Technical Notes 24F - The Contemporary Bearing Wall - Construction
[Nov./Dec. 1974] (Reissued Sept. 1988)

INTRODUCTION

The Contemporary Bearing Wall concept as conceived and being applied today is based upon rational engineering design. This concept requires floors and walls to work together as a system, each giving support to the other. A building of high strength, in which the structure provides finish, closure, partition, sound control and fire resistance, is thereby provided. In order to achieve this end, it is necessary that proper attention be given to design details and construction procedures. It is of utmost importance that constructors follow the plans and specifications of the designers.

Attention to detail and requirements for high quality materials and workmanship have not deterred the rapid acceptance and application of the Contemporary Bearing Wall concept. Numerous cases can be cited where bearing wall buildings have been built faster than scheduled or anticipated, and, in many cases, these buildings have been built at less than the estimated cost of alternate designs utilizing other materials and structural systems.

SPECIAL REQUIREMENTS

The design of these buildings may be based upon the *Building Code Requirements for Engineered Brick Masonry,* SCPI (BIA), August 1969, which contains various additional construction requirements not required by most other modern building codes. The following sections relating to both materials and workmanship are specifically called to the attention of the reader:

1.1 SCOPE

1.1.1 General This standard provides minimum requirements for the design and construction of brick masonry of solid masonry units, both plain (non-reinforced) and reinforced. It does not include requirements for construction using hollow masonry units nor requirements for fire protection.

1.1.2 Analysis The design of brick masonry shall be based on a general structural analysis and the requirements of this standard.

1.1.3 Special Structures For arches, garden walls, retaining walls, tanks, reservoirs and chimneys, the provisions of this standard shall govern so far as they are applicable.

1.2 PERMITS AND DRAWINGS

1.2.1 Copies of structural drawings and typical details showing the sizes and position of all structural members, steel reinforcement, design strengths, and live loads used in the design shall be filed with the building department before a permit to construct such work shall be issued. Calculations pertaining to the design shall be filed with the drawings when required by the building official.

1.3 INSPECTION

1.3.1 With Inspection When the design of brick masonry is based on the allowable stresses and other values given in Tables 1, 2, 3, 4 and 5 for "With Inspection", the construction shall be inspected by an engineer or architect, preferably the one responsible for the design, or by a competent representative responsible to him. Such inspection shall be of a nature as to determine, in general, that the construction and workmanship are in accordance with the contract drawings and specifications.

1.3.2 Without Inspection When there is no engineering or architectural inspection as specified in Section 1.3.1, the allowable stresses and other values given in Tables 1, 2, 3, 4 and 5 for "Without Inspection" shall be used.

2.2.1 Brick

2.2.1.1 Brick and Solid Clay or Shale Masonry Units Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale), ASTM C 62, or Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale), ASTM C 216.

2.2.1.2 Grades and Types Brick subject to the action of weather or soil, but not subject to frost action when permeated with water, shall be of grade MW or grade SW, and where subject to temperature below freezing while in contact with soil shall be grade SW. Brick used in loadbearing or shear walls shall comply with the dimension and distortion tolerances specified for type FBS of ASTM C 216. Where such brick do not comply with these tolerance requirements, the compressive strength of brick masonry shall be determined by prism tests. (See Section 4.2.2.1.)

2.2.1.3 Used Brick Used or salvaged brick shall not be permitted under the provisions of this standard.

2.2.2 Mortar and Grout

2.2.2.1 Non-Reinforced Brick Masonry Mortar for use in non-reinforced brick masonry shall conform to Standard Specification for Mortar for Unit Masonry, ASTM C 270, types M, S or N. except that it shall consist of a mixture of portland cement (type I, II or III), hydrated lime (type S) and aggregate where values given in Tables 1, 2 and 3 are used.

2.2.2.2 Reinforced Brick Masonry Mortar and grout for use in reinforced brick masonry shall conform to Standard Specification for Mortar and Grout for Reinforced Masonry, ASTM C 476, except that mortar shall consist of a mixture of portland cement (type I, II or III), hydrated lime (type S) and aggregate where values given in Tables 2 and 4 are used.

2.2.2.3 Air-entraining admixtures or hydrated lime containing air-entraining admixtures shall not be used in mortar.

2.2.2.4 Calcium chloride or admixtures containing calcium chloride shall not be used in mortar or grout in which reinforcement, metal ties or anchors are embedded.

2.2.2.5 Other mortars not specified in Sections 2.2.2.1 and 2.2.2.2 may be used when approved by the building of official, provided strengths for such masonry construction are established by tests made in accordance with Section 4.2.2.1 and Standard Methods of Conducting Strength Tests of Panels for Building Construction, ASTM E 72.

5.2.1 Mortar Joints All brick shall be laid with full head and bed joints and all interior joints that are designed to receive mortar shall be filled. (See Section 5.8.3.) The average thickness of head and bed joints shall not exceed 1/2 inch.

5.2.3 Tolerances for Brick Masonry Construction Based on Actual Dimensions

5.2.3.1 Variation from the Plumb

(1) In the lines and surfaces of columns, walls and arrises: in 10 feet-1/4 inch; in any story or 20 feet maximum-3/8 S inch; in 40 feet or more-1/2 inch.(2) For external corners, expansion joints and other conspicuous lines: in any story or 20 feet maximum-1/4 inch; in 40 feet or more-1/2 inch.

5.2.3.2 Variation from the Level or the Grades Indicated on the Drawings

(1) For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines: In any bay or 20 feet maximum-1/2 inch; in 40 feet or more-3/4 inch.

5.2.3.3 Variation of the Linear Building Lines from Established Position in Plan and Related Portion of Columns, Walls and Partitions

(1) In any bay or 20 feet maximum-1/2 inch; in 40 feet or more-3/4 inch.

5.2.3.4 Variation in Cross-Sectional Dimensions of Columns and in the Thickness of Walls

(1) Minus 1/4 inch; plus 1/2 inch.

5.9 CHASES AND RECESSES

5.9.1 Chases and recesses shall be considered in the structural design and detailed on the building plans. Chases not shown on the plans shall be permitted only when approved in writing by the structural engineer and the building official.

EXPERIENCE AND EXAMPLES

Pennley Park. This complex of eight buildings was one of the first major U.S. projects utilizing rationally designed brick bearing walls as a major structural system, (Fig. 1). The cost was approximately $4,500,000 or $13.89 per sq ft of floor area including architectural and engineering fees, soil analysis and site work. The project was scheduled for 21 months of construction; it started May 1, 1964 and 12 months later was 98 per cent completed. The bearing wall structural system resulted in approximately a 10 percent savings of the cost over a structural steel frame alternate. Included in this savings of approximately $420,000 was $69,000 for fireproofing of the steel frame. Tenants occupied some of the buildings seven months after the start of construction. The construction superintendent of the project, Mr. A. M. DiFerio, attributed this low cost and speed of construction to a number of reasons, including the simplicity of construction, the use of fewer cranes and other heavy construction equipment, and a simple spread footing, which was used in lieu of caissons.

Pennley Park North, Pittsburgh, Pennsylvania

Tasso G. Katselas, Architect; R.M. Gensert, Structural Engineer

FIG. 1

Penn Plaza. This project, quite similar to the above, consists of six buildings, (see Fig. 2). The masonry contractor for this project, Charles L. Cost, stated that his men "enclosed a floor every two and a half days and the masons worked fast and efficiently. They were very enthusiastic about this construction. We went on the job with very little advance notice, and with more planning time we could have finished the masonry work in seventy-four working days, rather than ninety-four working days actually required." The cost per square foot of the Penn Plaza project was $13.15.

Penn Plaza, Pittsburgh, Pennsylvania

Tasso G. Katselas, Architect; R.M. Gensert, Structural Engineer

FIG. 2

Oakcrest Towers. Oakcrest Towers is a series of 14 apartment buildings, eight stories in height, being constructed on a 50-acre site outside of Washington, D. C., (Fig. 3). Each building contains a total of 161,334 sq ft. In good weather, the contractors report construction of one story per week. Mr. Stanley Reed, Vice-President of L. F. Jennings Inc., the masonry contractor for Oakcrest Towers, said that, in their experience, bearing wall buildings were built faster than structural frame buildings and, typically, the time required to complete a bearing wall building and have it ready for occupancy was approximately equal to the time required to erect the structural frame and enclose the frame with masonry walls for a project of similar scope. Mr. Reed reported that savings on the Oakcrest buildings resulted from lower initial cost for bearing wall than for structural frame construction, and elimination of finishing and painting of interior exposed brick walls.

Oakcrest Towers, Prince Georges County, Maryland

Bucher-Meyers & Associates, Architects; Keller & Marchigiani, Structural Engineers

FIG. 3

Some bearing wall thicknesses in the first buildings were in excess of 20 in. in thickness. Buildings built after the SCPI (BIA) standard was introduced had thicknesses reduced to 8 and 6 in. of brick masonry for exterior and corridor walls, respectively.

Park Lane Towers. Park Lane Towers is a group of 20-story structures located in Denver, Colorado, (Fig. 4). Each building is 206 ft high containing 38 one-bedroom, 73 two-bedroom, 4 three-bedroom units and one penthouse. Fireplaces are featured in the two and three-bedroom units beginning at the 15th floor.

Ground breaking for Park Lane Towers No. 1 began in May of 1969. The masonry work was started in the fall of 1969 and progressed through the winter. By March 1, the masonry construction was at the 16th story. By May of 1970, the first building was topped out. BIA recommendations for cold weather construction were followed.

Total time sequence per floor averaged six to eight days, depending upon weather and other non-controllable factors. An average of three and one-half days was required to construct all walls per story. Twin tee floor slab erection averaged one day per floor.

The unit cost of Park Lane Towers, based on an area on 156,280 sq ft. excluding the area of the basement, was $ 14.71 per sq ft. The total cost of the building was $2,300,000, including drapes, carpets, kitchens, parking garage, basement and landscaping (excluding land and professional fees).

Park Lane Towers, Denver, Colorado

Joseph T. Wilson, AIA, Architect; Sallada & Hanson, Structural Engineers

FIG. 4

Woodlake Towers. Woodlake Towers is a group of ten-story, T-shaped buildings, each containing 215 units, which consist of efficiencies, one, two and three-bedroom units, (Fig. 5).

Bearing walls consist of 8-in., single wythe, solid brick supporting a precast concrete floor system. The first building was completed in 1970 and contains 268,450 sq ft at a cost of $2,700,000 or $ 10.06 per sq ft (excluding land, interim financing, professional fees, builder's fee and entrance lobby finishing). The cost figure of $2,700,000 includes all general construction, electrical and mechanical work, parking lot paving, landscaping, furnished kitchens and corridor carpeting.

Woodlake Towers, Fairfax County, Virginia

Collins & Kronstadt, Leahy, Hogan, Collins, Architects; Keller & Marchigiani, Structural Engineers

FIG 5

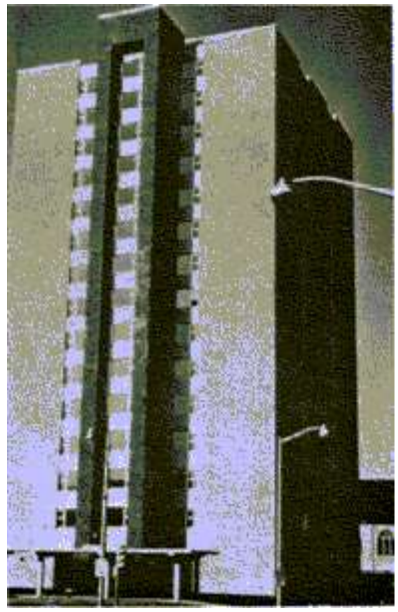
Twin Tower Apartments. Twin Tower Apartments consist of two identical structures of 11 stories in height for elderly residents in Jacksonville, Florida, consisting of a total of 120 efficiency and 80 one-bedroom units, (Fig. 6). The 10-in. bearing walls were grouted cavity walls (4-2-4) with varying amounts of grout and reinforcement, depending on loading and location. A 6-in. cast-in-place concrete slab provided the floor system. The masons rotated between buildings so the walls could be built on one building while the floor was formed and poured on the other building.

Twin Tower Apartments, Jacksonville, Florida

Sheetz & Bradfield, Architects; Bennett & Pless, Structural Engineers

FIG. 6

Episcopal House of Reading. It is 15 stories tall and contains 141 units for middle income, elderly residents in Reading, Pennsylvania, (Fig. 7). All the bearing walls are 8 in. thick, single wythe, non-reinforced, solid brick masonry with the exception of some walls on the first floor level which are 12 in. in thickness.



Episcopal House of Reading, Reading, Pennsylvania

Muhlenberg & Greene, Architects; Long & Tann, Structural Engineers

FIG. 7

The floor system consists of two layers of concrete. The first is 2 1/4-in. precast concrete containing positive steel and the second is 5 3/4-in. poured concrete with polystyrene foam sections to create internal voids.

The basic construction process consisted of building brick masonry walls and placing concrete floors in a "leapfrog" fashion. While a crew of 8 to 12 masons, using corner poles, erected walls on one side of the building, the 2 1/4 in. concrete floor slabs were placed by tower crane on the other side and were positioned and shored as required.

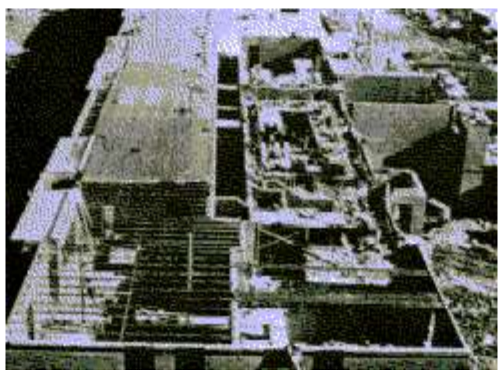
Construction continued throughout the winter. All materials were stored off the ground and covered for protection from the elements. A mortar mixing station was constructed adjacent to the structure, complete with propane gas equipment to heat sand and water. A custom-made sand measuring device permitted rapid and accurate proportioning by volume of portland cement-lime and sand mortar. The quantity of sand held by this device was 9 cu ft. Figure 8 shows this simple but workable setup for mixing mortar.

Measuring Sand Automatically.

FIG. 8

TECHNIQUES

Sequence and Scheduling. Most Contemporary Bearing Wall buildings can be planned so that the floor erection crew will place the floor in about the same length of time as is required for the masons to build the walls. When the crews are balanced in this manner, it is usually possible to schedule the construction so that neither the floor crew nor the wall crew will be in the way of the other. An example is shown in Fig. 9 where a floor system of steel joists with concrete topping is used. The plan of the Oakcrest project is tee-shaped with a short leg. The masons are completing the walls on the leg of the building and the area immediately next to it. In the background, concrete is being poured; in the center, steel decking is being placed; and in the foreground, steel joists are being set and spaced. In this manner, the contractors built a story per week in good weather.



Floor and Wall Construction of Oakcrest Towers.

FIG. 9

Foundations. Studies have indicated that, in many cases, foundation costs are reduced by delivering the loads into the soil in a series of lines or paths which might utilize spread footings, rather than in a series of points, which may require piles or caissons. A case in point is the Oakcrest project in which spread footings for bearing walls resulted in a savings in cost and time, (Fig. 10).

Corridor Bearing Walls at Oakcrest Towers.

FIG. 10

Formwork. In the construction of Contemporary Bearing Wall structures with joists or plank floor systems, there is little or no need for formwork, thus permitting the other trades to work immediately below the level of the wall and floor crews. In the case of a cast-in-place concrete building, the formwork is often such that other trades cannot conveniently work for several stories below the level where concrete is being placed, (Fig. 11).

Formwork for Cast-in-Place Concrete Frame.

FIG. 11

Coordination. The space immediately below a floor system of plank or joist is available; therefore, mechanical and other trades can closely follow the wall and floor crews, so as to contribute to the overall speed of construction, (Fig. 12).

Working Space is Provided for Other Trades at Oakcrest Project.

FIG. 12

Scaffolding. The scaffolding requirements are simplified in bearing wall buildings, usually requiring only one lift per story, (Fig. 13). Scaffolding used for one and two-story construction is often applicable to high-rise loadbearing construction when the masons work overhand from the inside. All of the examples cited above were built in this manner.

Scaffolding is Simple for Bearing Wall Construction.

FIG. 13

"SCR masonry process" (Reg. U.S. Pat. Off., SCPI (BIA)). The "SCR masonry process" is a development of the Structural Clay Products Research Foundation (now a part of BIA). It consists of a continuously adjustable scaffold and corner poles which carry the lines. This provides a means whereby skilled masons can increase productivity and enhance the quality of their work, resulting in better masonry at lower cost. For the construction of a series of three-story barracks, at Ft. Gordon, Gal, bearing walls were selected under "Contractor's Option" in lieu of a reinforced concrete frame with masonry curtain walls. The masonry contractor on the project, Phiffer and Goodwin, stated that, four weeks after installing the "SCR masonry process", their records indicated a 37 percent increase in overall production of the 75 masons working the project, (Fig. 14).

Use of "SCR masonry process" (Reg. U.S. Pat. Off., SCPI (BIA)), For Gordon, Georgia.

FIG. 14

Prefabricated Elements. Prefabricated stairs, door and window combinations and other elements which can easily be set in place prior to the masonry work will eliminate cutting and fitting after the masonry is complete. In many cases, the prefabricated elements can become guides for the masonry. In the case of the stairs, illustrated in Fig. 15, the landings become bench marks for the floors and the stairs themselves provide continuous access during construction.

Prefabricated Metal Stairs Used in Bearing Wall Construction.

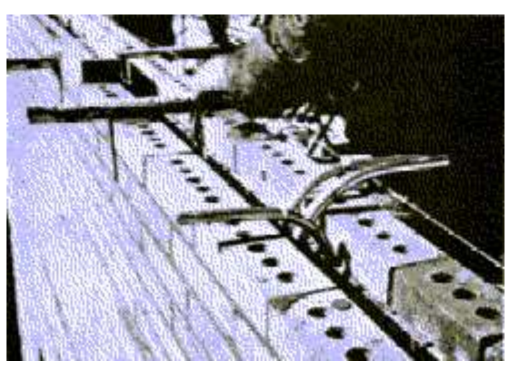
FIG. 15

Keeping Walls Clean. Frequently it will be desirable to place concrete for various members supported on brick walls. In such cases, care should be exercised to prevent the dropping of concrete on brickwork to be left exposed. This can be prevented by covering the walls with polyethylene sheets under formwork to make them watertight, (Fig. 16).

Polyethylene Sheets Under Corridor Formwork in Construction of Oakcrest Towers.

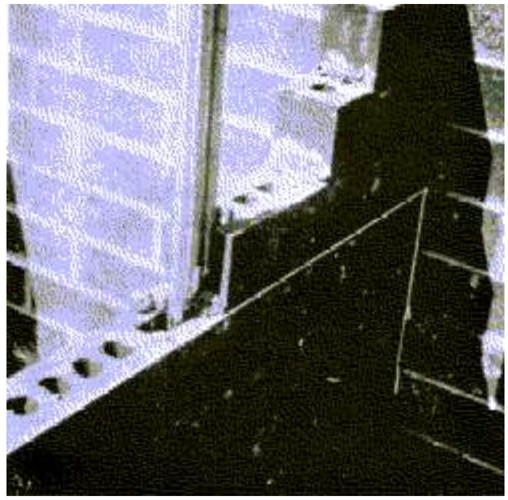
FIG. 16

Building in Accessories. When cavity walls are used, conduit and other accessories are often built in place as the walls are constructed. Also, in multi-wythe walls, this is easily accomplished as the walls are built. In many cases, through-the-wall units are designed so that they can be slipped over or conveniently built around conduit and other such elements, (Figs. 17 and 18).



Building in Conduit and Sleeves at Park Lane Towers.

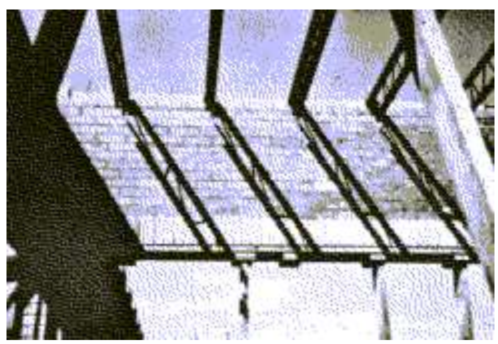
FIG. 17



Conduit in 4-in. Wall at Fort Gordon, Georgia.

FIG. 18

Lintels. Frequently, in the construction of brick masonry buildings, it is convenient to build horizontal elements on shoring, with reinforcing steel to span openings, (Fig. 19). Reinforced brick lintels have several advantages, including built-in fire resistance and elimination of structural steel, which requires maintenance and is more expensive in many cases. For further information on reinforced brick lintels, see *Technical Notes* 17H.



Construction of Reinforced Brick Lintel on Shoring.

FIG. 19

Cold Weather. Complete enclosure of bearing wall structures is not always the most economical way of providing protection for winter construction. In severe climates contractors may enclose the particular walls being worked upon.

Figure 20 shows Jayhawker Towers, a dormitory at the University of Kansas in Lawrence. Kansas, where a prefabricated wood-frame assembly covered with a polyethylene film was lowered over the work area to protect walls under construction during cold weather.

Temporary Enclosure at Jayhawker Towers, Lawrance, Kansas.

FIG. 20

Where the weather is not severe enough to enclose the construction, heating of materials and proper covering of walls may be all that is necessary. In all cold weather construction, the masonry should be constructed so strength will develop and the mortar will lose sufficient water to prevent expansion upon freezing.

For further discussion of winter construction, see *Technical Notes* 1 Revised*, "Cold Weather Masonry Construction-Introduction",* December 1967.