THE DESIGN OF A CONCRETE HOME

Thesis for the Degree of B. S.

MICHIGAN STATE COLLEGE

Edward Rohacz

1949

THESIS

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The Design of a Concrete Home

A Thesis Submitted to

The Faculty of

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of

AGRICULTURE AND APPLIED SCIENCE

by

Edward Rohacz

Candidate for the Degree of

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THESIS

This Thesis is Dedicated

to my Parents

in deep gratitude and sincere appreciation for the encouragement and patient understanding which they so willingly gave to make this work possible.

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PREFACE

As is customary for all graduating civil engineering students, the task of writing upon some subject, based entirely upon our engineering education in college, is at hand. The selection of a worthy subject, one that would be of benefit to the average individual, was by no means an easy matter. With the invaluable assistance and approval of Professor Chester L. Allen, the topic of designing a concrete home was selected in the hope that it would provide, to potential home owners, practical information regarding the construction of a home of concrete masonry, as well as a typical design.

To uncover any practical and useful information, relative to concrete construction and architectural design, a large amount of research was found necessary. Although the college library in all likelihood contained a great deal of valuable information, the inability to have free access to the stacks as well as the fact that many choice books were loaned out to various school departments somewhat limited the inclusion of what might have been extremely useful information.

If this work, as presented to the reader, appears to be unusually short, it should be brought to mind that the time in which this work was to be completed was also unusually short. It is hoped that in the future this similiar

type of situation will not reoccur. It would be wise if all future civil engineering students, confronted with the task of writing a thesis for their Bachelor of Science degree, would select their subject , and do as much research as is possible, well in advance of the term for which their thesis is scheduled.

Gathering as much research information as is possible beforehand cannot be overstressed. Without the help of the Portland Cement Association, which supplied the author with a wealth of information, this thesis would be of no value, but had there been time to gather more outside information, this thesis would certainly be of greater value. It would be well, at this time, to pay tribute to Mr. J. A. Overhouse for the very valuable suggestions and advice given for the preparation of this thesis. Not to be forgotten are the many fellow students, too numerous to mention by name, for their helpful and sometimes very critical advice.

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BASIS FOR DESIGN OF CONCRETE HOME

Since a home is usually the largest single investment that any family ever makes, it should be safeguarded by the most careful and adequate planning and by the most economical and practical methods of building. After the first steps of room layout and general architectural design have been agreed upon, there comes the vitally important matter of selecting the best building materials, which will provide the greatest number of advantages and yet be within the original building budget.

Needless to say, the structural materials that go into a home are the most important single consideration. Concrete masonry is an all-purpose material, which, in its newer forms and quality, has moved into the forground of modern construction during the past few years. It is recommended and used by some of the leading architects and builders throughout this country and the world. Few small home owners, however, are aware of the advantages that concrete masonry construction possesses over that of wood frame construction.

One of the greatest advantages is that concrete masonry construction throughout will make a home firesafe without sacrificing architectural beauty. Although concrete masonry may become slightly damaged when exposed to fire, as will most anything, it has definitely been proved that concrete walls and subfloors will not burn. Even roofs can be made firesafe by the application of cement asbestos shingles.

This type of roof covering acts as a safeguard against any sparks from the chimney.

Use of concrete blocks also provides a home with built in insulation. The empty cells of the blocks contain dead air which in turn acts as an insulating agent. Blocks properly bonded will prevent cold air from entering and heat from escaping. A further reduction of heat loss may be obtained by furring the inner wall surfaces with insulating material and also by filling in the hollow cores of the units with lightweight aggregates or similar materials.

While still on the subject of insulation, it might be well to state that concrete masonry, when meeting standard specifications and when properly laid, is remarkably weather resistant. Concrete masonry walls, when mortared together as complete units, are built to resist high wind pressures and driving rains. It will stand up in the face of hurricanes and tornadoes, which is evident by the large number of concrete homes in the State of Florida.

The natural porosity of the aggregate materials used in making concrete blocks help to deaden the transmission of sound by breaking up and partially absorbing the sound waves. Creaks and squeaks, caused by the swelling of structural members such as floor boards and wall studs, are eliminated when a concrete subfloor is used. The danger of plaster cracking is also eliminated.

In modern concrete masonry construction, great strength

and durability are secured, not only as a result of the materials used, but also through the design and texture of the units, the regularity and size of the units, and through the use of a strong mortar. Examples of the permanence of of concrete is attested to by the still standing and well preserved ancient buildings such as the Pantheon, the Bassilica of Manentius, and others which were built in Rome more than two thousand years ago. Although the methods of concrete construction may have changed somewhat thru the years, the same basic ingredients are still being used today.

Concrete masonry homes never lose their livability nor their complete freedom from dry rot and infestation by destructive forms of rodent or insect life. There is no cellulose in concrete upon which termites can thrive. Rodents can no longer nibble or gnaw their way thru walls or floors built of concrete.

Inside and outside, a concrete masonry home can be kept clean with the least amount of human effort. On the inside, it is kept free from dirt catching cracks and crannies by its snug and tight-fitted construction, which prevents dust and dirt from sifting in from outdoors during windy weather. While on the outside, the concrete walls can be painted with water-proofing paint and as a result can be washed without in any way affecting the finish, as the cement paint actually becomes an integral part of the concrete.

The ordinary home, of less substantial construction than

concrete masonry, deteriorates and depreciates in value very materially over a period of years. Considerable reconditioning is frequently required to put a house in sufficiently saleable condition to realize a fair price. What slight additional cost may be involved in building a concrete home is rapidly absorbed by savings in maintenance and repair bills. Over a long period of time, a concrete home costs far less to own than a home built of less durable materials.

Having mentioned and discussed the major advantages of a home constructed of concrete masonry, and realizing that many other minor advantages were not discussed, it is hoped that at least enough facts have been presented to clear up any doubts that may have been had by those who are considering to build a new home, but who as yet are uncertain as to the type of material to use.

SELECTION OF CONCRETE BLOCK

Since a thorough knowledge of a material is necessary before it can be used intelligently, it might be well at this time to present some information about the basic unit of concrete construction, the concrete block. Some effort will be made discuss something of the types and sizes available and something of their manufacture.

Concrete building units are available in a wide variety of standard shapes and sizes to fill virtually every construction need. Sizes of concrete block conform to modular dimensions; standard units are made 16" long, 4" to 12" thick, 8" high (including joint allowance). Block are classified as load-bearing or non-load-bearing; types available include: building units, partition and back-up units, filler units, surfacing units, chimney, joist, sash and jamb units, and slabs.

Texture of block surfaces varies from coarse to fine, according to the grading of the aggregate used. Blocks of light-weight aggregate have better acoustical properties than those made of heavy aggregate, and greater thermal insulation value.

In order to insure a good quality of concrete block, manufacturers must conform to A.S.T.M. and Federal specifications, and to the A.S.A. Masonry Code. Concrete blocks are a combination of portland cement, aggregate, and water, usually in a mix such that surface texture can be controlled easily and

and forms re-used rapidly. A wet mix is sometimes used to secure a very dense surface and to obtain web markings which may be desired. Too wet a mix, because it produces a block that will slump if forms are removed too soon, prevents rapid production. Too dry a mix will produce a block of poor strength.

While there is a wide variety of sizes and shapes normally available, and although it is possible to cut, chip, or saw a block to fit special job requirements, it is more economical to design it in terms of standard shapes. It is not unusual, however, to find manufacturers who carry special types of block.

In selecting blocks for specific uses there are certain characteristics which require attention. Strength is one; blocks with an average compressive strength of 1000 psi are suitable for exterior walls below grade and for unprotected interior walls above grade. For general use above grade, when protected from weather with two coats of portland cement paint or other satisfactory waterproofing, compressive strength may be reduced to 700 psi.

Rough texture of block is desirable for such uses as partitions where plaster or stucco will have to bond directly to the block. Fine texture is suitable for exposed interior or exterior surfaces, either painted or natural. Coarse texture can be used on exteriors if properly painted.

DESCRIPTION OF DESIGNED HOME

In designing any type of home the first thing to consider is the positions of the various rooms in relation to the position of the sun. Generally the living areas should be to the south to take advantage of the sun for the greater part of the day, and the bedroom areas to the east to avoid the afternoon sun. The home about to be described has been oriented in the above manner.

The building itself is small in its over-all dimensions, being only 32 feet by 26 feet. It need not have been limited by these dimensions, but could have been designed to any size or shape since concrete construction is not restricted to any particular style of architecture. It was felt, however, that it would be best to show the possibilities of design for a simple structure rather than for one too complicated and elaborate to understand.

Since concrete masonry provides an unexcelled base for portland cement stucco, an attractive Modern American stucco texture is used. The exterior wall surface above the ceiling line consists of knotty pine panelling to provide additional beauty to the home. Above every thing else, as is usually the case, is the roof, designed at a pitch of 1 to 2, so as to provide additional storage overhead if necessary. Although ordinary shingles could well have been used for the roof covering, cement asbestos shingles are used since they possess not only the properties of being more resistant to the

wear of sun, rain, and snow, but also are considered a good safeguard against fire.

Looking at the design plans one is apt to feel that there are more basement windows than are absolutely necessary. It is felt that the windows are necessary,as shown, in order to provide adequate lighting in the basement. The windows certainly do not destroy the outward appearance of the home since they are all below grade and can be further concealed by appropriate landscaping.

At the rear of the home, along the north-east wall, will be found a secluded terrace, which consists of precast concrete flagstone. All of the walks, as shown on the plans, will also consist of the same material.

The main entrance is not in its conventional position of being in the front, but instead is situated on the west side, where it cannot be seen quite as readily from the street. As a result it presents easy access to the driveway and an atmosphere of privacy to the home owner.

Upon entering the living room one is immediately aware of being in a spacious and well-lighted room. At first glance it would seem that there are no panes of glass in the windows but actually the windows are of thermopane construction. Actually a thermopane window consists of two sheets of ordinary glass with a layer of dehydrated air sandwiched in between the glass. As a result the beauty of the outdoors is magically brought into the home. Since these windows are set firm-

ly place and cannot be openned at will, louvres are installed beneath every window to permit fresh air to enter the rooms whenever necessary.

In the center of the living room a small wall of glass blocks, 3 feet in height, projects southward from the north wall producing a semi-private area near the fireplace. The fireplace is built about an efficient Heatilator unit. It is a scientifically designed steel form that has the firebox, damper, smoke dome, and downdraft shelf all built into it. It circulates heat that would otherwise be wasted up the chimney. On either side of the fireplace are placed shelves upon which books are to kept, within easy reach, for fireside reading.

Continuing further to the eastern wall of the living room and looking to ones left, one will arrive at the entrance of the hallway which leads to the bedroom area. The bedrooms, which are to be found in the eastern end of the building, are identical in construction, differing only as to their relative positions. The doors of the rooms are of the sliding door variety, as are the doors of the Kenna Wardrobe units which are to be found in both rooms replacing the conventional closets. These units are made of wood and as such can be easily constructed to any size. The windows are placed so as to obtain a maximum amount of light, with the louvres permitting cross-ventilation for comfortable sleeping in the evenings.

Leaving the bedroom area and proceeding westward down the hall, easy access is had to the bathroom, which is situated along the north end of the building. In addition to the conventional toilet fixtures is found a metal cabinet that is to be used as the linen closet.

In continuing the examination of the home, one becomes suddenly aware of the fragrant aroma of a juicy tenderloin steak sizzling in a frying pan in some corner of the house. Without further explanation it is quite obvious that the kitchen is somewhere nearby. To be more specific the kitchen is to be found in the north-west corner of the house. Since this is where, it is hoped, the housewife will spend most of her time, the kitchen is made to look as pleasing in appearance as possible. The various units have been so placed so as to avoid unnecessary walking within the kitchen.

Before leaving the first floor level, to inspect the basis, something should be mentioned of the interior wall finish, the floor, and the ceiling. The interior walls as well as the ceilings throughout the house have a smooth texture plaster finish. In the bathroom, in addition to the plaster finish, tile is employed to a height of 4 feet above the floor level. The floors are constructed of concrete, having been poured over standard Soffit floor filler tile. In the kitchen and in the bathroom, the floors are covered with asphalt tile, while in the remaining rooms, oak lumber is used, being nailed to the sleepers already placed in the concrete.

Having gone thru the rooms on the first floor level, it is felt that a brief description of the basement should now be given. Although basementless homes have been gaining popularity of late, it is hoped that the mention of the proposed use of some of the basement rooms will prove the desirability and the necessity of having a basement.

Entry into the basement is made by descending the stairs leading from both the kitchen and the rear door. These stairs consist of precast concrete steps. The first room that is entered is that of the recreation room. Here both a billiard table and a ping pong table are to be placed, assuring at least some pleasant evenings at home.

In the north-west corner of the basement will be found the laundry room. The reason that it is in this locality is due to the fact that the kitchen is directly overhead and as a result, the plumbing is made easier and less costly to install. To the west of the stairs is the boiler room, where heat is produced as a result of burning oil. Further west there is the workshop, where one can repair or make useful or odd items for use in and around the house. In the south-east corner of the basement is the cold storage room as well as a roomfor the storage of almost anything.

It is hoped that the preceding description, as given above, has been of some value , not only to those interested in the possibilities of design of a concrete home, but also to those who may have had difficulty in interpreting the enclosed plans.

PROCEDURES AND SPECIFICATIONS FOR CONSTRUCTION

FOOTINGS--

The weight of the entire structure is supported on the footings. This weight is of two types, termed dead and live loads. The dead loads consist of the weight of the materials entering into the construction. The live loads consist of the combined weight of a variable number of people, movable furniture, equipment, or snow load. The combined live and dead loads impose heavy stresses on the structural parts of a house, which must be adequately provided for in the design.

Unless the footings are suitably reinforced to permit reduction of their thickness, it is general practice to make the width of the footings twice the thickness of the walls they are to support. It is essential that the footings be placed on solid ground to afford adequate support.

Concrete for the footings should be machine mixed in the approximate proportions of 1 volume of portland cement to 2 3/4 volumes of sand and 4 volumes of gravel or crushed stome. Not more than 7 gallons of water per sack of cement should be used.

FOUNDATION WALLS--

Foundation walls of concrete masonry give needed stability to new structures, and make it easier to have dry, watertight basements. Since foundation walls are practically always exposed to ground water, some precaution should be taken. The water may be drained away from the foundation by

the use of drain tile. This tile should be covered with a course of broken stone or coarse gravel to a depth of 1 or more feet. Splash blocks should be provided to protect the foundation wherever roof water empties from downspouts at grade.

Recommended types of damp-proofing or waterproofing consist of bitumen or asphalt, tar or pitch, or plaster coat of portland cement mortar at least ½ inch thick applied to the exterior surface of the foundation. Bitumen or tar applications are brushed in several layers on the wall surface. Membrane waterproofing is generally applied when subsoil water conditions are known to be severe. This type of waterproofing consists of several layers of felt well lapped, being thoroughly coated with asphalt or tar applied hot.

The mortar for the concrete masonry walls, not only of the foundation walls but also of the walls above grade, subject to average loading and exposure is to be made in the proportions of 1 volume of masonry cement and between 2 and 3 volumes of damp, loose mortar sand; or 1 volume of portland cement and between 1 and 1¼ volumes of hydrated lime or lime putty and between 4 and 6 volumes of damp, loose mortar sand.

BASEMENT FLOORS--

Concrete basement floors should be at least 4 inches thick. One-course construction is recommended. This term indicates that the same mixture is used for the full thickness of the basement floor. The concrete slab commonly is placed

directly on the earth. On soil which is waterlogged, a fill of gravel 4 to 6 inches thick and properly drained should be placed to provide a dry base for the concrete. It is essential that the joint between the floor and the wall be tight. This can be done by providing a joint $\frac{1}{2}$ inch in thickness made of two beveled strips of wood inserted when the floor is laid and removed after the concrete has hardened. This joint is then filled with hot tar or bitumen.

Concrete for basement floors should be well mixed and in proportion of 1 volume of portland cement to $2\frac{1}{4}$ volumes of sand and 3 volumes of gravel or crushed stone. Not more than 6 gallons of water should be used per sack of cement.

STAIRS AND STEPS--

The stairs and steps are of the precast variety of steps. They can be had with any of the coverings and finishes being used for concrete floors. Concrete for use in precast stairs and steps should have a strength of not less than 4000 pounds per square inch at 28 days.

WALLS ABOVE GRADE--

Exterior walls above grade may consist of one or two withes of concrete units. Single block walls 8 inches to 12 inches thick can be rendered reasonably waterproof if dense, homogeneous block are employed, and the wall is properly flashed and its exterior face waterproofed. However, condensation will occur on the inner face in some cases, so that

interior finishes are preferably furred out. The exterior wall can be finished either with an application of portland cement paint or with a choice of one of many attractive stucco finishes.

All stucco shall be composed of three coats and the total thickness shall not be less than 7/8 inches. The first coat shall consist of a scratch coat 3/8 inches thick with sufficient pressure being applied to form a good bond. A brown coat 3/8"thick shall be applied not sooner than 48 hours after application of the scratch coat. The finish coat shall be applied not less than 1/8 inch thick and not sooner than 7 days after application of the brown coat.

All coats shall consist of 1 volume of portland cement and between 3 and 5 volumes of damp, loose aggregate to which may be added not to exceed ½ volume of hydrated lime, hydrated lime putty or slaked lime putty or 2 to 3 pounds of diatomaceous earth,clay or similar admixtures used to increase plasticity.

Wood and metal door casings, furring, baseboards, and trim of all kinds can be nailed directly to lightweight block, which holds nails. Electric conduit and many plumbing lines can be run vertically in the voids of the block. Access panels, apertures for outlets, switches, faucets, horizontal piping, etc., may be cut into the block. If special chases are used, special concrete units may be used to close the chases, and "broken"joints may be employed to match the remainder of the wall so that no evidence of the chase will show on the face.

FLOORS ABOVE GRADE--

The concrete floors above grade shall be constructed using Soffit floor filler tile units. Concrete, of the same proportioned mix as that of the basement floor, shall be poured to a depth of at least 2 inches above the tile. These units, made in modular dimensions to coordinate with other modular material, are laid quickly with the aid of Acrow floor centers, which replace wood shoring with considerable saving in time, labor, and lumber cost. The finished floor and ceiling surfaces can be left exposed, painted, or finished in any way desired.

CHIMNEY AND FIREPLACE--

The usual requirements are that the chimney project at least 2 feet above the highest ridge for pitched roof construction or not less than 3 feet above the roof deck for flat roof construction. The minimum flue sizes shall be 8½" x 8½" for heating plants; and 8½" x 13" for fireplaces. Circular flues of equivalent cross-sectional area may be substituted if desired.

All chimney footings shall be cast in forms on undisturbed firm earth and shall not be less than 12 inches in depth and should project not less than 6 inches beyond the chimney base on all sides.

Concrete for chimney footings shall be machine-mixed in the approximate proportions of 1 volume of portland cement, 2½ volumes of sand and 3½ volumes of coarse aggregate.

Maximum size of the coarse aggregate shall be 1½ inches. Not more than 6 gallons of water per sack of cement shall be used. Mortar used in laying up the chimney and flue lining shall be the same as that used in tha adjoining walls.

WALKS--TERRACES--

The proportion of mix used for the walks and terrace shall be the same as that used for the basement floor. The terrace, however, shall consist of precast concrete flagstone. This concrete shall be machine-mixed not less than 2 minutes after all materials have been placed in the mixer. After being deposited in the molds, the concrete shall be struck off and compacted with a wood float.

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