NATIONAL BUREAU OF STANDARDS REPORT

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REQUIREMENTS FOR

CONCRETE-MASONRY CONSTRUCTION

by The Staff of

The Building Technology Division

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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REQUIREMENTS FOR

CONCRETE-MASONRY CONSTRUCTION

This report has been prepared at the request of the Engineering Division, Military Construction, Office, Chief of Engineers, for use as a chapter in the OCE Engineering Manual on Military Construction.

1. SCOPE. The instructions in this chapter contain design and construction procedures for walls and partitions of concrete-masonry units. Its purpose is to inform Corps of Engineers personnel and consulting architect-engineers of criteria to be followed in the preparation of working drawings and specifications for military construction. It also contains background material. This chapter is not concerned with floors, roofs, or other constructions not involving the use of masonry units. The "American Standard Building Code Requirements for Masonry" (ASA A41.1-1944) and 1953 revision (see par. 13a), hereinafter referred to as "A41.1", is the basis of masonry-construction design, and applicable sections may be used in conjunction with this publication except as modified herein. Other codes and specifications referring to subjects discussed herein are listed in paragraph 13.

2. CONCRETE-MASONRY UNITS. Concrete-masonry units as used in this manual include: hollow load-bearing concrete block, solid load-bearing concrete block, non-load-bearing concrete block, and concrete brick. The units may be used for exterior and interior load-bearing and non-load-bearing walls, partitions and fire walls, backing for brick or other facing, fireproofing over metal structural members, piers, retaining walls, and chimneys. A "concrete-masonry unit" is defined as a building unit made from cement and suitable aggregates such as sand, gravel, crushed stone, cinders, burned clay or shale, or blast-furnace slag. A "hollow-masonry unit" is defined as a masonry unit whose net cross-sectional area in any plane parallel to the bearing surface is equal to or less than 75 percent of its gross cross-sectional area measured in the same plane. A solid concrete masonry unit is a masonry unit whose net cross-sectional area of concrete in all planes parallel to the bearing surfaces are more than 75 percent of its gross cross-sectional area measured in the same planes. The moisture content of concrete units gives a rough measure of the tendency of the construction to crack as the result of the drying and shrinkage of the units. Concrete shrinks with the loss of moisture while drying to an air-dry condition. When moist units are placed in a wall and the wall is restrained, tensile and shearing stresses are developed as the units dry. These stresses may cause unsightly cracks in the wall.

2a. Concrete-masonry units should conform to the OCE Guide Specification CE-206.01 (par. 13b). The requirements of CE-206.01 should have preference over those contained in other specifications and standards for concrete-masonry units mentioned herein.

2b. Load-bearing and non-load-bearing hollow-masonry units should conform to the following requirements of Federal Specification SS-C-621 (see par. 13c) for compressive strength: For load-bearing units, if the thickness of the outer shell parallel to the exposed surface of the wall is 1 1/4 in. or more, the required minimum average compressive strength for the five units tested shall be 700 lb/in^2 of gross area, the minimum for individual blocks 600 lb/in^2. If the thickness of the shells is 3/4 in. to, but not including, 1 1/4 in., the minimum average shall be 1000 lb/in^2 of gross area and the individual minimum 800 lb/in^2. As the compressive strength of masonry walls is approximately proportional to the thickness of the bearing shells, greater strength for the units with thin than with thick shells is required so that the compressive strength of the masonry walls of thin-shelled units will not be less than required. The following exception will be made: Concrete block used in exterior walls below grade, not parged, and subject to frost action, shall have a minimum average compressive strength of 1000 lb/in^2 of gross area for the average of five units tested, and a minimum compressive strength of 800 lb/in^2 for individual units regardless of the shell thickness. The average compressive strength of non-load-bearing units shall be at least 350 lb/in^2.

2c. The compressive strength of solid load-bearing concrete-masonry units shall conform with the requirements of ASTM Standard C145-40 (see par. 13d).

2d. The compressive strength of concrete building brick should meet the requirements of Federal Specification SS-B-663 (see par. 13e). For Grade A brick, these requirements are not less than 2500 lb/in^2 for the average of five bricks and not less than 2000 lb/in^2 for individual bricks; for Grade B brick not less than 1250 lb/in^2 for the average of five bricks and not less than 1000 lb/in^2 for individual bricks.

2e. Hollow and solid concrete-masonry units intended for use in fire-resistant walls should meet the requirements of Underwriters Laboratories "Standard for Concrete Masonry Units" (see par. 13f).

2f. For load-bearing units exposed to soil or weather, the absorption shall not exceed 16 lb/ft^3.

2g. The average moisture content in the units at the time of laying should not exceed 30% of the total absorption of the units (see par. 13b). Where such blocks may be difficult to obtain because of high humidity in a locality, the Contracting Officer may revise this requirement to allow not more than 35% moisture content subject to the approval of the Chief of Engineers.

2h. Units must be protected from rain and kept dry prior to laying. Units should be stacked in such a way that air circulation may occur, thus facilitating drying; no units should be placed directly on the ground while being stored. The contractor will be held responsible for providing and maintaining the protection necessary to prevent rewetting of delivered units prior to their use. Units which fail to meet the moisture-content limitation should be set aside for further drying and should not be used until retested and proved satisfactory. Unprotected units which have been wetted should be considered too wet to use unless they have been shown by test to be adequately dry.

2i. Units should be of the same manufacture and composition for each building, unless otherwise approved by the Contracting Officer. Units made by more than one manufacturer for use in the same building, when permitted, should be of similar composition, size, and appearance. All units should be sound and free from cracks or other defects which would interfere with proper setting of the units or impair the strength, appearance, or durability of the construction.

2j. Masonry shall be protected against freezing for at least 48 hours after being laid. No masonry should be built on frozen material. No masonry units should be laid when the air temperature is less than 40° F unless the temperature is rising, and no units shall in any case be laid when the outdoor temperature is below 35° F unless provisions are made to maintain the masonry at a temperature above 40° F for at least 48 hours (see par. 10e).

3. MORTAR. To obtain masonry joints of high quality with ordinary construction methods, an intimate and complete contact of the mortar with the surface of the masonry unit is necessary. Although the skill and the amount of effort exerted by the mason affect the quality of the joints in masonry, the quality and the condition of the materials are the important factors. Mortars which have low water retentivities tend to stiffen so rapidly when in contact with the surface of an absorptive masonry unit that they become too dry and stiff to permit an intimate and complete contact of the mortar when the second unit is pressed against it. Also, mortars of low water retentivity tend to "bleed" if allowed to stand. The wetness (flowability) of the mortar being used by the mason has an important influence on the extent and intimacy of the bond between the mortar and the units; the wetter the mortar the more complete and the stronger the bond between mortar and unit and the more watertight the joint.

3a. Mortar materials and proportioning should comply with the requirements of the OCE Guide Specification CE-207 (see par. 13h) and Federal Specification SS-C-181b (see par. 13i).

3b. Water used in mixing mortar should be clean and free from acids, alkalis, and organic materials. Sand should conform to the requirements of the ASTM Specification C144 (see par. 13j). Sands deficient in fines generally produce harsh mortars, difficult to handle. Fine sands that are deficient in the coarser properties give mortars that may shrink excessively.

3c. Mortar used in masonry construction will be classified as follows:

Type	Average compressive strength of three 2-inch cubes, lb/in^2
A-1	2500
B, B-1	750
C, C-1	350

See par. 12f

3d. Mortars of the following proportions may be assumed to meet the strength classification:

Mortar type	Proportions by volume: Cement	Hydrated lime or lime putty allowable range	Aggregate measured in a damp and loose condition
A-1....	1 (portland)..	1/4.....	3
B.....	1 (portland)..	2/3 to 1 1/4....	5 to 6
B-1....	1 (masonry)/a.....		2.5 to 3
C.....	1 (portland)..	2 to 2 1/2.....	7.5 to 9
C-1....	1 (masonry)/b.....		2.5 to 3

/a Type II Masonry Cement, ASTM C91-51.
/b Type I Masonry Cement, ASTM C91-51.

3e. Mortar should have a flow after suction of not less than 70% of that immediately before suction.

3f. Mortars which have stiffened because of chemical reactions associated with hardening should not be used, but those which have stiffened because of the loss of mixing water through evaporation should be retempered to restore their workability. Water should be added as frequently as needed. In general, masons should be encouraged to use as much mixing water as possible without impairing the workability of the mortar.

3g. The standard thickness of mortar joints for both horizontal and vertical joints should be 3/8 in. The horizontal and vertical ends of the shells of the units that are parallel with the faces of the wall shall be covered with mortar, and the spaces between these shells and those of adjacent units shall be filled completely. Mortar shall not be placed on the ends of the interior webs of the units. Mortar joints on the weather side of exterior walls should be thoroughly compacted and pressed tight against the edge of the units with a proper tool to provide a concave or V-shaped joint.

3h. Masonry may be laid in type A-1, B, B-1, C, or C-1 mortar, with the following exception: Type C and C-1 mortar should not be used in isolated piers or load-bearing or exterior walls of hollow-masonry units.

4. STRUCTURAL DESIGN. Contracting Officers and contractors are referred to A41.1 for a more detailed discussion of some of the phases of structural design using concrete-masonry units.

4a. The allowable compressive stresses in pounds per square inch of gross cross-sectional area should not exceed the following amounts:

Brick and other solid units of sand-lime or concrete

Average compressive strength of units/a	Mortar type		
	A-1	B, B-1	C, C-1
lb/in^2	lb/in^2	lb/in^2	lb/in^2
2500 to 4500	175	140	110
1500 to 2500	125	100	75

/a Tested in the position used in the masonry.

Solid concrete-masonry units

Grade	Mortar type A-1 lb/in²	Mortar type B, B-1 lb/in²	Mortar type C, C-1 lb/in²
A....	175	125	80
B....	125	100	60

Hollow-masonry units

Unit	Mortar type A-1 lb/in²*	Mortar type B, B-1 lb/in²*
Hollow units	85	70

*gross area

In walls composed of different kinds or grades of units or mortar, the maximum stress shall not exceed the allowable stress for the weakest combination of unit and mortar of which the assembly is composed.

4b. Walls of hollow-masonry units not designed as reinforced masonry should be supported at right angles to the wall face at intervals not exceeding 18 times the nominal wall thickness. Solid-masonry walls should be supported at right angles to the wall face at intervals not exceeding 20 times the nominal wall thickness. Lateral supports may be defined as the vertical and horizontal members of a structural frame in contact with the wall, including floors and roofs intersecting a load-bearing wall, pilasters, and columns or struts supporting roofs. If the limiting distance for support is selected horizontally, then no limits are set for the distance between floors. If the limiting support distance is vertical, that is if the floors and roof serve as the lateral support and are placed closer together than the limiting distance, cross walls or other vertical members which provide lateral support are not required. Sufficient bonding or anchorage shall be provided between the walls and the supports to resist the assumed lateral load.

4c. The minimum nominal thickness of masonry bearing walls not exceeding 12 ft in height should be at least 8 in.; where the height exceeds 12 ft but does not exceed 35 ft, walls should be 12 in. thick.

4d. Non-load-bearing exterior walls and walls enclosing stairways, elevator shafts, penthouses, or bulkheads may not be less than 8 in. thick.

4e. The vertical or the horizontal distance between lateral supports of non-load-bearing partitions should not exceed 36 times the thickness of the partition, including plaster. For non-load-bearing walls that are not plastered, the unsupported length or height, whichever is the smaller, should not exceed the following:

Nominal wall thickness	Maximum distance between lateral supports
in.	ft
4	12
6	18
8	24
12	36

4f. Fire walls shall have a thickness not less than that required to provide the needed fire resistance rating and should be built of suitable units (see pars. 2e and 13f). The maximum distance between lateral supports of fire walls should not exceed 20 times the wall thickness, including plaster.

5. CONTROL OF SHRINKAGE CRACKS. Shrinkage cracks in concrete masonry may be controlled by the use of bond beams, joint reinforcement, and control joints. The steel bars and wires in bond beams and in joint reinforcement are depended upon to greatly reduce the width (but possibly increase the number) of shrinkage cracks in the masonry. Control joints, in effect, limit the length of a wall and thereby tend to reduce the tensile stresses which cause the shrinkage cracks. The amount of drying shrinkage which may be expected from a concrete-masonry unit depends upon its composition, method of manufacture, and the amount of moisture that it loses after being laid in the masonry. (Measures for controlling the moisture content of the units are given in pars. 2d and h.) In order to correlate the potential shrinkage of the units with the necessary preventative measures for the control of cracking, the units are divided into the following two groups:

Drying shrinkage grouping of concrete-masonry units

Kind of masonry unit	Weight of concrete	Maximum linear shrinkage*	
		Group 1	Group 2
	lb/ft^3	percent	percent
Sand-lime and concrete bricks	125 or more	no limit	0.03 or less
Hollow or solid concrete block	100 or more	no limit	0.04 or less
Hollow or solid concrete block	Less than 100	no limit	0.05 or less

*See par. 12b for method of testing.

5a. Bond beams should consist of at least two No. 4 steel bars or the equivalent in cross-sectional area set in bond-beam (open-top) block filled with concrete. The bars should conform to the requirements of ASTM A305-49 (see par. 13ℓ), and the concrete should be Class B 2500 lb/in^2 concrete conforming with the requirements of OCE Guide Specifications for Concrete, CE-204 (see par. 13m). When the concrete in the bond-beam unit is deeper than 7 in., half as much reinforcement will be added at the top of the beam as is required in the bottom. Typical bond-beam units are shown in figure 1.

5b. Bond beams should be placed in the top courses of all concrete-masonry foundation walls and near the top courses of all load-bearing walls built of concrete-masonry units, preferably above the highest opening. Bond beams should form a continuous, horizontal, reinforced concrete belt connecting and capping all intersecting load-bearing walls. The bond beams should be continuous across control joints; but dummy joints, corresponding in location with control joints, may be placed in them. Bond-beam units and reinforcement may be used as lintels over door and window openings instead of poured or precast concrete lintels. Bond beams are not required in interior non-load-bearing walls. Bond-beam requirements are given in the table in paragraph 7b.

6. JOINT REINFORCEMENT. Joint reinforcement may consist of 3/16-in (No. 6 gage) parallel wires with 1/8-in. (No. 9 gage) welded cross ties or 3/16-in. horizontally trussed parallel wires. The cross wires should be placed at intervals not exceeding 6 in. for smooth, longitudinal wire, and at intervals

not exceeding 16 in. for deformed wire. The cross wires or trussed webbing should preferably be welded to the longitudinal wires in the same plane as the longitudinal wires and without crossing or lapping them. The longitudinal reinforcing wires should be of a cold-drawn steel conforming to ASTM Standard A82-34 (see par. 13n) except that the tensile strength should be at least 100,000 lb/in^2. The joint reinforcement should be made flat, not coiled. When laid in the joint, the longitudinal wires, at splices, should be lapped at least 32 diameters and should be bent and lapped at corners of the wall. The laps in straight lengths may be made by bending the longitudinal wires inward at one end of a section. See figure 2 for methods of using joint reinforcement. Joint reinforcement should be terminated at each side of a control joint. Typical reinforcement requirements of a non-bearing wall construction are shown in figure 3.

6a. Joint reinforcement should be placed around openings where high tensile stresses are usually developed. All walls containing openings and built of Group 1 units should contain joint reinforcement in the first bed joint over a lintel and in the first two bed joints under a sill. Walls containing openings and built of Group 2 units should have joint reinforcement in the first bed joint beneath a sill.

6b. Additional requirements for joint reinforcement are listed in the table in paragraph 7b.

6c. Where joint reinforcement is used, the minimum thickness of the shells of units shall be 1 1/4 in.

6d. Vertical, reinforced concrete studs tied into the footing and the bond beams shall be required in earthquake and hurricane regions at the corners of buildings or at regular intervals. Reinforced concrete frames may be used at large openings. Reinforcement should consist of at least one No. 4 bar or the equivalent cross-sectional area.

7. CONTROL JOINTS. Control joints divide a masonry wall into longitudinal segments, thereby minimizing the tendency for shrinkage cracks to occur. They provide a continuous vertical separation between bond beams through the entire thickness of the wall, including any facing or rigid finishes. The joints may be masked by the use of pilaster blocks and column faces. Preference should be given to control joints which provide for the possible transfer of lateral loads across the joint. Control joints should be used above expansion joints in monolithic concrete foundation walls, at junctions in L-,

T-, or U-shaped buildings, at jogs or offsets if the wall on either side is more than 10-ft long, at abrupt changes in wall height and thickness along a lateral plane, and at the intervals specified below. Control joints should be filled with light-colored plastic calking compound and are illustrated in figures 4, 5, 6, and 7.

7a. No control joints are required in walls of Group 2 units except over expansion joints in monolithic concrete foundations.

7b. A summation of the requirements for bond beams, joint reinforcement, and control joints is given in the following table:

Summary of Bond-Beam, Joint Reinforcement, and Control Joint Requirements for Concrete Masonry Units

Kind of unit	Type of wall		Bond beams	Joint reinforcement	Control joints
Group 1	Exterior and interior load-bearing walls	Option 1	At intervals of 10 ft in height (but not between openings), including bond beams just above concrete masonry foundation walls and near the top of walls.	In first two joints beneath sills and the first joint over lintels.	Above expansion joints in foundation walls, and at wall junctions, offsets, and changes in wall height or thickness.
		Option 2	Just above concrete masonry foundation walls and near top of wall (just above highest opening.)	At intervals not exceeding 16 in. vertically, including the first two joints beneath sills and the first joint over lintels.	Same as Option 1, above.
		Option 3	Same as Option 2, above.	Same as Option 1, above.	At intervals not exceeding 15 ft, including joints in the places specified in Option 1, above.
Group 1	Exterior and interior non-load-bearing walls	Option 1	None (except that below-grade walls should be topped by a bond beam.)	Same as Option 2, above.	Same as Option 1, above.
		Option 2	None (except that below-grade walls should be topped by a bond beam.)	In the first two bed joints beneath sills, and in the first bed joint over lintels	At intervals of 15 ft of wall length, including control joints above expansion joints in foundation walls, at wall junctions, offsets, and changes in wall height or thickness.
Group 2	Exterior and interior load-bearing walls		Just above concrete masonry foundation walls and near top of wall (just above highest opening.)	In the first joint under a sill.	Same as Option 1, above.
Group 2	Exterior and interior non-load-bearing walls		None (except that below-grade walls should be topped by a bond beam.)	In the first joint under a sill.	None.

8. CONSTRUCTION DETAILS. Methods of bonding walls shall be as shown in figures 8, 9, and 10.

8a. Concrete floor or roof slabs cast on the tops of walls provide sufficient attachment to the walls so that additional anchorage is not required. Provision should be made to reduce the lateral forces exerted at the top of concrete masonry bearing walls by the expansion and contraction of cast-in-place roof slabs. The top of the bond-beam course, when used, shall be screeded, covered with a thin bed of mortar that is carefully troweled to a smooth surface, parallel with the plane of the under side of the roof slab. After the troweled surface has hardened, and before placing the roof slab, the surface shall be covered with smooth-surfaced asphalt roll roofing 55-lb grade conforming with the requirements of ASTM Standard D224-50T (see par. 13o). This method of construction is shown in figure 13.

8b. The supporting joints of wood and of other lightweight roofs should be anchored to the masonry by 5/8-in. diameter, steel bolts having a minimum length of anchorage of 6 in. in the bond beam and spaced on 4-ft centers. The construction for a wood roof is also shown in figure 13.

8c. Lintels over door or window openings shall be designed to support the full weight of the masonry above plus the imposed load on the wall. They may be formed of reinforced bond-beam units filled with Class B concrete and should bear on the wall at each end not less than 1/10th of the span but at least 8 in.

8d. Window sills may be precast or cast-in-place. Window and door framing details are shown in figures 11 and 12.

8e. Flashing should be provided at projecting trim, under vertical joints in sills, and over windows. The flashing should conform with the requirements of Guide Specification CE-220.08 (see par. 13t).

8f. Methods of handling joint reinforcement at corners shall be as shown in figure 2.

8g. Methods of handling intersections of walls with columns are shown in figure 14.

8h. Weep holes in panel walls of frame structures shall be constructed as shown in figure 15.

9. MODULAR DESIGN. To the extent consistent with other requirements, masonry wall heights and lengths, sill and lintel heights, location and size of openings, and related architectural and constructural features should be dimensionally coordinated so as to minimize cutting of masonry units or the use of special fractional-size units. Modular design, based on an 8-in. module, is preferred. Mortar joints should be 3/8 in., so that a nominal 8 by 8 by 16-in. unit, for instance, would have an actual width of 7 5/8 in., a height of 7 5/8 in., and a length of 15 5/8 in.

9a. In modular design, all window and door frames will be of dimensions which are multiples of modular full or half-size units. It is preferable to locate window heads and doors in a horizontal line coinciding with the under side of a bond beam, thus eliminating separate lintels. For an 8 by 8 by 16-in. full block, for instance, both horizontal and vertical dimensions of openings should be multiples of 8 in. Where the sizes of local units differ from this, the module sizes should be adjusted accordingly. In modular design, the dimensions shown in working drawings are nominal and are from center to center of mortar joints. The designer should ascertain the availability of blocks conforming with the shrinkage requirements for the two block groups and should determine if blocks of special shapes are available.

10. ERECTION. Weathertight concrete-masonry walls are obtained by a combination of proper design, the use of good materials, and good workmanship.

10a. On delivery to the building site, units should be neatly piled free from contact with the ground, and should be covered by a tarpaulin or building paper to prevent wetting of the units prior to use. The mason should cover the top of the unfinished wall with waterproof paper upon leaving the job at night or when it rains. The contractor should provide and maintain the protection necessary to prevent the rewetting of units prior to use. The dampening of units to reduce suction during laying should be prohibited except in extremely arid regions, and then should be undertaken only with the approval of the Contracting Officer, who may permit slight dampening of the tops and bottoms of the face shells with a whitewash brush. Units which do not meet the moisture-content limitation should be set aside for further drying and should not be used until retested. Unprotected units which have been rewetted should be considered too wet unless shown by test to be otherwise.

10b. The wetness of the mortar affects the strength and watertightness of masonry joints. Mortars should have high water retentivity, and the maximum amount of mixing water should be used which is compatible with the consistency needed by the mason. When mortar has stiffened because of the loss of mixing water through evaporation, the mortar should be re-tempered. Water should be added as frequently as needed.

10c. The method of making mortar joints is important in building a watertight wall. Head joints should be carefully buttered to fill the joints tightly.

10d. Masonry walls in locations where they may be exposed to high winds are vulnerable to overturning, and during erection adequate provision should be made to prevent their being damaged by wind.

10e. Masonry shall be protected against freezing for at least 48 hours after being laid. Unless adequate precautions against freezing are taken, no masonry shall be built when the temperature is below 35° F with the temperature rising, or below 40° F with the temperature falling. No frozen materials shall be built upon.

10f. A properly laid out story rod should be used for all construction to insure accuracy of construction. Units should be cut only when unavoidable; a power saw should be used for such cutting.

10g. Reinforcement should be properly placed to insure complete coverage with mortar.

10h. Tooling of the joints should be delayed until after the mortar has begun to stiffen, and the tooling operation should not expose the joint reinforcement. Joint reinforcement that has been exposed by tooling should be covered with mortar. All cracks and openings in the wall face should be filled with mortar to the depth of the face shells.

10i. At the conclusion of the masonry work, all mortar projecting from the wall faces should be cut away with a putty knife or other tool, and all scaffolding, equipment, surplus materials, and debris should be removed.

11. PAINTING. Portland cement-water paints or grouts shall be used as base coats on the exterior faces of all above-grade concrete-masonry walls that are to be painted. The grouts shall be used on rough-textured masonry surfaces,

and the paints shall be used on smooth surfaces. The base coats may be applied at any suitable time after completion of the walls. There are certain advantages in favor or early and of late applications. An early application tends to protect the masonry against saturation by heavy and long continued wind-driven rains, thereby preventing an immediate moisture expansion and a later shrinkage of the masonry. A late application tends to seal and fill shrinkage cracks which have developed in the masonry since its completion. Pneumatically applied coatings of suitable cementitious materials may be used as alternate base coats instead of portland cement paints and grouts.

11a. Portland cement grouts used as base coats on rough-textured walls shall be either of the two kinds listed below:

(1) Job mixed grout containing 40 to 50 percent of either white or gray portland cement and 60 to 50 percent of a suitable sand aggregate. The sand aggregate shall pass a No. 24 sieve and shall otherwise be suitable for use as a concrete or masonry mortar aggregate.

(2) A paint meeting the requirements of Federal Specification TT-P-21, type II, class B (see par. 13g).

11b. Portland cement paints used as base coats on smooth-textured walls shall be either of the two kinds listed below:

(1) Either white or gray portland cement.

(2) A paint meeting the requirements of Federal Specification TT-P-21, type II, class A.

11c. Before applying the base coat, the masonry shall be clean, and all cracks or openings in the wall facing that are larger than 1/16 in. in width or diameter shall be filled with mortar or grout. The masonry shall have been wetted and shall be in a damp condition but without water showing on the surface at the time the base coat is applied. Paints and grouts shall be applied by vigorous scrubbing with brushes having stiff-fiber bristles. The base coat shall be cured by light wetting at least twice per day for two days after application.

11d. Finish coats shall be of water-cement paint and shall be applied after the base coat has hardened. The base coat provides protection against the leakage of wind-driven rain, and the time of application of the

finish coats should be selected so that weather conditions and the dryness of the base coats are suitable for the type of paint that is used. The finish coats may be expected to seal fine hairline cracks and crazing in the base coats resulting from further drying of the masonry, and application of the finish coats may therefore be delayed until such drying may have occurred.

11e. An optional method of applying a cementitious base coat in lieu of that specified above may be selected by the contractor. This consists of coating the surfaces with a mortar consisting of portland cement, a water-repellant admixture, and selected aggregates (excluding soft aggregates), applied pneumatically by spray in one continuous operation to a minimum thickness of 1/8 in. beyond the nominal face of the wall. Application shall be by a firm specializing in this type of coating. Specifications for similar but thicker cementitious facings are given in ACI Standard 805-51 (see par. 13s).

11f. Finish coats on interior surfaces may be either organic or cement-water paints. Interior surfaces should be prepared for painting in the same way as exterior surfaces.

11g. Contracting Officers and contractors are referred to the following publications for the solution of specific problems of surface preparation, paint handling and storage, and paint failures:

ACI Standard 616-49 (see par. 13r)
NBS BMS 105 "Paint Manual" (see par. 13u)
NBS BMS 110 "Paints for Exterior Masonry Walls" (see par. 13v)

12. SAMPLING AND TESTING.

12a. Except as modified herein, methods of sampling, testing, and inspecting hollow-masonry units shall be in accordance with Federal Specification SS-C-621 (see par. 13c), and methods of sampling, testing, and inspecting concrete brick shall be in accordance with Federal Specification SS-B-663 (see par. 13e). Prior to acceptance of concrete-masonry units, samples will be taken at the manufacturer's plant and tested in accordance with the above specifications.

12b. The manufacturer shall certify that concrete-masonry units delivered to the construction site will be manufactured, cured, and dried in the same manner as were

the samples on which acceptance was based. If the manufacturer is forced for any reason to alter the manufacturing, curing, or drying procedures, he shall submit in advance a written description of the proposed changes to the Contracting Officer.

12c. At least 10 days should be allowed for completion of the drying shrinkage tests. Ten individual units shall be selected from each lot of 10,000 units or fraction thereof and 20 individual units from each lot of more than 10,000 and less than 100,000 units. For lots of more than 100,000 units, 10 individual units shall be selected from each 50,000 units or fraction thereef contained in the lot. Additional specimens may be taken at the discretion of the Contracting Officer. The units selected for testing shall be of full size and shall be representative in every respect of those to be used or being used in the construction of the masonry. Units previously subjected to any of the tests which involve their being subjected to temperatures exceeding 150° F shall not be used in the drying shrinkage test. At the discretion of the Contracting Officer, bars not less than 2 in. in width and equal in length to the height of the full-sized units may be cut from the units selected for use in the drying shrinkage test.

12d. The specimens shall be prepared with suitable contacts for use in measuring their changes in length to the nearest 0.0003 in. They shall then be submerged in water at 73 ± 5° F for 48 hours, following which the initial length shall be measured. The specimens shall then be dried in a ventilated oven at 230 ± 5° F for 48 hours, after which they shall be stored for 24 hours in a vapor-tight container at 73 ± 5° F. Their lengths shall then be remeasured. The percentage drying shrinkage shall be calculated as $100 \frac{(\text{length wet} - \text{length dry})}{\text{length wet}}$.

12e. Representative samples shall be taken from the on-site stockpiles for check of moisture content. Two such checks will be made per week for each 5000 full-scale blocks. Each test will be made on at least three full-scale blocks. The tests will be performed in accordance with Federal Specification SS-C-621 or SS-B-663, or ASTM Standard C145, whichever is applicable. Units which fail to comply will be rejected in accordance with the applicable specifications, except that in the case of rejections based on field tests, the contractor shall have the option of further drying the units until on retest they are shown to comply with the moisture-content requirement.

12f. Mortars shall be tested in accordance with ASTM C270-51T (see par. 13k).

12g. Sampling and testing as above will be at the expense of the Government.

12h. The above tests and any other tests required in determining the acceptability of masonry materials should be made, insofar as possible, before said materials are incorporated in the structure.

13. REFERENCES. Codes and specifications referred to above are as follows:

13a. American Standard Building Code Requirements for Masonry (ASA American Standard A41.1-1944), National Bureau of Standards Miscellaneous Publication M174, as revised (1953).

13b. Department of the Army, Corps of Engineers, Guide Specifications for Masonry, CE-206.01.

13c. Federal Specification for Concrete Units; Masonry, Hollow, SS-C-621 (1931).

13d. American Society for Testing Materials Standard Specifications for Solid Load-Bearing Concrete Masonry Units, C145-40.

13e. Federal Specification for Brick; Concrete, SS-B-663 (1932).

13f. Underwriters' Laboratories, Inc., Standard for Concrete Masonry Units, Subject 618 (1949).

13g. Federal Specification for Paints, TT-P-21.

13h. Department of the Army, Corps of Engineers, Guide Specifications for Mortars, Masonry. CE-206.

13i. Federal Specification for Masonry Cement, SS-C-181b.

13j. American Society for Testing Materials Standard Specifications for Aggregate for Masonry Mortar, C144-44.

13k. American Society for Testing Materials Standard Specifications for Mortar for Unit Masonry, C270-51T.

13ℓ. American Society for Testing Materials Standard Specifications for Deformed Bars, A305-49.

13m. Department of the Army, Corps of Engineers, Guide Specifications for Concrete for Building Construction, CE-204.

13n. American Society for Testing Materials Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement, A82-34.

13o. American Society for Testing Materials Standard Specifications for Roofing, Asphalt, D224-50T.

13p. Federal Specification for Cement-Water Paint, Type II, TT-P-21.

13q. Department of the Army, Corps of Engineers, Guide Specification for Military Construction, Painting, General, CE-250.

13r. American Concrete Institute Standard, Recommended Practice for the Application of Portland-Cement Paint to Concrete Surfaces, 616-49.

13s. American Concrete Institute Standard, Recommended Practice for the Application of Mortar by Pneumatic Pressure, 805-51, Title 47-48.

13t. Department of the Army, Corps of Engineers, Guide Specification for Flashing, CE-220.08.

Additional references of interest are as follows:

13u. Paint Manual, National Bureau of Standards Building Materials and Structures Report BMS105 (1945).

13v. Clara Sentel, Paints for Exterior Masonry Walls, National Bureau of Standards Building Materials and Structures Report BMS110 (1947).

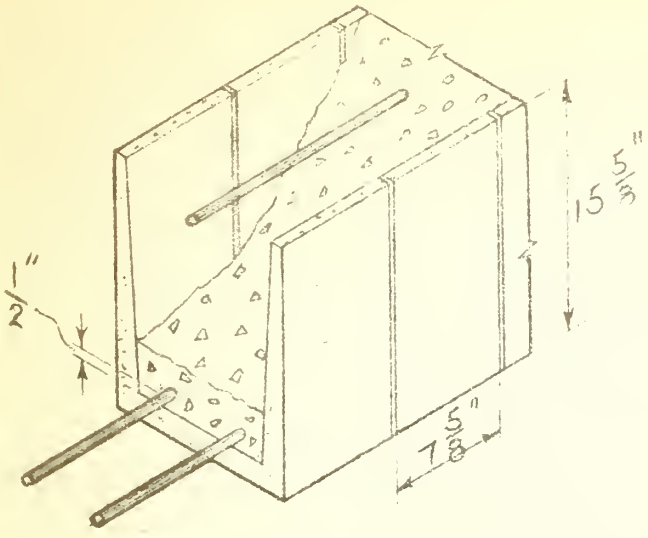
13w. British Standards for Precast Concrete Blocks, 492, 728, and 834 (1944, amended 1946).

13x. K. C. Tippy, Good Practice in Concrete Masonry Wall Construction, J. of the Amer. Concrete Inst., Vol 13, p. 317 (1942).

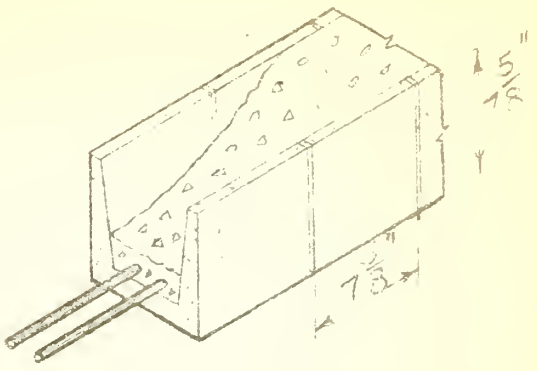
13y. R. E. Copeland, The Problem of Shrinkage Cracking, National Concrete Masonry Association, 38 So. Dearborn St., Chicago 3, Illinois (rev 1951).

13z. Concrete Masonry Handbook (1951), Portland Cement Association, 33 West Grand Ave., Chicago 10, Illinois.

LIST OF DRAWINGS



BEAM LINTEL BLOCK



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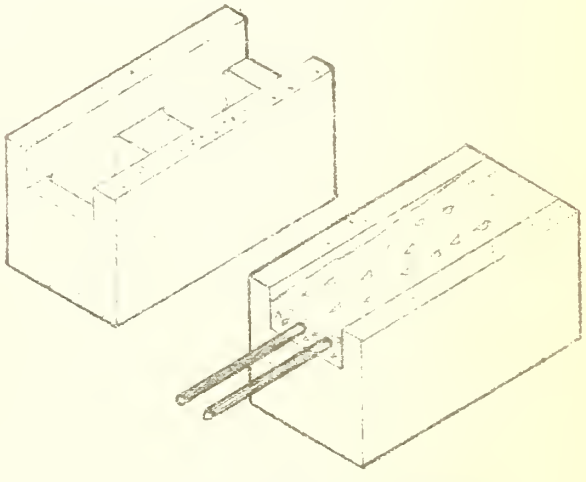
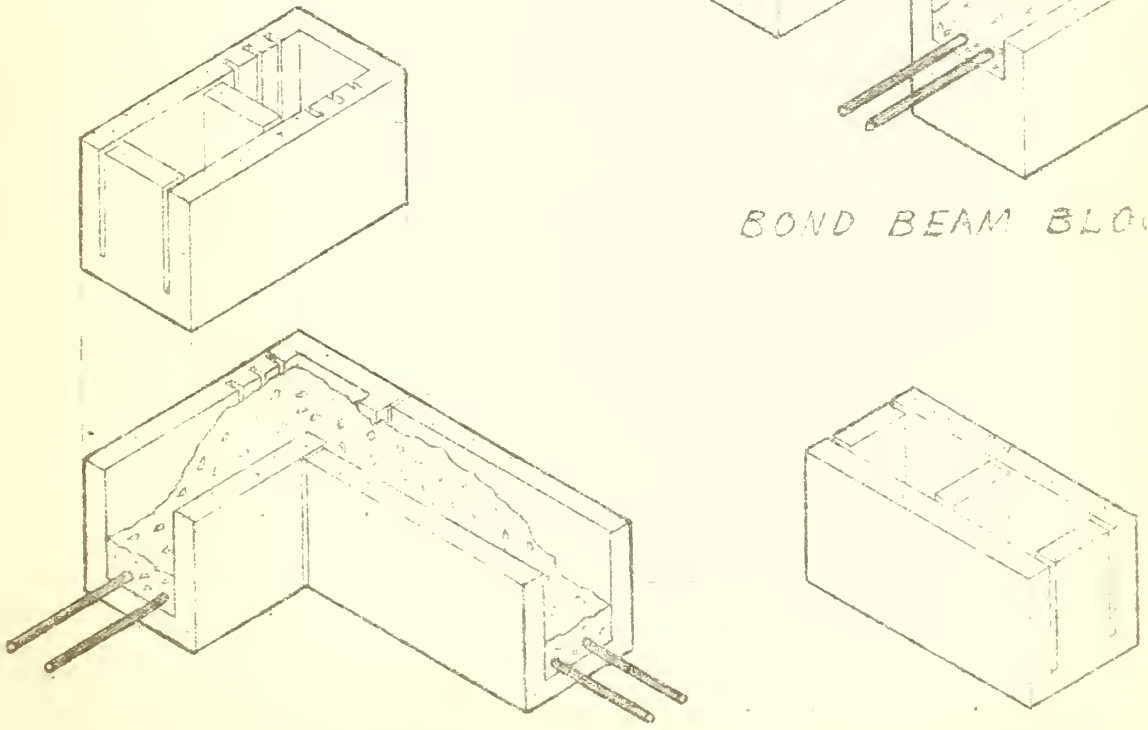


BOND BEAM BLOCK



. BOND BEAM BLOCKS AT CORNER

FIG. 1 TYPICAL BOND BEAM UNITS

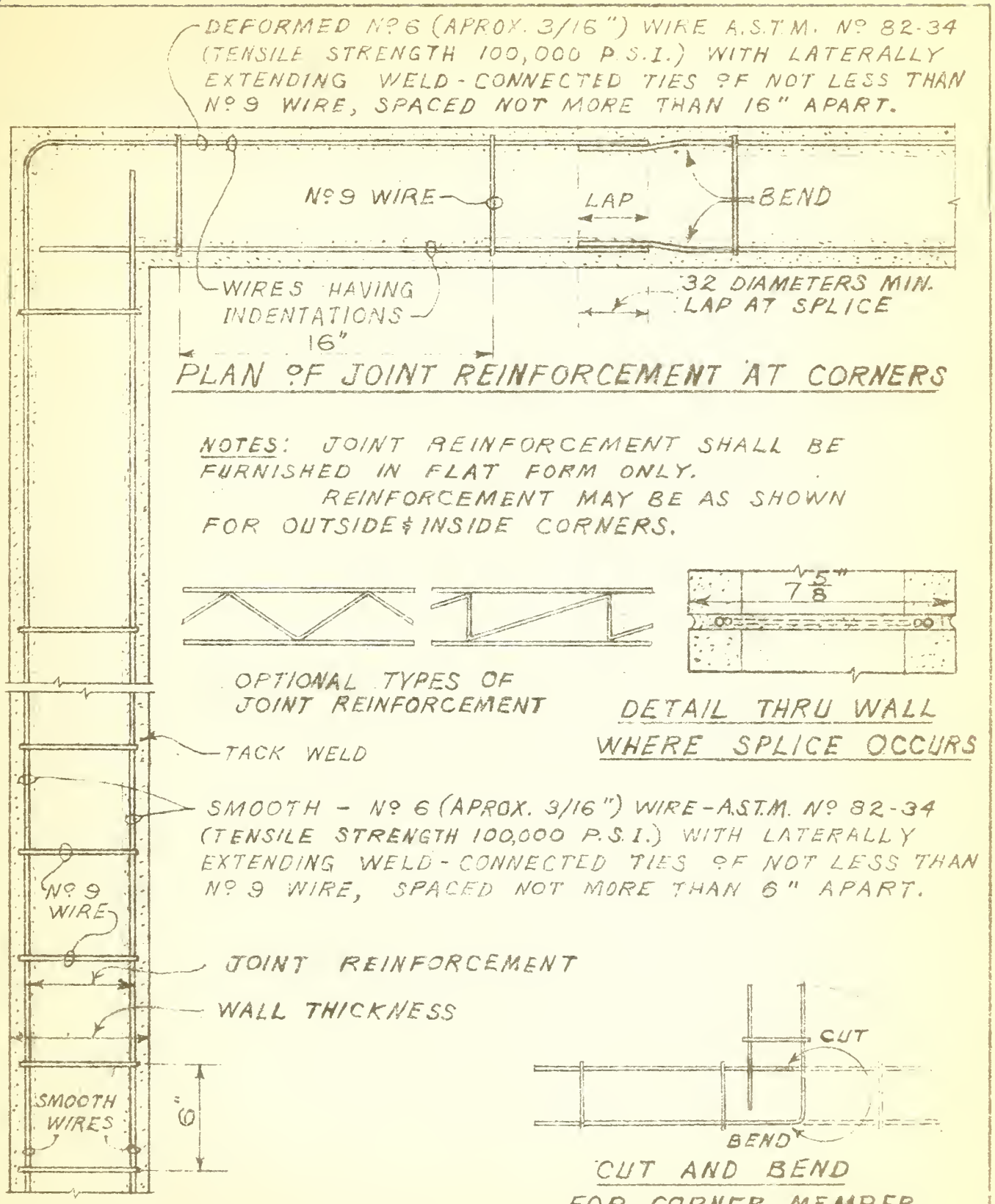


FIG. 2 PLAN OF JOINT REINFORCEMENT

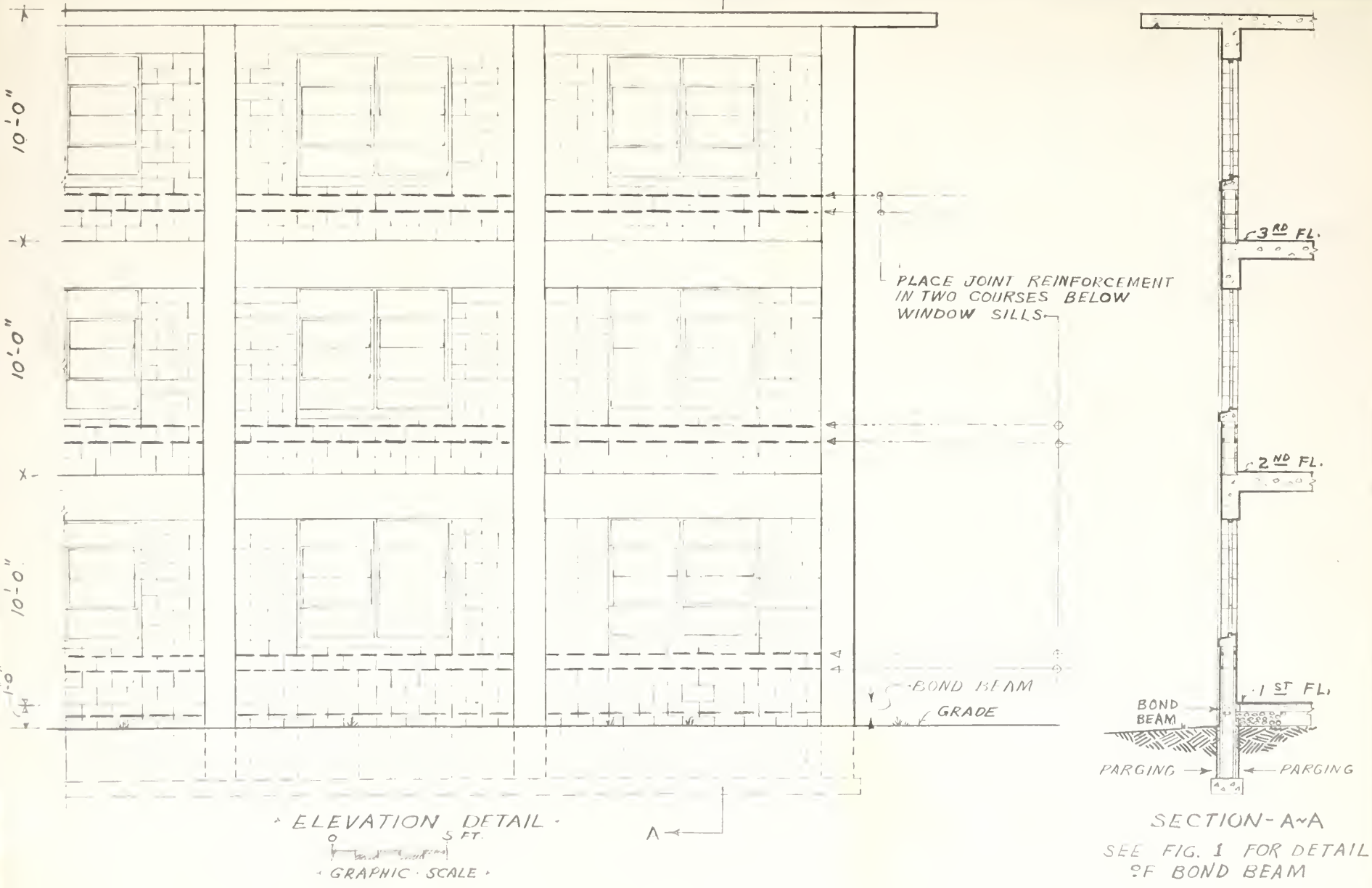


FIG. 3 NON-BEARING WALL CONSTRUCTION

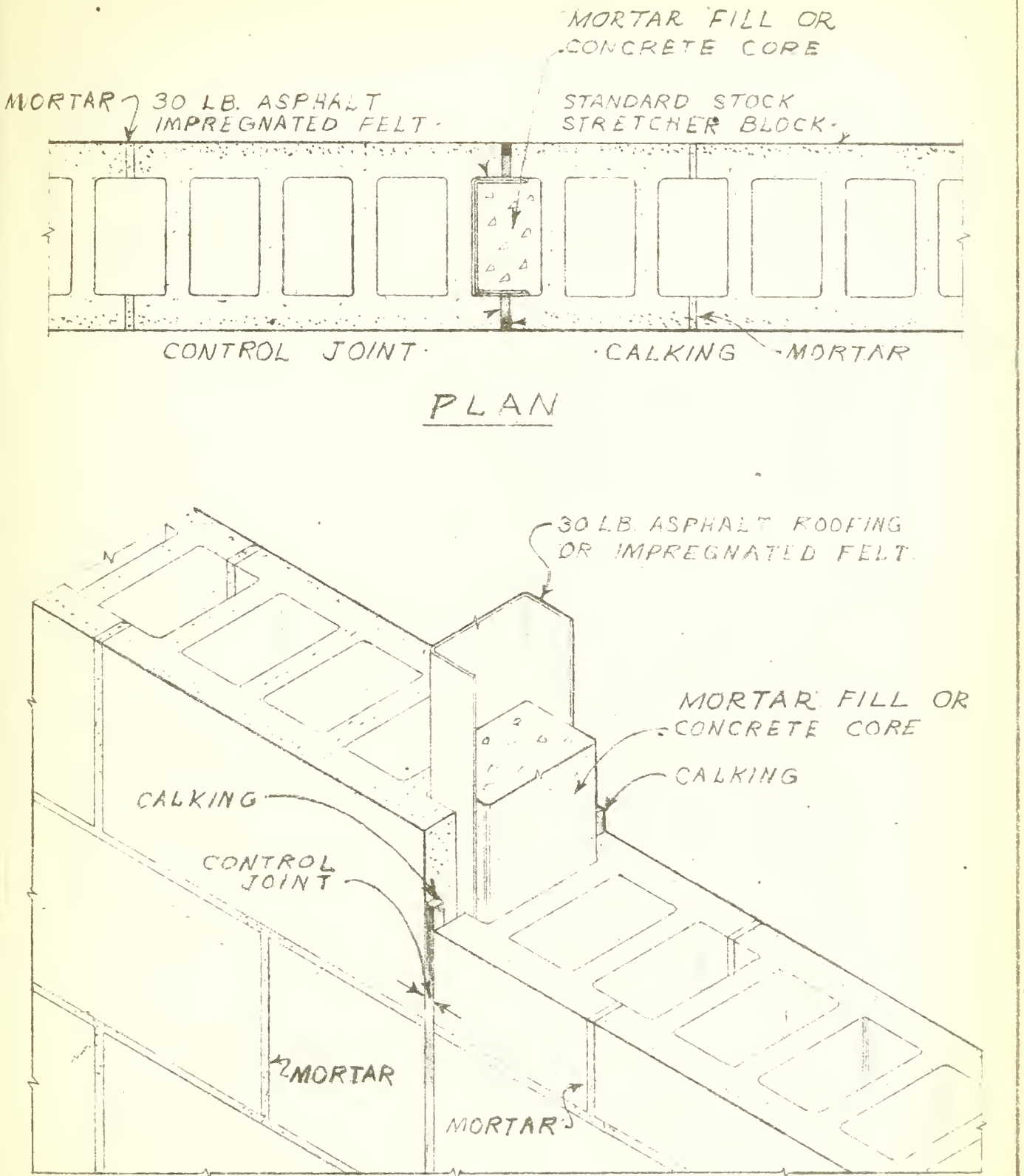


FIG. 4 TYPICAL CONTROL JOINT USING STANDARD STOCK STRETCHER BLOCK AND CONCRETE CORE.

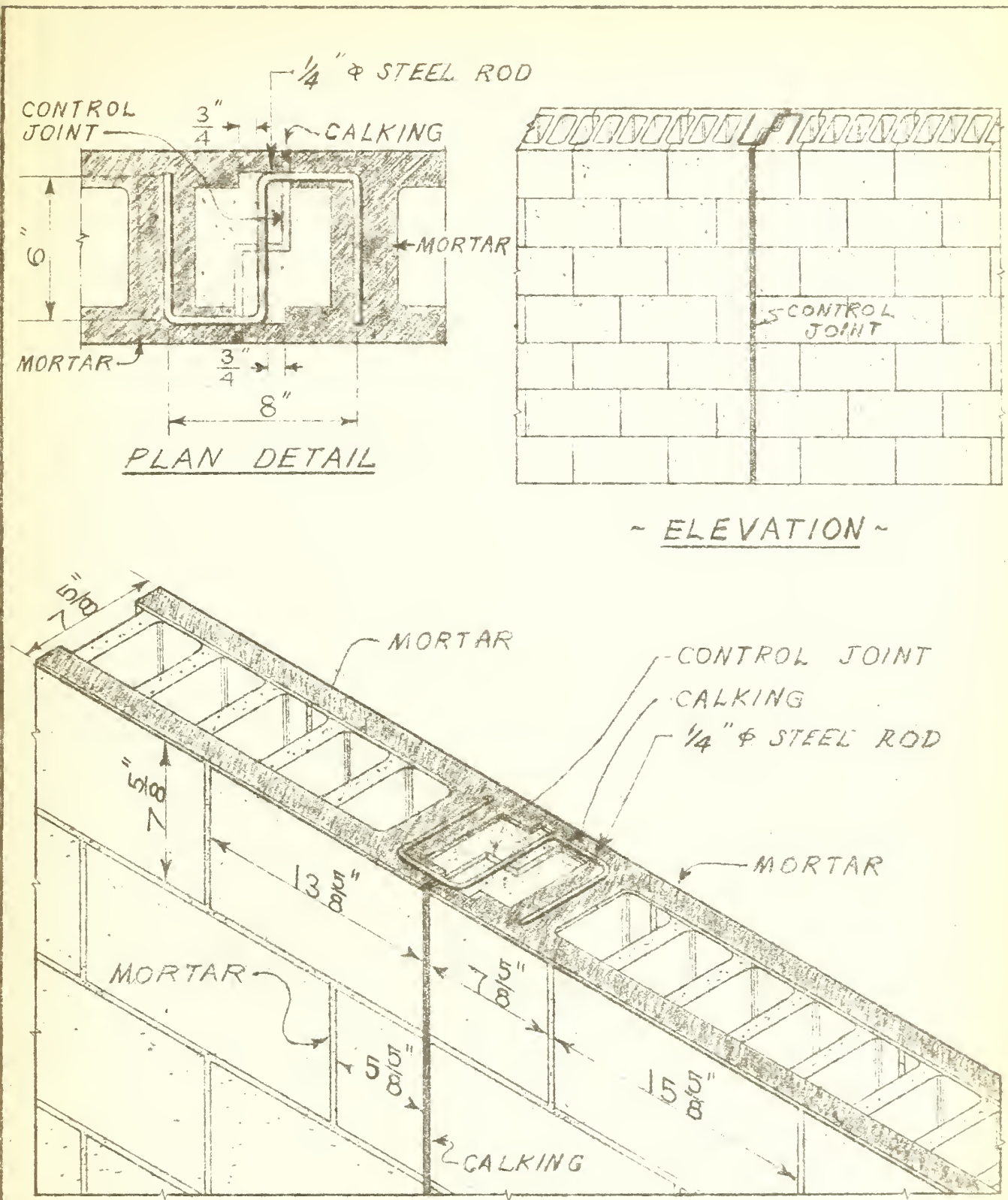
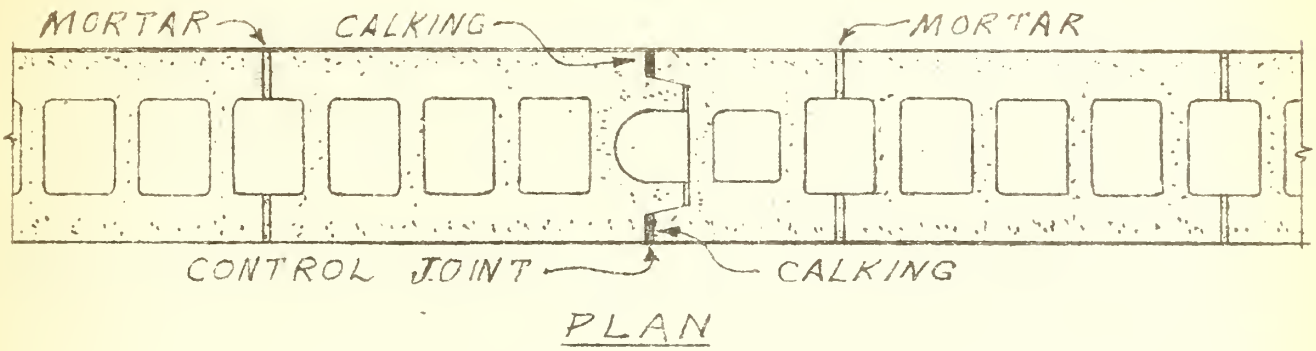


FIG. 5 TYPICAL CONTROL JOINT USING STANDARD STOCK JAMB BLOCK AND METAL TIES.



PLAN

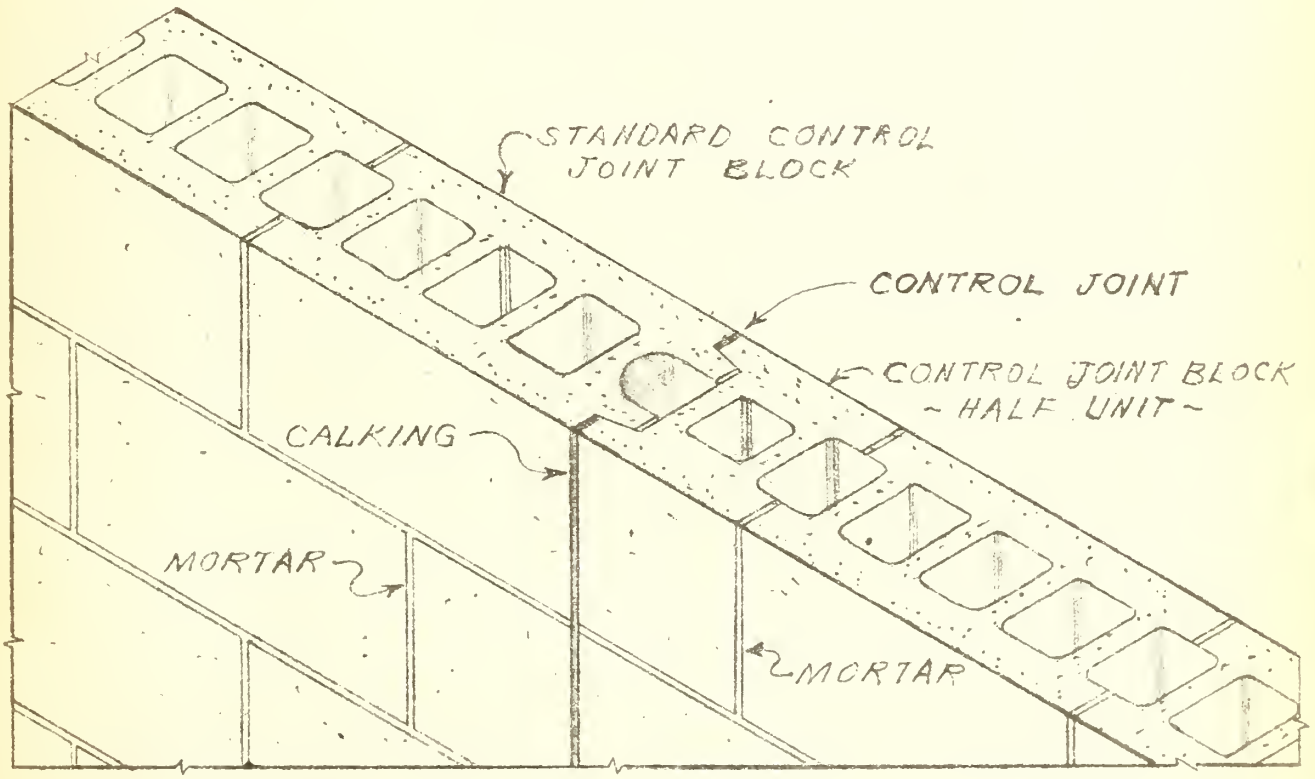


FIG. 6 TYPICAL CONTROL JOINT USING STANDARD CONTROL JOINT BLOCK

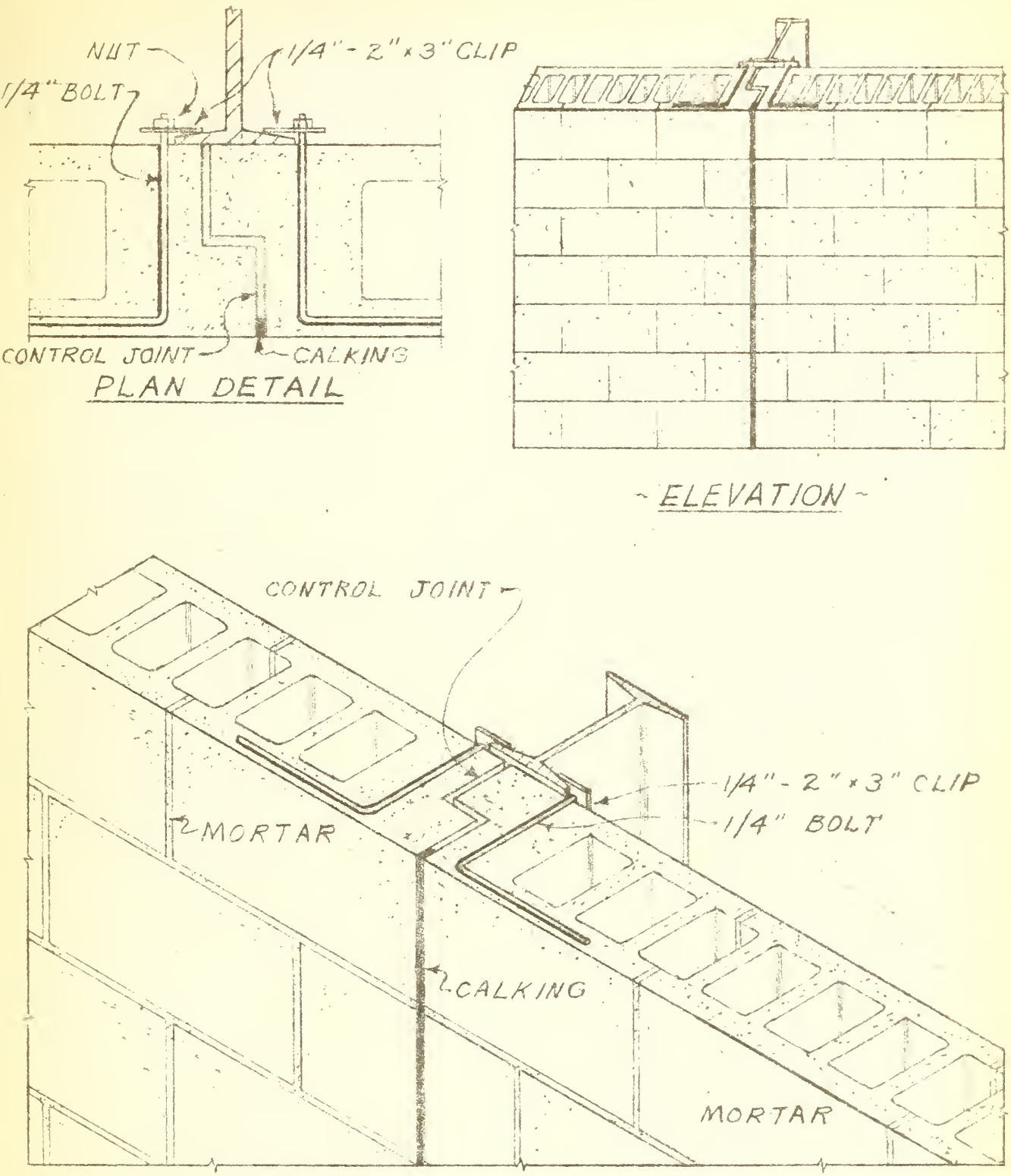


FIG. 7 TYPICAL CONTROL JOINT USING STANDARD STOCK JAMB BLOCK AND METAL CLIPS & BOLTS

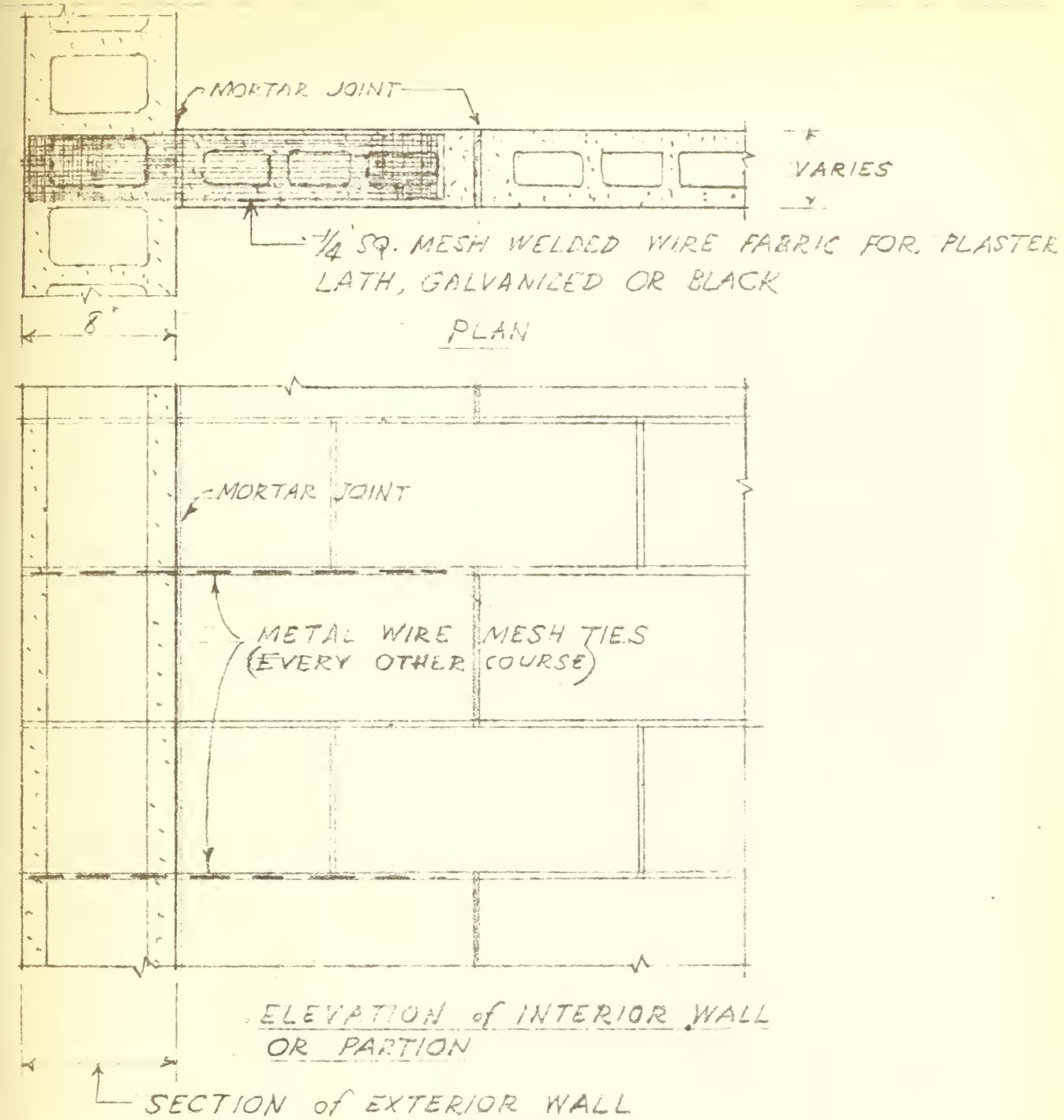


FIG 8. WALL INTERSECTION:
EXTERIOR WALL & INTERIOR PARTITION
DETAIL SHOWING WIRE MESH WALL TIES

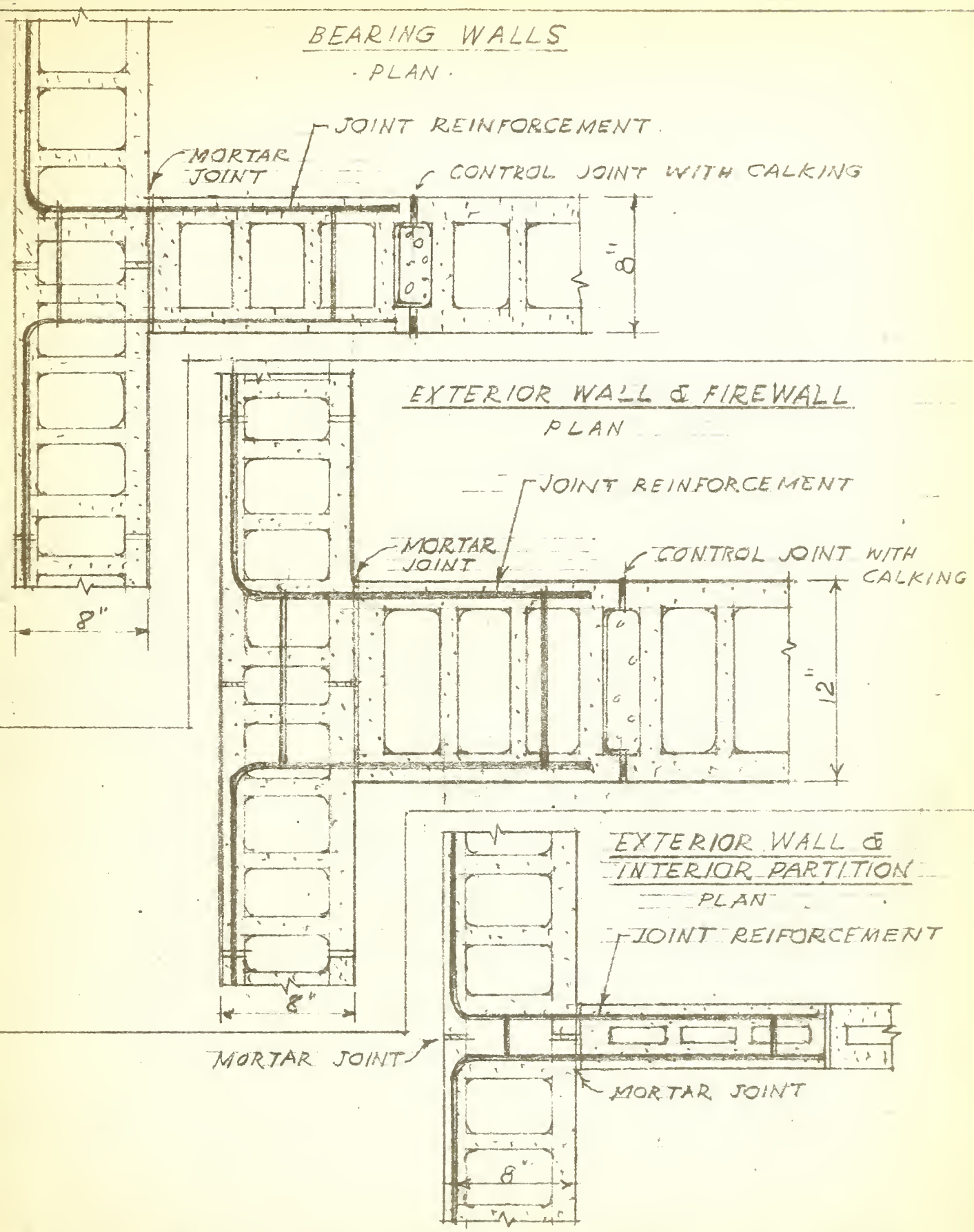
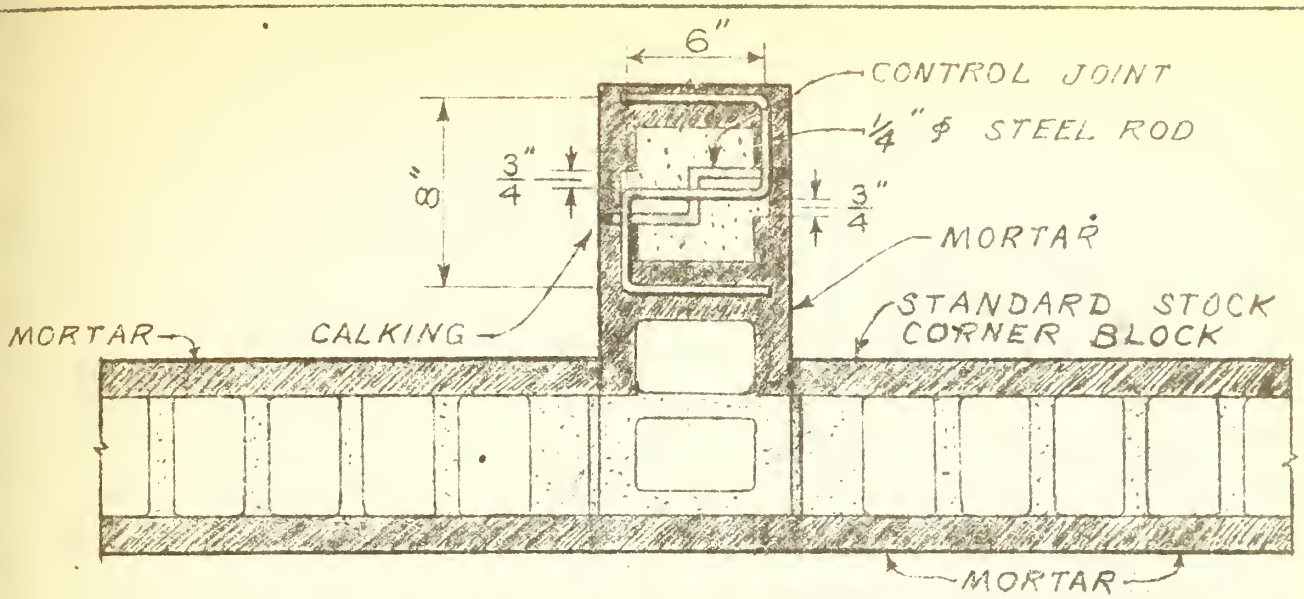


FIG. 9 WALL INTERSECTION SHOWING WIRE WALL TIES



- PLAN -

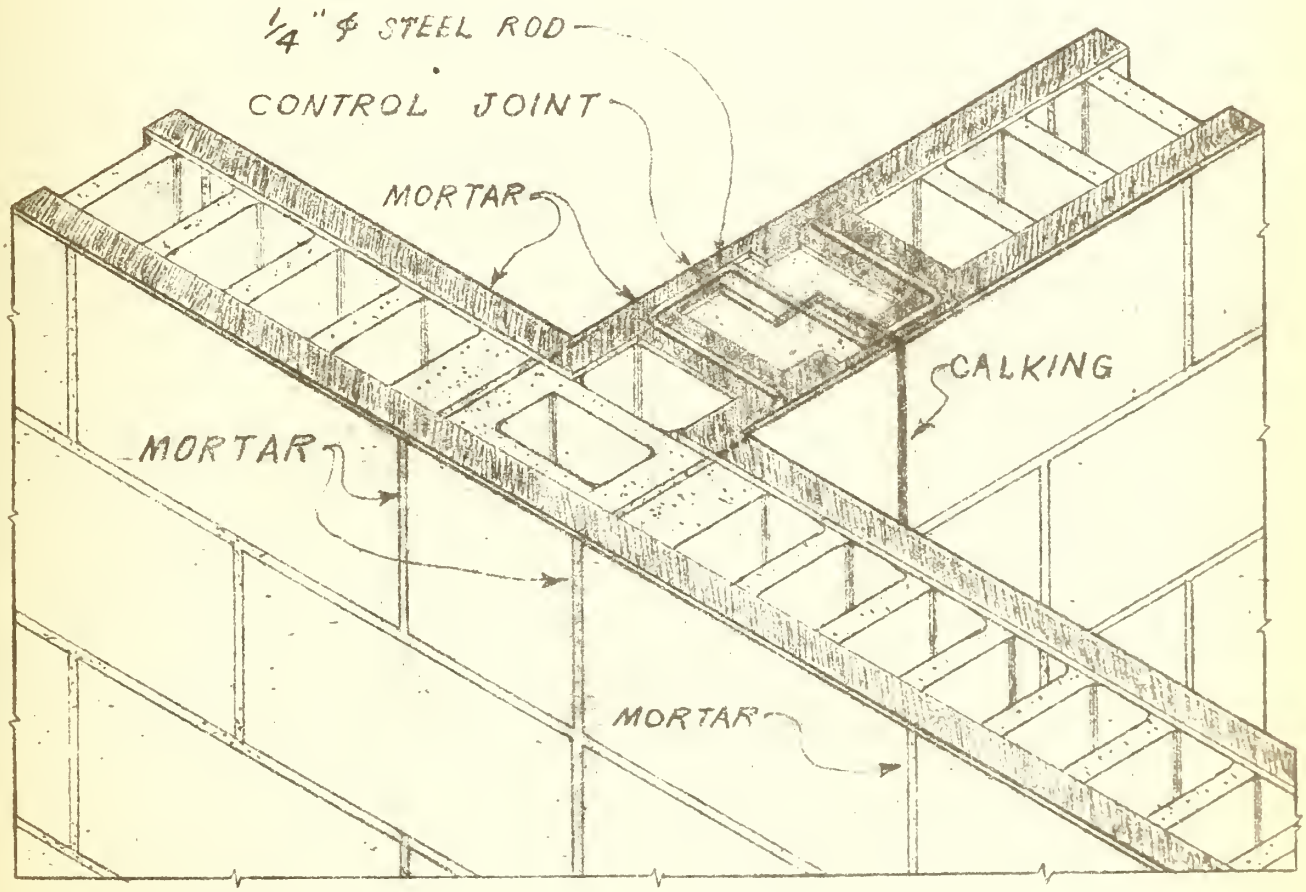


FIG. 10 INTERSECTION OF TWO BEARING WALLS.

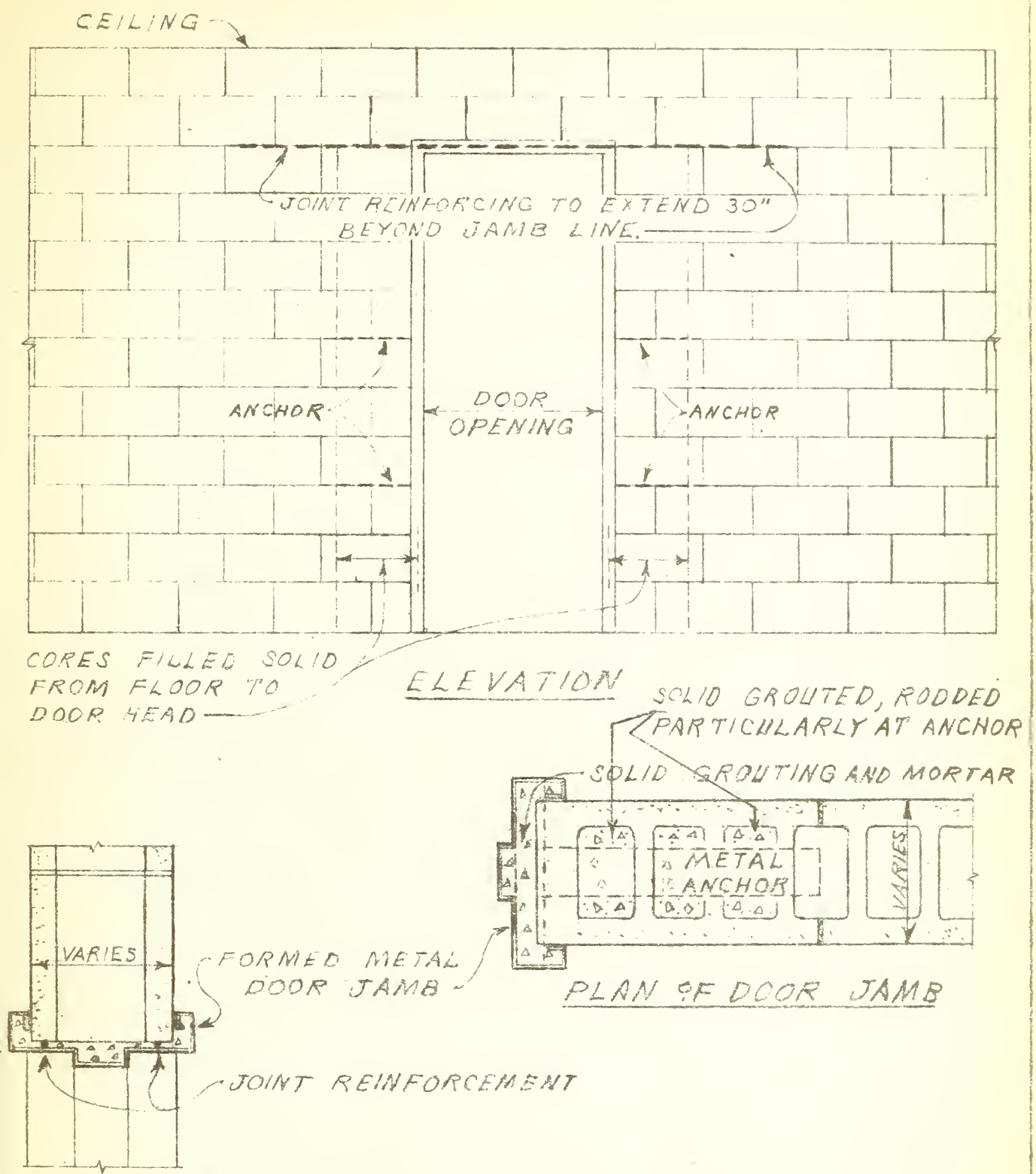
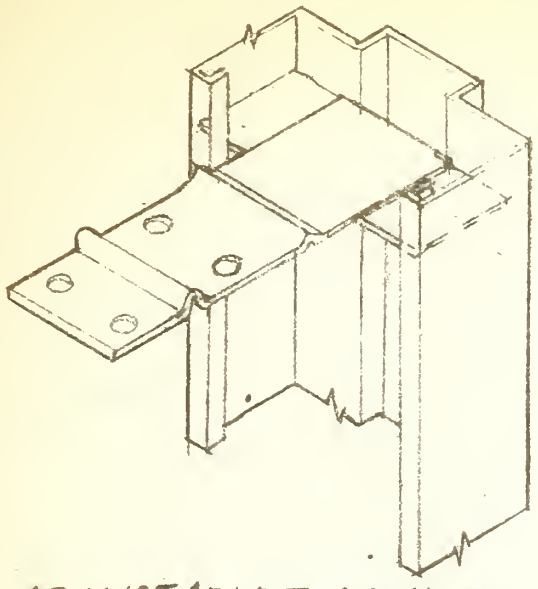
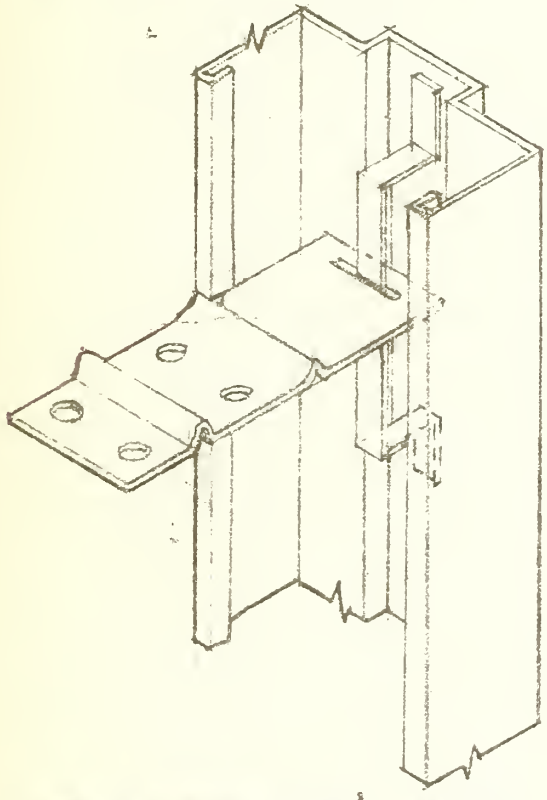


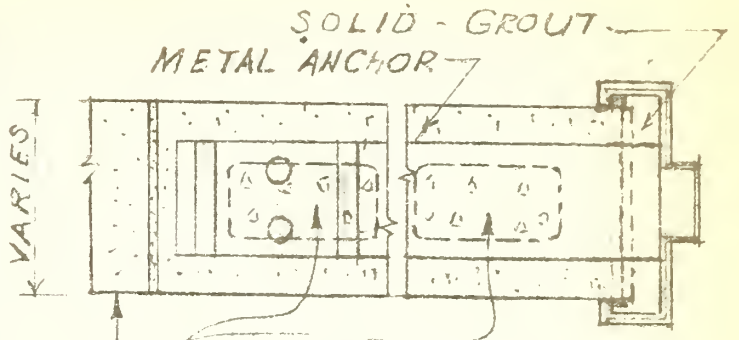
FIG. 11 – DETAIL OF TYPICAL METAL DOOR FRAME IN PARTITION.



ADJUSTABLE T-ANCHOR

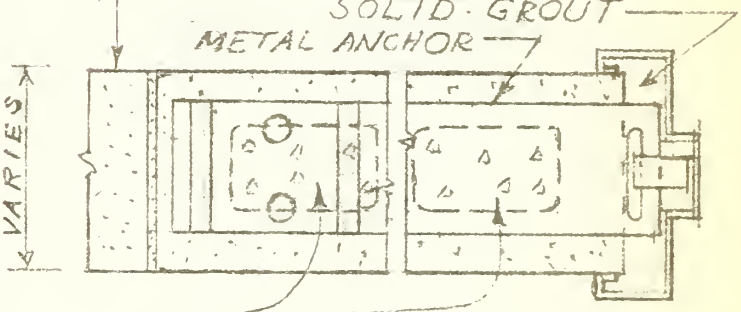


UNDERWRITER'S TYPE ANCHOR



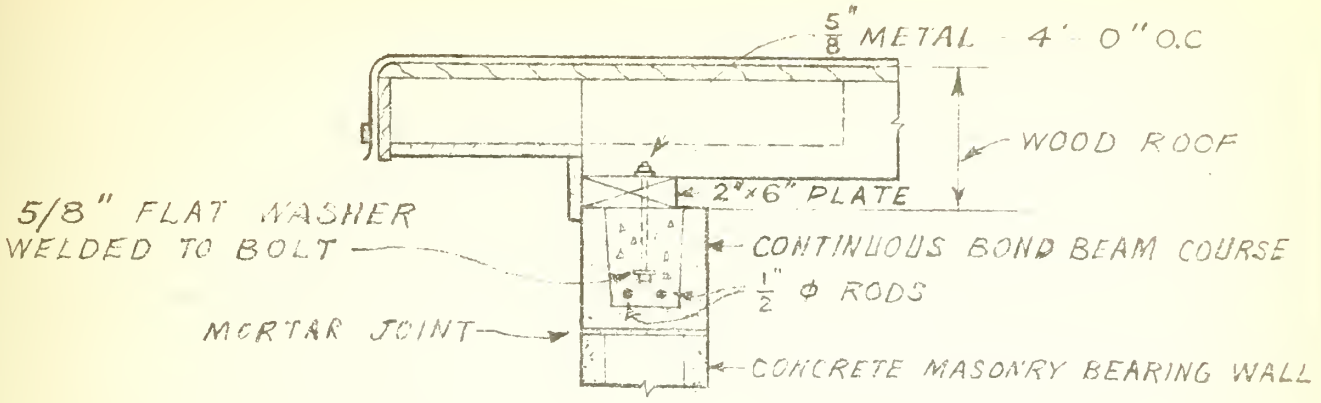
PLAN

CONCRETE MASONRY PARTITION

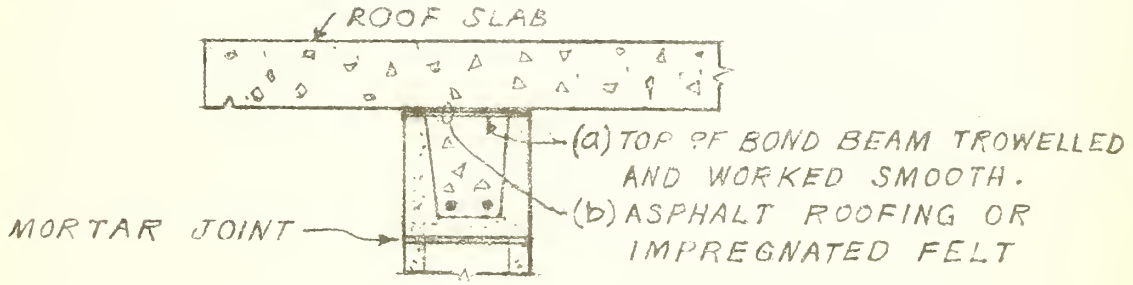


PLAN

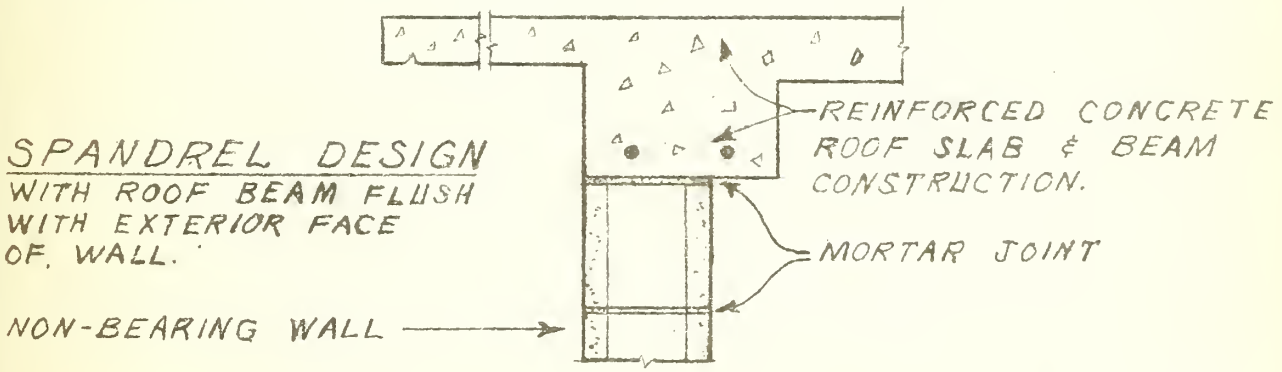
FIG 12. OPTIONAL TYPES of TYPICAL JAMB ANCHORS FOR METAL DOOR FRAMES IN INTERIOR PARTITIONS



DETAIL OF INTERSECTION OF ROOF & WALL OF ONE STORY STRUCTURE WITH BEARING WALL & WOOD ROOF.

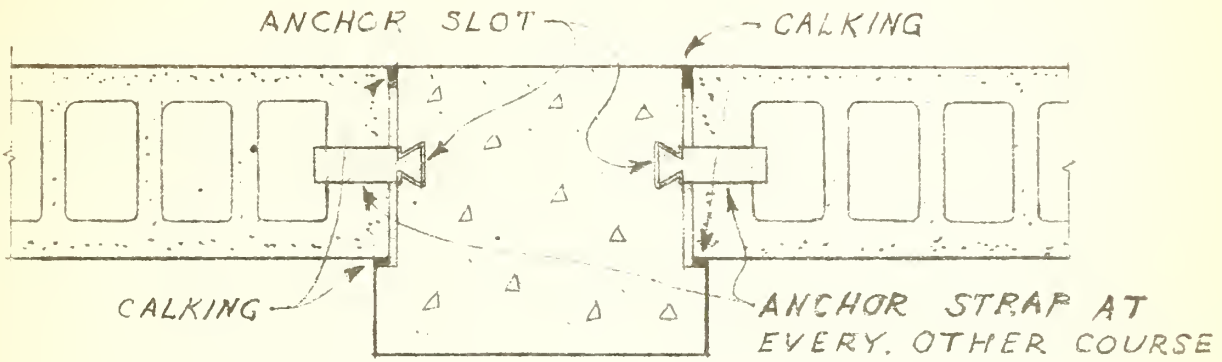


DETAIL OF INTERSECTION OF ROOF & WALL OF ONE STORY BEARING WALL STRUCTURE HAVING CONCRETE ROOF SLAB.

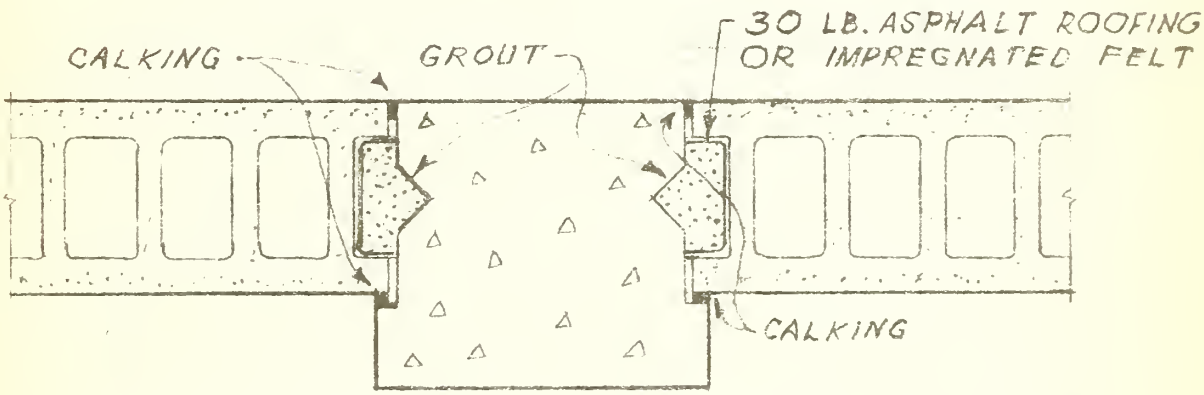


DETAIL OF INTERSECTION OF ROOF & WALL WITH NON-BEARING WALL STRUCTURE.

FIG. 13. TYPICAL DETAILS OF ROOF & WALL INTERSECTIONS.

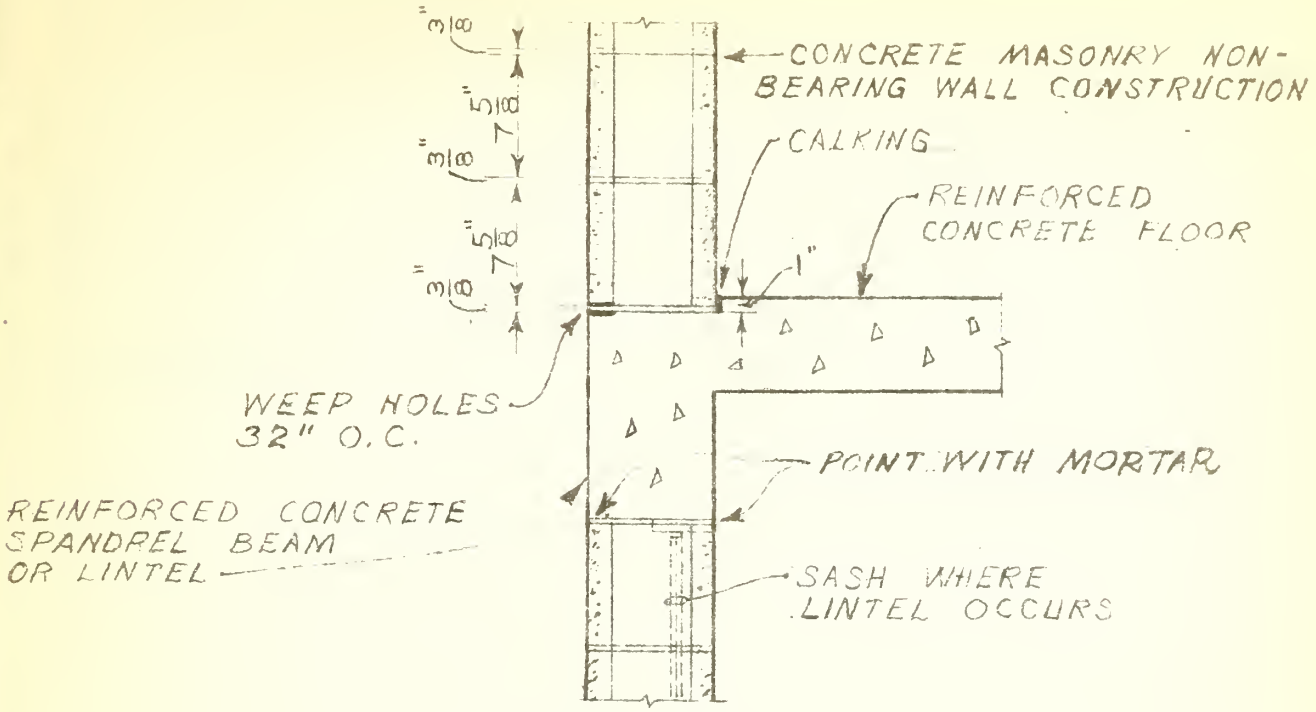


PLAN OF REINFORCED CONCRETE COLUMN
SHOWING DOVETAIL TIE.

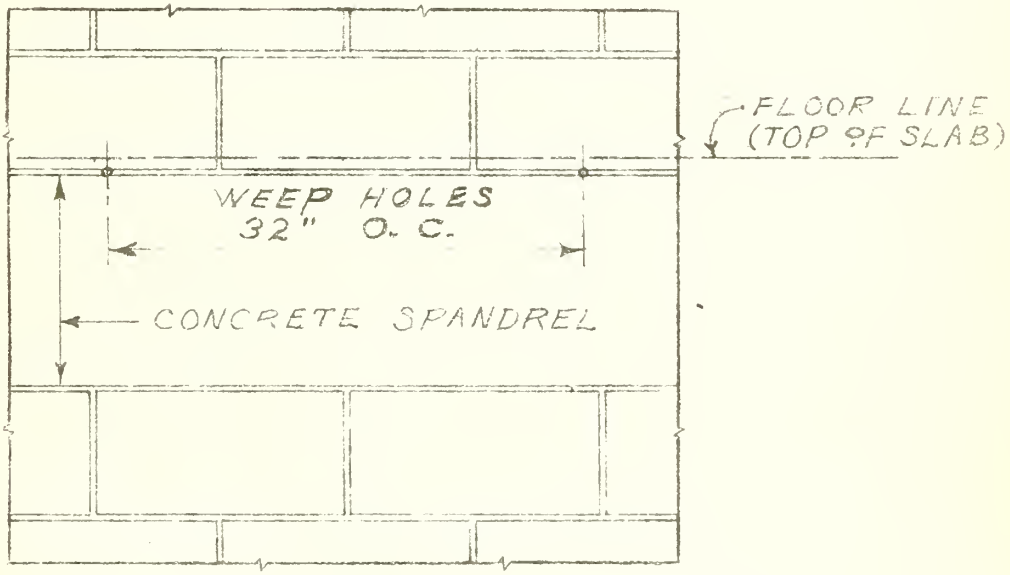


PLAN OF REINFORCED CONCRETE COLUMN
HAVING V-SHAPED DEPRESSIONS.

FIG. 14 - COLUMN AND WALL INTERSECTION.



SECTION



ELEVATION

NOTE: WEEP HOLES MAY BE FORMED BY PLACING A 12" LONG, NO. 8 (1/4" DIA.) SASH CORD OR THE SAME DIAMETER RUBBER TUBING SPACED 32" O.C. IN MORTAR JOINT. CORDS OR TUBES SHALL BE REMOVED AFTER MORTAR HAS SET.

FIG. 15 NON-BEARING-WALL CONSTRUCTION DETAIL SHOWING ARRANGEMENT OF FLOOR SLAB AND WEEP HOLES IN MORTAR JOINT AT BASE COURSE.

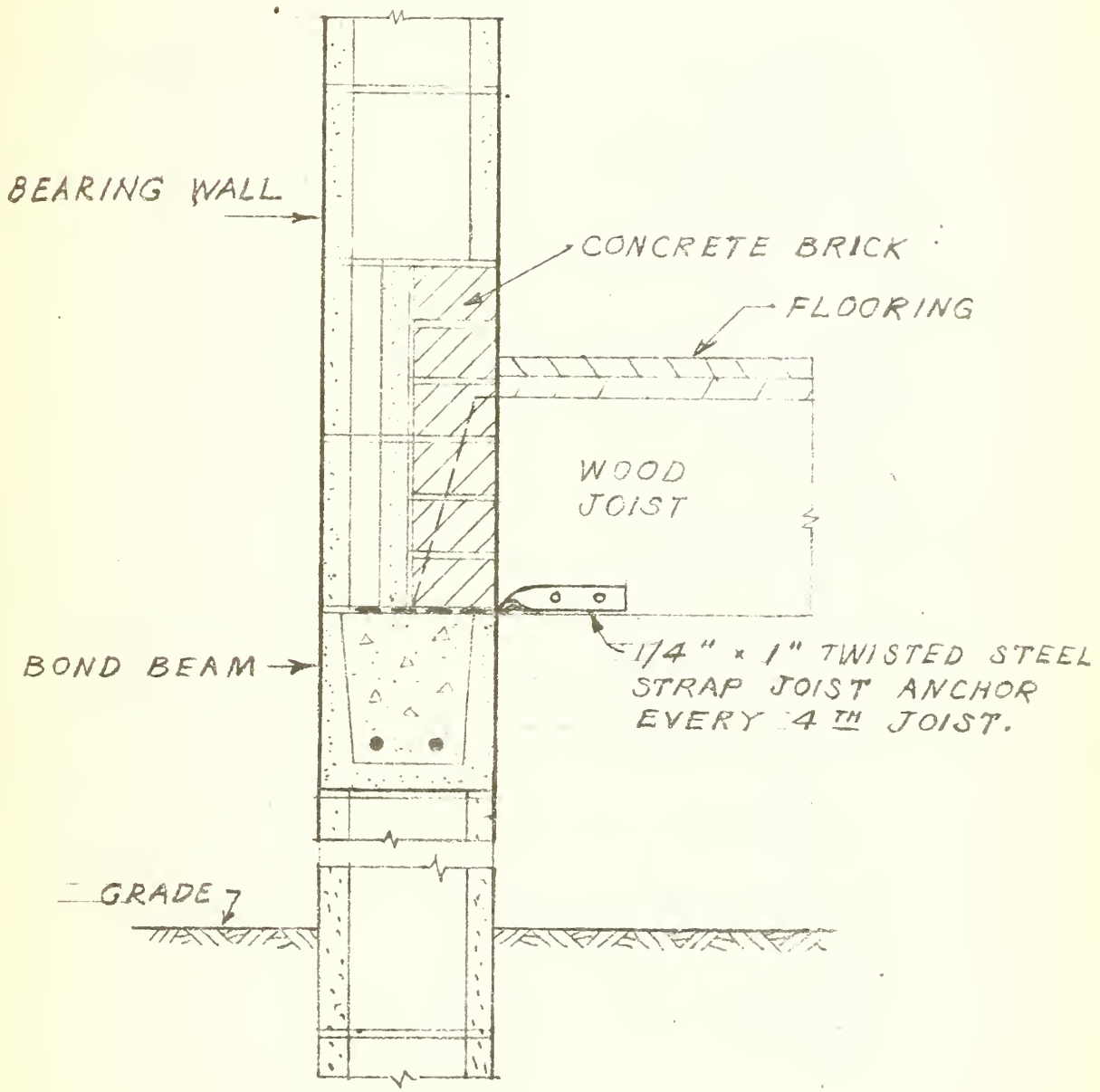


FIG. 16 TYPICAL WALL SECTION AT WOOD JOIST FLOOR

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.00). Information on calibration services and fees can be found in NBS Circular 483, Testing by the National Bureau of Standards (25 cents). Both are available from the Government Printing Office. Inquiries regarding the Bureau's reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.


NBS