to be made within the established characteristics of prefabricated elements. As N.J.Habraken wrote:

> After WW II, in Holland, instant new residential areas were created, but with one critical mistake: these areas were ill-adapted to change during use. Projects which are only 15 years old and well maintained are outdated, because they cannot meet either new standards or the new expectations of the users. Now the government either has to ignore the developing discrepancy between user expectations and reality, or must begin a renovation which will be almost as expensive as new construction. We are only glimpsing the beginnings of the housing problem in Western Europe. It will begin to visibly manifest itself in the next twenty years when the mass-housing schemes of the fifties and sixties become obsolete. This is a real time bomb. [3] (fig.4)

All these factors, mentioned above, have to be taken into account when planning for industrialized housing systems in the future, not only in developing countries, but also in developed ones. The lessons learned in Europe by trial and error must be

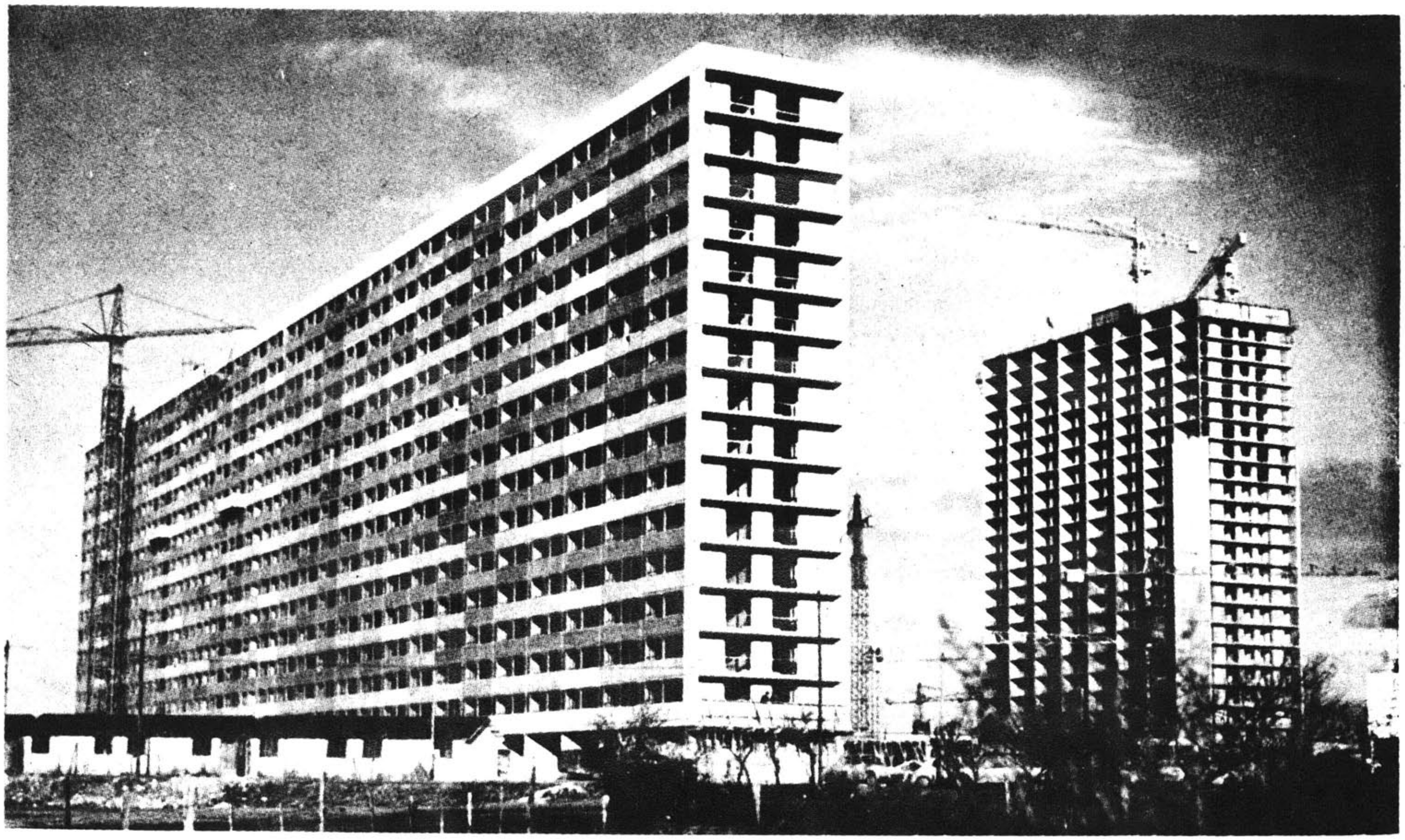


FIG.4 MASS HOUSING IN FRANCE. (15 PLANS -1400 UNITS)

analyzed in order to avoid similar mistakes , not only in contexts where the housing problem is quantitatively acute, but even in the European one, where the problem has shifted, since the late 60´s, from one of quantity to one of quality.

However, the failures mentioned before are not intrinsically inherent in the technical characteristics of industrialized systems. Rather, the problem can be attributed to the nature of the building task in housing as such and the way in which designers deal with the systemic approach to planning, procurement, implementation etc., to maximize available resources throughout the whole process of housing provision.

It is not merely a problem of providing quantity in terms of a standardized product that lies at the heart of the question of industrialization and prefabrication, but it is a matter of understanding that the quality of the product provided is equally important, and thus a matter of understanding the process as a total system.

Moreover, the design of a building system, even though conceived as a generic problem, has to be capable of being adapted to each individual site and adjusted to specific local conditions, since income capacity, life standard and user requirements vary from one case to the other. This means that plans, layouts, room sizes, will change with each project, while the components of the system remain standardized. In other words, the individual plan must remain open to modifications, specific to each project, while the components making up the plan must be capable of accommodating a given range of anticipated plan solutions without requiring major modifications in the process of production. This is why in the design of a building system we need to provide for the technical capability to change in space, over time, and in use.

At this point, it is important to emphasize that the study of housing as a process requires a full understanding of the forces which govern this process in constant evolution.

> Housing is an evolutionary process, dynamic, continuous over time, which proceeds in stages, rather than a static conception of a definitive product. Such a process of evolutionary dwelling calls for the design of evolutionary building systems. While the

> architect wields control by means of expecting complete verisimilitude between paper simulation and realized objects (to the last detail, as if born fully developed and complete), low-income dwelling types are conceived as a continuous changing process, marked by successive stages of completion, in forms of increments of space, level of finish and variation of living patterns over time. In that sense, the "informal"house is never "finished" while -paradoxically- it is always complete.[4]

Equally, the role of the dweller has to be accepted as one of the most important powers which affects the housing process.

> Only when users themselves exercise power by directly influencing and controlling a part of the physical environment, can we expect healthy, vital, steadily improving environments.[3]

The above mentioned theorical ideas about efficiency and economy of construction of housing projects as well as their quality, resulted in the concepts of so-called "staged" housing and user participation. These concepts developed as a reaction to the mistakes of the 60´s and 70´s, and were instrumental in the development of various new methods for the design of adaptable and participatory housing programmes (i.e.

Chermayeff, Turner, Alexander, Kroll, Habraken, et.all.). In turn, these theories and methods need to be subjected to empirical testing in the 80´s and beyond, precisely because at the very source of their inspiration lies the notion of change and adaptation.

In this thesis, the proposed design of a housing project by means of a precast concrete building system allowing for flexibility and user involvement, is an attempt to translate these ideas testing their viability, and, hopefully, opening the field for further research before a real implementation.

At this point, it is important to remind the reader that the technological approach proposed here represents only one solution to the housing problem, but it is certainly not the only one . It is not being proposed as the sole alternative for solving the housing shortage in developing countries. Rather, it has been chosen as a means to develop a thesis elucidating a process, and thus, it represents the author´s view of how the process can be translated into a system.

CHAPTER 1. THE SYSTEM APPROACH.

1.1 THE CONCEPT OF SYSTEM.

The issue of Rationalized Building Systems applied to housing projects has been a very controversial subject for the last decade, and even nowadays remains the theme of many discussions among designers, builders and policy makers in the field of low-cost housing.

Before approaching the thesis´ final objective of designing and applying a building system to a housing project, it is important to define and clarify some concepts related to prefabrication, system building and building systems, since these terms will be frequently used throughout this thesis.

According to Churchman´s book The System Approach, any system, building systems included, is defined as a set of structuring rules that establish the system´s "internal logic." By complying with these ordering rules, the elements of the system can accommodate possible design solutions within certain specified programmatic constraints.

1.2 OBJECTIVES OF THE SYSTEM APPROACH.

The system approach to buildings aims towards a design synthesis in which explicit means are provided to accommodate anticipated changes. Those means have a spatial potential to provide a range of solutions without requiring any radical modifications of the basic ordering rules of the system.

In broad terms, it could be said that the system approach allows designers to solve a problem in an organized manner, defining final objectives and analyzing the ways to achieve them. To apply the system approach to building construction, the problem has to be seen primarily in a holistic manner; subsequently the solution should be based on a process of evolution from the general aspects of the problem to its particulars with a minimum of preconceived concepts.

Some definitions may be appropriate at this juncture to illustrate the above:

System Building: A process of project development which involves planning, design, procurement, production, transportation, assembly etc. By applying the system building approach, the building process is organized and realized as a whole. [5]

Building System: The organization of tasks, resources, materials, components, etc., which, through a process of design in a pre-engineered manner, results in methods of construction of buildings. [6]

From these definitions we can infer that "system building" is a way of applying or achieving a systemic approach to the building process, while the term "building system" refers to a particular technical procedure.

1.3 INDUSTRIALIZATION AS AN AGENT OF OVERALL MODERNIZATION.

As a matter of fact, there is nothing new about the notion of building as a system. The understanding of a building as a relationship among structural system, circulation system, infrastructure system and so on, is commonly accepted. However, the whole building as an industrialized system, where design and variable product must be conceived simultaneously, is a concept which is still evolving and which has been very seldom applied in the past.

There are certain prerequisites for the application of the system approach to buildings. The importance of these prerequisites is based on the fact that technology has been changing as a factor of general industrial evolution, which has provided the tools for modernization, as well as affected the mechanization and industrialization of the general construction sector of the economy.

First, since the change of technology, in terms of its relation to industrialized production in construction, has resulted in new methods, materials, resources and skills available in the marketplace, the concept of "building industry" has to be considered from a different viewpoint in order to take into account all the activities involved in the entire building process.

Second, the concept of prefabrication in the building industry has to be considered as a segment of overall industrialization, apart from its more restricted role as a sub-sector of the general construction industry.

The application of prefabrication and rationalization in the process of production and in the management of the all construction activities imposes fundamental economic changes, which are associated with the scale and cost of technology on the levels of the national economy, including the construction sector. This explains why, rather than assessing technology against conventional construction methods, or choosing any particular building system to provide "magic" solutions, it should be selected and assessed in terms of efficiency and performance within the framework of overall industrialization, and as an integral part of development goals on a national level.

According to the definition of the Webster´s Dictionary, technology has to be considered as the "means by which a society provides itself with the objects of its use rather than the objects as such". It is not the level of high or low technology that determines development, but rather the effects that the level of technology has on the quality of life of the society.

Once we understand the generic differences between the structure of the organization of the industrialized sector and that of the craft-based construction process, we realize that prefabrication as such is neither the main problem nor the main cause of repetitiveness, monotony and failure of mass housing schemes, even though the tendency of repetition of mass produced elements may be recognized as a contributing factor, especially when combined with the repetition of standard plans.

This controversial situation is the direct consequence of interrelated mistakes, caused mainly by the wrong understanding of technology in the design process. In other words, monotony is not a result of industrialization as such, but is closely linked to the way in which the decision-makers and designers program, plan, and design with these technologies.

> Our most advanced technologies, organizations, tools, automation, control systems, planning, design and research are focused on making obsolete houses faster and cheaper.
> Yet, we can not take full advantage of our new technologies until both, product and process are changed, until both are understood and attuned to each other.[7]

This is an important factor to be understood during the design process of a project which intends to apply rationalized building systems; not only is it important to be aware of all the technical specifications and characteristics of the system in itself, but it is also mandatory that we understand the links between the design process and the prefabrication process as a conceptual and systemic whole.

Any thought concerning the provision of dwellings for anonymous users by means of prefabricated systems needs to shift from the concept of housing as a mere matter of standardized quantity production of layouts to new programmatic concepts related to two major issues i.e.:

1) A new interpretation of the role of the architect (from provider of finished products to enabler of adaptable systems for further intervention)

2) The application of technical innovations as a means to provide healthy and qualitative living environments, rather than as a means to obstruct the decision-making process by forcing the final design to be conceived solely as a subordination of human needs to those of production process and

technical efficiency alone.

This does not mean that prefabrication in itself does not present certain constraints. Due to its generic characteristics (repetitiveness, continuity, speed of production, etc.), prefabricated techniques do exclude some solutions. At the same time, these prefabricated techniques also offer a wide spectrum of different alternatives. Actually, this situation has very little to do with prefabrication in itself; no matter what construction system we are dealing with --traditional systems, industrialized systems etc.--, the designer will always face situations in which certain solutions are excluded while others are made possible, since any technique always dictates a specific set of constraints.

Therefore, the real task is to integrate technology and architectural design, and to optimize them as a unified process under conditions established by both the adopted technology and the design´s ultimate goals.

1.4 STANDARDIZATION IN THE PROCESS OF INDUSTRIALIZATION.

The importance of rendering explicit the compatibility of industrialized building systems with the design process relies on the fact that industrialization provides a powerful arsenal of technical capabilities, potential knowledge and experience which go far beyond such simplistic ideas as the standardization of "ideal" plans multiplied ad infinitum to provide mass-housing projects which may quantitatively solve the problem of dwelling shortage, but fail to address their qualitative aspect. (fig.5)

At this point, the question of standardization in industrialization of rationalized building systems needs to be raised.

The experience gained so far from mass-housing projects has taught that the problem of monotony is caused by the standardization of so-called "ideal" plans rather than by prefabrication as such.

As a matter of fact, the real success of prefabrication is based on standardized production of elements or sub-systems

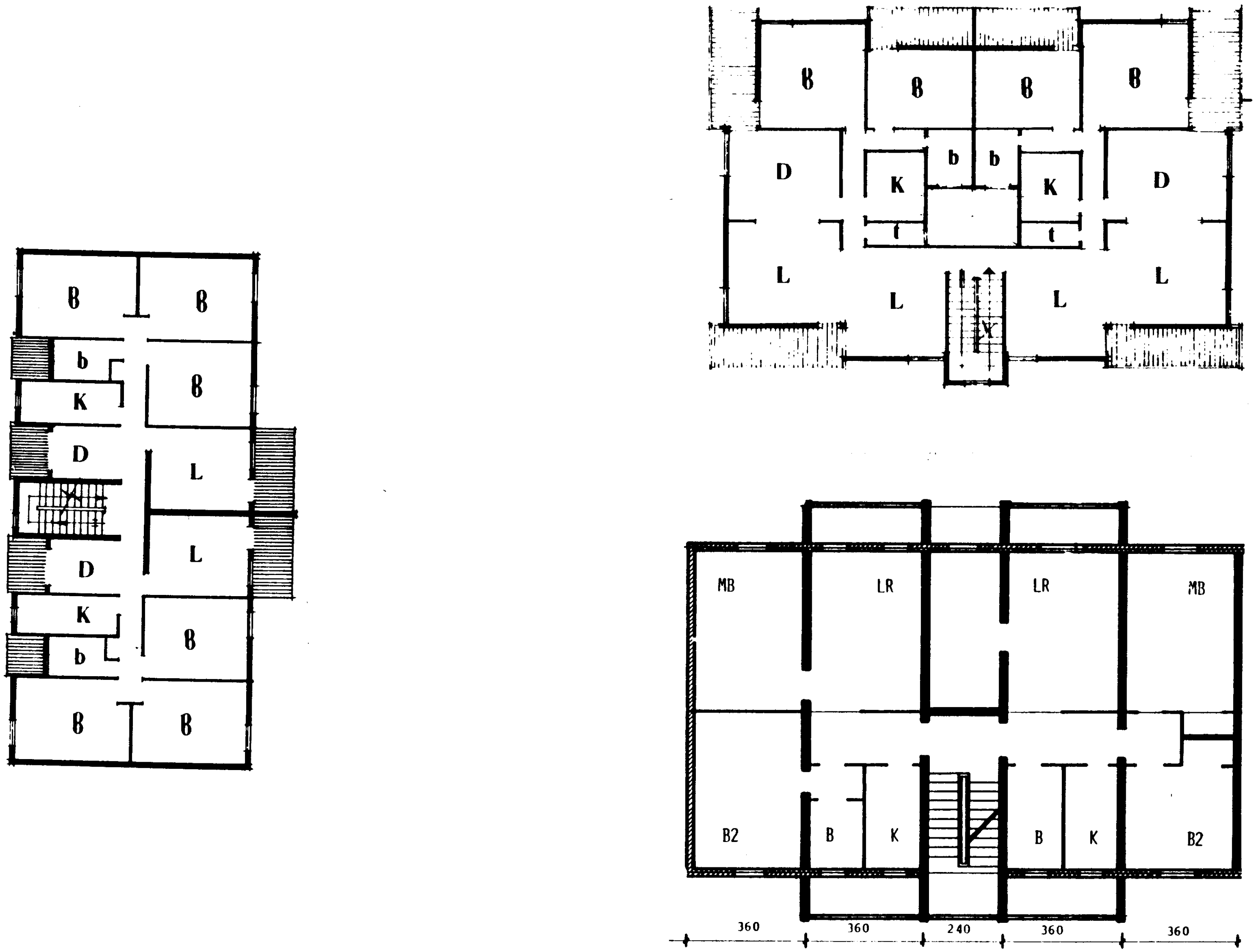


FIG.5 STANDARDIZATION OF "IDEAL" PLANS (EGYPT EXAMPLES)

(such as concrete blocks, beams, structural elements, etc.) in the open market and not on the repetition of similar layouts. It is under these conditions of standardization of products and not of plans that continuous mass production proved to be successful, accurate, fast and economical. This is due to many factors, but basically to:

- mass-produced products are available in the market to everybody
- financing and procurement depend on conventional commercial transactions
- production of elements is not limited only to special projects but can be sold on the open market.

Standardization of components does not necessarily mean that one has to strive for a universal "normative" design (typification). It rather means that standardized components should be designed in such a way as to encourage possibilities of optimal combinability among themselves as well as with other components.

This ability, far from promoting uniformity in layouts, allows for more flexibility and versatility in the whole design of the built environment.

Thus, if we understand standardization, not as a repeated spatial solution, but as a tool which allows the assembly of diverse mass-produced elements, in order to save time, effort and money, then, the standardization of components rather than whole floor plans is what authorities should aim at when planning housing projects.

In that sense, industrialized and rationalized technology cannot be blamed for the monotony and repetitiveness of mass-housing. It is a misconception that standardization must inevitably lead to "ideal" standard plans, composed of equally standardized prefabricated components, even if those ideal plans were to be the most accurate solution to "average" users´ needs, which, in fact, is seldom the case.

This misconception resulted, with little exception, not only in the repetition of layouts at the level of individual units, but also in the repetition of entire "blocks", leading to the construction of "average" repetitive mass-housing projects.

The fact that the standardization of finished plans is not the correct approach to solve the problem of mass-housing raises two main issues which have to be considered:

1) The participation of the users in the decision-making process, the construction process, and ideally, in all phases of housing.

2) The development of a basic housing typology most suited for a given situation, and best accommodated by available resources, in order to provide the basis for elaborating possible variations of different types of dwellings.

Both these issues will be addressed in following chapters.

CHAPTER 2. THE CONCEPT OF PARTICIPATION.

2.1 DEFINITION OF PARTICIPATION.

The term "participation" contains, nowadays, the broadest meanings and the most varied intentions.
Since the interpretation of these meanings usually varies, the implementation of users participation often leads to confusing ideas.
The term "participation" was first used in the 60´s by politicians, professionals, developers, sociologists, etc., in the most diverse situations, generally with the objective of supporting political or economic goals, and aimed at achieving greater democratization of decision-making for broad segments of the population.

Since the word "participation" is too ambiguous a term to be used without misunderstandings, for the purpose of developing this thesis, we will attempt to define it as follows:

The participatory process can be considered as a series of continuous and interdependent actions in which all those who are involved in the process of transforming their physical environment share the power of making decisions at different stages of the process. In other words, the concept of participation can be understood, in the broadest sense, as a mechanism through which authorities promote and allow for equity in the process of decision-making.

2.2 GOAL OF A PARTICIPATORY PROCESS.

An evaluation of the role of the dweller in relation to his/her immediate living environment is fundamental to understanding the housing process. Such an evaluation is important in order to change generally accepted ideas about users and dwellings; for instance, the false tendency to assess users as statistical numbers and the equally false tendency to provide dwellings as standardized items which respond primarily to quantity demands, while considering quality as a matter of separate "luxury" provision.

If we accept the idea that concern should shift towards issues of quality as part of an integral economic development, including socio-cultural considerations, and, where technical improvement facilitates, rather than obstructs, the process of decision-making, the involvement of the users acquires vital importance in the housing process "from inception to program, design and evaluation".

> Any design methodology that decides to deal with technology in a new and more open-ended manner, needs to recognize the problem of the participation of the users, i.e., how the user can be made to fit into the decision process of housing.[8]

By involving users in the decision-making process, authorities or developers give them direct responsibility for the consequences of the decisions that affect their physical environment. When users themselves are considered as an active power in controlling, affecting and modifying their physical living conditions, the possibility of having a healthy, improving environment is increased. This approach has been empirically verified by research which has shown that people´s satisfaction is not only related to the "finished" stage of their dwelling, but also to the degree of control they exert over it.

In the light of the above, it could be said that the goal of any participatory process in housing design is twofold:

- On the one hand, it raises the consciousness of the authorities regarding the user´s motivations in transforming their environment, the implementation of that process and the consequences of the intervention causing the environment´s change and evolutions

- On the other hand, it offers to the users options to become involved at different levels of decision-making, where they can exercise their right of choice, express their preferences, and set their own value judgments.

2.3 TECHNOLOGICAL DEVELOPMENT IN RELATION TO THE DEGREES OF INTERVENTION.

To promote a change in the approach to housing design allowing for different degrees of intervention according to the various stages of the housing process, designers have to understand two factors of primary importance.

First, the change between traditional methods of construction and new building techniques have resulted in an increasing complexity of the design process due to new procedures, materials and methods available in the marketplace. The proliferation of new building systems, with all their potential to address issues of adaptability, quality, quantity etc., changed the methods and procedures available to designers in addressing two major concerns:

1) The satisfaction of the users' basic needs

2) The provision of sufficient freedom for users to make their own decision about preferences and priorities.

Second, while nowadays, industrialized countries mass-produce almost all their goods for an anonymous market, there is a growing consciousness of the differences among users' needs, preferences and aspirations in diverse situation of people's daily life, particularly in the realm of the dwelling, which is the last bastion for privacy and individual expression.

Mass-education, mass-consumption, and mass-housing do not satisfy the need for individuality. People want to decide about the factors that shape their environment and condition their lives. This consciousness about human preferences and aspirations, transcending basic needs, directly affects the design of the built environment, and thus, pure technical knowledge about new methods and products offered by building industry is not enough to be the only source of information for the designer to deal with diversified user needs and preferences.

Thus, what is important for designers to understand, is that rapid changes in technology should reflect a better understanding about man´s need to express himself in relation to his environment, and that, such better understanding will inevitably lead towards the development of more adaptable building systems.

By means of their adaptability to provide variable spacial arrangements, these new building systems must prove that technological improvements do indeed allow for different degrees of intervention, and that users´ preferences can be satisfied through "trade-off" decisions included a-priori by the designer in his/her program of action.

2.4 LEVELS OF PROFESSIONAL INTERVENTION.

The housing process involves rational considerations, such as construction, finance and organization, but also involves considerations of psychological and physiological aspects which are rooted in the fundamental characteristics of human existence and which are difficult to quantify.

Thus, when architects come to a decision about the "best" design solution for a specific housing project, they are linking, in a very complex network, possible alternatives of technical solutions, feasible economic strategies, acceptable norms and established regulations, with human needs, activities and aspirations which transcend purely technical, statistical and quantitative considerations.

In this sense, designers are dealing with some of the most deeply seated urges of mankind in its pursuit of happiness: the desire of exercise choice and wield power.

This consideration raises the question at which level professional intervention should stop, since unlimited choice can lead to chaos, as unlimited power leads to dominance of the stronger over the weaker.

Professional intervention has to be assessed differently for each particular case, since local initiative differs in relation to site, situation, money allocation or type of project proposed.

> ...studies have shown that when responsibilities are not precisely defined, individuals will encroach on public or shared space and those facilities will suffer. It has also been shown that projects incapable of growth and change will become failures. European mass housing is at the other extreme: virtually every aspect of the building is a result of professional intervention. This extreme is worse, because it stifles any exercise of small scale power.[3]

2.5 BALANCE BETWEEN INSTITUTIONAL AND INDIVIDUAL REALMS OF DECISION-MAKING.

It may be argued that a completely free initiative should be left to people as long as economic subsidy and legal security in terms of tenure are provided.

Although such security is important, people need the means to act; they need a physical structure in order to develop their own intervention, and this physical structure has to be provided by professional input, because it is not only in direct relation with the professional´s technical experience, but also beyond the decision-making power of the individual or the family.

> User participation in design should be a process by which users are informed as to the nature of the building development process and are given limited opportunities to influence decisions.[3]

It can also be argued that all the decisions should be left to the professionals. Actually, when we refer to the "natural" relationship and coexistence between the two decisional spheres --institutional and individual-- which affect and shape the environment, we realize that the concept of participation has often been more a point of confusion than a helpful tool during the process of design and elaboration of dwelling alternatives.

Those who support the idea of participatory design, more often than not, have a socio-political ideology supporting their position.

In general, proponents of participation advocate selective decentralization and maintain that the realm of decision-making should be left in hands of the users. To support their stand in economic terms, they explain, accurately indeed, the importance of relieving public authority from the burden of high-capital investment and the diversion of money in situations where an organized community could manage the problem more efficiently on its own.

Opponents to participatory design claim that fast provision and efficient management of large housing projects can only be achieved under a centralized organization where all decisions --from finances to programming to implementation-- can be made more efficient and cost effective by technical and economic rationalization, and by an elite of experts.

Aside from political reasons, there are two other major justifications which sustain this argument of a policy of full control. The first one is based on the philanthropic principle in which housing subsidy has the character of a "donation", provided by the authorities in an effort to increase the well-being of those who cannot afford the acquisition of their dwelling in the open market. By defining public subsidy as charitable action, the authorities justify their refusal to allow the low-income population to express their requirements or preferences even though the subsidy could theoretically be given directly to the needy as cash or construction materials.

The second justification for the "full control" policy is based on the assumption that the general provision of standardized, minimum-sized dwellings helps to distribute more evenly the resources available and to address faster, more cheaply and better the high demand for low-cost shelter on equitable basis.

Both justifications may be easily challenged. The first one can be questioned simply because people have diverse scales of values which do not necessarily coincide with those of their "donors", despite the fact that not all the actions initiated by authorities are necessarily always wrong.

The second justification can also be questioned if we consider that housing environments are something more than just architectural design exercises on a large scale. No justification of standardized, minimum-size dwelling as the most appropriate solution to mass-housing is valid, even considering that people being provided with such standard units, had lived before under worse conditions.

2.6 PROFESSIONAL´S CONGRUENCE TOWARDS INDIVIDUAL´S DECISION-MAKING.

In the specific area of housing, Argentina is facing a two-fold problem, which is basically related to the delicate balance between the institutional and individual realms of decision-making.

On the one hand, of the total number of low-cost houses which are annually built in the country, 56% is informally built by the low-income population outside the institutional framework of subsidized housing provision.

On the other hand, authorities also generate low-cost housing projects, but this process is too often affected by economic and political obstacles which hamper any initiative at national or private levels to start a sound process of investment and development.

In cases where the construction of the dwellings is initiated by the inhabitants themselves, it usually comes about in stages which are closely related to the pace of the saving capacity of each individual family. Users must undertake the dwelling construction on their own, because the financial mechanisms are not available to get long-term loans to finance the building of their dwellings.

In this sense, many of the inadequacies attributed to informal sector housing are not a direct consequence of an inherent incapacity of the lower income segments of the population to organize their own environment, but, on a larger scale, these inadequacies are the result of the authorities´ failure to provide low interest loans, adequate sites, municipal service infrastructure and tenure security, to name only the most important aspects of this problem.

Once the process of programming, design, construction, and general decision-making is made dependent exclusively on the authorities, almost all the decisions are made at an institutional and professional level, and the user is seldom recognized as an active participant during that process, but remains a passive "average" or statistical entity who is expected to accept without questioning a finished and virtually unalterable product.

His /her involvement in the housing process is relegated to making only minimal decisions, such as the decoration of the interiors or the location of the furniture.

However, if we were to analyze the nature of the real influence that the dwellers are actually capable to exercise, we would realize that it is by no means negligible, since the very act of dwelling is one of change over time, and thus stems from everyday actions and is a direct expression of essential human activities.

It is the imposition of rigid housing projects on large segments of the population what prevents people from engaging in activities intimately related to personal decisions and evaluations, to the power of exercising choice, to the awareness of their ability to act, and to the ability to fulfill their own desires.

> The idea that we have a right to impose our cultural biases and our class prejudices on the average user is something that requires very serious reconsideration.[8]

The tendency to exert full control over every decision, is based on the fact that architects have been trained to think about projects as a totality controlling every detail of it, and consequently, there is no allowance for including in the design any possibility of change in later stages of use.
The idea of allowing changes to be under the control of others is only reluctantly accepted by architects, not only because it means that they must give up a sphere of influence which, so far, was exclusively their own, but also, because from time immemorial, the role of architecture has been to transcend time through its symbolic meaning, placing primary importance on continuity and permanence.

In this sense, even nowadays design activity largely belongs to the domains of art and self-expression, and as a result, architects tend to be defensive and possessive of their design solutions. This explains why, sometimes, designers place an overwhelming reliance on their own experience as a basis for assessing the needs of others, accepting only relatively minor contributions from other sources such as clients or research reports.

Also, the tradition of dealing with a private client, where the designer has the privilege of face-to-face contact, any unpredictable change of decision is resolved by direct negotiation and mutually agreed upon compromise. In this situation, the architect can and must design a specific and complete product, since his/her design will be constantly evaluated, at each stage of the design process, against the client´s requirements and, hopefully, will finally be in harmony with the stated needs. In such a situation, the idea of change is conceptually dissociated from the designers´ realm of thought, and, under these conditions, the attitude of "full control" is understandable. After all, most architects do not chose their profession solely out of compassion for low-income people or out of a missionary desire to work only in impoverished areas, but because they want to design, build, and also, in their own way, exercise power.

However, when designing large-housing projects for anonymous dwellers, architects must learn to deal with dynamics and complexities which are significantly different from those when designing for private clients. In the case of large housing projects, designers cannot impose idiosyncratic or preconceived personal ideas without the danger of alienating people.

The idea that advocates user decision-making explicitly implies that designers should refrain from deciding certain things which they have been deciding until now, and that they should leave certain decisions open to the future. This also implies that the dimension of time has to be introduced into design thinking as an important aspect to change.

What is necessary, is to establish a duality of responsibilities, a balance between the decisions which have to be made by the authorities and those which legitimately can be made by the individuals, thus connecting the level of involvement of the users with the various stages of the housing process. To do this, it is necessary to assess the relevance and feasibility of user involvement according to two factors:

1) The different stages of the housing process

2) The inherent constraints of the adopted dwelling typology.

By assessing the feasibility of user involvement according to these two factors, it is possible to establish a hierarchy of different degrees of participation that are likely to come about. For instance, users may have no power of decision about the assignment of the site, type of municipal infrastructure, density levels in relation to the dwelling typology adopted, floor-area ratio etc; but, after these initial decisions have been made by the professionals, users should be able to intervene by deciding how to scale their personal investments for the improvement of their property.

2.7 DIFFERENT APPROACHES TO PARTICIPATION.

Certain approaches in the field of participation have assumed that it would be necessary to develop new technical methods before participation could be permitted and put into practice. The assumption is made that people can only participate if the architect has first devised some technical framework which will permit the users to express their preferences and to achieve them by making various "trade-offs" among different design solutions and diverse technical implementation strategies.

Most of the time, this technical framework has been studied under two basic approaches. The first one consists in the development of participatory techniques that allow the users to manipulate models and sketches to express their preferences within a framework previously set by the professionals.

The second approach provides an "open building system" in which permanent (primary) and non-permanent (secondary) elements are clearly differentiated, thus creating "supports" structures within which users can alter or manipulate elements and spaces.

In England, architects N.Hamdi and J.Wilkinson applied this principle of permanent and non-permanent elements in a scheme which differentiated public from private realms of decision-making. The scheme highly satisfied tenants, but closer examination has shown that the scheme´s flexibility is very limited. Its success is said to have had more to do with the location of the scheme, the special selection of tenants and their control over management, than the limited amount of participation which was permitted.

The work of N.J.Habraken and the S.A.R. Research Center has certainly not ignored social and political issues, and strongly supports the idea that technical frameworks do not develop in isolation but along the same path with the design process.

> Basically, the SAR method provides a convenient and structured means by which to deal with housing environments both relative to participatory decision-making and in terms of its technical aspects as far as explicit normative strategies for implementation are concerned.[9] (fig.6)

The "support and infill" approach to housing is an attempt to reconcile modern system building techniques with social objectives, combining the energy and commitment of low-income

S.A.R. Methodology: Assumptions and Hypotheses

ASSUMPTION	HYPOTHESIS
In the process of contemporary mass housing, there is no place for the individual dweller.	The dweller must be re-introduced into the process to participate in planning, design and realization.
The norms, standards, and other rules of housing have evolved without the direct involvement of the user.	The user can only participate, if rules are based on mutual "agreement," i.e., explicit communication.
Any dwelling exists in two mutually dependent spheres: 1. Public-communal 2. Private-individual	The concept of supports and infill (detachable units) recognizes the two spheres.
Each sphere responds to different levels of decision-making and implies different production methods.	The supports are the product made in the public sphere (made for the community) the infill is made up of elements and products about which the dweller can make direct decisions.
Production in the public sphere results in "real-estate" Production in the private sphere results in "durable consumer goods"	The basic definition of the two spheres is not technical but based on division of decisions to be made in each. Thus, production mode is not pre-determined and may or may not be prefabricated.
It is not the proper task of the architect to produce mass dwellings by conventional repetition.	Architects should conceive supports and detachable units. Builders should build supports. Industry should produce detachable units.
In order to give dwellers the possibility to act, the role of specialists in the housing process must be re-defined.	Specialists will have to communicate about the design of dwellings by means of explicit, mutually agreed upon rules.

FIG.6

population with the management and coordination of technical decision-making, which, by nature, belongs to the realm of professional practice.

> In fact, it may be socially and economically more efficient to allow the dweller to make decisions about the completion of his/her dwelling when they are appropriate and necessary, since much of the evidence in the informal sector points to the inherent correctness of such an approach, and since historically the act of dwelling has been delicately balanced between the concerns of the private and public realms, a balance between family and neighborhood, individual and collective needs, and the desire to control one´s immediate environment, coupled with the need to participate in a communal way of life, which ultimately, defines the fabric of any culture, traditional or modern.[10]

2.8 THE CONCEPT OF "SUPPORT" OR PRIMARY ELEMENTS.

With this term J.Habraken defined the elements of the dwelling environment which are beyond the realm of decision-making of the individual.

These elements are considered as permanent, i.e., elements less prone to be subject to change over time as a result of new technical or functional requirements.

The support elements are not necessarily limited to the structural framework only, although structural elements are usually included within the "support" provision.

Neither are they limited to the elements exclusively belonging to the dwelling as such. Infrastructure provision, lot division and dimensions, floor-area ratio, etc., are items usually decided upon by professionals and thus, also provided as "support" structures.

In short, support elements are primarily determined in terms of their capability to accommodate a defined range of alternative spatial solutions. This means that each support solution "must be subjected to a carefully detailed, rigorous analysis and evaluation in terms of all the functions to be accommodated, equipment, finish and various alternative layout options (and their respective trade-off possibilities), including the determination of construction methods and materials." [10]

2.9 THE CONCEPT OF "INFILL" OR SECONDARY ELEMENTS.

In N.J.Habraken´s terminology, the "infill" concept is defined as the elements which are within the realm of decision of the individual. The infill elements usually represent the variable characteristics of the dwelling, which can be changed or upgraded during the life time of the dwelling.

Because they are non-permanent elements, they do not have a pre-established location in relation to other elements of the support system. This explains why infill elements usually do not involve structural components, but, instead, partition walls, finishes, facade elements, service cores, etc.

> Many secondary elements and operations should be provided only as they become affordable or necessary, by either conventional construction methods or as industrially produced items. The only important thing is to make sure that later upgrading is made possible by providing sufficient spatial capacity in the support, based on agreed-upon positional and dimensional agreements i.e., modular compatibility.[10]

2.10 RELATION BETWEEN THE PROPOSED BUILDING SYSTEM AND THE CONCEPT OF PARTICIPATION.

In almost all developing countries, a large number of sub-urban dwellers live in houses that have been built on their own initiative, and, more often than not, the land they occupy had been taken without any legal approval or formal registration.

To a large extent, this low-income sector produces as an end product large and permanent houses, often up to 3 or 4 stories high. Once these houses are finished, not only is it very difficult to label them as illegal, but it is also very difficult, or impossible, to demolish them in order to replace them with official housing projects.

Sometimes the dwellings are put up by dwellers and neighbors themselves, but more often, small contractors are charged with the job since many people in the low-income sector are--in fact--construction workers. (fig.7)

In this "informal" sector, the use of reinforced concrete to build the bearing structure is a very common and widespread practice. As J. Habraken postulates:

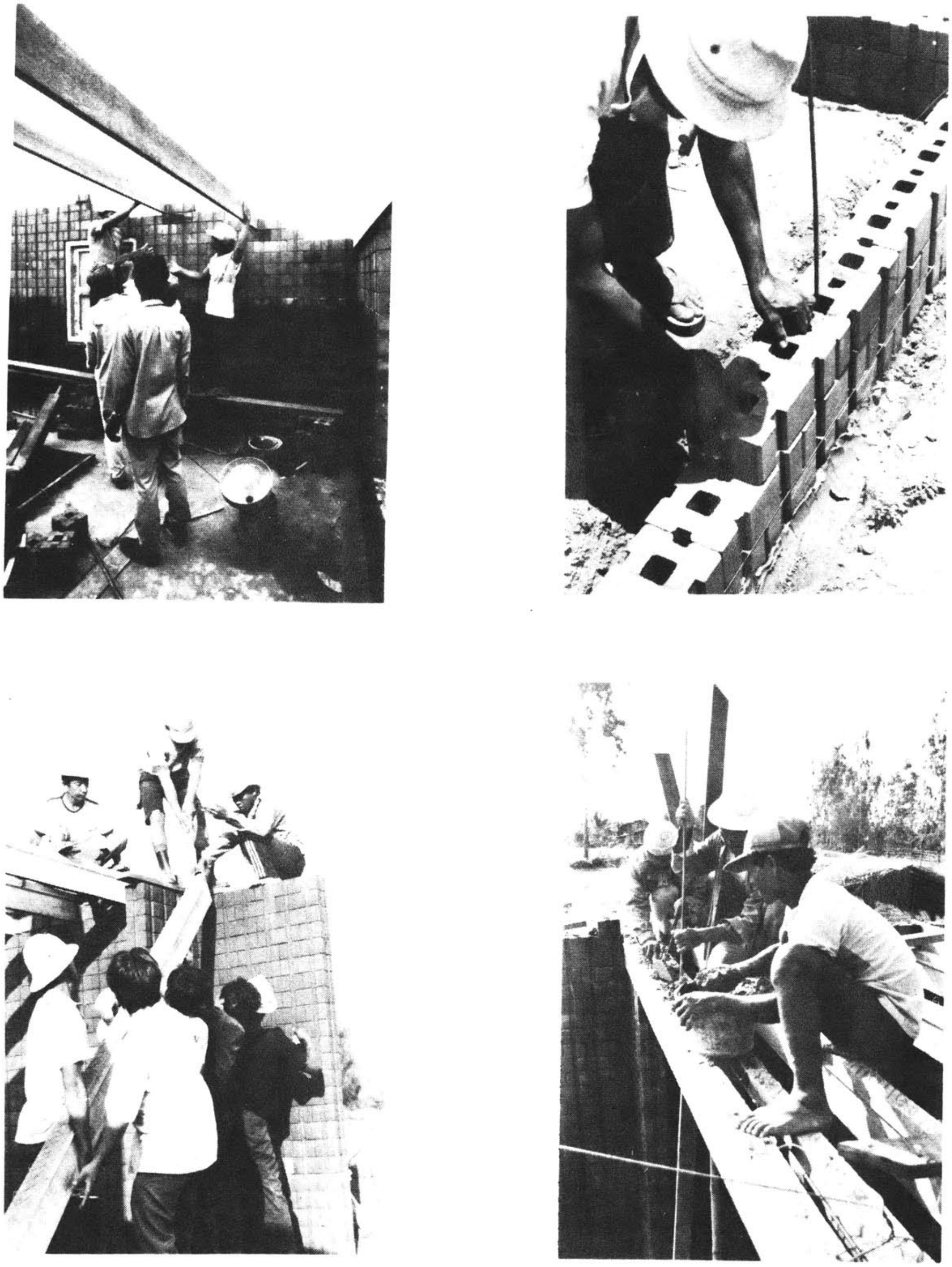


FIG.7 SELF HELP CONSTRUCTION (EXAMPLE IN THAILAND)

> Informal-sector people are likely to make concrete blocks, tiles or to build by themselves to a certain point. In the informal sector one finds small local entrepreneurs and craftsmen who make these elements, which are purchased one at a time. It would be worthwhile to see how these small-scale producers might be encouraged to improve their products and their productivity. Other elements, like plastic pipes, sanitary facilities, etc., cannot be done or produced locally; these requires major investments towards mass production in a few places capable of serving large regions. All of these procedures are already followed in the informal sector. There is no contradiction between sophisticated mass production technology and the user-builder market, in the developing countries or any other.[3]

In order to exemplify the concepts described so far, the appropriateness of the proposed building system will be discussed in the next chapters.

The proposed design solutions will be based on certain housing typologies which have been selected as most suitable candidates for the Argentinean context (row houses, core houses, middle-rise high density).

However, these types should not be considered as the only possible layout solutions; they merely simply exemplify the possibility of the application of the "support/infill" approach by means of a rationalized building system, and suggest the diverse levels where people can participate, according to different trade-off possibilities.

CHAPTER 3. THE CONCEPTS OF FLEXIBILITY, ADAPTABILITY AND VARIABILITY.

3.1 DEFINITION OF FLEXIBILITY, ADAPTABILITY AND VARIABILITY.

In Chapter 1 the key definitions and the conceptual approach to prefabrication, system building and building systems were established. In Chapter 2 a similar procedure was followed to define the concept of participation of future residents.

In this Chapter it may be useful to start by clarifying the meanings of such terms as Flexibility/ Adaptability/ Variability since these concepts mean different things to different people, and are usually applied in different frames of reference regarding morphology, dimensions, positioning of elements, variable layouts etc.

The American´s Heritage Dictionary gives the following definitions about these concepts.

Flexible: 1)capable of being flexed, pliable.

2)capable of or responsive to change, adaptable.

Adaptable: able to become adjusted to new or different conditions.

Variable: changeable, liable or likely to vary.

Considering that these definitions are quite limited for the purposes of this work, they need to be expanded in order to provide a more precise conceptual framework for further understanding of their implications in the design and development of a system.

> The issue of flexibility/ variability/ adaptability can be treated from two points of view:
> 1) Epistemological: i.e., what has led us to arrive at the discussion of this subject in view of the development of the notions of flexibility/variability/adaptability.
> 2) Ontological: what is the meaning of these concepts in human existence and in the development of collective as well as individual identity. At the root of this is the determination of the respective demarcation between communal (collective) and private (individual), between that which is "normative" and that which is "idiosyncratic"." [11]

Expressing these concepts in another way, we can define flexibility/variability/adaptability in the following way:

Flexibility: defined as the capacity of adaptation in conformity to different needs.

It has to be provided without alterations of the basic system or its elements as such.

The provision for flexibility has to be achieved as an integral part of the initial design phases.

Flexibility basically refers to " adaptation to change". [12]

> Flexibility is the capability of the given building system to adjust to varying tasks without changing the system or its elements. It is the capability of the system which determines how widely the properties of the building designed and constructed with it can differ. [15]

Variability: defined as the possibility to make subsequent changes by means of changing the position of elements within the rules established by the system. [12]

Variability basically refers to "changes as such".

> Variability is the measure of the possibility of how far subsequent conversions and changes

> can be realized by the given building system without changing the system or its elements. [15]

<u>Adaptability:</u> defined as the ability to respond or be readily adjustable to changing conditions. [12]

3.2 FLEXIBILITY, ADAPTABILITY AND VARIABILITY IN MEETING OFFICIAL APPROVAL AND REGULATIONS.

Having established the definitions of the terminology in use, it is necessary to clarify the reasons why these criteria have to be considered in conceptual and operational terms in the design of building systems for housing projects.

The necessity for more flexibility and adaptability in the design and implementation of housing projects became imperative as the failures in most mass-housing schemes became more and more evident as the years went by, especially in the decades of the late 60´s and early 70´s.

It has been widely said that the serious lack of flexibility and adaptability in most mass-housing projects stems from the failure of designers and planners to provide flexible/adaptable housing, not only with respect to technical performance criteria, but also according to "multifarious needs and requirements of a pluralistic, socially mobile and culturally differentiated, class stratified society". [8]

It has also been said that, while designers deal with creativity and originality in terms of abstract notion of space responding programmatically to "universal" circumstances, the users deal with creativity and originality in terms of concrete space in "specific" circumstances and on the basis of direct psychological and physiological contact.

However, the lack of ability of architects to provide solutions capable of transformations in space and over time has many times been tacitly or explicitly endorsed by the tendency of the authorities to "expedite" approval by refusing to process variable plans for mass-housing projects. Their attitude responds simply to a natural tendency to reduce energy and effort in the process of bureaucratic approval. No variant can be considered, let alone proposed, because each one requires checking it against norms and codes, breaking routine and bureaucratic inertia.

Thus, officials charged with the approval of housing projects usually do not find it suitable or convenient to check each possible variation of a housing layout against the codes and specifications. They do not understand that the solution may actually be a legitimate variation within a normative system of rules, rather than just another layout of two-dimensional partitions of rooms to which regulations must be applied one by one. This means that repetition is not only a method by which designers standardize a plan in order to make the process of building easier and faster, but, in addition, repetition and standardization of plans are equally used by the authorities to simplify the task of administrative effort to enforce minimum standards and mandatory code requirements on an equitable basis (i.e., by treating everybody as a statistical "unit").

This is very much tied to the current professional role of the architect, as a de facto facilitator of bureaucratic fiat. As long as the architect works within the codes and norms imposed by the bureaucracy, the entire building process tends to reflect this attitude in its organization and products, with the results described in the preceding chapters.

In part, this problem has been provoked by the notions of the Modern Movement which sustained that the standard plan should be considered as an "ideal"plan and also that repetition is good in itself, because not only does it lead to more efficiency in economic and technical terms, but also fosters equality in housing on social and political terms.

A good example of the opposition to the above is the experience of one of the most prominent advocates of adaptable housing, Prof. J. Habraken. It took him many years to convince Dutch authorities that standards could be established in which variations would be checked and approved in an efficient system of new rules, while at the same time allowing for user intervention, change, and efficiency. His goal was, in fact, to try to convince the authorities that to allow for flexibility and variability within the codes, norms and standards was not only possible but could also be made efficient and convenient in administrative terms.

3.3 FLEXIBILITY AND THE BUILDING SYSTEM APPROACH.

Since this thesis will propose the design of a small-component prefabricated building system, which facilitates plan flexibility by means of its adaptability to change, the concepts of flexibility, variability and adaptability become important as a way to differentiate design methods and strategies of the conventional design approach from those of the building system approach.

In the design and development of a project by means of conventional design procedures, each design has to be worked out individually and separately for each building, with its own plan, layout and specifications.

In contrast, the design process of a building system aims at an array of alternative open-ended solutions, each of which must be conceptually and physically capable of satisfying the following performance criteria:

1) Capability to allow for diversity within a specified project typology. This means that the building system concept must take into account design and planning options of

individualized projects within a given typology --be it housing, hospitals, schools-- and thus allow design freedom for individual architects using the system.

2) Capability to allow for flexibility and adaptability based on the projected life-cycle of the building.

Within the parameters of a generic use, it is common that changes occur during the building life-cycle, resulting in major alterations such as expansion, upgrading, or change of function. At this level, flexibility and adaptability have to respond to different user requirements, allowing for staged spatial/material solutions as part of its programmatic possibilities.

3.4 FLEXIBILITY AND THE CONCEPT OF STAGED DWELLING.

The advantage of flexibility and adaptability to respond to different user requirements, providing "staged" solutions, acquires fundamental importance if we consider that the ideas of dwellings evolving over time, and of freedom to grow and modify at the scale of the individual dwelling, have always been inherent to the natural process of habitation, from time immemorial.

Dwellings designed with the prerequisites of possible extension following a staged process of construction, or of flexibility to allow for diverse layouts, have become a subject of major interest to housing designers, policy makers and theoreticians, especially during the past two decades.

> Transformation is an intrinsic aspect of the built environment, its purpose and its meaning. Architecture must develop institutions, values, methods and techniques which accept change as the natural state of the environment. [13]

The interest in staged and variable dwellings as a typological problem, emerged when authorities, designers and dwellers themselves faced people´s initiative to change, improve or adapt their dwellings within large-scale, rigid mass-housing projects. It was then that authorities realized that design professionals should provide solutions for the implementation of the changing and evolving requirements of the users, and learn from the dynamic forces that determine the life-cycle of a dwelling. Socio-economic changes, evolution in people's aspirations and life standards, technological and social changes influencing the meaning and use of the dwelling etc., confirmed the new definition of housing as a process in constant evolution; a process which, among other factors, is materialized through successive modifications of the building, through growth, personalization and, in general, through a continuous process of transformation.

3.5 STRATEGIES FOR PLAN FLEXIBILITY AND VARIABILITY.

The various strategies for plan flexibility and variability can be represented in different ways:

- Minimum provision of dwelling space with possibilities to expand over time
- Provision of bearing structure and service infrastructure capable of accepting "free" plans in which different layouts can be accommodated
- Provision of envelope (enclosed space) plus load-bearing

structure within which variables of a layout already proposed can be accommodated.

In general, these strategies for plan flexibility can be differentiated on the basis of:

- The degree to which flexibility and variability are planned and structured
- The level and kind of provision of shelter in the first stage
- The variation in resources allocation
- The way in which the limits of possible growth are defined
- The type of physical modifications required to accomplish expansion
- The enclosed space variation (i.e., if it is necessary to add structure or if all the structure is completed in the first stage).

There are three basic strategies to allow for plan flexibility:

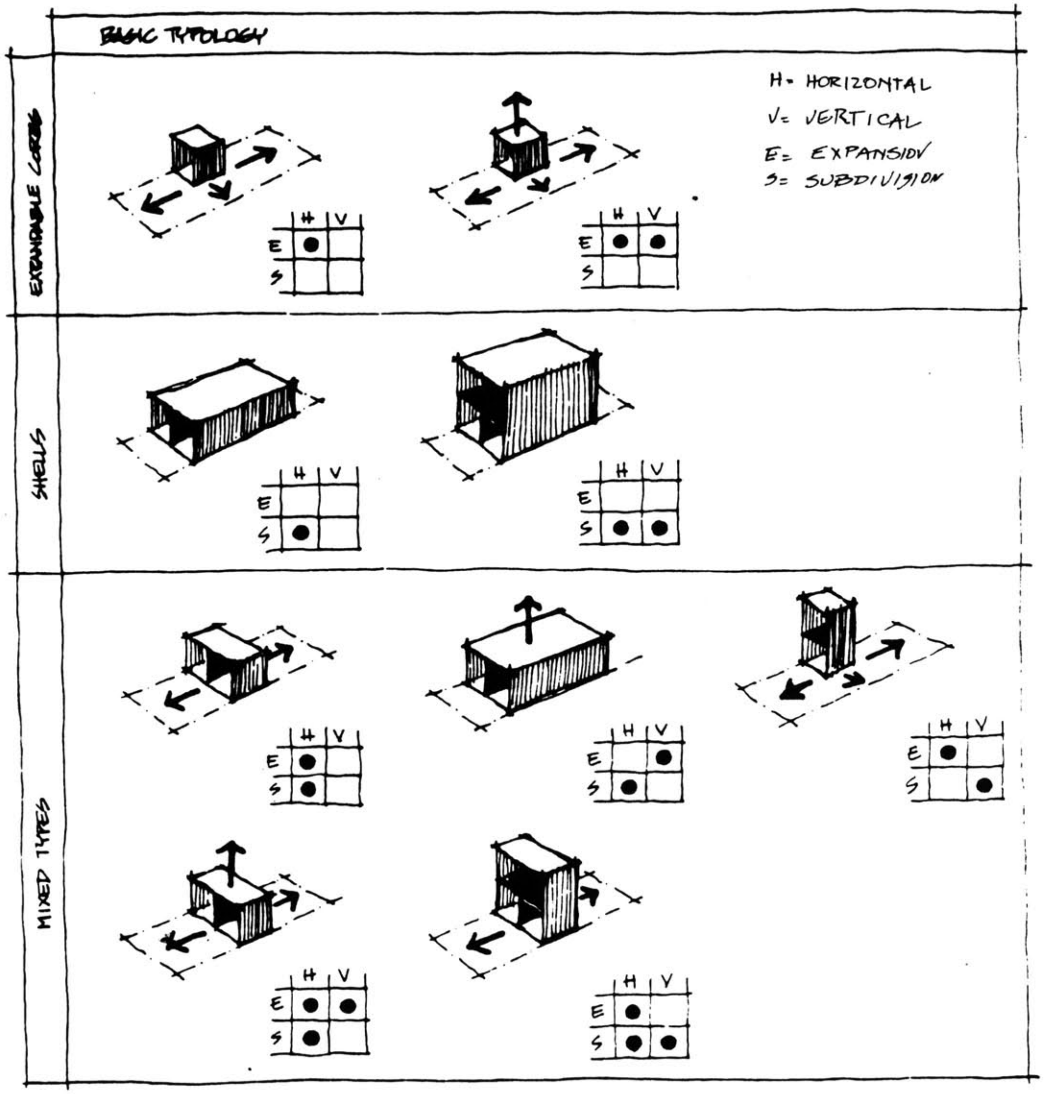
1) Combination
2) Internal Division
3) Addition.[13]

1) The strategy of combination controls the disposition and rearrangement of the partitions between dwellings as a means of increasing or decreasing the floor area between two adjoining units. This means that space is traded between adjacent dwellings, i.e., the increase in one causes a decrease in the floor area of the other and vice versa. This modification can take place not only in plan but also in section and, usually, no changes to the existing bearing structure are involved, even though some interior walls added in the process of growth may have structural capacity.
It is important to note though, that, the enlargement of one dwelling at the cost of another requires an agreement between neighbors which, in general, is rare.(fig.8)

2) The strategy of division refers to the gain of usable floor area without actually increasing the floor area occupied by the house. There are various ways of applying this concept:

- Expanding over unused floors; i.e., the dwelling expands vertically or horizontally over an adjacent open or enclosed unused area where structure and vertical circulation

FIG.8 BASIC STRATEGY FOR PLAN FLEXIBILITY



already exist

- Adding partitions within a multi-level envelope, i.e., the dwelling is designed to occupy two or more levels and the total envelope is completed during the first stage of dwelling construction. The owner occupies a multi-story volume and expands his usable floor area by adding a new floor structure, vertical circulation elements, partitions and wiring.(fig.8)

3) In comparison with growth by combination and division, in which no structural modification is required, the strategy of growth by addition deals with the particular case in which new structural elements have to be added as growth takes place. For instance, this occurs when an open terrace is covered or when an enclosed space is added on top of a roof. (fig.8)

> Additive transformation is only one of the possible mechanisms of growth and change, but it presents some characteristics which are important for the quality of the town.
> First, by being a gradual and organized incorporation of parts into an existing structure, it extends the likelihood of this being in use for a prolonged period.
> Second, by being based on the retention of

what already exists, additive transformation allows for a form of development characterized by its low cost in both social and material terms.
Third, because it is a sedimentary process, additive transformation ensures a sense of continuity in the construction of the town, and a sense of "place" in both historical and spatial terms. [13]

3.6 ADVANTAGE OF PLAN FLEXIBILITY OF STAGED DWELLINGS.

Aside from the issue of changing family-cycles, variety of user needs, legal-administrative requirements, etc., there is one additional issue which is important to mention in more detail.

One of the most prominent motives for proposing flexibility and variability for dwellings in developing countries, is the fact of first cost vs. the strategy of deferred expenditures. This means that the authorities have the opportunity to minimize first costs as a result of a limited but active involvement in the initial stages of construction. Clearly, initial involvement in planning and provision of minimum facilities enables the authorities to estimate the cost and effort required to develop alternatives for the eventual completion or variations of the project by deciding, for instance:

- Nature of land division
- Size of lots
- Initial and ultimate proportion of open and built-up spaces
- Frontage width
- Level of infrastructure
- Height limitations
- Foundation type

From the users´ point of view, the opportunity to improve and enlarge their dwelling according to their saving capacity, and in making changes to suit their own needs and wishes, translates into the benefit of a deferred expenditure. In the first stage, with a subsidized provision of a serviced shelter, the percentage of savings which can be achieved as a result of deferred construction costs is important. In later stages, and considering the total cost of housing including land, site development, and general utilities,the relative cost of adding space is small and cost-effective in relation to both, the adaptability it adds to the dwelling, and the choice that future options open up by the staging of various alternatives for completion. (fig.9)

3.7 FLEXIBILITY APPLIED TO THE DESIGN OF DIVERSE LAYOUTS.

The staged dwelling concept is concerned with two main issues:

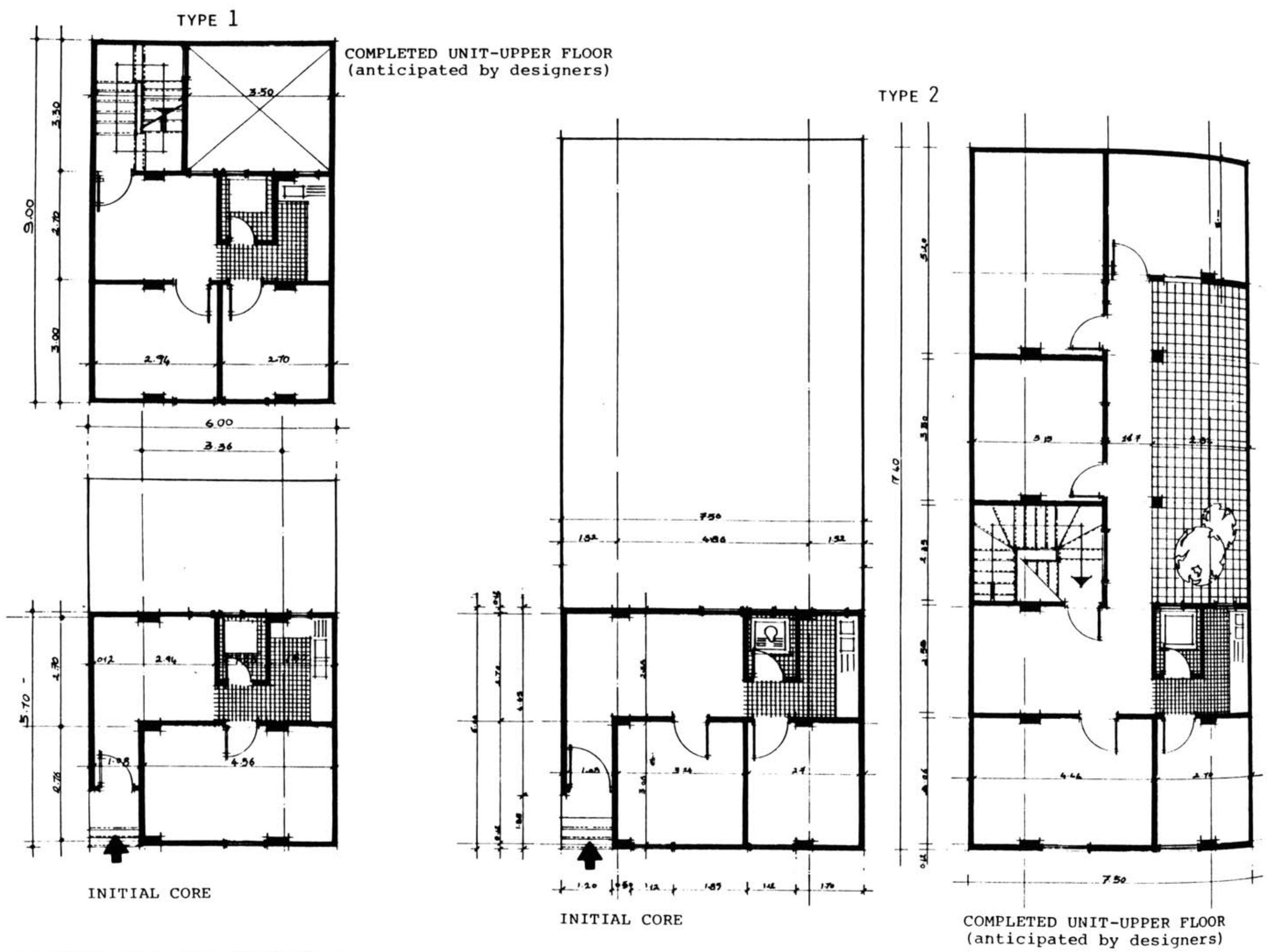
1) The physical elements of the dwelling, such as vertical and horizontal structural components, internal partitions, finishes, etc.

2) The programmatic variations of the dwelling layout.

The range of programmatic variations goes from "site and services" projects, " core-houses", "shell-houses", to "middle rise apartments", including the staged provision of utilities to be upgraded in later phases.

Growing row-houses, patio houses or any other typology offers examples of the way in which the particular architectural type develops its own generic possibilities to

FIG.9 STAGED HOUSING (EGYPT EXAMPLE)



PROPOSED MODEL CORE HOUSE UNITS

allow for additions, subdivisions, or expansions.
This concept raises the importance of analyzing housing typologies.

In Chapter 1 it was mentioned that, according to the experience of the last decades, the standardization of dwelling layouts as repetitive units was not an appropriate procedure to provide housing in quantity. It was also mentioned that it was wrong to standardize plans and that the correct approach should aim at standardization as a tool to facilitate the assembly of products coming from different producers, i.e., making those products more universally applicable, and thus saving time and money.
Since standardization of dwelling plans is not an appropriate response to mass-housing, special stress should be placed in establishing a typology of dwelling categories in order to provide realistic basis for generating variations.

> The development of basic housing typologies, based on accepted or desired socio-cultural and environmental criteria, would facilitate the rational and orderly development of each new project based on explicit and clearly documented needs criteria, rather than stock

> plans, often imported from foreign contexts". It would also provide a better context for the long-term success of industrialization than the current single project approach, which leads to the creation of potential urban slums, and which ignores the element of time so vital in the development of viable and human dwelling environments. [14]

The study of prototypes is particularly useful in the design of housing projects because they persist for long periods of time, often centuries, and thus, the process of housing lends itself to systematic, typological study.

Although each housing scheme seems to allow for almost unlimited variations, globally there is only a limited number of basic organizational possibilities. Certain generic prototypes --row houses, court-yard houses, attached units, apartments, etc.-- are universally accepted by the population as valid a-priori solutions, and those types can be systematically categorized.

At the same time, by dealing with dwelling types which are already familiar to people and accepted as part of the culture, orderly improvements of the dwellings can be expected when their process of transformation and completion is influenced by the inhabitants themselves.

According to Roger Sherwood, only a few dwelling types are really plausible, however, within each generic type, many variations are possible, allowing for individual needs, site characteristics, market constraints, or different building construction techniques.

In the following chapter, the proposed building system will be tested in its capacity to allow for variability of layouts and user intervention; and, to do so, it will be applied to two different typologies:

1) Single houses

2) Middle-density apartments (up to four stories high).

In the case of single houses, the support structure to be provided by the authorities will be the general infrastructure at neighborhood scale, and the load bearing structure of the dwellings.

In the case of four-story high apartments, the support structure will be again the general infrastructure, the bearing structure and the common areas of the building such as ground floor and vertical circulation staircases.

CHAPTER 4. PROPOSED BUILDING SYSTEM

A LIGHT WEIGHT, REINFORCED CONCRETE SMALL COMPONENTS BUILDING SYSTEM

4.1 INTRODUCTION

The light-weight, small components building system proposed in this chapter has been designed as a search for a method and a technical solution in the application of the concepts of flexibility and participation in low-income housing projects.

This proposal recognizes the importance of these issues, as discussed in previous chapters, and provides a technical solution to be used specifically in contexts where sophisticated prefabrication plants, techniques and equipment are not economically feasible, and where low-cost labor is easily available.

4.2 SYSTEM COMPONENTS.

The system consists of 4 basic structural elements forming a dimensionally coordinated "kit of parts" that can be precast on or off site.

The 4 structural elements of a structural bay are:

1. Columns
2. Base/Capitals
3. Beams
4. Joists

In the following pages, the elements of the system, their assembly sequence and the system´s applicability will be described. All the drawings--from now on abreviated dwg.--, shown in this work have their dimensions expressed in centimeters as a unity of meassurement.

4.2.1 COLUMNS

Each column is made of four identical U-shaped reinforced concrete components (drwg.1). These elements are positioned in their base with their U-shape forming a hollow core column within which reinforcement bars and concrete are placed on site at the moment of erection (see also assembly sequence # 1).

The dimensions of each column component are 17cm width; 10cm depth; and 240cm length; and its weight is 97,92 kg. as shown in the following calculation:

17cm x 10cm x 240cm = 40800cm3

0,0408m3 x 2400 kg/m3 = 97,92kg.

4.2.2 BASE/CAPITALS

The base/capital is a reinforced concrete square element with an octagonal recess and a smaller octagonal hole through its center (drwg.2 and 3).

This element is used as column base as well as capital.

When the element is used as capital, the four column components are fitted within its octagonal recess, held tightly in place. The capital carries the beams which in their turn carry the joists.

This same element which is used as a capital is also placed, inverted, on top of the joists. It is vertically aligned with the capital underneath, serving as a base of the next column components to be assembled. Again, the four column components are fitted within the octagonal recess of the element.

The dimensions of this base/capital element are 52cm lenght; 52cm. depth; and 20cm. height.

The capital´s weight is 84,22 kg as shown in the following calculation:

$$(52cm \times 52cm - 27cm \times 27cm + 4 \times \frac{8cm \times 8cm)}{2} \times 12cm +$$

$$+ (52cm \times 52cm - 40cm \times 40cm + 4 \times \frac{8cm \times 8cm)}{2} \times 8cm =$$

$$= (2704cm2 - 729cm2 + 128cm2) \times 12cm + (2704cm2 - 1600cm2 +$$

$$+ 128cm2) \times 8cm =$$

$$= 2103cm2 \times 12cm + 1232cm2 \times 8cm =$$

$$= 25236cm3 \quad + 9856cm3 \quad = \quad 35092cm3$$

$$0,035092m3 \times 2400\ kg/m3 = 84,22\ kg.$$

4.2.3 BEAMS

Each beam is composed of two L-shaped reinforced concrete elements (drwg.4).

These L-shaped elements are placed on the capitals with their horizontal parts adjacent forming a U-shaped hollow beam.

This U-shaped hollow beam is filled with concrete at the moment of erection and assembly.

The overall dimensions of these L-shaped elements are 18cm height; 10cm width; 300cm length and their weight is 95,04 kg as follows:

(18cm x 6cm + 6cm x 4cm) x 300cm =

= (108cm2 + 24cm2) x 300cm = 132cm2 x 300cm = 39600cm3

0,0396m3 x 2400 kg/m3 = 95,04kg.

4.2.4 JOISTS

Each joist is an inverted T-shaped reinforced concrete element (drwg.5). These are placed on the U-shaped beams, spaced 35 cm between their axes. This distance is established in relation to the hollow-block floor components, which are placed between the joists.

The overall joists dimensions are 15cm height; 15cm width; 310cm lenght and they weight 97,09kg as shown bellow:

(15cm x 6cm + 2 x 4,5cm x 4,5cm) x 310cm =

= (90cm2 + 40,5cm2) x 310cm= 40455cm3

0,040455m3 x 2400kg/m3 = 97,09kg.

4.3 ASSEMBLY SEQUENCE.

The assembly sequence is a relatively simple process that can be carried out by unskilled labor, since the system´s components are light enough to be lifted by two workers and the connections between elements are realized by grousing the joint.

However, despite the simplicity of the assembly process, it is advisable that it be done by people with some knowledge and experience or building practice, or, at least, supervised by someone with technical understanding of building principles, so that, the correct positioning and connections of the elements are observed, in order to guarantee the proper transmission of loads.

4.3.1 ASSEMBLY SEQUENCE: STEP # 1. BASE AND COLUMN. (dwg.6)

The column´s base/capital is placed on a reinforced concrete, cast-in-place base. This base is a square of 1 m2 and 10cm thick (minimum dimensions), and it is reinforced by bars of 10mm diameter.

Within the base´s octagonal recess, the vertical reinforcement bars and the column´s four components are placed, held together by a temporary brace until concrete is placed within the column´s hollow core.

4.3.2 ASSEMBLY SEQUENCE: STEP # 2. CAPITAL. (dwg.7)

The column´s capital is placed on top of the four column´s components in order to: - keep them together

- distribute evenly on them the loads transferred by the beams to the capital.

> The strength of a structure depends on the strength of its connections; especially at the corners where the columns meet the beams. A column capital acts as a small arch. It reduces the length of the beam, and so reduces bending stress. It works effectively because the line of action of a vertical force in a continuous compressive medium spreads out downward at about 45 degrees. It provides the path for the forces as they move from one vertical axis to another, through the medium of the beam. [16]

4.3.3 ASSEMBLY SEQUENCE: STEP # 3. MAIN BEAMS. (dwg.8)

The two L-shaped components which form the main beams (and the frame-rigidizing beams) are positioned on the capital spanning the distance between columns.

These elements are placed in such a way that their horizontal parts form a U-shaped hollow beam which is later filled with concrete.

4.3.4 ASSEMBLY SEQUENCE: STEP # 4. FRAME RIGIDIZING BEAMS (dwg.9)

The same procedure followed to form the main beams is followed to form the frame-rigidizing beams. Both beams are formed by the same L-shaped elements. Consequently, both beams have identical structural capacity allowing for two possible orthagonal directions to place the joists on the beams.

4.3.5 ASSEMBLY SEQUENCE: STEP # 5. BASE (dwg.10)

After filling with concrete the main beam´s and rigidizing beam´s hollow cores, the base/capital element is placed over the beams aligning it with the capital underneath.

4.3.6 ASSEMBLY SEQUENCE: STEP # 6. JOISTS (dwg.11)

The joists are placed on the main beams, spaced according to the dimension of the infill hollow blocks used for the floor.

4.3.7 ASSEMBLY SEQUENCE: STEP # 7. INFILL FLOOR HOLLOW BLOCKS (dwg.12)

The infill hollow blocks are placed between the joists and a final layer of concrete is placed on the hollow blocks, joists and beams covering them totally. In this way, a continuous floor surface is defined which can be used as such. Otherwise, at this step of the assembly sequence, the surface is ready for any kind of flooring.

In drwgs.13, 14 and 15, the whole assembly sequence is shown in a complete structural bay. Drwg.15 shows the special case of cantilever beam.

The details of the connections between the components of the frame system are shown in drwgs.16 to 21.

Drwgs.16 to 18 show, in the case of beam and internal column-connection, the positioning of all the frame system components in relation to each other. In drwg.16 is important to notice the position of the vertical reinforcement.

The vertical reinforcement bars have to be placed as far as possible from the column´s gravity center.

> If the column takes bending, the highest strength materials should be concentrated towards outside. Buckling and bending strength both depend on the moment of inertia, which is highest when the material is as far as possible from the neutral axis.[17]

Similar to drwgs.16 to 18, the connection between beams and corner column at the edge of the structural bay is shown in drwg.19.

In drawg.20, is shown the brick infill as temporary finishing between the base and the capital. This finishing can be removed in case an extension of the dwelling requires the addition of a main beam.

The detail of a connection between column and cantilever beam is shown in drwg.21. Again, it is important to notice the continuity of the vertical reinforcement to produce a monolithic connection.

> In an efficient structure, it is not only true that individual elements have even stress distribution in them when they are loaded. It is also true that the structure

> acts as a whole. When the building is continuous, like a basket, so that each part of the building helps to carry the smallest load, then, the unpredictable nature of the loads creates no difficulties at all.
> Members can be quite small because, no matter what the loads are, the continuity of the building will distribute them among the members as a whole. [18]

4.4 SYSTEM´S RESPONSE TO THE ISSUES OF FLEXIBILITY AND PARTICIPATION.

The first aspect of flexibility that is important to mention is the possibility to combine different structural bays without altering any joint or component of the system (drwg.22). These structural bays, combined in different ways, allow for a large number of feasible layouts to be accommodated within the diverse bays groupings.

In drwg.22, some of the possible combinations of structural bays are shown. Possibilities #1 and #2 (with and without cantilever beam) have been chosen to be used as "support" structures of the two apartment-layouts schemes, designed in further instance.

The second aspect of flexibility that is important to mention is related to the system´s applicability to both 1-2 story high single housing units (core houses, row houses), and to 2-4 story high apartments.

In the case of single-unit housing (drwg.23), diverse stages of plan flexibility and variability can be achieved by means of this system.

For instance, authorities could start providing a minimum yet safe shelter, designed according to available public budgets, economic constraints and projected income flow of the future residents.

In subsequent stages, the structural components of the system can be assembled in modular bays and added vertically (up to 4 stories) as well as horizontally within the limits of the lot division, thus enlarging and improving the dwelling condition as families needs require.

The proposed system is designed with the objective to reach the low-income strata of the population without sacrificing the potential of people to improve their housing

situation over time either on the basis of guided self-help or by later stages of small scale subcontracting activities.
While providing people with ownership of the support structure, the acquisition and installation of secondary elements (infill elements) can be left to private initiatives, to be carried out during the different stages of the dwelling´s life, thus allowing for the direct intervention of the residents in the process of construction or in the enlargement of his/her dwelling.

This direct participation of the resident is made possible by the fact that the structural bays can be erected manually at the building site by people with basic construction experience, and no construction machinery or sophisticated lifting equipment is required, since all components weigh less than 100 kg. and thus can be lifted and set in place by two or three workers.

In the case of 3-4 stories high apartments, the system responds to the issues of flexibility and participation as well.

By forming a frame or skeleton as the basic structural bay, it allows for an absolute separation between load-bearing and space-enclosing elements. (figs.10 and 11)
Since the frames are designed to bear the total live or dead loads of the finished structure, the walls may be supplied and erected by the resident in accordance with his/her means and requirements at any point in time. The structural frame permits the use of non bearing wall material that functions primarily as a climatic barrier, as well as providing the required privacy and security. The frame allows the dwellers to choose locally available materials for low-cost partitions, without regard to their structural or load-bearing properties. In addition, the frame offers an extense diversity of possible column-partition connections (drwg.24).

Since the system is dimensionally coordinated by means of a modular tartan grid, it allows for the combination of its parts with standard non structural manufactured elements or assemblies easily found in the market, avoiding waste, mistakes of fitting and positioning in installation.
Given the modular dimensions set by the framing system, the

partitions may also be panelized and mass-produced under factory conditions, and could be attached to the frame at the job site by simple fastening devices. This opens up the possibility for using the basic frame for small commercial structures, often much desired by potential entrepreneurs in low-income sectors (i.e. small shops, markets,etc.).

Moreover, partitions do not necessarily have to be placed on the modular grid of the structure. They can be deployed in diverse ways without regarding the presence of the coordinating grid, defining different layouts, as long as they can be accommodated within the larger geometry of the structural frame

Drwg.25 shows the two support structures of the schemes of apartments layouts. It is assumed that these support structures--bearing structure, vertical circulation, corridors, ground floor and common areas-- can be provided through public subsidy, and, therefore, they belong to the public realm of responsibility and decision making.

Within each of the two support structures, eight variations of apartment layouts are proposed (drwgs.26 and 31.)

These are not all the possible layouts the support structure

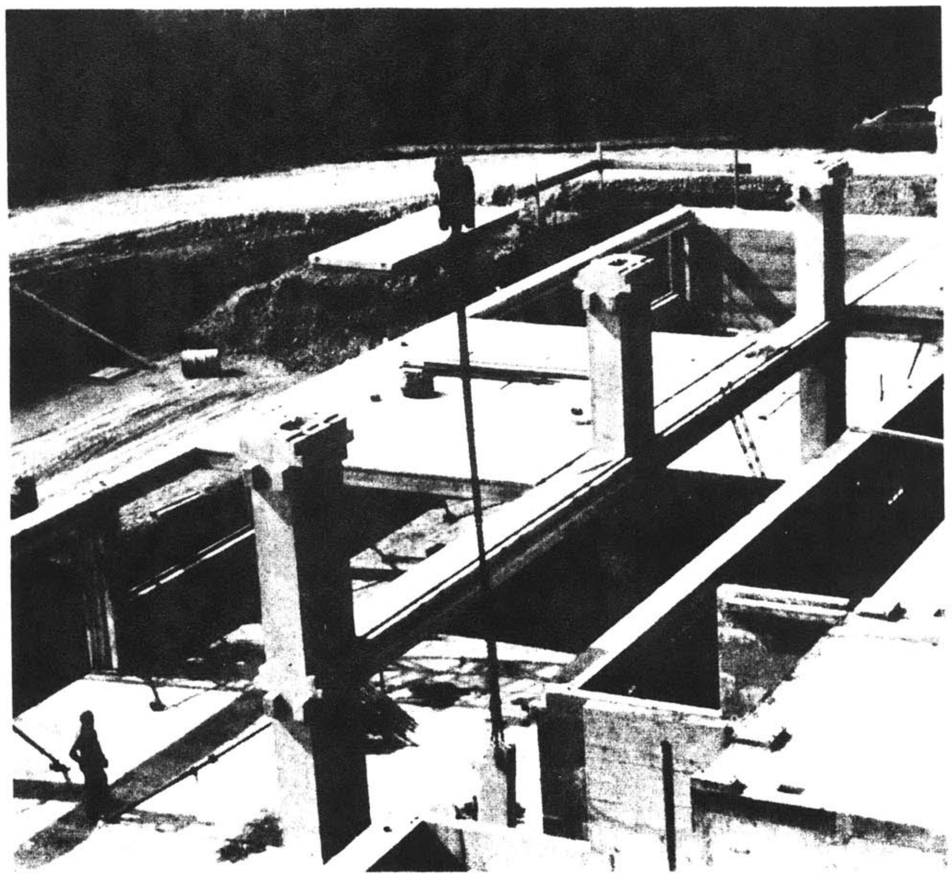
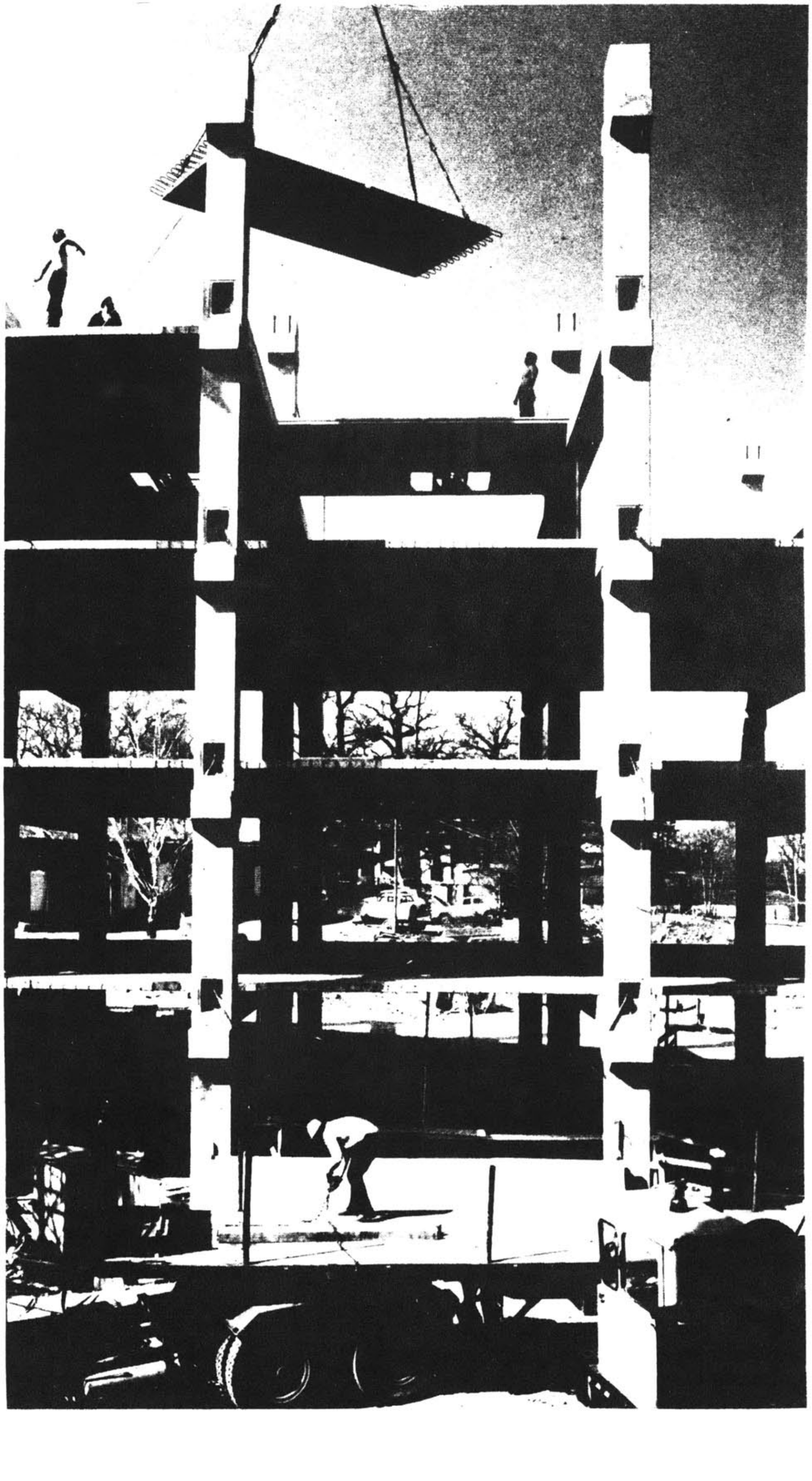


FIG.10 FRAME AS A BASIC STRUCTURAL BAY

FIG.11 FRAME AS A BASIC STRUCTURAL BAY



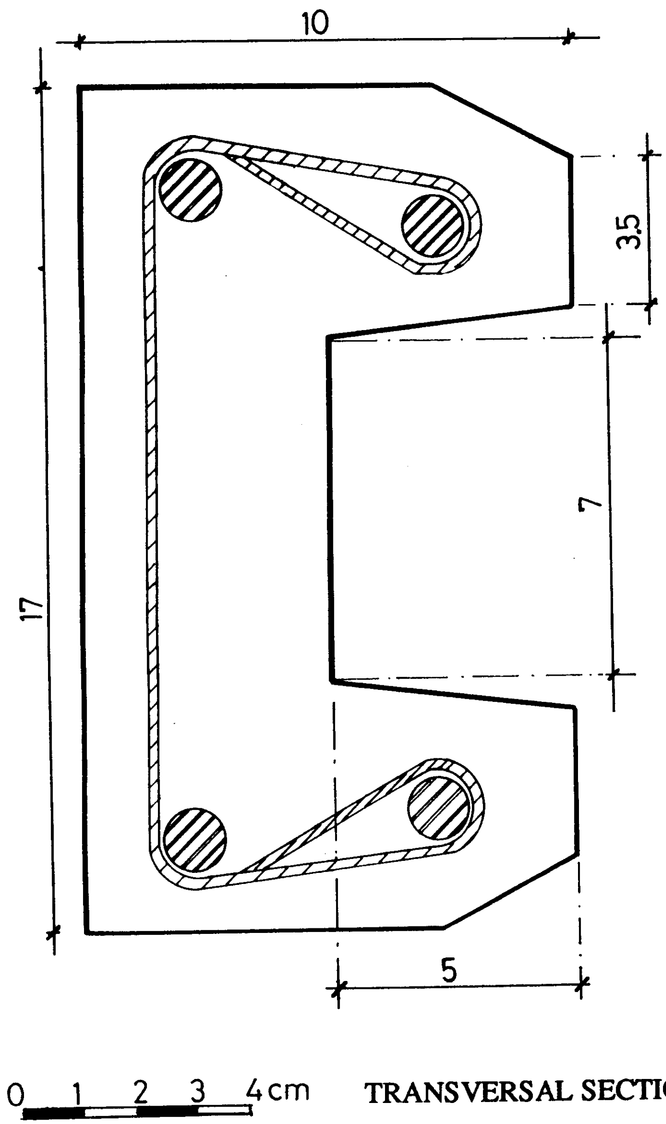
can accommodate; simply, they are the most significant to exemplify the adaptability of the system in accommodating different plan possibilities.

Drwgs.27 to 30 show in detail the internal organization of the eight apartments in the first possibility of support structure; and drwgs. 32 to 35 show the internal organization of the apartments of the second possibility of support structure.

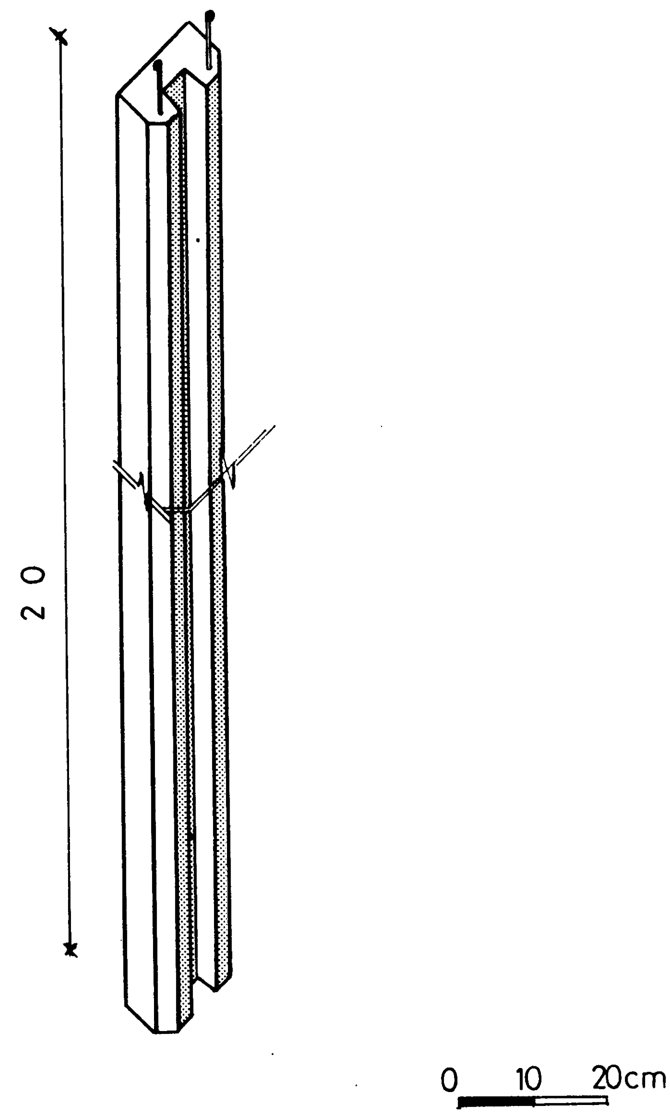
As side information, drwg.36 generally shows a different applicability of the system in case of irregular sites which do not respond to orthagonal rules of shaping. This possible application has not been explored, nonetheless, it is here included in order to show its feasibility for further inquiry and development.

Before finishing this chapter, drwg.37 shows a possible inhabited situation where the infill facade can be done by the residents themselves with local available materials.

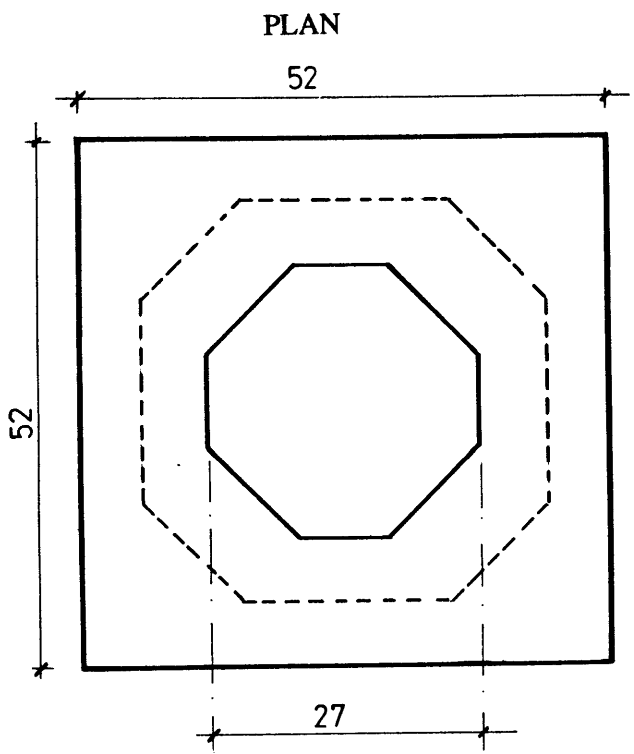
DWG. #1: COLUMN COMPONENT

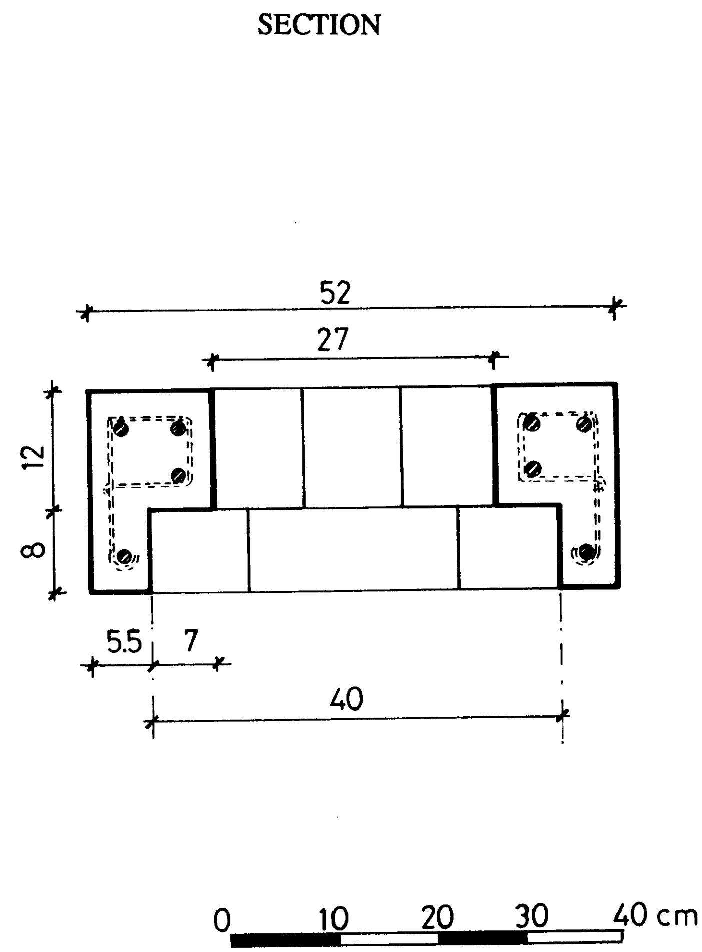


TRANSVERSAL SECTION



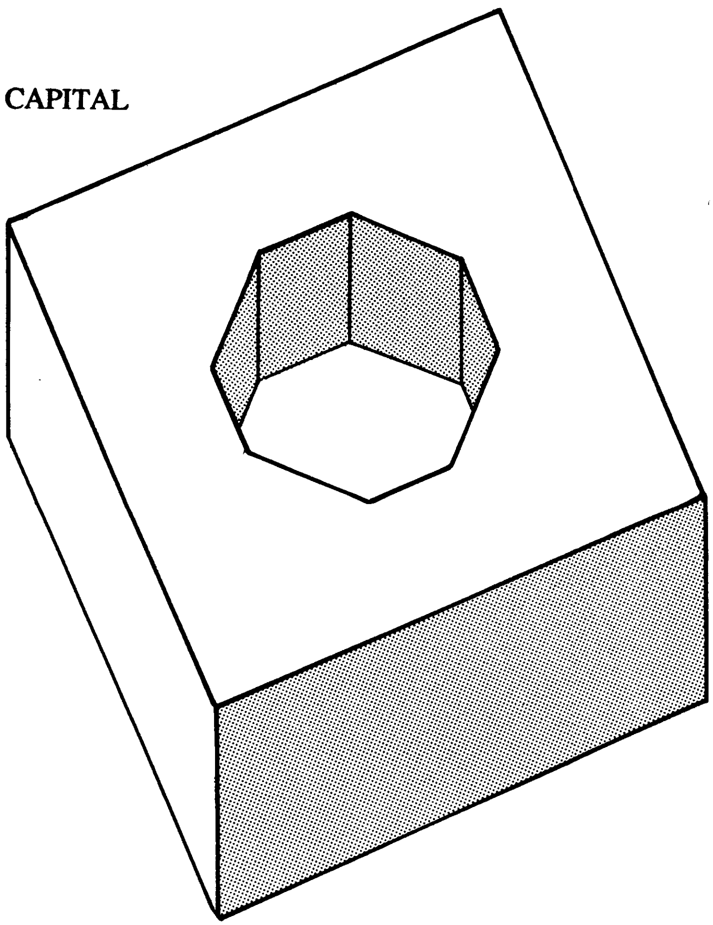
<u>DWG. #2: BASE/CAPITAL</u>



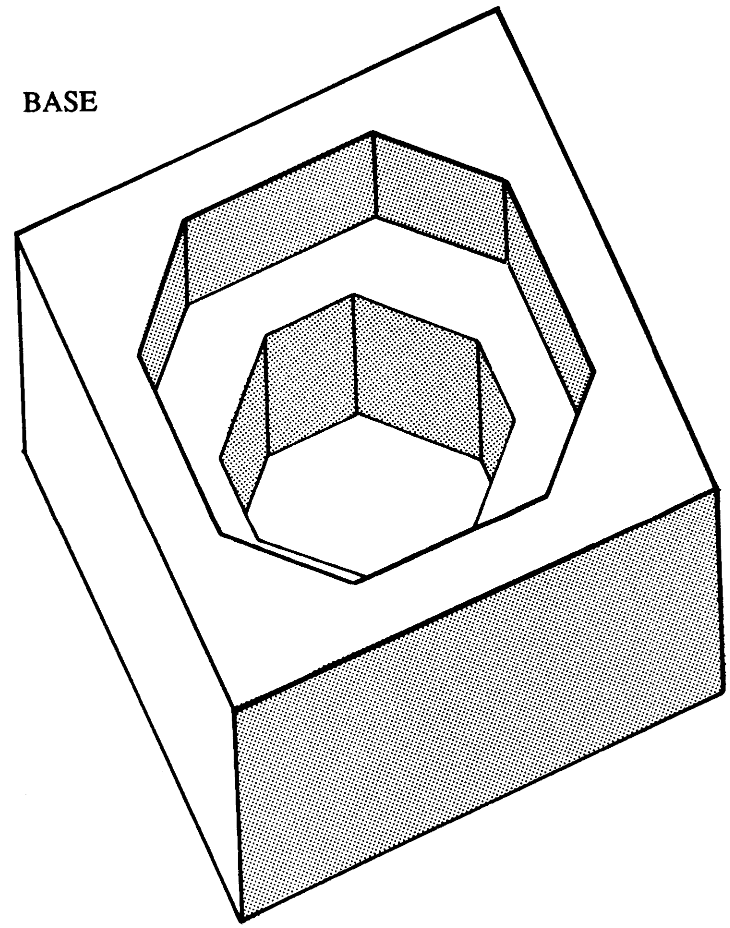


DWG. #3: BASE/CAPITAL

CAPITAL



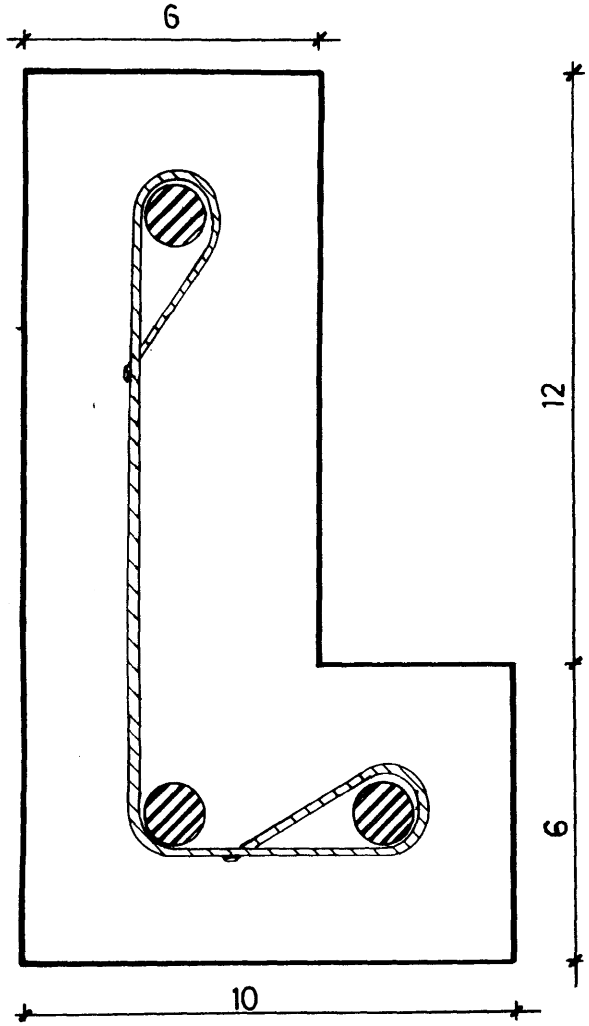
BASE

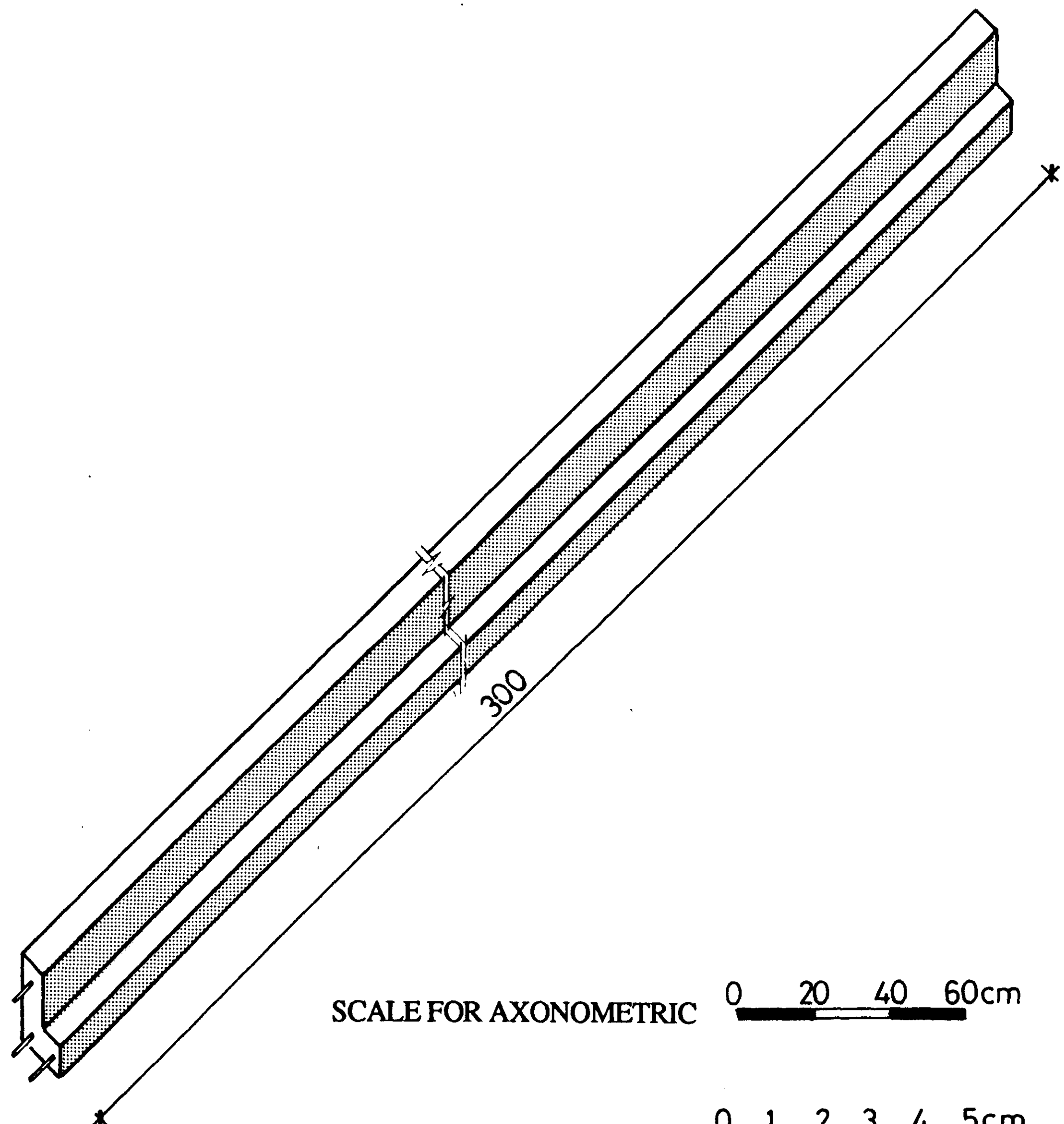


0 10 20 30 40 cm

DWG. #4: BEAM COMPONENT

TRANSVERSAL SECTION

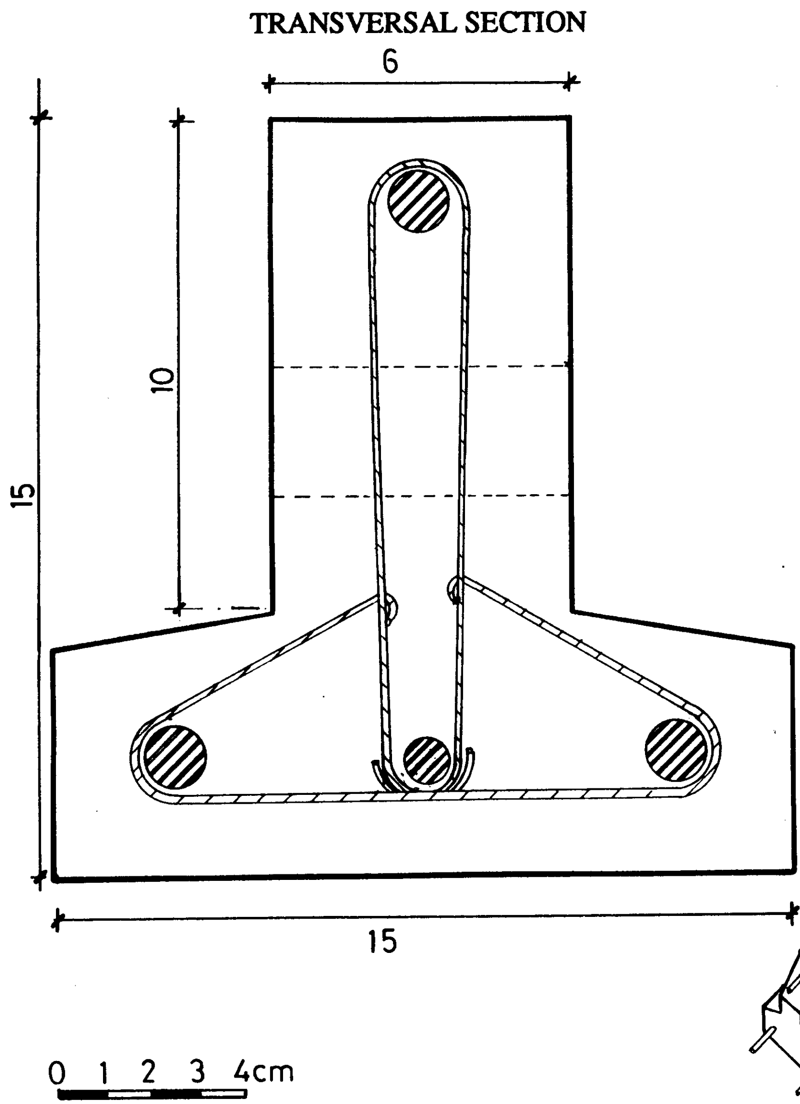


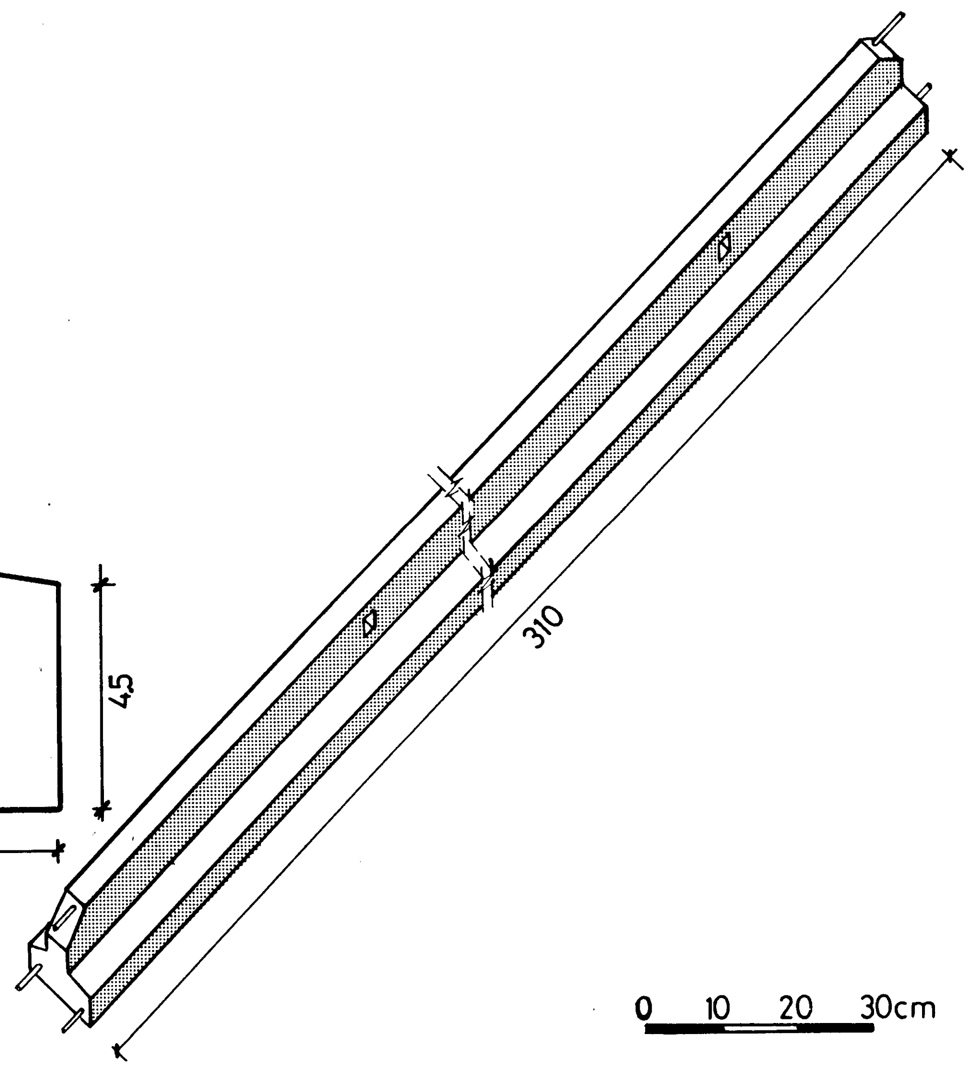


SCALE FOR AXONOMETRIC 0 20 40 60cm

SCALE FOR SECTION 0 1 2 3 4 5cm

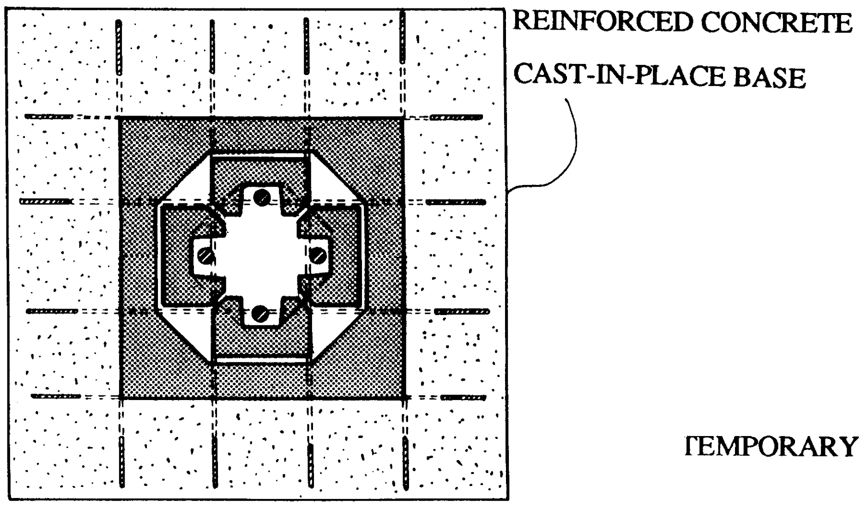
DWG. #5: JOIST



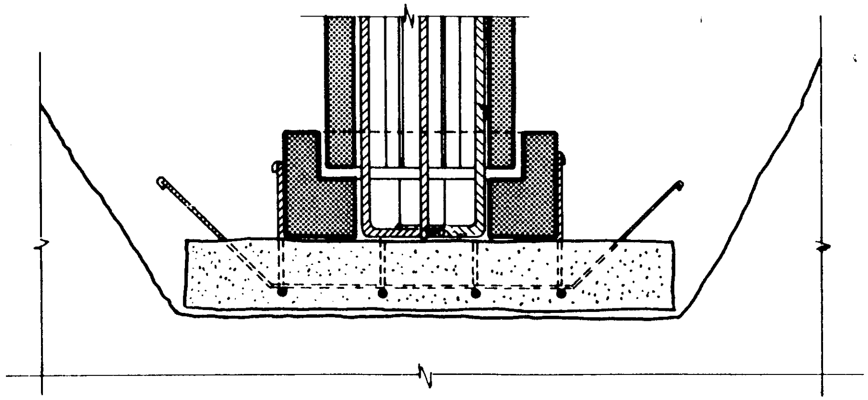


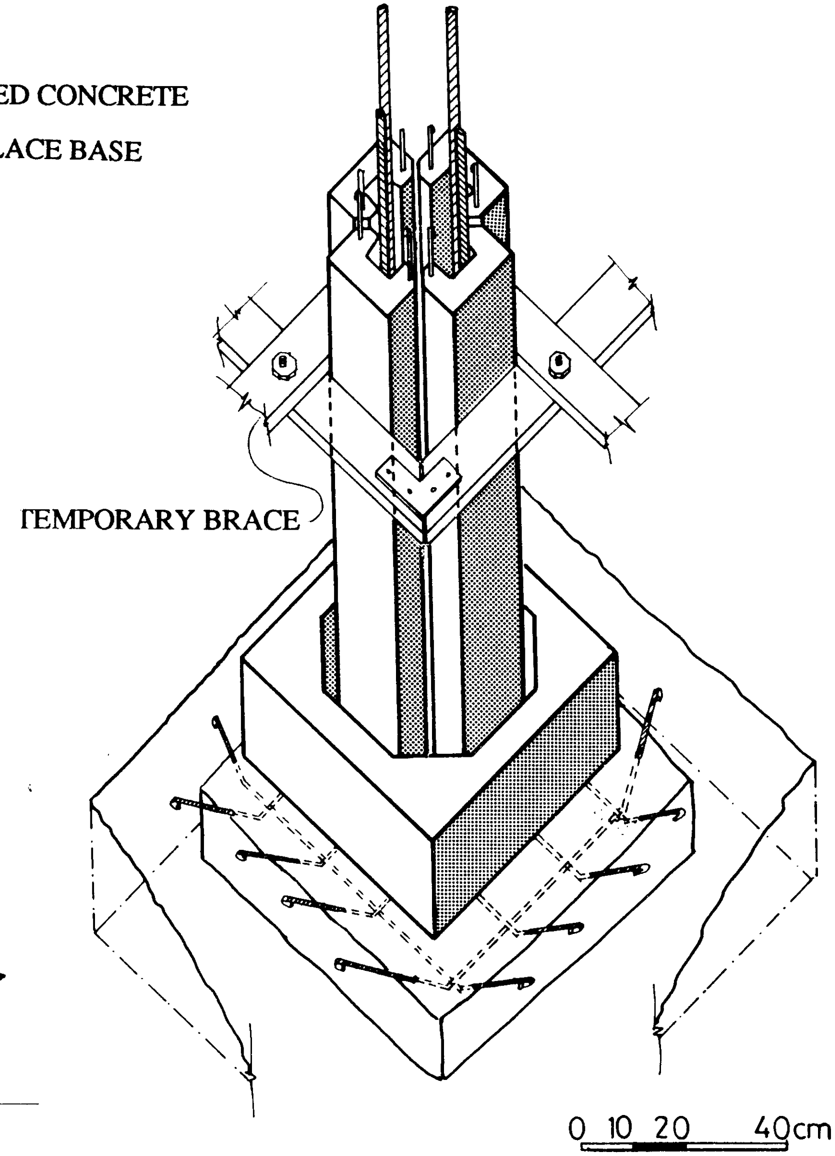
DWG.#6: ASSEMBLY SEQUENCE: STEP 1. BASE AND COLUMN

PLAN



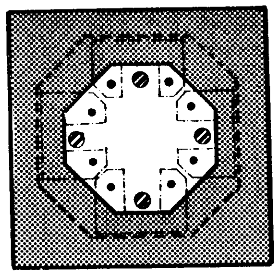
SECTION



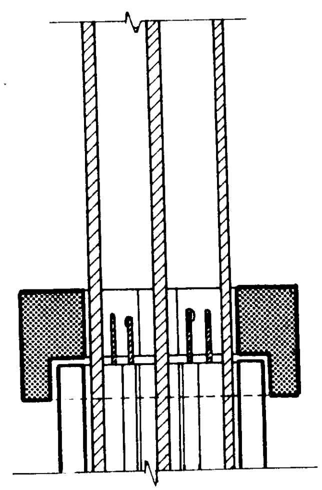


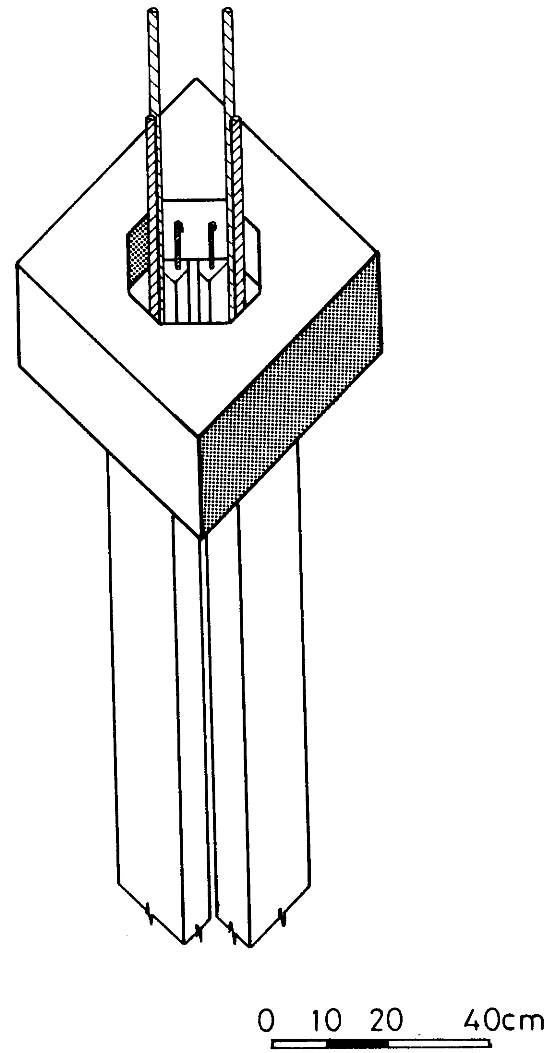
DWG.#7: ASSEMBLY SEQUENCE: STEP 2. CAPITAL

PLAN



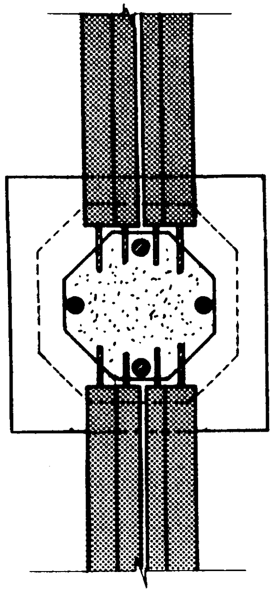
SECTION





DWG. #8: ASSEMBLY SEQUENCE; STEP 3. MAIN BEAMS

PLAN



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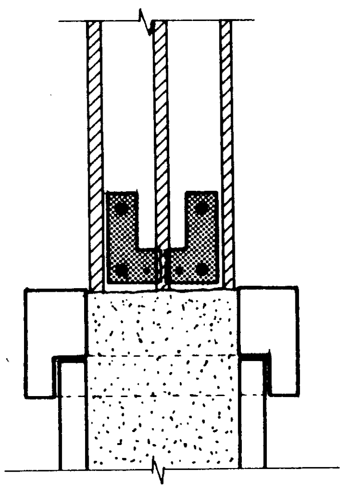
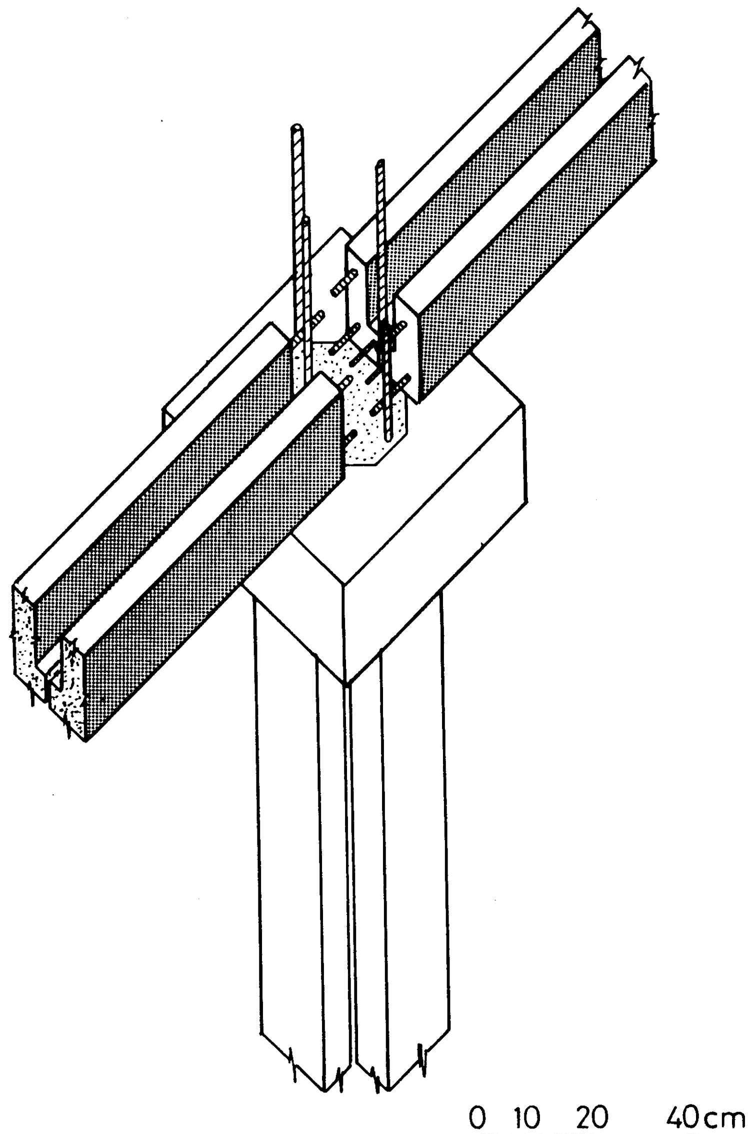
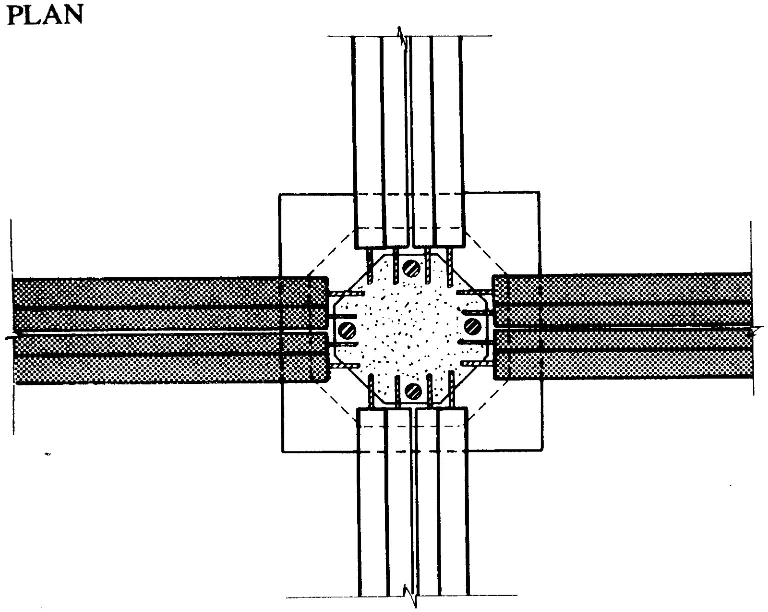




DWG. #9: ASSEMBLY SEQUENCE: STEP 4. RIGIDIZING BEAM

PLAN



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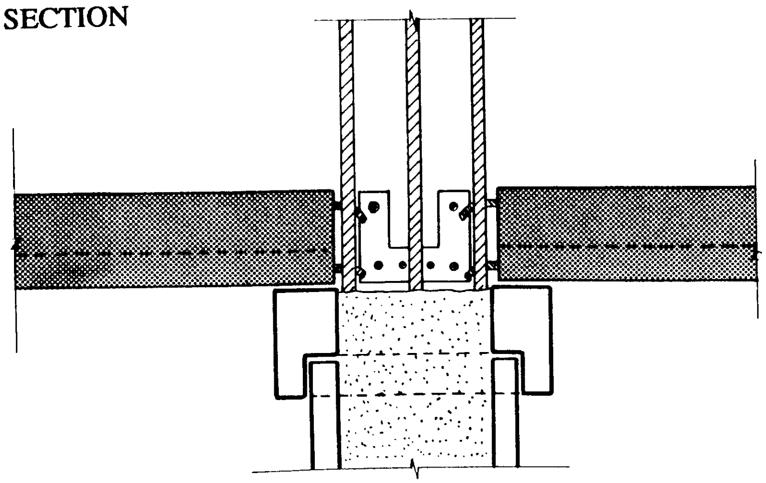
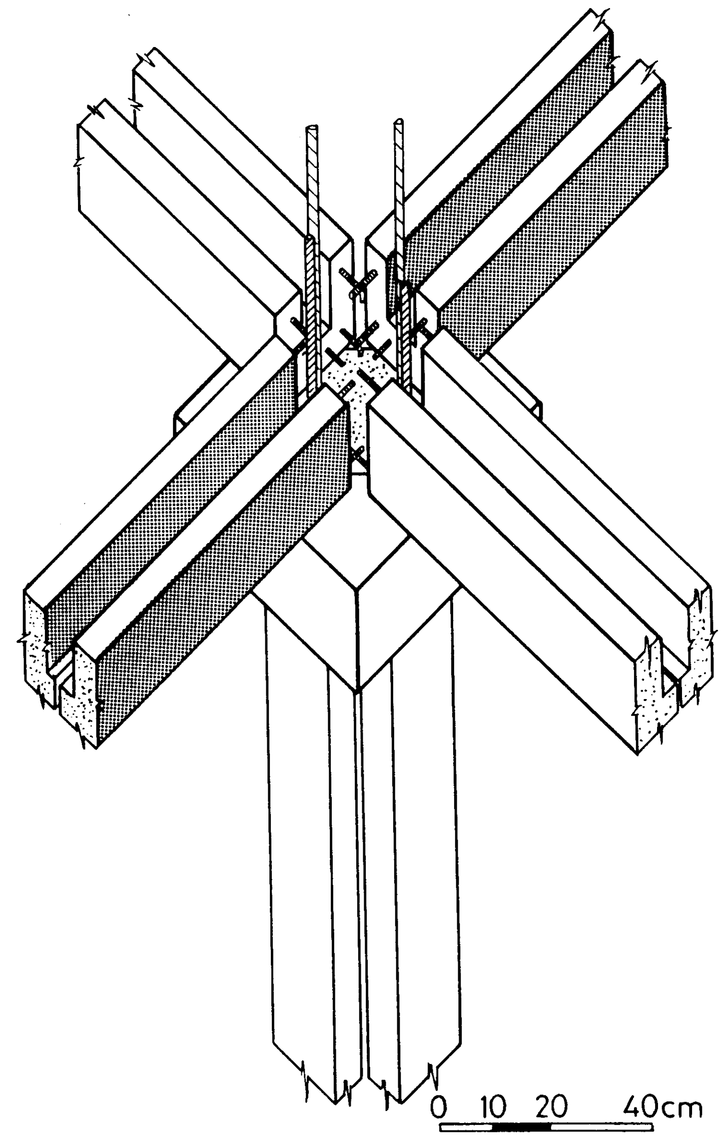
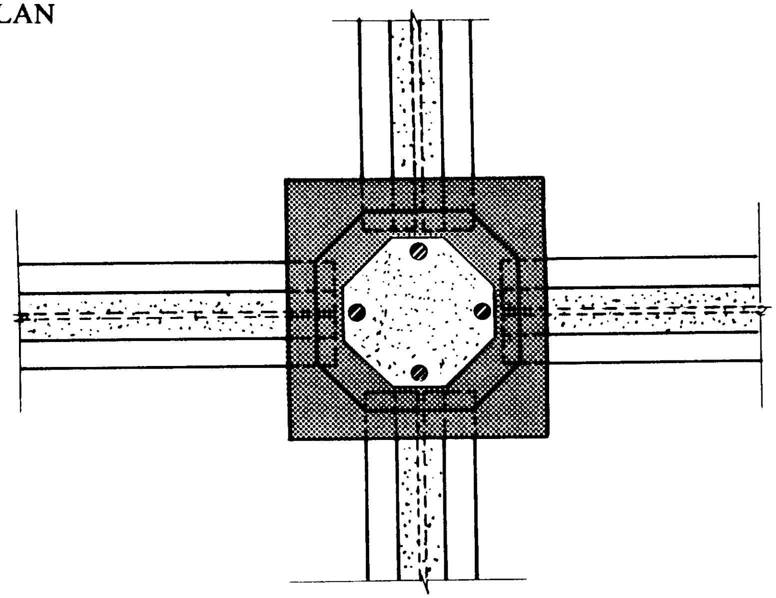




DWG. #10: ASSEMBLY SEQUENCE: STEP 5. BASE.

PLAN



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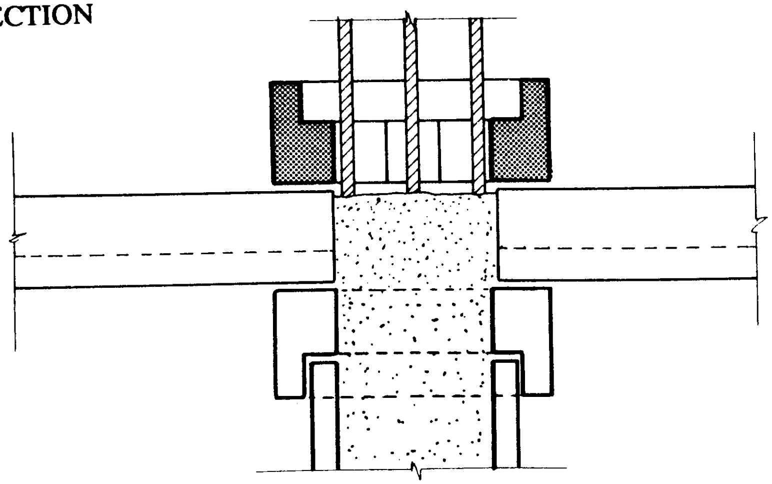
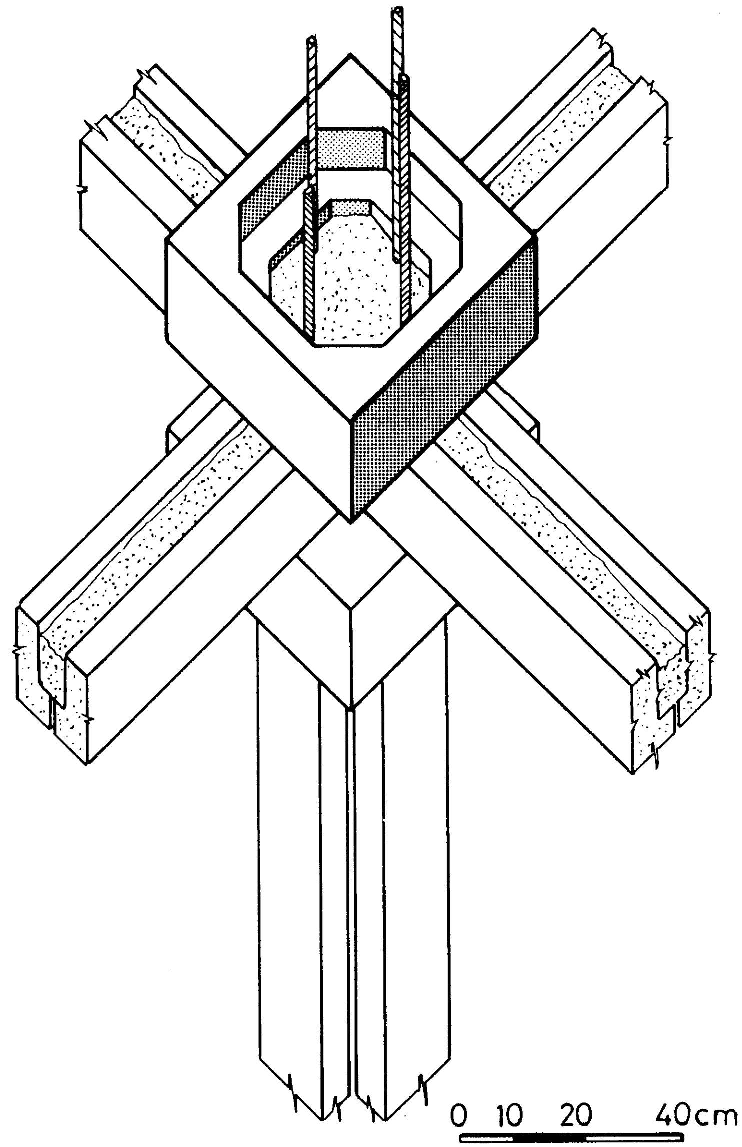
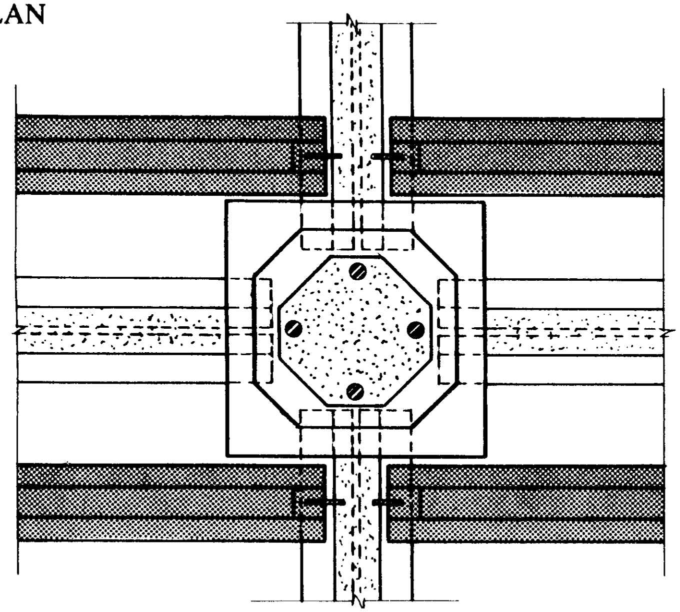




<u>DWG. #11: ASSEMBLY SEQUENCE, STEP 6, JOISTS</u>

PLAN



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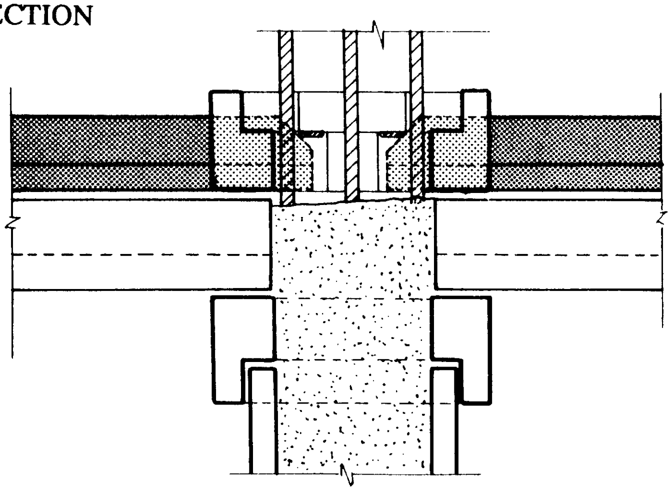
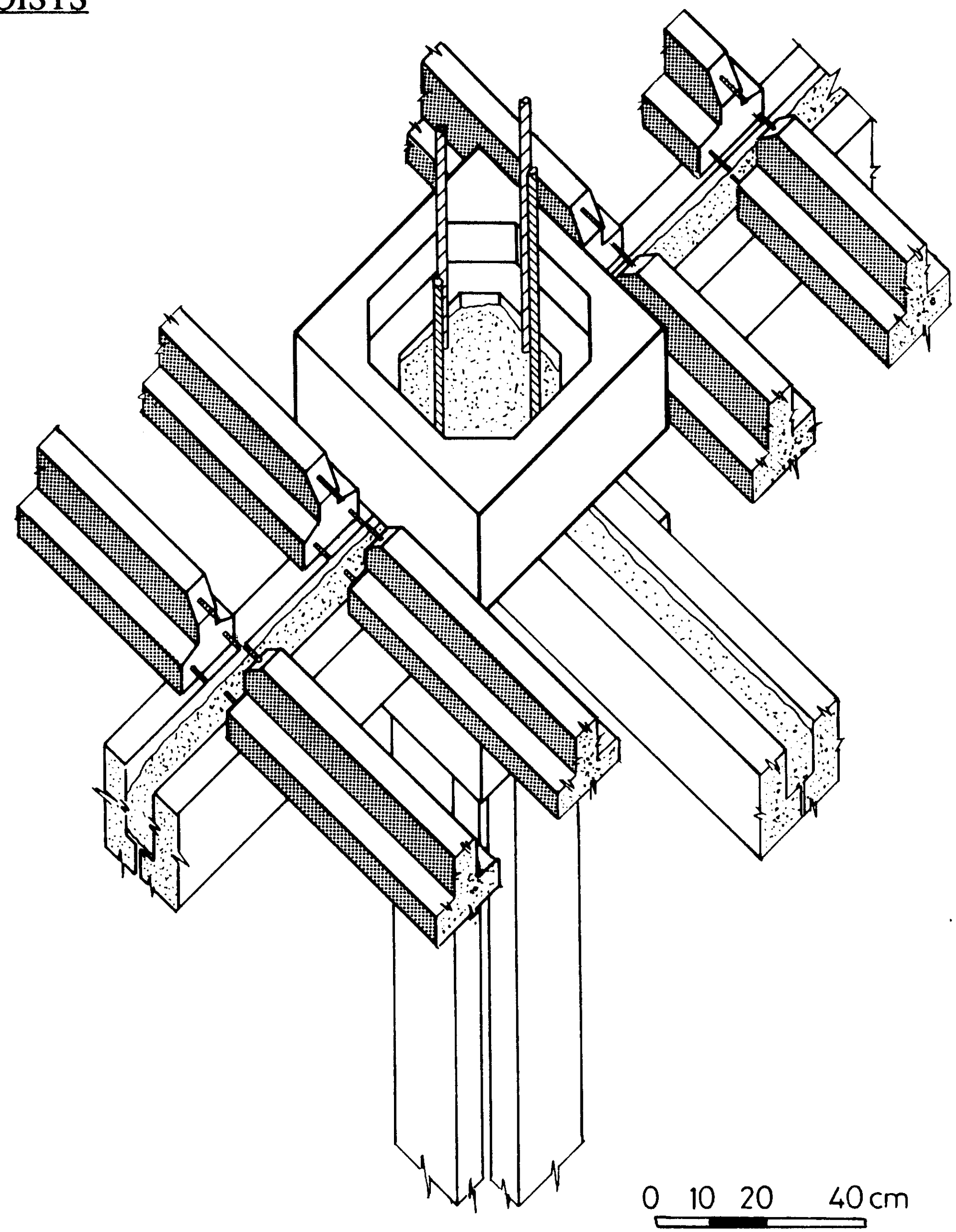
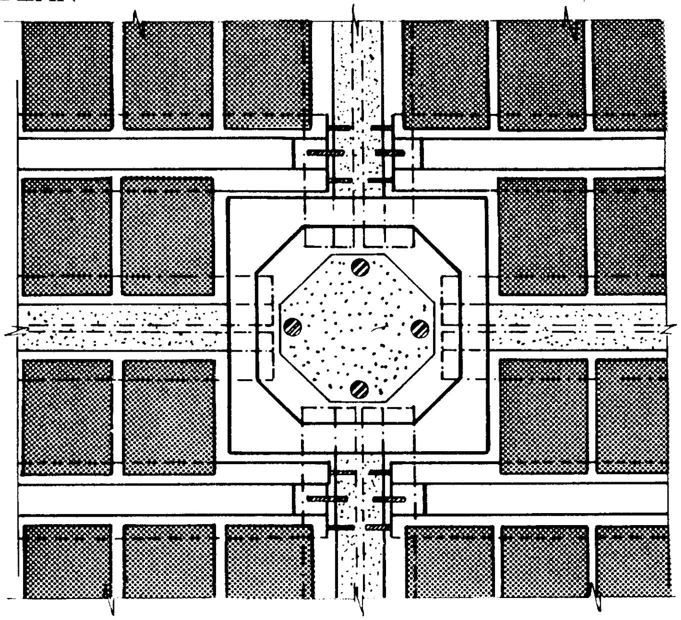




DWG. #12: ASSEMBLY SEQUENCE, STEP 7. INFILL HOLLOW BLOCKS

PLAN



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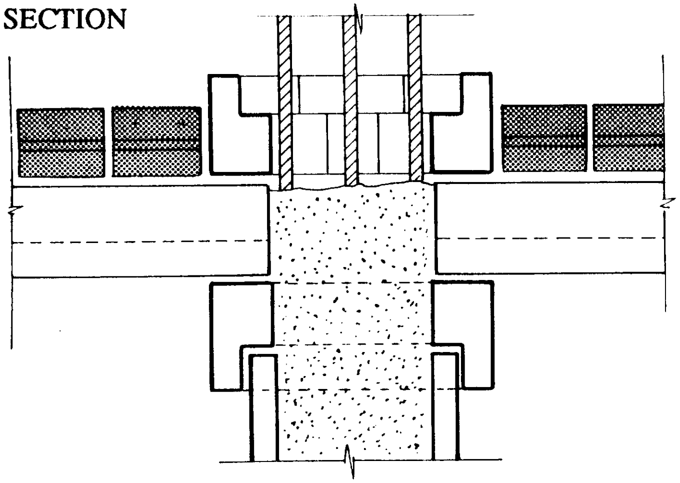
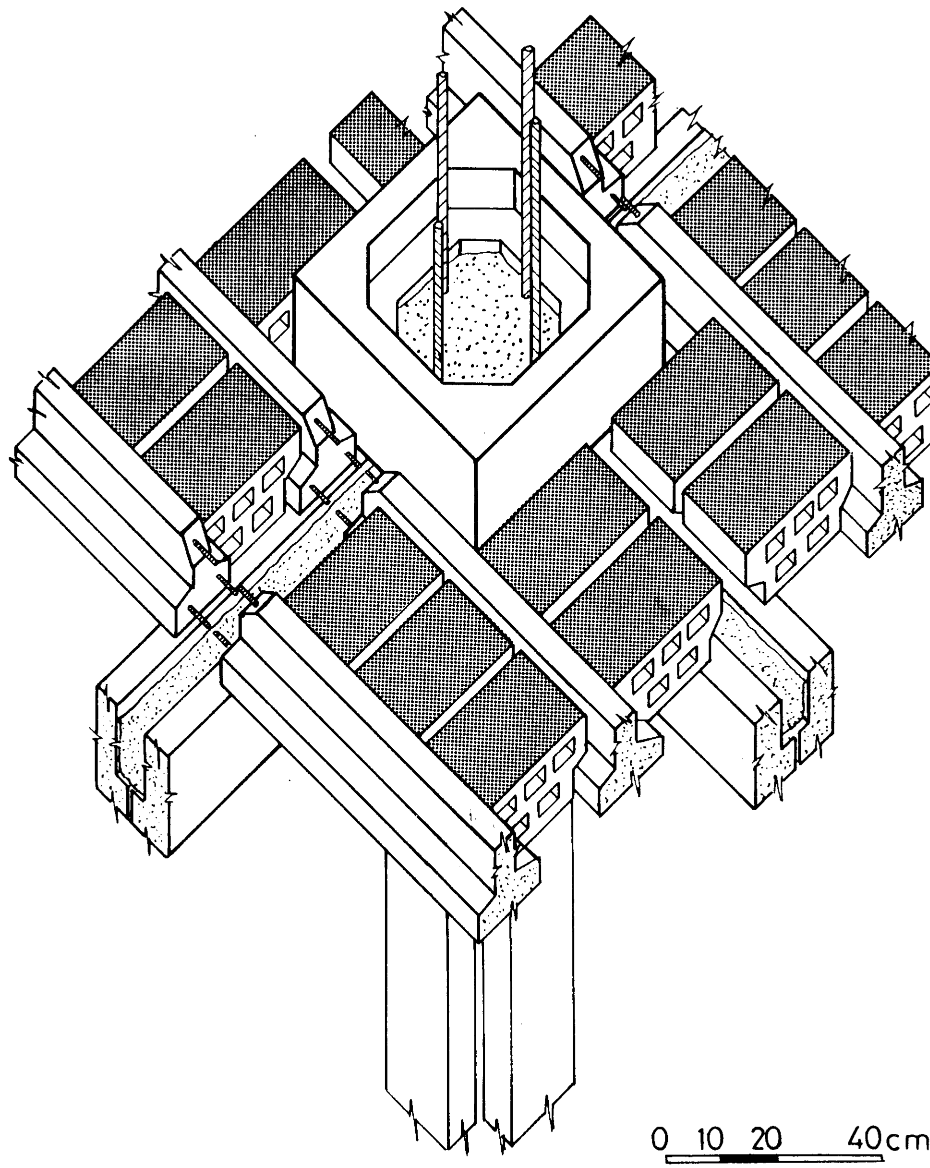
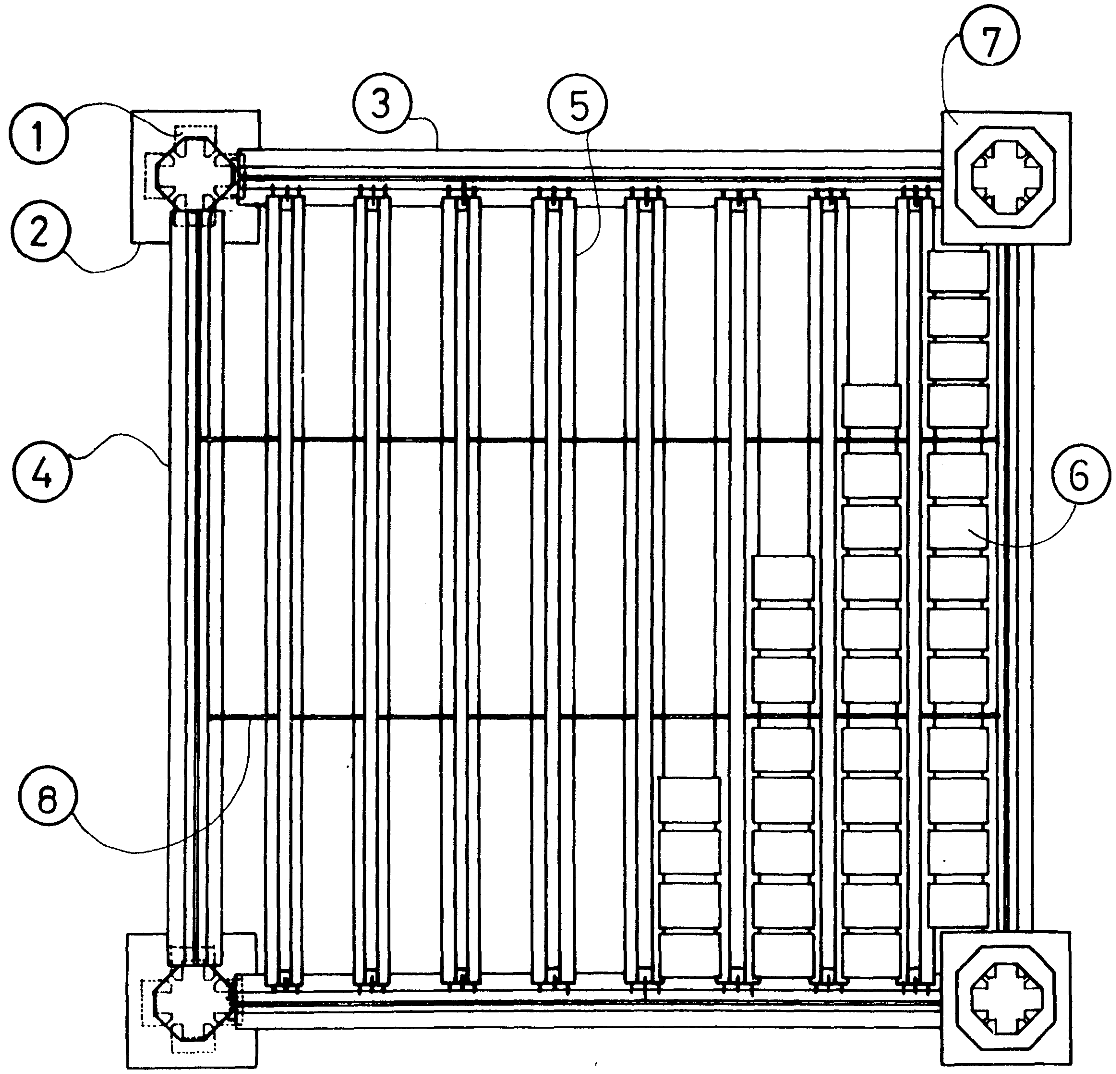
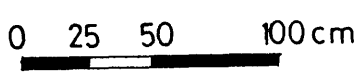


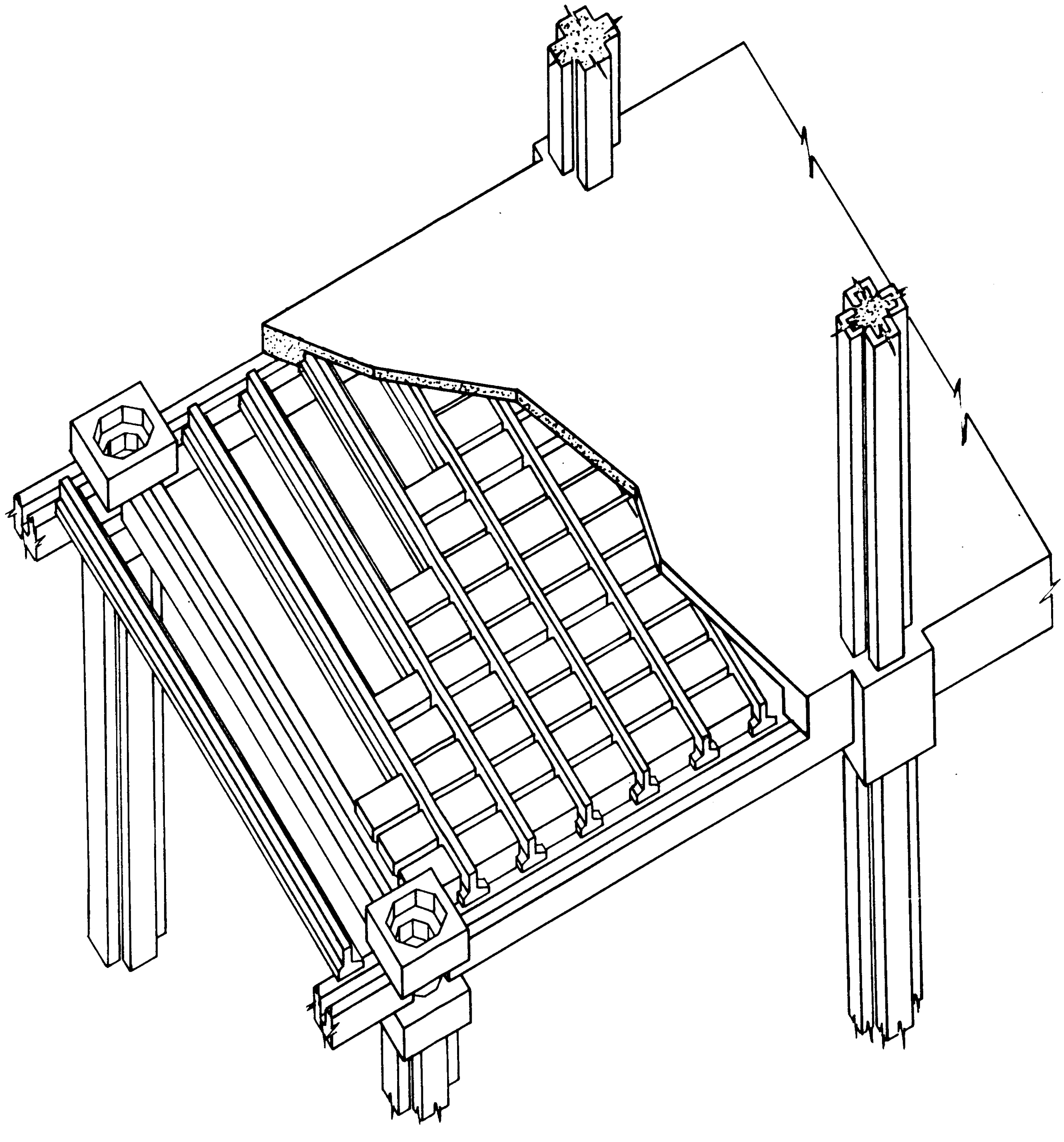


DWG. #13: PLAN OF A STRUCTURAL BAY.

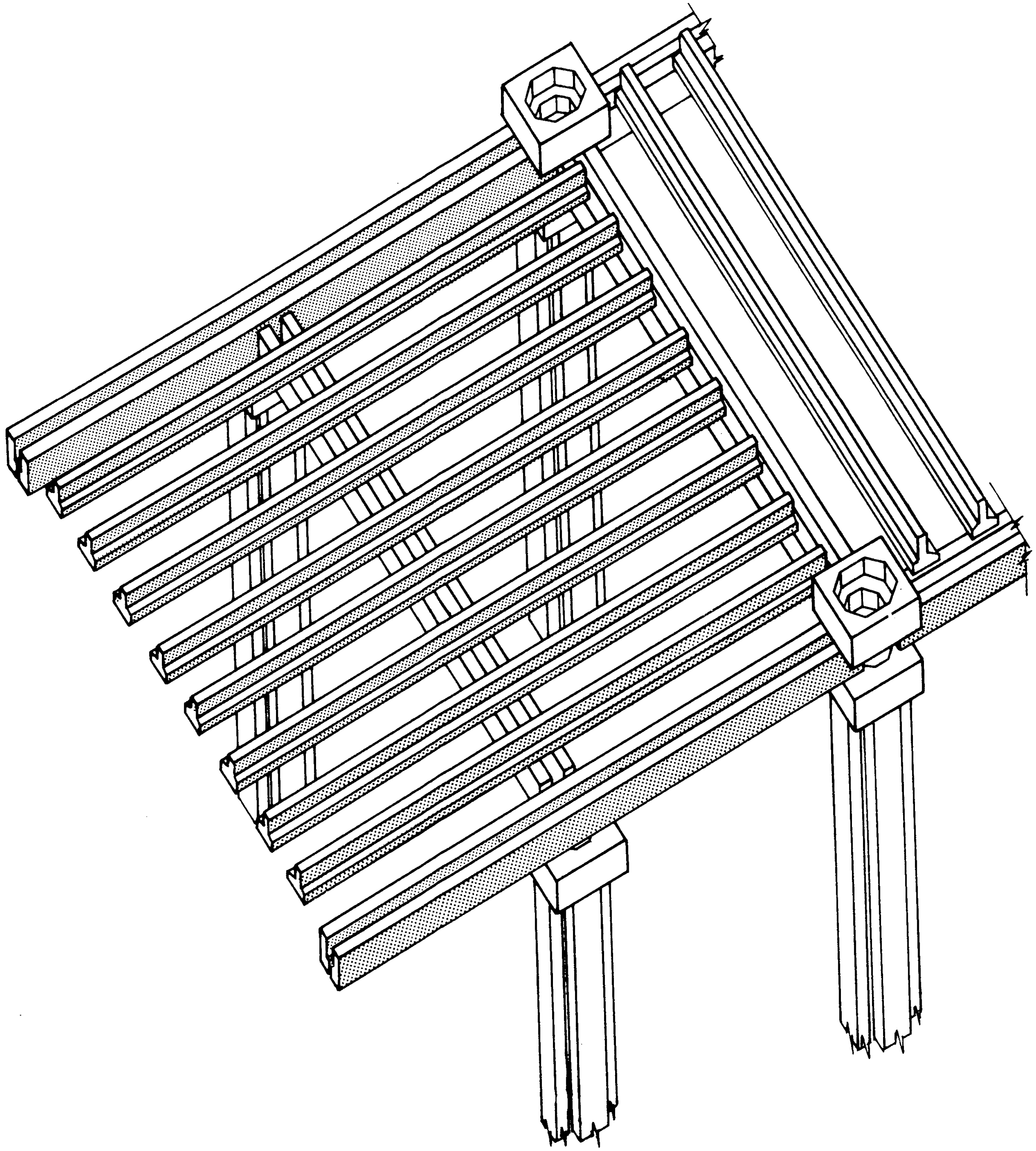


1. COLUMN
2. COLUMN CAPITAL
3. MAIN BEAM
4. RIGIDIZING BEAM
5. JOIST
6. INFILL HOLLOW BLOCK
7. COLUMN BASE
8. REINFORCEMENT OF THE CAST IN PLACE RIBS ACTING AS TRANSVERSAL STIFFENERS OF THE FLOOR.



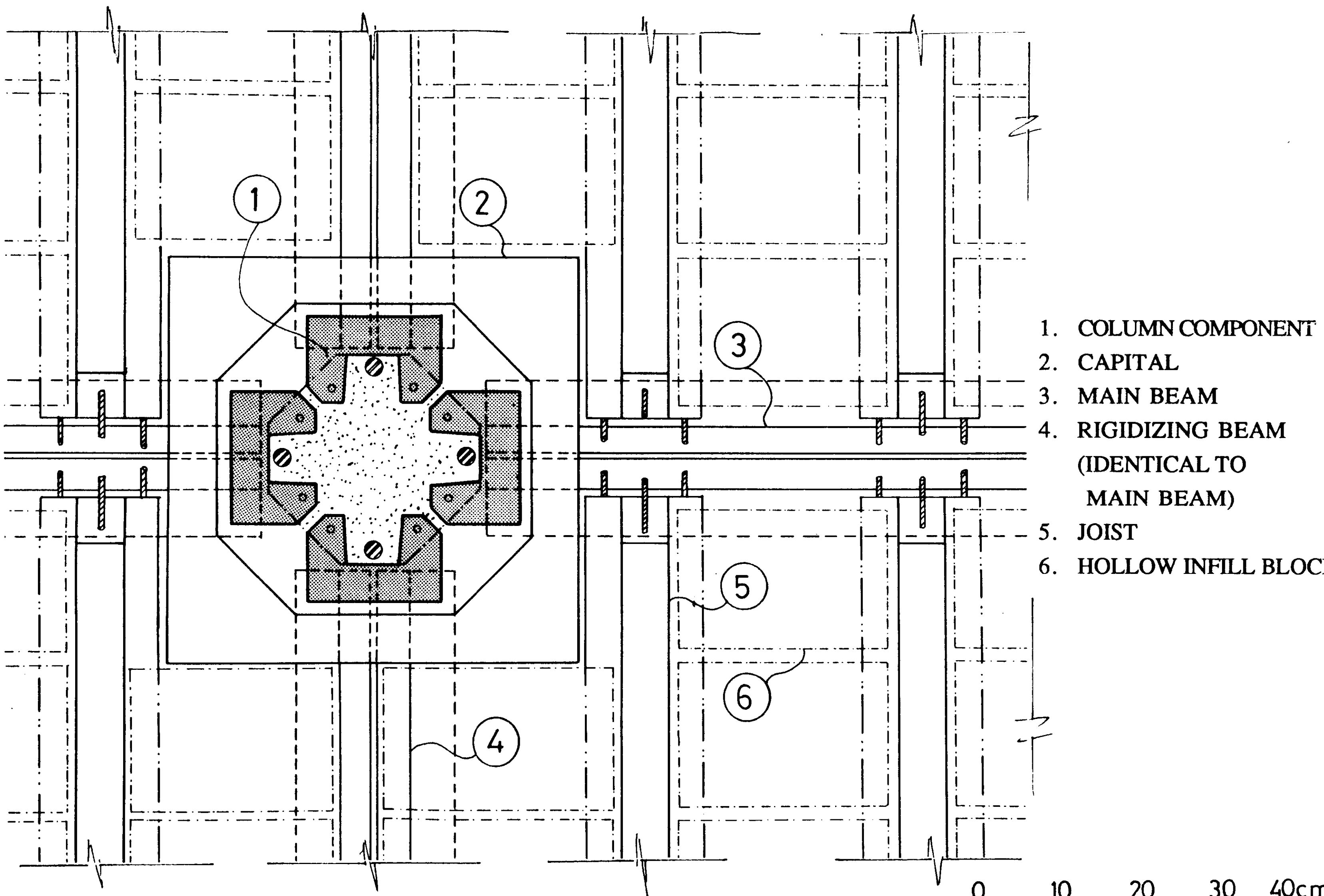


0 05 1 2m



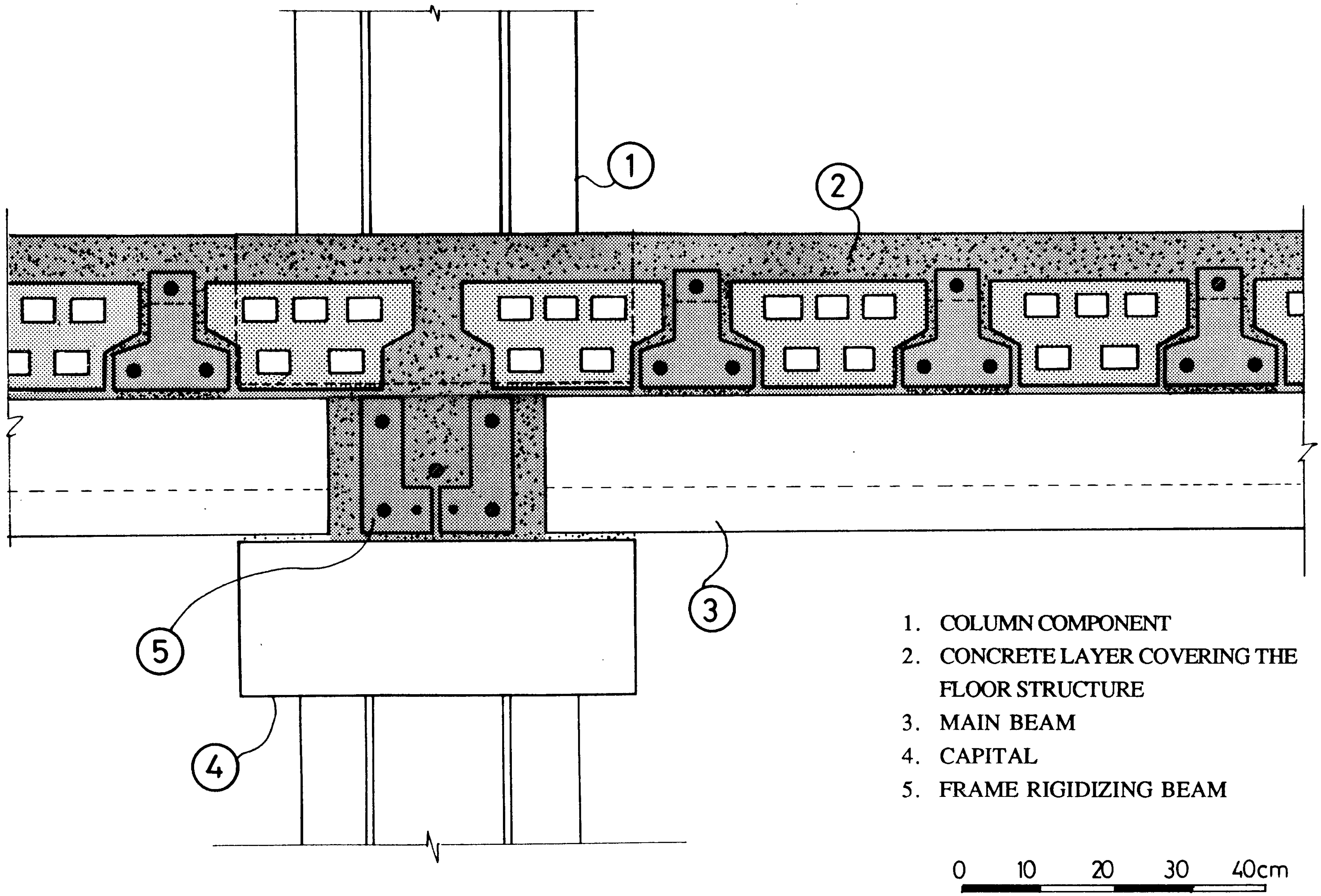
0 0.5 1 2m

DWG. #16: PLAN OF THE CONNECTION BETWEEN FRAME SYSTEM COMPONENTS.



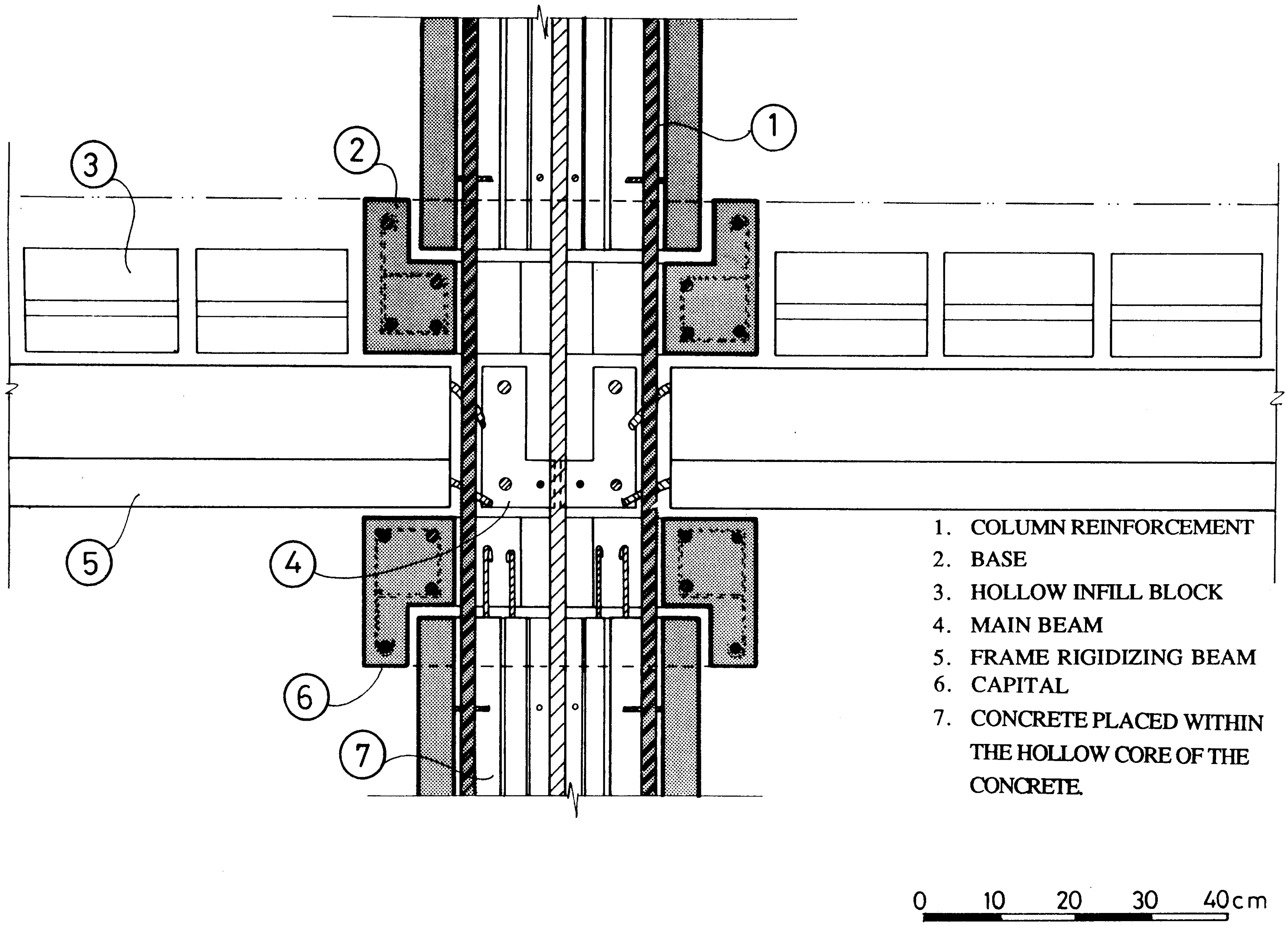
1. COLUMN COMPONENT
2. CAPITAL
3. MAIN BEAM
4. RIGIDIZING BEAM (IDENTICAL TO MAIN BEAM)
5. JOIST
6. HOLLOW INFILL BLOCK

DWG. #17: SECTION THROUGH JOIST AND RIGIDIZING BEAM



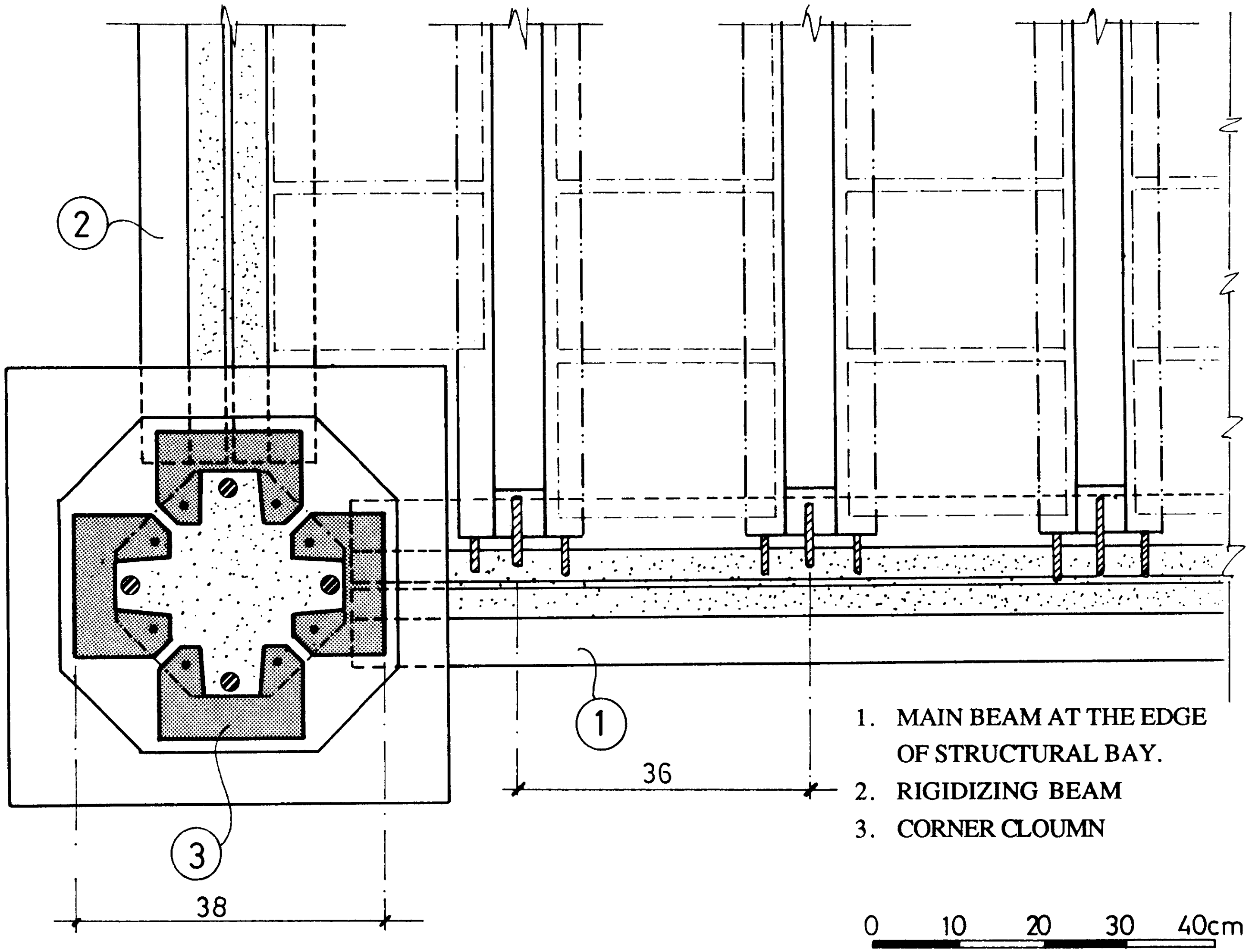
1. COLUMN COMPONENT
2. CONCRETE LAYER COVERING THE FLOOR STRUCTURE
3. MAIN BEAM
4. CAPITAL
5. FRAME RIGIDIZING BEAM

DWG. #18: SECTION THROUGH COLUMNS AND BASE/CAPITAL



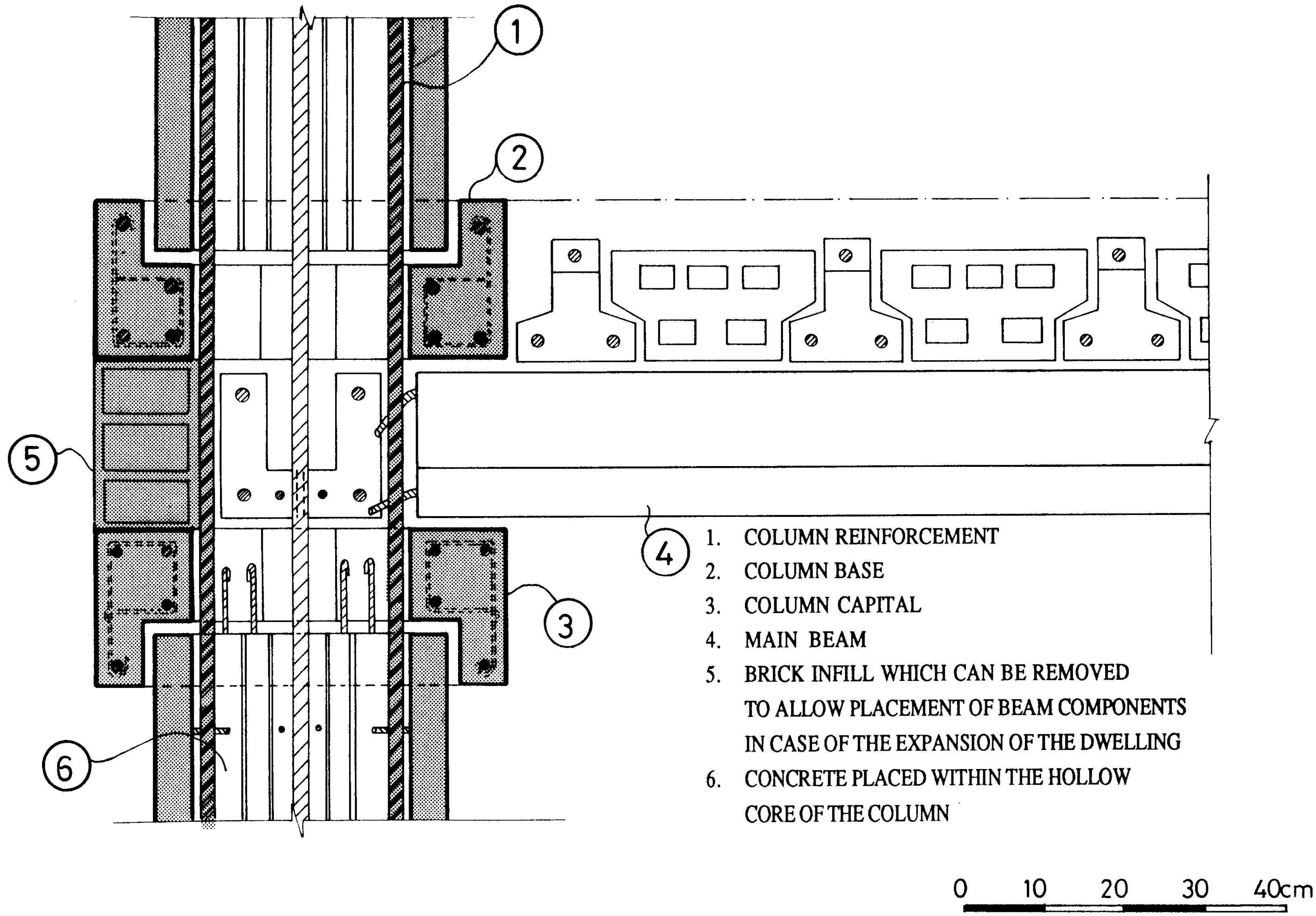
1. COLUMN REINFORCEMENT
2. BASE
3. HOLLOW INFILL BLOCK
4. MAIN BEAM
5. FRAME RIGIDIZING BEAM
6. CAPITAL
7. CONCRETE PLACED WITHIN THE HOLLOW CORE OF THE CONCRETE.

DWG. #19: PLAN OF THE CONNECTION BETWEEN FRAME SYSTEM CONPONENTS: CASE OF JOINT AT CORNER COLUMN.

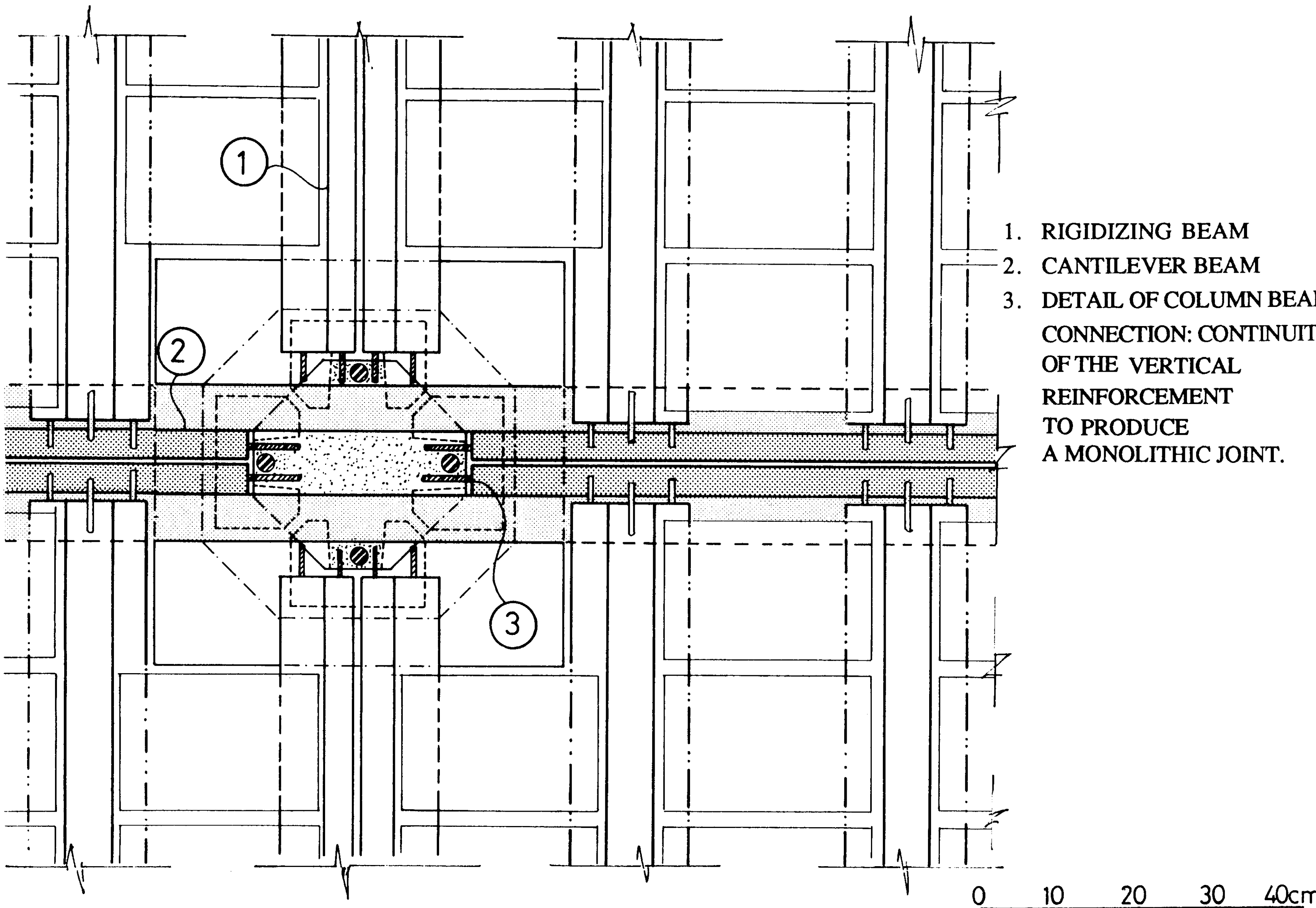


1. MAIN BEAM AT THE EDGE OF STRUCTURAL BAY.
2. RIGIDIZING BEAM
3. CORNER CLOUMN

DWG. #20: SECTION THROUGH CORNER COLUMN.

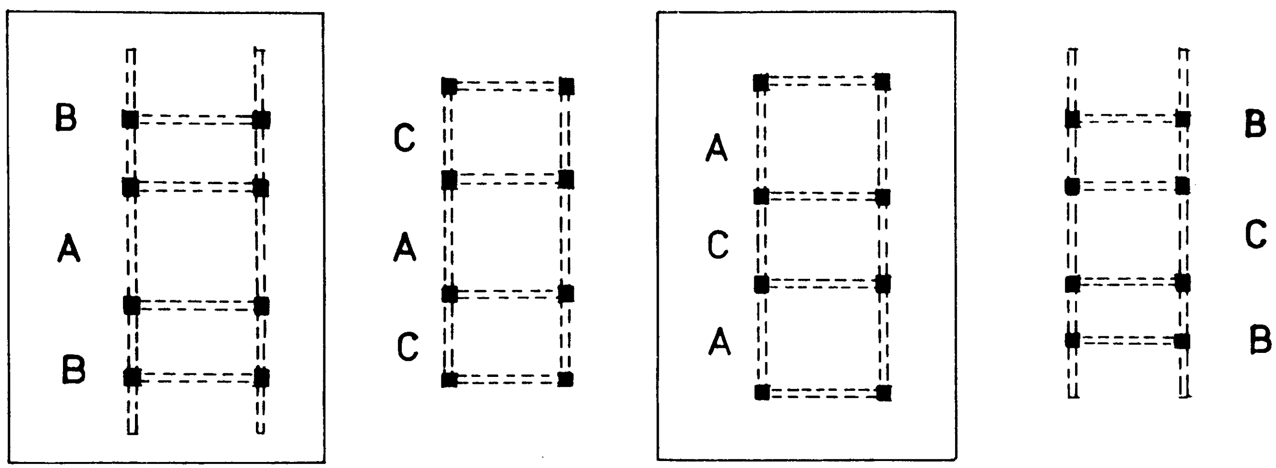


DWG. #21: CONNECTION BETWEEN COLUMN AND CANTILEVER BEAM.



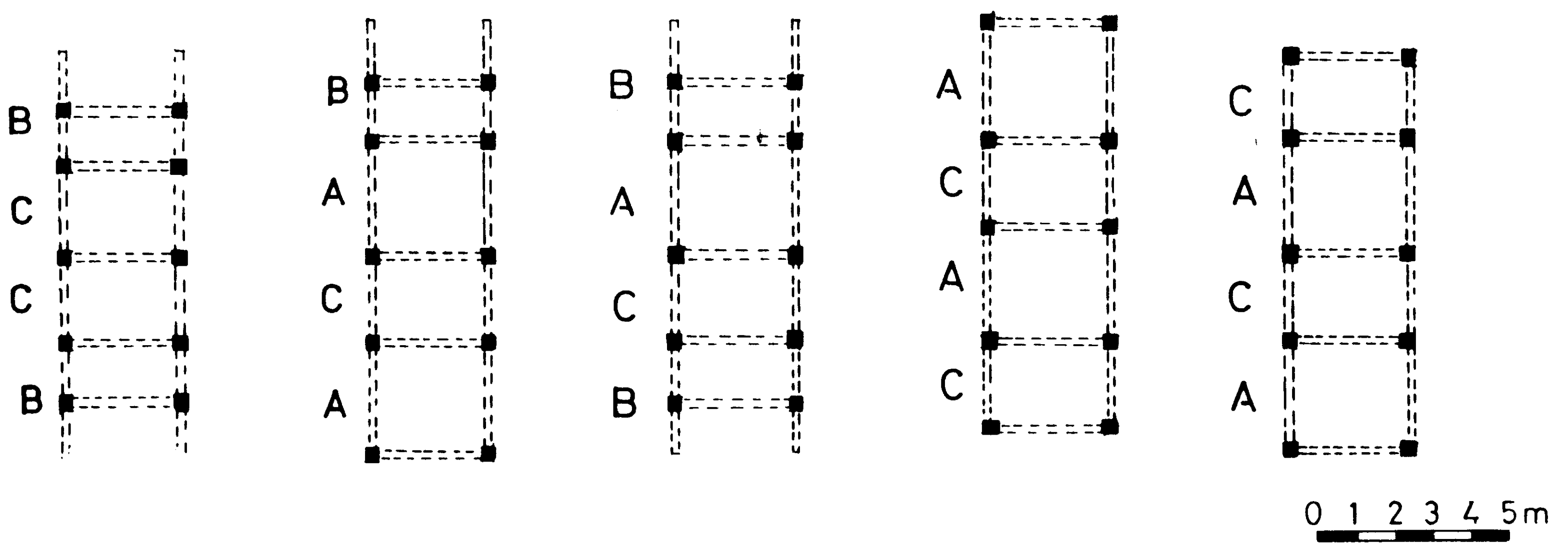
1. RIGIDIZING BEAM
2. CANTILEVER BEAM
3. DETAIL OF COLUMN BEAM CONNECTION: CONTINUITY OF THE VERTICAL REINFORCEMENT TO PRODUCE A MONOLITHIC JOINT.

DWG. #22: POSSIBLE MODULAR COMBINATION OF STRUCTURAL BAYS

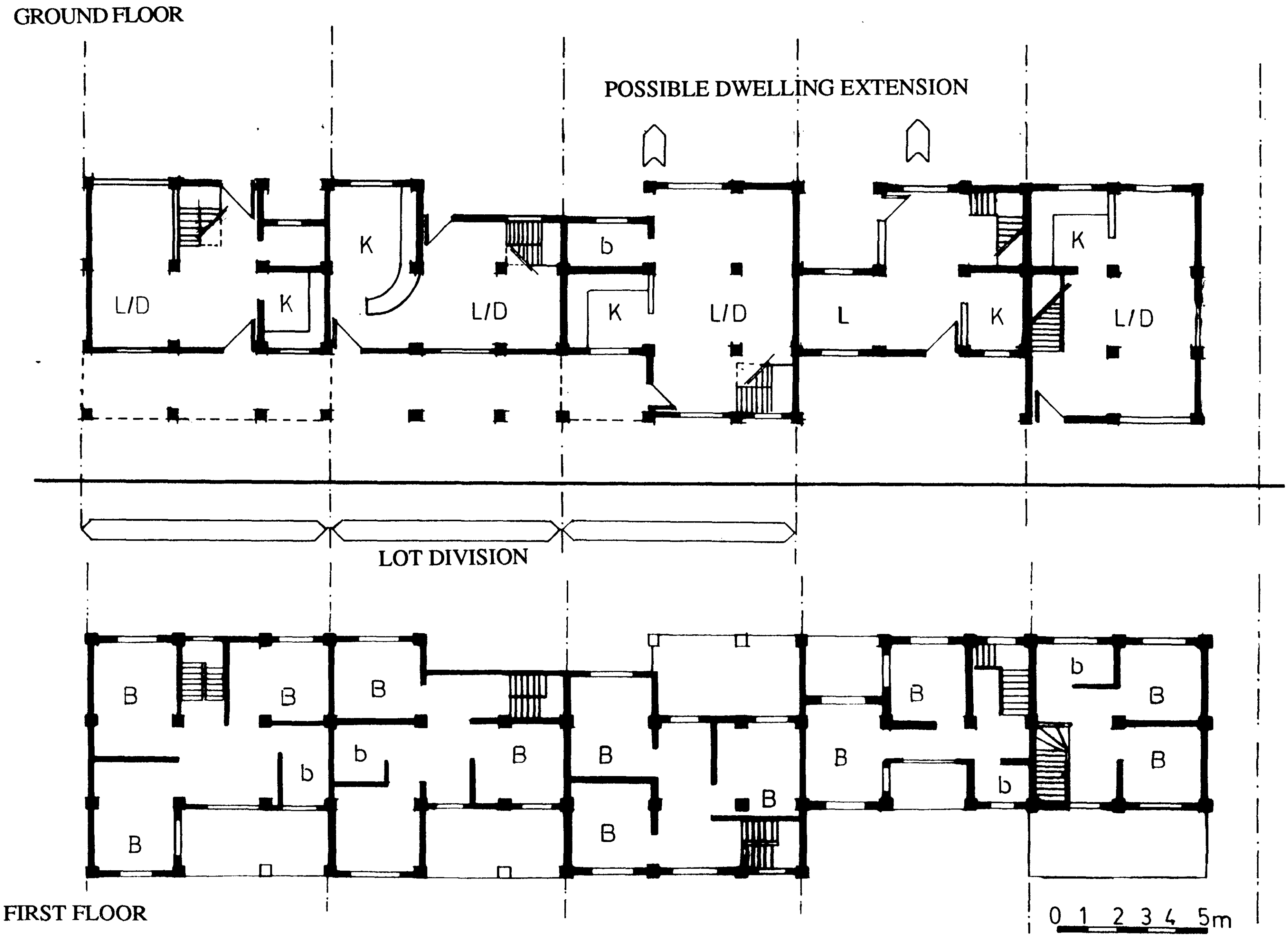


POSSIBILITY #1

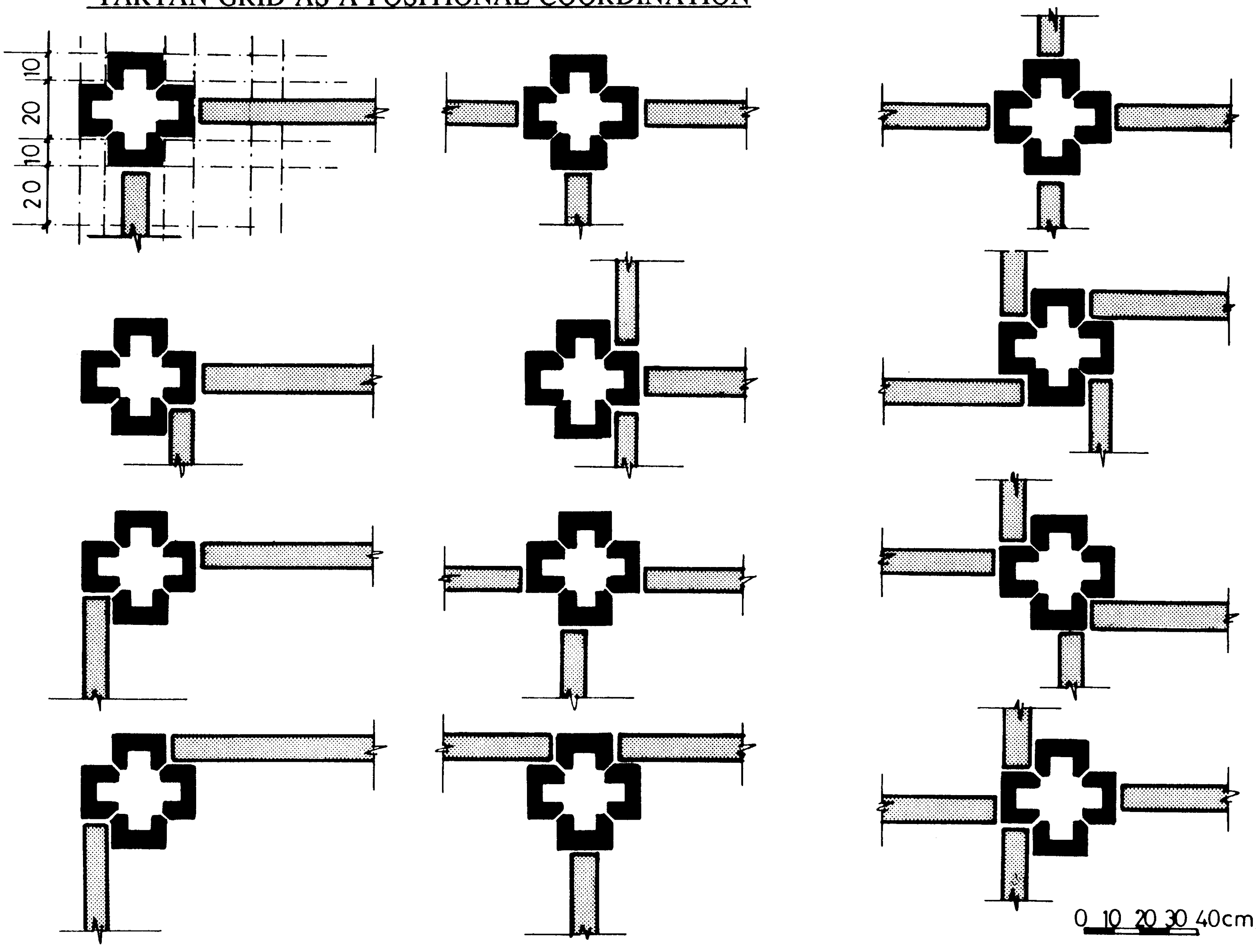
POSSIBILITY #2



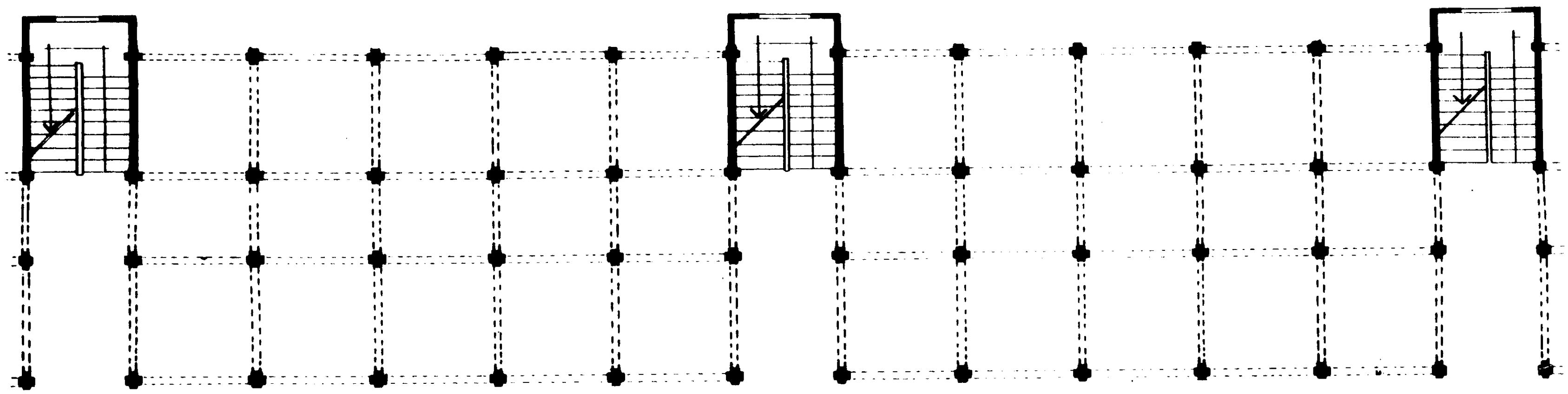
DWG. #23: SYSTEM'S APPLICABILITY TO SINGLE HOUSING UNITS



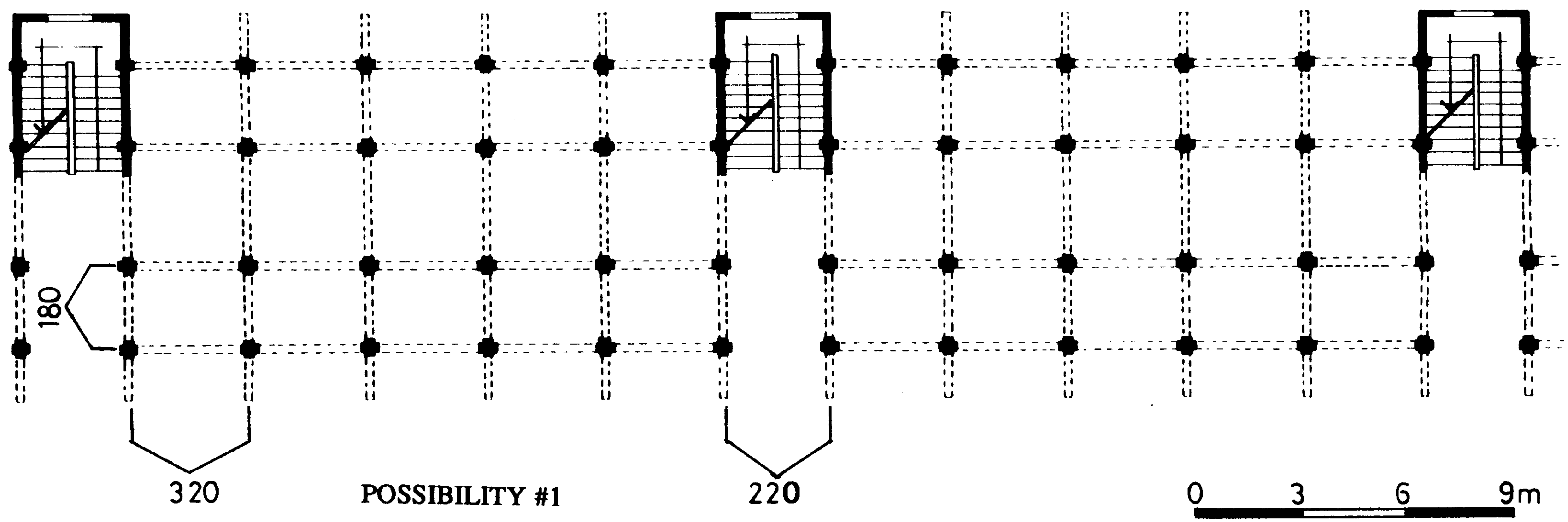
DWG. #24: POSSIBLE COLUMN-WALL CONNECTIONS
TARTAN GRID AS A POSITIONAL COORDINATION



DWG. #25: SYSTEM'S APPLICABILITY TO FOUR STORY-HIGH APARTMENT BUILDING. SUPPORT STRUCTURE

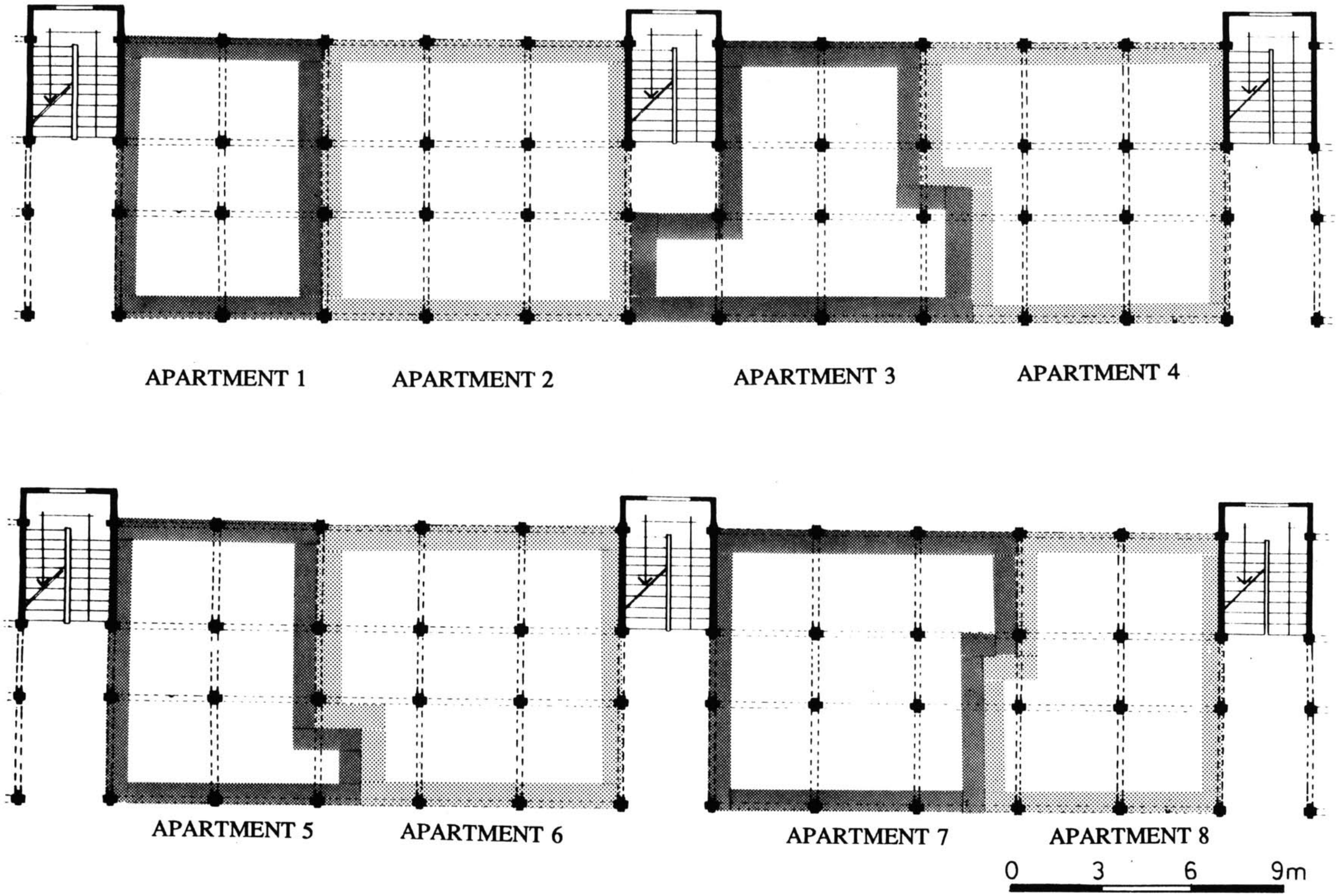


POSSIBILITY #2

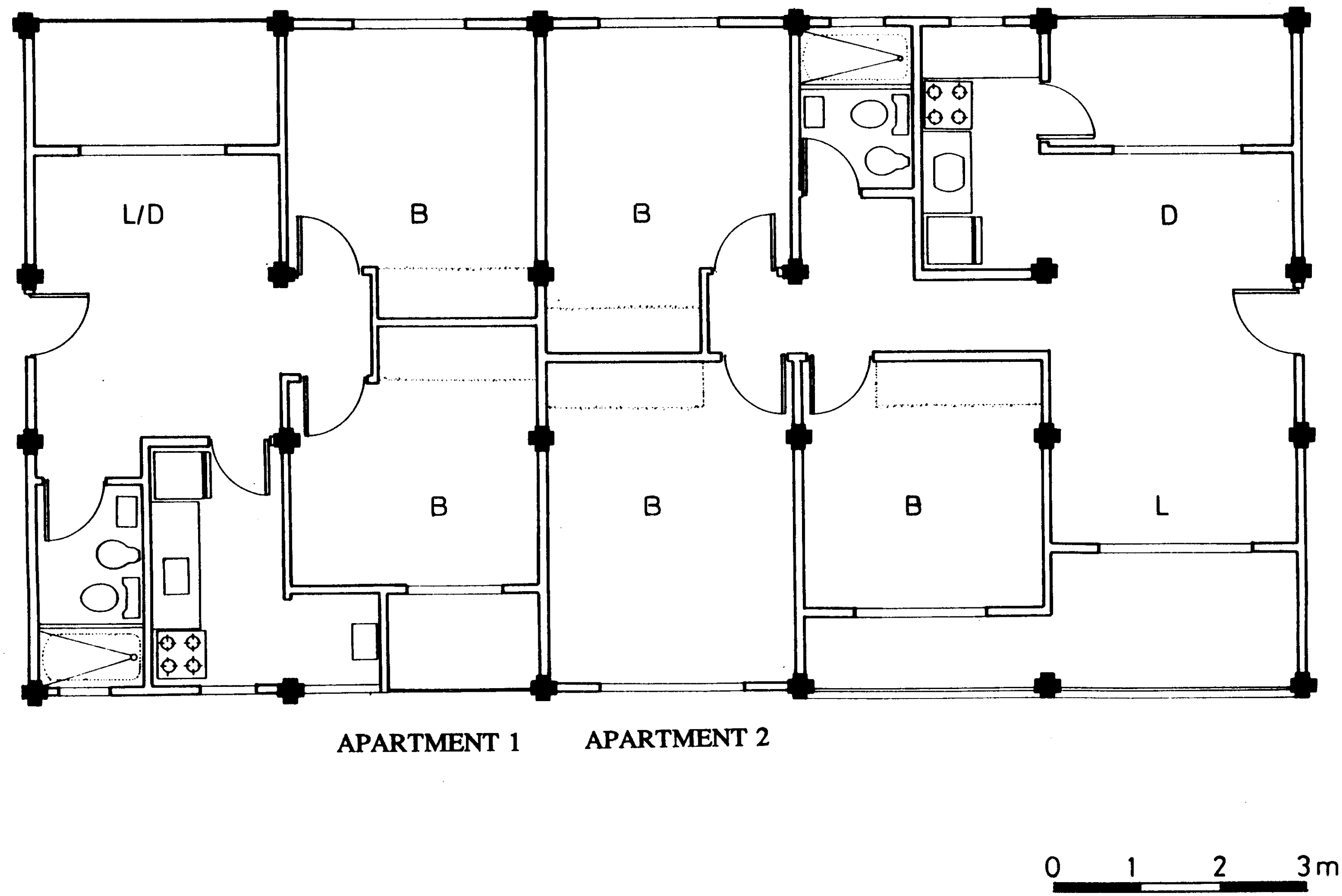


POSSIBILITY #1

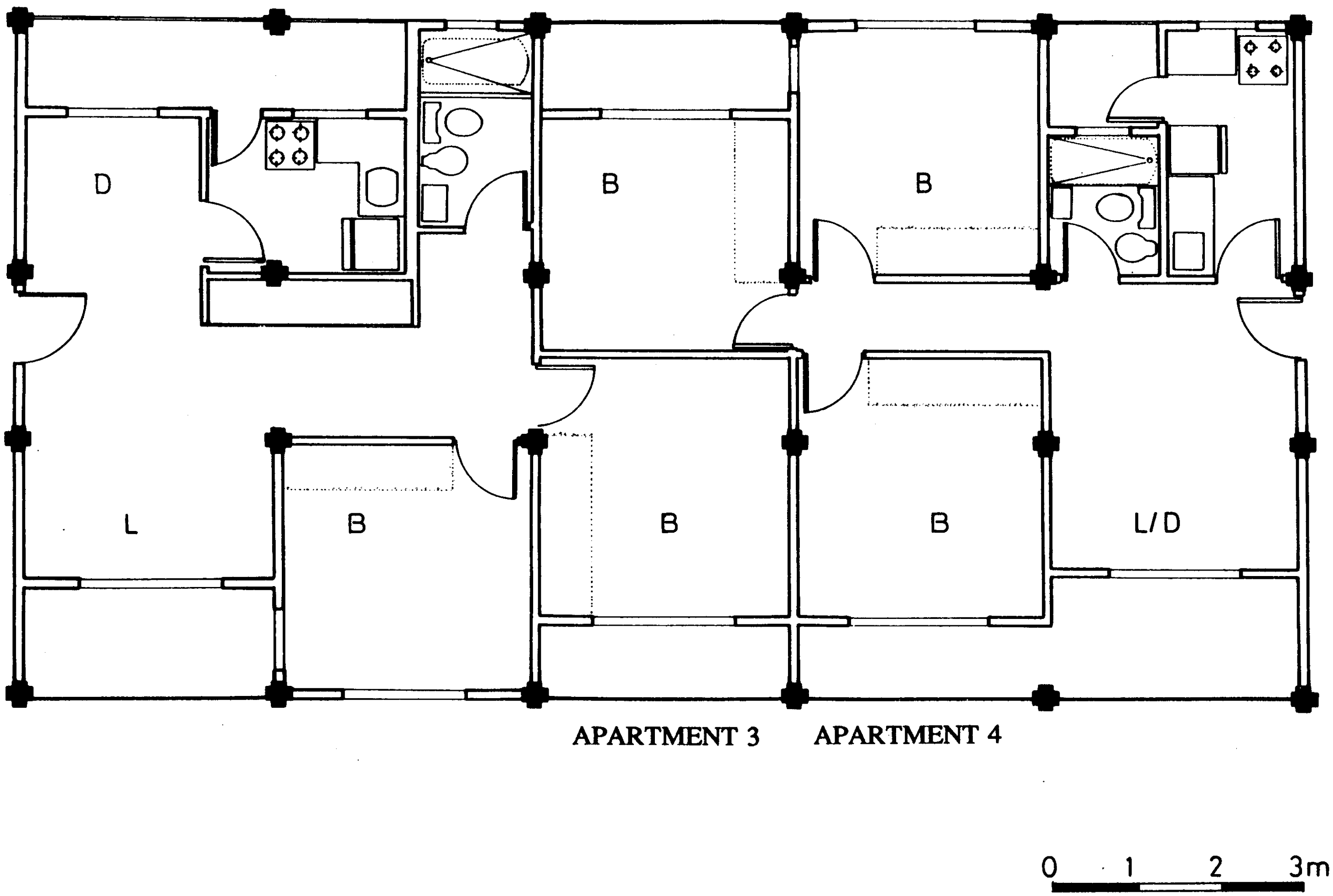
DWG. #26: EIGHT VARIATIONS OF APARTMENT LAYOUT IN SUPPORT STRUCTURE: POSSIBILITY #1



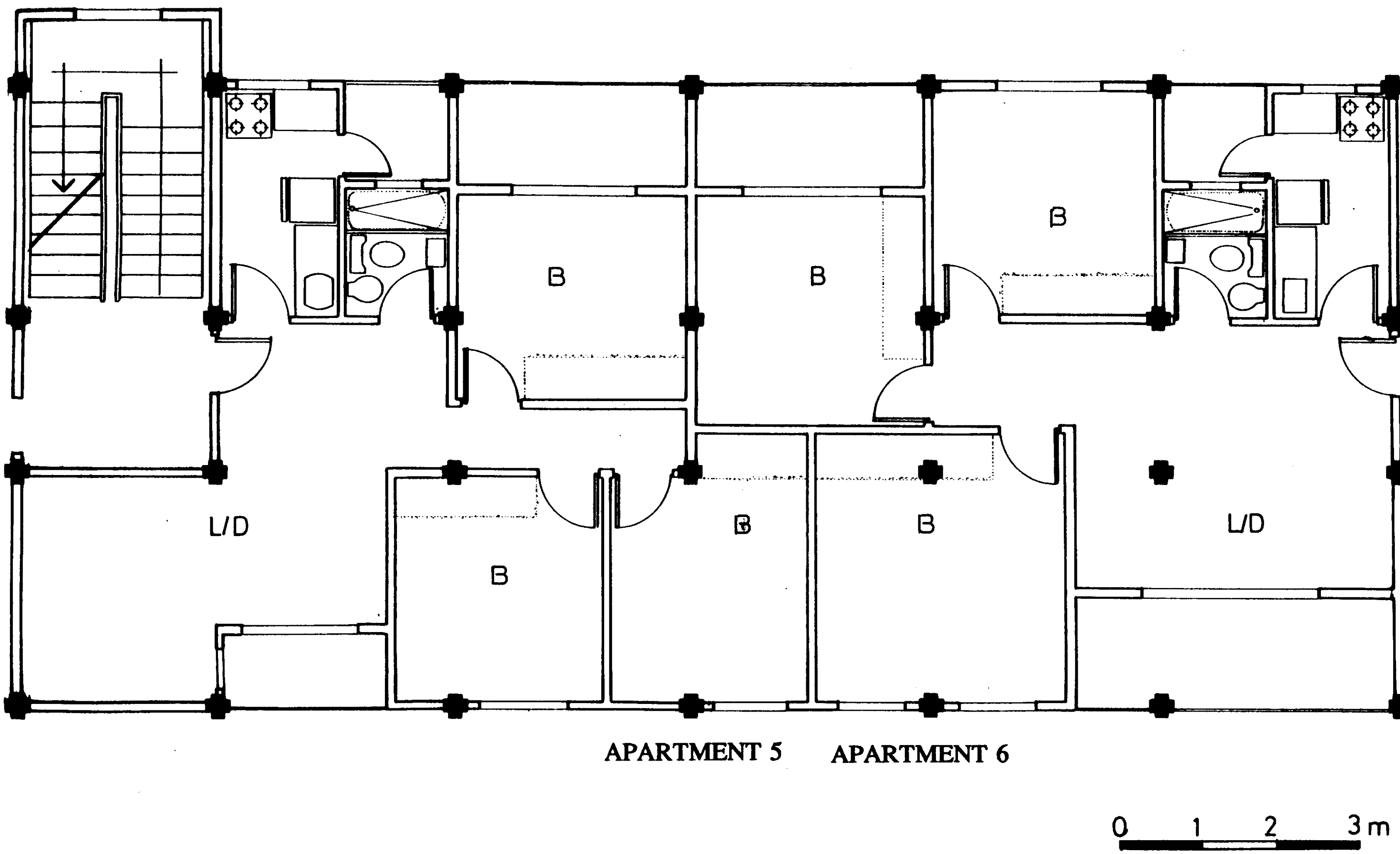
DWG. #27: SUPPORT STRUCTURE; POSSIBILITY #1. INTERNAL ORGANIZATION OF APARTMENTS 1 AND 2



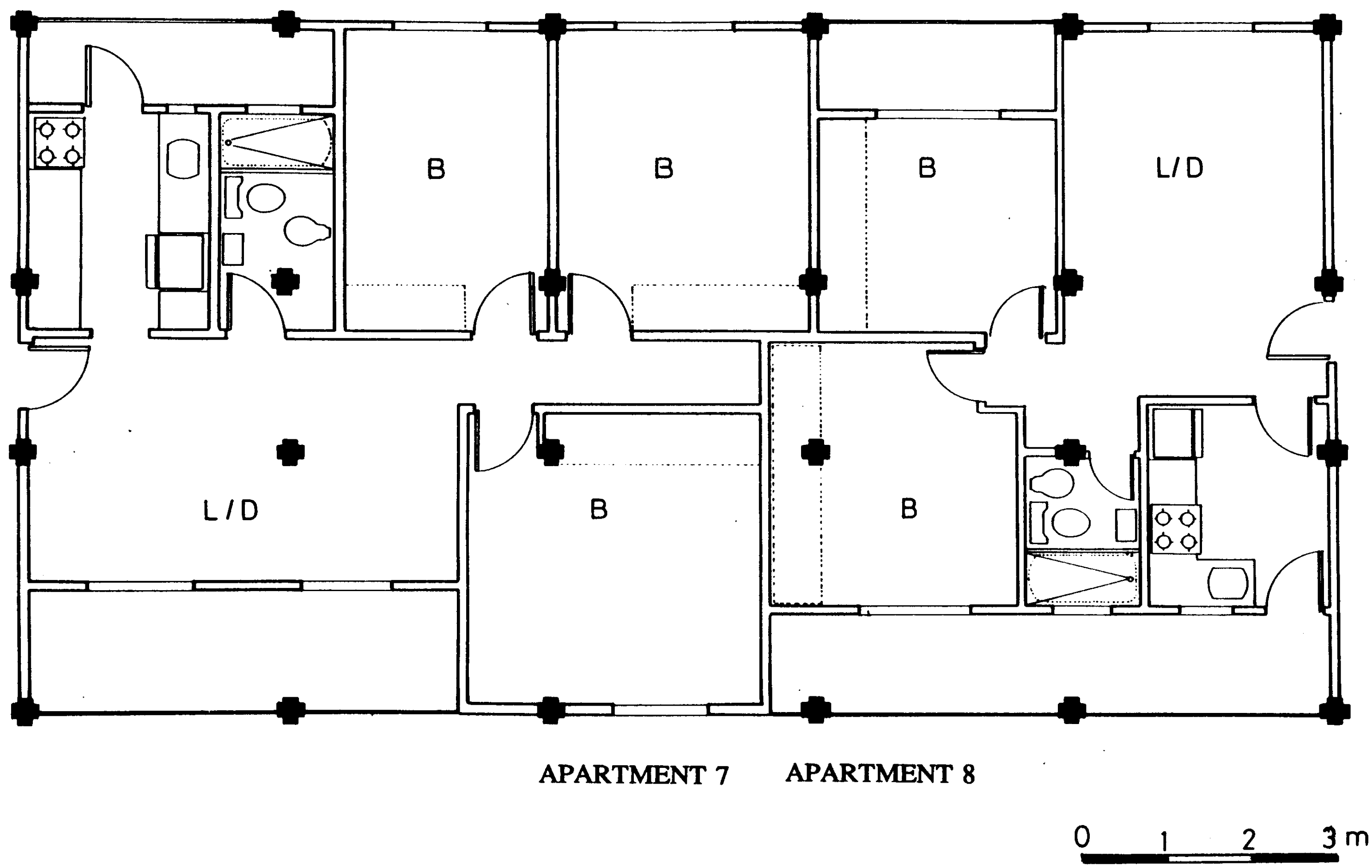
DWG. #28: SUPPORT STRUCUTRE: POSSIBILITY #1. INTERNAL ORGANIZATION OF APARTMENTS 3 AND 4



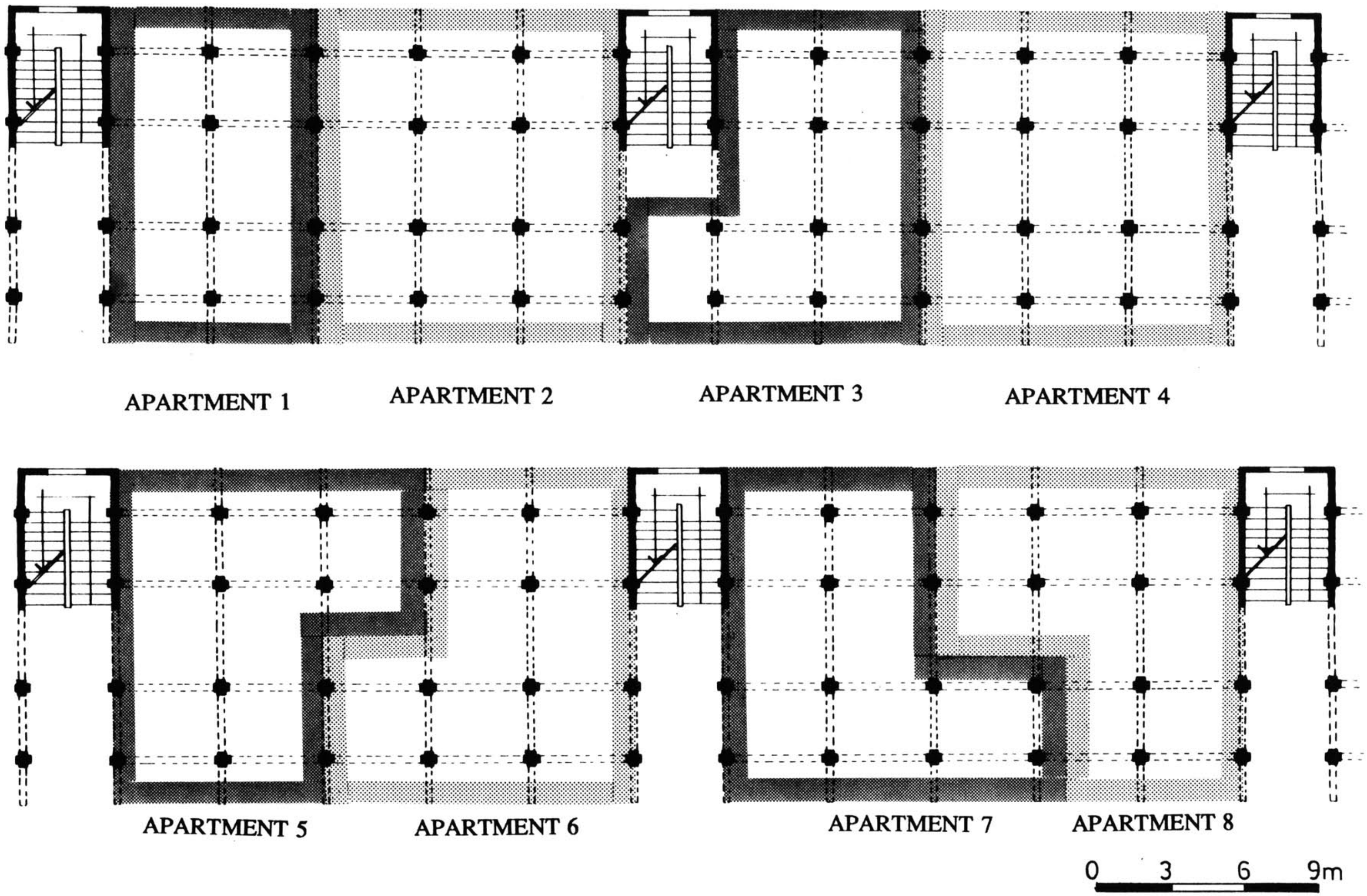
DWG. #29: SUPPORT STRUCTURE: POSSIBILITY #1. INTERNAL ORGANIZATION OF APARTMENTS 5 AND 6



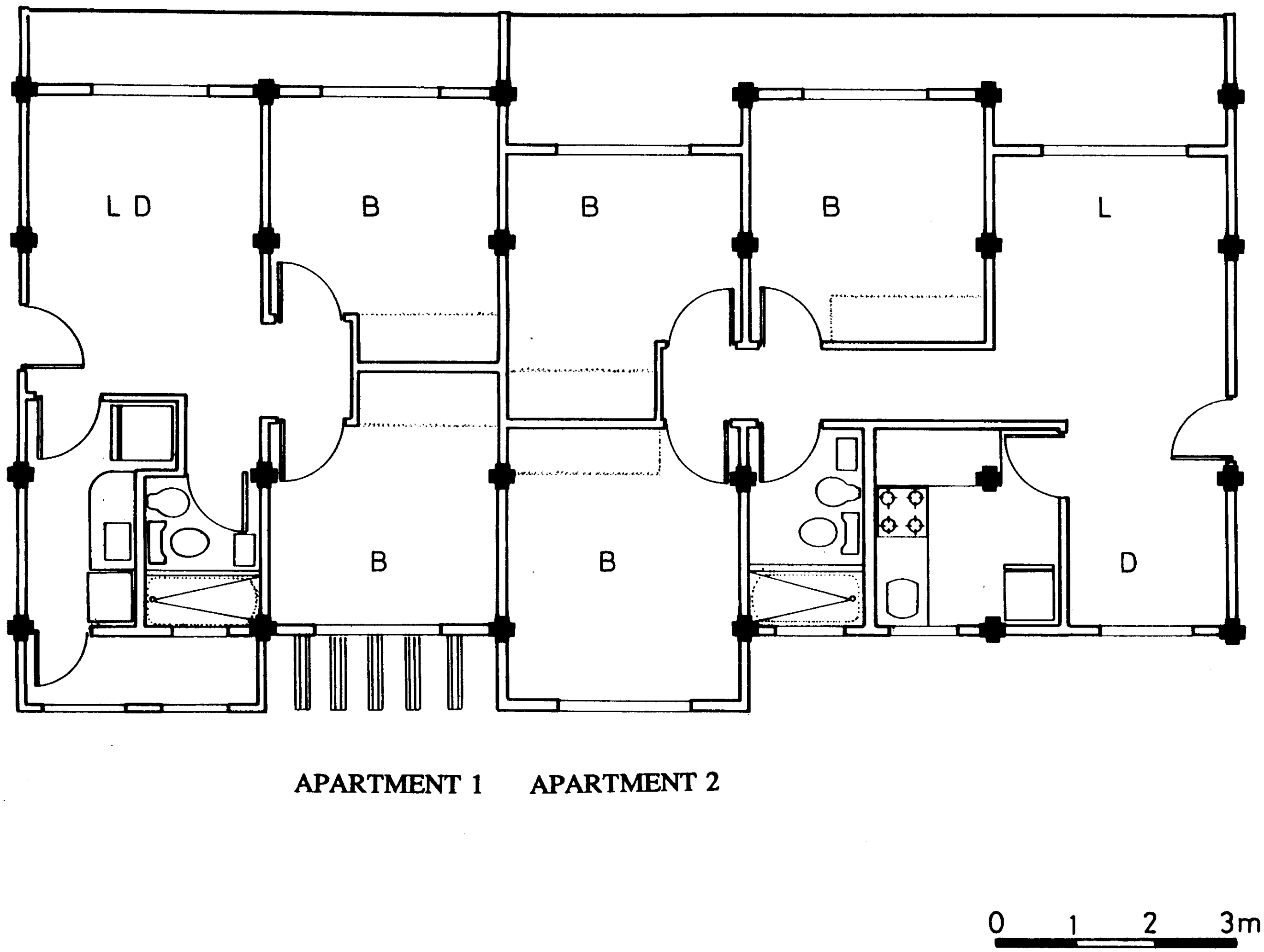
DWG. #30: SUPPORT STRUCTURE: POSSIBILITY #1. INTERNAL ORGANIZATION OF APARTMENTS 7 AND 8



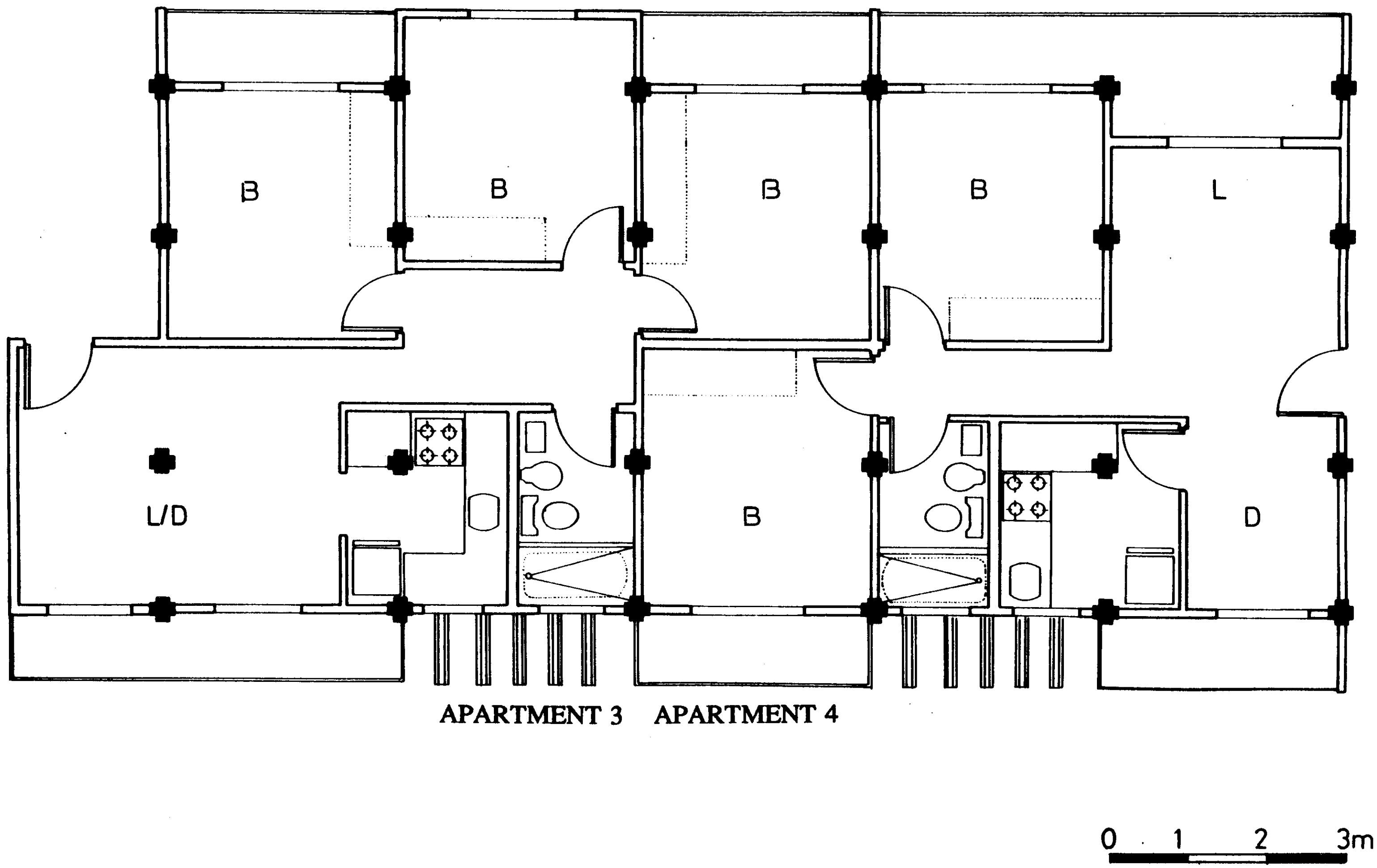
DWG. #31: EIGHT VARIATIONS OF APARTMENT LAYOUT IN SUPPORT STRUCTURE; POSSIBILITY #2



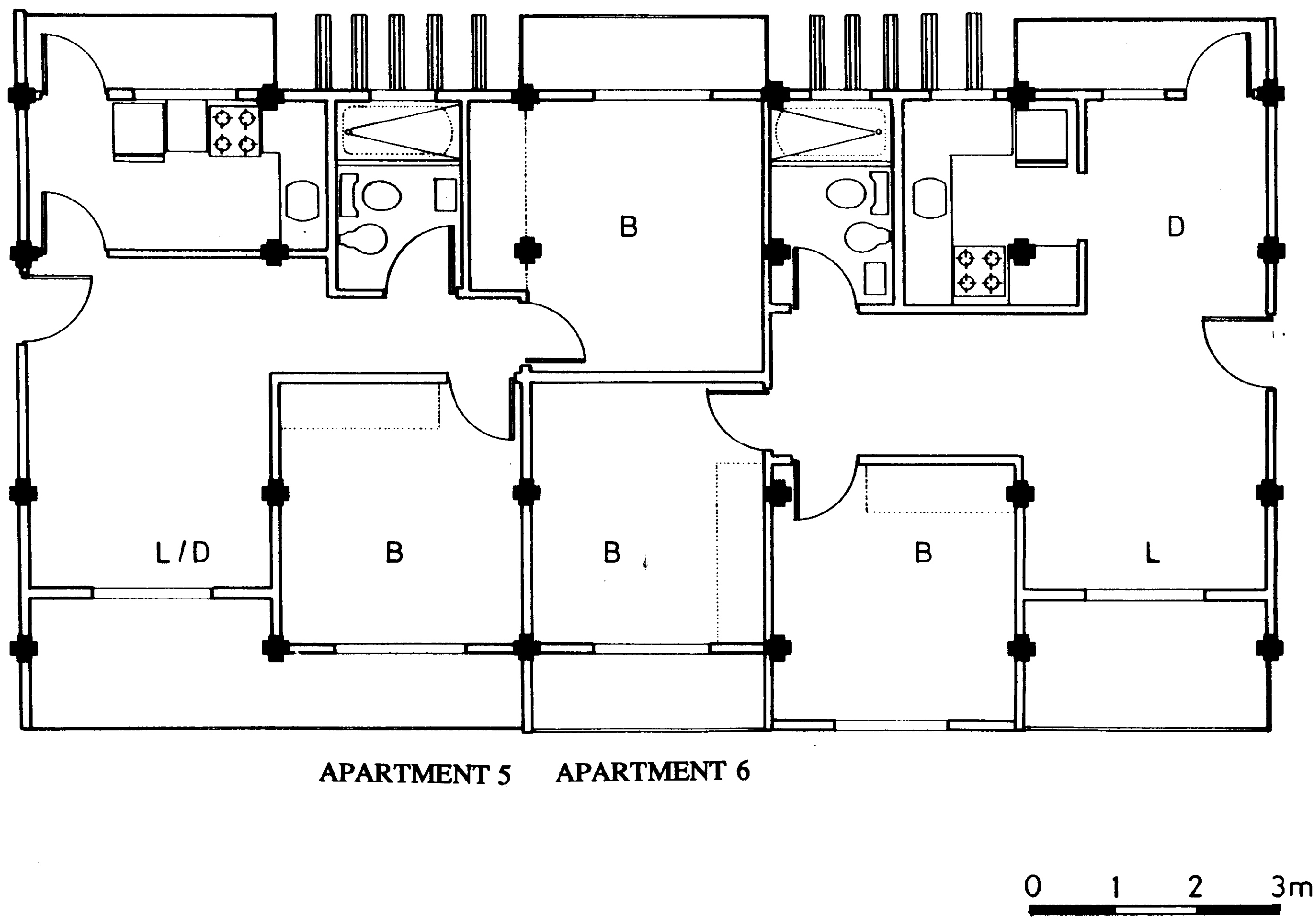
DWG. #32: SUPPORT STRUCTURE; POSSIBILITY #2. INTERNAL ORGANIZATION OF APARTMENTS 1 AND 2



DWG. #33: SUPPORT STRUCTURE; POSSIBILITY #2. INTERNAL ORGANIZATION OF APARTMENTS 3 AND 4

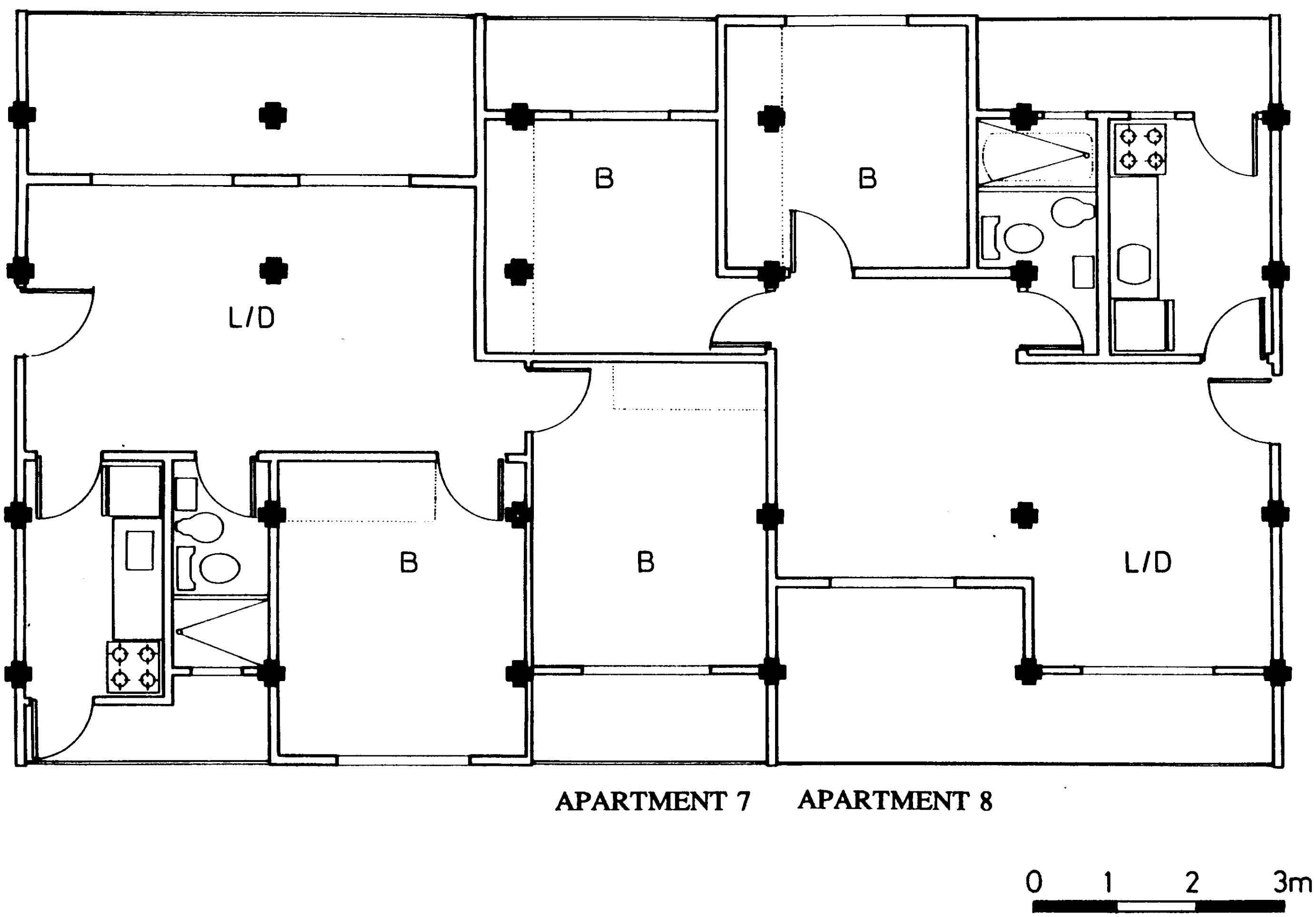


DWG. #34: SUPPORT STRUCTURE: POSSIBILITY #2, INTERNAL ORGANIZATION OF APARTMENTS 5 AND 6

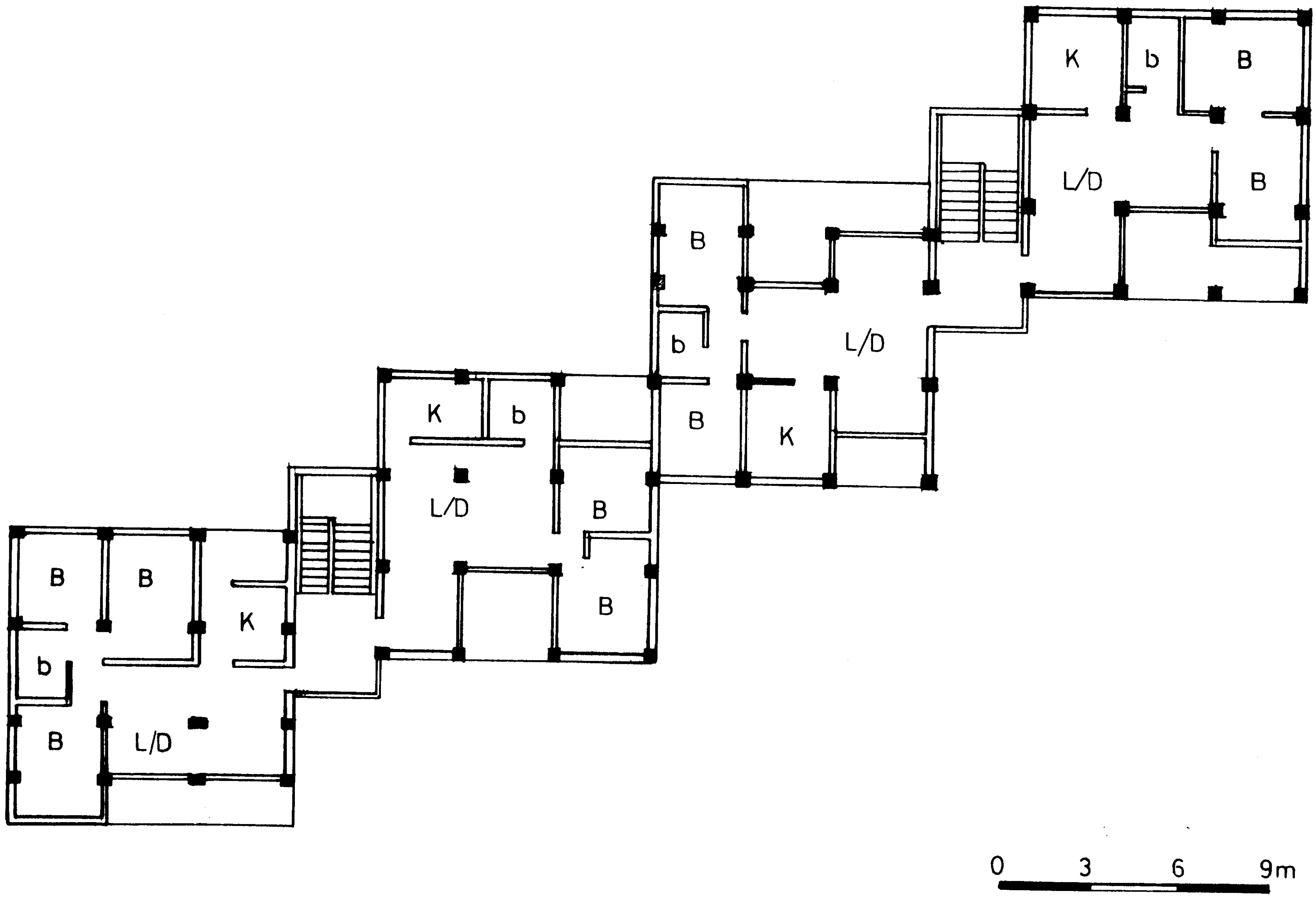


APARTMENT 5 APARTMENT 6

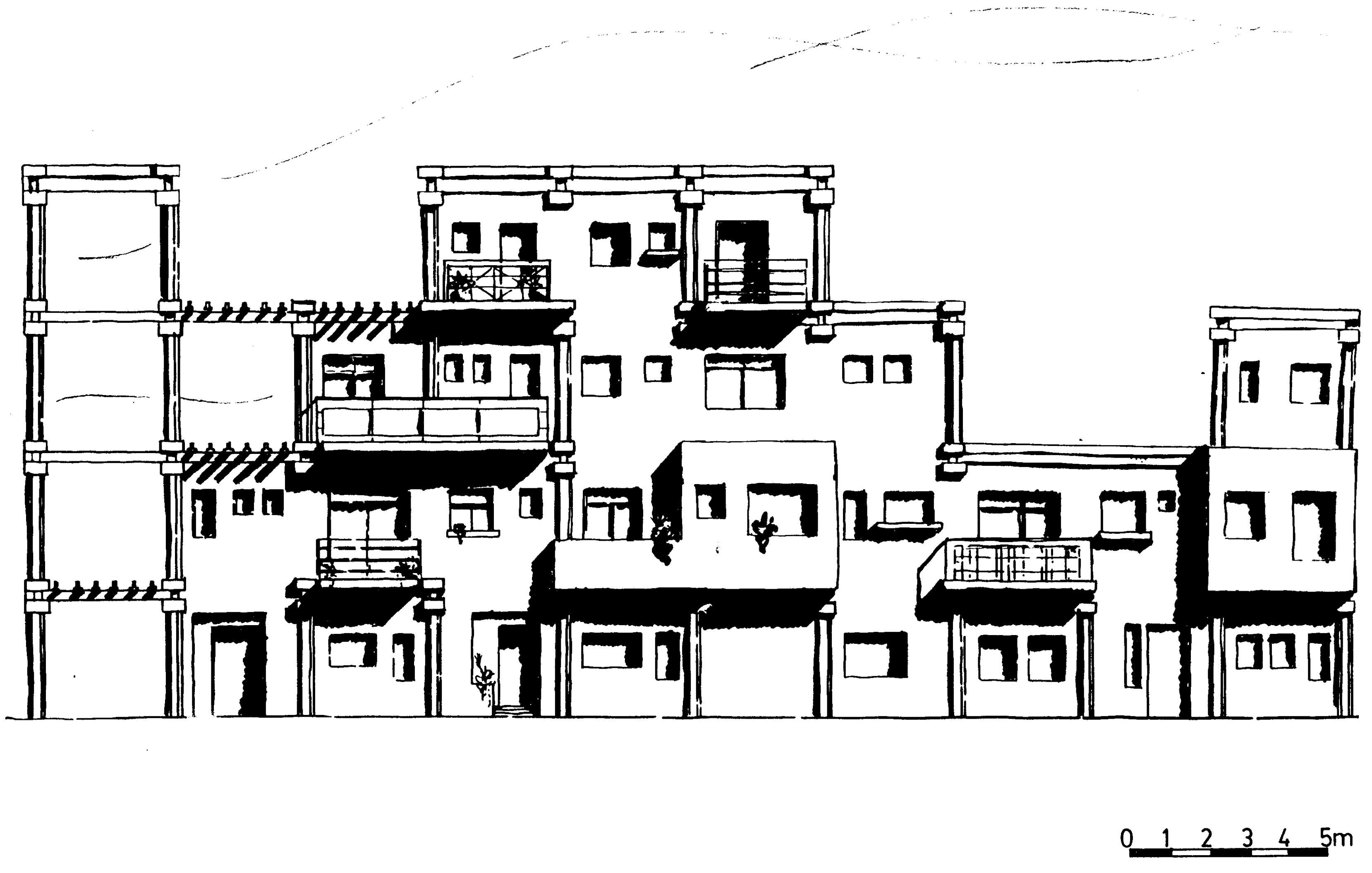
DWG. #35: SUPPORT STRUCTURE; POSSIBILITY #2, INTERNAL ORGANIZATION OF APARTMENTS 7 AND 8



DWG. #36: APPLICABILITY OF THE SYSTEM TO IREGULAR SITES



DWG. #37: POSSIBLE INHABITED SITUATION: INFILL FACADE



CONCLUSION.

The provision of appropriate housing for all the people of the low-income sector has proven to be difficult, not only in Argentina, but throughout the world. Public and private initiatives tried to solve the problem by various strategies, such as sites and services, core houses, shell houses, and fully finished, minimum standard high-rise buildings, these last ones usually provided by means of prefabricated "closed" building systems. None of these approaches have succeeded entirely, mainly because of two factors:

1) An excessive centralization in terms of decision-making and resource allocation

2) An inappropriate use of prefabrication techniques of the building industry, adopting rigid solutions reluctant to change over time.

The main objective of this study was to propose a Building System capable of allowing for flexibility in the design of low-income housing projects, and for residents´ intervention in different stages of the design and construction process.

The System Approach was suggested in the design of the proposed system, to solve, in an ordered manner, the problem of low-income housing provision.

Considering the building as a whole, and subsequently, proceeding from the general to the particular aspects of the design, the System Approach provides the tools to analyze goals and the means to achieve them in order to facilitate the design of successful buildings. In this sense, the System Approach can be considered as conceptually applicable to any context, and physically, applicable to many diverse building types. In addition, the System Approach allows for interventions in the built environment in accord with dwellers´ needs as a primary concern.

Special emphasis was also placed on "dwellers participation" theories based on experiences that showed peoples´capacity to participate in the process of planning, designing, and building their dwelling. However, it was acknowledged that, even though these participation theories are usually proposed as cure-all solutions, they are not a panacea for the apparently intractable problem of meeting dwellers´ needs.

As a result, the SAR approach was adopted to allow for a balanced interaction between governmental and individual interventions in the environment.

Its basic premise is the conceptual division between the physical "Support" elements of the dwelling (which are determined by long-term communal needs) and the secondary "Infill " elements (which respond to individual choice or needs and are subject to change over short periods of time). Such a differentiation between primary and secondary elements of the dwelling permits both qualitative and quantitative response to change and adaptation in terms of higher living standards and improved technical equipment and processes. The essential feature of the "support" approach is its ability to direct future transformations rather than merely containing them.

In consequence, a Building System composed of precast, reinforced-concrete small-components was proposed as a possible solution to satisfy the issues of dwellers´ intervention and flexibility in design, mentioned before and developed in more detail in previous chapters.

By being an open system, the kit-of-parts frame system proposed broadens the possibility of designing diverse internal arrangements of individual units as well as multiple volumetric patterns of the whole project in relation to the site´s characteristics.

Numerous studies related to building systems have confirmed that, within a fixed plan of buildings designed by means of "closed systems", changes are costly, time-consuming and more often than not, impossible to accomplish. A rigid pattern of interior partitions or structural elements can pose great obstacles to any alteration, resulting in a shorter building life time.

Accordingly, rather than facing change in an ad-hoc manner resulting from lack of anticipation of probable changes, this work proposed the design of a system which responds to demands of layout variations, upgrading and expansion, providing explicit means to accommodate change by exploring the spatial potential of the "support" structure proposed.

Thus, the examples shown in this proposal should not be seen as " ideal" solutions of conventional mass-housing production.

Conversely, they should be seen as representative of a process of analysis, allowing for future change by testing the capacity of a given "support" to accommodate the broadest possible range of plans within a given context of life-style parameters and a given range of technical options.

In conclusion, the complex problems originated by the lack of adaptability to change and by the reluctance to consider dwellers´ influence in shaping the living environment, are beyond the capability of currently used prefabricated building techniques, and thus, different building systems more adaptable to change are required.

In the light of the above, the open building system and the methodological approach proposed in this work become a promising alternative which combines traditional construction methods and recognition of the country´s cultural heritage with technological improvements. However, in order to be implemented, this solution would require a deeper consideration of the programmatic, technical and economic factors pertaining to the complex problem of providing a human responsive dwelling environment to the low-income people of the developing countries.

REFERENCES

[1] "External Debt and Social Inference in South America", Extract of International Monetary Fund Conference, Buenos Aires, 1983.

[2] "Desarrollo Experimental de la Construccion", Facultad de Arquitectura y Urbanismo, Buenos Aires, 1985.

[3] Habraken, N.J., "Interventions: Professional and User Input. Design for Adaptability, Change and User Participation", Mimar Vols. 15-18, #15.

[4] Dluhosch, E., unpublished lectures notes, 1985.

[5] Brandle, K., "The System Approach to Building: A Core of Information", I.F. Vol. 1, #1, 1969, pgs. 19-22.

[6] Ibid., pgs. 53-54.

[7] Bender, R., A Crack in the Rear-View Mirror. A View of Industrialized Building. Van Nostrand Reinhold Company, New York, 1973, pg. 9.

[8] Dluhosch, E., "Constraints of Conventional Prefabrication Systems in Housing", class notes, 1981.

[9] Dluhosch, E., "The "Support-Infill" Approach to Housing (SAR Methodology)", International Conference on Low-Income Housing-Technology and Policy, Bangkok, Thailand, June, 1977.

[10] Dluhosch, E., "Housing and Construction Industry in Egypt." Working Papers 1978.

[11] Dluhosch, E., unpublished class notes, 1987.

[12] Parsons, D., "Building Performance: Concept and Practice", I.F., Vol. 3, #3, 1972, pgs. 23-32.

[13] Perez de Arce, R., "Urban Transformations and the Architecture of Additionns", Architectural Design 4/78 pgs. 237-266.

[14] Habraken, N.J. and Dluhosch, E., "The Role of Industrial Production for Increasing Housing Production in the Low-Income Sector in Egypt", Ekistics 280, Jan./Feb. 1980, pgs. 51-52.

[15] Sebestyen, G., "What Do We Mean by Flexibility and Variability of Systems?", Building Research and Practise, November/December 1978.

[16] Alexander, C., A Pattern Language, Oxford University Press, New York, 1977, pg. 1070.

[17] Ibid., pg. 1014.

[18] Ibid., pg. 951.

BIBLIOGRAPHY.

- Habraken, N.J. and Dluhosch, E., "The Role of Industrial Production for Increasing Housing Production in the Low-Income Sector in Egypt", Ekistics 280, Jan./Feb. 1980.

- Habraken, N.J., Supports: An Alternative to Mass-Housing, The Architectural Press, London, 1985.

- Habraken, N.J., Transformations of the Site, A Water Press, Cambridge, Massachusetts, 1983.

- Habraken, N.J., Boekholt, Thijseen and Dinjens, Variations: The Systematic Design of Supports, MIT Press, Cambridge, Massachusetts, 1976.

- Kroll, L., An Architecture of Complexity, The MIT Press, Cambridge, Massachusetts, 1987.

- Habraken, N.J., "Interventions: Professional and User Input. Design for Adaptability, Change and User Participation", Mimar Vols. 15-18, #15.

- Sherwood, R., Modern Housing Prototypes, Harvard University Press, Cambridge, Massachusetts, 1978.

- Dluhosch, E., "Design Constraints of Conventional Prefabrication Systems in Housing", class notes, Department of Architecture, MIT, Cambridge, Massachusetts, 1981.

- Dluhosch, E., "Strategies for the Design and Delivery of Staged Housing", class notes, Department of Architecture, MIT, Cambridge, Massachusetts, 1985.

- Dluhosch, E., "Involving People in the Housing Process- the Story of Habraken´s Supports and Detachables", I.F., Vol. 7, #1, 1979.

- Caulfield, D.A. and Handa, V.K., "The User´s Role in Programming and Design", I.F., Vol. 5, #5, 1984, pgs. 56/59.

- Fischer, R., "System Building: What it Really Means?", Architectural Record, Jan. 1979, pgs. 157/168.

- Sittipunt, P., The Systems Approach to Buildings: a Study of Systems Building Development, S.M.Arch.S. Thesis, Department of Architecture, MIT, June 1984.

- Solana, M.B., Evolving Building Systems fot Expandable Housing by Means of Corrugated Metal Sheets, S.M.Arch.S. Thesis, Department of Architecture, MIT, June 1986.

- Alexander, C., A Pattern Language, Oxford University Press, New York, 1977.

- Enrenkrantz, E., "The System to Systems", A.I.A., May 1980, pgs. 56-59.

- Heath, T., "Programming and User Involvement: An Issue Based Approach", I.F., Vol. 5, #5, 1974, pgs. 3-8.

- Rabeneck, A., "Whatever Happened to the Sysrem Approach?", Architectural Design, Vol. XLVI, May 1976, Pgs. 298-303.

- White, J., "Improved Building Procurement Means a Changed Building Process", I.F., Vol. 5, #1-2, 1974, pgs. 39-44.

- Berndt, K., Prefabricacion de Viviendas en Hormigon, Editorial Blume, Madrid, Spain, 1970.

- Meyer-Bohe, W., Prefabrication, Editorial Blume, Barcelona, Spain, 1976.

- Weber, J., "Some Physical and Non-Physical Aspects of the

Support-Infill COncepts in Contemporary Building Practice", I.F., Vol.7, #1, 1976.

- Froyen, H.P., "Structures and Infills in Practice- Four Recent Projects", I.F., Vol. 7, #1, 1976.