



107
434
THS

FIRE-PROOF AND FIRE-RESISTING
RESIDENCE CONSTRUCTION

THESIS FOR THE DEGREE OF B. S.

Edward Earl Ellwood

1934

THESIS

Fireproofing

cop. 1

FIRE-PROOF AND FIRE-RESISTING RESIDENCE
CONSTRUCTION

A THESIS SUBMITTED TO
THE FACULTY OF
MICHIGAN STATE COLLEGE
OF
AGRICULTURE AND APPLIED SCIENCE

BY
EDWARD EARL ELLWOOD
CANDIDATE FOR THE DEGREE OF
BACHELOR OF SCIENCE

THESIS

cop. 1

INDEX

INTRODUCTION	PAGE 1
FOUNDATIONS	PAGE 6
WALLS	PAGE 9
Masonry	Page 9
Monolithic Concrete	Page 15
Precast Concrete	Page 19
Steel Framing	Page 25
FLOORS	PAGE 30
PARTITIONS	PAGE 34
ROOF DECKS	PAGE 36
ROOFS	PAGE 38
STEEL SASH	PAGE 43
METAL TRIM	PAGE 43
SUMMARY AND CONCLUSION	PAGE 44

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100

INTRODUCTION:

A good many attempts have been made in the last few years to develop an improved house construction, but the actuating motive has been to introduce into the great housing industry the largest quantity of a specific material - such as steel, concrete, brick, or gypsum - without considering its proper relation to the production of the economical house. Each material has a legitimate relationship to the private dwelling, and this thesis is an attempt to determine what that relationship may be, always keeping in mind that the real problem is to provide a well-built, desirable, economical house by the correct use of the proper material.

It is easy to erect a well built house by substituting non-combustible materials for those commonly used in wood construction, but the result is too costly for the average home owner. A concrete example of this might emphasize the remoteness of this possibility. Recently a local architect designed and drew the plans for a large home, the construction was to be wood frame, brick veneer, and asphalt shingle roof. Bids were taken, and the job let to the contractor at a figure of seventeen thousand dollars. Hardly before the ground had been broken, the owner began to better the type of construction. Clay tile replaced the wood studding and sheathing in the exterior walls; Eates expanded metal trusses covered with hirib lath and two inches of concrete replaced the wood joist and rough flooring;

steel casements replaced the double hung wood sash; interior partition of four inch steel channels with metal lath poured full of concrete replaced the wood studs, wood lath, and plaster of the old partitions; metal trim replaced the wood trim; and other smaller changes were effected. The final cost slightly exceeded the figure of seventy thousand dollars, or better than four times as much the original figure.

The possibilities of effecting economy in residences lie in the proper selecting of material for the duty to be preformed, elimination of the waste in home building (which by the way is set by the Department of Commerce at fifty-three percent), elimination of labor by building units in factories under mass production, the units being fitted and ready for installation. By combining the above economy, then eliminating from the home all unnecessary space, and replacing the more expensive sections of the home with sections whose construction cost will run less, you will then have effected the possibilities of economy.

New materials necessarily require new methods. With the use of steel for the frame of a house a change becomes evident in the relationship of the structural parts, and the function of the walls, partitions and floors must be studied in the light of new conditions. Many successful attempts will be made to bring together these functions and the materials that suit them.

- The function of a house wall has always been to

support the floor loads, furnish rigidity, offer protection from the elements, and provide architectural treatment for the exterior and interior. Such a wall was necessarily heavy and built by a slow hand process. But if the functions of strength and rigidity are transferred to a steel frame of the type used in office buildings, so that the columns are at the corners of the room, with girders between columns and a filling in of floor beams, the frame becomes simple, is made up of the lightest and cheapest shapes obtainable, has the fewest pieces to handle and takes but little space.

This allows the wall to become merely a clothing on the outside of the framework, and, having fewer functions to perform than the old fashioned bearing wall, it offers great flexibility of treatment and a wide choice of materials. Weight and strength cease to be essential. Small, heavy pieces laboriously piled one on top of another are not necessary for beauty.

Good quality wood has been abundant in this country, and wood studs, wood lath and plaster made a cheap partition. But the expansion, contraction, and shrinkage of the wood caused the plaster gradually to loosen and drop off, it made good housing for vermin and supplied fuel for any fire that might develop.

With a steel frame to carry all the loads of floors and partitions, the partitions are merely curtains between rooms. Sufficient strength to carry their weight from floor

to ceiling can be obtained without the thickness required of the load-bearing partition. Good insulating materials are available.

Partitions do not have to be large, bare surfaces requiring special treatment to break their monotony. The side of a room may be made in easily-handled units that in themselves break the monotony, and require no artificial treatment to make them attractive. Shop-made units may extend from floor to ceiling and require no labor after installation except decoration.

It is difficult to solve the floor problem until we cease to imitate the traditional wood joists with a wood flooring fastened to the top and a ceiling plastered to the bottom. This was the only floor possible in its day, but the entire construction had all the bad qualities of wood construction. The flat ceiling was difficult and expensive to decorate.

With the use of steel it is not necessary to have the joists close together. Slabs four feet wide need not be over three inches thick if cementitious materials are used. Such slabs are economical to make, easily installed, can be insulated for sound. The bottom of the slab when installed is ready for **paint** or other finished decoration.

Thin, strong slabs for walls, partitions and floors are made possible by use of steel reinforcement and the strength of the steel connections to the steel frame.

-Such buildings could go through the convulsions of an

earthquake without loosening the slabs from the frame. Steel is used for strength, and insulating materials are used for insulation, and by the correct combination of materials according to their functions we hope to reach the goal in good house building.

But the ability to produce an economical steel frame and slab construction will not solve the housing question. How to create an attractive house and then the merchandising of it are problems of equal importance.

According to data compiled by the Portland Cement Association residence construction in the United States totals more than three billion dollars a year, about one-half of which is in single and two-family houses costing under \$20,000. The average residence costs about \$4,500.

A good site is essential and so too high a percentage of the cost may be spent for the land; after which beauty of architecture and then convenience are the most important factors in selling a house. When these requirements have been satisfied economy necessarily asserts itself, so that permanence and safety of construction are not given the serious consideration they deserve. It is obvious that these requirements must be provided without additional cost.

FOUNDATIONS:

Undoubtedly footing and foundation wall designs suffer more from our present day methods of construction than any other part of residence or small building construction. The greater part of our homes originate not in the architect's office but in the rooms of a real estate agent. Plans are forthcoming either from the lumber company or from the hands of an individual even less able to design a structure. Footings, usually of the continuous wall footing type, are the minimum size set by the building code. No attention is paid to calculating of the loads supported by the footing or to the bearing pressure of the soil, to the changes in types of soil, and to the history of the section which may have been a swamp filled with rubbish. It is safe to say that seventy-five percent of the houses built are under the direct supervision of carpenters who have no knowledge of foundation work; pouring of the footings and building of the foundation walls are probably let on a contract to some individual owning a concrete mixer, with no attempt to obtain a concrete of definite strength or uniformity. How can we expect to find homes free of unsightly cracks in the masonry, and checks in the plaster?

Footings and foundations are two of the most important parts of a residence. It would be too costly to make borings to determine the condition of the sub soil, and since the size of the footing can be easily and quickly figured it probably would be wise to excavate and then

design the footing to meet the requirements.

Three types of footings lend themselves readily to residential construction.

First a cantilever slab which projects in two balancing directions. A projection of at least four inches should be used which serves as a ledge on which wall forms can be conveniently placed. The minimum depth of the footing should be twice the projection. In this type of footing it would be advisable to place three five-eighth inch round reinforcing bars continuously in the bottom. Foundation walls on this continuous footing may be poured concrete either plain or reinforced, brick, or concrete precast units laid in cement mortar.

Secondly the building load may be distributed to the soil by a number of single slab footings which would receive the building load from reinforced concrete beams which also serve the purpose of foundation walls. This type of construction would need the most careful study and design for not only must the footings support the building but there must be a minimum of deflection in the beam foundation walls.

Thirdly the house might be supported by a concrete raft foundation, covering the entire building site. The raft might be designed either as a flat slab or as beam and slab construction. The beam and slab is usually more expensive, but has the advantage over the flat slab of allowing all piping below the basement floor to be in-

stalled after the foundation work has been completed.

All three types of footings should be protected by drain tile as the rain or ground water may wash the superimposed earth into crevices allowing the residence to settle, thus badly cracking the walls and plaster. This action sometimes continues over a period of years.

Waterproofing foundation walls maybe accomplished from the exterior very cheaply. A coating of asphalt, thined slightly with oil, fills the pores and may be applied with a three nob brush; this treatment, under ordinary circumstances and combined with the action of drain tile, works very well. Under severe conditions it might be advisable to apply an asphalt saturated fabric to the coated wall through the medium of hot asphalt.

WALLS:

Walls present to the architect or builder the greatest variety of problems in the building of a home. The wall must be designed to withstand all loads which may be imposed upon it. It must present a favorable appearance both from the exterior and interior. Material from which to build the wall must be available in large quantities, and must be of such a character that it may be readily erected without excess labor and equipment costs. Incidental to these characteristics the wall must be resistant to corrosion, must be waterproof, and the interior must be free from condensation, and if the wall is not an insulating material in its self it must be easily insulated with insulating material.

Despite the great number of conditions which must be met in building walls there are a large number of materials available and the number of combinations of these materials run into the hundreds. But of all these materials and their combinations we have yet to find a perfect or ideal wall. A large number of baked shale and clay products, and molded concrete blocks are used in wall construction. To a lesser extent poured concrete walls are used, and to a still lesser extent, due to its newness in the field, light steel sections.

An important class of materials of wall construction comprises products of clay burning kilns. The burnt clay products include building brick (hard and soft), terra

cotta blocks, clay tiles and porcelains.

Bricks and clay tile are formed from a plastic mass of finely ground clay and water. The molded bricks and tiles are dried for several days after which they are burned in kilns for approximately one week after this they are cooled slowly. Three classes of brick are obtained: arch brick (over burnt), red brick (well burnt), and soft brick (under burnt) Of these three types of brick only the red brick may be used for exteriors, and the soft brick may be used for backing up the face brick or for interior walls.

Terra cotta is made in the same general way as is brick, except that it is burned at such a high temperature that the resulting product has a slightly vitrified surface.

Porcelain is a special burnt clay product and is coming into use in the construction field as a hard glossy coating on rigid metal slabs or sheets. Its use has been limited to roof construction but with the introduction of metal studing its use has been extended to exterior and interior wall finish.

Masonry is always used in compression. The compressive strength per square inch of brick or tile masonry is much less than the compressive strength of the individual units. In general, stronger bricks and tiles make stronger masonry than do weak bricks or tiles, but the quality of mortar used, the closeness of fit between adjacent units, and the care used in laying the brick or tiles, are all important

factors in the strength of the masonry. In walls cracks occur most commonly along the mortar joints. When individual units crack it is almost always due to shear rather than crushing.

Brick, clay tile, and terra cotta masonry, if well built and of good materials, are as nearly permanent as any structural material. However, they may finally suffer disintegration under weathering, and usually the freezing and consequent expansion of absorbed water is a prominent factor in the disintegration process. Porous brick absorbs much more water than does hard burnt brick, and the porous brick, in general, weathers poorly. Disfiguration of the masonry may be caused by the dissolving out of lime and salts causing a streaked appearance. Mortar joints in any type of masonry are especially liable to be damaged by weather. Absorption of water and freezing has the most marked effects, although an acid effect of the atmosphere with the continually washing by rains soon disintegrates the joint.

Burnt clay products are without a doubt the most used of fireproof materials in homes and buildings now constructed. From the stand point of appearance any color, texture, or design can be obtained. Were every home and building to be built of brick, such are the combinations, that they would never become monotonous. The clay used in the making of bricks is very common and large deposits of it are found in many locations. Raw

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100

materials cost little and no extensive equipment is needed in the manufacturing, thus a great many sections of the country are served by local plants. Because of the availability of the material, freight and hauling are at a minimum and the material can be furnished for erection without delay. Erection of burnt clay materials is quite costly. High grade mechanics and the influence of unions run the labor costs a little high. Size of the units, the weight of the material, and the care in laying, slows down the speed of production. Erection so increases the cost of this type of wall as to place it out of reach of most home builders. Durability of the material has already been discussed. The chief fault with masonry construction is its inelasticity. Much disfiguration results from excess deflection of lintels over windows. This deflection results in the masonry being subjected to tension, and being of nonuniform material it cracks on the plane of weakness which is the joint. The greatest asset of this wall is that if correctly designed and constructed, the upkeep over a great number of years will be practically nihil. A solid masonry wall is not water proof and if subjected to large quantities of water, such as might be experienced from a leaking eavetrough or conductor pipe, the decorations on the interior may suffer. Proper insulation of the wall, such as furring and using an insulating plaster base, is necessary to avoid heat losses and possible condensation from cold walls and high humidity within the house.

A modern development in the masonry field is the increasing use of ashlar construction employing concrete masonry units. Concrete ashlar is a form of concrete masonry, which is the term applied to building units molded from concrete and laid by a mason in a wall. The concrete is made by mixing portland cement with water and other suitable materials, such as sand, pebbles, crushed stone, cinders, burned shale, or slag.

In concrete ashlar construction, special effort is made to produce wall effects having architectural interest. There are various methods by which this may be done: choosing or grading aggregates to produce desirable textures; painting the concrete units when they are manufactured; incorporating mineral color pigments in the faces of the units; texturing the units during manufacture by means of wire or fiber brushes or by spraying with water; covering finished walls with one or two coats of portland cement paint, or similar methods which the architect may devise.

Like concrete masonry construction, concrete ashlar provides at moderate cost the desirable properties of strength, firesafety and attractive appearance as well as the permanence inherent in concrete. Concrete ashlar is used regularly in constructing both interior and exterior walls, -- load-bearing or non-load-bearing.

The shaping of concrete masonry units used in concrete ashlar is done in large machines which mold the units in exactly the right sizes and which turn out great quantities

in a day's time. When this rapid mass production of units is considered, the economy of concrete ashlar is readily apparent.

Another factor which results in considerable saving is low labor cost. The erection of concrete masonry is facilitated by the large size of the units and their lightness. One 8x8x16 unit replaces twelve brick, and consequently less mortar is used in the bedding of the blocks.

Considerable trouble due to cracking has been experienced with concrete masonry in walls. Improper curing of the blocks and poor design of footings and lintels might be blamed, but the fact remains that the inelastic properties of the masonry wall still exists. Concrete masonry is not waterproof and the lath should be furred and be of an insulating material.

Proper laying of concrete masonry will reduce the trouble experienced with dampness and condensation. The blocks are somewhat porous and contain considerable air space which acts as an insulation, but the mortar containing excess cement, fills the voids of the sand giving a dense mortar of no insulating value. The mason should be very careful to see that the mortar does not extend way across the bed of the block. A small air space, the equivalent of an insulation will do much toward relieving the trouble with condensation and dampness.

Monolithic concrete walls have been used extensively in commercial and factory buildings and to a small degree in residences. A monolithic or poured concrete wall can be made very uniform in structure, flexible in design and cheap in cost. Its chief criticism lies in its lack of color and texture, and the trouble experienced in remodeling. The incorporation of color and texture to exterior surfaces on concrete walls is an easy matter. Frequently only a coat or two of white or colored cement paint on a monolithic wall will give a pleasing appearance. A rougher coat may be obtained by mixing sand with the cement paint and brushing it onto the wall. A still rougher coat may be obtained from a coat of stucco. Rubbing the surface with an abrasive stone will produce a pleasing surface and white color. This type of wall is available anywhere that concrete masonry units are available, the same materials being used in each one. There are three different types of monolithic walls: solid, hollow double, and cored and ribbed sections.

Each section has certain advantages and disadvantages in comparison with the others.

Solid Wall: It is logical that the form work for the solid section should be more readily erected and stripped and cost less than forms for the other wall sections. The cost of concrete and reinforcing material for the solid wall compares closely with the hollow and cored types but is higher than for the ribbed section. In general, the cost of insulating the solid wall will be higher than for the

other types. It has been used more extensively than either the cored or ribbed sections and somewhat less than the hollow double wall. When properly built and insulated, solid walls have given satisfactory results.

The following systems are designed to build solid walls: Adjustable Steel Forms, Fellgren, Flagg, Gleason, Hueber, Hydraulic, Ingersoll, Knipe, Lambie, Metaforms, Morrill, Schub, Simplex, Tucker, and Uni-Form.

Hollow Double Wall: The hollow wall with a continuous air space usually is built with forms that slide vertically or horizontally. The air space provides sufficient insulation, permitting plaster to be applied direct thus saving the expense of furring strips and lathing. The use of sliding forms which are moved soon after filling requires a semi-dry, stiff concrete mix and the resulting surface is rough textured and with noticeable course markings. Generally the exterior of such walls is stuccoed one or two coats if a smooth finish is desired. Two coats of portland cement paint also have been used with good effect and at a substantial saving over stucco. Form costs with the special hollow double wall machines actually are little more than for solid walls, and considering the economic advantage of the built-in air space insulation, this type has proved as inexpensive as any. It has been widely used, there being an estimated three to four thousand homes with monolithic hollow double walls.

The following systems are designed to build hollow double walls: Frost, Hillman, Lehrack and Van Guilder.

Cored Wall: The cored wall has been used principally in California. Usually it is made twelve inches or more thick. Its main advantage compared with the solid and hollow types is its greater thickness and lateral stability for a given amount of material. The core spaces add to its insulating value and in California, it is common practice to plaster directly on the concrete. However, for such jobs built in Northern states, it would be advisable to provide additional insulation by furring out the plaster or by other means. The cored wall ordinarily will prove more expensive than the other types due to the higher form costs incurred in building the core spaces.

Systems building cored walls include: Adjustable Steel Forms, American Engineering and Development Company System, Banks, Brandt, Concrete Hollowall, Cresmer, Kreil, Larson, Merriett, Monocrete, Monolithic Hollow Wall, and Simplex.

Ribbed Wall: The ribbed section more commonly is employed in conjunction with precast units but is also the basis of a few monolithic systems including the Gottschalk and Olmsted. From the standpoint of concrete materials, it is the most economical of all types. Form work generally is more expensive than for the solid section due to the necessary forming for the ribs and for sills, lintels and jambs at openings and for spandrel beams or other

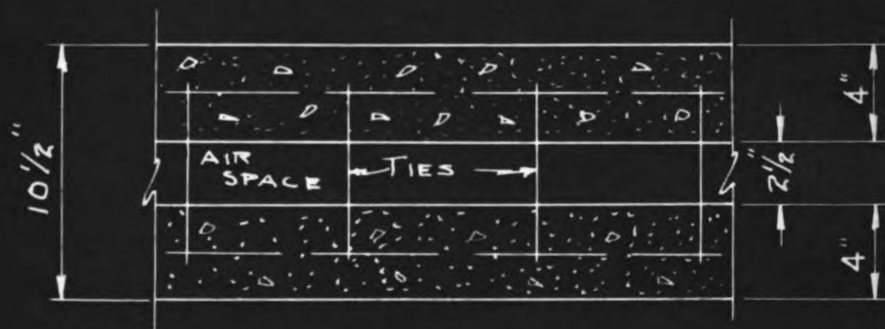
suitable bearing for the floor system. The ultimate economic possibilities are greater perhaps for this type than for the others because of its basic economy in materials.

Less trouble with the inelasticity of monolithic wall construction is experienced due to uniformity of the material and the use of reinforcing steel in the lintels. Concrete in general is not waterproof but the degree of waterproofness depends upon the density of the material.

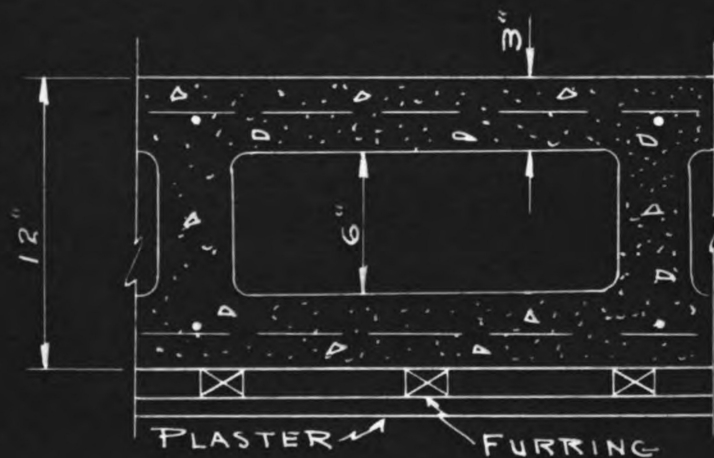
The material used in concrete wall is very cheap, practically no skilled labor is needed except in the erection of the forms. Forms are an additional cost to the wall, but may be used several times. Placing the concrete may also prove difficult if the wall is high.



SOLID WALL



HOLLOW DOUBLE WALL



CORED WALL



RIBBED WALL

Precast unit systems deals with those systems which employ precast concrete units other than the masonry type. The various systems may be classified on the basis of size of unit as follows: large unit systems - units up to 160 square feet or more in area; panel unit systems - units of story height and one to four feet in width; and small unit systems - units up to four or five square feet in area.

Large Unit Systems: The most extensive use of this classification was at Youngstown and Forest Hills, Long Island. The latter project consisted of a group of attached dwellings built for the Russell Sage Foundation, mostly for experimental purposes to determine the possibilities of large unit construction in achieving a durably built home at a low cost. Grosvenor Atterbury of New York City was the architect. The units were cast in a central plant and transported to the site by an industrial railway as contrasted with the methods used at Youngstown where the slabs were cast at a convenient location on the site and transported by trucks from the storage piles to the erection derricks. According to the information available, the system as used at Youngstown proved the more economical probably due to the larger number and simpler design of the dwellings.

The Tri-Ply and Hansen systems also employ a large wall unit which is cast flatwise on the floor construction and is tilted to a vertical position on the foundations as soon as the concrete has sufficiently hardened. The

unit is made complete excepting for the interior plaster which is applied after erection. This method has been used with reasonable economy for several hundred dwellings and is considered adaptable to group housing and single dwellings. It practically dispenses with the problems of form work and transportation of the slabs. The principal extra equipment required is the hoisting or raising rig which will cost about \$300 to \$350. One of the main disadvantages has been the delay in time necessary between casting and erecting the section. The use of high early strength concrete would tend to meet this objection.

Panel Unit Systems: The most extensively used panel unit systems are Armostone, Moore, Simpsoncraft and Broughton. The Armostone and Broughton units are made in a plant whereas the Moore and Simpsoncraft systems employ a casting yard on the job.

The economical use of this class of construction depends to a large extent on the development of more efficient equipment and methods used in the manufacture and erection of the units. The laborious hand methods used in making the units in the past have proved inefficient and costly. It has been estimated that in order to compete with concrete masonry, it will be necessary to attain a production of eighty 3 by 8-foot slabs per day with a five man crew. It does not seem that this can be done without substantial improvements in manufacturing technique and equipment.

It is conceivable that a specially designed plant could produce a panel unit system at a competitive price but in order to justify the large investment, it would be necessary to operate the plant as a permanent proposition regularly serving a definite market territory.

Economical erection also demands suitable equipment. The units are too heavy for efficient handling by manual methods. A crawler type crane having a 30 to 35-ft. boom should serve satisfactorily. Due to the large size of the unit, it is possible that very low erection costs may be ultimately achieved.

The use of panel units will restrict architectural design to some extent. They are best suited to standardized floor plans dimensioned to fit the units. A large manufacturer of such units probably would prepare a selection of architectural plans based on the construction system.

Several of the systems employ a very thin section and thereby save in materials. The Armestone unit is an example of this. Past experience has indicated, however, that the saving in material is not sufficient to offset the inefficient practices in manufacture, transportation and erection.

Small Unit Systems: This classification includes the Hahn, Hartley, Lockwood, Osakis, Rackle and Underdown systems. Precast slabs from $1\frac{1}{4}$ to 3 inches thick and about 3 feet

long and 12 inches high are set in a double row with pre-cast or cast-in-place studs provided at the ends of the units.

The most extensive use of this method has been in Great Britain where groups of dwellings totaling about three thousand have been erected at Leeds, Swansea and Newcastle in England and at Edinburgh, Scotland. The English system was developed by Sir Edwin Airey of Mr. Airey and Son, Ltd., the contracting firm on these projects. The erection proceeded in much the same manner as employed in this country, the main difference being in the manufacture of the slabs, which was done on the job using simple molds. It is claimed that one experienced workman would cast 100 slabs in a day, which figures about 2½ cents per square foot based on a wage of \$6.00 per day. In this country, the Hahn, Hartley, Lockwood and Underdown systems have been used in actual work. It will be observed that several of these employ specially shaped units designed to inter-lock with the cast-in-place stud. This feature is desirable from a structural standpoint but tends to complicate the economical production of the slabs in large volume. The plain, rectangular section with the beveled ends as in the Airey and Underdown slabs is better suited to large scale production. Multiple molds set up for casting large numbers of slabs on edge at one time should be practicable. The molds could be assembled on a vibrating table in sets of 100 or more and the filling and

casting completed in a relatively short time. A production of 100 to 150 units per hour possibly could be accomplished with a five-man crew at a labor cost of around one cent a square foot of slba. The manufacture of the units in single molds and with hand operations obviously cannot compete with the high production machines used in making concrete masonry.

In addition to the use of vibration and multiple molds, it should be feasible to design a power tamper for making units that are two inches or more thick and which are not more than twelve inches high.

Where light-weight aggregates are available, their use for concrete slabs of this type should be given particular consideration.

The stud forms in this construction are of simple design and quickly erected and held in place by clamps or ties. Ordinarily, lintels are not required over openings that come between the studs. Bond beams at the floor levels may be built by placing the reinforcement and concrete in the space between the opposite rows of slabs. Strips of metal lath inserted in the joint will serve as a bottom form for the beam.

In the precast unit classification, it is believed that the systems employing precast units about $1\frac{1}{2}$ or 2 inches thick by 12 inches by 36 inches in conjunction with precast or cast-in-place studs have the best possibilities for economical use and commercial development at the pre-

sent time. They do not seriously restrict the style, shape or dimensions of the house and are applicable to large enterprises of single residences.

The Tri-Ply and Hansen systems, although utilizing a large unit, are believed to have considerable merit because of their basic plan of casting the slab in a position which reduces form costs and from which it can be tilted readily into its final place in the wall,

The panel unit systems which are considered the most economical and practical include the Armostone and Broughton, although by reason of their close similarity, others such as the Swan and Conzelman should be accorded practically the same recognition. The panel unit type is not regarded as being as adaptable to immediate development and use as the small unit systems already specifically mentioned. Ultimately, it may become an important type of construction, particularly for small four to six-room houses built according to stock plan furnished by the manufacturer.

The other systems should not be overlooked. Some of them contain worth-while features and it is advisable to maintain an open mind regarding their potential importance.

In the many attempts which have been made to extend the use of steel in the construction of private residences much effort has been expended in the mere substitution of a steel member for a corresponding wooden member. This idea is said by deep students of this subject to be erroneous. The structure should be designed as a complete and harmonious whole using steel and other materials wherever they can be best adapted to the purpose at hand. This would not be a mere substitution of one material for another of similar characteristics, but would furnish a new type of structure differing from its predecessor in most construction details and like it only in that it incloses rooms for human occupancy.

The search for better ways of doing things is never ending. Today's methods, however successful, can never be taken as wholly right. They represent simply the best efforts of the moment. Tomorrow must bring improvements in the methods of the day before.

The importance of the use of steel in relation to the private residence is in proportion to its ability to make possible an improved construction at a reduced cost. The replacing of the wooden frame with steel members results in a substantially increased cost a more rigid and permanent structure.

There are in general three different types of exterior walls using steel as a main member, namely: steel framing, structural steel frame, and the all steel wall. Each type has certain advantages and disadvantages in comparison with

the others,

Steel Framing: It is natural that the first methods employing steel in wall sections would be to replace the wood framing with a steel framing used on similar centers. The cost of the steel sections replacing the wood studs and runners is considerably more, but the waste is eliminated and a great saving on labor is effected. In general, the cost of insulating the steel framing will be higher than insulating either masonry or concrete walls, but will compare favorably with the cost of insulating wood framing. It follows that practically every exterior may be used with a framing of this type and many patented exteriors, designed to give a massive appearance at a minimum of weight and cost, are now being placed on the market. These exteriors employ artificial stonepanels, and enameled porcelain steel plates.

The Walter Bates Steel Corporation, Cary, Indiana, built all - steel frame houses by substituting steel studs and joists for wood. The bracing was made by fastening together the thin strips sheared from one leg of the vertical angles.

The Gabriel Steel Co., Detroit, has a distinctive steel frame made of channels fastened together with a welded bracing. Quoting from their catalog: "The sections which we have employed are standard rolled steel sections, built into smalltrussed members, in such a form as to permit the erection of the steel frame in about one-half

of the time that would be required for its construction in wood. The form of the material also overcomes the usual difficulty which a comparatively thin wall construction presents, namely, transmission of heat and cold. The attachment of the interior plaster lath is made to one main member of the vertical studs, and the attachment of the insulating material on the outside to the other member. Except at the corners of openings, no through-bolts for the attachment of any material are required.

Walls of this character possess an insulating value far superior to that of stud walls or steel structures using solid sections. The design of the individual member used creates a flexibility of construction comparable with that of wood. All vertical and horizontal members are multi-punched on 2-inch centers so as to permit attachment, one to the other, of any given spacing within the 2-inch multiple."

The Safety Welding Company, New York, has an all steel frame, similar to Gabriel Steel Company's, with its sections welded together to form large pieces. The claim is that shop welding saves money on both fabrication and erection.

The Stran-Steel Corporation developed studs consisting of two 13 gauge channels with special corrugations rolled in the web. These channels are welded back to back and bossed at the weld so that a small space is left between the channels in which nails may be driven in attach-

ing metal lath and other material.

The dimensions of this stud section are 3-5/8"x2". A narrower stud is made as above except that it has one corrugation of a slightly longer radius, and dimensions of 2-5/16"x2". It is recommended that these studs be placed 24" on center.

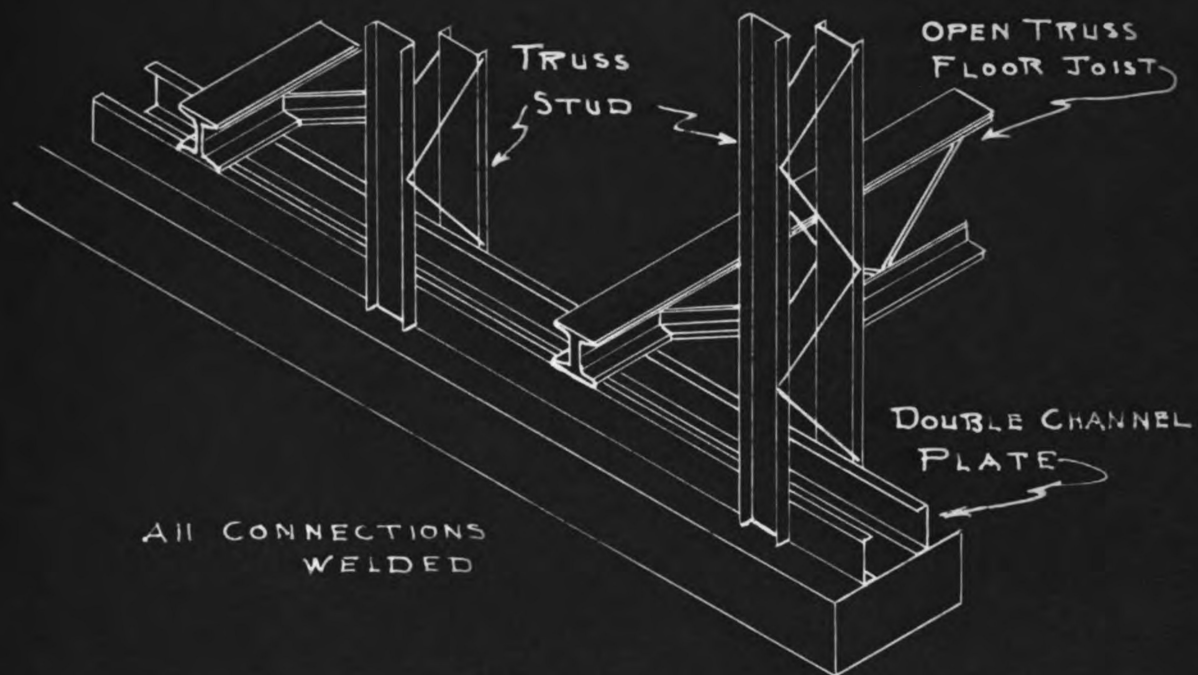
Structual Steel Frame: If a structural steel frame should be made to carry all the load, then the wall would become merely a garment, clothing the house, its construction will be at once greatly lightened and inasmuch as our present wall materials are designed with the idea of carrying loads, we find them unsuitable for use with a frame which will support them. Hence research work is necessary to a final solution of the proper materials and their shape or form. One type of wall material used at present is a cast gypsum block, tongue and grooved as lumber, and extending from floor to floor in one piece.

This type of construction conforms with our present office buildings and commercial construction, and is a logical method to follow. Standard shapes and practices may be strictly adhered to and should figure prominently in reducing wall costs. Insulation may be cleverly attained at no extra cost in the proper selection of wall materials.

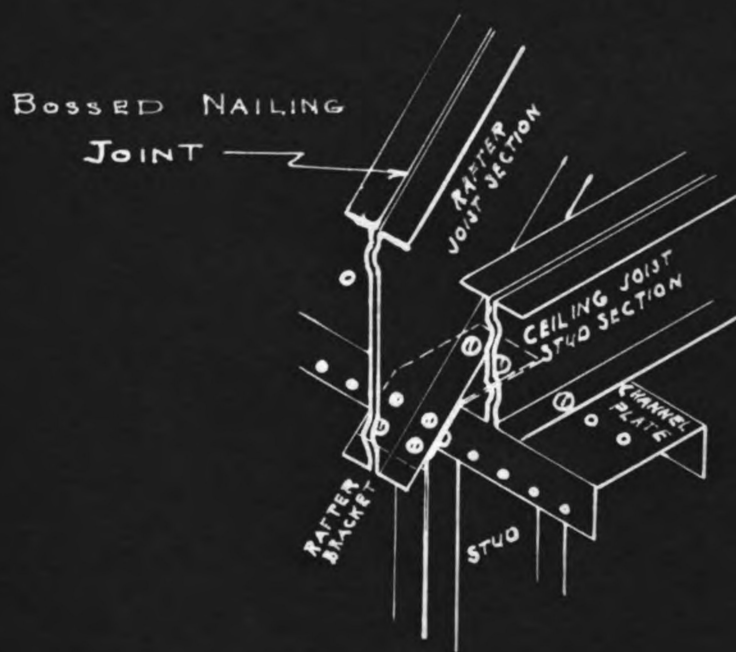
The Universal Building Corporation of Sheboygan, Michigan, uses a structural steel frame with 4 inch cast Hydite wall, with 1½ inch cork insulation and ½ inch plaster on the interior.

Robert Taft recently presented his findings and views before the Better Home Association, favoring a structural steel frame with vertical members between four and five feet on center. Rods were to be fastened to the up-rights, to which wire lath could be secured as a base for a stucco finish.

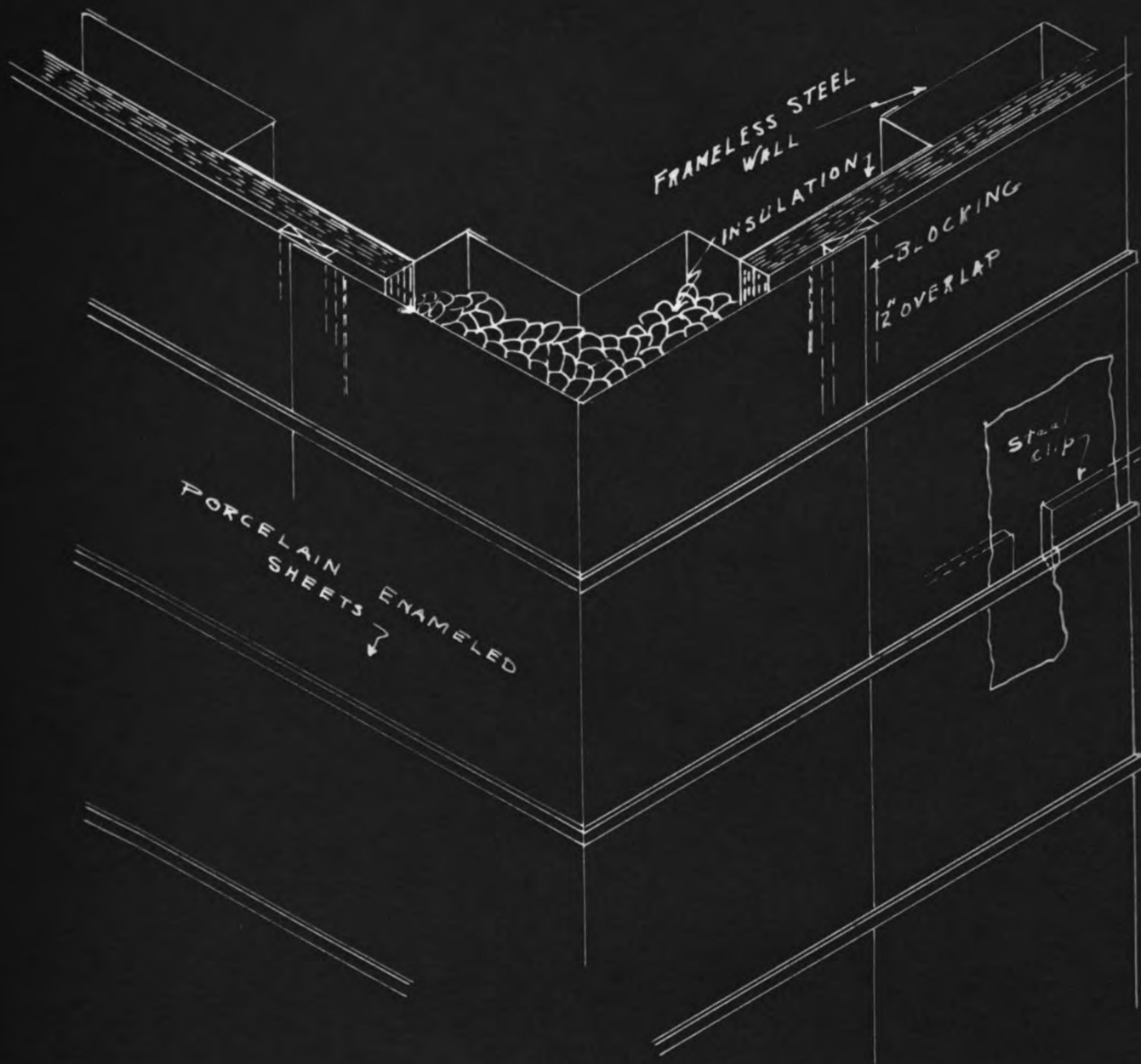
All Steel Walls: All steel walls are a . . . innovation and can hardly be considered to be out of the experimental class. These walls are frameless consisting mainly of pressed steel panels. Two types of panels are in general use: a Z and a U shaped section. The entire wall section becomes self-supporting as the sections are over lapped and welded in place. The only insulating quality incorporated in this wall is the dead air space between the interior and exterior surface. Some idea of the economy acquired in this construction may be realized when it becomes evident that this type of wall supplies: first, the structural shell of the house; second, contains within itself an exterior finish; and thirdly, it may also constitute an interior finish. The finish necessarily involves a panel effect with widths from sixteen inches to thirty inches.



GABRIEL STEEL FRAMING



STRAN STEEL FRAMING



FRAMELESS STEEL WALL CONSTR.

FLOORS:

During the past few years, with the demand for more building of the permanent type, many new types of floor constructions have come into common uses. Some types make use of new ideas and materials and are patented, while others are the result of new methods of using, in a more economic way materials previously used in building construction. Economy has called for low cost of the floor itself and for a saving in weight to be carried by columns and walls, also for types of floors which can be rapidly installed at as low labor cost as possible. In all types, a balance must be struck between the factors just mentioned and the ability of the floor construction and its supporting members to resist fire and to provide substantial, permanent construction.

Solid slab concrete floors, to date, have been the most common used in residence work, practically all porch slabs are of this construction. For a small slab this construction has two advantages; knowledge of reinforcing concrete may be at a minimum, and the form is simple and very economical. The disadvantages of this floor far offset the advantages. An unusual amount of concrete is used which increases the cost, and makes the floor excessively heavy. The one place in the modern residence where this may be used is in conjunction with the raft or floating footing. Economy is effected in as much as the concrete

preforms two duties: that as a footing and as a floor.

Tile and concrete joist floor construction eliminates in part the disadvantages of the solid slab without altering the advantages or the appearance. Less material is needed in the forms as the tile may be used to replace one-half of the form floor. The floor is lightened due to replacing a large volume of concrete with claytile. The cost of this construction runs a little less than the solid slab.

Ribbed floor construction differs only from the tile and concrete joist floor in that the clay tile is replaced by a metal form usually 20 inches in width. Less form material, and less concrete is used by this construction than the tile and joist. This floor is the lightest and most economical to build of the monolithic type of floors.

Slightly in advance of these types of floor constructions is the precast joist and concrete slab. The joists are fabricated under constant supervision giving an article of tested capacity, and uniformity. Increased strength per volume of concrete may be obtained by supervision and control, lowering the water cement ratio, rolling joist under pressure to obtain maximum density, and by steam curing. Decreases in the dead load may be effected by using lighter aggregate such as haydite, and by using fewer joists due to the increased strength per joist. Form work is cheaper due to the elimination of shoring

as the joists are constructed so as to support their own floor forms.

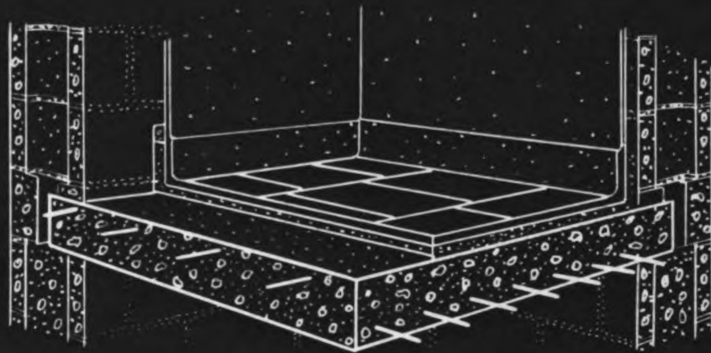
All floor constructions so far discussed are in general considered by most authorities to be fireproof. The remaining types of floor constructions will be given a rating of fire resisting.

The use of steel for light floor loads has evolved three general types. The majority of builders use the open web joist closely spaced (18" to 27"), on which three types of forms may be placed to take the 2-inch concrete slab. One is a paper-backed lath stretched across the top of the joist, another is a Hy-Rib metal lath placed the same way, and the third is a solid plate floor. Whenever concrete is used over a flexible form, care must be taken to keep all stresses off the floor until it is thoroughly set.

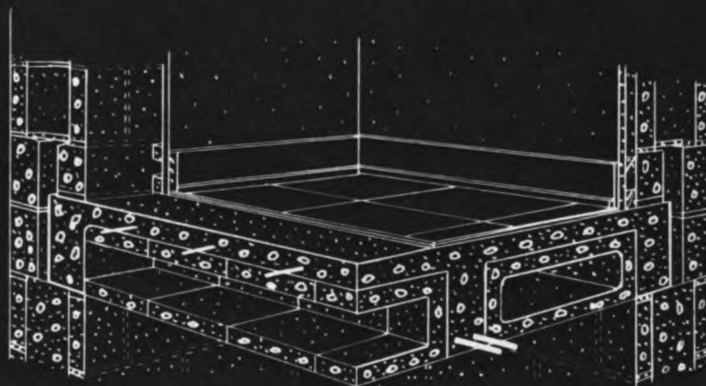
The Jones and Laughlin Steel Corporation uses a type of light floor similar to the floor previously discussed, except they replace the open web joist with a light rolled section called the J and L Junior Beam. This section is stronger and more rigid, thus allowing the joists to be spaced further apart (30" to 36"). With such wide spacing a more rigid form is needed and a $\frac{3}{4}$ " hi rib lath is usually used.

The battle deck type of floor construction is admirably suited to the architects needs with reference to floor, roof, porch, decks, stairs and windows.

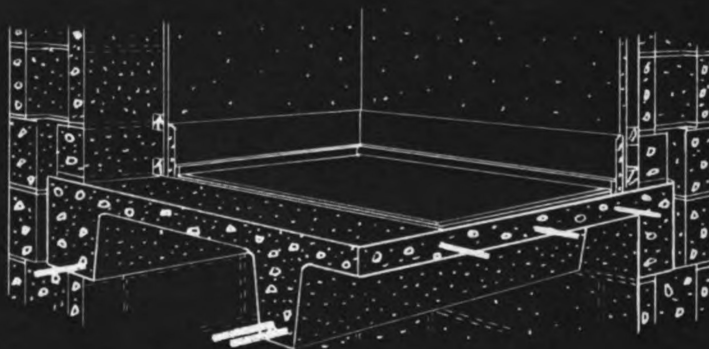
The structural design of battled deck floor consists in determining the plate thickness that will carry the floor finish and live load over a span of 24 inches center to center of the floor beams and the combined beam and plate that is necessary to carry the load between beam supports. The plate thickness usually required is $3/16$ inch and is assumed to act continuous over supports. This type of floor has the advantage of a very light dead load, which in turn makes possible a saving in story height by using joists of less depth. Erection of steel floor panels by welding will greatly speed production, and an advantage of time will be gained both in erection and time of curing the concrete slabs.



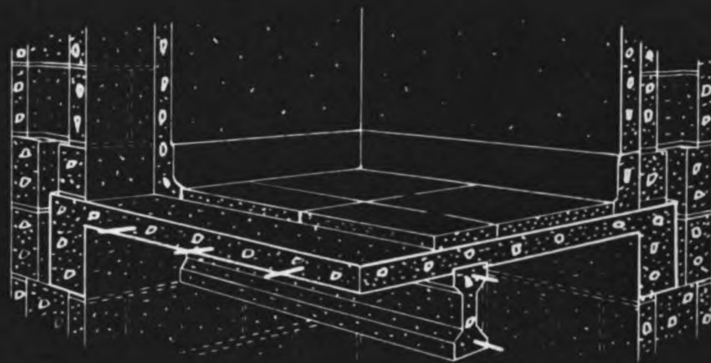
SOLID SLAB CONSTR.



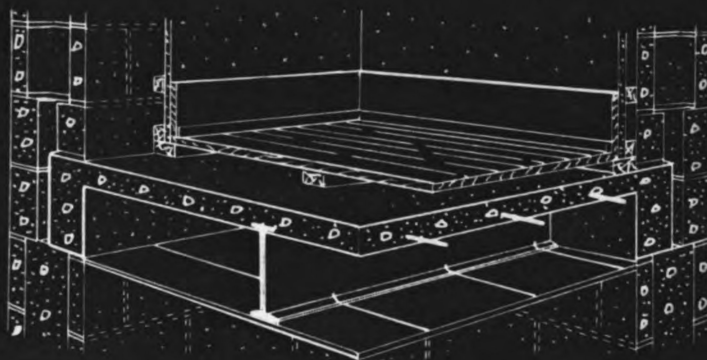
TILE AND JOIST CONSTR.



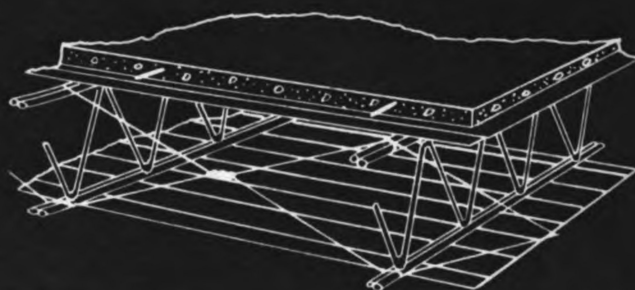
RIBBED CONSTR.



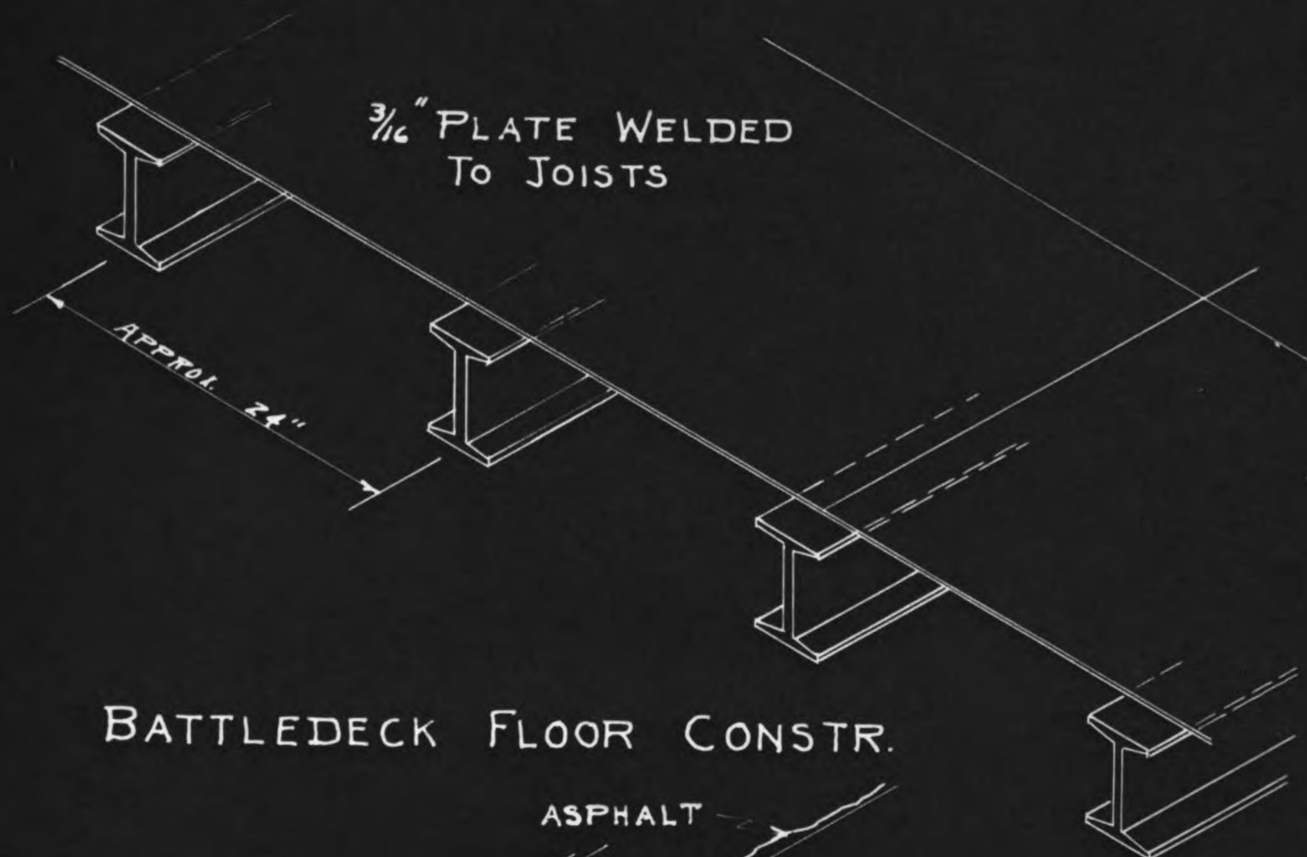
PRECAST JOIST CONSTR.



J-L BEAM AND CONC. SLAB.



STEEL JOIST AND CONC. SLAB.



PARTITIONS:

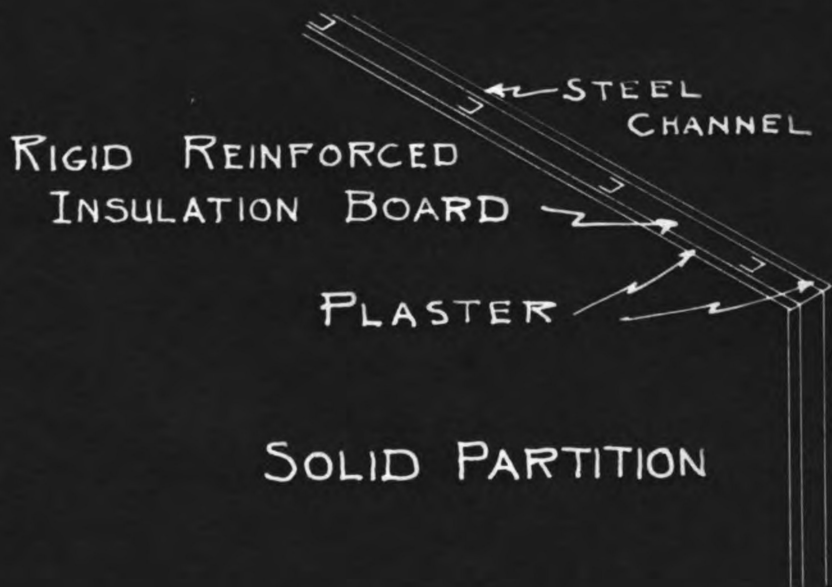
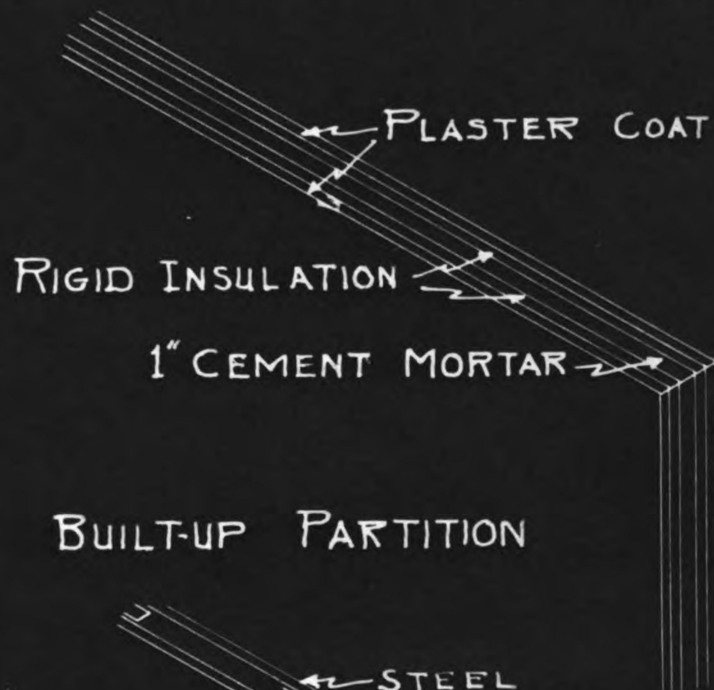
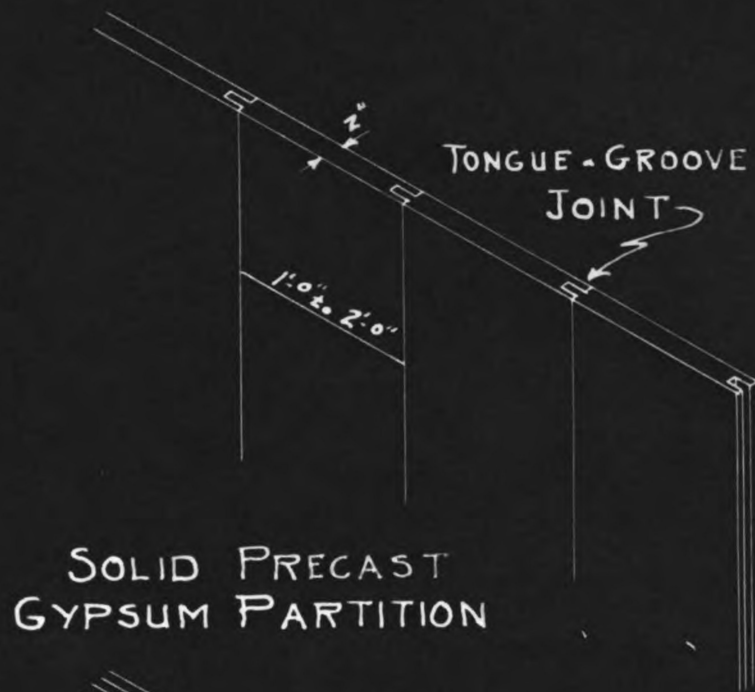
The elimination of heavy, bulky partitions in the residence may be one means of effecting economy, and reducing the cost of our fireproof home construction. We have already mentioned that steel frame and concrete construction should remove the need of wall bearing partitions in the building. It necessarily follows that wall bearing partitions can be no different in construction or lessingcost than the exterior walls which have been discussed previously. In developing a curtain partition which has only its own weight to support it may be possible to eliminate nearly all material except a plaster base and the plaster finish.

Metal lath supported by one inch channels set 18 inches on centers, bent and punched at the ends for fastening to floor and ceiling has been used in conjunction with two inches of solid plaster. Along this same line Truscon Steel has developed a self supporting metal lath called Trussit which has been used to date only in cheap factory construction as a stucco base. Inasmuch as Trussit has worked satisfactorily with stucco, it seems reasonable to assume it might be used as a plaster base with two inches of solid plaster.

The reinforcing with steel of a one inch insulating material, such as celotex, maftex or insulite, to give it rigidity and strength, might not only produce a self supporting plaster base for interior partitions, but also might

prove to be a sound absorbing material which would be very desirable in some parts of the house. A double insulation board partition can be formed by cementing to layers of insulation together with cement mortar and plastering both sides.

It is possible to build a partition from precast gypsum slabs, tongue and grooved, which are rigid enough to support their own weight. These slabs are so finished that no plastering is needed and the appearance presented is that of a paneled wall.



ROOF DECKS:

The modern trend in architecture has greatly simplified fireproof roof construction and at the same time eliminated much of the excess cost and waste space of the residence. With flat roof decks used as porches and recreation rooms the design need not be much different than floor construction. In fact any type of floor may be used with only the addition of insulation and water proofing.

Concrete and gypsum decks should be covered with one inch of rigid insulation; such as, celotex, wathtex, and insulite. This rigid insulation not only prevents heat loss through the ceiling but protects the deck from low temperatures which cause cracks from contraction. It is not generally conceded by engineers but nevertheless any rigid roof deck should be provided with some material which will not transmit stress to the thin brittle water proofing membrane.

Light gauge sheet steel crimped, to give it stiffness, has rapidly come into prominence as a fire resisting roof deck. Many advantages are offered by this deck: light weight, strength, low cost, and low cost erection.

Welding has made possible the use of steel roof decking, equipped with insulation at the factory, on pitched roofs where the frame is of structural steel, and where slate, tile, or asbestos shingles are to be used as an ornamental roof. Gypsum supported by T bars was practi-

cally the only fire proof roof deck applicable to pitched roof decks and the use of rigid shingles.

It would be entirely possible to use precast haydite or cinder block on steep roofs with precast concrete joists. Shingles could be nailed to the slabs and the slabs held to the joists by gravity. A poured header would be needed at the eaves to prevent the slabs from sliding and as an anchor for the joists. Another poured concrete header should be used as an anchor at the peak of the roof.

ROOFS:

A good roof is just as essential as a safe foundation. A perfect foundation secures the building against destruction starting at the bottom; a good roof affords protection for the building itself and what the building contains, prevents deterioration starting from the top. In selecting the roof and roofing material the general requirement is to provide the best. To arrive at a solution for the best roof, the agencies must be considered which attack the roof. These agencies depend upon the climatic conditions, and the use to which the roof deck is put.

The climatic conditions which tend to effect the integrity of a roof are the following: rain, snow, ice, winds, heat and cold.

Rain - To provide for rain, the roof must be tight and have proper drainage. By proper drainage is meant a fair slope for the roof surface, so that water will not remain in puddles, and also a proper distribution of good size gutters and sumps. The accumulation of leaves, twigs, and rubbish of various kinds necessitates strainers at all downtakes and a periodical inspection of the roof.

Snow - Snow sometimes causes exceptionally heavy loads on roofs having a slight slope, or on roofs with parapet walls. Drifting snow may bank up and hold melted snow in contact with the roof for long periods of time.

Ice - Ice is likely to cause trouble on account of its expansive action and its tendency to accumulate when

once started. On account of this it is necessary to have perfect roof drainage, and capacious downtakes which are not impeded with rubbish. In valley's or gutters where ice is apt to form in spite of precautions taken in planning the building, a steam pipe running under the full length of the valley or gutter will be found to do good service. In the draining of all flat roofs it will be found advantageous to run the drain down through the building instead of down the outside, inasmuch as the heat around the drain will tend to keep the ice melted and the drain open.

Wind - The influence of high wind on the roof or roof covering becomes most evident in its driving action on snow and rain; in its tendency to raise up light roofing units and dislodge thin roofing materials, like sheet metal, corrugated steel, prepared roofing felts and shingles.

Heat and Cold -Heat and cold acts on roofs in various ways. Variation in temperature causes expansion and contraction, which in some materials causes buckling and cracking. Great heat will dry out tarred and asphalt felts allowing them to become like blotting paper. Attention should be given to the composition of the coatings for such felts, avoiding volatile tar compounds which flow at a comparatively low temperature. Some trouble has been experienced in using oil asphalt under high temperature, being volatile, gas is formed between layers of felt.

Large blisters have been formed several feet in diameter and two or three feet high due to this action.

Roofs in general fall in two classes: built up roofs and shingle roofs. These two types have nothing in common, except their duty.

The types of built up roofs vary with the construction and slope of the roof, together with the expected life of the building and amount of money available. The various types of built up roofs are classified on the basis of the kind of felt and number of layers used in their construction.

Three general types of materials are used in built up roof construction: pitch and tarred felts, asphalt and asphalt felts and asphalt and asbestos felts.

Tar and Gravel - Tar and gravel roofing may be laid on concrete, gypsum slab, or plank roofing. With plank sheathing the roof should first be covered with dry felt. Then two ply of tarred felt is laid and mopped with pitch. On top of this three-ply, tarred felt is laid and mopped on top with pitch. While the pitch is soft, it is covered with four pounds per square foot of clean gravel. With a concrete or gypsum slab the dry felt should be omitted and the slab mopped with pitch before laying. A good tar and gravel roof should last from 20 to 25 years. Slopes of more than 1" in 12" should be avoided as the pitch coating under high temperatures will run, filling drains and leaving the felts bare.

Asphalt Roof- An asphalt roof may be laid on any type of deck without preliminary treatment. First a heavy two ply felt (30#) is made fast to deck either by sticking

or nailing. Then on top of this, two one-ply (15%) felts are mopped and the finished surface mopped with not less than 50% of asphalt to the 100 square foot. Oils of asphalt do not evaporate as quickly as those of pitch; hence, the life and flexibility of the asphalt roof is greater. Natural asphalt, such as mined in the Trinidad Islands, has proved much more satisfactory than oil asphalt in wearing qualities.

Asbestos Roofs - Asbestos roofs are similar to asphalt roofs in appearance and application. The difference is in the material used in the felts, asbestos fibers being substituted for rags and paper. This type of felt not only gives a fireproof roof but is absolutely impervious to the elements.

Shingles - Shingles are made of wood, metal, asphalt coated felt, slate, concrete tile, clay tile or asbestos which is composed of 15% asbestos fibers and 85% portland cement, combined under approximately 700 tons per square foot of pressure. All rigid shingles such as slate, tile and asbestos are fireproof and suffer very little from climatic conditions, but their purpose is entirely ornamental and all water proof qualities must be supplied by roofing felts laid underneath the shingles. Good asphalt shingles are waterproof and fire resisting, their life can be approximately set at 15 years. Metal roofs in this district have not proved satisfactory as expansion and contraction soon opens the soldered joints.

All roof are poor insulators. Warm air goes through the roof deck quite readily and strikes the cold under surface of the roofing causing condensation. To prevent condensation forming under the roof decks they must be insulated. This may be done by insulating the outer surface from the cold or the inner from heat radiation.

All roofs to be used as porch decks must be protected from wear by cheap tile or asbestos slabs laid in a mastic material. This treatment not only protects the roof from wear but also from the elements.

STEEL SASH:

Very little need be said about steel sash in fire-proof construction. Steel casements and steel double hung sash are already used universally throughout the country. Their neat appearance, increased strength, architectural beauty, ease of operation, low price and ease of installation have all been factors contributing to their rising popularity.

The only possible economy in steel sash would be to eliminate the ventilators. This could readily be done if the home was to be equipped with an air conditioner.

METAL TRIM:

The advantage of metal trim is that it may be completely assembled in the shop and the work at the building site confined to only the installation.

Simplicity and sanitation may both be realized in the use of metal trim. Light small sections flush with the plaster finish erases all abrupt lines of color and eliminates all dust catching ledges.

SUMMARY AND CONCLUSION:

A large number of permanent fireproof house construction systems, covering a wide range in design, materials and methods of application, have been discussed in regard to principal details, use and structural properties. Also included were general notes regarding the progress made in the technical and architectural phases and the structural requirements in the design and erection of fireproof homes. Observations were made pertaining to some of the important considerations in the further development of the main types.

A survey shows that hundreds of homes have been erected using masonry, concrete, and steel frame methods. A large number of these dwellings have been examined and with few exceptions were found to be in satisfactory condition. They have proved comfortable to live in and well-liked by the owners and occupants.

In the light of what is known regarding the use and performance of the construction methods and materials discussed herein and with due regard of their possibilities for home building, the following general conclusions are indicated:

Several of the materials and methods of erection appear to be capable of satisfactory and economical adaptation for use in home building by able, experienced contractors. Probably each system could be appreciably improved by study and use.

Frameless steel probably represents the ultimate in permanent dwelling construction. It possesses distinctive advantages not found in any other material or type of construction. The method has proved possibilities and its further development and application may be undertaken with confidence.

Monolithic concrete and structural steel frame also are regarded as being well suited for home building and capable of development to an important position of use in this field.

Important technical progress in construction methods and equipment, and the possible changes in housing practice will have considerable influence on the potentialities of many systems irrespective of their past experience.

Modern homes are readily insulated to any degree. The amount of insulation actually required varies for different conditions of climate and exposure and should be accurately determined. Experience has indicated that the tightness of a wall is a considerable advantage in minimizing the transmission of heat and cold and should be taken in to account as an important factor in connection with the installation of air conditioning systems.

Pleasing architecture, textures, colors, and materials are readily incorporated in the modern fireproof home at little added expense. Color, material, and design are primary considerations and must be made an important part

of home development.

The most satisfactory results will be obtained only when the home is carefully planned with regard to architectural and structural design. An adequate knowledge of the fundamentals of materials, design and construction must be available. Any one about to build a home should employ the services of a recognized architect.

Many contributions to beauty, sanitation, and convenience are offered to the home builder today, and are included in his idea of what constitutes a modern home. However, considerations of convenience and style have, in many instances, diverted attention from a fundamental significance of the term modern as applied to homes. The fact that between 4,000 and 5,000 people are fatally burned in residence fires and property damage amounts to over \$500,000,000, shows that to be modern according to the basic connotation of the term, a home must be firesafe.

MANUFACTURERS AND PATENT HOLDERS

MONOLITHIC CONCRETE FORMS

Adjustable Steel Form Co., Los Angeles, Calif.

American Engineering & Development Co., Chicago, Ill.

J. S. Banks, Norfolk, Va.

George W. Brandt, Leonis, N. J.

Concrete Hollowall Co., Los Angeles, Calif.

J. H. Cresmer, Riverside, Calif.

C. W. Fellgren, Chicago, Ill.

H. T. Frost, Hollow Concrete Wall Co., Mitchell, S.D.

Ernest Flagg, architect, New York, N. Y.

Miss Kate Gleason and Associates

Prosper L. Gottschalk, Milwaukee, Wisconsin

L. G. Knipe, Los Angeles, Calif.

Monolithic Hollow Concrete Form Corp., Los Angeles, Calif.

Haeber Bros., Syracuse, N. Y.

Hydraulic Steelcraft Co., Cleveland, Ohio

C. H. Ingersoll.

Lambie Concrete House Corp., Cleveland, Ohio

F. K. A. Kreil, Los Angeles, Calif.

Carl T. Larson, contractor, Moline, Ill.

Charles R. Lohrck, Los Angeles, Calif.

A. S. Merriett, Los Angeles, Calif.

Metal Forms Corp., Milwaukee, Wisconsin

William Otterson and Arthur E. Hatch, contractors

E. W. Marten, Los Angeles, Calif.

Milton Dana Morrill.

A. H. Olmsted, Rye, N. Y.

C. H. Schub, New York, N. Y.

C. T. Tucker, Rochester, N. Y.

Universal Form Clamp Co., Chicago, Ill.

Axel G. Wedberg, Chicago, Ill.

W. H. Van Guilder, Van Guilder Double Wall Co.,
Rochester, N. Y.

PRECAST UNIT SYSTEMS

Concrete Housing Corp..of America

Paul Betzler, Jackson Heights, Long Island

J. A. Bow, Cleveland, Ohio

Brice-Pearson Corp., Niles Center, Ill.

The Froughton Co., Kansas City, Mo.

L. L. Burton, Fort Worth, Texas

John E. Conzelman, Los Angeles, Calif.

A. H. Coombs, Atascadero, Calif.

O. A. Deichmann, San Francisco, Calif.

Leopold C. Egloff, Forest Park, Ill.

Hahn Concrete Lumber System, Decatur, Ill.

Louis Hansen, Racine, Wisconsin

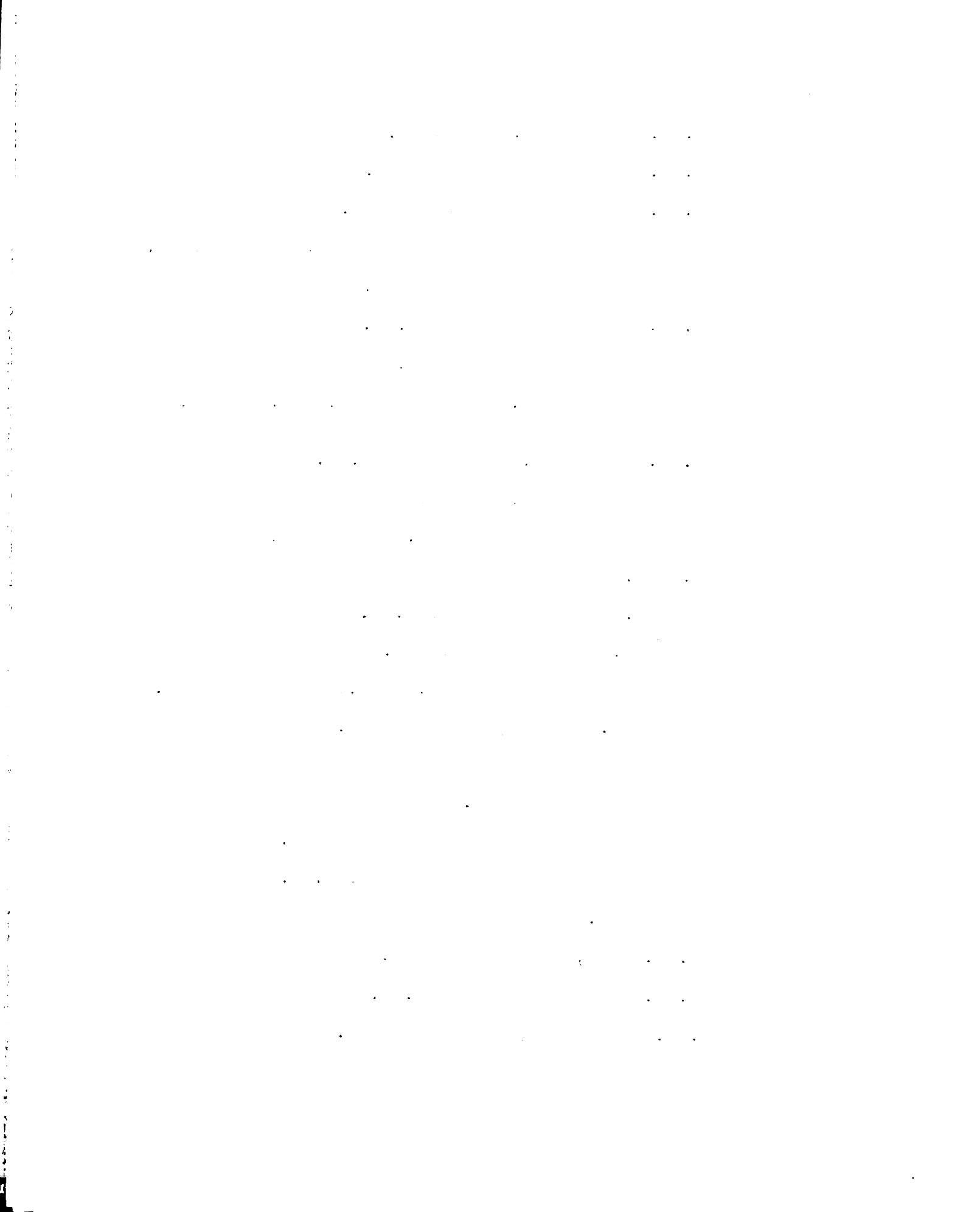
E. C. Harloff, Springfield, Gardens, L.I., N.Y.

H. C. Hartley, Fireproof Construction Co.,
Los Angeles, Calif.

W. H. Houghton, Beverly Hills, Calif.

F. W. Fitzpatrick Evanston, Ill.

T. L. Johnson, St. Louis, Mo.
H. G. Larzelere, Orlando, Fla.
E. H. Lockwood, Pasadena, Calif.
The Texas Concrete Construction Co., Houston, Tex.
The Needham Concrete House Co., Houston, Texas
R. C. Olmsted, New York, N. Y.
Peter Ritten, Osakis, Minn.
Pancrete Wall Co. of Texas and F. McM. Sawyer,
San Antonio, Texas
L. M. Parkhurst, Lackawanna, N. Y.
Hugo Effenberger, Racine, Wisconsin
George Rackie and Sons Co., Cleveland, Ohio
F. McM. Sawyer, architect
John T. Simson, Newark, N. J.
Frank S. Swan, Chicago, Ill.
Frontier Construction Co., Ltd., Fort Erie, Ont.
Samuel P. Carroll, Chicago, Ill.
Joseph Winston
Unit Construction Co.
Donald Underdown, Los Angeles, Calif.
Nelson K. Vanderbeek, Red Bank, N. J.
Charles R. Weeks, Houston, Texas
R. C. Webb, Baton Rouge, La.
E. M. Winter, New York, N. Y.
H. H. Zimmerling, Bloomfield, Ia.



STEEL FRAMES

Bruhn Steel Products Co., Griffith, Ind.

California National Steel Co., Los Angeles, Calif.

Gabriel Steel Co., Detroit, Mich.

Housing Co., Boston, Mass.

Safety Welding Co., New York, N. Y.

Steel Bilt Homes, Inc., Cleveland, Ohio

Steel Frame House Co., Pittsburgh, Penna.

Stran Steel Corp., Detroit, Mich.

Walter Bates Steel Corp., Gary, Ind.

FRAMELESS STEEL

The Insulated Steel Construction Co., Middletown, O.

American Rolling Mills

STEEL ROOF DECKING

Detroit Steel Products, Detroit, Mich.

Milcor Co., Chicago, Ill.

Truscon Steel Co., Detroit, Mich.

U. S. Gypsum Co., Chicago, Ill.

ROOM USE ONLY

Apr 16 1948

ROOM USE ONLY

MICHIGAN STATE UNIVERSITY LIBRARIES



3 1293 03056 1363