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# Systems and Standards in American Building: Research and Design

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# SYSTEMS AND STANDARDS IN AMERICAN BUILDING

RESEARCH AND DESIGN

by
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PREFACE

Coming from Switzerland and having an European background I was fascinated to encounter a different approach towards building in the USA. It is interesting to see how simple buildings like single family houses but also complex structures like skyscrapers are built with a similarly rational and economical attitude.

This thesis is subdivided in two parts. The first part describes the specifically American properties of building and the historic circumstances that led to the present situation. This research leads over to the second part, a design for a prefabricated housing system which tries to combine the rational American way of construction with more European concepts of high-density housing.

## HISTORY

When the first settlers landed in New England, they were very badly prepared for the climatic conditions they encountered on the new continent. Nothing in their European experience prepared them for the severity of cold winters and the heat of the summers. In Plymouth, England, they left a moderate climate with stable temperatures, without very cold winters or very hot summers. In Plymouth, Massachusetts, they found a climate with a temperature spread more than twice as great as in England. They experienced tornadoes and cyclones, heavy snowfalls and long freezes for the first time.

The urgent need for shelter was therefore obvious. At first they had to live in sod huts and dugouts, which means that they were living in dwellings on a lower technological level than the Indians were at this time in their bark-and-bent-wood "long house".

Unlike other territories where European settlers found an indigenous architecture they could adapt for their own use, like the Spanish in the South West of America, where they found mud masonry buildings quite similar to their own building technology, the settlers did not encounter an indigenous architecture, because the Indians in the North West were still nomadic hunters. The Indians of the Pacific Northwest had a quite highly developed wooden architecture, but contact with the settlers did not occur until the nineteenth century, when a white American building technology was already developed.

The result was that American architecture began with the import of building concepts and techniques from Europe, developed for different climates and conditions and not especially well suited for the New World. But two characteristic tendencies came up already at this time: the need for speedy development of new architectural forms appropriate to the New World and the necessity for the colonists to do all the work by themselves.

Although almost all the settlers arrived as members of planned expeditions, it seems that the first ships not only forgot to bring carpenters and masons, but also adequate building tools. However they soon discovered their error and were ordering specific types of skilled building craftsmen. They sent also detailed lists of tools required and allowed each immigrant family to take a set of carpenter tools with them for their new home.

There was more than enough raw material. They found vast resources of wood, stone, marble, slate, sand and clay. However, access to these materials is one thing, converting them to building products is something else.

More or less all the colonists were familiar with the then standard structural systems: wood framing, brick and stone masonry. The great all masonry construction of the Gothic period never has been a popular building technology in the sense that it was used for common housing, it was limited to representative buildings, like the enormous cathedrals. Although uncut stone was used in some parts of the colonies, it was never a real competitor to brick. Its small size, standardized production and general availability made it the predominant masonry material.

But soft wood was to become Americas principal building material, because it was available in abundance throughout the East of the USA. It was also the only compressive and tensile material available for framing floors and roofs and has a relatively easy workability. Compared to the production of bricks, requiring kilns for the production, everybody could with a few tools fell a tree and saw it into framing members.

The English unquestionably brought their woodframing system, consisting of a wooden skeleton with brick infilling. However it was crude and inexact, moreover English wood frames turned out to be unsuited to the new climate. In the moderate English climate the movement of the frame was minimal, but on the new continent abrupt and violent temperature changes led to cracks between frame and infilling, which reduced the efficiency of the wall.

At first the colonists merely covered the medieval English frame with two relatively impervious skins, clapboard on the exterior, plaster on the interior, but ultimately the bricks disappeared altogether. Naturally it was a long process of small changes here and there, which resulted in a characteristic American system. Since wood was the most abundant and easily workable material in the new continent and since many settlers were thoroughly familiar with it, it is not surprising that they adopted it as their favorite material. Surprising however is the application of a relatively sophisticated system like wood framing, which provided most efficient structures, but also implied most advanced equipment.

Both English and Dutch were familiar with pitsawing, long straight saws operated by two men, one above, one below the trunk. But as hand labor was scarce and too slow for their needs they mechanized pitsawing. So they were establishing, as early as thirteen years after the landing of the first settlers, their first powerdriven sawmill at the falls of Piscataqua between Maine and New Hampshire. Before there were any mills in England, the colonists had mechanized the process.

In the following centuries a giant lumber industry would arise, stimulated especially by the appearance of steam powered sawmills at the end of the eighteenth century. However the development of the most American of all wooden structures, the balloon frame, had to wait for the emergence of both standardized, sawn lumber and cheap, industrially produced nails. Until then the wood skeleton had to bee assembled with mortise-and-tenon and hardwood pegs. Because of these connections framing members had to be bigger than the required structural depth and skilled carpenters were neededfor their fabrication.

The industrialization started an actual revolution in the building field. The price for nails dropped from 25 cents a pound at the beginning of the 18th century to three cents in 1842. Nailed connections became timesaving and are much easier to produce, especially with the use of soft pinewood. But they require slender pieces for firm connections, that's why framing members were be slimmed down dramatically and through steampowered sawmills lumber became industrially produced in standard sizes. Trunks were generally cut in two-inch boards, which was very economical because very little waste was made. These conditions enabled the development of the balloon frame, one of the biggest inventions of the American building technology. Two-by-four studs running along the whole height of the building were set up, usually spaced 16 inches on center, only held by nails. That must have been revolutionary for carpenters. This invention practically converted building in wood from a complicated craft into an industry. Skilled carpenters were replaced by unskilled laborers, as everybody equipped with hammer and saw could build an entire house. The conquest and the settlement of the West wouldn't have been possible in such a short time without the balloon frame. Sometimes entire houses were precut somewhere in the East and then shipped in parts to the West, where they were erected in two, three days. For the first time buildings were produced thousands of miles away from their location. This evolution dominates still, almost twohundred years later, the housing market. About eighty percent of all individual houses are built with typical wood framing, which is very different from European framing. All members have slender proportions and are spaced closely. Floors require bridging in order to prevent torsion or twisting of the joists. First it was done with short pieces of two-by-eigths, then smaller sticks placed crosswise between the joists were used in order to save material Several circumstances made this development possible. The East of the USA was covered with immense forests and pinewood was immediately available for everybody, because these forests didn't belong to anybody (except the Indians), in contrast to Europe, where the forests were in possession of the aristocracy. Pinewood is a soft wood, easier to work than hardwood. Compared to masonry, requiring quarries, kilns, etc., wood construction didn't need a big investment in tools and production facilities, especially after the introduction of industrialized lumber in standard sizes. All parts are light and of a rather small size which makes them easy to handle. Furthermore there is basically just one trade involved, the carpenters. So building an individual house became very simple and the frame construction is so flexible that later changes or additions are equally simple.

The other true American invention is the skyscraper, which had an incredible influence on a lot of different aspects in the building field. But several events and developments had to happen before the construction of a skyscraper became possible.

Under the constant threat of great fires new fire-proof buildings were built consisting mainly of brick and heavy timber beams. Another reason for the replacement of wood frames is the limitation to usually two to four floors. Growing land prices and the concentration of commerce in the cities required higher structures to use property economically.

The industrialization brought epoch-making innovations. At the beginning of the last century the production and the treatment of iron became practicable. Experiences made in the fabrication of steam-engines were adapted to the building field. One of the pioneers was James Bogardus. Having passed an apprenticeship as a watchmaker, he held patents for clocks, an eccentric sugarmill, a dry gas meter etc. 1848 he constructed one of the first iron fronts in New York. The structure still employed brick party walls and timber beams. It took only three or four days to erect the whole facade. The new idea of mass-production came up with the fabrication of iron facades. An almost unlimited reproduction of the same piece with one single casting mould became possible. In fact Bogardus employed the same moulds for different commissions several years after his first iron wall. The reason was to save time between the award of the commission and completion. Iron fronts became fashion and strong production arose. Because of the civil war large industries for weapon production and a dense railroad network came into being. These infrastructures became available for the construction field and iron walls produced in New York were shipped as far as San Francisco.

The Chicago Fire of 1871 marks the next step towards the skyscraper. Up to this point floor construction and partitions in buildings were still made out of wood. Large commercial Buildings employed largely brick with wood floors and roofs supported by cast-iron columns and sometimes cast-iron beams. The so-called "fire-proof construction" turned out to be a tragic misunderstanding, the exposed cast-iron members melted into a completely fluid state.

This event led to the introduction of complete fire-proofing. Floors were constructed of hollow tiles and exposed iron members covered with the same material. Two of the greatest sources of danger in the event of fire were eliminated. The hollow space enclosed by the extremely fire-resistant tiles acted as an insulator and the iron could be prevented from deforming. The inflammable materials were considerably reduced.

Another step was the invention of the elevator. Till then buildings were limited to five or six stories. Rooms above this limit could not be rented. Suddenly this limitation was overcome. New York was the origin of the iron facades, now it was Chicago for a new building type, the so-called "elevator buildings". Within a few years dozens of twelve or more stories high buildings were constructed. But they still had loadbearing walls with an internal column-and-beam construction. The Monadnock building with its seventeen stories represents the final point of this development. The load bearing facade had reached the limit.

In the meantime a strong steel industry had developed. Cast and wrought iron were already available for almost a century in sufficient amounts for building purposes. The first step towards the concept of the skeleton frame and curtain wall was made in 1879, when William LeBaron Jenney built the First Leiter Building. He introduced rectangular cast iron columns to the inner faces of the east and the west walls and piers to support the timber girders of the floor system. On the facade each bay had triple windows divided by two mullions running continuously to the roof. The windows were carried by cast-iron lintels supported by the mullion columns and at the ends by the masonry piers. Four years later, 1883, Jenney constructed the first true skeleton frame, the Home Insurance Building. A clear separation between load-bearing structure and enclosure appeared for the first time. Thanks to the properties of the meanwhile introduced Bessemer-steel to withstand great compressive and tensile stresses with a minimal amount of material it was now possible to build to almost unlimited heights. The facade now only had to separate the inside from the outside.

One can call this new construction concept revolutionary. In an almost scientific manner a building is dissected in different parts. Every part now has one clearly defined function and is made of a material best suited for its function.
Naturally this concept didn't just happen by itself. In the big cities there was a growing demand for higher and higher buildings and a shorter and shorter construction time. Due to the increasing complexity of execution of a building the architect didn't manage the construction himself, the new profession of the general contractor came up. In the same way the building is separated in different parts, like structure, enclosure, partition, e.t.c., also the process of the different activities are clearly organized and defined. In order to save time the different activities are coordinated closely. So for example the setup of the curtain wall starts before the structure is completed.
It seems so obvious to us nowadays, but with this then new building concept a lot of new ideas arose, which still are valid almost a century after their introduction.
Construction is seen as mere assembly of mass produced parts, seen in contrast to the cut-and-fit method or the production of the parts on site. These parts may produced hundreds of miles away from the location of the building and then shipped at the proper time as needed. The workmen on the site have clearly defined activities and there are a wide range of very specialized trades.

## Designprocess

To see the specific responsibilities of an architect in America for the design- and building process, we have to look at the situation of the European architects. Because design and building process are not clearly separated, like in the USA, but overlap each other, design work is still proceeding after the start of construction. The European architect has the role of the coordinator of the different trades. He usually keeps the responsibility from the first design up to the completion of the building and its handing-over to the owner.

He designs the project, gains the building permit from the authorities, takes care of the financing and procures bids from contractors of the different trades. Then follows the supervision of the construction. But this is not a linear process. During the construction of the structure  the design and calculation of secondary elements (e.g. interior equipment) is still in progress. He also controls and adjusts the budget, but he usually does not guarantee a fixed price for the whole building. One can say that an architect in Europe acts also as a "general contractor" and keeps control up to the finished product as almost every building is custom made. But there is also a tendency towards specialization of functions perceptible, especially for large building projects where the architect looses his role of a generalist and becomes more a specialist.

Compared to that the situation of an American architect is very different. One aspect is that architects are usually not involved at all in the production of individual houses, which take up the biggest volume of building in the USA, because the construction is much simpler than in Europe, since there is basically only one trade, the carpenter, required for building a single family house. The typology is simple and is available in many variations, so that there is no need for design work and coordination. A future building owner is likely to select his house from a catalogue and requests for changes are  executed by the general contractor.

For that reason architects are mainly designing large scale buildings, custom designed houses or apartments for upper class clients. Because a lot of commissions are for buildings of a very large size, there are a lot of architectural firms of a big size and very often with branches in different cities (e. g. SOM).

But there is one very significant difference from architects in Europe. The profession in the USA is much more specialized. It requires a great deal of organization to construct a building, especially in the big cities, where there is merely no storage space available and every part has to be delivered to the minute and immediately put in place. In addition there is the pressure to complete a building in very short time because of high mortgages. That brings in the role of the general contractor. He is responsible for the execution of construction. The usual process in the USA is that the architect designs a building down to the last detail, writes the specifications and then obtains bids from different contractors. The general contractor usually furnishes the basic support services (cranes,forms,etc.) and the supervision of the subcontractors. He furnishes the prices according to the specifications, but also a breakdown of different trades and sequence of the building process. That means that he and not the architect organizes the realization of the building. The architect gives different choices for parts like windows e.t.c. in specifications, but they need to be approved. The general contractor also has to get an approval of the different sub-contractors by the architect.

The architect's responsibility is to check the bids and the sequence, that means he needs an understanding of building. He controls the shop drawings, approves material samples and supervises the general contractor. In case a general contractor goes bankrupt during construction the architect is liable for the completion. But there are certain security measures to protect the architect and the owner. A contractor has to submit a bid bond of 5% at the moment of the award of the contract and a performance bond of 100% prior to construction. The bonding companies now determine how much credit a contractor has and the height of a contract he can enter into.

This procedure, complete design by the architect prior to execution by the general contractor was the standard in the USA for decades. But there is a new trend in the construction business. The USA were looking to Europe in order to speed up building. But the development doesn't go towards the architect as a general manager, but towards a further specialization, the new profession of the building construction manager as a consequence of construction mortgage costs. He is employed by the owner and stands between architect and general contractor. His purpose is to start building as early as possible and to keep costs low in order to keep interest payments to a minimum during the period of construction. So building starts already in the sketching phase of a new design.

Consequently it is almost impossible to develop a design that is the best solution and the building quality is equally in danger because of time pressure.

Design itself, detailing in particular, is different from Europe. Custom detailing is in most of the cases too expensive in the USA. Architects have to deal with standard sized products and whole systems on the market. In the same way building products are rationalized, a design has to be rational too. Variations and custom designs are practicable only, if they are not more expensive than standard details. For example, supposing a sufficient number of equal parts, it is possible to fabricate custom designed door frames without additional cost, but the doors themselves to remain standard products. Therefore the goal is to produce a good design with common standardized parts.

## Construction and building parts nowadays

The steel skeleton frame and the successor of the balloon frame, the Western platform frame, are firmly established as the two structural systems employed in the USA. For large scale buildings there is almost no alternative to the steel frame, except for housing.

Until the second world war hot rivets driven with compressed air riveting guns have been popular for shop and field assembly, holes are drilled and connecting angles attached in the workshop simplifying and reducing on-site labor. But this technique was replaced when welding became safe for building purposes. Electric arc welding allowed the simplification of connection between members of the steel frame and therefore saves steel and labour. It was then succeeded by high-strength bolts.

Concrete of course is also applied, but is, compared to Europe, not the main structural material. It is widely used for precast factory-produced elements. Economical reasons sometimes also make concrete preferable to steel, but it has the disadvantages of the field production. An all-concrete structure needs molds to pour in and needs curing time, which can delay the building process. Furthermore the molds have to be dismantled and carried away after completion of the structure. Interesting to see is that concrete structures are treated in a very similar way to steel structures. Only a minimal amount of material is used to form a skeleton. There are no bearing walls. So concrete is mainly used for footings, in connection with steel decking for floors and for precast elements.

In the small-scale building field the balloon frame was succeeded by the Western platform frame. The difference are one-story high wall frames compared to the studs of the balloon frame running along the whole height of the house. One reason is fire safety. Without fire-stopping on the floor level fire can run up the walls between the studs like in a chimney and reach the next floor. Long framing members are also much more expensive than the nowadays standard dimensions of eight or ten feet for studs. So walls can be assembled on the previously built floors and tilted up afterwards. It also allows shop production of the walls because their size and their weight make shipment rather easy.

Timber is widely used for this kind of construction. But increasing prices for timber made cold formed steel competitive. These are made from thin sheet metal and have similar formats like timber joists and studs. The connections look strikingly similar to the timber details. There are even certain cold formed sections with curved, doublesided webs to receive nails. Whether timber or metal, the erection of small scale buildings remains very simple and fast.

In the field of building materials there is a widespread modular coordination in the USA. Modular measure provides a three-dimensional four-inch grid for the assembly of parts. It was proposed in 1936 by Albert Farwell Bemis, an industrialist outside the building industry, in order to reduce housing cost. This so-called "A62 project of modular coordination" establishes sizes of building products and determines assembly details of these standard-sized products. The building industry in the USA adapted this system. As different products like masonry or gypsum wallboard, but also windows and doors fit into the four inch grid. The 16-inch on center system of the wood frame and the 4' by 8' sheets of material fit in the same way. There is a very important idea behind the modular coordination, radically different from the custom manufacture where finishing parts are adjusted to the previously produced. A very famous sentence on working drawings in Europe is: "All measures are to be verified on the site by the manufacturer." For example a window fabricator measures the rough opening of a masonry wall previous to the fabrication of a window. In the modular measure system details are designed to leave enough tolerances to join parts produced in standard sizes without further adaptions on the site. Site construction of houses is quite similar to production of automobiles in the factory.

A distinction has to be made between standardized products and custom sized products. Examples for standardized ready-to-use products are windows, doors, door frames, but also structural elements like openweb, light-weight steel joists. These joists illustrate the difference between USA and Europe. There they would be too expensive to produce requiring too much costly labor of skilled craftsmen, here they are industrially manufactured. They are able to carry the same loads like heavy wide-flange beams with a lot less material, they require however bridging like joists in wood floors. The whole production is automated employing a lot of machinery and very little skilled labor. The result is savings in material and manpower. On the field of custom sized products manufacture is equally industrialized. Often the finished products are made by the same manufacturer who also produces the primary products. The market is dominated by a relatively small number of big manufacturers. The local contractors often only assemble parts produced by big manufacturers, whereas in Europe they are producers of finished products and erectors in the same person.

There is a widespread employment of whole building systems. Dry-wall systems are a good example. The same manufacturer furnishes very different materials like gypsum wallboard, metal studs fasteners and even the respective tools. Details are standardized as well and are a part of the system.

The tendency in the building part industry is going towards simplification of the erection process and savings in material and labor. What ever can be done in the factory is done there. The permanent quality control is another advantage of factory production. Lots of products are on the market to facilitate site construction. Other products are reduced to thinnest possible sections in order to save material. Although it makes  sense to rationalize and industrialize building, it is obvious with this development that the building quality is in jeopardy and the question is where is the bottom line.

Building process

The way buildings are constructed in the USA has a strong impact on the design. One important principle is that every trade should do its job without being obstructed or interrupted by other trades. Therefore structural systems mostly consist of one single system. Multi story structures made of steel columns and concrete flat-plate, very common in Europe, are not practicable here. Another factor is that often labor-union regulations prevent trades from handling any product or process any material other than that belonging to their own craft. Perfect timing of different trades depending on each other for the progress of construction is almost impossible. Consequently buildings are designed in a way that every trade can pursue its job without interference by others as much as possible. The technical term for it is "bypassing system".

Another principle in systematizing the building process is to have as many similar parts as possible. This explains the observation that the exterior columns of a lot of steel structures are of the same size over the whole height of the facade. On the ground floors the flanges and webs are very thick and then continually decrease with increasing height. That allows to use beams of equal length throughout the whole building and reduces the number of different parts. The same buildings often have steel decking for their floor system. Every deck unit immediately becomes a usable working platform, even before the concrete contractor pours the floors, there is also no formwork necessary. Therefore the finishing trades can follow very closely behind the steel contractor.

Another characteristic feature is that many parts are preassembled in the workshop. Framing members are delivered to the site with connecting angles already attached, curtain-wall elements are already glazed. For housing entire walls are produced in the factory and then shipped to the site. In many cases the producer and the erector of a building part are not the same person.

Industrialization of work on the site also happens, especially in housing developments with many houses of the same type. The contractor organizes his workers along the idea of a mass-production line of an automobile factory. Gangs of men move from one house site to the next doing one specific job; one on foundations, one on framing, one on floors and sheathing, etc. This system doesn't have to be limited to individual housing, it could also be applied to large scale, multistory apartment buildings. However the housing market is at present almost exclusively focused on single family houses.

## Industrial building systems

It is difficult to draw the line between conventional and prefabricated construction in the USA. Almost every building employs a certain number of prefabricated standardized parts. But a distinction could be made wether a building is assembled entirely of factory produced standard parts, belonging to one system, or custom built using certain mass-produced elements. The interest for prefabricated building systems diminished for the last twenty years, although many systems were developed before and after the second world war. Obviously there does not seem to be a great demand for housing at present. Prefabrication was of immediate interest during the great depression in the thirties and the boom years of the sixties, when there was a shortage of living space. The purpose of factory production is to transfer as much work from the site into the controlled environment of the factory, thereby saving time and capital.

Basically there are three different types of industrialized building systems: box systems or "modulars", structural frame systems and bearing panel systems.

Box systems consist of three-dimensional space-enclosing units usually fabricated in an off-site location. They can be either just basic shells or fully equipped with integrated electrical and mechanical systems and even furnished. There are two basic structural variations. The boxes are either loadbearing and stacked on top of each other in a number of different ways or they are nonstructural and inserted in a structural frame. The inherent disadvantage are transportation constraints limiting the width between 12 to 14 feet and the large volume containing nothing but air that has to be shipped.

The second system is a structural frame system usually consisting of premanufactured columns and beams and infill panels. Compared to box or panel systems they have more potential for flexibility. They are however economically feasible for high-rise structures of six or more stories only.

Load bearing panel system are composed of two-dimensional units: wall and floor panels. This system stands somewhere between the two others. Space is enclosed quicker than with a frame system, but doesn't take as much shipping volume as a box system.

Mobilhomes are the closest to the completely factory built house. They require very little sitework and basically only need to be connected to the supply lines when shipped to the site. They are aimed at the lower end of the housing market and have filled this niche successfully. Yet they are of a poor quality and their features limit them to one story. It is questionable if they can be seen as real houses or just as temporary housing.

In the USA prefabrication is very strong compared to Europe. About twenty percent of the housing production come from industrialized building manufacture. But this industry is divided in about 170 small companies, of which everyone sells only a few of their standard models per year, if any at all. Often they produce houses for builders with their own unique shop drawings, losing this way certain advantages of the standardized production. The potential and the infrastructure for a large mass-production exists in the USA, problematic are the long shipping distances and probably the widespread claim for absolute individuality on the side of the buyers.

Conclusions

This study tries to work out peculiarities of American building. The most remarkable fact on the American building field came up with the development of the skyscraper: the coexistence of a low technology with a high technology. On the high technology side immense structures like skyscrapers are built in an incredible short time with the employment of most advanced technology, a big, highly skilled workforce, a lot of machinery and equipment and wide diversity of materials. A strong specialization can be observed both in planning and construction. The complexity and the size of these buildings require a general contractor doing the organization of the execution .There is even a tendency to a further specialization with the rise of the building construction manager. Among the crafts there is a similar separation in specialized trades.

On the low technology side however smaller buildings, especially housing, are built using mainly wood as a building material with very few tools and a very simple building technique. For a lot of buildings architects are not involved at all and skilled craftsmen are not necessarily required.

But inspite this strong separation both technologies have certain common features. One is flexibility. American buildings are easy to adapt for new functions and requirements, wether it is a skeleton structure of an office building, where the partitions do not have structural functions and can be displaced or a wood framed house, where a new opening is easily cut in a wall and a new room added.

Americans took a rational approach to building from very early on. The invention of the balloon frame is the result of simplification and rationalization of English wood frames, very flexible, well suited for the differing climates and easy to erect. With the introduction of the skeleton frame and the curtain wall a building was dissected into different parts and every part was assigned one specific function. This approach facilitates the industrialization of building. Building becomes industrial mass-production like automobiles and is no longer manufacture of unique structures. One reason for the industrial production was the constant shortage of labor. The absence of sufficiently skilled craftsmen and the great demand for building materials led to the mechanization of the production of wooden boards and studs soon after the settlement of the new continent. The conquest of the West accelerated the industrial production. This might be the reason that there are no real apprenticeships in building crafts. There are very skilled craftsmen, educated by the trades, but also many unskilled workers.

Standards are a result of industrial production, both in construction methods and sizes of products. Another advantage is the controlled environment, where parts can be manufactured with much more precision and the constancy of the quality can be guaranteed. Steel has lower safety factors than concrete produced on the site where conditions are always changing. Lower safety factors means also less material. This goes together with the attitude to enclose as much space as possible with as little material as possible. It possibly led to the sometimes very poor quality of houses. In this mobile society people do not buy a house and keep it for a lifetime. Low cost and fancy gadgets are more important than quality. But this is not the fault of American building. It would be possible to produce much better buildings with industrialized building methods.

Introduction to the project

This project is the design of a prefabricated housing system, developed according to the nature of American building. The starting idea was placing a mobile home on one story high walls. The mobile home itself becomes the second floor and the space underneath ground floor. The result is a two story building. The goal of the project to develop a kit of parts that can be assembled according to this idea in a wide variety allowing flexibility on the level of the house itself, but also on an urban level.

The building system can be broken up in two series, one 25 feet, the other 19 feet wide. For the former there are three types of boxes available: the first has two, the second one large and the third one room with a bathroom. these boxes can be joined in every possible combination.

For the 19-feet series there is one box with and one box without bathroom available.

The ground floor is basically one open space, only the location of the stair is determined. This space can just be enclosed or divided into separate rooms.

The basement is available in two versions. Either a full basement equipped with a channel for utility lines and reachable over stairs from the ground floor or a basement reduced to a central tunnel element containing utility lines and eventually the heating furnace accessible only for service personnel. The former is rather for housing owned by the occupants, while the latter is rather intended for rental / co-op purposes.

The system consists of several groups: The foundation, the boxes (or "mobile homes"), the part for the zone between the boxes and the enclosure of the first floor.

The foundation system includes several precast concrete elements: Two tubular pieces of the same dimensions as the boxes, four walls supporting the boxes and some additional elements to bridge the gap between the two tubular pieces.
The boxes are traditional wood framing. The big difference however is the construction of the floor and the roof spanning the long way allowing the ground floor to be free of structural elements. Heating ducts and other supply lines can be run within the depth of the floor. As only the short side walls are load bearing it is possible to introduce very large openings in the long wall without any additional structural provisions.
The third group are the parts for the middle zone: Some of them would be shipped on top of the boxes (e.g. the roof) or would be shipped separately (e.g. bathroom boxes). As all vertical connections occur in this middle zone also a prefabricated plumbing wall could be part of this group.
The fourth group consists of planar elements for enclosure and partitions of the ground floor. Almost all of them have dimensions of four feet by eight feet and therefore can be stored within the boxes for shipment this way reducing the volume of shipped air. Flooring panels would also be part of this group.

Every unit consists of a main house and a studio with parking space on the ground level. The sequence through one lot is: Street - studio / parking - semipublic courtyard - main house - garden, but could be changed if site conditions would require it.
The studio can be rented out as a separate apartment. In case more space for the occupants living in the main house is needed it would become functionally a part of it.
The building system has two basic widths of units, 25 feet and 19 feet. Inserting a narrow unit in a 25-feet-grid creates a pedestrian alley running perpendicular to the streets. By overlaying an irregular system of pedestrian alleys and public spaces over this regular

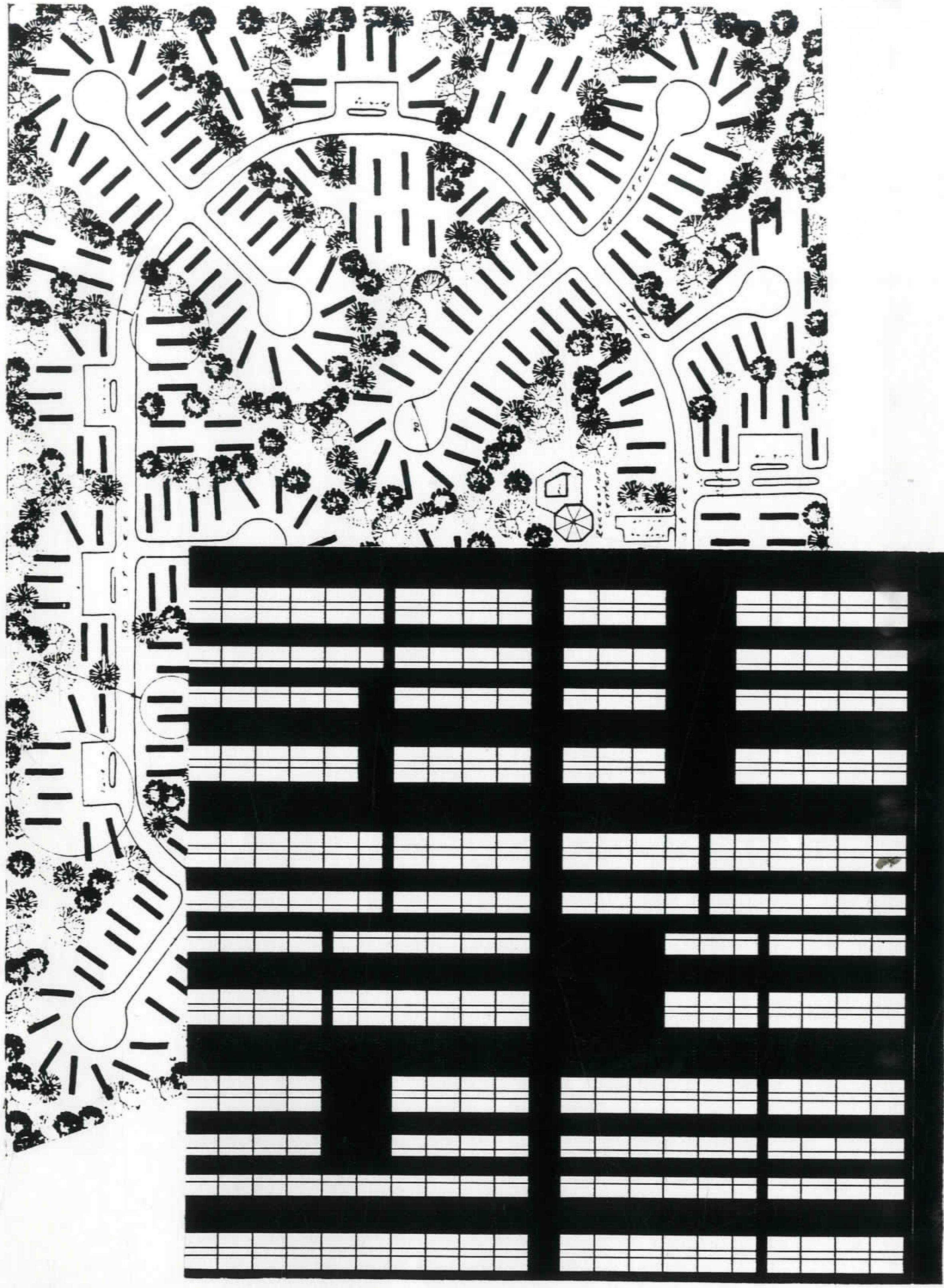
grid by leaving out a certain number of units and inserting 19-feet-units it is possible to create a differentiated urban scheme.

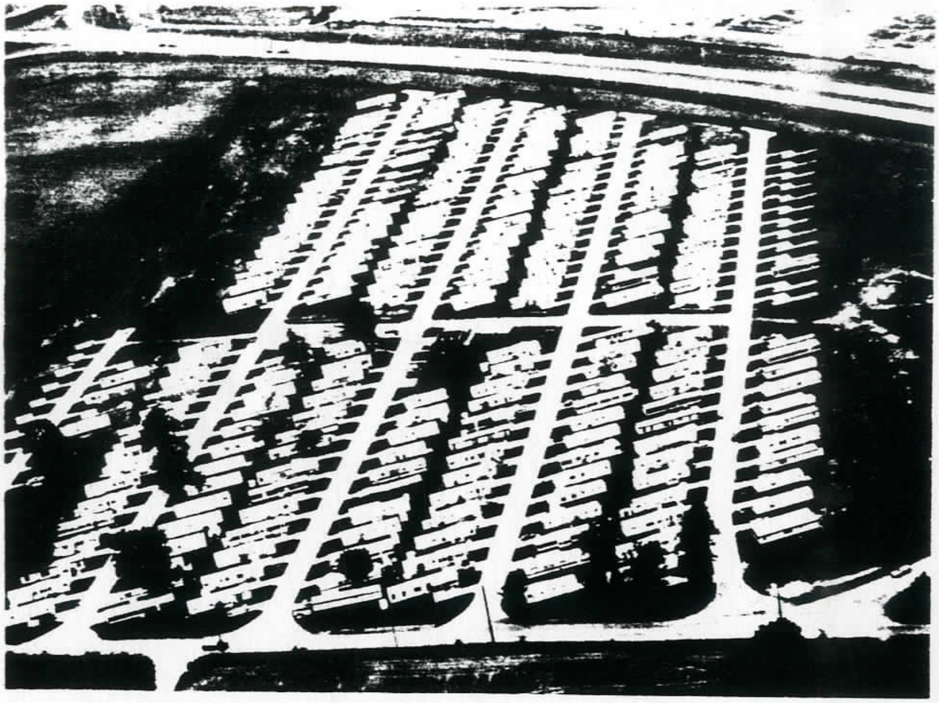
Looking at mobile home parks one can observe the lack of a clearly defined hierarchy of spaces. There is no separation between private outdoor spaces and public spaces. The mobile homes are evenly distributed in a suburban pattern and all have pretty much the same appearance. There are attempts for individualization by adding elements like entry porches and demarcation from the neighbors. The thesis project develops a strategy that allows flexibility without destroying a certain uniformity necessary for a more urban scheme. The boxes on the second floor give a strong continuity, but on the first floor a variety of configurations is possible. The occupants of these houses are free in the design of the ground floor. It can be one open space separated from outside only by glass walls or it can be divided in a number of small rooms with closed surfaces. The same is possible with the private outdoor spaces without affecting or destroying the public space. The system gives choices for the personalization of the houses.

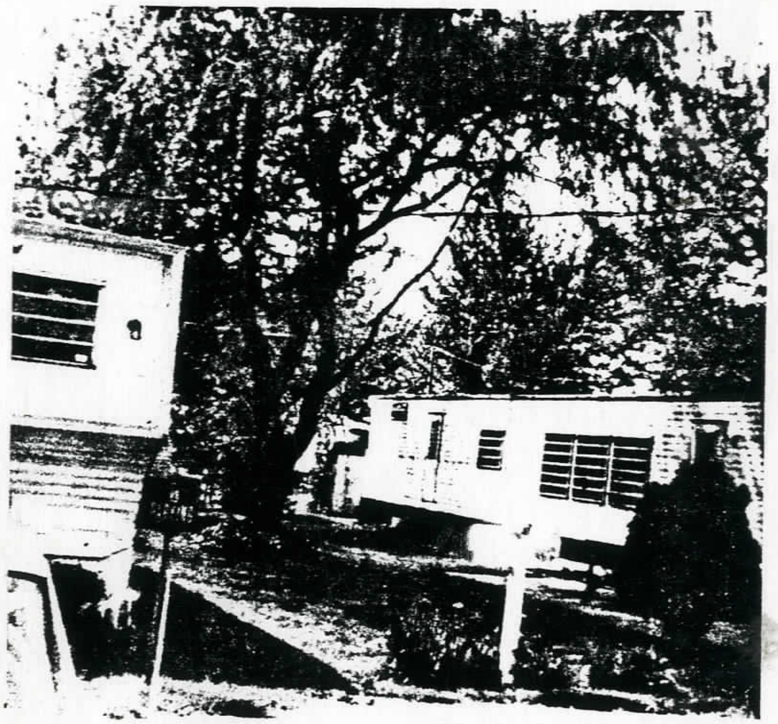
Another intention behind this project is the use of an already existing very simple technology and taking advantage of the better conditions of factory production versus field production. It takes an already existing industry and produces a better, more urban system for prefabricated housing.

By the combination of three dimensional with two dimensional elements for this system site labor can be reduced because fewer parts have to be connected on the field, but also the volume is reduced by shipping the planar elements within the boxes.

The basic idea of this project is to take the American free-standing single family house and the typical row house types and convert them to a system that is economical to realize and equally economical in consumption of land.







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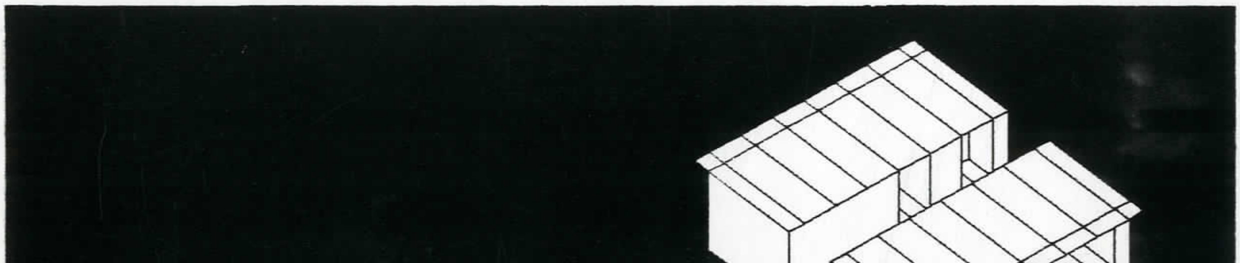
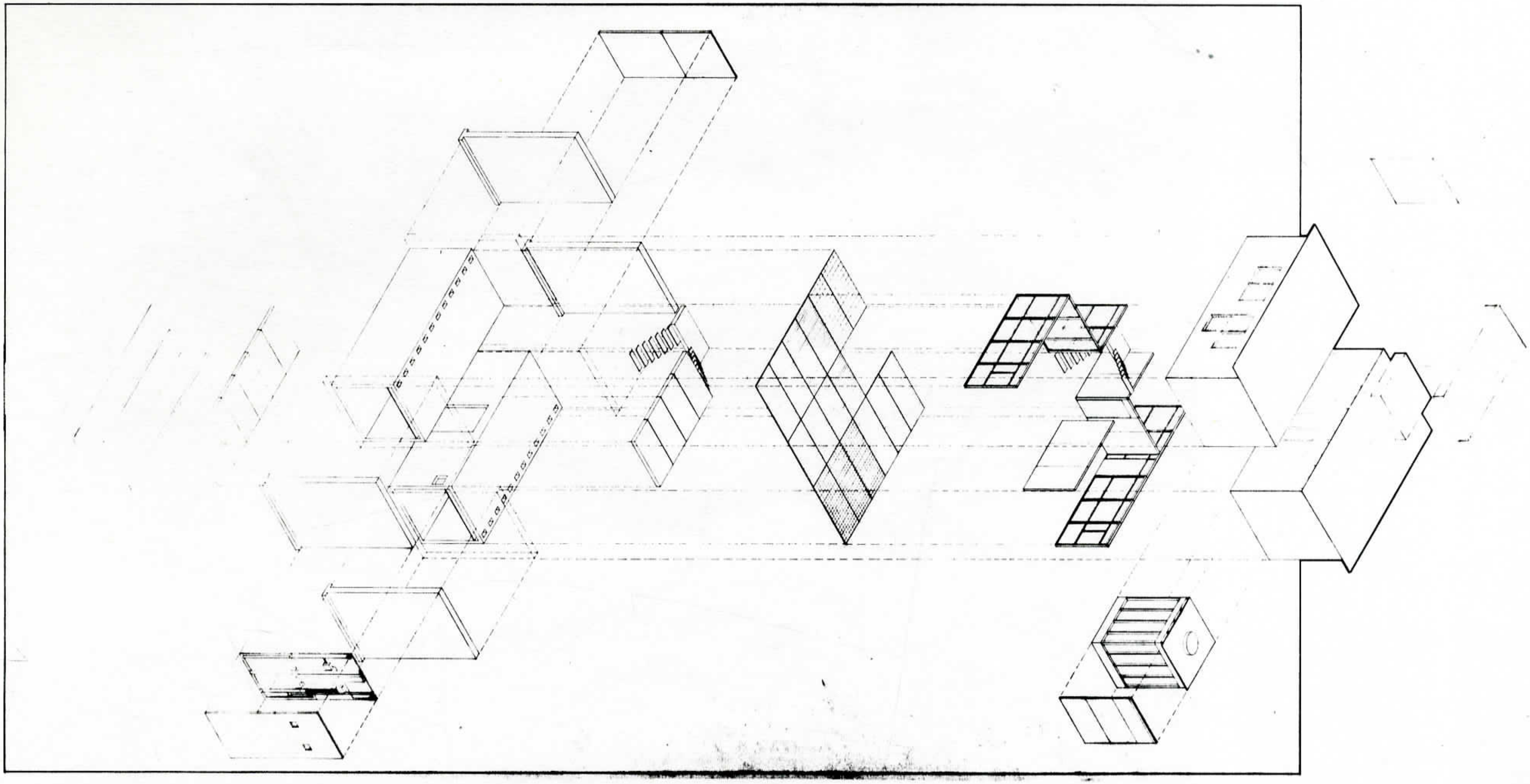
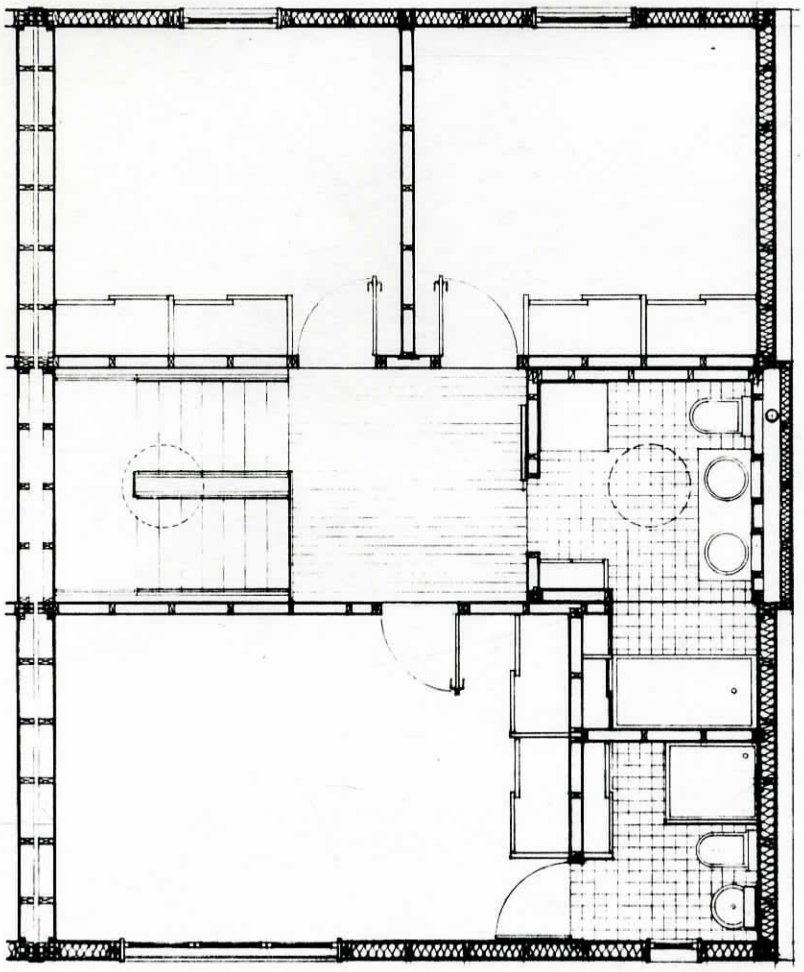
DRAWINGS



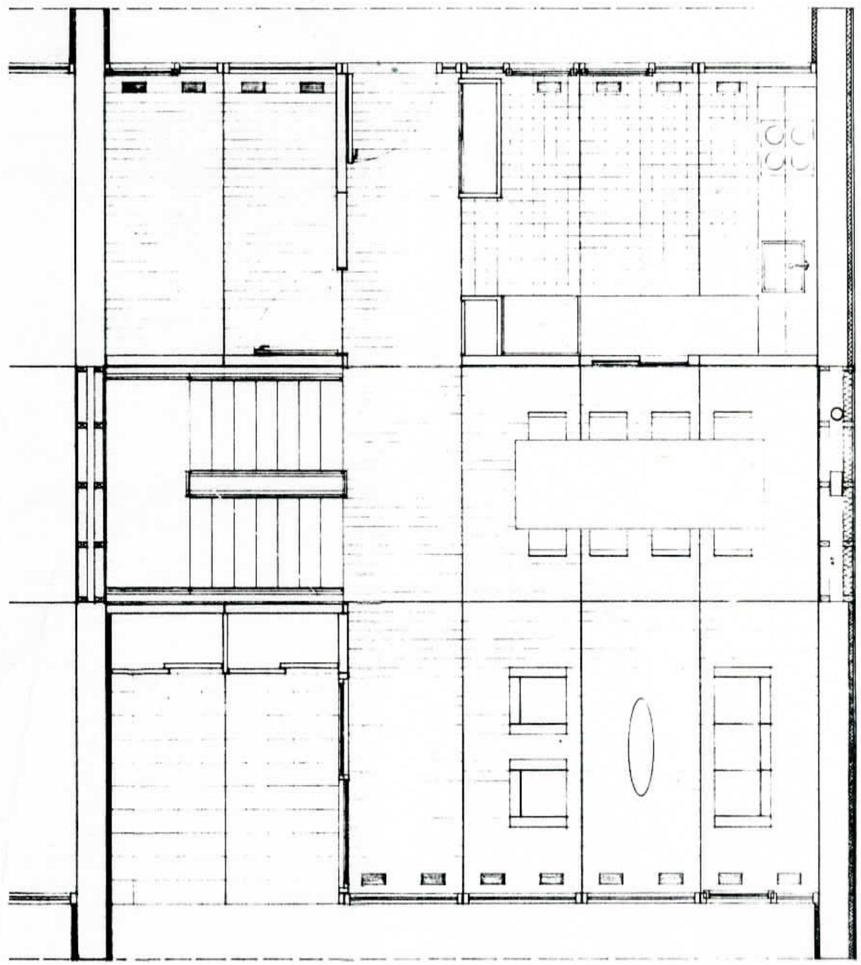


ASSEMBLY OF SYSTEM

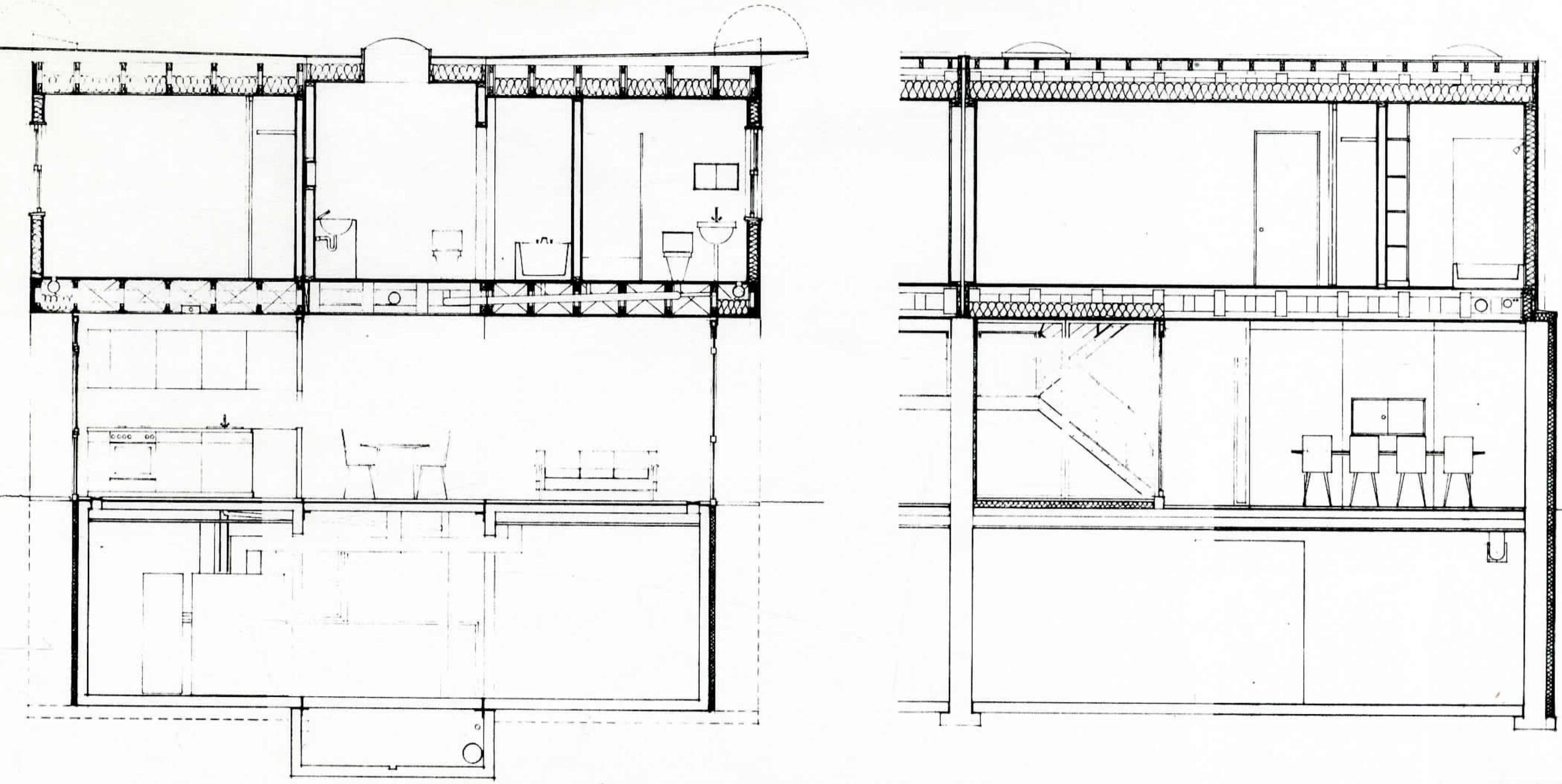


2nd floor

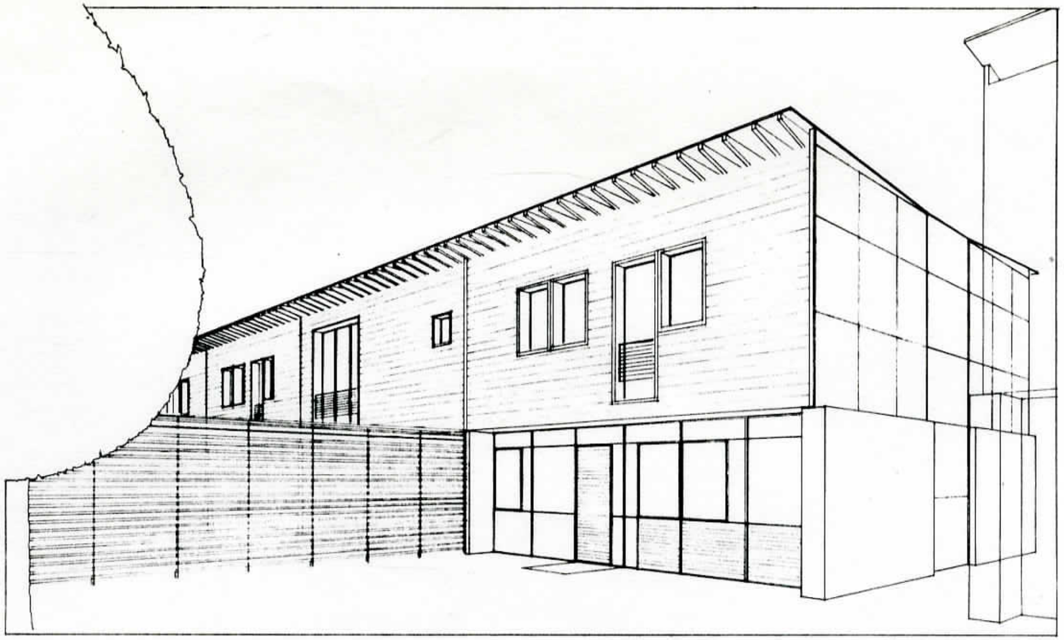
PLANS

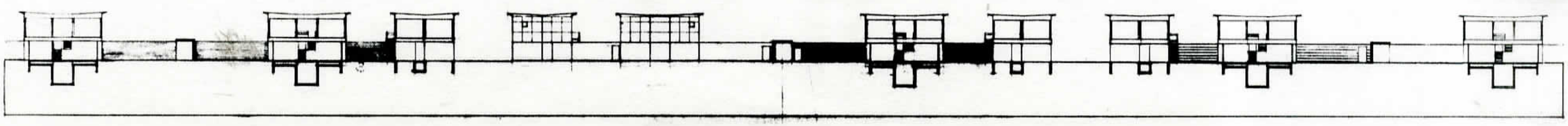


1st floor

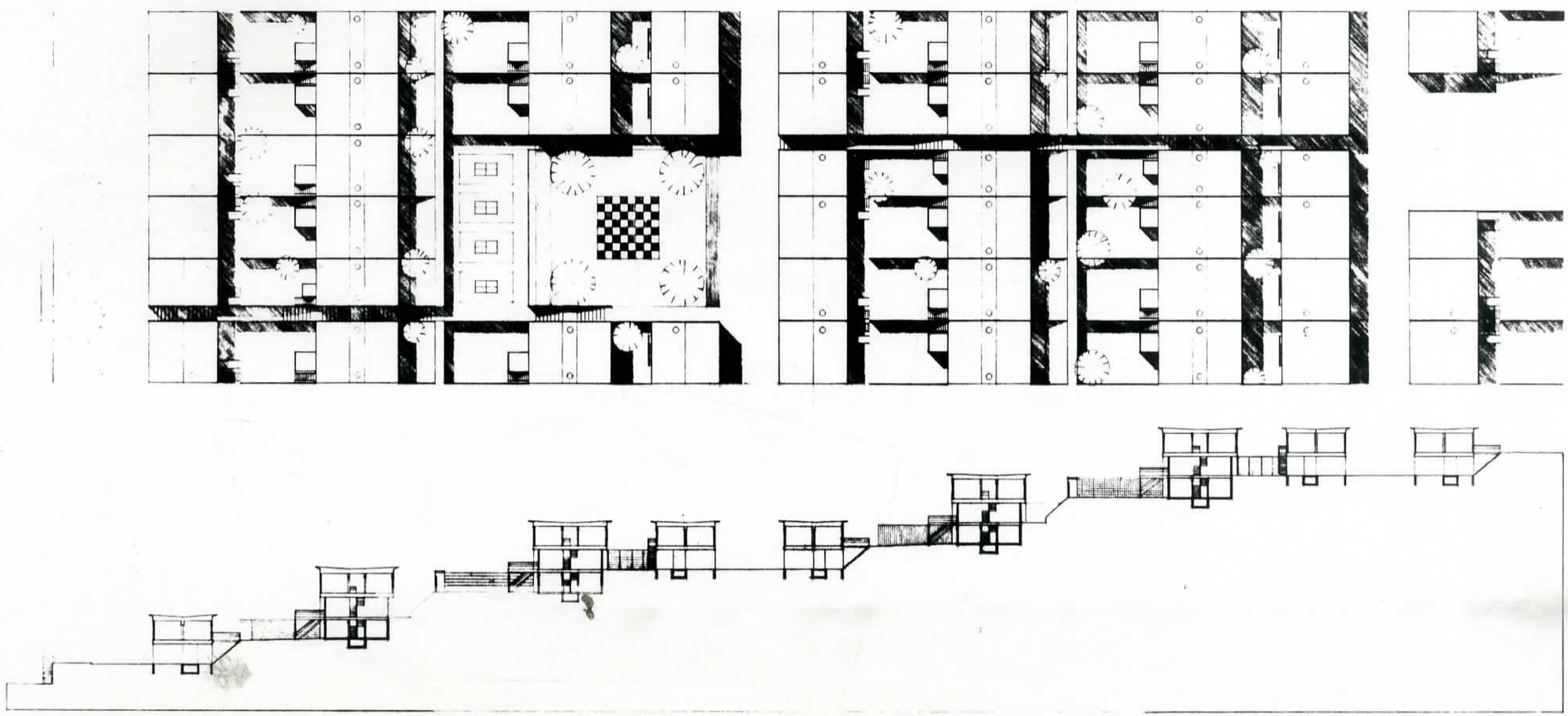


SECTIONS





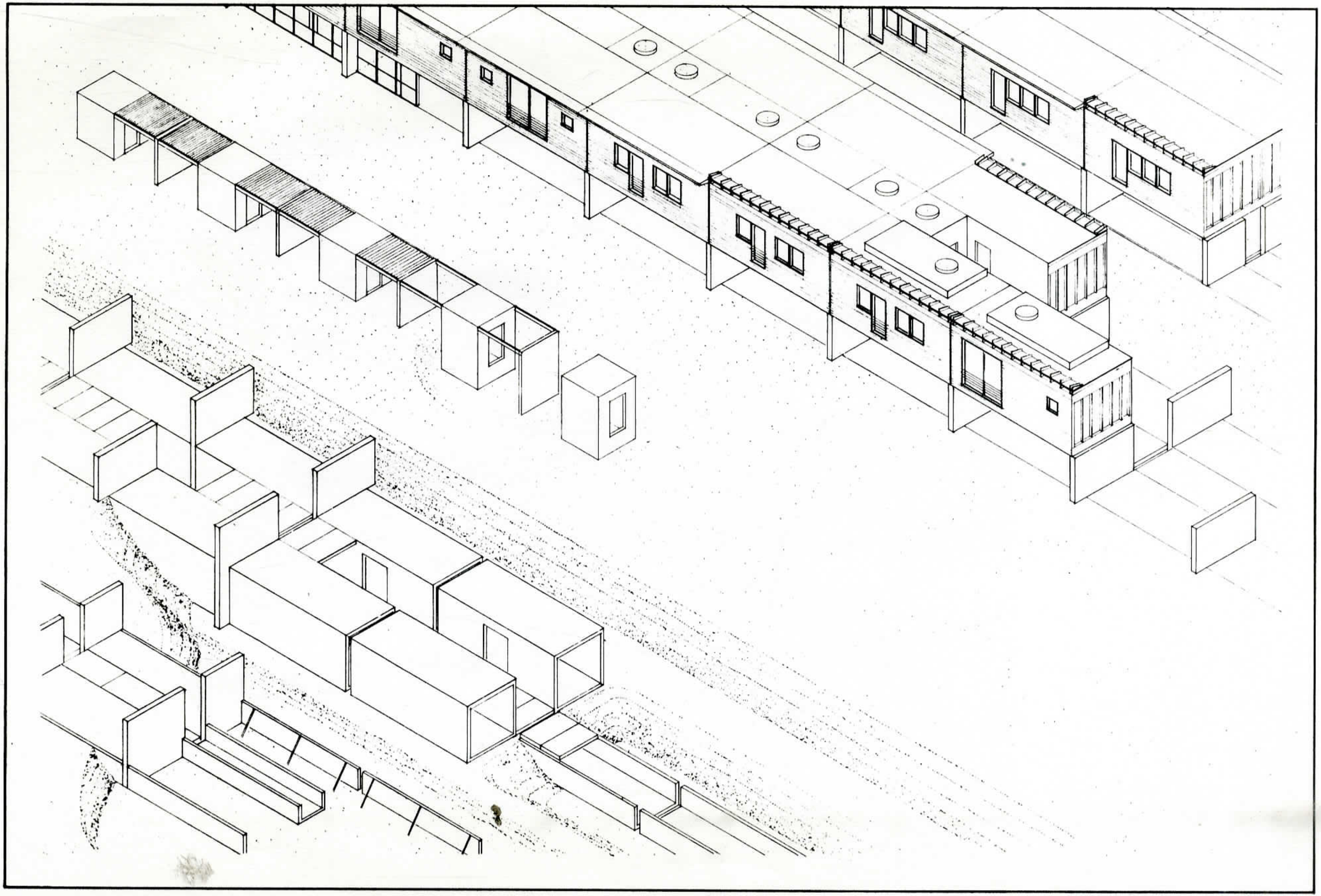
FLAT SITE



SLOPED SITE


2nd floor
1st floor
2nd floor
1st floor
25'-SERIES
19'-SERIES


Main house
Courtyard
Studio / parking
2nd floor
25'-SERIES
1st floor
2nd floor
19'-SERIES
1st floor



PROCESS OF ASSEMBLY ON SITE