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CONCRETE MASONRY UNITS

Contents

CONCRETE MASONRY UNITS

I. INTRODUCTION

The manufacture of concrete masonry units on a commercial basis is a complex, highly technical operation requiring a considerable investment in plant and equipment. The Bureau has not investigated the advantages and disadvantages of the different kinds and types of equipment used for handling materials and for molding and curing masonry units, but such information is contained in the publications listed at the end of this circular. This circular, with its list of references, is intended to answer inquiries about concrete masonry units in a more comprehensive manner than may be done by correspondence.

II. MATERIALS

1. Aggregates.

Specifications for concrete masonry units permit the use of sand, gravel, crushed stone, natural lightweight aggregate such as pumice and scoria, slag, cinders and expanded or processed materials such as slags, burned clays and shales. Aggregate meeting the requirements of Federal Specifications SS-A-281a (38) /1, and A.S.T.M. Standards C 33-46 (39) and C 130-42 (40), should be satisfactory for use in concrete masonry units. Some of the lighter aggregates have not been proved to be satisfactory for use in the manufacture of load-bearing units.

If cinders are used the A.S.T.M. Standard C 90-44 (31) for concrete units requires that the combustible content shall not exceed 35 percent by weight. Some cinders contain substances which promote staining and popping of the units. The popping rarely has a serious effect in the strength of walls made from the units, but paint applied to the wall surfaces may become badly stained and disfigured. Tests have indicated that the deleterious substances which cause pop-outs and staining of the masonry are tramp iron, hard burned lime nodules and sulphates. The Portland Cement Association has devised a simple method for testing the cinders and has proposed remedies to reduce the incidence of pop-outs and staining. (10).

2. Cements.

Both Federal and A.S.T.M. Specifications for concrete masonry units require that portland cement be used in the units. High-early strength portland cement is occasionally used to reduce the time required for curing and to meet delivery requirements of the units. The Federal Specification for portland cements is Fed. Spec. SS-C-192 (41) and the A.S.T.M. Standards are C 150-47 (42) and C 175-47T (43).

/1. The numbers in parenthesis cite references in part VI of this Letter Circular.

3. Admixtures.

Some commercial manufacturers find it advantageous to add chemicals or other materials to the concrete used in masonry units. Some of these admixtures accelerate the hydration of the cement, others act as plasticizers, and a few reduce the water absorption of the concrete.

Accelerators: Calcium chloride is chiefly used as an integral accelerator in amounts that should not exceed 2 percent of calcium chloride by weight of cement. The use of accelerators of this nature may be advantageous in plants that do not employ high temperature or steam curing of the units. The Calcium Chloride Association states in its Brief No. CB-1 (17) that the salt should be dissolved in water to make a standard solution which is added to the mix.

Plasticizers: Air-entraining agents and finely divided materials such as sand, hydrated lime, kaolin, and diatomaceous earth are some of the plasticizing materials that may be used to increase the workability and density of the concrete. The air-entraining agents are said to increase the density and strength of the units, improve the surface texture, and reduce the breakage of uncured units (15). Portland cements containing air-entraining agents are available although it may be advisable to add the plasticizer at the mixer to control the amount used.

Water Repellants: Calcium or aluminum stearates, oils, and bituminous emulsions or other water repellents may be used as admixtures in the concrete to reduce the water absorption by capillarity. These are not effective in preventing the penetration of water through walls built of the units. Tests have shown that walls of concrete masonry units are generally permeable to wind-driven rain and that much of the water penetrates the joints. To prevent rain penetration, concrete masonry walls are painted with cement-water paints or faced with stucco or brick. Joint treatments applied after the walls are built may also be of some benefit.

4. Facing materials and coatings.

Facing materials and coatings such as colored aggregates and pigments may be applied to concrete building units at the plant and may greatly enhance their appearance. However, if the units used in exterior walls are exposed to wind-driven rains, a waterproofing treatment may be needed.

Colorless surface treatments are usually ineffective as waterproofings on highly permeable masonry walls. Coatings of cement-water paints or stucco facings, widely used as waterproofings on concrete masonry walls above grade, will hide the facing applied to the units at the plant. The resistance to water penetration of joints in masonry walls is increased by wetting the units but concrete masonry units contract on drying so that unsightly and

permeable shrinkage cracks may develop in the wall if the units are laid when wet. This is the principal reason why specifications for concrete masonry limit the moisture content of the units on delivery and on laying.

Faced and coated units may, however, be suitable for use in cavity walls. In properly constructed cavity walls, any leakage through the facing wythe is diverted to the outside through weep holes, and flashings are then placed at the bottom of the cavity and over all wall openings to prevent the passage of the water into the inner wythe. Information on the water permeability of cavity type and other masonry walls, and on waterproofings for concrete masonry walls, is contained in the references (50, 53, 54, 55, 56) at the end of this Letter Circular.

III. COMMERCIAL MANUFACTURE

Usually considerable business and technical knowledge as well as capital outlay is needed to establish a successful concrete block manufacturing business. Representatives of the industry state that a new modern plant with one high-capacity block-making machine, located in a large city or industrial center, may require an investment of as much as $200,000. Information on the commercial manufacture of concrete masonry units is contained in articles published in technical magazines such as "The Concrete Manufacturer" (26), "Pit and Quarry" (27), and "Rock Products" (28). Additional information may be obtained from the National Concrete Masonry Association, 38 South Dearborn Street, Chicago 3, Illinois, the Portland Cement Association, 33 West Grand Avenue, Chicago 10, Illinois, and The American Concrete Institute, 7400 Second Boulevard, Detroit 2, Michigan.

The "Concrete Industries Yearbook" (1) contains information of especial value about the commercial manufacture of concrete units. This periodical discusses plant layout, materials, proportioning, mixing, curing, and other matters pertaining to the manufacture of concrete masonry units.

A list of manufacturers of equipment for concrete products plants (2) and copies of the report of Committee 208, "Proposed Recommended Practice for the Manufacture of Concrete Building Block and Tile," (3) may be obtained from the Portland Cement Association.

Information on materials, maufacturing, and curing concrete masonry units including specification designations is contained in part VI of this circular.

IV. REQUIREMENTS OF CONCRETE MASONRY UNITS

The building code requirements relative to the absorption and limitations of the structural use of his product may be

obtained by the block manufacturer from the building department of the city or county in which his product is used. The National Board of Fire Underwriters' Standard for Concrete Masonry Units (37) and both the Federal (30) and A.S.T.M. (31 to 36, inclusive) Specifications for concrete masonry units are listed in part VI.

V. HOMEMADE UNITS

The making of concrete masonry units by hand or with a small power-operated mixer and block machine, is a laborious operation. To insure adequate strength, more cement is required in homemade units than is used in commercial manufacture and a longer time usually is necessary for proper curing. Because of the inconvenience and extra expense in making homemade units, they are ordinarily used only if the commercial product is unobtainable. Since commercial plants manufacturing concrete masonry units are widely distributed, the limited number of units required for the construction of farm buildings and dwellings can usually be delivered at the site of the buildings.

1. Materials.

If the units are to be homemade, the aggregates should be carefully chosen and properly graded. Gravel, crushed stone, sand, and other aggregates suitable for use in structural monolithic concrete should be satisfactory. Farmers' Bulletin No. 1772 (51) gives information on this subject. Fine aggregate (sand) is usually considered to be material passing a No. 4 sieve. About 15 percent by weight of the sand should be retained on a No. 8 screen and not more than 10 percent should pass a No. 50 screen. When combinations of fine and coarse aggregates are used, the proportion of fine to coarse aggregates should be higher than that ordinarily used in structural monolithic concrete.

Portland cement is the only cementing material that should be used in making concrete masonry units. If high-early strength portland cement is used the length of time required for curing the units may be greatly reduced (14). Cement should be stored in a dry place and should be free of lumps.

2. Mixing and molding.

If the compressive strength of the cured, dry units is to be measured and checked frequently before they are used, the proportions of cement to aggregates may be determined by trial to meet the minimum strength requirements. If compressive strength tests are not to be made, the concrete should contain not less than 1 part of cement to about 3 parts of sand and 2 parts of coarse aggregate, by volume. Where no coarse aggregate, is used, the concrete should contain not less than 1 part of cement to 4 parts of sand by volume.

Wet mixtures may be poured directly into metal or wooden molds and either solid or hollow units may be made in this manner.

Nominal sizes of block are 8- by 8- by 12-in., 8- by 8- by 16-in., and 8- by 4- by 16-in. For ease in laying, the block should weigh not more than 55 lb each. Concrete block machines that make 20 or more blocks per hr are available on the market. In such machines the concrete is compacted by pressure or tamping. The consistency of the concrete depends upon the machine and must be controlled so that the units may be removed promptly from the machine and stored without damage.

3. Curing

The curing of homemade concrete masonry units is an important part of their manufacture. The units should be kept in a moist condition at temperatures above 60° F so that the hydration of the cement is continued without interruption.

The units should be thoroughly wetted at least 3 times daily for 3 days after making and should be protected from the drying effects of the sun and wind. After the third day of wetting, the units should be kept moist for one week by covering with damp straw or burlap. They should then be stored so that they may dry in air at temperatures above 55° F for at least 3 weeks (57). If high-early-strength cement is used the units may be wetted as before for 2 days only and then allowed to dry in air for at least 3 weeks.

If any doubt exists as to the strength of the units, it is essential that the compressive strength of at least a few of them be determined before the remainder are used in construction. The A.S.T.M. requirements for the minimum compressive strength of hollow load-bearing concrete units of Grade A is 1,000 lb/in^2 on the gross area of the units. This requirement applies regardless of the aggregate used in the manufacture of the block. Similarly, solid units of Grade B should have a minimum compressive strength of 1,200 lb/in^2 on the gross area.

A simple field test of the units may be made by striking them a sharp blow with a hammer. A clear ringing sound should result from the blow of the hammer and the unit should not be cracked or broken, in which case they may be considered satisfactory for most uses. However, this field test should not be construed to be an adequate method of measuring compressive strength.

VI. LITERATURE REFERENCES

Reference Number

1. Plant equipment and operation

1 Concrete Industires Yearbook. Complete Service Publishing Company, 538 South Clark Street, Chicago 5, Ill. $1.00 .

2 Manufacturers of Equipment for Concrete Products Plants Portland Cement Association, free. /2 .

3 Proposed Recommended practice for the Manufacture of Concrete Building Block and Tile. Report of Committee 708, P. M. Woodworth, Proc. Am. Conc. Inst., 27, 1001, 1931. Free copies are available from the Portland Cement Association. ACI Journal, April 1937 $1.25 /3 .

4 Tests on Concrete Masonry Units using tamping and vibration Molding Methods, K. F. Wendt and P. M. Woodworth. Proc. Am. Conc. Inst., 36, 121, (1940) /3 . Reprint 36-7 60¢ .

5 Design of Concrete Products Plants for Single or Multiple Shift Operation, Benj. Wilk, Proc. Am. Conc. Inst., 26, 498, (1930.) ACI Journal February 1930 $1.25 . /3 .

6 Operating Problems in Concrete Products Manufacture, W. H. Warford, Proc. Am. Conc. Inst., 23, 179, (1927.) Out of print. /3 .

7 Properties and Manufacture of Concrete Building Units, National Bureau of Standards Circular 304, (1926) Out of print. /4 .

8 The Use of Vibration in the Manufacture of Concrete Products, Miles N. Clair, Proc. Am. Conc. Inst., 29, 383, (1933.) ACI Journal, June 1933 $1.25 . /3 .

9 Cinders as Concrete Aggregate, Einar Christensen. Proc. Am. Conc. Inst., 27, 583, (1931.) ACI Journal, February 1931. $1.25. /3 .

10 Simple Methods for Detecting Substances in Cinders which may cause staining and pop-outs. Portland Cement Association. Free. /2 .

11 Lightweight Aggregate for Concrete. Bureau of Mines Information Circular 7195. Bureau of Mines, Washington 25, D. C. Free.

12 Building Blocks from Natural Lightweight Materials of New Mexico. Bulletin No. 25. New Mexico Bureau of Mines and Mineral Resources, Socorro, N. M. 50 cents.

13 Pumice Aggregate in New Mexico its Uses and Potentialities. Bulletin No. 28. New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico. $1.00

14 High-Early Strength Cement in Concrete Masonry Manufacture. Report of Committee 710. Benj. Wilk, Proc. Am. Conc. Inst., 33, 499, (1937.) Reprint 33-26, 35 cents. /3.

15 Air Entraining Cement in Concrete Block. H. G. Farmer, Rock Products. Jan 1945, 209. Tradepress Publishing Corp., 309 West Jackson Blvd, Chicago 6, Ill.

16 The Application of Air Entraining Agents in Concrete and Products, Henry M. Kennedy and Edward M. Brickett. Pit and Quarry, March 1946, 144. Complete Service Publishing Company, 538 S. Clark St., Chicago 5, Ill.

17 Calcium Chloride for Concrete and Cinder Blocks, Brief No. CB-1 Calcium Chloride Association, LaSalle Building, Washington 6, D. C. Free.

18 The Use of Color in Concrete, W.D.M. Allen, Proc. Am. Conc. Inst., 27, 975, (1931) ACI Journal, April 1931 $1.25. /3.

19 High Pressure Steam Curing, Progress Report Committee 716 Proc. Am. Conc. Inst. 40, 409, 144 Reprint 40-20, 35¢. /3.

20 Studies of High Pressure Steam Curing of Tamped Hollow Concrete Block, Carl A. Menzel Proc. 32, 51, (1936) ACI Journal, September-October 1935. $1.50.

21 Studies of High Pressure Steam Curing of Concrete Slabs and Beams, Carl A. Menzel, Proc. Am. Conc. Inst., 32, 621, (1936.) ACI Journal, May-June 1936, $1.50. /3.

22 Studies of High Pressure Steam Curing, J. C. Pearson and E. M. Brickett. Proc. Am. Conc. Inst., 28, 537, (1932.) ACI Journal, April 1932. $1.25. /3.

23 Some Tests of Concrete Masonry Units Cured with High Pressure Steam, P. M. Woodworth, Proc. Am. Conc. Inst., 26, 504, (1930.) ACI Journal, February 1930. $1.25. /3.

24 Drying Concrete Brick to Take Out the Shrinkage, L. E. Gruhe, Proc. Am. Conc. Inst., 24, 451, (1928.) Out of print.

25 Shrinkage Measurements of Concrete Block Masonry, W.D.M. Allen, Proc. Am. Conc. Inst., 28, 177, (1932.) ACI Journal, November 1931. $1.25. /3.

26 The Concrete Manufacturer. The Concrete Manufacturer, 540 S. Clark Street, Chicago 5, Ill.

27 Pit and Quarry. Complete Service Publishing Co., 538 S. Clark Street, Chicago 5, Illinois.

28 Rock Products. Tradepress Publishing Corp., 309 Jackson Blvd, Chicago 6, Illinois

Part II - Specifications

30 Concrete-Units, Masonry, hollow
Federal Specification SS-C-621 5¢ /4.

31 Concrete Masonry Units, Hollow Load-Bearing
A.S.T.M. Standard C 90-44 25¢ /5.

32 Concrete Masonry Units, Hollow Non-Load Bearing
A.S.T.M. Standard C 129-39 25¢ /5.

33 Concrete Masonry Units Solid Load-Bearing
A.S.T.M. Standard C 145-40 25¢ /5.

34 Concrete Masonry Units for Construction of Catch-Basins and Manholes. A.S.T.M. Standard C 139-39 25¢ /5.

35 Concrete Building Brick
A.S.T.M. Standard C 55-37 25¢ /5.

36 Sampling and Testing Concrete Masonry Units
A.S.T.M. Standard C 140-39 25¢ /5.

37 Standard for Concrete Masonry Units, Underwriters' Laboratories Inc., Subject 618 Underwriters' Laboratories Inc., 207 East Ohio Street, Chicago 11, Ill.

38 Aggregate (for) Portland Cement Concrete
Federal Specification SS-A-281a 5¢. /4.

39 Concrete Aggregate
A.S.T.M. Standard C 33-46 25¢. /5.

40 Lightweight Aggregates for Concrete
A.S.T.M. Standard C 130-42 25¢ /5.

41 Cements, Portland
Federal Specification SS-C-192 5¢ /4.
Type I For Use in General Concrete Construction
Type I-A Air-Entraining Cement
Type III For use where high-early-strength is required
Type III-A Air-entraining cement for the same use as Type III.

42 Portland Cement
A.S.T.M. Standard C 150-47 25¢ /5.
Type I For Use in General Concrete Construction
Type III For Use when high-early-strength is required.

43 Air-Entraining Portland Cement
A.S.T.M. Standard C 175-47 T 25¢ /5.
Type I Shall correspond to Type I of Standard C 150-47 (above).

44 Calcium Chloride
A.S.T.M. Standard D-98-46T 25¢ /5.

Part 3 - Miscellaneous

50 Dampness in Masonry Walls above Grade, LC865, National Bureau of Standards, Washington 25, D. C. free.

51 Use of Concrete on the Farm, Farmers' Bulletin 1772 10¢ /4.

52 Facts about Concrete Masonry, National Concrete Masonry Association, 38 S. Dearborn Street, Chicago 3, Ill.

53 Water Permeability of Walls Built of Masonry Units. Report BMS82 20¢ /4.

54 Water Permeability and Weathering Resistance of Stucco-faced, Gunite Faced and 'Knap-Concrete-Unit' Walls. Report BMS94, 10¢ /4.

55 Tests of the Resistance to Rain Penetration of Walls Built of Masonry Units, R. E. Copeland and C. C. Carlson, Proc. Am. Conc. Inst., 36, 169, 1940. Reprint 36-9, 60¢ /3.

56 Tests of Cement-Water Paints and Other Waterproofings for Unit-Masonry Walls. Report BMS95 25¢ /4.

57 Good Practice in Concrete Masonry Wall Construction. Kenneth C. Tippy. Proc. Am. Conc. Inst., 38, 317, 1942. Reprint 38-22 35¢.

Footnotes

/2 The address of the Portland Cement Association is 33 West Grand Avenue, Chicago 10, Illinois. Publications may also be available at the branch offices of the Association.

/3 Copies may be obtained from the American Concrete Institute, 7400 Second Boulevard, Detroit 2, Michigan at the prices stated. Reference No. 4 also contains information on the proportioning of a variety of aggregates.

/4 Copies may be obtained from the Superintendent of Documents Government Printing Office, Washington 25, D. C. at the prices stated. Publications that are out of print are not available for distribution but may be consulted at technical and public libraries.

/5 Copies may be obtained from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., at the prices stated.