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The L-Block

A TYPE OF CONCRETE BLOCK ADAPTED TO THE ECONOMICAL CONSTRUCTION OF FARM BUILDINGS

BY J. B. DAVIDSON AND HENRY GIESE



The L-Block

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The L-Block

A TYPE OF CONCRETE BLOCK ADAPTED TO THE ECONOMICAL CONSTRUCTION OF FARM BUILDINGS

BY J. B. DAVIDSON AND HENRY GIESE

The L-Concrete Block, so named on account of its shape, is an outcome of a careful study and search by the Agricultural Engineering Section of the Iowa Agricultural Experiment Station for a durable and economical type of construction for the walls of farm buildings. With normal costs for the constituent materials, concrete in the plastic stage as it comes from the mixer or mixing board is an economical building material. The problem of economical construction with concrete, therefore, depends upon efficient utilization of the material and labor. The L-Block reduces the amount of material usually required and greatly reduces the cost of placing the concrete in the building. With ordinary concrete blocks, or the so-called unit construction, much labor is required in making, handling and placing the blocks in the wall, while with monolithic construction the cost of forms is often excessive, exceeding in some instances the cost of the concrete.

Practical Tests Made of the L-Block

Experimentation with the L-Block in various forms has continued over a number of years; the first actual making of the



Fig. 1. An experimental building 24 by 84 feet in size made of L-Blocks.

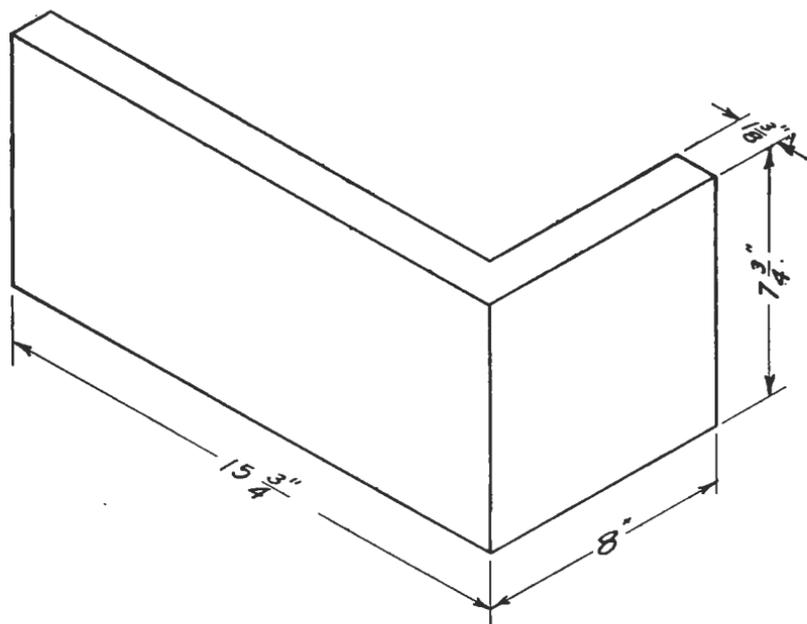


Fig. 2. A sketch of the L-Block giving the dimensions that were found satisfactory.

blocks being carried out in 1919. The building shown in fig. 1 was built in 1923 and is essentially experimental, for several methods of using the L-Blocks were tried. The building shown in fig. 3 was one of the first of this type to be built by a private party. Altho little publicity has been given to the experiments with the L-Block, it has been used in the construction of many buildings in Iowa and other states. The block has given general satisfaction.

A Description of the L-Block

The L-Block consists of a thin faced member from one end of which another member or leg extends at right angles, as shown in fig. 2. In the early experiments the face of the block was made $15\frac{3}{4}$ by $7\frac{3}{4}$ inches. This block, when laid in the wall with mortar joints $\frac{1}{4}$ inch thick, fills a wall area of 8 by 16 inches or $\frac{8}{9}$ of a square foot. The thickness of the face and the leg are each $1\frac{3}{8}$ inches. A block of this size weighs from 18 to 20 pounds and seven can be made from a cubic foot of concrete.

For heavy walls, the web thickness of the block might be increased; or to secure greater stability of wall, the short member might be lengthened. Experiments have been made with heavier and lighter blocks, but the foregoing dimensions seem

to meet the average requirements of farm building construction.

The Utility of the L-Block

The advantages of the L-Block are quite specific and may be cited as follows:

1. **Efficient Use of Material.** The L-Block represents an efficient use of material, in that the minimum amount is used to secure enclosure, and because the material is spread in the wall, it furnishes stability with little material. As cited before, the stability of the wall depends upon the length of the short member or leg of the block. When double-wall construction is used, two walls of minimum thickness are placed on either side of an open space with the minimum amount of connecting material.

2. **Dry Wall Construction.** The L-Block may be used effectively in the construction of a dry wall, as there are at least three ways to insure such results: (a) by the use of a dense mixture, perhaps with an admixture of a small amount of lime to provide greater waterproofing qualities; (b) by coating the inner surface of the block with waterproofing, such as coal tar, paraffin, or other cheap waterproofing material; and (c) by applying plaster or stucco to the exterior, a very practical procedure owing to the ease of securing a good and lasting bond.

3. **Warm Wall.** The L-Block, when used in single or double wall construction and in combination with insulation and plaster, provides a good wall for retaining or excluding heat. Double wall construction with or without insulation may be laid up with little concrete extending from inside to outside to conduct heat. Details for construction for warmth will be given later.

4. **Economical Construction.** The making and laying of the L-Block may be carried out with unusual economy of labor. The blocks are made without any great amount of tamping and, on account of their lightness, they can be handled easily and quickly. Finally, the L-Block owing to size and weight may be laid up rapidly in a wall.



Fig. 3. One of the first buildings made with L-Block walls.

Some Limitations of the L-Block

The L-Block is too light to be satisfactory for heavy construction, unless it is used as a form of backing for brick or other material. Where building regulations or codes are in force the L-Block usually cannot be used. However, farm buildings are generally light structures and not subject to building codes.

The long vertical joint in the wall requires considerable care in the laying of the block to insure a good joint. A type of block was experimented with which provided a lapped joint, but it appeared that the extra advantage so gained was of little importance. The bond in the single wall, which is limited to the thickness of the short member, likewise requires good workmanship in the laying of the blocks.

The Quality of Concrete to Use

The L-Block requires the use of a rich, dense grade of concrete, (often referred to as Class 1) because it is desirable to handle as little material as possible. Furthermore, a good grade of concrete insures a more nearly moisture proof wall.

Great detail as to the selection of materials and methods of mixing will not be gone into in this bulletin. A publication on this subject may be secured upon request.* It should, however, be emphasized that clean, well graded materials should be used and carefully mixed with the proper amount of water. If the materials that will not pass thru a $\frac{1}{4}$ inch mesh screen be specified as gravel, a mixture of 1 part cement, 1/10 part lime, two parts sand, and three parts gravel will make good blocks. Crushed stone may be substituted for the gravel. Altho gravel or crushed stone ordinarily reduces the cost of the concrete, this kind of material may be very difficult and expensive to secure, in which case a cement-sand block may be most practical. The lime is added to increase the density.

Class 1 or rich dense concrete, such as is advised for use in the L-Block, should, when properly made and cured, have a crushing strength of 2,400 to 3,000 pounds per square inch. Thus, the crushing strength of a well made block would be 30 to 45 tons.

The mixture should be just *wet enough* to fill the forms without excessive tamping. It will, of course, be necessary to work the concrete in the forms while filling sufficiently to let out the entrapped air. An excessive amount of water in the mixture will reduce the strength of the block. Care in mixing and placing the concrete in the forms insures good quality

*Design and Control of Concrete Mixtures—Bulletin published by Portland Cement Association.

blocks, free from pit holes and uniform in dimensions. Persons undertaking to make L-Blocks who are not familiar with the mixing of concrete and the proportioning of materials should first secure information upon this subject. The Agricultural Engineering Section will advise where such information can be readily obtained.

The Forms or Molds

The first forms used in the experiment of making L-Blocks were very simple. A collapsible box or trough was made with cleats nailed to the sides in such a manner as to hold in place the thin dividing plates of No. 16 gauge sheet metal. Fig. 3 illustrates the first type of forms used.

Altho good blocks may be made in forms of this type, the dimensions are apt to vary considerably, owing to the shifting and distortion of the thin plates. With any block, especially one with thin walls, it is desirable to have uniformity in form and dimension.



Fig. 4. The forms used in the first experiment.

In order to insure a more uniform spacing of dividing plates and to facilitate cleaning, several variations of construction were tried out among which the forms shown in fig. 5 were most successful. With this form the ends of the metal dividers were turned at right angles, thus dispensing with the spacing blocks riveted to the metal plates. As the experiments were continued, heavier plates were found desirable because their shapes were retained better and they could be handled more roughly.

Later, the all-metal forms shown in fig. 6 were developed, in which the sections are latched together as shown in fig. 7; two sections provide a mold for one block, three for two blocks, or, for instance 26 sections are required to mold, 25 blocks.

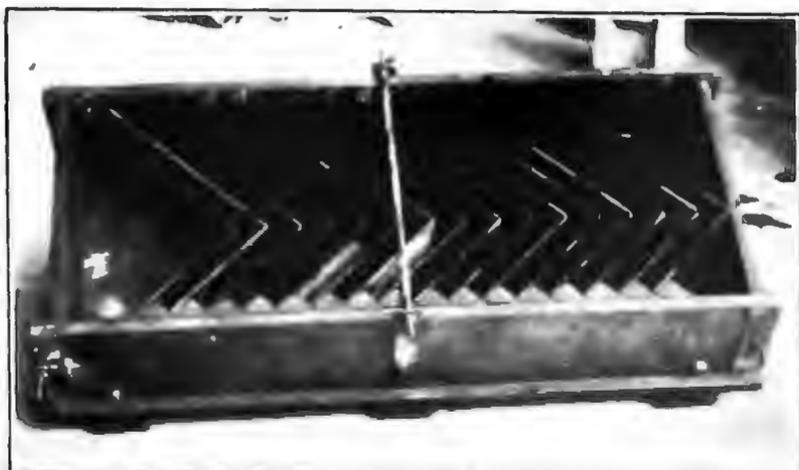


Fig. 5. Another type of form tried.

Twenty-five is a sufficient number to form a convenient gang. The all-metal forms should be made of heavy metal; No. 10 gauge which is $\frac{9}{64}$ inch thick has proved satisfactory. It is to be noted that at end A, as shown in fig. 7, the plates are hooked together, and at end B the forms are drawn tightly together by a lever set into a tapered notch. The block is beveled slightly at end A so that it can be removed easily from the form. The all-metal forms are made of heavier plates than usually can be handled in an average sheet metal shop and

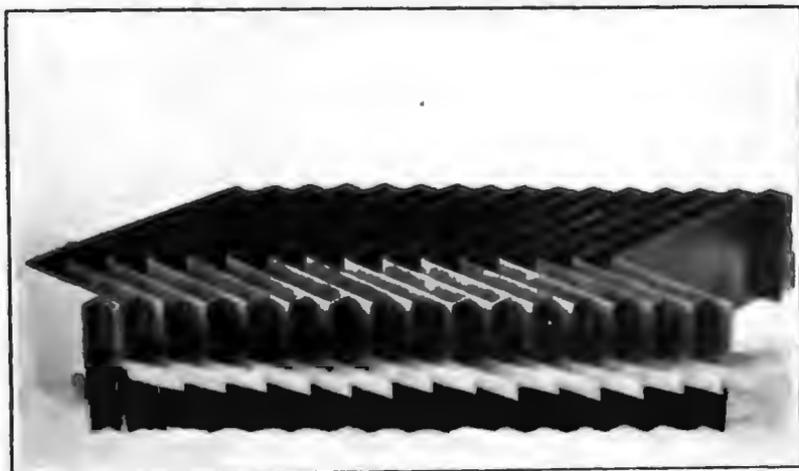


Fig. 6. The type of form finally developed.

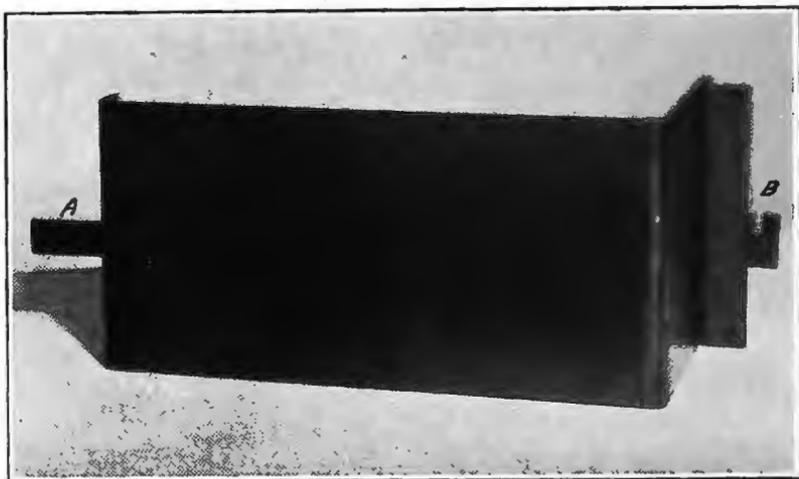


Fig. 7. An all-metal form showing method of latching together.

consequently are not so universally available.* The shape and accuracy of dimensions of the finished blocks will depend directly upon the degree of accuracy followed in the making of the forms. They should vary less than 1/16 inch in dimension and be perfectly square.

Making L-Blocks

The objectives sought in the experiments with the L-Block were: first, to reduce the amount of material used; and second, to reduce the labor required for making the blocks and for laying them in a wall. A reduction of labor is accomplished by moving the concrete directly from mixing board or mixer to the forms, by using a mixture of such a consistency as to require very little tamping and by allowing the blocks to remain in the forms until sufficiently set to permit preliminary handling. This method dispenses with the usual labor required in carrying the blocks to a curing yard on individual pallets. The method of procedure is well adapted to intermittent work, thus enabling a private builder to fill a gang of 25 blocks once a day and in a comparatively short period accumulate enough blocks for a good sized structure. Under ordinary conditions the filling of the forms once each day is a very satisfactory procedure. However, in experiments it has been found practicable in warm weather when using warm materials to fill the forms twice a day with little loss of blocks in handling. In cold weather it is best to leave the blocks in the forms two days.

*The Agricultural Engineering Section, Iowa Agricultural Experiment Station, Ames, Iowa, will furnish names of manufacturers of forms upon request.

The Amount of Labor Required

The amount of labor used in making the blocks will depend largely upon the convenience arranged for in handling the materials and blocks.

Fig. 8, illustrates a good arrangement of equipment. The materials are scooped directly into the mixer; the mixed concrete is hauled directly from the mixer to the forms; and the blocks, after having sufficiently hardened for handling, are removed directly from the forms and placed into the curing pile. With the arrangement shown in the illustration it was possible to make 107 blocks, do all the work of mixing materials, filling forms, taking down forms, piling blocks, cleaning, oiling and assembling forms, and cleaning tools and mixer in an average period of 165 minutes, or at the rate of 1.55 minutes per block. It appears possible, with more carefully planned equipment, to reduce still further the labor required. The making of a small number of blocks at a time would tend to increase the labor requirement.

Filling the Forms

Much care should be taken to measure the materials and water accurately so as to secure a uniform concrete of right consistency to fill the forms easily without the expenditure of much labor. A trowel or thin bladed tool should be run around the edge of each block to let out any bubbles and insure a smooth faced block. It is possible to make a block that closely resembles cut stone in appearance. A little experimenting with carefully measured materials is necessary to secure the best results in any situation.



Fig. 8. Equipment layout.

Cleaning and Oiling the Forms

To insure smooth, uniform blocks and to reduce the breakage of blocks upon their removal from the forms, it is necessary to keep the forms well cleaned and oiled. This cleaning should be done as soon as the blocks are removed. A method found quite satisfactory is to brush the forms with a wire brush and then spray or brush them with oil. Discarded crank case oil from an automobile motor is satisfactory for oiling the forms, and a spray pump like that shown in fig. 8 is a labor saver. In order to use crank case oil successfully, provision must be made to settle and strain the oil or the spray nozzle will clog, and the sediment in the oil will darken the blocks. Best results were obtained from spraying the forms just before filling them. The forms, if kept clean, become more easily handled the longer they are used. Systematic methods are a great conserver of time and effort. Furthermore, the breakage of blocks may be almost entirely overcome by skill and care in handling.



Fig. 9. Oil tank and spray pump for oiling forms.

Curing the Blocks

In order to secure the full strength of concrete the material should be cured in a moist condition. If concrete blocks are allowed to dry out immediately upon removal from the form, the strength of the material will be greatly reduced. The L-Blocks as removed from the forms should be placed in a nested pile, out of the direct sun, and sprinkled with water often enough for 10 days or more to insure an abundance of moisture. A tarpaulin or canvas cover placed over the pile of blocks will aid in retaining the moisture.

At the end of one month the blocks will be sufficiently well cured to be handled easily. If placed in the wall earlier, the wall should be kept moist during the curing period.

Cost of the L-Block

The L-Block can, with good management, be made cheaply, because the amount of material is small, the labor is not great, and the cost of equipment is not excessive even when a limited number of blocks is to be made. The L-Block of the dimen-

sions shown in fig. 2, page 227 weighs from 18 to 20 pounds, and 190 blocks may be made from a cubic yard of concrete. With cement at \$2.80 per barrel, sand at \$1.00 per yard and gravel or broken stone at \$1.50 per yard, a cubic yard of Class 1 concrete made of a mixture of 1 part cement, 1/10 part lime, 2 parts sand and 3 parts gravel or broken stone will cost about as follows:

Cement, 1.8 bbl. @ about \$2.80.....	\$5.04
½ cu. ft. Lime.....	.25
Sand, .50 yds. @ \$1.....	.25
Gravel, .76 yds. @ \$1.25.....	.85
	\$6.39
Cost of concrete per yd. (27 cu. ft.).....	\$6.39
Cost per block034

The cost of equipment will vary largely with conditions of use. In general, equipment that is used extensively gives a lower cost. Assuming that the concrete mixer is to be used for other purposes and that each form will make at least 100 blocks during its life, it is safe to say that the cost of equipment should not exceed 2 cents per block.

In the experiments conducted at Ames, Iowa, blocks were made as heretofore stated in 163 minutes, or at an average rate of 1.55 minutes per block. With labor costing 60 cents per hour the cost would be \$.015 per block. Thus, the actual cost of blocks in these experiments was as follows:

COST OF L-BLOCK PER BLOCK

Materials	\$.034
Equipment and Overhead.....	.020
Labor015
	\$.069

It would be comparatively easy, under favorable conditions, to reduce the cost of labor. The cost of material may be greater or less, depending upon availability.

Laying the L-Block in the Wall

The masons employed to lay the L-Blocks in walls of the experimental building found, after becoming accustomed to the blocks, that the blocks laid up easily and that the narrow mortar joints were not troublesome. The blocks laid up in a double wall with the same speed as 5x8x12 inch tile but required much less mortar. The single wall is laid up about twice as fast. The lightness of the block requires great care to be used in laying. The mortar should be rich cement mortar with as little lime as possible. Some masons are able to use well-mixed cement mortar of 1 part cement to 2½ parts sand without the admixture of any lime. Such mortar gives a stronger wall but usually requires more time in laying. One-tenth part of hydrated or

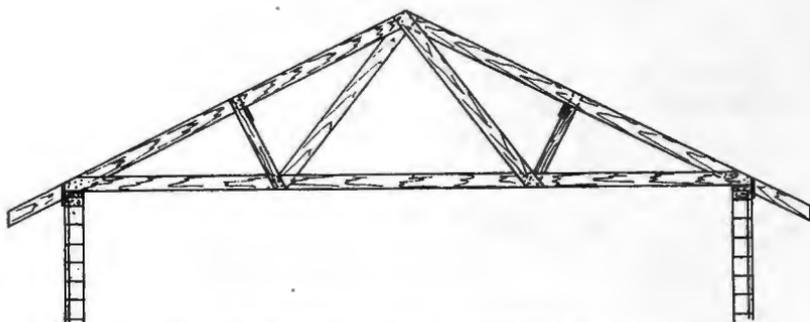


Fig. 10. Roof framing designed to keep roof loads vertical.

slaked lime is often added to each part of cement to make the mortar more workable and adhesive.

Foundations

The L-Block wall, in order to be a success, should be put on a good foundation. If the foundation settles out of place, such a light wall is sure to crack. On the other hand, when placed on a good foundation the wall will carry a very heavy load. The foundation should extend below frost, have wide footings and some reinforcement at corners and under the sections carrying the heaviest loads. When a heavy wall is desired it is practicable to lay the L-Blocks in a double wall and fill with concrete, thus dispensing with forms.

Roof Construction

The L-Block, when laid into a single wall, is not able to resist any unusual side thrust, and for this reason a roof design should be used that will not have large horizontal forces to be resisted by the wall. The use of joist or ties to take the horizontal thrust of rafters is necessary. The experimental building shown in fig. 1 has walls made of a single course of blocks and quite a large section is unsupported by a cross wall. The roof framing shown in fig. 10 is so designed that the roof loads are vertical and there is little tendency to push the walls of the building out of place.

Stucco Finish

When the L-Block is carefully made, the wall laid from the blocks has a pleasing appearance, somewhat resembling cut stone.

If it is desired to change the appearance of the L-Block wall, portland cement stucco, in any of its numerous variations may be applied with success. The fact that the base wall is concrete assures most efficient cohesion when the stucco is properly applied. In some experiments, a single coat of splatter dark was found successful.

If stucco is applied, it is desirable to brush off the glaze, given by the metal forms as the blocks are removed from the forms, to insure a better bond of the stucco.

Details of Construction

The L-Block may be used in so many ways that it will be impracticable to report all the various details of use which have been worked out. Nearly every practical builder who studies the blocks suggests new uses. It is planned, however, to present some of the more essential details with the assurance that others may be worked out by the builder as required.

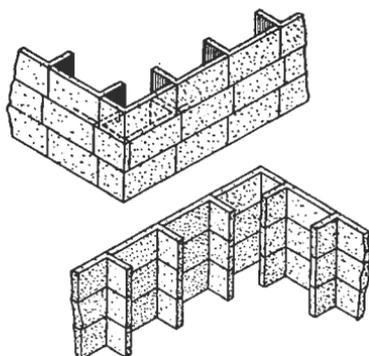


Fig. 11. Single wall construction with L-Blocks.

Single Wall Construction

The single wall shown in fig. 11 provides an enclosure with the minimum of material, and at the same time the studs formed by the short member of the block give considerable stability to the wall. It is the observation of the authors that this wall is much more stable and more able to resist side thrust than its open construction would seem to indicate. It is much more stable than a 5 inch wall laid up of hollow units. Since the mortar joints are of limited area and the bond between courses is limited, care should be taken to lay the block in the wall carefully.

It should be pointed out that the cost of the material in this wall is about the same as the cost of a single thickness of wooden sheathing.

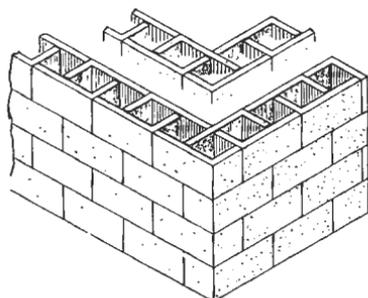


Fig. 12. Double wall construction with L-Blocks.

The Double Wall Construction

Where additional strength is desired, the L-Block may be laid in a double wall as shown in fig. 12. In this construction, it is feasible to bond the courses in a neat and effective way. In some instances, as for foundation, the double wall has been filled with concrete; thus giving a solid wall without the use of forms.

In fig. 13 the lower courses are double wall construction and the upper single wall construction.

An Open Wall

The wall shown in fig. 14 has been laid up to provide a dry and better insulated wall. Inasmuch as little material extends directly between the inside and outside surfaces, there is little opportunity for the transmission of moisture or the conduction of heat. Several modifications of this type of wall have been suggested by builders. For instance, it is possible to build a single wall quite independent except that headers or ties are used at intervals.



Fig. 13. The lower courses are double wall construction and the upper single wall construction.

A Reinforced Wall

With a light wall, such as those constructed of L-Blocks, it will be desirable at certain places to build in some steel reinforcement to care for unusual tensile stresses which may exist.

Fig. 21 shows a method of reinforcing with strips of wire cloth which is very convenient to use. If there is a danger of corrosion, galvanized cloth might be used and the cost will not be excessive if the amount used is not great. Where the tensile stresses or bending stresses are great, as over door and window openings, the blocks should be filled with concrete in which reinforcing rods are embedded.

Detail of Corner for Single Wall

The method of making a corner in a single wall is shown in fig. 11. With this method, one special length of block is required. In this block the longer member is $9\frac{3}{4}$ instead of $15\frac{3}{4}$ inches long. These shorter blocks are easily made by setting a wood block in the standard forms.

Corner for Double Wall

A method of making a corner in a double wall of L-Blocks is shown in fig. 12. This provides a good bond and does not require a special block.

Method of Strengthening the Single Wall

Where the single wall is built in rather long sections without the support of cross walls, pilasters or columns may be built into the wall to give additional strength as shown in fig. 15.

These pilasters may be placed under the ends of roof trusses when the latter are used. If additional strength is required, the hollow columns so constructed may be filled with concrete with reinforcements embedded. Such construction is very substantial. Often the use of pilasters will improve the appearance of a long stretch of plain wall.

The L-Block As Backing to a Brick Wall

Where a brick outside wall is desired, the L-Block may be used as backing as shown in fig. 16. The brick and concrete blocks may be tied together with metal ties or headers.



Fig. 14. There is little opportunity for the transmission of moisture or the conduction of heat in a wall laid up in this manner.

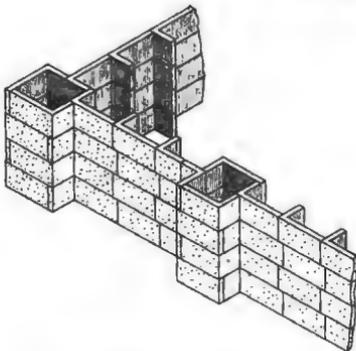


Fig. 15. Showing how single wall construction may be strengthened with pilasters.

Door Openings

Door openings should have reinforced concrete lintels extending across the openings as shown in fig. 17. In practice it has been found quite practicable to cast these lintels in place.

If large door openings are required without door frames, it will be found desirable to enclose the ends of the walls with blocks and fill them with concrete. The reinforcement may be used to give additional

strength. It should be observed that it is impractical to fill more than about 2 feet of such corners at a time, owing to the great bursting pressure exerted by concrete in the plastic state.

Window Openings

Many of the same principles of strengthening the wall should be followed around window openings. These principles should be followed in any type of construction and are not peculiar to L-Block construction.

Window sills can be precast with the blocks and set as needed. By varying the thickness of window sills, the opening may be adjusted to any standard window height. Window

jamb may also be cast in place like the lintels.

Much time will be saved in using window or door openings which can be easily arranged for without special blocks, other than the one mentioned which is $9\frac{3}{8}$ inches long. The possible openings which can be easily provided with the two sizes of blocks are as follows:

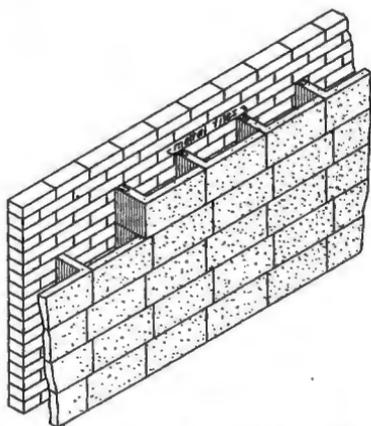


Fig. 16. A brick wall with the L-Block used as backing.

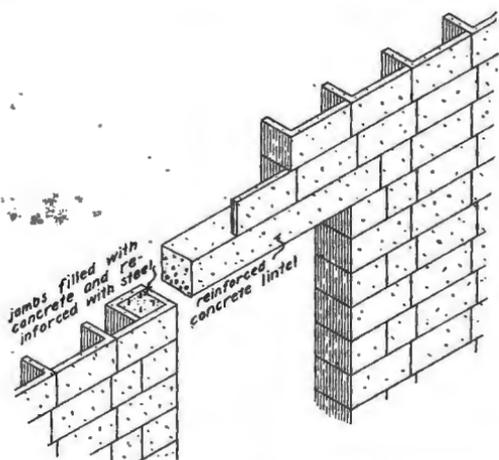


Fig. 17. Showing method of reinforcing lintels and jambs at door openings.

WIDTH OF POSSIBLE OPENINGS			
Single Wall		Double Wall	
Feet	Inches	Feet	Inches
1	2 1/2	1	6 1/2
2	6 1/2	1	10 1/2
3	10 1/2	2	6 1/2
5	2 1/2	2	10 1/2
6	6 1/2	3	6 1/2
		4	10 1/2
		5	2 1/2
		5	10 1/2
		6	6 1/2

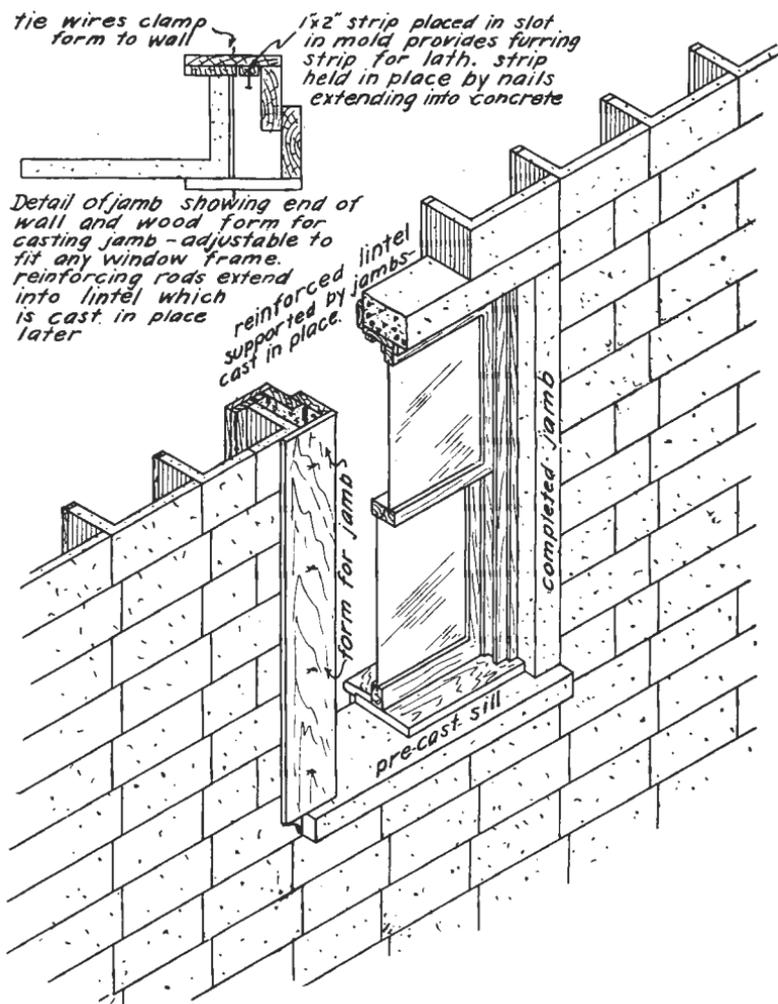


Fig. 18. Illustrating method of making a window frame of concrete.

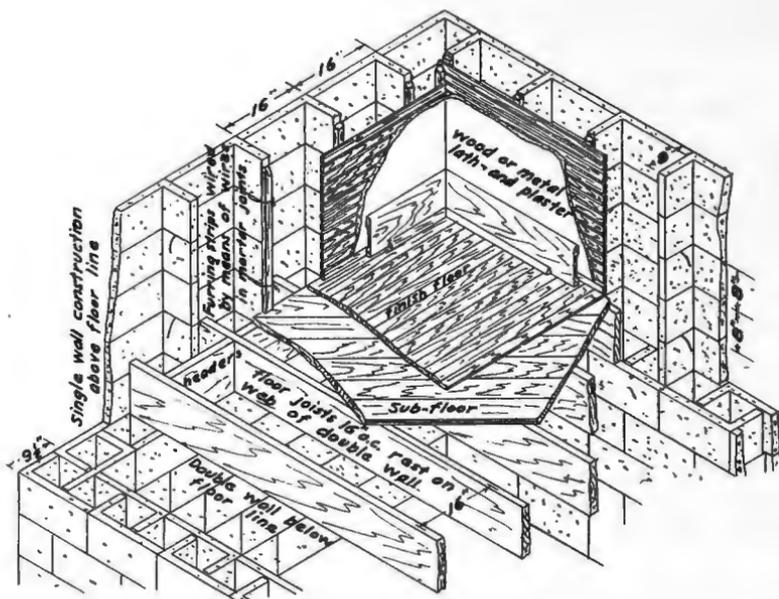


Fig. 19. Details of wall and floor construction.

Joist Supports

When a double wall is used below and a single wall above, the joist may be supported by resting on every other one of the connecting webs as shown in fig. 19.

If it is desired to continue the double wall above the joist, one course of blocks may be filled with concrete and short blocks used to fill the spaces between joists as shown in fig. 20. A strip of wire cloth laid in the mortar joint can be used as a support for the concrete filling.

Method of Attaching Wall Plate

With the single wall in particular, special construction is required for attaching the wall plate upon which the rafters are to rest. One method of accomplishing this is shown in fig. 21. In this case, a reinforced beam is cast on top of the block in a box form. In this beam bolts are embedded for attaching a wooden plate.

Special Block for Gables

With a little planning, special blocks for the gables may be made by setting wooden blocks in the forms to displace a part of the concrete and thereby mold blocks of the desired shape. The accompanying illustrations, figs. 21 and 22, show how these

special blocks are used to build a wall in a gable so as to make a fit with the roof.

Making a Moisture-Proof Wall

As mentioned in the discussion of the utility of the L-Block, a wall with unusual qualities for excluding moisture may be built with the L-Block. At least three methods of L-Block construction may be employed which will contribute toward providing a dry wall, and when used in combination, an unusually satisfactory wall is insured. These three methods are; (1), the use of a dense water-tight concrete. There is no reason why such concrete should not be used because of the small amount of concrete required. The reader is referred in this connection to suggestions on forming. (2) When an open wall is laid, the wall may be waterproofed on the inside by pointing and treating with waterproofing material such as a cement wash, tar or paraffin. In fact, any of the surface methods of waterproofing concrete could be used. (3) The application of a plaster or stucco coat to the outside of the wall ought to provide a very

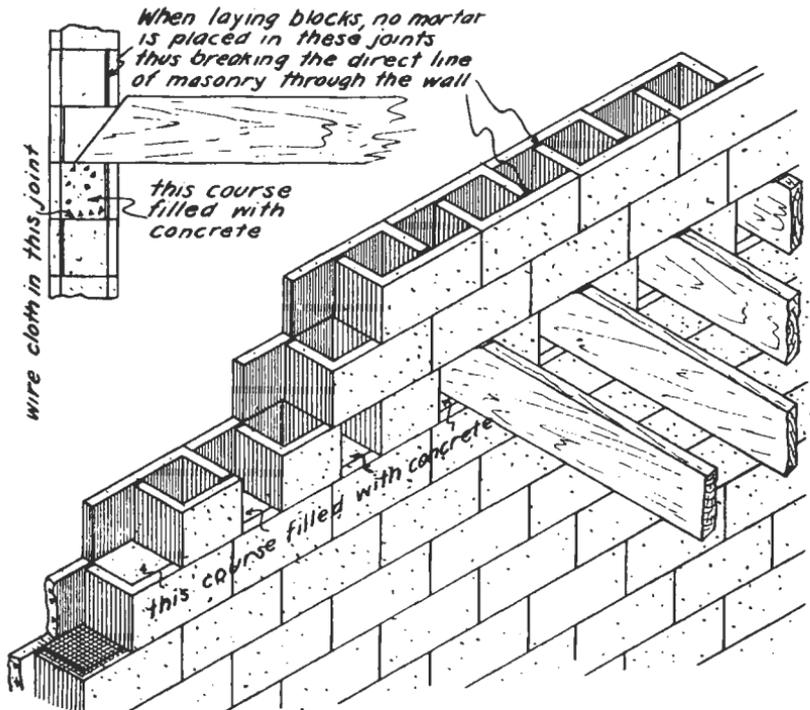


Fig. 20. A method of supporting floor joists.

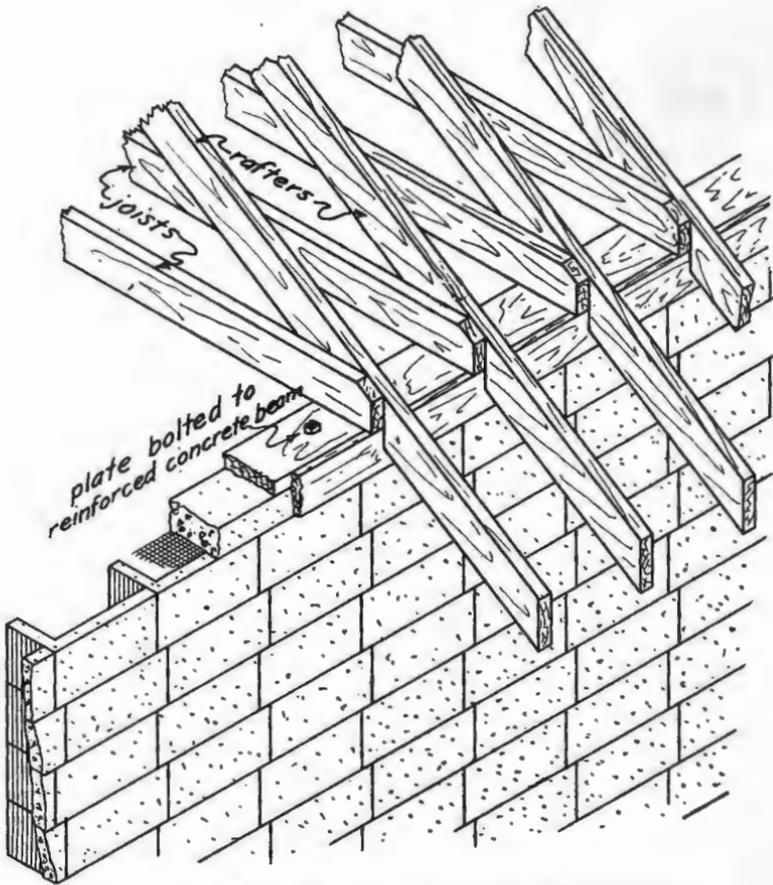


Fig. 21. A method of reinforcing wall and attaching wall plate.

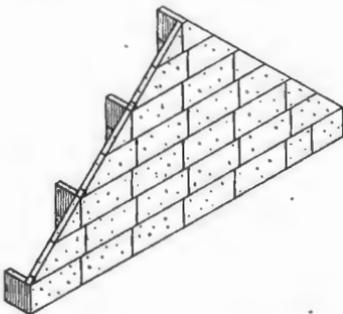


Fig. 22. Showing how a gable wall of one-half pitch may be finished with special blocks.

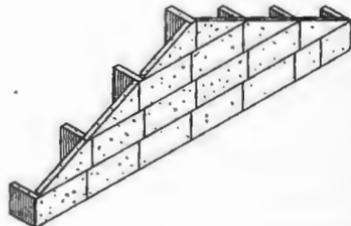


Fig. 23. Gable wall construction with special blocks for one-fourth pitch.

effective means of excluding moisture. When the L-Block is laid in walls provided with insulation, there ought to be much less trouble with condensation than with average masonry construction.

Waterproofing

The L-Block if made, of dense concrete, should be water tight. Furthermore, in the case of the single wall, it is possible to point the wall from the inside to overcome any imperfections in laying the blocks. Stucco, when applied to the outside, is another safeguard against moisture. As a still further protection, the wall may be treated on the inside with waterproofing in a most effective manner. Ordinary coal tar brushed on while hot has proven very satisfactory and economical. Hot paraffin may be used in the same manner. A wall treated in this manner is sure to meet the most exacting requirements for a dry wall.



Fig. 24. One method of applying insulating quilt between studs.



Fig. 25. A method of applying insulating quilt and lath.

Insulation

Altho the L-Block was designed for the construction of farm buildings, its merits for the construction of dwellings soon became apparent. In dwellings, however, more emphasis must be placed upon construction which enables the inside temperatures to be controlled effectively.

Furthermore, at the present time, investigations under way at several experiment stations indicate that for poultry in particular, control of temperature is a most important phase of housing as influencing egg production.

The control of temperature in buildings requires that the walls be poor conductors of heat and that the openings shall not permit the rapid transfer of heat thru air currents. One of the best ways of lowering the conduction of heat thru walls is to introduce efficient insulating materials into the walls. Usually this is the cheapest way to secure a so-called warm wall.

The single L-Block wall permits insulating quilts or insulating board to be used conveniently. As the blocks are laid, wire

loops are placed in the mortar joints for wiring furring strips to the studs formed by the blocks, as shown in fig. 23. Then an insulating quilt may be applied between the studs, as shown, or nailed to the furring strips as indicated in fig. 24.

After the insulating material is in place, the lath may be applied and the inside of the wall plastered in the usual way. Several methods of using insulation were tried out in the experiments with the L-Block, and the two methods described were found to be very satisfactory. Either wood or metal lath may be used.

It is practicable to stuff the double wall made of L-Blocks with insulating material, such as shavings or shredded corn stalks, and thus secure a very warm wall.