REPORT OF THE INVESTIGATION ON PREFABRICATED

HIGH RISE APARTMENTS IN IRAN

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OVERSEAS TECHNICAL COOPERATION AGENCY

P R E F A C E

The Overseas Technical Cooperation Agency (OTCA) has pleasure of presenting "Report of the Investigation on Prefabricated High Rise Apartments in Iran" to the Government of the Empire of Iran.

The Survey Party was organized and dispatched to Iran by OTCA upon instruction from the Government of Japan for conducting a technical survey on the Project for Prefabricated High Rise Apartments construction in Iran.

The Party headed by Dr. Yoshitika Uchida, Professor of the University of Tokyo, stayed in Iran from December 12 to December 25, 1969 and successfully completed the field survey including discussions with the authorities concerned and collected data with whole-heared cooperation from the Government of the Empire of Iran and other relevant organizations.

After its return to Japan, the party made further studies on data and information, and the results were hereby compiled into the present report for presentation.

It is hoped that this report will be assistance in promoting better housing policy in Iran.

1971

Kei-ichi Tatsuke
Director General
Overseas Technical Cooperation
Agency
Tokyo, Japan

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INTRODUCTION

This is the report of the study tour organized by Overseas Technical Co-operation Agency under the Colombo Plan of Japanese Government.

The members of the tour party are:

Yoshitika Utida, Professor at Department of Architecture, Faculty of Engineering, University of Tokyo

Ryoichi Matsushita, Chief of Prefabrication Division, Japan Housing Corporation

Eizo Nakaoka, President of Kudan Construction Engineering

The party left Tokyo for Iran on Friday 12th, December, 1969, visited the Ministry of Housing and Development, and returned Tokyo on 25th, December, 1969, except Mr. Matsushita who visited Thailand, Singapore and Hongkong on his way home. For further details refer to the itinerary that follows.

The party visited and interviewed with the people of Government of Iran, including Minister of Housing and Development, President of Housing Organization, and members of its board of directors, and reached an agreement that the party investigate the following items during its stay in Iran and that it submit a report of the investigation after its return.

1. High Rise Prefabricated Apartment Buildings
   The use of prefabrication for the purpose of reducing building costs to such an extent to make up for the increase of cost resulting from earthquake resistant design of buildings.
2. Walk-up Apartment Buildings
   Improvements of existing buildings in terms of structural soundness against earthquake, as well as the use of prefabrication as the means of reducing costs.
3. Observations on the Case Study Farm Housing and Technical Information Relating Vibration Test Equipments.
4. Modular Co-ordination
   Discussions developed in Japan and the party's own views on the subject.
5. Policies Against the Rise of Land Prices That Housing Projects Tends To Create.

During the twelve days stay in Iran, the party visited the construction fields and examined the drawings of the housing with the help of explanations given by the people concerned.

Materials including slides and films were supplied by the party regarding house buildings in Japan.

On return to Japan the party started preparing the report which was rendered into English upon its completion. In the course of writing the report, the party was able to collect necessary informations thanks to the cordial help extended by the Ministry of Construction, Japan Housing Corporation, universities, private research institutes and other related institutions, as well as the suggestions given by the following people who had visited Iran before. Tachu Naito, honorable professor at Waseda University, Ken Ichiura, president of Japan Institute of Architect, Shunichiro Omote, researcher of Building Research Institute, Ministry of Construction, Mitsuhide Sawada, investigatory director of the Ministry of Construction, Shigeo Tani, professor at Tokyo Municipal University, Kyoji Nakagawa, researcher of Research Institute of Obayashigumi Co., Ltd.

We, members of the tour party, take this opportunity to express our gratitude to scores of persons who helped us in completing this report. We are greatly indebted to the Government of Iran, especially the Ministry of Housing and Development and Housing Organization for their willing co-operation to our investigation.

Needless to say, house building is subject to the climate and the pattern of human life and therefore every housing must be tailored to suit particular needs of people in particular place. But since Iran and Japan share the geological conditions as far as seismic effects are concerned, there will be growing necessity of mutual co-operation with respect to technical development.

It is fortunate that we were able to recognize the prospective routes between two countries, through which technical intercourse will be activated in the future. If our study tour has contributed to the development of such routes, it would bring more success than is expected.

THE ITINERARY

Dec. 12th Left Tokyo at noon.

Dec. 13th Arrived at Teheran Airport at 1:00 a.m. Welcomed by Mr. Nagasaka, attaché of Japanese Embassy in Iran. Take a rest at Peansion Suisse.

Visited Japanese Embassy at 10:00 a.m., to have a meeting with attachés Nagasaka and Akutsu. Greeted Ambassador Maeda and councillors.

Visited the Ministry of Housing and Development, with Mr. Nagasaka. Talked with Mr. Sadr, chief of Public Relation Department. Interviewed with Mr. Pakdaman, Vice-minister, and confirmed the aims and the itinerary of our visit, as it was Minister Iegane's predecessor, Mayor of Teheran now, who had invited us.

Greeted Mr. Badie, Vice-minister, who is known for his profound understandings of Japan, and handed him a letter of introduction from Mr. Honjo, professor at University of Tokyo. As suggested to work with, visited Mr. Jahanshai, member of board of directors, Technical Bureau of Housing Organization, and discussed our schedule. Left Housing Organization at 1:00 p.m., and made a sightseeing tour of the city. Visited Japanese garden designed by Mr. Nakaoka in the Central Part.

Dec. 14th Discussed schedule again with Mr. Jahanshai, at Housing Organization. Mr. Ahari, a city planner, was to take care of us in undertaking the job. He prepared the library for our working place. Mr. Ayatorahi, chief structural engineer, Mr. Ali Salehi, chief architect, and Mr. Ahari, city planner, explained housing situation in Iran with the help of drawings.

Dec. 15th Examined the drawings. Discussed with Mr. Ali Salehi, Mr. Ahari and Mr. Dorudi on the size of dwelling, construction period, budget and building cost of 14-storeyed apartments for SAIE housing.

At 11:00 a.m. met Mr. Pakdaman, Vice-minister of Housing and Development, who asked us to submit a report of investigation on the following subjects.

1. Approaches toward low-cost housing.
2. Possible economical structural system for 4-storey, 8-storey

and 14-storey apartment buildings.

3. Possibility of application of Japan's prefabrication technology to housing in Iran, in relation to building costs.

4. The case study houses for labourers and farmers.

Left the Ministry at 1:00 p.m. Invited to a dinner by Mr. Nagasaka, technical attaché of Japanese Embassy.

Dec. 16th Visited the housing sites with Mr. Jahanshai, Mr. Ahari, Mr. Savagian, and Mr. Javad Salehi, Deputy Mayor of Teheran.

1. SAIE Housing
   Seven blocks of 14-storey reinforced concrete flats of tower type and zigzag type. Examined the schedule of progress, and observed the construction work in progress.
2. BEHJATABAD Housing
   A 14-storey reinforced concrete apartment, with shopping floors. Observed the pouring of concrete into the ground floor columns.
3. FORSAD Housing
   A completed apartments for sale, all sold out, consisting of four blocks of 4-storey brick building with steel used in part. Observed interior finishes, service installations and landscaping.

Dec. 17th Discussed with young architects and engineers at the library of Housing Organization. Asked for detail drawings and other data necessary for our further examinations.

From 11:00 a.m. showed the following films to some 40 people, including Mr. Pakdaman, Mr. Jahanshai.

1. Kasumigaseki Building (a 36-storey office building) (Narration in English)
2. Yawata's 11-storey apartments by HPC-SYSTEM (Narration in Japanese)
3. Industrialized Housing by Japan Housing Corporation (5-storeyed) (Narration in Japanese)
4. Industrialized Housing in Progress, produced by Japan Housing Corporation (Narration in Japanese) (not shown completely)

The films seemingly interested the audience greatly.

Left the Ministry at 1:00 p.m. and met Mr. Saldouzi.

Dec. 18th Visited two housing sites.

1. NARMAK Housing

   Case study houses at Narmak east of the city. Six types of houses for labourers and farmers are built. They are of concrete block and brick and other materials. All are suited to the climate of Iran. The size of each dwelling unit is about $30M^2$.

2. KAN Housing

   Approximately 1,000 prefabricated 4-storey apartment buildings. The 7 or 8 years old houses, each 60 or $70M^2$ wide, are occupied by lower class civil workers, drivers, store workers, etc. The quality of the interior space was similar to that of housings by Japan Housing Corporation, while the exterior space did not seem to be given much attention.

In the evening, invited by Mr. and Mrs. Badie, who gave us a cordial welcome. Together with other two guests, we talked about the case study house at Narmak.

Dec. 19th Left Teheran at 6:00 a.m. for Shiraz. Arrived at Shiraz at 9:00 a.m., met Dr. Azarnia and one other gentleman.
Visited the Persepolis.
In the afternoon, visited one of the typical farm villages. Houses are one-storey and of sun-burnt brick. Visited a model housing for farmers. Concrete block construction. Structural design was distinguished. The planned layout of buildings, pairing one-storey houses, was impressive. Communal facilities included farming houses and assembly house. The completed housing would look outstanding.

Dec. 20th After seeing around Shiraz city, left for Isfahan late in the afternoon. At 7:00 p.m., arrived at Isfahan airport. Welcomed by Mr. Zoufan of Housing Organization and one other gentleman.

Dec. 21st Tour around Isfahan, guided by Mr. Zoufan. Visited a new hotel and other newly built buildings. Left for Teheran late at night. A jeep was prepared for us by Housing Organization.

Dec. 22nd In the morning, made a report of our three-day tour to Mr. Jahanshai, and express gratitude for great facility and convenience given to us elsewhere by Housing Organization.
Interviewed with Mr. Beiloon, president of Housing Organization. Questions were raised on the land problem, financing and interest

rate of housing in Japan. Made answers with the help of the annual report of the Japan Housing Corporation.

Visited a housing near Rey south of Teheran. The well-planned housing accommodate 3,386 houses, as well as shops, schools, nurseries, a central park and so on. Each house is as small as 2DK, and townhouse type, intended for lower class labourers.

In the afternoon, invited to a luncheon by Mr. Javad Salebi, with Mr. Soldouzi and Mr. Savagian. Then requested by Mr. Inoue, councillor of Japanese Embassy, to investigate two houses, one of which Ambassador Maeda was planning to move in. Mr. Maeda was with us. The first one was not recommendable, because it was not earthquake resistant, although larger than the other. The second one, reinforced concrete, turned out to be acceptable from structural point of view, although the amount of reinforcing bars indicated in the drawings were not quite sufficient.

In the evening, we were invited to Mr. Jahanshai's house, together with Mr. Badie and a Japanese professor and his wife, who were living on the 4th floor of the house.

Dec. 23rd At 9:00 a.m., interviewed with Mr. Iegane, Minister of Housing Organization and explained the aims in our visit to Iran. (Our interview was reported on papers next morning.)

Visited FARAHABAD Housing, which was intended for high officials serving the Palace. All houses were detached and luxurious, with the total floor area of $400 \sim 600M^2$, each having a swimming pool of its own.

Mr. Ahmad Monadjemi, an architect, showed us the Hunting Museum located not far from the housing site. It was designed by him. Being a loyal building, the museum was really gorgeous, with marble finishes and sculptures, and huge garden surrounding the building.

Coming back to Teheran, went to see a high rise building built by Samon Corporation. The building, designed by a French architect, was of reinforced concrete with curtain walling and cast-in-place method combined. This was the most structurally sound structures that we had seen in Teheran.

In the evening, invited to a dinner at Hilton Hotel by Mr. Beiloon, president of Housing Organization. It was followed by the farewell party for us. People attended included the president, vice-president, members of board of directors of Housing Organization. Cigarette cases were given to us as the souvenir.

Dec. 24th In the morning, made preparations for leaving. Invited to a lunch at Mr. Soldouzi's house.

In the evening, invited by Mr. Nagasaka and Mr. Kato of Japanese Embassy.

At the airport many people came to see us off. Among them were Mr. Nagasaka, Mr. Jabad Salehi and Mr. Soldouzi.

Due to two hours delay, our plane took off at one o'clock in the morning.

OBSERVATIONS OF HOUSING IN IRAN

1. FORSAD Housing

General Design Four 4-storey walk-up apartments, one of which having basement, have two staircases for each, and run east-west. Buildings are spaced 17 or 18M apart, with parking pavement and lawn in between. A dwelling unit is either 2-bed or 3-bed type (corresponding to Japanese 2LDK or 3LDK, respectively), with floor area of approximately $180M^2$.

Structure Principally brick construction, with steel reinforced columns and beams. Floor slabs are brick arch resting on steel I-beams spaced every one metre.

Finishes Walls -- painted plaster or cloth (wall paper). Floors -- terrazo block. Ceiling -- plaster.

Equipments Water and gas supply. Central heating system for heating and hot water supply. Cooling is room cooler type. Boiler room is in the basement.

The dwellers belong to upper-class and have higher educational background. This reflects of the quality of service installations, and each apartment contains servant's room who cleans the rooms. Ceiling height is 2.8M, door height 2.1M, and storey height 3.1M. Interior space is comfortable. To the south there is a fairly wide balcony. But the window opening to the balcony seemed unnecessarily wide. It increases heat loss and affects cooling efficiency and economy. In fact, most of the double curtain was kept closed even in daytime. The prices vary between 1,400 to 1,600 rials on a long-term payment. The monthly payment is accordingly as high as 8,000 rials, but all are sold out. Consideration is, however, not given properly to the earthquake resistence of structure. The structure mainly consists of brick, although steel is used in columns and beams. We were able to see the same structure being constructed at the adjoining site. We strongly felt the necessity of improving the structural system from the viewpoint of earthquake resistance. (See Chapter II).

2. FARHABAD Housing

General Design Detached housing for high officials who serve the Palace. Each house has garden with a swimming pool. Floor areas vary from $400M^2$ to $600M^2$, each accommodating bedrooms for every family, a living room, dining room, home bar and lobby. In the basement there is servant quarters, as well as mechanical rooms. Installations are of the highest standard.

Structure   Reinforced concrete frame with brick or hollow block walls and floors. This is typical structure in Iran.

Exterior   The facade is magnificent.

The price vary between 3 to 5 million rials, or 8,000 rials per square meter, which is cheaper than it appears to be. In any case, reduction of costs seemed to be of minor importance. Some of the houses were inhabited, the rest being under construction. The emphasis seemed to be placed rather on aesthetic design. But for families having infants guard fences should be provided to keep them off the swimming pool when there is nobody watching.

3. Labourer's Housing

General Design   A large scale housing accommodating 3,386 dwellings. Each one-storey brick units, with terraced garden, are grouped into a row house. The communal facilities include 110 stores, 5 schools, one high school, 11 municipal offices, nurseries and a mosc that serves also as an assembly hall. The central park and playgrounds are also provided in conformity to the master plan intended for the community of 50,000 people. The size of a house is of 2DK type, and varies from $40M^2$ to $50M^2$ in floor area. This is too small to house more than 15 families as is the case with most houses.

The dwellers are lower class officials or typical labourers -- 233 railway workers, 79 suburban policemen, 92 soldgers, about 2,600 general labourers, and 200 - 300 others including teachers and military policemen. The nursery opens from 7:00 a.m. to 7:00 p.m. This reflects the labour policy of the local municipality. Each primary school adopts double shift system, and accommodates 1,200 pupils in all, which are divided into 11 classes. The housing standard is lower than we expected. There is no bed in a house. People seemingly sleep on floor carpet. The dining kitchen is poorly equipped. Storing spaces are lacking. In summer nights the front court seems to serve for outdoor living. The high walls enclosing the court help to secure privacy.

4. KAN Housing

General Design   Approximately 1,000 dwelling units of 2LDK type are housed. Each block is 4-storeyed. The whole sight was reminiscent of typical public housing in Japan.

Structure   Brick construction with partial use of steel. Some buildings are of precast concrete system (British Lima system). Most buildings are seven or eight years old.

Finishes   Interiors -- painted plaster, and painted fair-faced concrete for PC buildings. Floors -- terrazo block. Exteriors -- brick or painted.

Equipments   No heating, but hot water is supplied by home boiler. The dwellers seemed to be lower-middle income class, earning 10 or 12 thousand rials a month. Although buildings are laid out in a generous way leaving space measuring 40 or 50M between buildings, the space is not landscaped except that it is accented by the reddish brick. Each apartment is 60 or $70M^2$ wide, a little bit wider than 3DK type of Japanese public housing. Beds are accommodated. Living room is relatively large. There is also a service balcony, where people dry up clothings. Each building has three staircases. Occasional TV antennas on the roofs show more and more families are getting TV sets. There is no dust-chute, so people carry garbage down to the common disposal spot. Neither is there any public sewerage, so each building has vertical sewers plunged into earth by some twenty metres. The subsoil is dry enough to solidify dirts. This is typical sewerage in Iran. Balconies are continuous, except for the ground floor where there is no balcony and every window is protected by grillwork, perhaps against burglars. The surrounding land was left wild. It looked somewhat strange for us, because in Japan any public housing stimulates the development of surrounding land. It seemed that in Iran no land development is possible until the government decides to build public water supply system for the land. In fact, water seemed to be more precious than in Japan. This suggests that the government possesses one of the effective means of controlling the land prices around public housings.

5. NARMAK Housing

Refer to Chapter III.

6. High Rise Apartment Buildings in Iran

We visited several housings undertaken by SAZUMANE-MASKAN (Housing Organization) under construction at Teheran SAIE and BEHJATABAD, as well as the Samon Corporation's high rise prefabricated apartments being built at Elizabeth Street.

1) SAIE BEHJATABAD This is 13-storey apartment building with basement. The structure seemed to be relatively earthquake resistant, except that consideration must be given to the thickness and the layout of bearing walls. The construction method remains conventional cast-in-place concrete, having the drawback of requiring longer construction period. But the formwork seemed to be very accurate, and the placing of reinforcing bars and pouring of concrete was performed by good workmanship. The cost, higher than that of walk-up apartments, may be justified by the additional provisions for earthquake.

2) Samon's high rise prefabricated apartment buildings. This is of good quality in terms of both structural design and method of construction. The relatively high cost may be justified. The average cost of apartment buildings in Iran is much lower than that of Japanese equivalents. This is due in part to the structural design that puts earthquake out of consideration. But as long as high rise buildings are concerned, lateral forces must be counted in structural calculations. The resulting increase of building cost may possibly be made up for through further study of construction methods.

CHAPTER I. PREFABRICATION OF HIGH RISE APARTMENT BUILDINGS .

1. Introduction

Low-cost prefabricated high rise apartment buildings have not yet been built in Iran as far as we have observed. Those built in SAMON are for high income families. We will, therefore, introduce an example of low-cost prefabricated high rise apartments in Japan, and then present two basic schemes we have worked out on a basis of the plan of the apartments at SAIE. They are designed to best suit the conditions of Iran.

The first problem that high rise apartment buildings pose is the relative length of construction time, as far as they are dependent on cast-in-place concrete. To shorten the period, prefabrication is one of the most effective means. In Japan we have an example of 14-storey buildings that were constructed two times faster than those in conventional method, although prefabrication was partial. The labour cost is constantly rising as in Japan, if not so rapidly, and formwork costs nearly twice as much as in Japan. Such situation will no doubt make prefabrication one of the most effective means of reducing building costs.

The prefabrication system we are going to introduce is referred to as "HP-system" and is obtaining wider use in Japan for high rise apartment buildings. And this is considered one of the best suited systems for Iran, except that it requires more steel than others. It is necessary, therefore, to modify the system so that the amount of steel is minimized. This is possible because the intensity of earthquake against which a building is required to resist is smaller than in Japan. Another solution is to develop entirely new systems specifically designed to best fit the practice in Iran. They may be earthquake-resistant prefabrication system either of reinforced or prestressed concrete buildings. And this is what we like to suggest. In the schemes we are presenting we gave the first priority to such seismic considerations.

2. "HP-SYSTEM" ---- An example of prefabrication system for high rise apartments in Japan

2-1. Design Considerations

a) Structural economy is attained by combining rigidity of concrete and axial strength of H-section steel.

b) The horizontal rigidity of floor is secured by using cast-in-place concrete for floors and the fire protection of columns. This eventually simplifies the connections between fire protections and precast panels.

c) The erection is simplified and the alignment is eased by employing precast panels for exterior walls in general, and PC panels including steel beams for walls in ridge direction.

d) Variations in interior layout is allowed by installing wall panels so that each interior is free of columns and beams projecting inside, and by repeating panels for exterior walls allowing certain variation in the size and location of windows. (Fig. 1) (Fig. 2) (Fig. 3)

Fig. 1 Apartment house of Nagoya Works

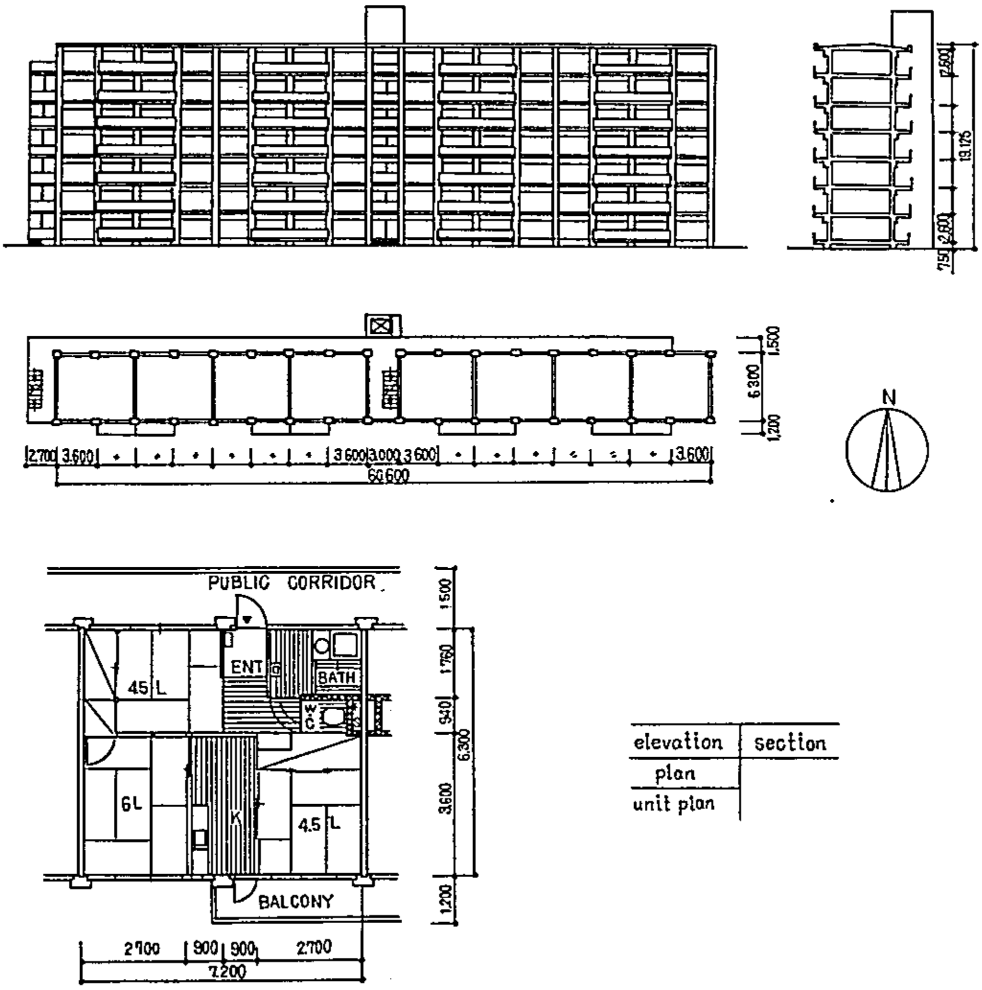


Fig. 2 Morisaki Dormitory of Nissan Automobile Co., Ltd.

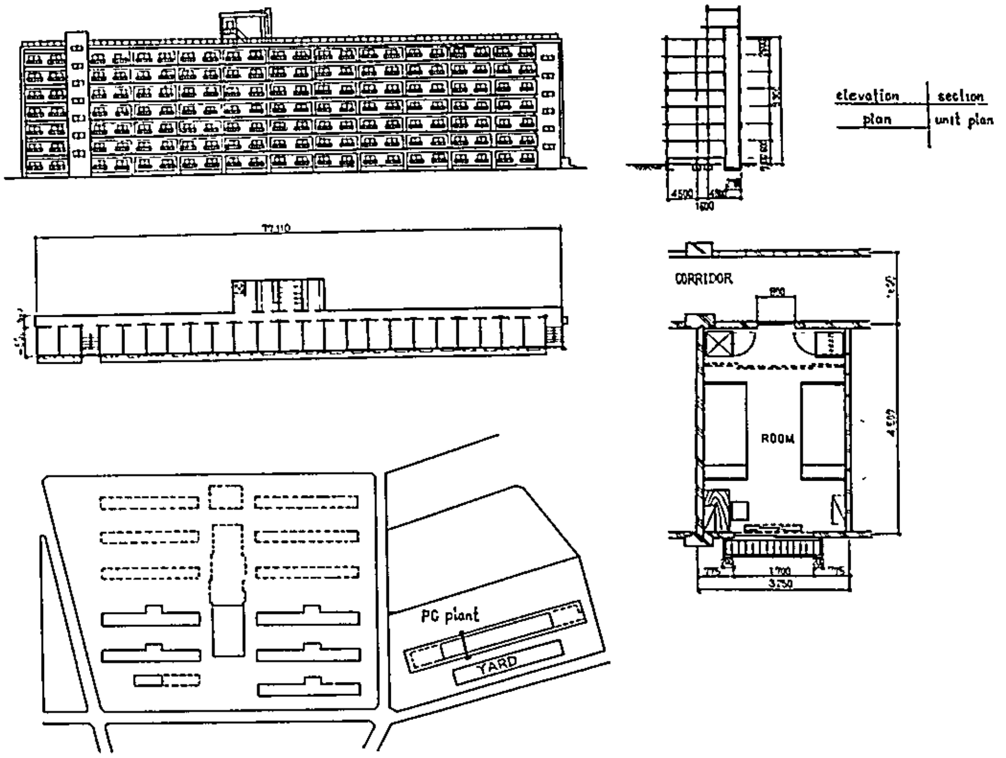
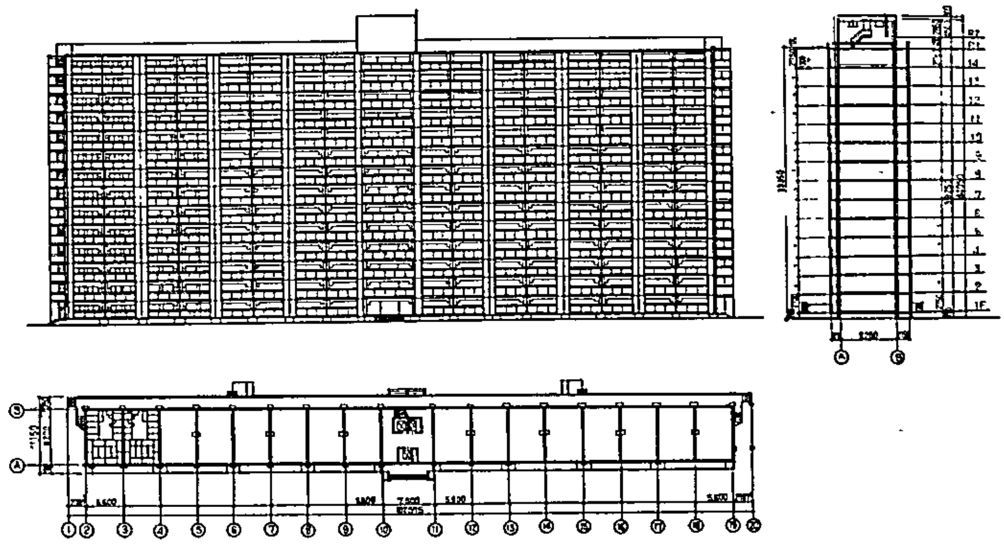


Fig. 3 General drawing (HP 14S)



The building is so simplified in its basic structure that it allows wide variations not only in its interior layout, but also in the way the dwelling units are combined to form a building block. (Fig. 4) (Fig. 5)

Fig. 4 Examples of block plan

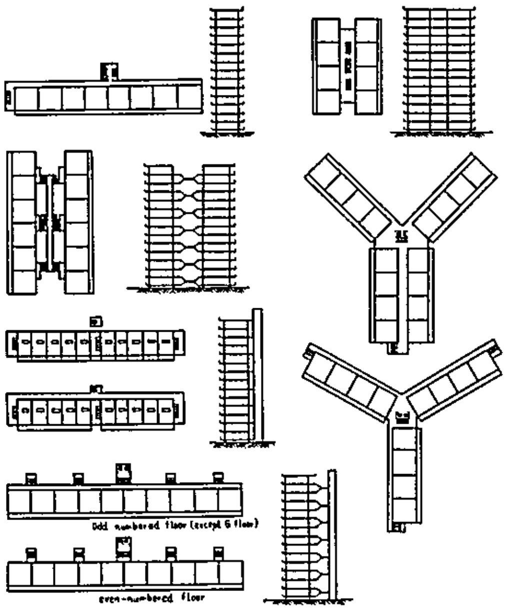
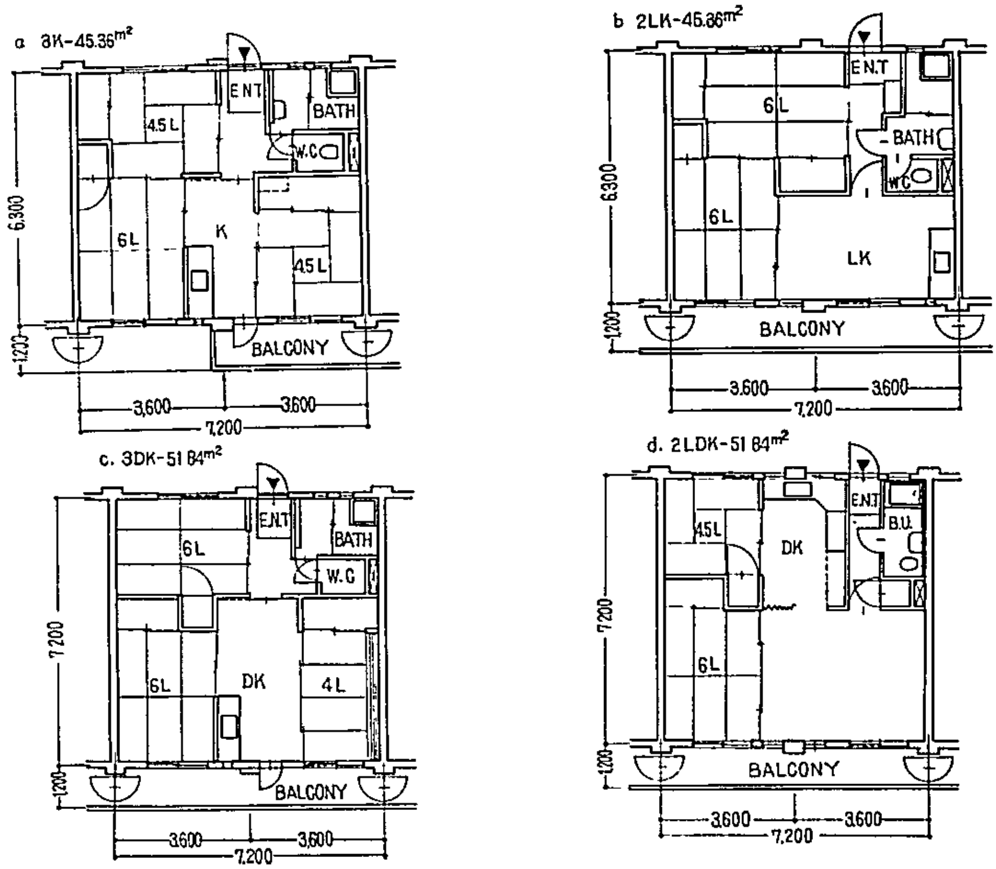


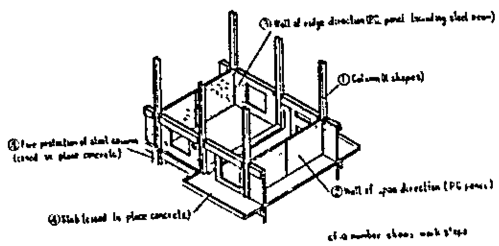
Fig. 5 Examples of unit plan



2-2. Structural Considerations

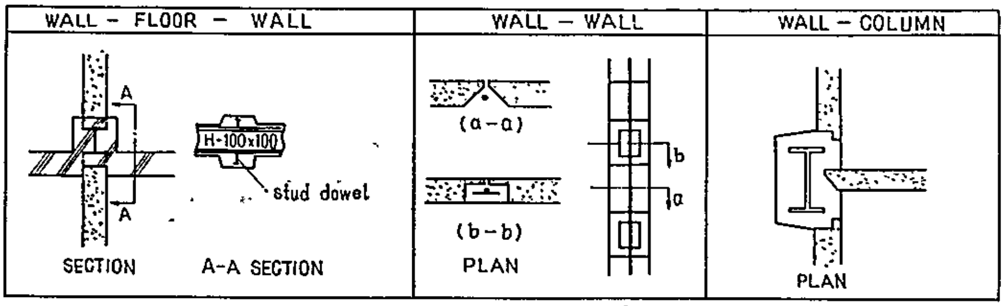
The structure is a combination of the rigid frame of steel in ridge direction and the bearing wall in span direction. The H-section steel columns act as a flange and the precast panel walls in between act as a web. (Fig. 6)

Fig. 6 Basis of HP system



a) Connections of PC Panels   Connections of panels had posed the most critical problems in the design of prefabricated concrete buildings, particularly in regard to earthquake-resistance. The HP-system has overcome this by using cast-in-place concrete to connect precast panels. In other words all joints are designed to be wet instead of being dry. (Fig. 7)

Fig. 7 Connections of P.C. panel



b) Span Direction   Blind bearing wall system is employed as described before. Other considerations are:

i) Horizontal shearing forces induced in the wall are carried through the connector, or stud dowel, attached to H-section beam (100 x 100) and the reinforced concrete beams covering them, onto the columns at the ends of the wall.

ii) Vertical shearing forces occurring between the column and the precast wall are carried directly to the steel column encased with reinforced concrete.

iii) Columns are designed to resist seismic forces adequately, whereas the walls are designed to allow crack when the force grows beyond certain limit, so that the energy be released before it is transmitted to the columns.

c) Ridge Direction   The rigid frame, or Rahmen structure, consisting of H-section columns and honey-combed beams are calculated as the active part of the structure, to hold the whole strength required by the standards. However, once these frame members are connected with precast concrete panels by cast-in-place concrete to form a monolithic wall, the external forces are resisted more by the wall panels than by steel members. Therefore, it becomes necessary to analyse more precisely the distribution of stress within the wall panels in relation to its displacement. Analysis with the help of experimentations must be made for further improvement of this system.

2-3. Building Considerations

a) Progress Plan   Progress schedule was built so that a certain number of workers (including carpenters and bar-formers) would be constantly working at the job site. For this purpose, the building block is divided into two working blocks A and B (Fig. 8) (Table 1) progressed with a lag of two or three days.

Fig. 8 Working block

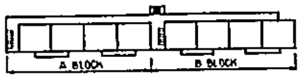
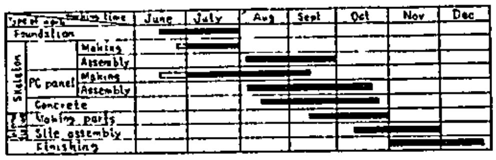


Table 1 Working cycle of skeleton (1 Floor)

Table 2 Progress schedule



b) PC Panels   The designed strength of concrete is $Fc = 180kg/cm^2$. The production of a panel takes 24 hours, following the process as follows.

1. pouring of concrete into the form.
2. trowelling of the surface.
3. applying of lids over the bed.
4. temporary steam-curing for one hour at the temperature of $40^{\circ}C$.
5. applying of the finisher to the surface.
6. steam-curing for 3 hours at $65^{\circ}C$.
7. leaving overnight in the pool covered with lids (the temperature inside the pool is controlled to be $40^{\circ}C$ in the next morning).
8. tilting up of the panel.

c) Joints   High-tension bolts with PI nuts are used for connecting coloms and beams. (Photo 1)

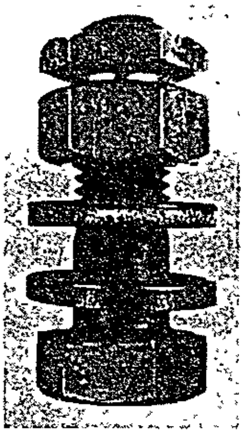


Photo 1 P I nut

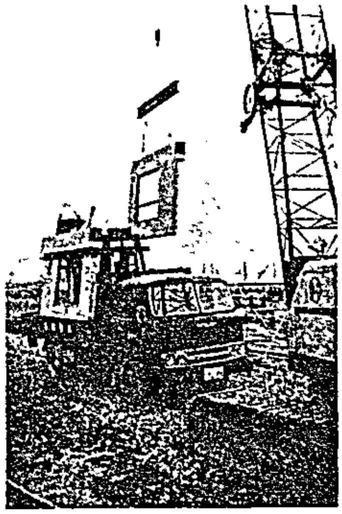


Photo 4: shipping of precast panels

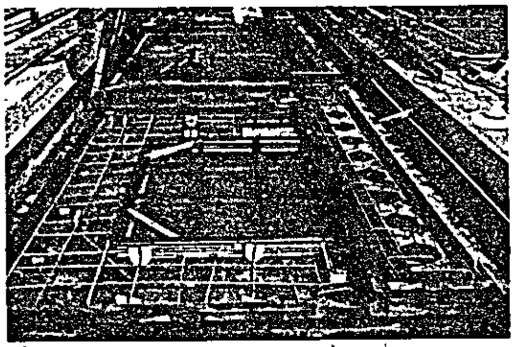


Photo 2: steel frames, reinforcing bars and window frames set inside the formwork.

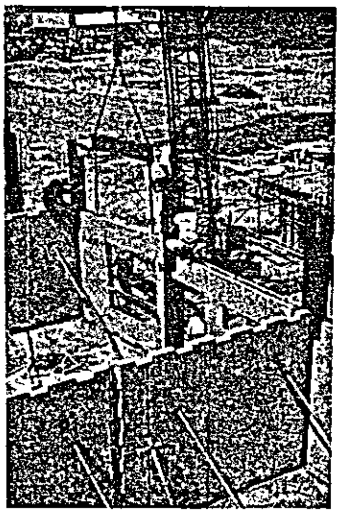


Photo 5: erection

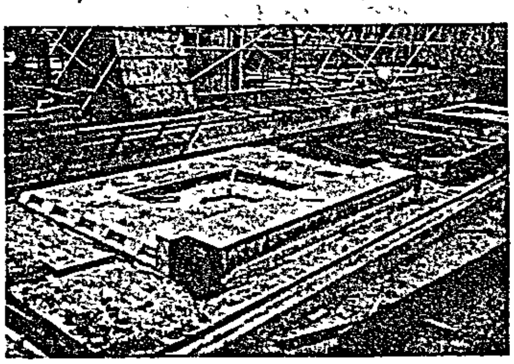


Photo 3: formwork being removed.

Photo 6: jointing of beam to a column

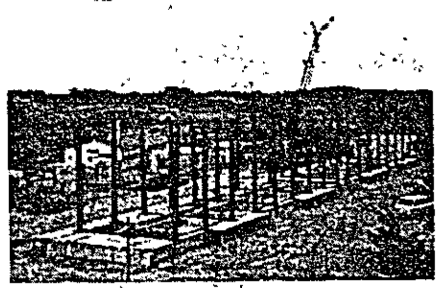


Photo 7 · Erection of steel frame

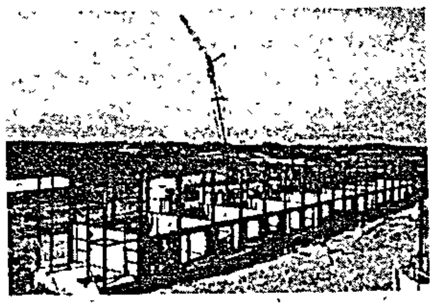


Photo 8 Erection of P.C. panel

Photo 9 Assembly of P.C. panel

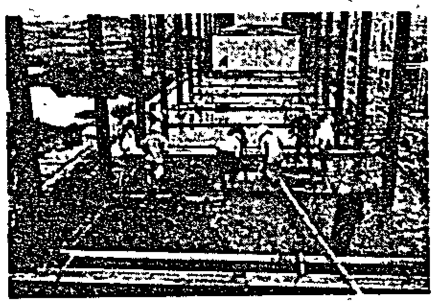


Photo 10 Concrete placing (floor)

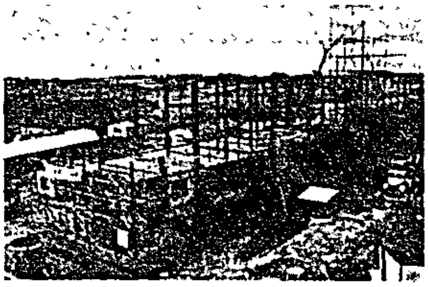


Photo 11 Erection of steel frame (No. 2 block)

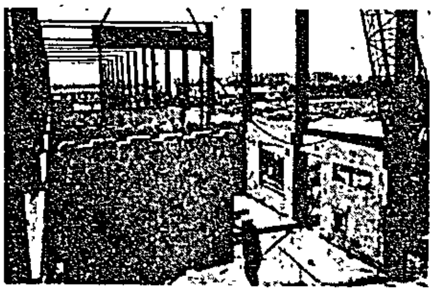


Photo 12 Assembly of P.C. panel (span)

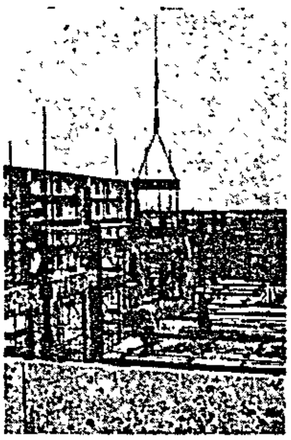


Photo 13 Assembly of P.C. panel (ridge direction)

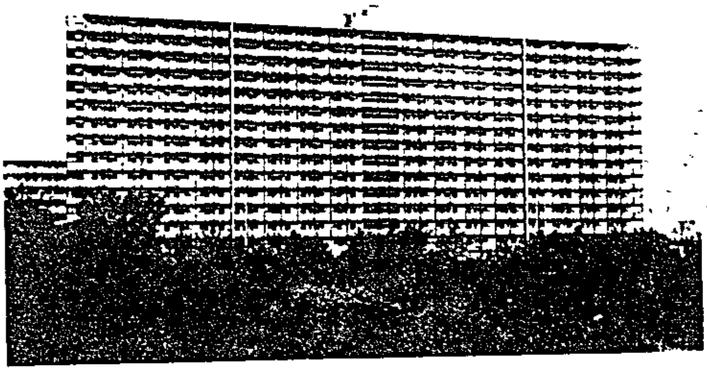


Photo 14: completed apartment building by HP-system

3. "HPC-SYSTEM" ---- A basic scheme of prefabricated high rise apartment building designed to be suited to Iran

3-1. Design Considerations

The planning is based on the SAIE Housing.

a) The structure consists of:

i) precast concrete beams including H-section of steel,

ii) cast-in-place reinforced concrete columns including H-section of steel to hold precast panels.

b) Lateral force is resisted by precast concrete wall which is made monolithic with the precast beams including H-section steel.

c) No beam is allowed to appear below the false ceiling to maintain freedom in the layout of partitions.

d) Spandrel walls and part of the curtain walls are of brick with adequate reinforcement against earthquake.

3-2. Structural Considerations

The structure is of steel-reinforced rigid frame type with lateral-load-bearing walls distributed throughout. Floors are precast concrete panels connected in the manner they maintain lateral rigidity.

a) Connections of PC Panels Connections of panels are no less important in view of earthquake, although the intensity is assumed half as much as in

Japan. Precast·floor panels are connected in a dry manner. But precast load-bearing wall panels are connected horizontally in a dry manner and vertically in a wet manner.

b) Rigid Frame The frame consists of the precast concrete beams including H-section steel and cast-in-place reinforced concrete columns including H-section steel receiving precast wall panels, in span and ridge directions. This will require less steel than foregoing HP-system, since reinforced concrete columns replace the steel columns fireproofed with concrete.

The load-bearing walls are adequately provided. They will i) transfer the horizontal shearing stress occurring inside them down to the footings through the connection gadgets, and ii) transfer the vertical shearing stresses occurring between columns and PC panel walls to the reinforced concrete columns including H-section steel through shear-cotters.

3-3. Building Considerations

a) Progress Plan The progress schedule is built so that a certain numbers of workers can work constantly at the field. Each working block covers two buildings, and the crane is to be installed in between. Within the sphere of reach is located the field plant fabricating PC components. In view of the traffic situation around Teheran, it is more advantageous to build field plants than to rely on ordinary ones located afar from the housing site in most cases.

4. "PPC-SYSTEM" ---- (PRESTRESSED-PC-FRAME-SYSTEM) Another basic scheme of prefabricated high rise apartment building designed to be suited to Iran

4-1. Design Considerations

The planning is based on the SAIE Housing. This system will suit the conditions in Iran, perhaps better than the HPC-SYSTEM, whose advantages may possibly be offset by the higher cost of steel and the difficulties in performing precision required for the connections of the frame. The possible advantages are:

1. Possibility of making use of domestic high strength cement.
2. Much less steel required.
3. Requires precision in connections to a lesser degree.
4. Requires less field formwork, due to reduced portion of cast-in-

place concrete.

a) The rigid frame is composed of PC beams with joint gadgets at the ends and prestressed PC frame units, having the shape either ─┼─┼─ or ├─┼─ , fabricated either on site or off site. The floors are PC panels.

b) The walls bearing lateral forces are fabricated monolithically with PC beams, so that even walls can be prestressed.

c) False ceilings are provided so that no beams appear inside interior space, ensuring freedom in partitioning.

d) Brick is used for spandrel walls and part of the curtain walls, with adequate reinforcing against earthquake.

4-2. Structural Considerations

The structure is basically prestressed concrete rigid frame, with adequately distributed earthquake-resistant walls. The PC panel floors are so designed and jointed as to attain adequate lateral rigidity. The frame in ridge direction is composed of prestressed concrete frame units, shaped ─┼─┼─ or ├─┼─ . The completed frame is to have columns and beams, each jointed at the inflection point and at the middle, respectively, by means of joiners fixed at the ends of each frame units.

The horizontal shearing forces occurring in the bearing wall are carried down to the foundation through the gadgets connecting wall panels. The vertical shearing forces occurring between columns and bearing walls are mostly resisted by the gadgets at the ends of beams over the walls, and resisted in part by the shear-cotter placed at the joint between columns.

4-3. Building Considerations

Same as HP-SYSTEM.

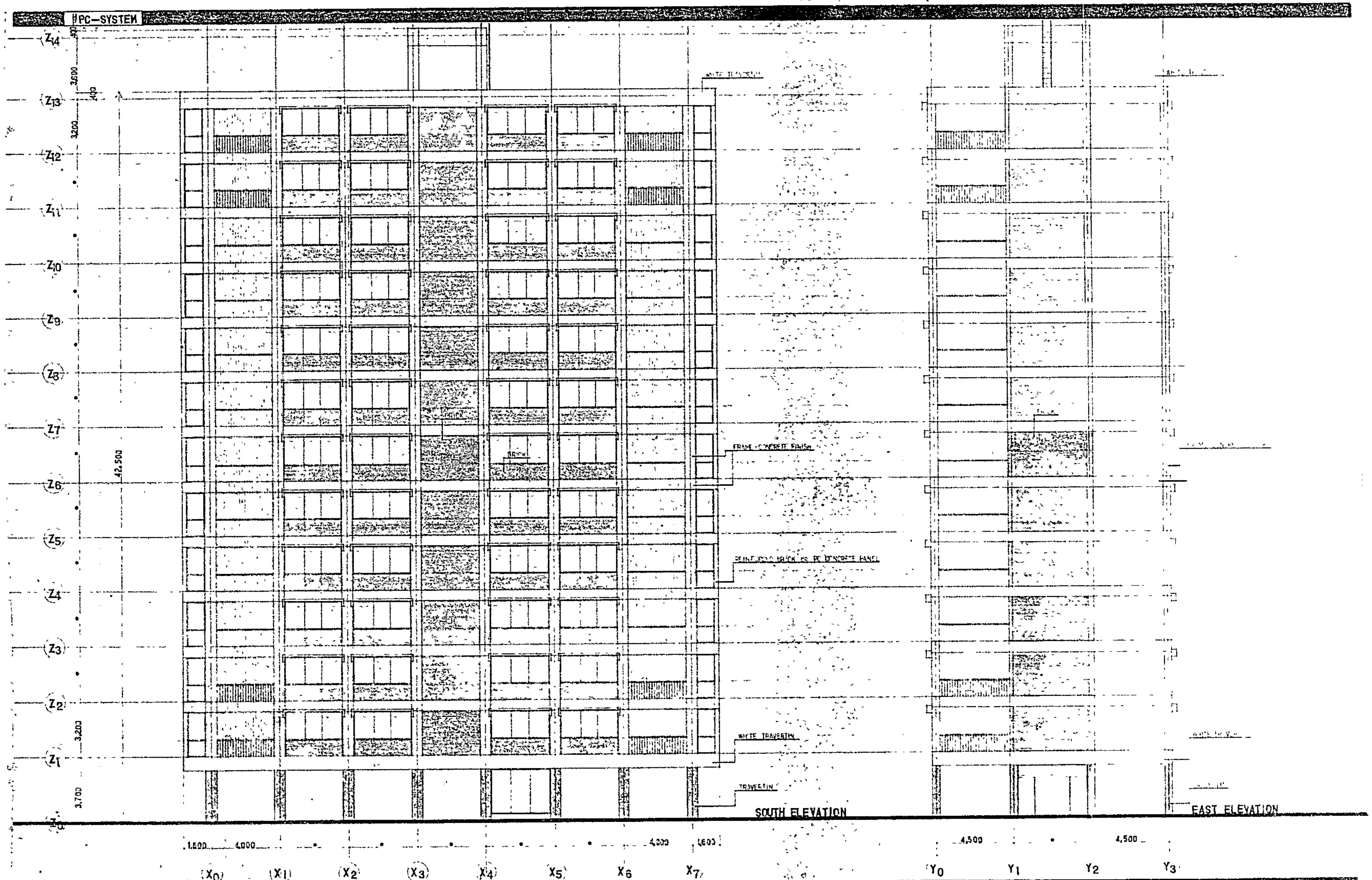
5. Basic Plans of HPC-SYSTEM and PPC-SYSTEM. (13 Drawings)

6. Conclusions

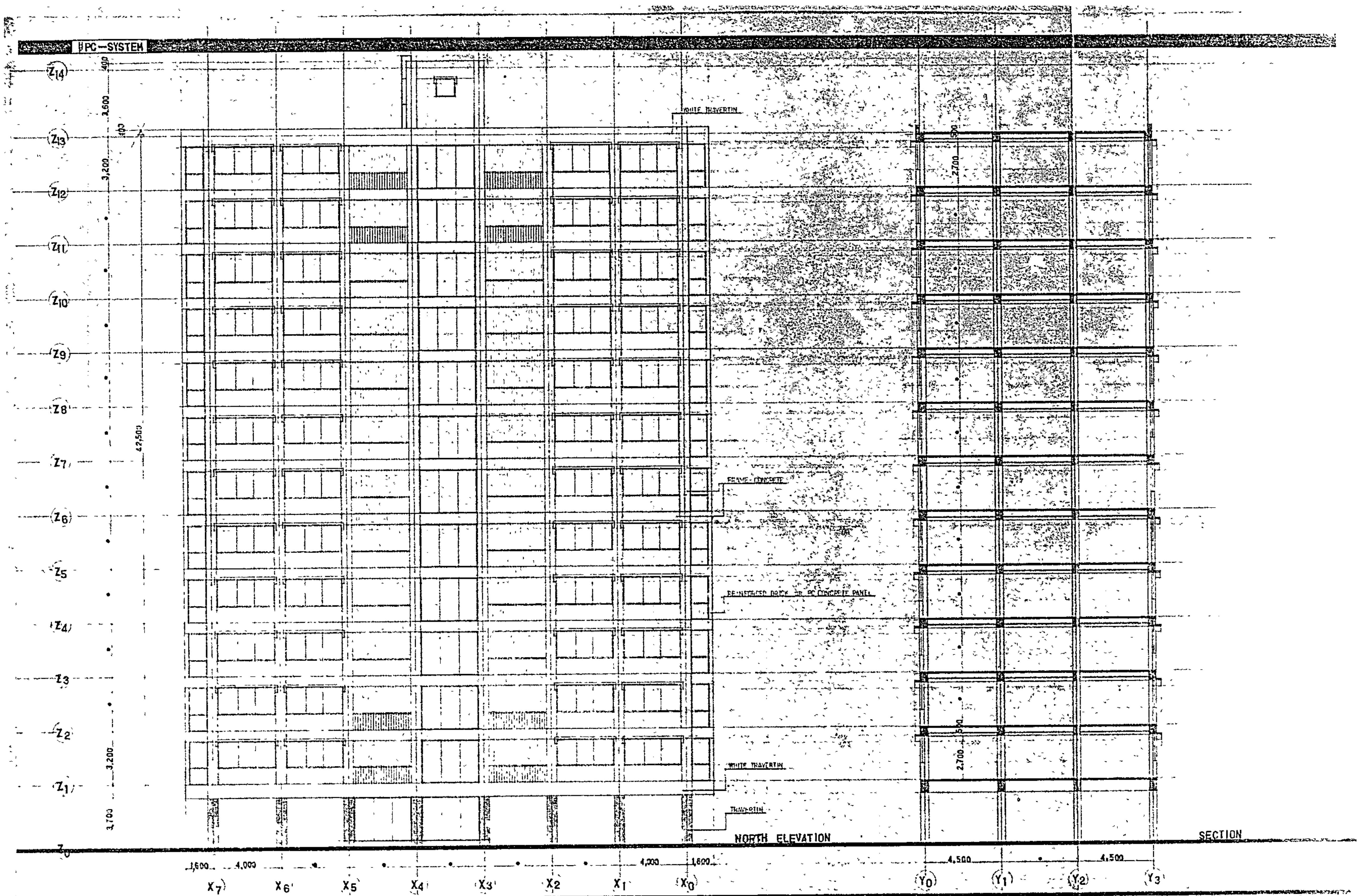
We believe the prefabrication systems outlined here will best fit the practice in Iran. For further informations refer to the attached drawings.

In view of the circumstances Iran is situated in, efforts should be centered on the research and development of such low-cost prefabricated high rise apartment buildings. We are sending the following materials in the hope that they may be helpful for such efforts.

1. Drawings of Uenodai Flats in Nagoya, by Fuji Steel Works Co., Ltd.,
2. Drawings of Kimizu Flats by Yawata Steel Works Co., Ltd.,
3. Drawings of flats by Kawasaki Steel Works Co., Ltd.,
4. An analysis of structural response to ground motion, and a vibration test of a HP-SYSTEM structure.



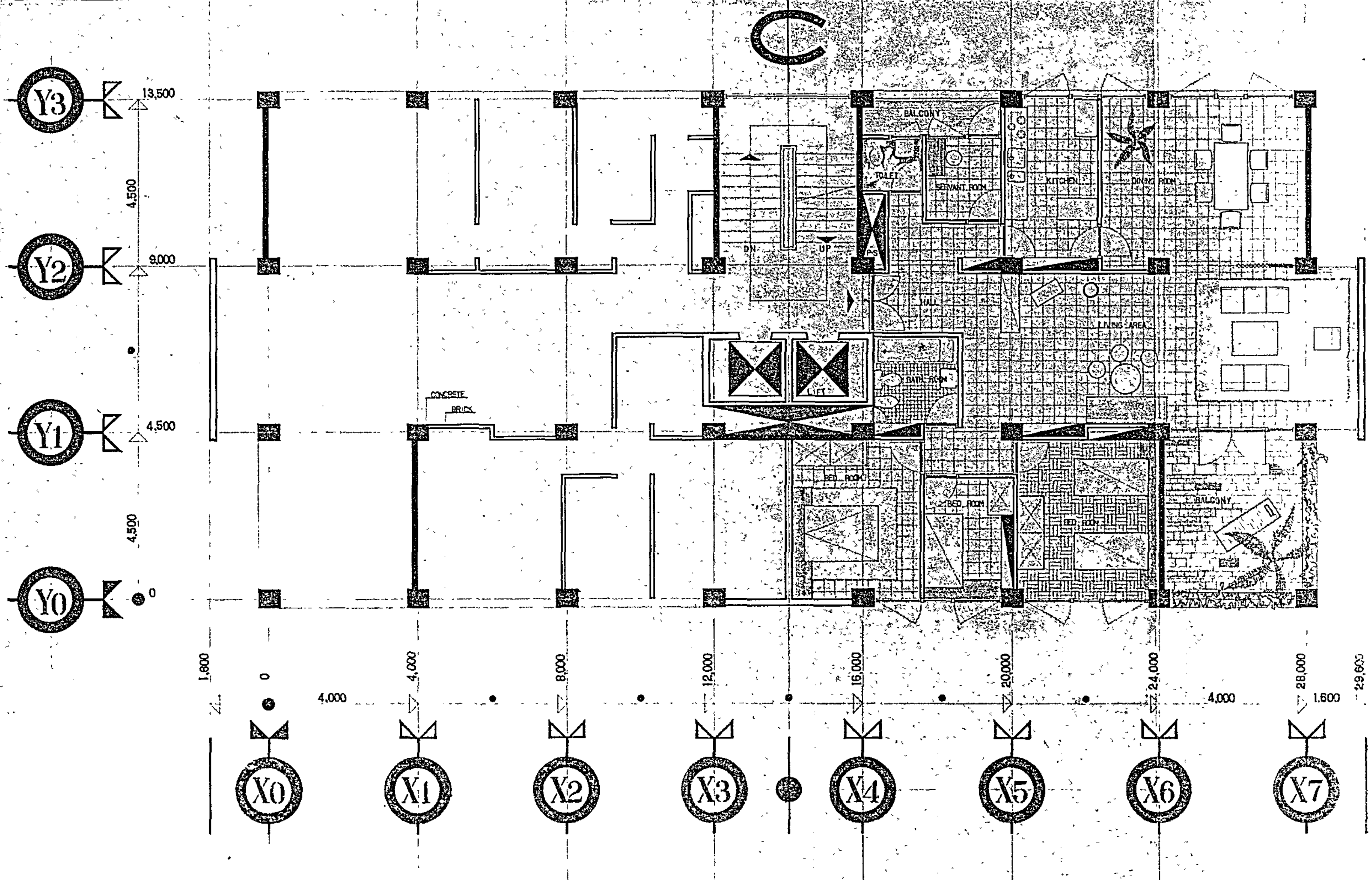
九段建築研究所	TEL 261-7357		45・2・28	HIGH-RISE PREFABRICATED APARTMENT FOR IRAN	EXPLANATION MAP FOR PC-SYSTEM	PC-SYSTEM



九段建築研究所 TEL 264-7357 | 45・2・28 | HIGH-RISE PREFABRICATED APARTMENT FOR IRAN | EXPLANATION MAP FOR PC-SYSTEM | 1/100

PC-SYSTEM

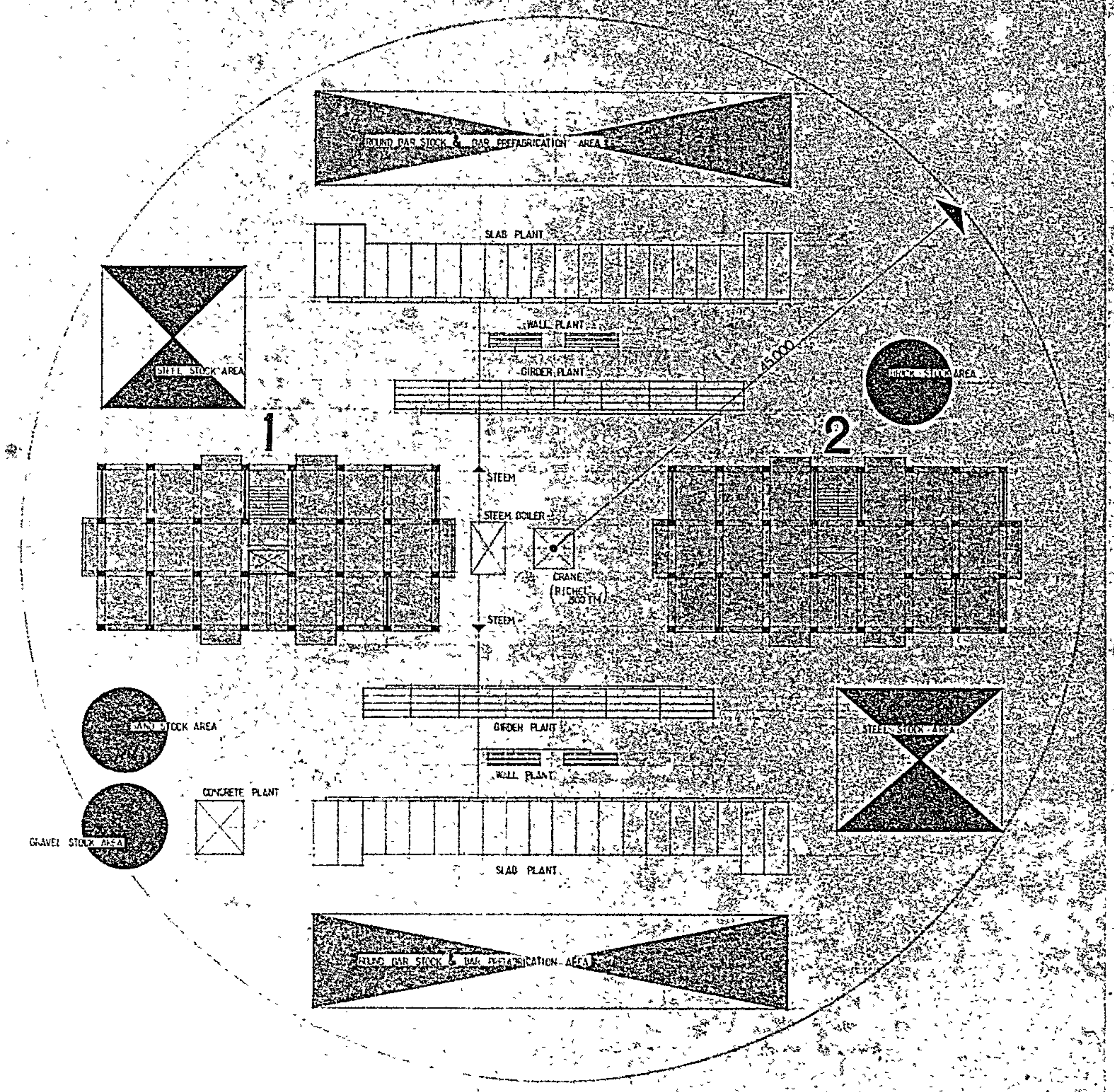
PC-SYSTEM



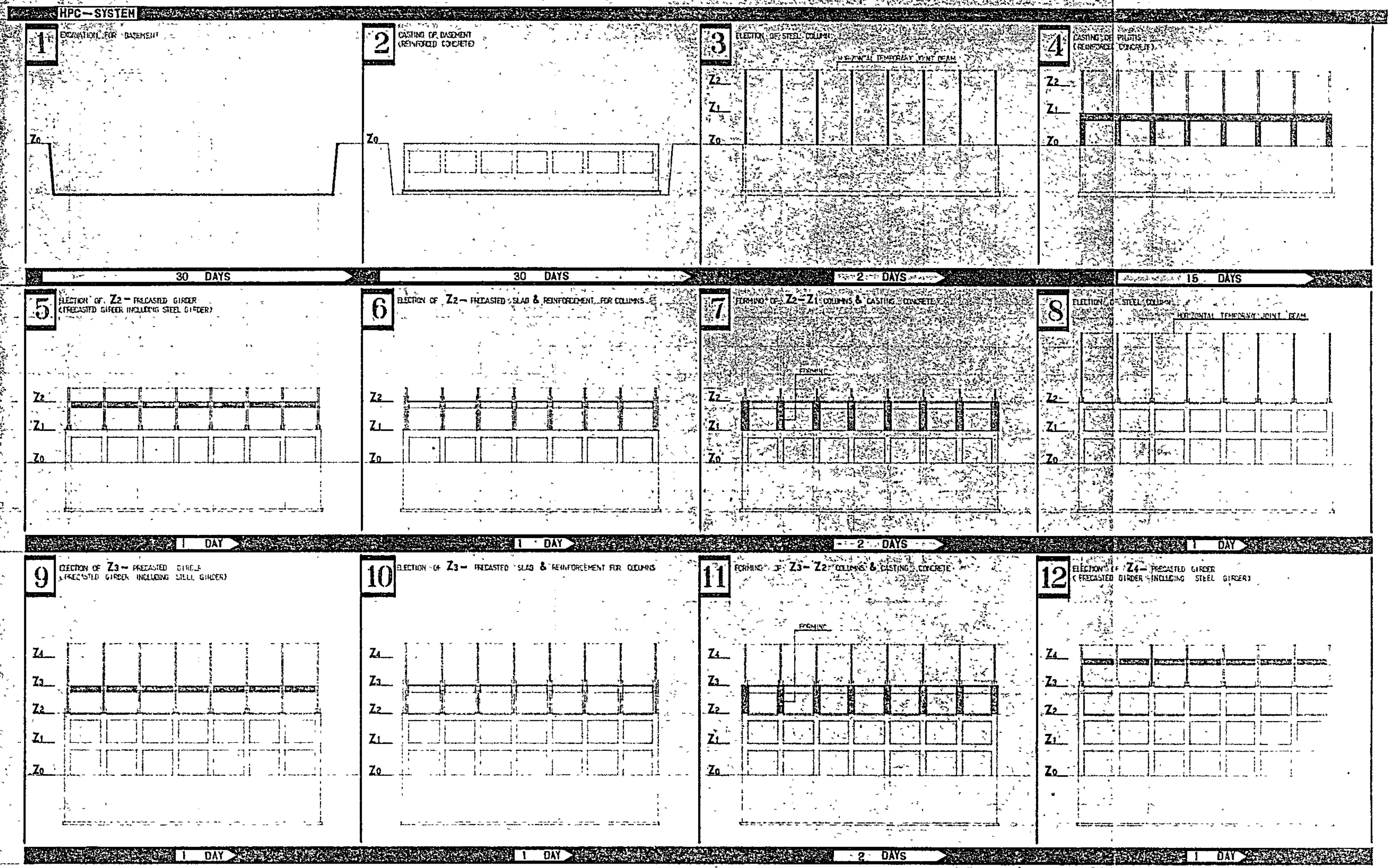
PLAN

株式会社 九段建築研究所 | TEL | 45・2・28 | HIGH-RISE PREFBRICATED APARTMENT FOR IRAN | EXPLANATION MAP FOR PC-SYSTEM | 1/50

PC-SYSTEM



LAY OUT OF TENPORARY WORKS

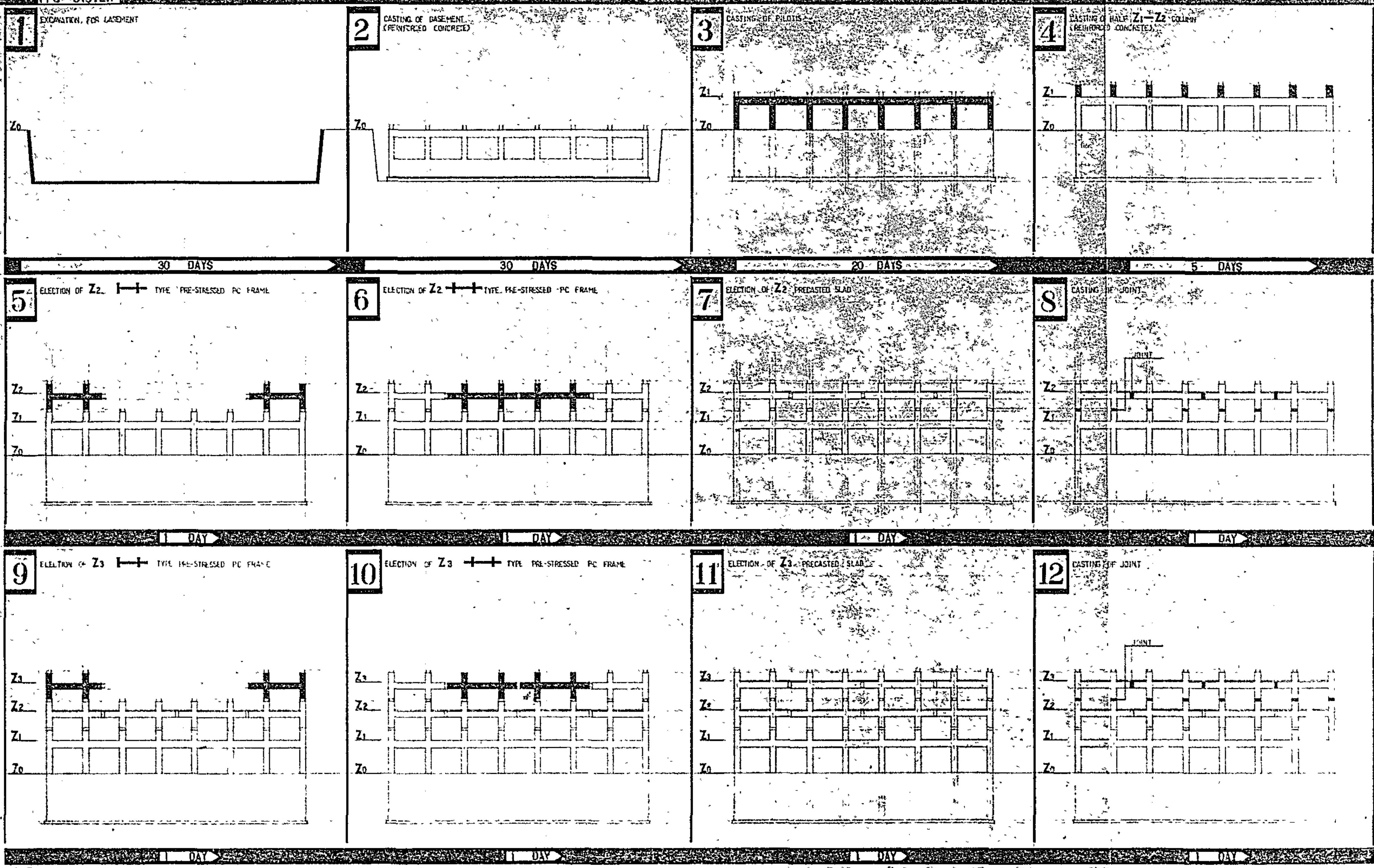


ASSEMBLY OF SKELETON

九段建築研究所	TEL 261-7357		45・2・28	HIGH-RISE PREFABRICATED APARTMENT FOR IRAN	EXPLANATION MAP FOR HPC—SYSTEM	1 / 200	A.5

HPC—SYSTEM

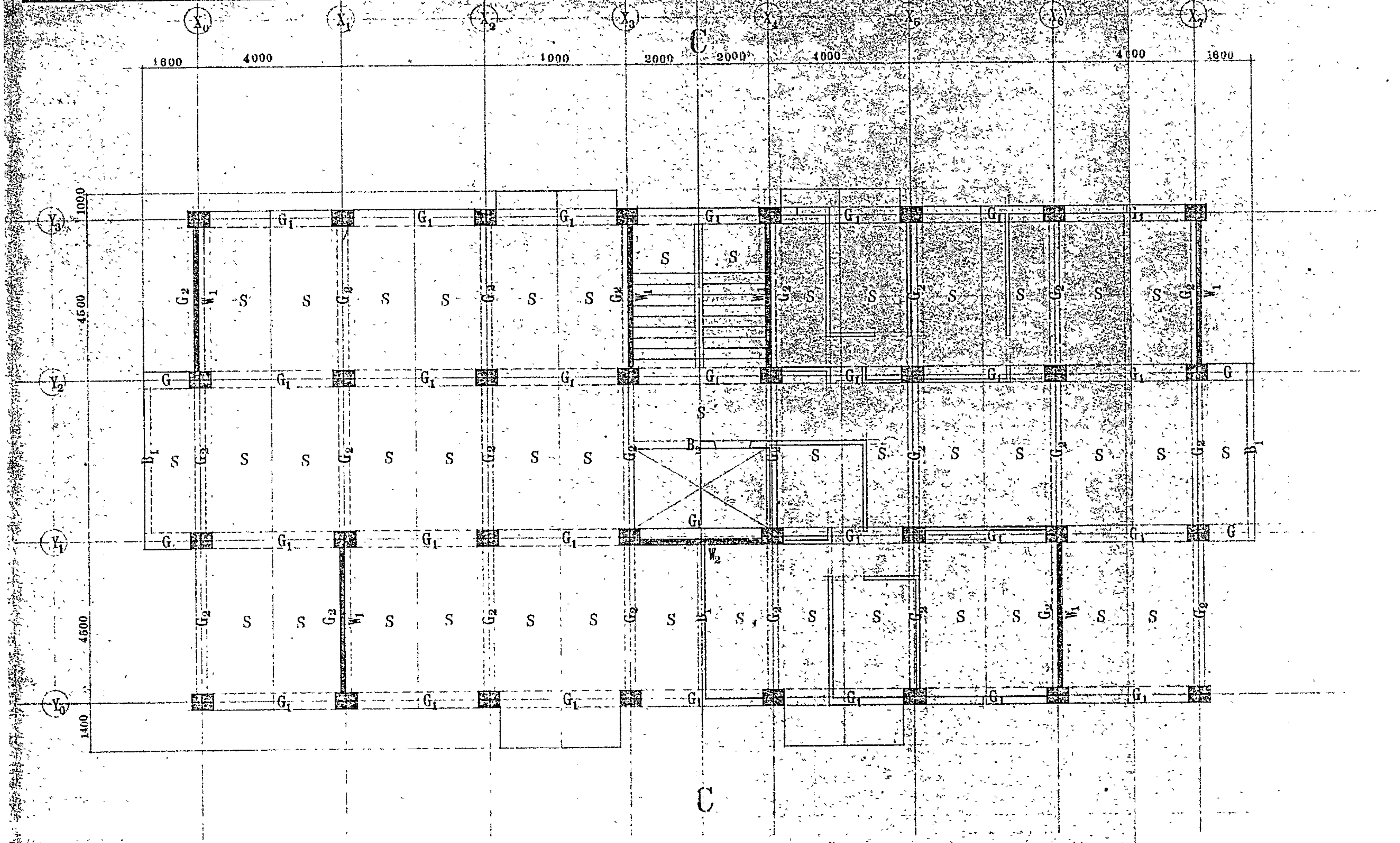
PPC-SYSTEM



ASSEMBLY OF SKELETON

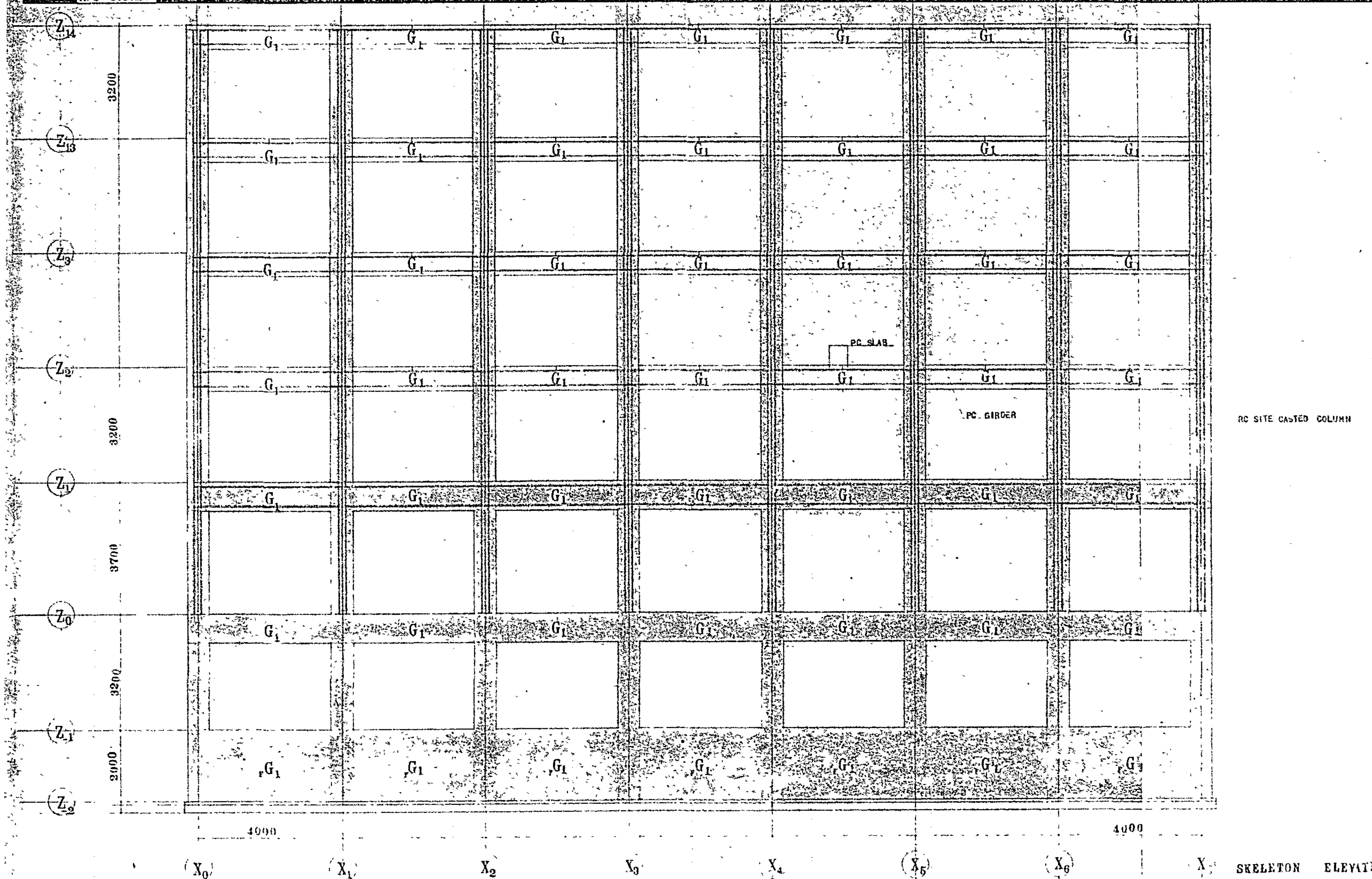
株式会社 九段建築研究所 TEL 264-7357	中 …	45・2・28		HIGH-RISE PREFABRICATED APARTMENT FOR IRAN	EXPLANATION MAP FOR PPC-SYSTEM	1 / 200	A-6

PPC-SYSTEM



STRUCTURAL PLAN

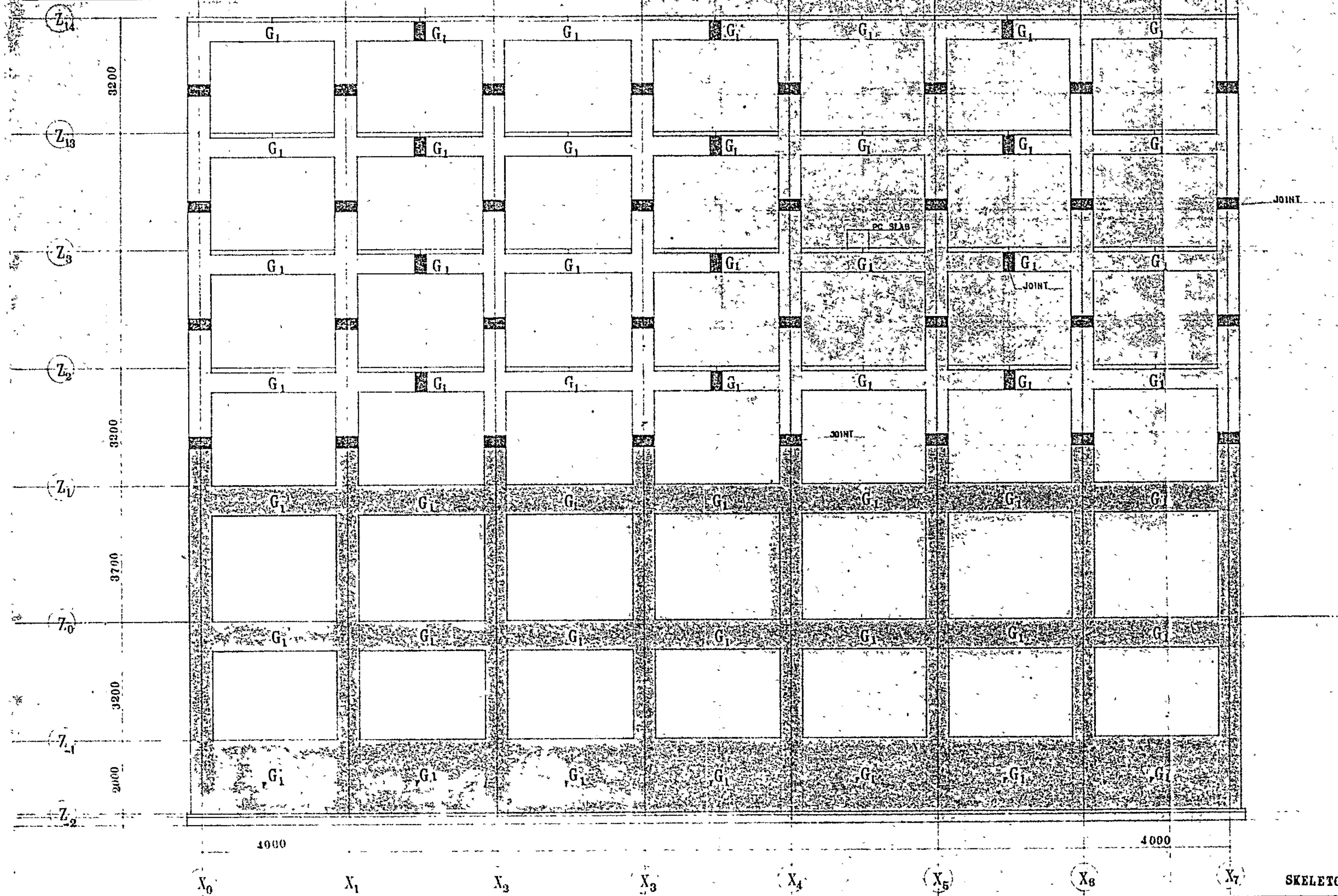
九段建築研究所 TEL 264-7357	45・2・28	HIGH-RISE PREFABRICATED APARTMENT FOR IRAN	EXPLANATION MAP FOR H/PC-SYSTEM	1/50	A・7



SKELETON ELEVATION

株式会社 九段建築研究所 TEL 264-7357		45・2・28	HIGH-RISE PREFABRICATED APARTMENT FOR IRAN	EXPLANATION MAP FOR HPC-SYSTEM	1/50	A-8

PPC–SYSTEM

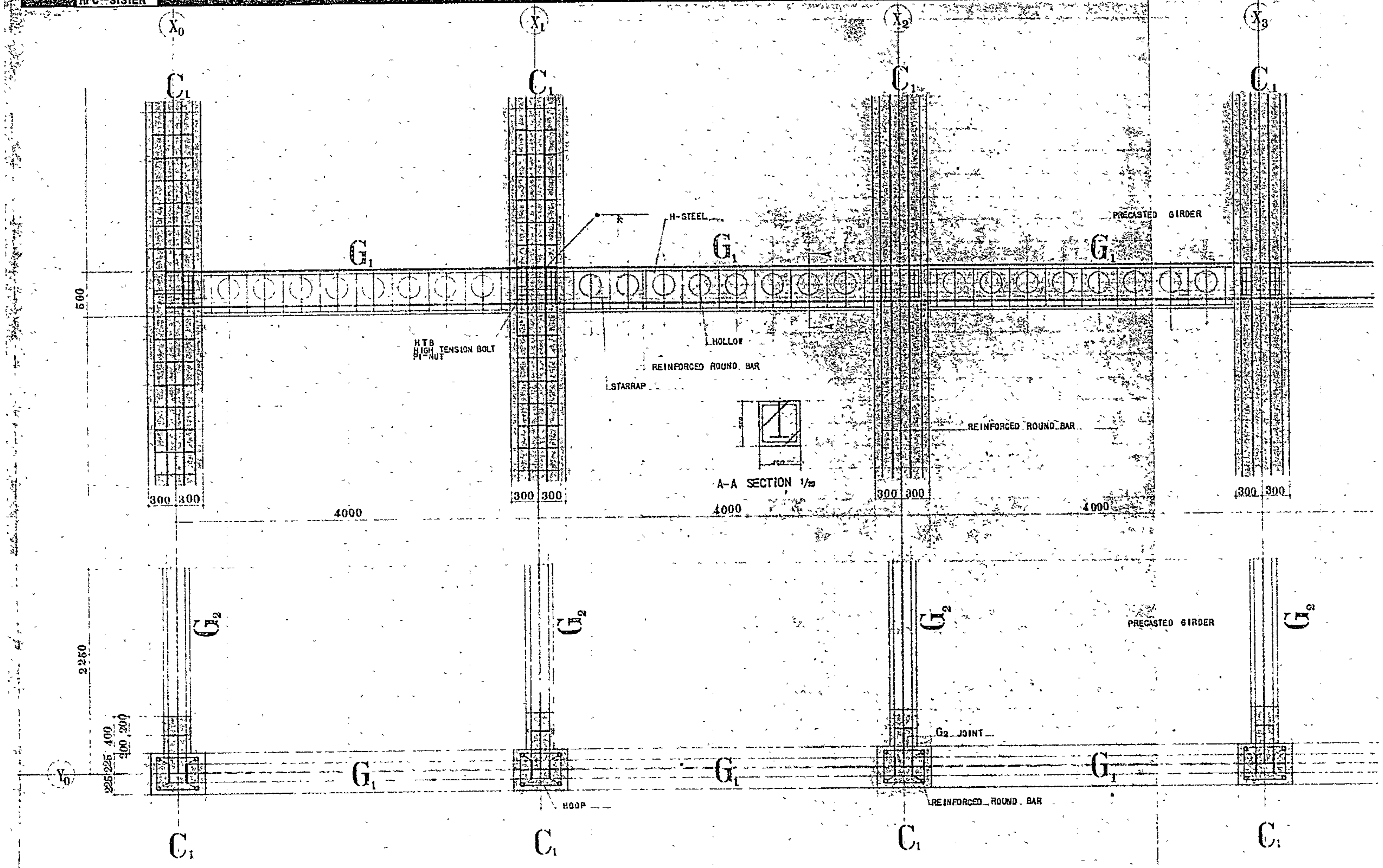


SKELETON ELEVATION

九段建築研究所 TEL 264-7357		45・2・28	HIGH-RISE PREFABRICATED APARTMENT FOR IRAN	EXPLANATION MAP FOR PPC-SYSTEM	1/50	A・9

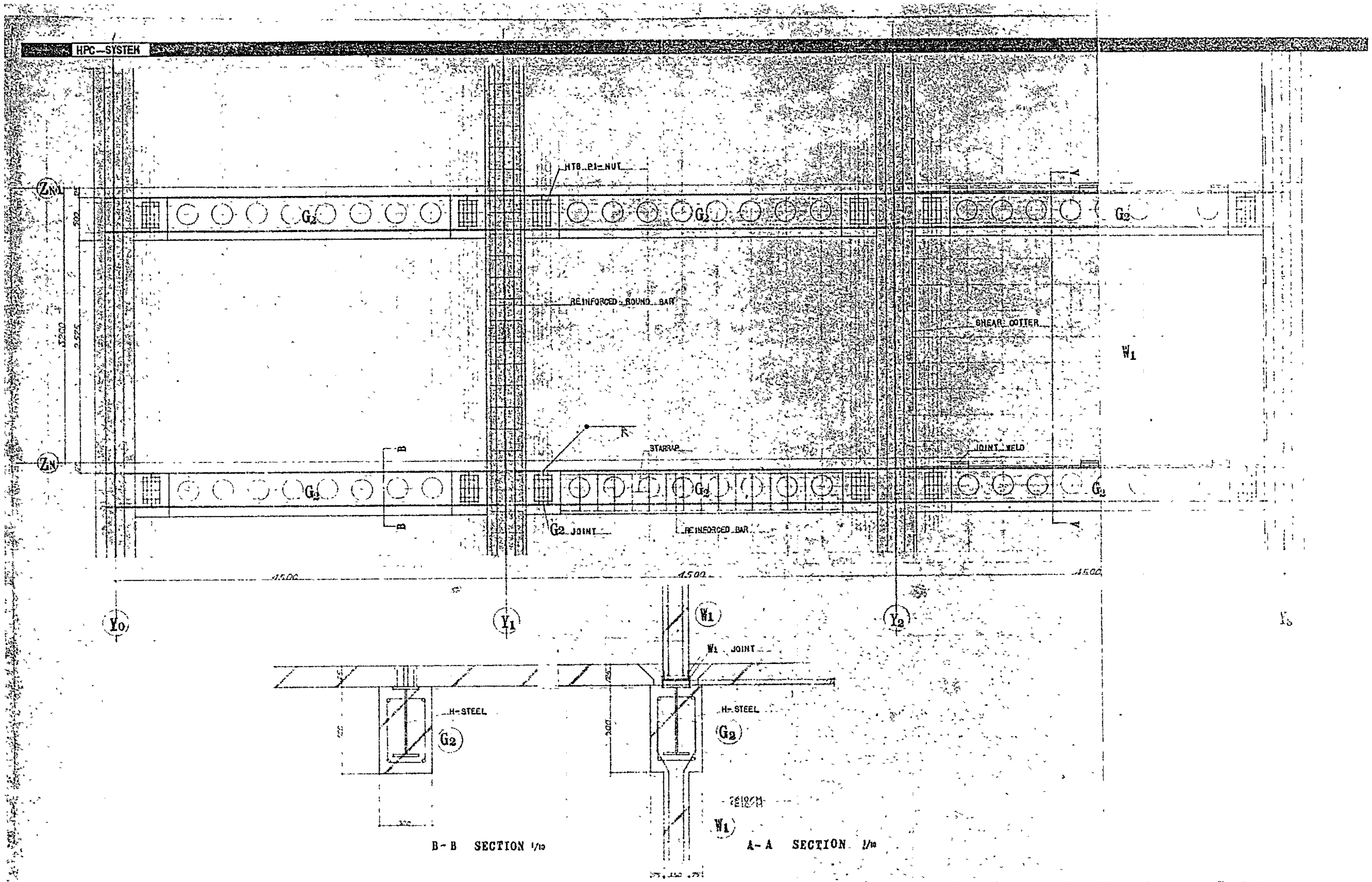
PPC–SYSTEM

HPC—SYSTEM



STRUCTURAL DETAIL (X- DIRECTION)

株式会社 九段建築研究所 TEL 264-7357	45·2·28	HIGH-RISE PREFABRICATED APARTMENT FOR IRAN	EXPLANATION MAP FOR HPC-SYSTEM	1/20	A·10	HPC—SYSTEM



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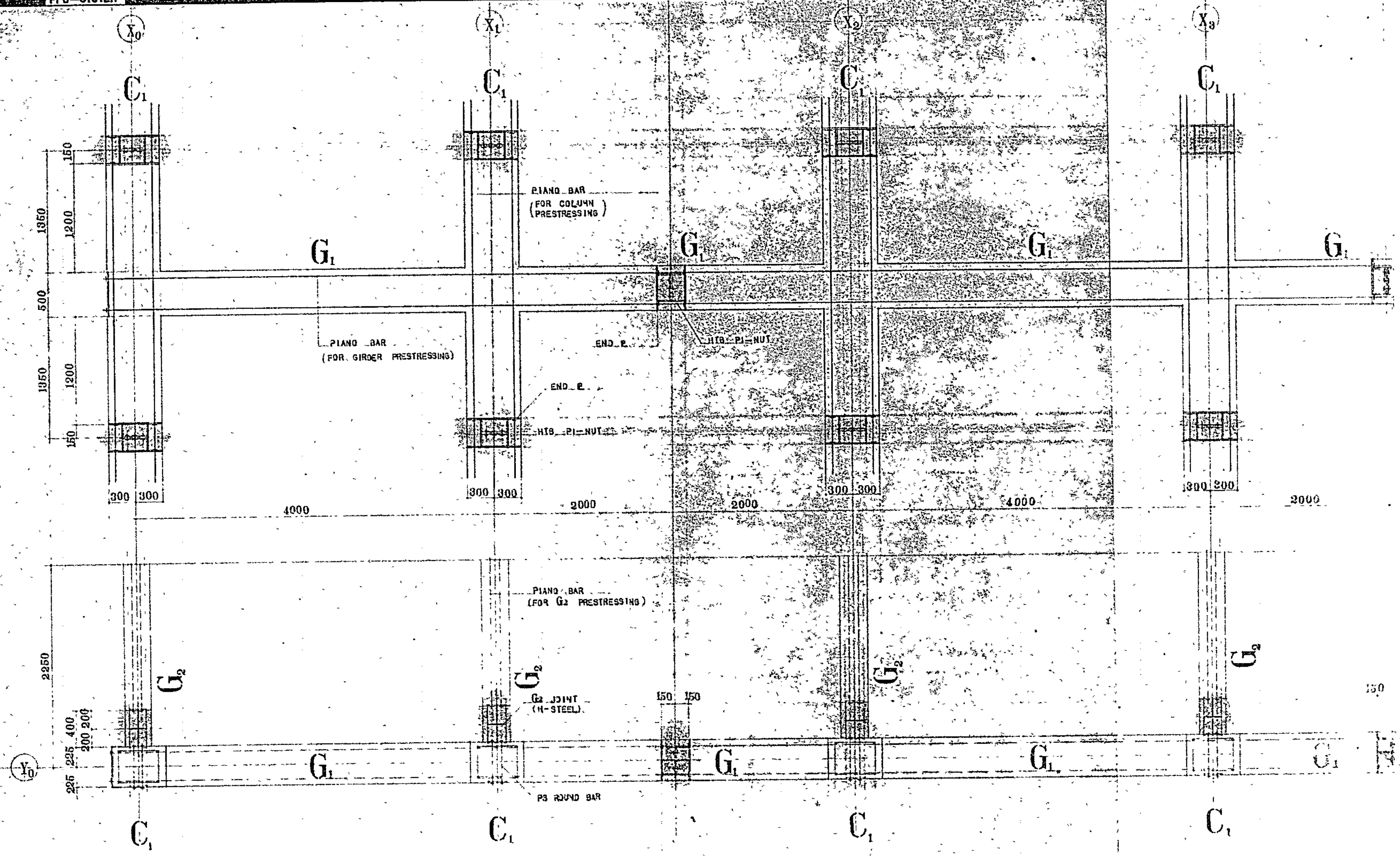

STRUCTURAL DETAIL (X-DIRECTION)

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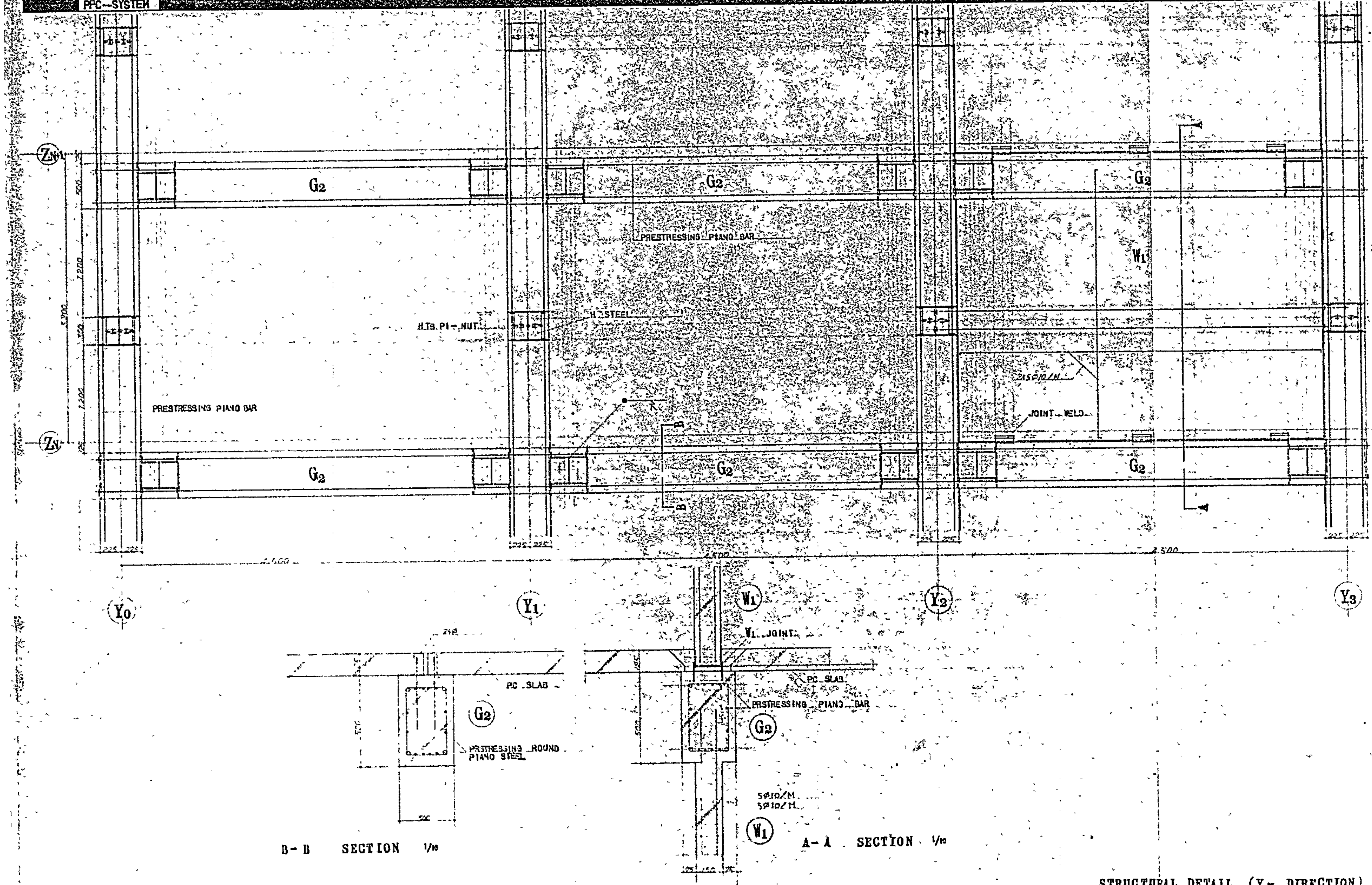


STRUCTURAL DETAIL (Y- DIRECTION)

株式会社 九段建築研究所 TEL 264-7337		45・2・28		HIGH-RISE PREFABRICATED APARTMENT FOR IRAN	EXPLANATION MAP FOR PPC-SYSTEM	1/20 1/10	A・13

CHAPTER II. WALK-UP APARTMENT BUILDINGS

1. Structural Observation of Walk-up Apartments

Most buildings in Teheran appeared extremely dangerous structurally to the eyes accustomed to see building structures in the light of earthquake resistance. It seemed obvious that earthquakes of Richter magnitude over 7 would cause desasterous damages. As we observed, for example, the extensive use of brick creates structural disadvantages with respect to earthquake resistance. The brick walls and floors do not work together with steel framework to resist seismic forces. On the contrary, creating great load on to steel framework, they would reduce the ability of the whole structure to resist earthquake.

Admitting that brick ensures the most economical insulation in hot summer, its structural drawbacks should be eliminated by replacing with reinforced concrete wherever required structurally. The structural drawbacks of brick as used in this way mainly lies in the facts as follows:

1. It is dangerous that floors are made of brick arch with only a little rise. This applies to high rise apartment buildings, as well.
2. The brick walls are not thick enough to carry structural load, though effective as insulation. Adding to dead load instead, they work to weaken the whole structure. For walk-up apartment buildings consideration must be given to reinforce concrete beams and corners of walls, as well as adequate reinforcement for foundation beams and footings.
3. The steel framework should be made much more rigid. For instance, beams and columns should be connected rigidly. To increase rigidity of the framework, it is recommended to allow beams appearing across a room, although such treatment seemed not to be desired. Beams may be allowed to appear at least over the partitions.
4. As suggested by Mr. Ayatorahi, the pouring of concrete against brick floor arches in 5 or 6cm thick may help to make floors much more rigid with the least additional cost, for the formwork costs relatively high in Iran. Reinforced hollow block is also recommendable.
5. As for precast concrete buildings, it is of structural importance that details of PC floor panel joint being used in Japan will apply to Iran, although the floor panel with its inferior insulation quality does not.
6. The use of precast concrete should be encouraged, for it ensures shorter construction period and eliminates formwork. The problem is whether the PC plant is feasible in Iran where labour supply is relatively stable

and labour cost is relatively low.

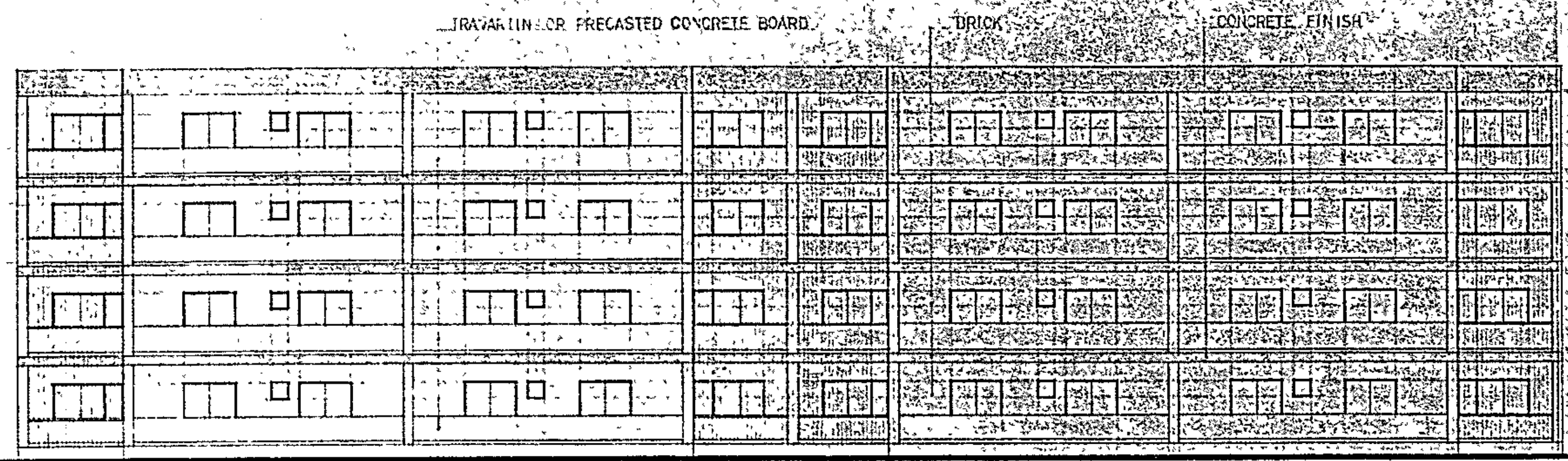
7. Metal forms do not require skilled labour and ensure accuracy in setting them in place.
8. The traditional techniques of brick work may be applied to more structurally advanced methods of reinforced concrete block construction for buildings not higher than two storeys, provided that due consideration is given to the floor design, as suggested before.
9. Taking the advantage of the climate in which steel is not subject to rust, steel framework may be combined with light-weight partition panels.

2. Improvement Proposal for FORSAD Apartments (built by Sazumane-Maskan)

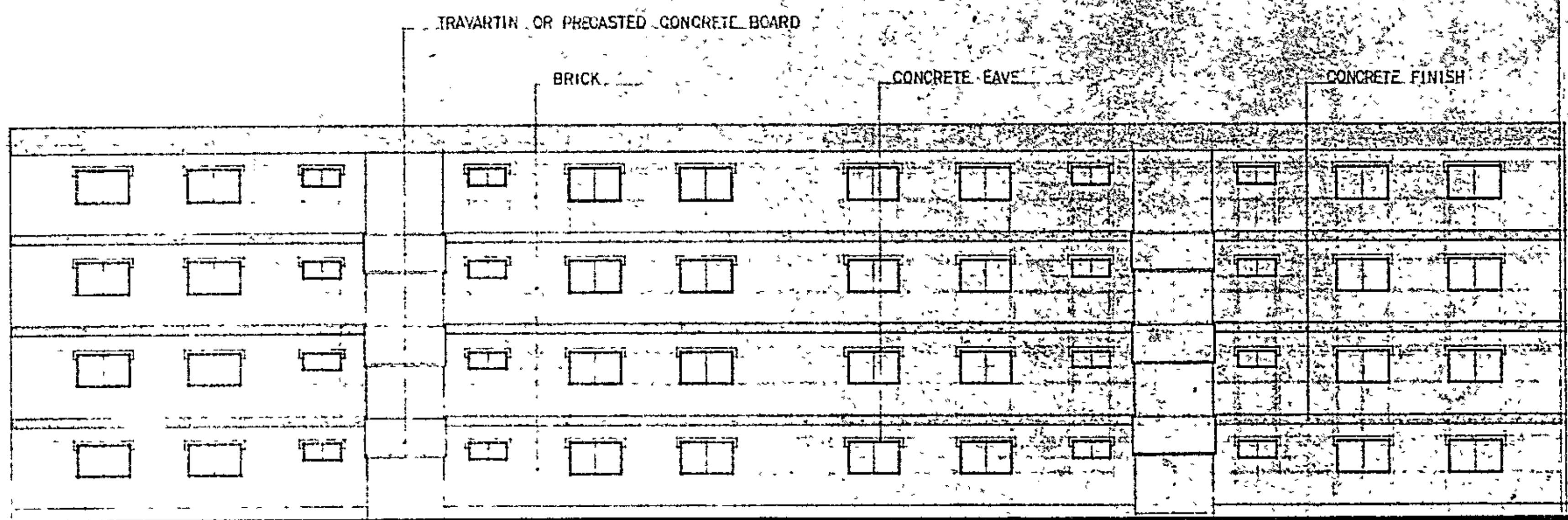
The walk-up apartment buildings in FORSAD consist of steel rigid frame in ridge direction, Jack-arch type of floors and brick walls. The improvements that we have worked out in an attempt to increase earthquake resistance and at the same time to reduce cost are, in short, a reinforced brick structure with reinforced concrete beams, and reinforced concrete slabs poured against hollow blocks, as shown in C-1, C-2 and C-3.

This method requires only one forth of steel required for FORSAD type. And construction period will be shorter. For buildings higher than four storeys, reinforced concrete columns may be used in addition to RC beams on which brick walls rest. The combination of reinforced concrete and domestic hollow blocks for floors will increase structural strength, with necessary insulation quality secured, and will lead to overall economy.

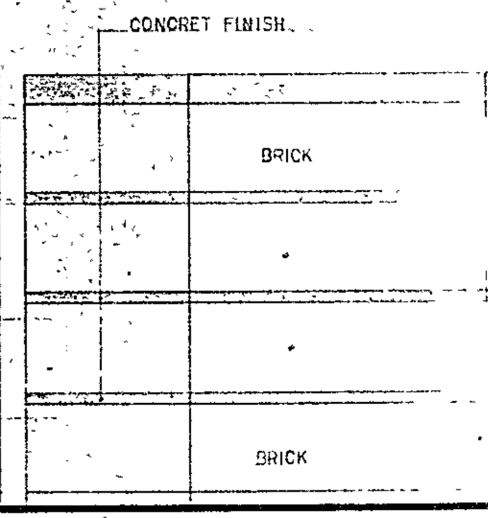
3. Basic Schemes of the Improvements (3 sheets)



SOUTH ELEVATION

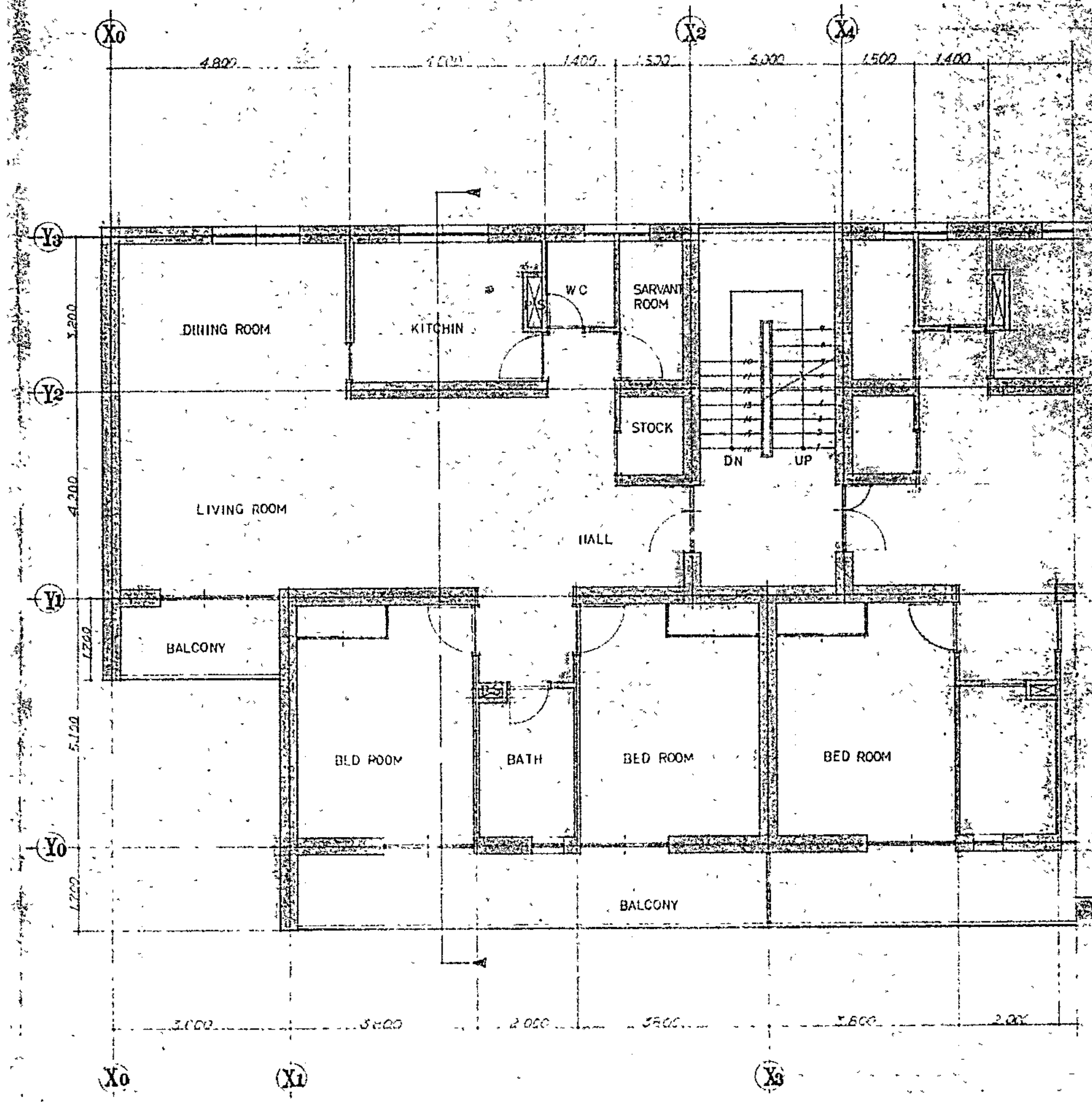


NORTH ELEVATION

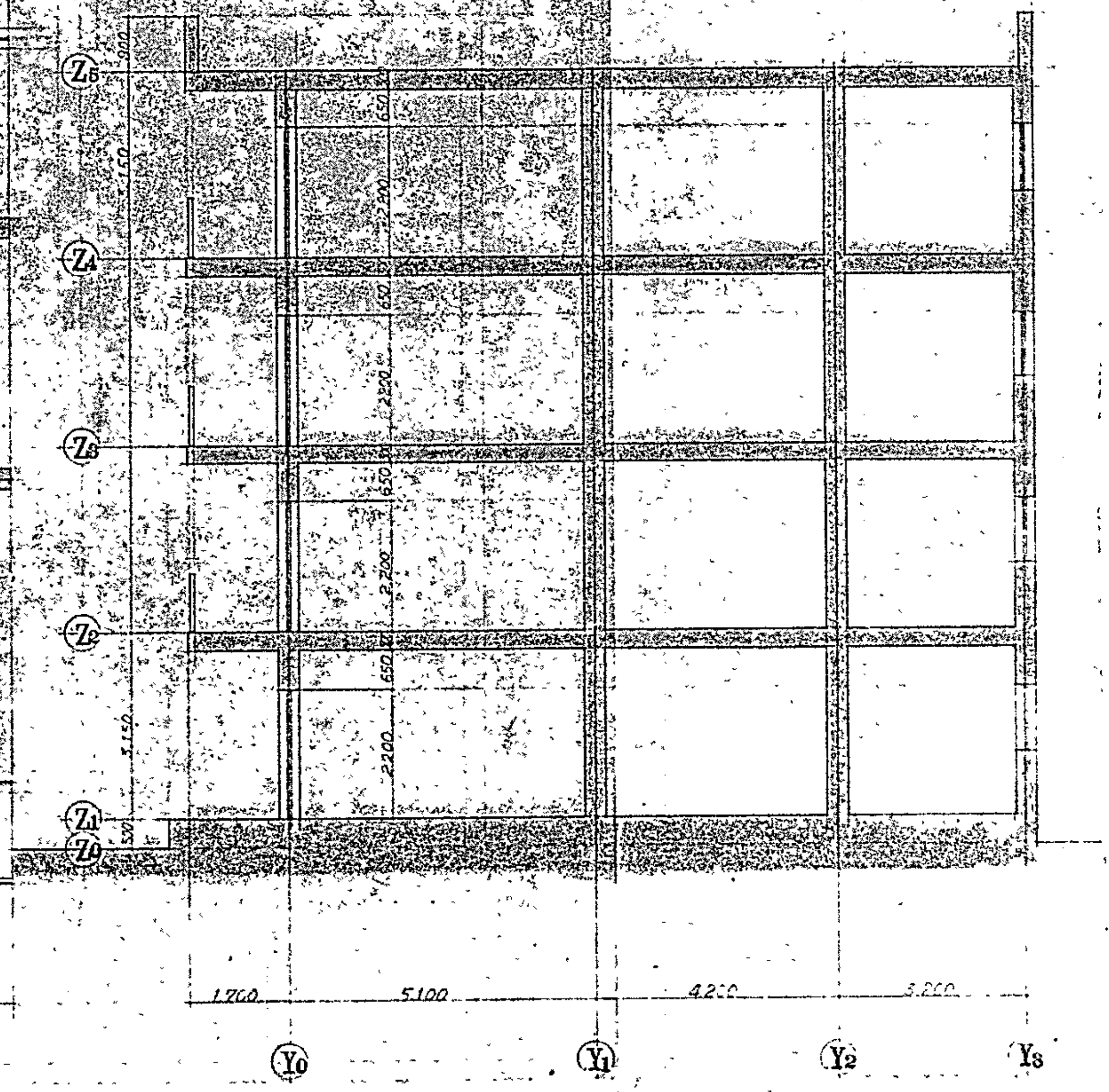


EAST ELEVATION

	45 3 31	LOWCOST APARTMENT FOR IRAN	ELEVATION	1/100	C-1

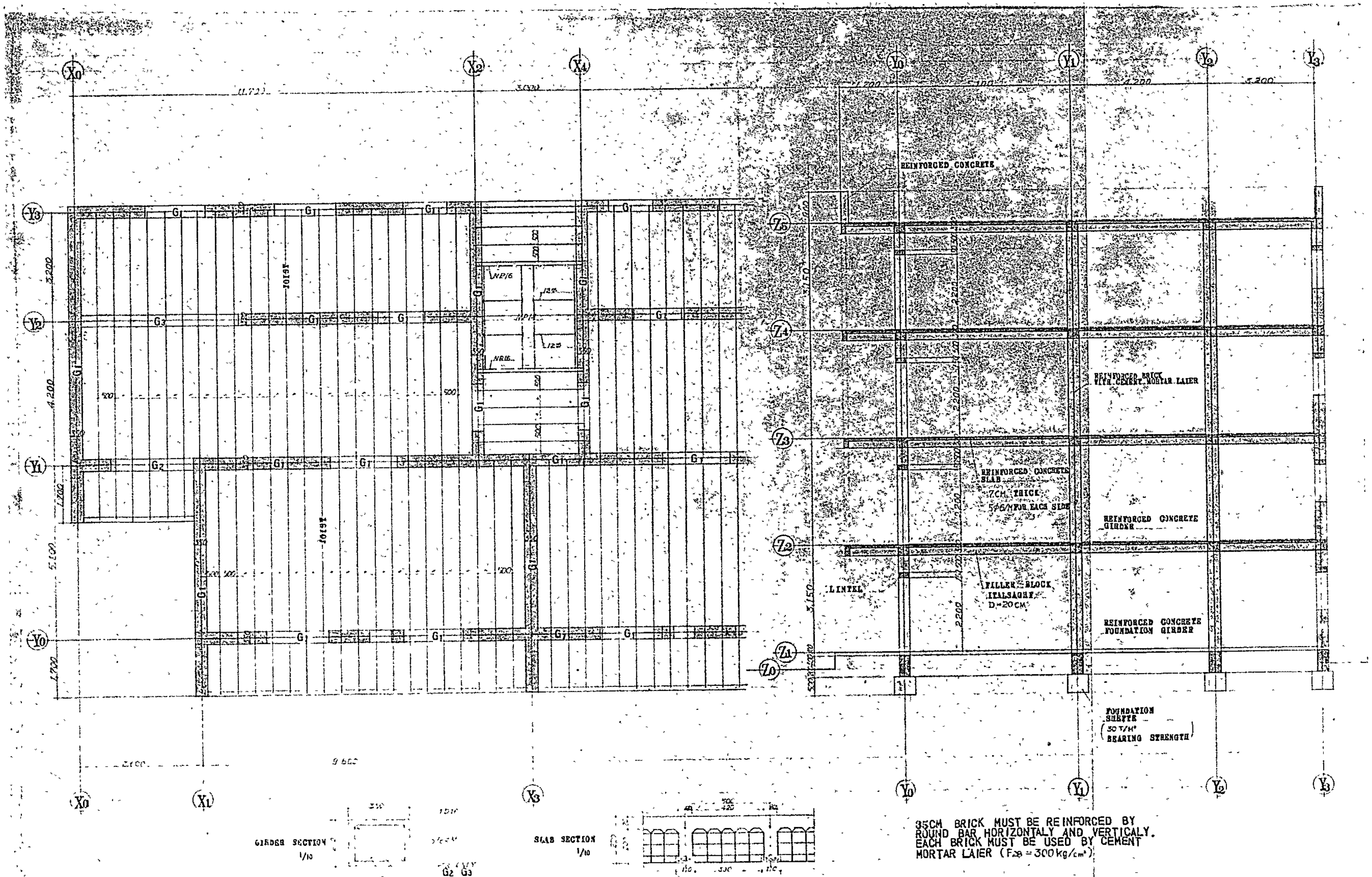


PLAN



A－A SECTION

45.3.31		LOWCOST APARTMENT FOR IRAN	PLAN & SECTION	1/50	C・2



35CM BRICK MUST BE REINFORCED BY ROUND BAR HORIZONTALY AND VERTICALY. EACH BRICK MUST BE USED BY CEMENT MORTAR LAIER ($F_{28} = 300 kg/cm^2$)

45.3.31	LOWCOST APARTMENT FOR IRAN	STRUCTUAL PLAN & SECTION	1/50	1/10	C. 3

CHAPTER III. VIBRATION TEST EQUIPMENTS

1. Vibration Tests of Buildings in Japan

Note: For detailed description of each type of vibration test equipments, refer to attached catalogues.

Vibration test equipments are largely classified into three categories by the method of shaking the structure model.

1) Shaking Method The table on which the model is installed is shocked by a weighted pendulum. (The spring may be used instead of pendulum for tests of smaller scale.) This method is not to detect structural response to ground motion, but to detect resistant capacity of a structure against the first shock of ground motion. It best applies to lower buildings which are likely to show remarkable failure by the first shock of ground motion. Being capable of generating greater load, this method can be used for relatively large scale tests. (Data No. 1, No. 7)

2) Simulation of Ground Motion This is to produce either the random vibration similar to actual ground motion or the simple sinusoidal vibration. This type of equipments are classified as follows by the driving devices. (Data No. 2)

i. Cam or Crank The shaking table is driven by cam or crank, which transfer the rotation generated by a motor into lateral motion. The frequency can be varied up to 15 c/s and the amplitude between 10 and 100mm. (Data No. 7)

ii. Electric Weights The driving device consists of two eccentric weights which are rotated about a common vertical shaft by a chain drive. The resultant eccentric load is proportional to the square of the rotation frequency. (Data No. 7, 8, 9, 10, 11)

iii. Electro-magnetic Methods The table is driven by electro-magnetic force generated by a permanent electro-magnet. Random waves can be input into this equipment.

iv. Electro-hydraulic Method The table is driven by the oscillator that consists of an oil storage reservoir, a high pressure pump and a motor. This equipment is capable of producing random waves, and greater load and displacement than other types of equipment. (Data No. 3, 4, 5, 6, 7)

3) Vibration Generator The building is directly shaken by vibration generators fixed to the building structure. The common method in Japan is to install several generators on the highest floors and synchronize them. They are usually driven by eccentric weights described before.

(Data No. 9, 10, 11)

4) Other Methods   Other methods to create forced lateral deformation or vibration of actual buildings are:

i. To pull a building at the top by wire rope, and then give a sudden release of tension.

ii. To make use of propulsive energy generated by jet or rocket engine.

iii. To swing a weighted pendulum fixed inside a building in accordance with the amplitude of the building. (Data No. 13)

iv. To shake a building by man power in accordance with the amplitude of the building.

2. House Buildings in Iran and Vibration Test

For buildings of the same size as those experimentally built in Narmak the method 1) or 2) is best suitable, for 3) and 4) are best suited to the relatively elastic buildings. Among the methods described in 2) section, the electro-magnetic and electro-hydraulic methods are not recommendable, because their high degree of accuracy is not required for the house buildings in concern. Therefore, we recommend the shock test equipment, cam (or crank) driven equipment, or eccentric weight driven equipment, for the houses of Narmak size.

3. Comments on the Case Study Houses for Labourers and Farmers

Among many types of houses exhibited in Narmak are the followings which we found necessary to examine from the viewpoint of their costs and structural soundness.

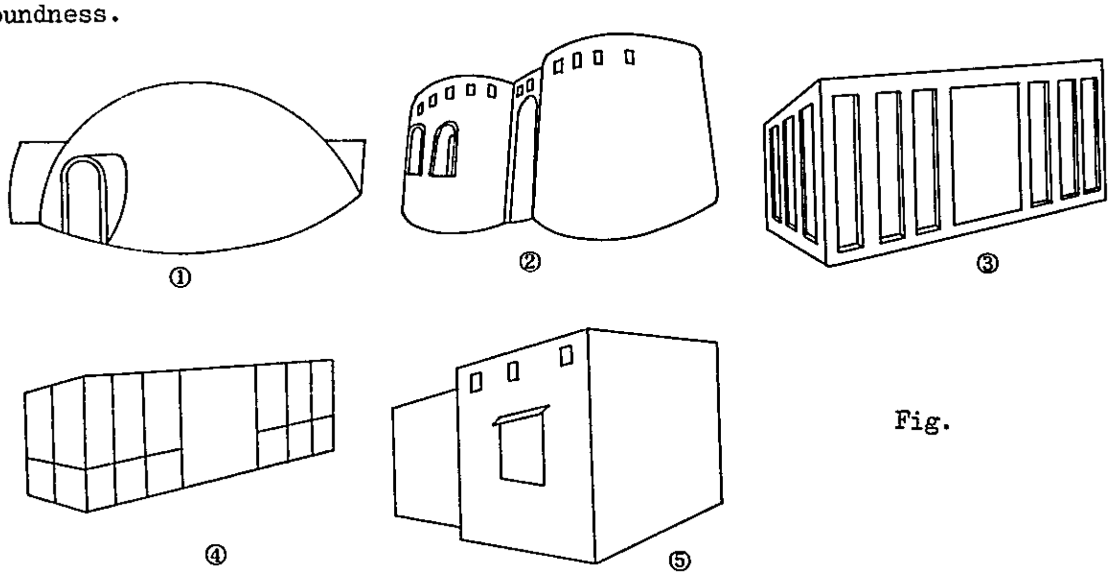


Fig.

1) (Fig. 1) A brick shell or dome house with sunken floor. As brick interior walls do not reach the ceiling, the interior space gives the sense of one room house.

2) (Fig. 2) A house enclosed by curved brick walls creating inside many alcoves for an oven and shelves. The roof is wooden structure. The house costs 1,800 rials per square metre.

3) (Fig. 3) A house enclosed by brick columns of one foot square spaced every 1 metre. Between columns are screened by horizontal reeds which are showered in hot summer. The wooden framed roof is covered with earth. The house costs 2,200 rials per square metre.

4) (Fig. 4) A post-and-beam wooden house sheltered with reed screens. It costs 1,800 rials per square metre.

5) (Fig. 5) A concrete block house with wooden beams and earthen roof, costing 1,100 rials per square metre.

It was observed in every type of houses exhibited here that great efforts have been made in pursuit of new prototypes of Iranian modern houses certainly represent another stride in the development of Iranian architecture.

Of these five examples 4) is the best in the term of earthquake resistance, because of its light-weight materials, while it is inferior in the ability of thermal insulation to 1), 2) and 5), which have thick walls and roofs.

To increase structural strength, 5) is the type that allow considerable reinforcement to be made in such parts as beams, footings and the corners of walls without bringing radical changes of the plan and the method of construction. For the type 2) consideration must be taken to secure structural strength at every curving part of the walls. The type 1) also needs reinforcement because the dome spans too wide for the materials used. As the form is simple, however, some slight reinforcement will do. The reinforcement of type 3) will not cost higher than the others, because the house is supported by many slender independent columns, each requiring individual reinforcement.

Viewed in the light of productivity, the type 5) and 2) are better than the others, for the type 5) is possible to be built with lower cost than the others, especially in areas where aggregate is produced and the portable block-making machine is available. The type 2) has, on the other hand, the advantage of requiring no skilled labour for the field work.

Every type of houses, simple as they appear, has such structure that is difficult to be structurally analyzed. Since structural uncertainties tend to result in more cost than is really needed, these structures will be best analyzed with the aid of full-size model testing. The most suitable method of testing the structural strength of these houses is to build each of these houses on a simple shaking table.

CHAPTER IV. MODULAR CO-ORDINATION

1. Building System and Modular Co-ordination

Modular co-ordination is one of the essential approaches to successful prefabrication of buildings. But it is no less important that the meaning of 'open' and 'closed' systems is properly understood in this connection.

1-1. 'Open' System and 'Closed' System

The system of assembling component parts into a complete product is referred to as 'closed' when they are specifically designed for the product, and as 'open' when pre-designed for general use.

When a system is 'closed', all components, mass-produced or not, could be coherent to the product, and the combination of the components to be jointed together is unvaried, making it possible to consider only the adjoining components in the detailing of the joints. The joint part might shape as irregular surface as a broken pot. In the 'closed' system, therefore, modular co-ordination is less important.

When the system is 'open', on the other hand, the combination of the components might vary and interchangeability might be required for. The dimensioning of the parts and the detailing of the joints should follow certain rules that may cover all the purposes that they are meant to meet. Modular co-ordination is more important in this case.

In practice, however, the system is more complicated. A 'closed' system might comprise many 'open' sybsystems, and vice versa. As a 'closed' product becomes of greater size and more complex, it becomes necessary that some of the components should have interchangeability within the product, calling for modular co-ordination for its own.

Generally, components decrease in number as they become of greater size, calling for modular co-ordination to a lesser extent. In this case each component might be fabricated in a 'closed' system, even when the final product is to follow an 'open' system.

It is now obvious that the utility of modular co-ordination is affected by many factors --- the scale of products and components, the scale of mass-production, the degree to which an 'open' system is made available in a country, and so on. Therefore, it is where an 'open' system is applicable that an extensive use of modular co-ordination makes sense.

1-2. Development of 'Open' System

In Japan a variety of houses and flats are being supplied in a mass by private firms and government-aided corporations, such as Japan Housing Corporation. Although they are more or less prefabrication-oriented, the present situation is that each firm or corporation is developing its own system, that is, a 'closed' system. A 'closed' system is inevitably dependent on skilled labour particular to the system. This is one of the reasons why the monthly output of dwelling units by each firm or corporation hardly exceeds five hundred or, at most, one thousand.

Meanwhile, Japan has made considerable advancement in the 'open' system as a whole. More and more building components have been made available for 'open' use in recent years. This is due in part to the fact that the installation of these 'open' components are usually left to general contractors, because they do not require any specific skilled labour for installation. These 'open' components, such as floor panels, window sashes, kitchen units, etc., are now widely used not only in public and private housing projects but also in custom-made detached houses. The growth accelerates mass-production and vice versa. Today they are available in such a variety that it is not impossible even to build a custom-made house by utilizing only 'open' components available.

As a matter of fact, Japan happens to be situated in favour of the 'open' system. What then are the factors conditioning the advancement of 'open' components?

Buildings have much longer life than automobiles, refrigerators, washers and the like, although there is a tendency to regard building components as movable properties. The life of a house would never be assumed less than ten years. Let us assume it twenty years, and that a new system or standard is authorized in a country. It comes to one twenties of all the newly built houses that may follow the new system. Actually it would be even less, because the new system would not be able to cover all the newly built houses. Assuming it be possible, it would be many decades until the new system covers all the houses that exist in a country.

This means that a new system would inevitably co-exist with the existing system, if there is any, for a considerable length of time. And in early stages the new system would remain only a small portion of the whole. Such a situation is not identifiable as an 'open' system. It is only individual building components that can be called 'open,' and the building industry remains 'closed' as a whole.

Consequently, whether or not it is possible to complete an 'open' system on a scale of a country within a reasonable length of time depends greatly on the adaptability of the existing system to the 'open' system to replace it. Let us see if the existing system in Japan lends itself to the 'open' system as a whole.

1-3. 'Open' System and Japanese Traditional Module System

It is well known that Japanese traditional houses are characterized by the use of wood, the planning on grid, both horizontal and vertical, and the post-and-beam construction.

That Japan has traditional module system is of the utmost importance in relation to the 'open' system. The module of 3 shaku, which took two hundred years to be finally established, approximates to 90cm in metric system, although a little off the round number of one metre. But one shaku approximates to many of the measures in the world (one foot for example), and closely related to the measurements of human body. In fact, East European countries where 6m is adopted as a basic module, also uses 30cm for smaller scale, and 90cm, 180cm and 360cm are most popular for the size of a room. Although 10cm is internationally accepted as the minimum module, it is 30cm that has been in practical use, especially in the countries where the industrialized housing is more advanced like France.

Next let us consider the contemporary meaning of such figures as 30, 60, 90 which form a basis for the Japanese traditional module system. As compared with 50 or 100, these figures may seem to be less useful. But it is not. The multiples of 3 are more important than they appear to be, especially in the design of the buildings. I shall discuss this later in more detail. I only point out the fact that 3 shaku, 6 shaku and 9 shaku have been more popular than 10 shaku, and interestingly enough, 30cm, 60cm and 90cm have been more popular than 100cm in the countries where 10cm is treated as the minimum module. This is something more than a mere coincidence.

The post-and-beam construction that stems from the use of wood form another important factor that may lead to the 'open' system. It may well be said that no traditional building practice in the world has ever given birth to more 'open' components than that of Japan. For example, we have TATAMI, or a 90cm × 180cm straw mat, SHOJI, or a sliding screen covered with translucent paper, and FUSUMA, or a sliding screen with paper glued on both sides, and so on. Above all, FUSUMA and SHOJI are the traditional building components that exceptionally satisfy the contemporary qualifications for the 'open' component. In addition, the post-and-beam construction allows more flexibility in planning than wall-constructions in which the layout of walls are structurally determined to a considerable extent. This means that the post-and-beam construction allows flexibility also in the use of building components to be inserted into the framework.

We have seen that the wooden houses forming the majority of the housing stock in Japan have a plenty of qualities that may possibly contribute to the advancement of 'open' systems. It is in this sense that I said Japan happens to be situated in favour of the nation-wide 'open' system to come.

2. Module and Modular Co-ordination

2-1. Modular Co-ordination

How can we get a rectangle that permits a complete subdivision into two halves similar to the original one? In modular co-ordination we often come across such problems. The answer is, of course, to make the proportion of the rectangle $\sqrt{2}$, and this is the only answer. Here the proportion $\sqrt{2}$ is a key to the problem.

There must be many such keys or instrument and if they could be integrated into a system, it would make modular co-ordination really effective and practical.

2-2. Proportion as an Instrument for MC

The square root is, however, less important for an architect who deals with simpler subdivision and addition of building units. To meet his needs we can provide such simple geometrical progressions as ..... 1/4, 1/2, 1, 2, 4, 8, ... which I might call "2^n- series." Here each is two times the preceding one, or one half the subsequent one. For the convenience of combining three units together or subdividing one into three equal parts, we can make "3^n- series," as ..... 1/9, 1/3, 1, 3, 9, 27, ...

Our traditional module system based on 3 shaku (≒ 3 ft) and 6 shaku (≒ 6 ft) shares the merits of this series.

Among the series of numbers generalized as a^n, the most essential to our daily purposes would be 10^n, since decimal notation is so deep-rooted in our life. It would be natural for man who has two hands, each with five fingers. In fact, man cannot readily understand the output of computers based on binary notation until it is transferred into decimal one. So let us add the decimal progression, or 10^n- series, ... 1/100, 1/10, 1, 10, 100, ...

The industrial Standard Numbers adopt the so-called "Renard Number," based on decimals. Renard, a French military engineering officer who served during the World War I, is said to have established this in an attempt to determine the diameter of a given rope to be used for baloons.

Now, let it be asked to find the value of a, when the continued multiplication of five a's is given as 10. The condition being denoted by $a^5 = 10$, we have $a = \sqrt[5]{10}$, or 1.5849 ..... By utilizing this value we get a^0, a^1, a^2, ... a^5, as follows,

a^0	1
a^1	1.5849 ...
a^2	2.5119 ...
a^3	3.9811 ...
a^4	6.3096 ...
a^5	10

These are called "Renard's five numbers," or briefly "R5." Since addition replaces multiplication in logarithms, we could easily get their mutual multiplications by mental arithmetic, as

$$a^2 \times a^3 = 10$$

$$a^3 \times a^4 = a^7 = a^5 \times a^2 = 10 \times a^2$$

and so on. Since 10 × 2.5119 = 25.119, it is to be noted that the memory of only five values lends itself to a variant combinations of their mutual multiplications.

When used for the Industrial Standard Numbers, R5, R10, R20 and R40 are all rounded off, as shown in Fig. 1, to avoid their being impractical infinite decimals. The Renard Number is also in use for many values found around us, especially those related to areas, volumes, squared distances, etc. Take a camera for example, the shutter speed is indicated by every four numbers of R10, and the aperture by every four numbers of R20, so as to make equal the effects of shifting the shutter speed to the next value and the lens aperture to the next smaller value.

Fig. 1

工 業 標 準 数				
R 5	R 10	R 20	R 40	計算値
1	2	3	4	8
1.00	1 00	1.00	1.00	1.0000
			1.06	1.0593
		1.12	1 12	1 1220
			1 18	1.1885
	1.25	1.25	1.25	1 2589
			1.32	1 3335
		1 40	1 40	1.4125
			1 50	1 4962
1 60	1.60	1 60	1 60	1 5849
			1.70	1 6788
		1 80	1 80	1.7783
			1 90	1 8836
	2 00	2.00	2 00	1 9953
			2.12	2.1135
		2.24	2 24	2.2387
			2 36	2.3714
2.50	2 50	2.50	2 50	2 5119
			2.65	2.6607
		2.80	2.80	2 8184
			3 00	2.9854
	3 15	3.15	3.15	3 1623
			3 35	3 3497
		3.55	3 55	3 5481
			3.75	3 7584
4 00	4 00	4.00	4.00	3 9811
			4 25	4.2170
		4.50	4 50	4 4668
			4.75	4 7315
	5 00	5.00	5.00	5 0119
			5 30	5 3088
		5 60	5 60	5 6234
			6 00	5.9566
6 30	6 30	6.30	6.30	6 3096
			6 70	6 6834
		7.10	7.10	7 0795
			7 50	7 4989
	8 00	8 00	8 00	7.9433
			8.50	8 4140
		9 00	9 00	8 9125
			9.50	9 4406

Fig. 2

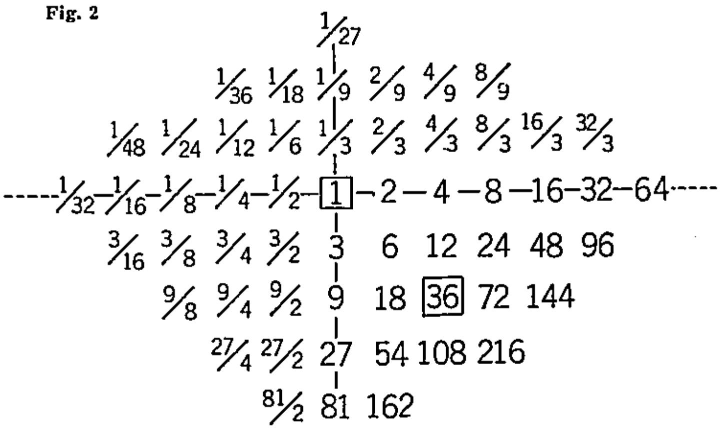
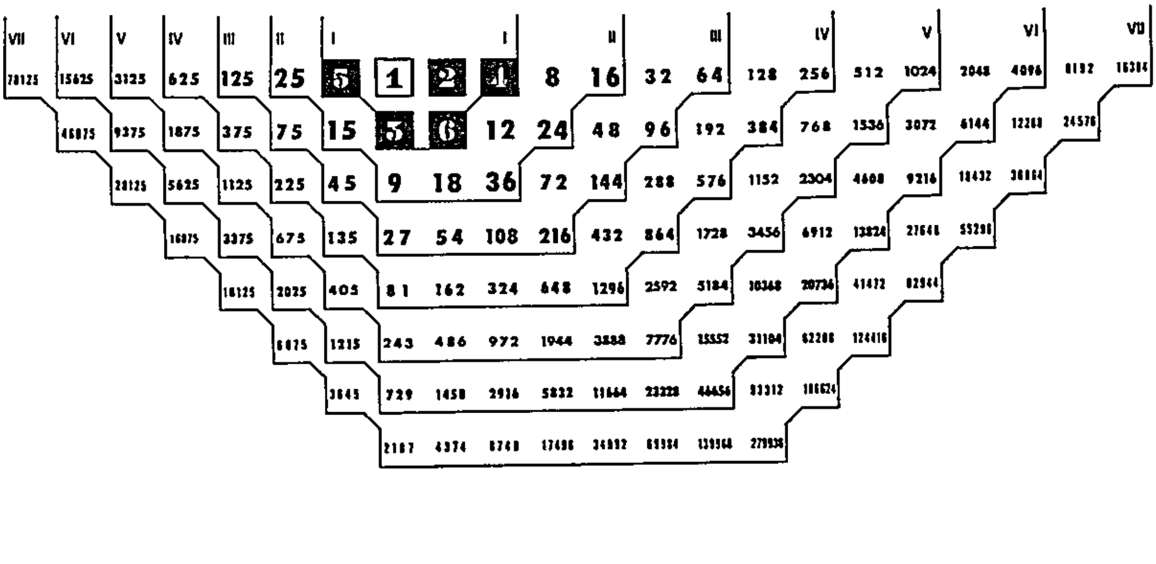


Fig. 3



With its flexibility in the location of decimal points, the Renard Number is capable of covering the whole range of numbers from infinitesimal to infinity, with limited components. This is one of its basic distinction with other simpler progressions mentioned before.

2-3. Module as a Ready-made Instrument For MC

Each of the sets of module I have discussed might be useful within certain fields. However, if we are to make modular co-ordination really effective and practical, we must be equipped with a much more comprehensive set of numbers that would perform maximum adaptability to all purposes with least possible component numbers. It might be compared to an all-rounder rather than a one-sided prodigy.

This basic fact is too often misunderstood. People having a little knowledge of module tend to regard it inconvenient because of the seemingly restricted use of numbers. But this is contrary to what a module system actually is.

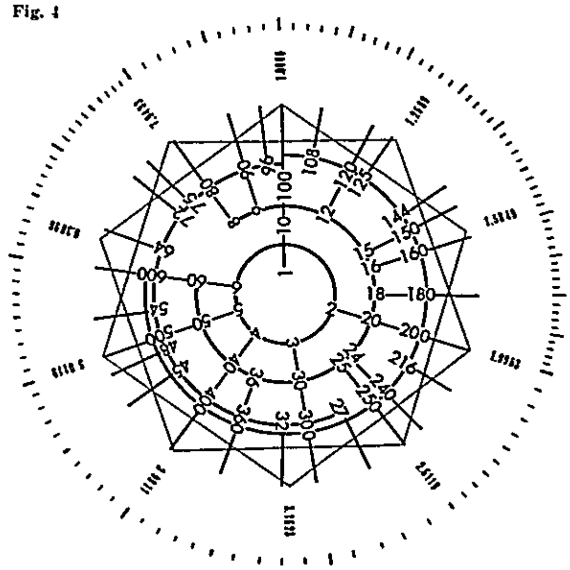
For one thing, a module system is a collection of "convenient" numbers. If a number is found to be convenient enough, it must be added to the system. On the other hand, if there were a set of numbers that fails to meet practical needs, it would be no more a module system. By "convenient" I mean the capability of meeting the majority of our daily needs. This eventually demands for less numbers to be used. But this does not mean the restriction nor the dictation of numbers to be used. When one has to use a non-modular number for certain specific reasons, nothing keeps him from doing so. A certain dimension might be determined by aethetic considerations, or it might be that the height of a table to perform a specific job on is specified prior to modular co-ordination. In such cases the use of non-modular numbers would be fully justified, even though it might cause slight confusion in the process of modular co-ordination. The advantages of following the determinant factors will certainly offset the possible disadvantages. A module is, so to speak, a ready-made instrument for modular co-ordination, and it is ready to give way to another custom-made number when the situations demand.

2-4. Mechanism of Module System

From what I have discussed it is obvious that a comprehensive module system should maintain the merits of as many progressions as possible.

A set of numbers that contains the multiples of 2 and 3 can be obtained by extending 2^n- series and 3^n- series in two ways --- horizontally and vertically, with corresponding numbers in between, as illustrated below. (Fig. 2)

Fig. 4



Take 36 for example, the following multiples of 36

36 × 1/2 = 78	36 × 1/3 = 12
36 × 2 = 72	36 × 3 = 108

appear around 36 in the table. To be more practical, it is desirable to establish a set of numbers that contains not only the two-fold and the three-fold of a given number, but also the four-fold, five-fold, six-fold and so on. We have already seen that a set of numbers containing two geometric progressions is obtained by extending them along two axes. Accordingly, if we want a set of numbers containing as many progressions as we need, we could conceive a three-dimensional space composed of as many axes. This might appear extremely complicated at first sight. But as we go on some unexpected simplifications turn out to be possible to make in the actual process.

For one thing, the multiplication of a number by 10 does not mean any addition in the number of components, as far as we maintain decimal notation. Moreover, it is known that if we permit certain approximation by rounding off the digits, R10 and R5 could possibly be replaced by the progression denoted by 2^n. This is due to the coincidence as

$$2^{10} = 1024 \fallingdotseq 10^3$$

This then leads us to generalize as follows.

$10^{1/10}$	$2^7 \times 10^{-2}$
$10^{2/10}$	$2^4 \times 10^{-1}$
$10^{3/10}$	2^1
$10^{4/10}$	$2^8 \times 10^{-2}$
$10^{5/10}$	$2^5 \times 10^{-1}$
$10^{6/10}$	2^2
$10^{7/10}$	$2^9 \times 10^{-2}$
$10^{8/10}$	$2^6 \times 10^{-1}$
$10^{9/10}$	2^3

This results can easily be applied to 4^n- series, which is identical with the alternate collection of numbers from 2^n- series.

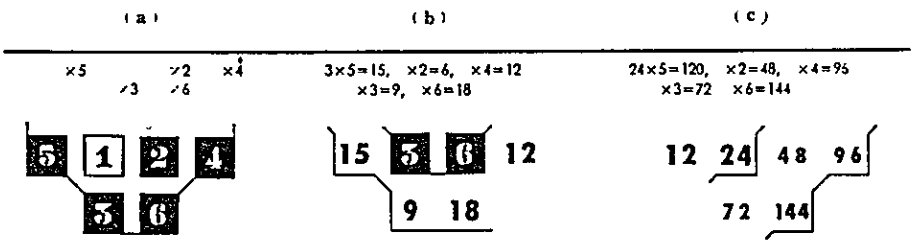
Consequently, what we really need are the axes of 2^n- series, 3^n- series, 5^n- series, ..., that is, n'th power of primary numbers.

2-5. Module Table --- DØ

Now let us consider only three primaries, --- 2, 3 and 5, without regard to decimal points. We then come to another important fact.

Look at the numbers listed at the top of the table (Fig. 3).

Fig. 3



この関係を N 段階のすべての数に及ぼすと N+1 段階の数値の範囲がきまる.
The Dφ numbers of (N+1)th order should be set up, by doing this treatment over all of the numbers of Nth order.

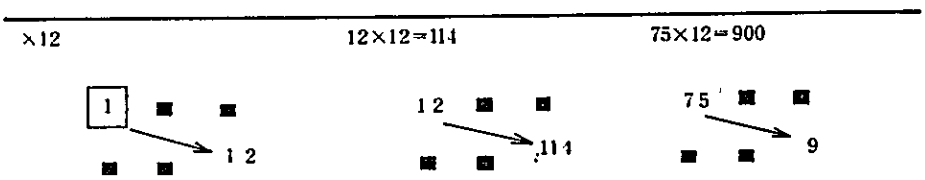
Now it would be understood that 125, 25 and 5 are identical with 0.125, 0.25 and 0.5, respectively, which in turn could be denoted in the form of fractions, namely 1/8, 1/4 and 1/2. This means that two progressions 2^n and 5^n written in this way are virtually identical with a single progression 2^n, with its fraction part replaced by 5^n.

Similarly, since 0.2, 0.4, 0.8, 0.16, ... are identical with 1/5, 1/25, 1/125, 1/625, ... respectively, the two progressions 2^n and 5^n written in the same way form a single progression 5^n, with its fraction part replaced by 2^n. In other words, the seemingly different progressions of 2^n and 5^n are completely superimposed in this table. This is due not only to our assumption that 125, for example, is identical with 0.125, but also to the fortunate fact that 10 is the product of 2 and 5.

Thus any number in this table finds its multiples by 1/2, 2, 1/5 and 5 as the components. And this is also true with 3^n- series. Any number finds its multiples by 1/3 and 3, except those listed atop, the table having no extension upward.

Now, notice that any number is either 6 or 0.6 times the number appearing above left, and either 15 or 1.5 times the one appearing above right. Therefore, this table also contains 6^n- series and 15^n- series. Thus we have seen that the set of numbers built in this way contains almost all practically valuable series of numbers, except those of n'th power of primaries greater than 7.

Such an infinite extension of numbers, however, does not meet the basic requirement for a module system. More practical numbers must be sorted out. To begin with, let us group them into "Phases" according to the frequency of their use. This is what is meant by the staggering lines across the table. To phase I belong the numbers enclosed with black or white squares. The white one indicates the original number of the table.



2-6. The Basic Pattern of DØ Module

With the aid of decimal notation, the six numbers belonging to phase I can be developed into a progression, as follows, ranging from infinitesimal to infinity as the Renard Number does, ... 0.3, 0.4, 0.5, 0.6, 1, 2, 3, 4, 5, 6, 10, 20, 30, ... This is the basic progression of the DØ module, and other numbers belonging to the subsequent phases would be picked up to supply the gap between these basic numbers. (See Fig. 5.)

The pattern that the phase I numbers form in the table is called "the basic pattern of the DØ module," which indicates the proportional relations between the components. (See Fig. 6-(a).) This relationship is maintained within any of the same patterns cut out from the table, as illustrated in Fig. 6-(b), (c).

In practice we may need a series of numbers based on the door height. If you choose 2,000mm for it, you will get the following progression only by cutting out the pattern centering either 2,000 or 200, ... 80, 120, 200, 400, 600, 800, 1,000, 1,200, 2,000, 4,000, ... This is also applicable to vertical module when standardized sashes are employed, for example.

A number corresponds to one pattern centering it, but to many patterns containing it. Therefore, when a number is needed, we might well choose whatever patterns containing it. For example, 3 and 6 are contained in the pattern (a) and (b) in Fig. 6 at the same time, so we can choose the pattern centering either 1 or 3, when 3 and 6 are both needed. Likewise, when 12 is needed, we can cut out the pattern centering either 3 or 24.

As the phase progresses, we get more flexibility in subdivision and multiplication, since the numbers become more extendable to more directions. But the demand for a number becomes less, as is evident by the definition of phasing. We have learnt by experience that in the phase I, 3 and 6 are the most useful numbers, and in the phase II, 9, 18 and 36 are.

2-7. DØ Module and Japanese Traditional Module

It is well known abroad that the traditional module system in Japan is based on 3 shaku and 6 shaku. The meaning and utility of these dimentions would now be apparent.

What is more, it is fortunate enough that 3 shaku and 6 shaku could be replaced by 90cm and 180cm by means of slight approximation, and that the latters are more adaptable in the term of the DØ system.

At present 10cm is accepted internationally as the basic module for buildings. But the recent trend is toward a greater and more adaptable one.

One shaku is nearly one foot, and many other modules in the world fall around this size. The prevailing explanation for this is that it represents human measurement such as those of man's foot and arm.

Although modules around one foot tend to be revalued in some European countries, their use is still limited to a small portion of industrialized new buildings. In Japan, almost all existing houses follow the traditional module system, and 90 percents of the newly-built ones are based on the 90cm module.

I hold that Japan should make the most of this advantage, if she is to aim at the effective industrialization of buildings.

CHAPTER V. POLICIES OF LAND PRICE CONTROL

1. Introduction

In a free-enterprise economy the perfect competitive market system is conceived as a model for the best allocation of resourses. In its ideal operations prices are governed by the principles of market competition. If the real estate market follows this principles, the rise of land price induced by land development plans may be justified, or even encouraged, insofar as the rise as such is part of the market operation that presumably guarantees the best allocation of resourses. And there would be no demand for governmental intervention in the market.

However, the actual market does not function ideally and tends to cause significant disadvantages to national economy. It then becomes necessary that government as an economic body take direct actions to regulate the market operation, and in doing so avoid such disadvantages as far as possible. In fact, many governments of free-economic countries have used its policies for this purpose.

In our country the major failure of the real estate market lies in the extraordinary rise of land price occuring when a developer, public or private, discloses its plan to buy and develop a parcel of land into more intensive use like housing than before. It has barred not only developers from developing lands, but also the government from achieving its fundamental objectives such as raising of housing standard and improving urban environments. What can and should be done by the government to remove the barrier or at least to minimize the social disadvantages caused by the adverse rise of land price?

Land is the most important of all resourses especially in densely inhabited countries like Japan. Therefore, policies regarding land use have exclusively important bearings on every aspect of social and economic life of a country. Governmental assistance to more effective utilization of land and its enforcement of rigid control over land price is the most fundamental of all other policies.

In view of the wide and profound influence that the public intervention may exert, it is also probable that policies intended to control land prices may inevitably impede achieving other equally important objectives, depending the way they are enforced. The goverment should, therefore, have adequate knowledge of the effects of its policies, so that it becomes capable of coordinating the related policies. But this is extremely difficult to achieve.

No government in the world has yet been equipped with any theory that works.

In this chapter I will analyse the causes of the rise of land price, identify the alternative objectives and discuss some of the policies in relation to their effects.

It is to be noted that the effect of a policy implementation depends to a large extent on the specific conditions of a country, and my argument may not apply directly in Iran.

2. Causes

When a developer discloses its plan to buy a parcel of land and turn the use into more intensive one, the land price tends to rise as high as the buyer is expected to become capable of paying as a result of the planned development. This phenomenon, stemming from the competitive market principles mentioned before, will on one hand help to encourage the supply of land resourses to meet the growing demand for new developments, and on the other possibly becomes an impediment to every new development, because of the natures of real estate as a commodity.

Commodities that are limited in quantity and/or that incur less cost to hold are more likely to create a seller's market than other types of commodity. And the rise of market price is more sensitive to the rise of demand. Moreover, the price once arisen hardly falls lower even after demand has started to decline. Such commodities, providing most effective means of holding assets, tend to induce speculative market operations. This means that demand for land can expand through speculative motivations whether or not there is particular requirement for space. What the buyer expects is the gains out of the possible rise of price in accordance with the future development of the lot he is going to buy.

When such speculative demand is involved in the market operation, prices tend to become unstable. This condition may create another impediment to effective land developments.

Another notable factor is that the land's liklihood to seller's market due to its fixity of location is one of the distinctive features of the real estate market. Since land is fixed in location, the buyers have much fewer alternatives in determining the location of their development projects than they have in the markets of other commodities. This condition eventually forces developers to buy land on less advantageous term. This is almost inevitable when a land development is to be undertaken in conformity with a long-range comprehensive plan.

In conclusion, the extraordinary rise of land price stems from the competitive market principles themselves, and is accelerated by the speculative operations, the liklihood of land to seller's market and the fixity of location inherent to real estate.

3. Aims of Policies

The most direct method of control over land prices by the government is the setting of official prices. But this seems too direct. It is probable that advantages of preventing the adverse rise of land price be offset by the possible disadvantages of impeding the free market from performing its normal functions leading to national growth in the end. If a government is ever to take such actions, it should extend the range of control towards all aspects of national economy. Then the government will eventually approach to the model of an administered or regulated society generally followed by socialistic countries.

The next important aim of policies is the proper allocation of benefits accruing from land development. It is reasonable to re-distribute part of the unearned income of landowners to the developers who bear the cost of utilizing the land to its full potentialities. Policies intended for this aim will serve not only to restrict unearned income, but to reduce costs of land development and in doing so help avoid inflation at large.

Thirdly, there will be policies intended to prevent the seller's market from existing all the time.

Forthly, restriction of buying land through speculative motivations.

Fifthly, there may be policies to free housing developers from the unfavorable condition in the market due to the fixity of location. If the development plan would be made flexible in regard to its location, it would be possible for him to acquire as much land as needed at lower costs.

In view of the social significance of housing as an instrument to achieve better living environment, this idea goes against the nature of public development especially when it is undertaken as a part of a comprehensive long-range plan.

Finally, what is no less important is to exert governmental control over the use of the parcels of land that the government is planning to acquire for future development. It may not contribute directly to the regulation of land price, but it will serve to prevent the prospective parcels of land from being utilized on the purpose of placing barriers in the way of the planned development, as is often the case when landowners are in protest against it.

4. The Means of Plan Implementation

Now I will examine the political means of regulating the real estate market in relation to the policy objectives discussed before, in an attempt to clarify the effectiveness and interrelationship of these policies. The political means of regulating land price include (1) coercive actions, (2) taxation, (3) financial means, (4) considerations in plan implementation.

(1) Coercive Actions The most direct of all coercive actions that a public authority can take is the freezing of land price prior to the disclosure of the development plan. This is too close, however, to the actions generally taken in administered societies, which deny the utility of market principles. Secondly, there are many plactical difficulties involved in achieving the policy objectives, incurring much cost and great efforts on the the part of the government. Much of the success in controlling land price through this method depends on the way it is enforced. For instance, experiences indicate that the freezing method is best effectuated when public authority limits the area on which it exerts its action, or when the action is taken in conjunction with the enforcement of other political powers such as eminent domain, priority and restriction of land use.

In some cases the priority of land acquisition is conferred, usually within certain period of time, on a public authority for the purpose of avoiding speculative purchase of land. The power of priority differs from the power of eminent domain in the United States in that, under the priority power, priority is given to the public authority in the acquisition of a certain piece of land needed for a public purpose, whenever the landowner has determined to sell the lot, even if there were any competitive buyers. Under eminent domain, the government may take any private property at any time without the consent of the owner, who in turn will be justly compensated.

For the purpose of preventing a piece of land from being developed in the way detrimental to the plan implementation, the public authority may exert specific control in the form of deed restrictions over the use of the particular lot that the authority is planning to acquire and develop. The scope of this type of control is, in most cases, limited to the extent that the control can be exerted reasonably.

Because coercive actions as such have unparalleled effects on economic activities, it is of utmost importance for the government to take these actions only when and where there is no alternatives. The property rights would otherwise be threatened, and free market operations.

(2) Taxation One of the effective means to re-allocate the monetary benefits accruing to landowners from the rise of land price due to public developments is to levy tax on the capital gains, or the profit resulting from the sale of land, in proportion to the rise of price after the plan was disclosed. The revenue gained by this kind of tax may either be added to the housing fund or appropriated to other improvements like community buildings for the housing. For the purpose of preventing the seller's market from lasting too long, it may be effective that government increase the property tax to the extent that the tax burden exceeds the owner's advantages of holding the property.

(3) Financial Means Controls over land price may be attained through financial means, as well. They are generally indirect as compared with those discussed in the following sections, and will be best effectuated if used in conjunction with other related policies.

One of the fundamental policies is to allocate more budget to the acquisition of land than the current programs demand. The land thus acquired will meet the demands for space that future public development projects require. The advanced acquisition of land as such may help to stabilize the land price that tends to skyrocket the moment a public development plan is disclosed. However, this policy must be enacted on a long-term basis. If the government is to leap the crop in a shorter period, this policy should be accompanied with other more direct actions I have discussed.

It must be noted that this policy will not achieve its objectives untill the land acquired will account for considerable share in the total supply of land.

Another financial means that might be instrumental in restricting large scale speculative purchase of land by private enterprises is the contracting of financial aids by public authorities to private enterprise in need of large amount of fund on a long term basis for the purpose of acquiring land. Success of this policy, however, seemingly depends on the existence of such situation that the demand for land expands on the part of private sector.

(4) Considerations of Plan Implementation Besides the foregoing policies,

there are several facts that government or municipalities should take into account in the process of plan implementation. The first point is that the planning authority must by no means reveal the plan to the public until it is completely consolidated or officially adopted, no matter what policies may be used for its implementation. The prices of the particular tract of land and that of its vicinity would otherwise be raised up to deadlock the plan implementation, or land purchase on speculative motivation would be stimulated. Difficult as it may be, all effort must be made to keep the plan in secret as far as possible.

To avoid impediments that public plans may induce, it is often effective to make swift alterations of the plan with respect to its location, for instance, or the timing of its execution. It must be noted that this applies only projects of smaller scale on a short-term basis. As for long-term plans the effect may probably reversed.

Our forgoing discussion may be illustrated as the table on the next page.

Of all the policies I have discussed the coercive actions and taxation imply considerable alterations of current institutions. And once such alterations have been made, it is not easy to bring back again, no matter whether the policies attain their aims or not. It is of utmost importance, therefore, that they be viewed in a long run, and exercised in harmony with other related policies. What is no less important is that these more or less coercive actions will never attain their objectives unless there is a firm support to and understanding of these policies on the part of the majority of the people. The cost that may be incurred by the excercise of policies is another important factors to be taken into account. In some cases the enforcement of a policy eventually incur much more cost than expected. Careless decisions will cause not only wasted expenditures but also distrust against politics. Therefore, any decisions regarding policies and their enforcement must be made on a basis of rational judgement with the help of adequate and detailed informations of the present situation, and understanding and co-operation on the part of the majority of the people.

OBJECTIVES / POLICIES	Against market principles	In favour of market principles			Neutral	
	Establishment of official land price	Re-allocation of benefits from land sales	Shift from seller's to buyer's market	Restriction of speculative land purchase	Flexible siting of projects	Avoidance of detrimental activities
1. Coercive control Freezing of land price	o	-	o	o	×	-
Priority of acquisition	-	-	o	o	×	-
Land use control	-	-	-	-	×	o
2. Taxation Capital gain tax	-	o	-	o	-	-
Property tax	-	-	o	o	-	-
3. Financial means Expansion of public-owned land	-	-	o	-	o	o
Contraction of aids for land purchase	-	-	-	o	-	-
4. Plan implementation Secured secrecy	-	-	-	o	-	-
Swift plan alteration technique	-	-	-	o	o	-

o positive effects
× negative effects
- no interrelation

MODEL TESTING BY MEANS OF VIBRATION TEST EQUIPMENT

Vibration test equipments have long been in use as the means to prove seismic theories, especially in the fields like soil mechanics, and civil engineering that deals with structures greater in size. Accordingly, there has been greater demand for greater capacity of vibration test equipments. However, such equipment, if any, was either too expensive or too unprecise to be practical. It is only recently that progress has been made in the high rise building field, with the aid of computers. However, the ability of computer is not unlimited. There is certain roles left to the model testing with the help of vibration test equipments. For example, soil conditions, rigidity of joints and twisting vibration of structures can hardly be input into computers. On the other hand, a well designed model is capable of responding both qualitatively and quantitatively to given conditions however complicated they may be. In short, computer and model testing are complemental. In addition to such theoretical usages, model testing may apply to the tests of fatigue of full size materials, peeling test of external finish materials, vibrations of curtain walls or large windows, vibrations of precise machines and vibration control of full-size structures.

A SHOCK TEST EQUIPMENT

The shock test equipment is capable of producing such load, equivalent to the first shock of earthquakes on a model composed of the same materials used for the building to be tested. The period of acting the load is designed to be variable. So it is possible to record how a structure collapses by replacing the first eminent ground motion with the equivalent shock wave. Moreover, the destructive load it can produce is great enough to test structure models of considerably great size.

The equipment consists of the framework weighing 70 tons and a pendulum with a weight varying from 15 tons to 30 tons, as illustrated in Fig.1. The weight is lifted to a certain height by 50HP winch and then the rope is suddenly reliesed so that the weight makes a natural fall, which produces the shock of the testing table with the structure model on it. The intensity of the shock can be controlled by varying the weight, the height of the fall and the strength of the springs of the bumper attached to the colliding surface of the testing table. The Fig.2 shows the side view and the plan of the equipment, and the Fig.3 and Fig.4 show details of the testing table and the weight. The outline of the component parts is as follows.

Framework:	Steel
Pendulum:	Cast iron weighing 15 tons, to which weights can be added up to the total weight of 30 tons.
Testing table:	Concrete poured into steel framing. The surface is grooved in two directions for the anchoring of test pieces, and there are also holes to hold anchors for test pieces of larger scale.
Bumper:	Each bumping unit is made of steel and synthetic rubber alternately sandwitched. The bumper contains 35 units at the maximum, 5 and 7 in each direction. The intensity of the bumper is controlled by changing the number of bumping units it contains.
Lifting device:	50 HP winch capable of lifting 30 tons of weight up to the height of 3.5M.
Reliesing device:	A cutter with a gas burner that cuts off a steel plate. The burner is remote-controlled.
Others:	A hoist with the capacity of 3 tons.

If a stopper is added to the testing table, this equipment will become capable of testing the second shock that follows the first one.