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BUILDING METHODS FOR POPULAR HOUSING[1]

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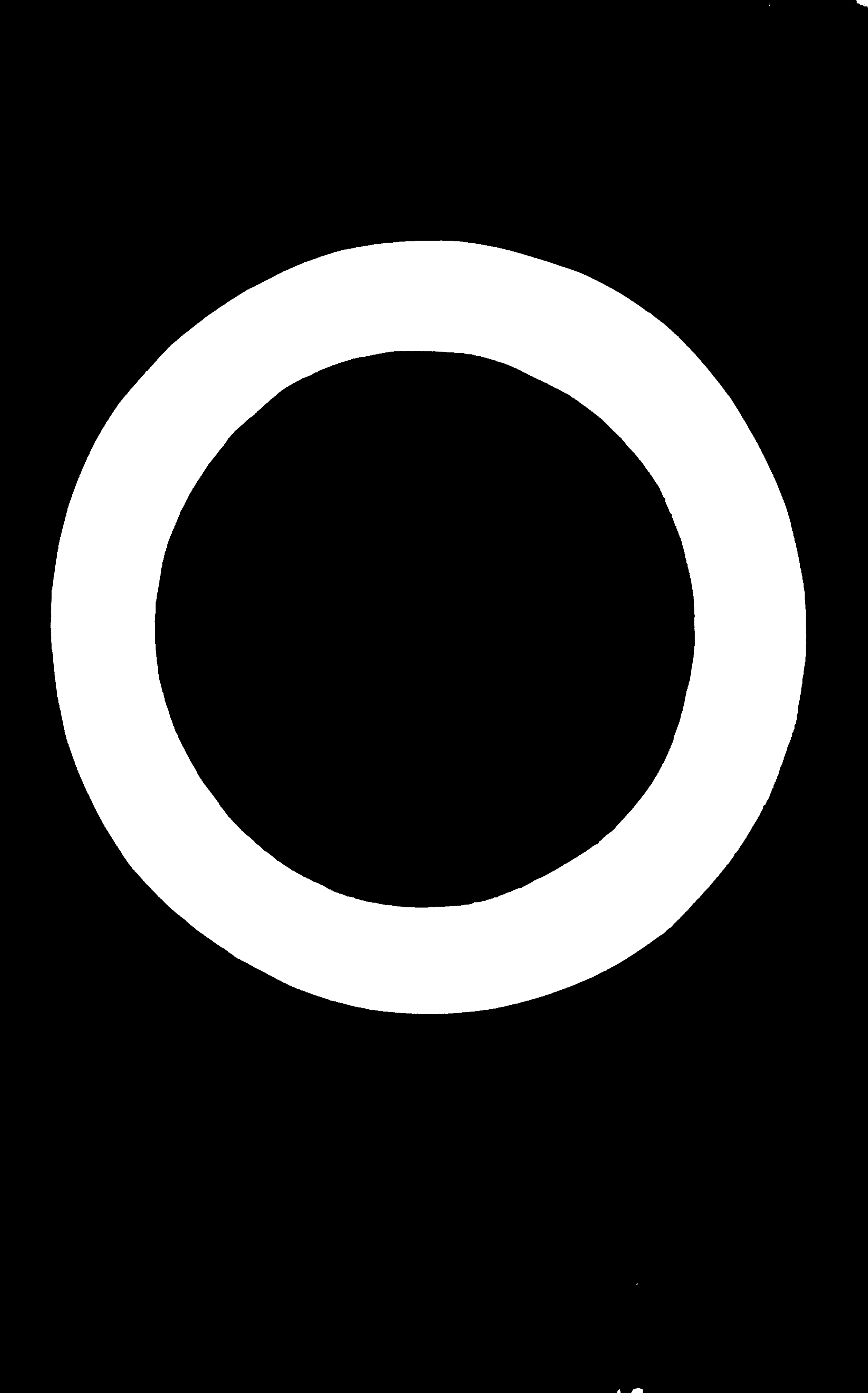


BUILDING METHODS FOR POPULAR HOUSING

The urgency of the problem of building popular housing results from the endeavour of the nation that all its members shall have a worthy home and the responsibility for fulfilling these natural wishes falls upon the whole nation.

This problem is so gigantic, that it cannot be solved by the actual technical and financial means. More economical building materials as well as working methods increasing and facilitating the workers performances have to be found. The actually deficient hand labour is, therefore, to be replaced by industrial production in order to reduce labour on the building site to a minimum and to enable the building to be composed of ready-made elements.

The establishment of methods for the industrial production in the building trade is naturally closely connected to the mass production of homes. The assembling building method and mass building are only realizable on the basis of ingenious constructions, well thought-out working methods and project worked out to the last details and characterized by extreme simpleness.

Realizing those facts we linked with other experts in order to prepare methods suitable to solve the housing problem of a nation. We are pleased to explain the solutions found to any interested party.

A) Method for the building of houses exclusively from baked clay without timber, iron or cement.

Provided that the brick industry is established in a country, a method for the building of houses exclusively from baked clay may be used. The aim of this method is to save timber, iron and cement and to build fast and easy with unskilled labour. The building material exclusively used is baked clay, the new method of erecting buildings permitting thus an essential economy of material, labour and transport means, as well as unlimited durability, fire-poorness, with good external appearance.

The above mentioned qualities will have an essential influence on the choice of types for rebuilding damaged or ruined regions, as well as in all those cases where a settling program on a large scale is to be quickly and economically organized. Since suitable clays for the production of building elements are often found on the place of the selected settlement or in its vicinity, the fundamental and almost exclusive raw-material for realizing housings, following this method, is thereby given. Thus this building method complies with the necessity of savings of more expensive materials, as mentioned above and allows a maximum economy in this respect in comparison to other methods known.

The masonry consists of clay mould stones having seven times the volume of ordinary bricks but weighing only 13 kgs, thus enabling double the output of the brick layers against the use of standard bricks. (fig. 1).

The heat insulation is substantially increased thanks to the cavities (with a wall-thickness of 0.40 m K=0.96). This design offers the advantage, on the one hand, of the possibility of quick erection of the wall, and on the other hand of a comparitively small weight of the masonry material which advantage is particularly important in the cases where such material has to be bought up to a distant building site. The volume weight of a brick wall is about 1.7 kg/dm^3, the same portion of a wall, made from clay mould-stones comes up to abt. 0.8 kg/dm^3.

The carriers needed above all kinds of doors, windows or floors and replacing different special building materials as iron, timber or cement are hollow bricks of special production, 1.5 to 2.5 m in length. For the manufacture of ceilings, baked clay beams, reinforced by tensioned steel strings, are to be utilized (fig. 2). Those ceilings require no timber, and a few unskilled hands are sufficient for performing the erection of the ceiling. The admissible useful load immediately after the installation is 200 kg/sq.m.

Under application of the above mentioned elements housing types have been developped, which are to be compared with building types of other nations as follows:

	kitchen	combined kitchen &sitting room	sitting room	sleep. room f. parents	sleep. room f. childr.	sleep. room f. children
	sq.m	sq.m	sq.m	sq.m	sq.m	sq.m
England	7,5	-	16,6	11,3	9,6	7,0
USA	5,0	-	22,2	16,7	12,7	-
Sweden	10,0	-	15,0	13,0	10,0	-
Germany	-	22,0	-	16,0	10,0	-
Czechosl.	14,0	-	24,0	24,0	18,9	-
clay house						
min.	5,4	-	15,8	6,0	6,0	6,7
max.	7,8	-	24,9	17,6	10,9	10,15

Among the clay-house-types there is a dismountable standard housing of minimum size, where the necessity of saving space

Fig. 1:

Clay mould-stones

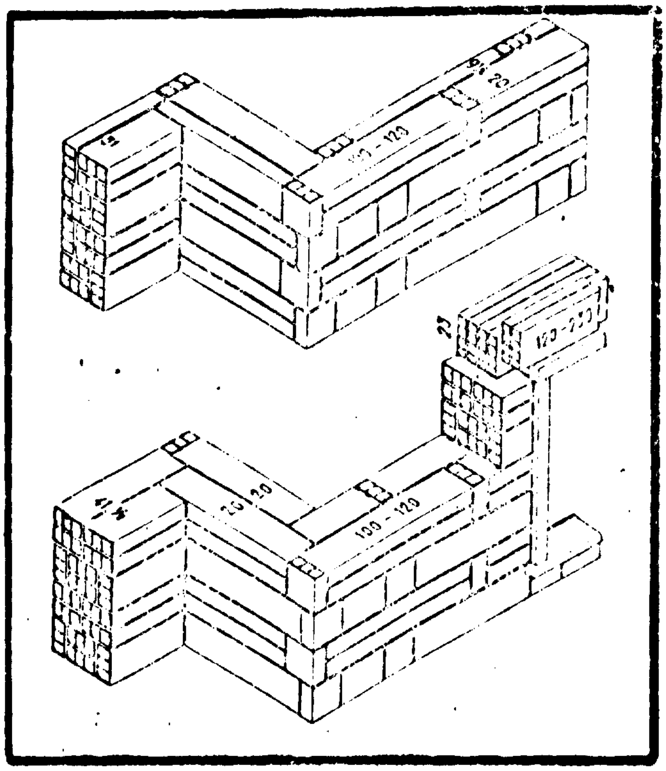
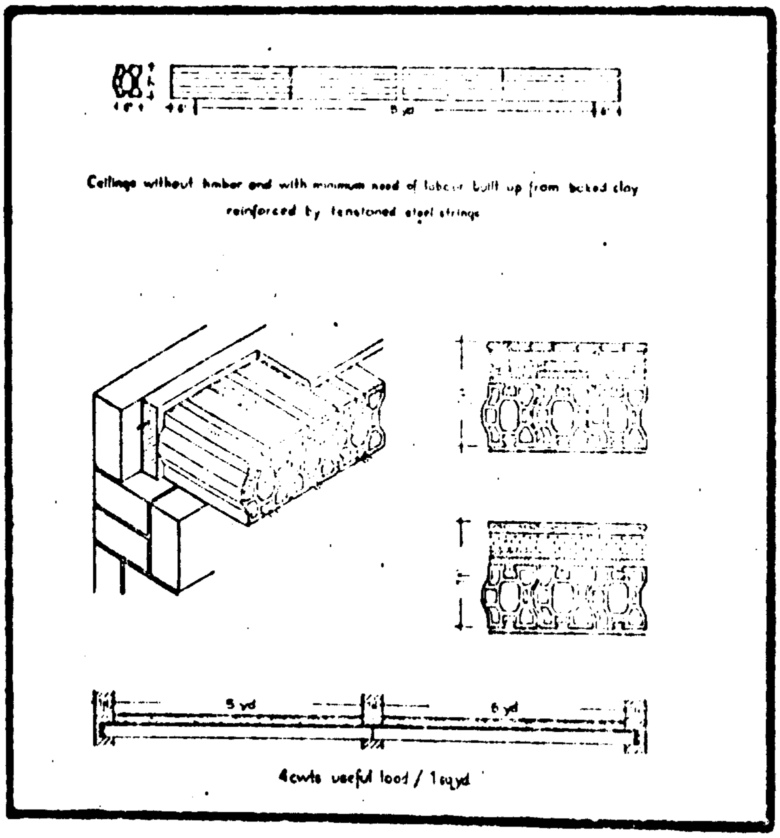


Fig. 2:

Ceilings



imposed quite new arrangements of the room and equipment. This building (fig. 3) is practically tested, was found very suitable in all cases where it is primarily important to build quickly and to attain minimum costs. The material for the building can be loaded on one 20 t-truck.

Furthermore, the housings can be altered to store rooms, shelters, barracks etc. (fig, 4). In any case a small number of baked profiles will give the masonry its openings, the ceiling, the roof and tile as well as the floor.

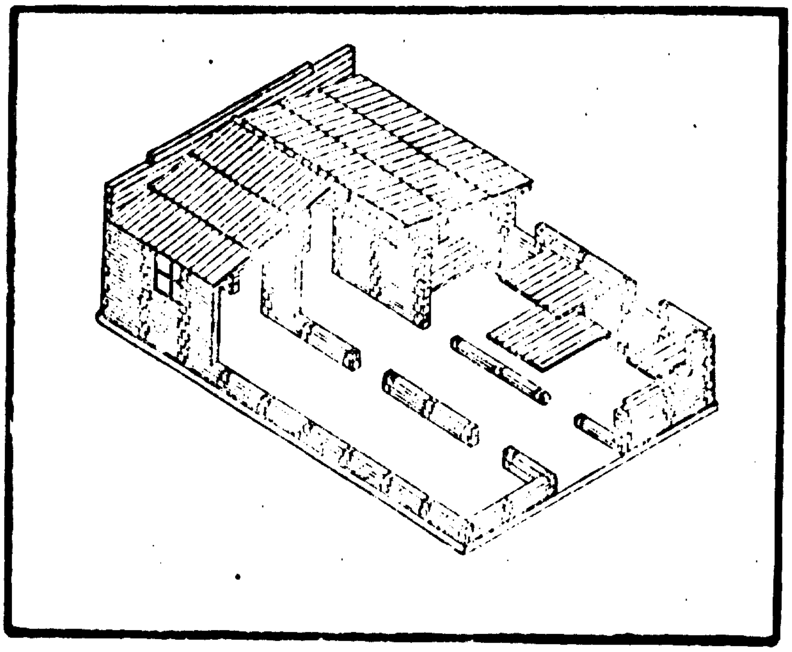
Guided by the above principles, we summarize the tender of services as follows:

Projecting, establishing and outfitting plants for the production of building elements from baked clay on the emplacement of the settlement scheme;

putting the building plans of housing types at disposal, these types being standardized, built up with the aid of the industrially produced elements from baked clay;

instruction of local labour and experts how to practice the construction of assembling buildings.

Fig. 3:
Standard housing



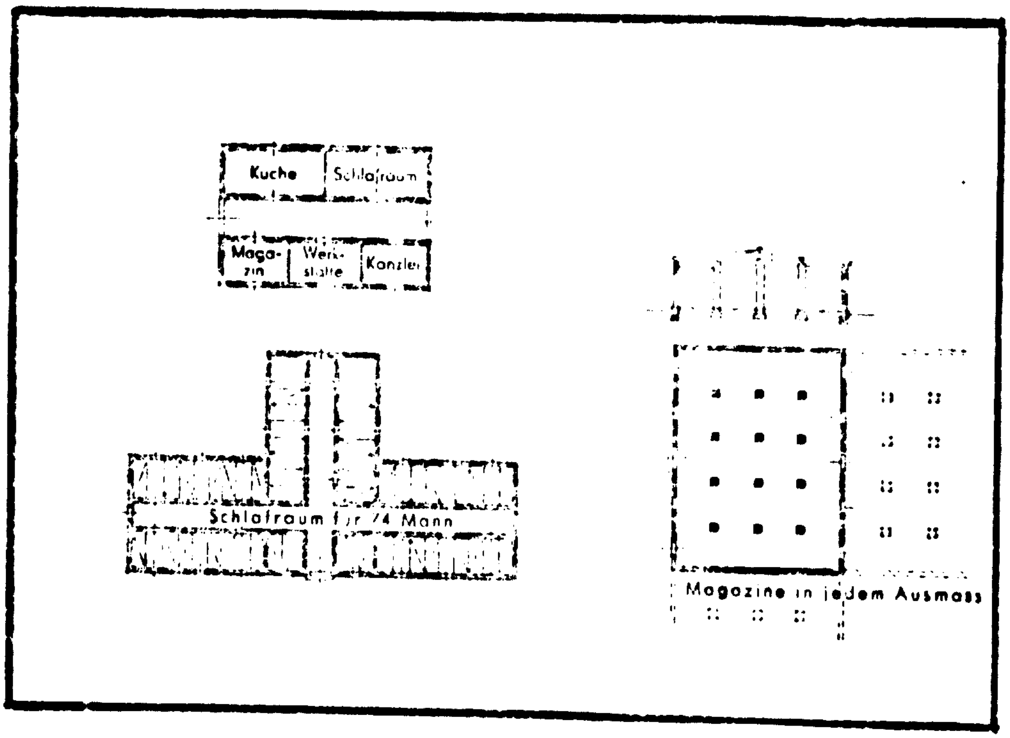


Fig. 4: Variation

B) Method for the production of prefabricated houses from concrete

The PREFAB-system, described hereafter, grew up from the experience aquired by a group of civil engineers during the last years in Greece. The plant respective to that system has been formed following the recommendations of the Greek engineers working with the PREFAB-system under contract of the Greek government. Both, plant and system, form a complete unit providing for the budget-price erection of one- and two-storey residental buildings, barrack-blocks, school buildings as well as buildings for the tourist trade, all at the basis of the prefab principle. The construction material to be used is customary concrete.

The essential advantage offered by the plant is that the layout of the plant system provides for the dismantling and reerection in another location any time. The design of the plant layout has already allowed for total mobility, so that assembling and dismantling costs can be reduced to a minimum.

Due to the reduction of the required prefab patterns which, however, still permit easy solutions to individual layout problems, to a minimum number, and due to thoroughly developped formwork elements, the utilization of a large number of unskilled labour as well as of semi-skilled labour is possible without jeopardizing quality standards and production capacity.
The managing staff - also to be considered as the permanent staff - is made up of two or three engineers and anything between five and seven foremen. The rest of the operating staff can be made up of unskilled workers. The above staff is required for production, erection and interior finishing so as to attain an annual capacity of 10.000 sq.m of ground area, which is equal to a flat floor space of 9.000 sq.m.

The houses according to the prefab-system can be adapted to meet any and all requirements set forth with regard to constructional physics. Buildings, erected on the basis of the prefab-system are to be considered earthquake-resistant in conformity with the Greek Standards.

The moulds and production facilities permit, as already mentioned, the creation of any given layout solution. Possible are:

1. Residental buildings
   a) single family houses, single storey
   b) multi-family houses, single storey
   c) multi-storey residential buildings

2. School buildings

3. Pavillon-type houses for the tourist trade

4. Storage sheds and office buildings

5. Barrack blocks.

Equipment and quality standards of the individual buildings can be varied.

For example, the main data for a plant for a daily output of 40 sq.m of ground area, equal to a flat floor space of 36,4 sq.m shall be mentioned. Based on 250 working days p. a., the annual capacity will raise to 10.000 sq.m of ground area, as mentioned before.
The production of 40 sq.m of ground area per day is equal to a concrete volume of abt. 30 m^3. The following materials are needed:

a) aggregate (gravel, sand)	30 m^3
b) cement	8,5 t
c) steel	0,9 t

d)	rapid setting additivs	
e)	water, for preparation of concrete	6 m3
f)	windows, doors	11,1 m^2
g)	roofing material	40,3 m^2
h)	floor covering	36,5 m^2
i)	wall and ceiling paints	145 m^2
k)	installation material.	

For production and assembling, electricity and liquid fuel is required.

The precast concrete members are produced in a few molds only (12 pieces), vertically or horizontally, depending on the type of mold.

The concrete mix is produced in a completely automated concrete mixing plant and, transferred to the steel molds across a concrete pump or a concrete hauling unit. The concrete mix is then fed into the molds either across a hopper or the existing gantry crane to be eventually compacted in the molds.

The accelerating agent added to the concrete mix and the heating of the steel molds provide for the formwork removal within a short period of time (6 to 10 hrs), so that a continuous use of the steel molds is warranted.

All piping is placed in the formwork to be encased in the concrete mix so that, once the precast concrete members have been erected, only the valves and fittings have to be attached.

The plant is optimum-mechanized and the plant-layout provides for the maximum number of precast concrete members to be produced by way of the available mold sizes.

The advantage of this plant system is based on the thoroughly developed steel mold design; the molds are readily assembled and dismantled and their layout provides for extremely high output numbers, so that the formwork (molds) can be considered as wear-resistant.

During the time the precast concrete members are in the production process, the construction sites of the individual houses are prepared for the erection of the precast concrete members. Foundation trenches are to be excavated, the foundations to be laid and, the terrain to be levelled for the delivery of the precast concrete members to the site.

Once all preparation-work is completed, the precast concrete members are to be delivered on low-loaders (short hauling distances) and, to be set up in accordance with the structural drawings by way of a mobile crane.

The design of the system-method eliminates the need for any local formwork.

All structural joints are filled with plastic mortar, which is subsequently compacted (immersion vibrator with handle - 4.00 m length).

The door and window casings have already been placed in the formwork and are cast in, so that the windows and doors need only be attached once the joints have been poured.

As soon as the building can be locked securely, the final (interior) fitting work can be performed on continuous basis. The sanitary installation items can be fitted, floor covering can be laid down and the walls can be painted or papered.

The system assembly advantage is represented in the form of relatively simple designed connecting points, permitting the use of auxiliary labour in the erection and assembly work involved.

The following are required for the production of 40 square meters of ground area (equal to a flat floor space of 36,40 square meters) i.e. production of the precast concrete members inclusive of erection and assembly right up to turn-key completion (on the basis of 250 working days per annum at 8 working hours per day):

1. 2 Engineers
2. 7 Foremen
3. 23 Skilled workers (or semi-skilled workers)
4. 50 Unskilled workers.

The plant system, as defined hereunder, includes all the equipment necessary for the complete scope of work. The plant consists of:

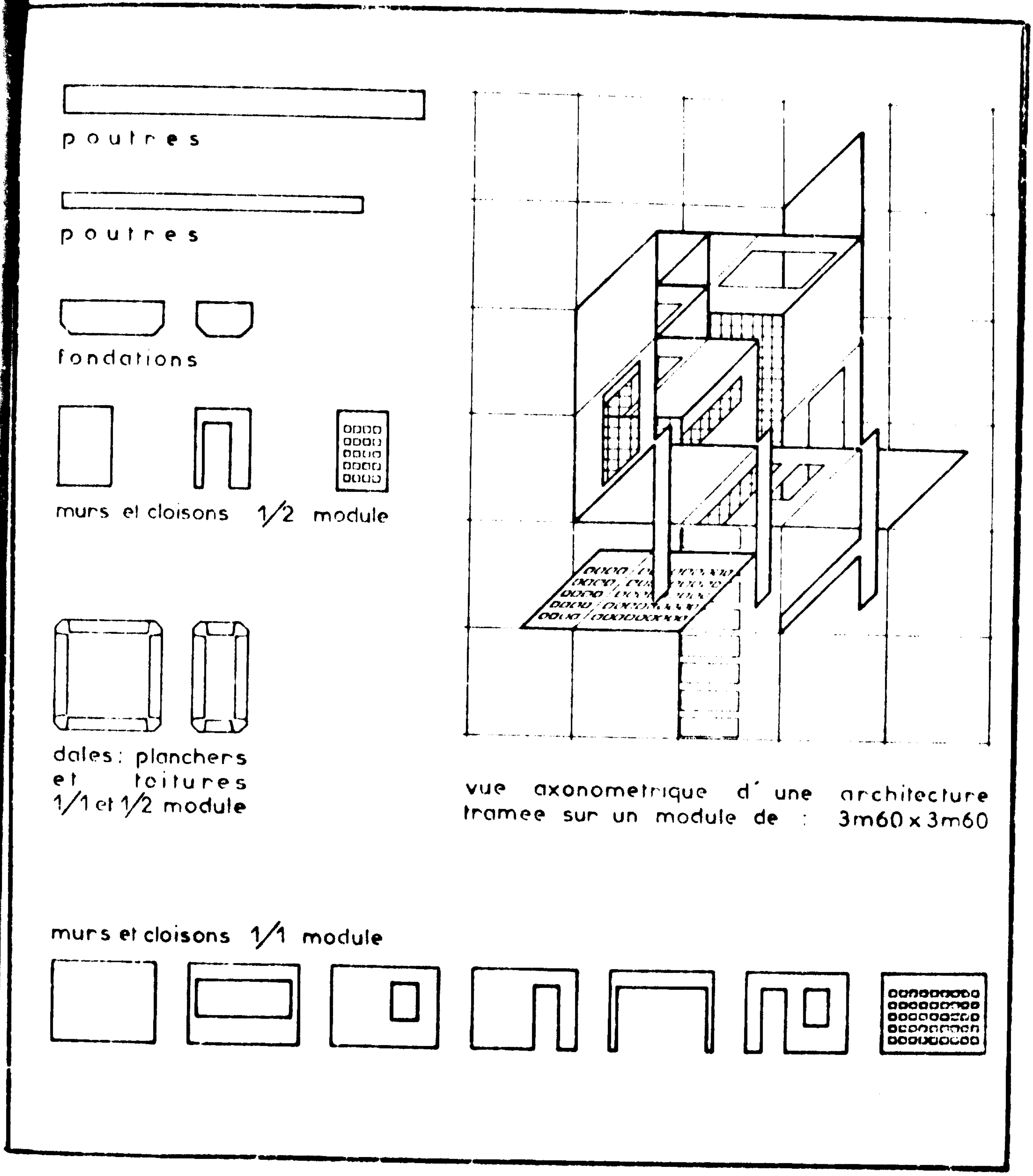
1. Equipment items for preparatory work, specifically with regard to earth-work.
2. Plant system items for the production of the concrete mix as well as for the conversion of the concrete mix into precast concrete members
   a) utilization of horizontal steel molds
   b) utilization of vertical steel molds

   (the utilization of either mold type is possible within one and the same production plant system).
3. Equipment items for the erection and assembly of the precast concrete members and, for the performance of turn-key final fitting work.

The following services are included within the range of our activities:

1. Master Development Plan
2. Constrution Planning
   a) for the Residential Buildings
   b) for the Road Layouts
   c) for the Water and Sewage Systems.
3. Exact technological specifications for the plant and systems to be supplied.
4. Schedule and operational supervision of the complete supply volume.
5. Preparation of the required technological specifications and instructions covering theerection, assembly, operation and maintenance of the plant system sections.
6. Replacement Parts Specification.

The capital investment needed for the complete plant is abt. 1.4 Mio. DMarks. The personnel expenses for an operation time of one year (250 working days) is roughly DM 800.000,--. The costs of the material are, based on BRD-rates, abt. 2.4 Mio DM. The power costs amount to DM 40.000,-- per year. Thus, the production costs, incl. 10 % maintenance charge and amortization over 3 years are abt. 400,--DM/m^2 ground area or 440,-- DM/m^2 flat floor space.



PREFAB - SYSTEM MODULES

C) Method for the production of buildings, mainly consisting of brick material by means of the concrete technology

The method to be described hereafter has been newly developped during the last two years. The inventive idea was to find out a building material having the weight of a light concrete (max. 1,6 kp/dm^3), the strength of a normal concrete (more than 300 kg/cm^2) and the physiological attitude of brick work. Furthermore, the material should be suitable for the use of conventional concrete construction in order to render possible the production of prefab elements as well as the poured concrete method.

This aim was reached by separating the method into two steps. The first step is to produce a light weight additive to be made from brick material. This will be done that way:
Clay or loam is dressed as it is usually done in the brick industry, then a separately prepared foam, similar to a shaving foam, is added and both the materials are carefully mixed by means of a double-shaft mixer. The foamed clay is formed to chips and the chips are dled and burnt like normal brick material. From this procedure a light-weight admixture results with a bulk weight ranging from 0,6 kp/dm^3 to 0,9 kp/dm^3. The bulk weight dependes on the portion of foam added to the clay and the burning temperature existing during the burning process. The size of the chips or pellets is between 0-4, 4-8 and 8-16 mm. The brick pellets are to be compared with the well-known expanded clay but the difference is that the so called CFC-(cold foamed clay)pellets do not have a melting phase in the surface but a uniform porosity. The water sorption is similar to the data known from normal bricks (abt. 8 to 12 %).

According to German conditions, a plant for the production of 500 m^3/day finished product (pellets) equal to a yearly capacity of 165.000 m^3, the pellets having a bulk weight of 0,7 kp/dm^3, will cost abt. 3 Mio DM, erection, foundation and setting in motion included. The average production costs will be abt. DM 20,-- to DM 22,--/m^3 pellets. The sales price, if the material is sold as a normal admixture in comparison to expanded clay, is DM 30,--/m^3 in minimum. That means, that the product, originating from the first step of the method, must be censured as profitable. Furthermore, the investment needed to erect a plant with a capacity mentioned above will be less than the amount necessary for a comparable expanded clay plant. An essential advantage is the fact that the material to be foamed may be a given type of clay or loam, for the production of conventional expanded clay the raw material must be of a certain quality as far as the contents of gasifying components goes.

The CFC-pellet may be used instead of gravel or pumice in such contries where the natural deposits of these types of material are missing.

The second step is processing the CFC-pellets to a building material by means of the concrete method. Due to the fact that the process has been newly developped we are, at the time being, still scrutinizing the method, that means, that all the tests necessary are not yet finalized. In spite of that, some basic data are available, which have been tested out in the laboratory of a well-known Western German building company. The data are mentioned hereafter:

All tests have been made according to the prospective DIN-standards.

a) Shape of pellets

The check of the pellet shape by means of a pellet shape gauge gave the result that the shape is 100% advantageous (relation length to thickness smaller than 3:1).

b) Frost resistance

The resistance of an admixture against frost must be sufficient for the use together with cement. For concrete which may be often exposed to changements between frost and dew the resistance of admixture against frost can be judged as sufficient if after ten times frost- dew changement the loss of material does not exceed more than 4 % of weight. In the actual case, the loss is 0,4 % of weight.

c) Detremential parts

Those substances which prevent the concrete from setting, which lower the strength of the concrete, whichcause blastings or impair the rust protection of the reinforcement must be considered as detremential parts. Those parts are not existing in the CFC-admixture. As to the test results:

1. Parts to be washed away (max. 5 %)	= 0,9 % of weight
2. Parts which prevent the setting	= none
3. Parts of organic origin	= none
4. SO_3-Contents (max. 1.0 % of weight)	= 0,03 % of weight
5. Cl-contents (max. 0,02 % of weight)	= 0,002 % of weight
6. Loss by burning (max. 5 % of weight)	= 0,3 % of weight.

d) Bulk weight

Grain size 4/ 8 mm	=	0,80 kp/dm^3
grain size 8/16 mm	=	0,80 kp/dm^3

e) Water sorption

	within 30 minutes
grain size 4 /8 mm	12 %
grain size 8/16 mm	9 %

f) Attitude of CFC-pellets in concrete

The measurement for the strength of the pellets and the grain density of the admixture will result from the statement of the pressure strength and volume weight of a concrete made with admixture.

The concrete tested was made by means of cement PZ 350 F. The pressure strength and the tensile strength of that cement after 28 days was measured with 448 kg/cm^2, resp. 69,6 kp/cm^2.

The concrete was mixed as follows:

337	kg	PZ 350 F
235.2	kg	CFC-pellets 0/4 mm
145.2	kg	CFC-pellets 4/8 mm
105.5	kg	CFC-pellets 8/16 mm
206	kg	H_2O

The volume weight of the concrete was:

1.820 kp/dm^3 after 29 days.

The pressure strength of the concrete was:

275 kp/cm^2 after 8 days,

313 kp/cm^2 after 29 days.

From these tests results the judgement that the CFC-admixture is suitable for a concrete quality L Bn 300 having an adequate good insulation against loss of heat.

In the interim, further tests have been made with a state testing laboratory, giving better results as a concrete voulme weight of 1,6 t/m^3 and a pressure strength of 380 kp/cm^2. Those different data result from the various burning temperatures of the CFC-pellets.

The so called CFC-concrete made as described, can be used in a similar way as normal concrete is applicated.

From this method results a building material similar to conventional brick work but to be handled by the means of the well-known concrete technology. So the advantages of the brick material and the concrete building method are combined to a modern building method.

D) Method for the making of calibrated bricks and system of dipping mortar brick masonry.

The methods described hereafter are based on a normal brick fabrication. The aim of the methods is to allow the making of brick masonry of a high quality standard by means of unskilled labour. Theefficiency of unskilled hands is, according to the experience, higher compared to conventional masonry. This method will give the possibility to erect fast and easy houses and buildings whereever they are needed. This may be of interest for those countries having a brick industry which is suffering from a lack of skilled workers.

In spite of the fact that the method has been newly developped we try to give the information being at hand at the moment.

The calibrating of the bricks is done by means of the NOVAMUR-brick-calibrating machine, type ZKN. The standing surfaces of the rough brick are cut to a tolerance of ± 0,4 mm on the way to the burning kiln. This takes place in the calibrating machine itself, which is proceeded by the feeder and subseded by the unloader.

The bricks must be charged to the feeder one following the other. They are centered on a straightening device to minimize the thickness to be cut in order to reach tolerance level. Calibrating is carried out by a patented arrangement of abrasive wheels and cup wheels. rotating at a speed, convenient for the process. A high speed corresponds to a very sensitive feed, guaranteeing perfect and resisting edges.

The calibrating process is continuously controlled, the cutting and grinding tools automatically set accordingly. The grinding wheels are provided with a number of slits, which permit the suction of the resulting grit by an exhauster. The suction equipment, i. e. the exhauster, the cyclon and piping and, if necessary, the dust removal from the exhaust air, can be adapted to the particular customer's needs.

The bricks being calibrated are leaving the machine by the unloader in order to be burnt in the kiln.

The calibrating machine, consisting of feed conveyor, straightening arrangement, calibrating machine itself, delivery conveyor and control cabinet having a capacity of 10.000 to 12.000 NF according to 2.000 pieces bricks 30 x 24 x 17,5 cm/hour, costs abt. DM 120.000,-- without dust-removal. The machine, having a total length of roughly 12 m, incl. feeder and unloader, can be installed in any existing brick-making plant.

The machine, which is protected by patents, is sold by the NOVAMUR AG, Glarus/Switzerland.

Due to the fact that the calibrated bricks are of great accuracy and parallelism of upper and lower surfaces the dipping mortar method can be used. As already mentioned, the masonry can be done by unskilled labour with high erection speed and good quality of the masonry itself. The brick is dipped with its lower surface into the prepared mixture of mortar to a depth of abt. 0,5 cm. Due to its consistency the mortar adheres to the brick. So the brick can be placed to the wall under work. Due to the accuracy of the bricks a straight wall will result.

The mortar is delivered to the site ready mixed in bags.

Tests which have been made with walls of calibrated bricks built-up by the dipping mortar method gave the result, that the technical data regarding insulation against loss of heat and sound insulation are better than those of conventional walls. Furthermore, the pressure strength is in the upper range compared to conventional bricks of same size. At least, the dipping mortar can still be used when temperatures are ranging under 0°C down to -10°C.

We feel, that these methods under development may be of interest for some parties due to economy and plainness in application.

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