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DETAILING CONCRETE MASONRY FIRE WALLS

TEK 5-8B

Details (2005)

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INTRODUCTION

Concrete masonry, due to its inherent durability, reliability and superior fire resistance characteristics, is well suited to a range of fire protection applications.

The *International Building Code* (IBC) (ref. 1) defines three wall types for fire protection—fire wall, fire barrier and fire partition—depending on the level of protection provided for the type of occupancy and intended use. Of the three defined fire-rated assemblies, a fire wall is generally considered to provide the highest level of robustness and fire safety. As such, it is intended to provide complete separation and must be structurally stable under fire conditions.

Generally, fire barriers and fire partitions are required to provide the minimum protection necessary to assure that building occupants can evacuate a structure without suffering personal injury or loss of life. In addition to these requirements, fire walls reduce the likelihood of fire spread into the adjoining space, thus minimizing major property loss. Potentially significant architectural and economic advantages can be gained from using fire walls since each portion of a building separated by fire walls is considered a separate building for code compliance purposes.

Designing and detailing fire walls is a complex task with many facets, including structural criteria, fire resistance, vertical and horizontal continuity, and criteria for protecting openings and joints. It is beyond the scope of this TEK to include every code provision and exception for fire wall design for all project conditions. While much of the information in this TEK is applicable to both the IBC and the NFPA 5000 (ref. 2) building codes, the provisions are based on the 2003 IBC, so certain provisions may be different from NFPA 5000 requirements. Hence, the information may or may not conform to local building code requirements and should be carefully reviewed to ensure compliance. In addition, the details shown here are not the only ones that will comply, but are included as examples. Project-specific needs will dictate the final detailing decisions.

FIRE WALLS

By Code (ref. 1), fire walls are required to have the minimum *fire-resistance rating* acceptable for the particular occupancy or use group which they separate and must also have *protected openings and penetrations*. A fire wall must have both *vertical and horizontal continuity* to ensure that the fire does not travel over, under or around the fire wall. In addition, the wall must have sufficient *structural stability under fire conditions* to remain standing for the duration of time indicated by the fire-resistance rating even with the collapse of construction on either side of the fire wall.

Fire-Resistance Rating

Because fire walls provide a complete separation between adjoining spaces, each portion of the structure separated by fire walls is considered to be a separate building. Fire walls in all but Type V construction must be constructed of approved noncombustible materials. Table 1 shows minimum required fire-resistance ratings. Information on determining the fire-resistance ratings of concrete masonry assemblies is contained in *Fire Resistance Rating of Concrete Masonry Assemblies*, TEK 7-1A and *Standard Method for Determining Fire Resistance of Concrete and Masonry Construction Assemblies* (refs. 3, 4).

**Table 1—Required Fire Wall
Fire-Resistance Ratings (ref. 1)**

Group	Fire-resistance rating, hr
A, B, E, H-4, I, R-1, R-2, U	3 ^A
F-1, H-3 ^B , H-5, M, S-1	3
H-1, H-2	4 ^B
F-2, S-2, R-3, R-4	2

^A Walls shall not be less than 2-hour fire-resistance rated where separating buildings of Type II or V construction.

^B For Group H-1, H-2 or H-3 buildings, also see IBC Sections 415.4 and 415.5

Protected Openings and Penetrations

The IBC states that fire walls must have closures such as fire doors or shutters which automatically activate to secure the opening in the event of a fire. Further, openings in fire walls are restricted to a maximum size of 120 ft² (11.2 m²). An exception permits larger openings provided both buildings separated by the fire wall are equipped throughout with automatic sprinkler systems. In all cases, the aggregate width of all openings at any floor level is limited to 25 percent of the wall length.

Through-penetrations in fire walls must utilize either fire-resistance-rated assemblies or a firestop system which is tested in accordance with either ASTM E 814 (ref. 5) or UL 1479 (ref. 6). The annular space between steel, iron or copper pipes or steel conduits and surrounding concrete masonry fire walls may be filled with concrete, grout or mortar for the thickness required to provide a fire-resistance rating equivalent to the fire-resistance rating of the wall penetrated. In addition, the penetrating item is limited to a 6-in. (152-mm) nominal diameter and the opening is limited to 144 in.² (92,900 mm²). Openings for steel electrical outlet boxes are permitted provided they meet the Code-specified requirements.

Combustible members, such as wood, are permitted to be framed into concrete masonry fire walls provided that, when framed on both sides of the wall, there is at least 4 in. (102 mm) between the embedded ends of the wood framing. The full thickness of the fire wall 4 in. (102 mm) above and below, as well as in between, the combustible member must be filled with noncombustible materials approved for fireblocking.

Voids created at the junction of walls and floor/ceiling/roof assemblies must be protected from fire passage by using fire-resistant joint systems tested in accordance with ASTM E 1966 or UL 2079 (refs. 7, 8). Control joints in fire walls must have fire-resistance ratings equal to or exceeding the required rating of the wall. Recommendations for locating and spacing control joints in concrete masonry walls also apply to concrete masonry fire walls. *Control Joints for Concrete Masonry Walls*, TEK 10-2B (ref. 9) includes control joint spacing criteria and illustrates control joint details for various fire-resistance ratings.

Vertical and Horizontal Continuity

The IBC mandates vertical continuity of a fire wall by requiring that the wall extend continuously from the foundation to a termination point at least 30 in. (762 mm) above both adjacent roofs. Exceptions permitting the fire wall termination at the underside of the roof deck or slab are listed in the Code. These exceptions require the use of Class B roof coverings (minimum), no openings within 4 ft (1.22 m) of the fire wall and other criteria for roof assembly protection. Buildings located over parking garages and stepped buildings are subject to additional requirements and permitted exceptions.

Horizontal continuity limits the spread of fire around the ends of a fire wall. The IBC requires that fire walls be continuous from exterior wall to exterior wall and that they

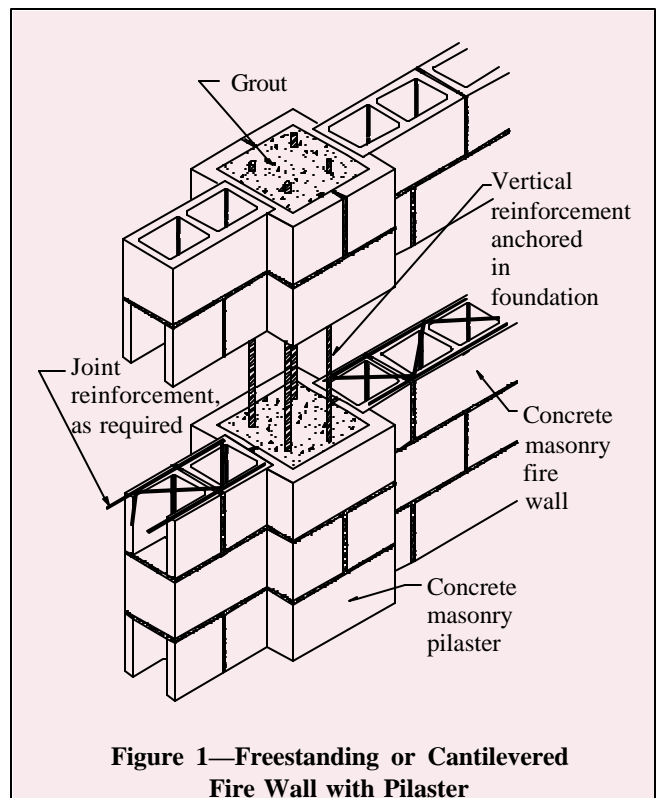
extend at least 18 in. (457 mm) beyond the exterior surface of exterior walls. As with the vertical continuity requirements, there are criteria for terminating the fire wall at the interior surface of an exterior wall based on the types and fire-resistance ratings of the intersecting wall constructions and on the presence of an automatic sprinkler system installed per Code requirements.

Structural Stability Under Fire Conditions

While concrete masonry remains structurally stable during the extreme temperatures experienced under fire conditions, steel framing undergoes a reduction in strength as the surrounding temperature and duration of exposure are increased. This decreased structural capacity is evidenced by a dramatic increase in the deflection and twisting of steel members. Wood framing may burn, collapse, shrink and/or deform under fire exposure and it too loses its load-carrying capability. For these reasons, concrete masonry fire walls should be designed and detailed to withstand any loading imposed by fire-compromised framing systems or detailed so that those loads are not imparted to the fire wall during a fire. This is perhaps the most difficult detailing provision in fire wall design.

DETAILING CONSIDERATIONS FOR STRUCTURAL STABILITY

Because most fire wall criteria relating to fire-resistance rating, protected openings and penetrations, and vertical and horizontal continuity are prescriptive, the designer's primary challenge when engineering and detailing a concrete masonry fire wall relates to maintaining the structural



stability of the wall under fire conditions.

There are various methods of designing, detailing and constructing fire walls for structural stability during a fire. Among the systems recommended for use as fire walls are: (a) cantilevered or freestanding walls, (b) laterally supported and tied walls, and (c) double wall construction.

Cantilevered or Freestanding Walls

Cantilevered walls (Figure 1) do not depend on the roof framing for structural support. The wall is cantilevered from the foundation by grouting and reinforcing, or by prestressing. Freestanding walls may also be designed to span horizontally between pilasters or masonry columns integral to the wall.

It can be difficult to design a cantilevered single wythe loadbearing fire wall. Thermal stresses may cause deformation in steel or wood joists or framing systems which can eccentrically load the top of the fire wall. Designing the wall to remain stable under that loading condition may be difficult especially for tall or slender walls. For this reason, cantilevered single wythe fire walls are often designed as nonbearing walls with the primary roof framing system running parallel to the fire wall. Column lines on either side of the wall support the roof framing. Details for cantilevered/freestanding fire walls are similar to those for laterally supported walls (shown in Figures 2, 3 and 4) with the exception that cantilevered walls do not include through-wall ties or break-away connectors.

Laterally Supported or Tied Walls

Laterally supported or tied walls rely on the building frame for lateral stability. The fire wall is laterally supported on each side by the framing system. As such, forces

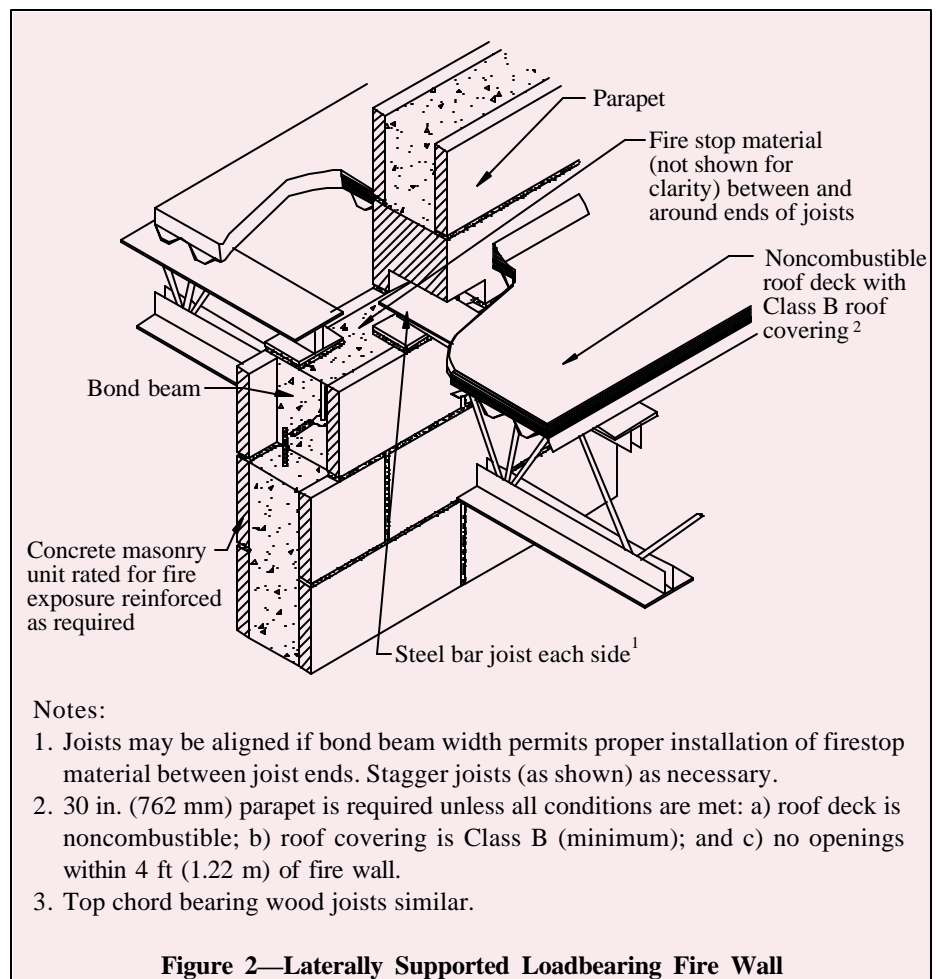
due to the collapse of the structure on one side of the fire wall are resisted by the structural framework on the other side of the wall. Adequate clearance, as listed in Table 2, between the framing and the concrete masonry fire wall is necessary to allow framing expansion or deformation without exerting undue pressure on the wall.

Laterally supported fire walls may utilize break-away connectors manufactured with metals having melting points lower than structural steel (generally about 800° F (427° C)), so that, in the event of fire, the connectors on the fire side of the wall will give way before those on the non-fire side. In Figures 2 and 3, the structural diaphragm on the side of the wall opposite the fire provides the stability. The connections between the roof and wall must be designed to resist these forces. If the diaphragms occur at different elevations, the wall must be designed to withstand the anticipated flexural forces that will be generated as well.

Figure 4 shows a laterally supported fire wall with combustible framing supported by metal joist hangers. Joist hanger manufacturers may have alternate details as well. Note that there may be code limitations on the use of combustible framing.

Figure 5 shows design and detailing options for tied fire walls. Tied fire walls are a type of laterally supported fire wall where the roof structure is not supported by the fire wall, but rather by the roof structure on the other side

Length of bay perpendicular to fire wall ft. (m)	Minimum clearance "X" between wall and steel, in. (cm)
20 (6.1)	2 1/2 (6.4)
25 (7.6)	3 1/4 (8.3)
30 (9.1)	3 3/4 (9.5)
35 (10.7)	4 1/2 (11.4)
40 (12.2)	5 (12.7)
45 (13.7)	5 3/4 (14.6)
50 (15.2)	6 1/4 (15.9)
55 (16.8)	7 (17.8)
≥ 60 (18.3)	7 1/2 (19.1)



of the fire wall, thus the two roof structures are tied together across the fire wall. Figure 5a illustrates one choice for a “double column” detail which uses a through-wall tie to connect the primary steel on both sides of the fire wall. In this detail, the primary roof framing steel is parallel to the fire wall and supported on fireproofed columns. One column is used on each side of the fire wall to support the roof system for that building. Both steel columns and primary support beams/trusses should be aligned vertically and horizontally with the columns and beams/trusses on the opposite side of the wall and should be fireproofed. If the primary steel is not parallel to the fire wall Figure 5b shows a through-wall tie which can be used.

As an alternative to using two steel columns, Figure 5c shows one steel support column encased entirely within the concrete masonry fire wall. Fire protection requirements for steel columns are included in *Steel Column Fire Protection*, TEK 7-6 (ref. 11). This system creates a single column line tied at the top of the wall to horizontal roof framing. Detailing the connection of the steel beams to the concrete masonry fire wall varies based on the framing layout, but the wall must be supported at the top and the connection must be fire protected.

Double Wall Fire Wall

Double wall construction (Figure 6) is generally easy to design and detail for loadbearing conditions, especially for taller walls. It utilizes two independent concrete masonry walls side by side, each meeting the required fire-resistance rating. In the event one wall is pulled down due to fire, the other wall remains intact, preventing fire spread. Floor and roof connections to each fire wall are the same as for conventional concrete masonry construction. These walls are often cantilevered or freestanding but may be tied or laterally supported as well if so detailed and designed. This system is also easy to use when a building addition requires a fire wall between the existing structure and the new construction.

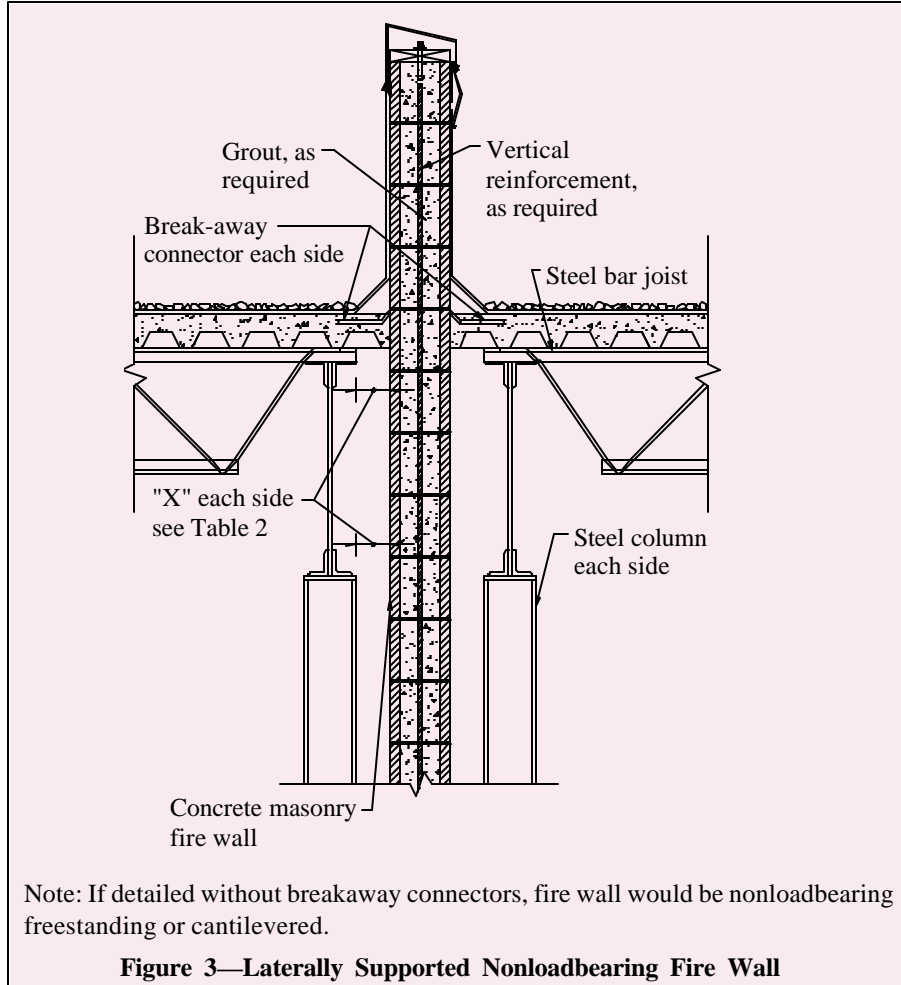


Figure 3—Laterally Supported Nonloadbearing Fire Wall

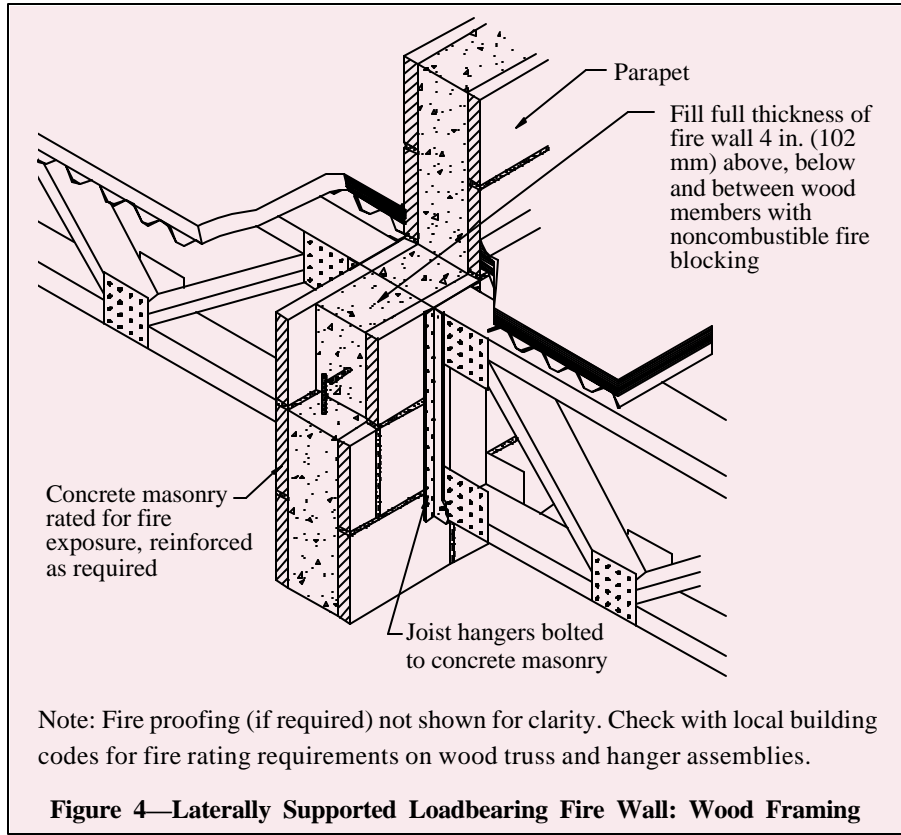
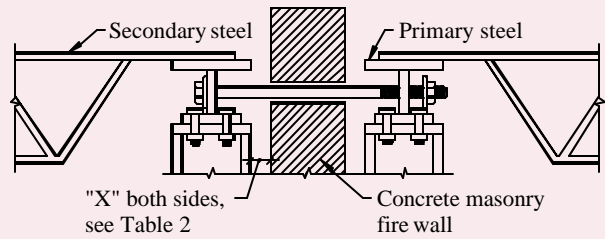
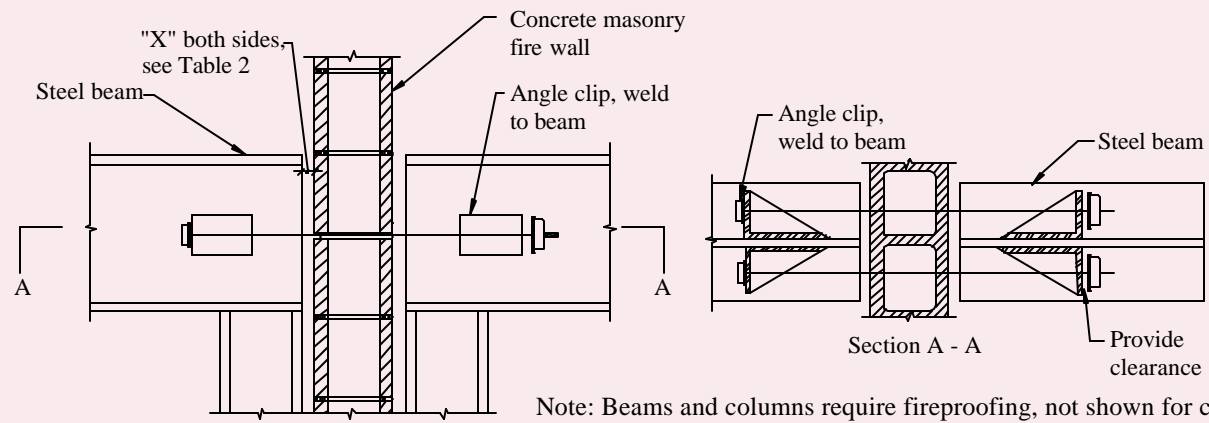


Figure 4—Laterally Supported Loadbearing Fire Wall: Wood Framing



Note: Beams and columns require fireproofing, not shown for clarity.

Figure 5a—Double Column Method, Through-Wall Tie Detail: Primary Steel Parallel to Fire Wall



Note: Beams and columns require fireproofing, not shown for clarity.

Figure 5b—Double Column Method, Through-Wall Tie Detail: Primary Steel Perpendicular to Fire Wall

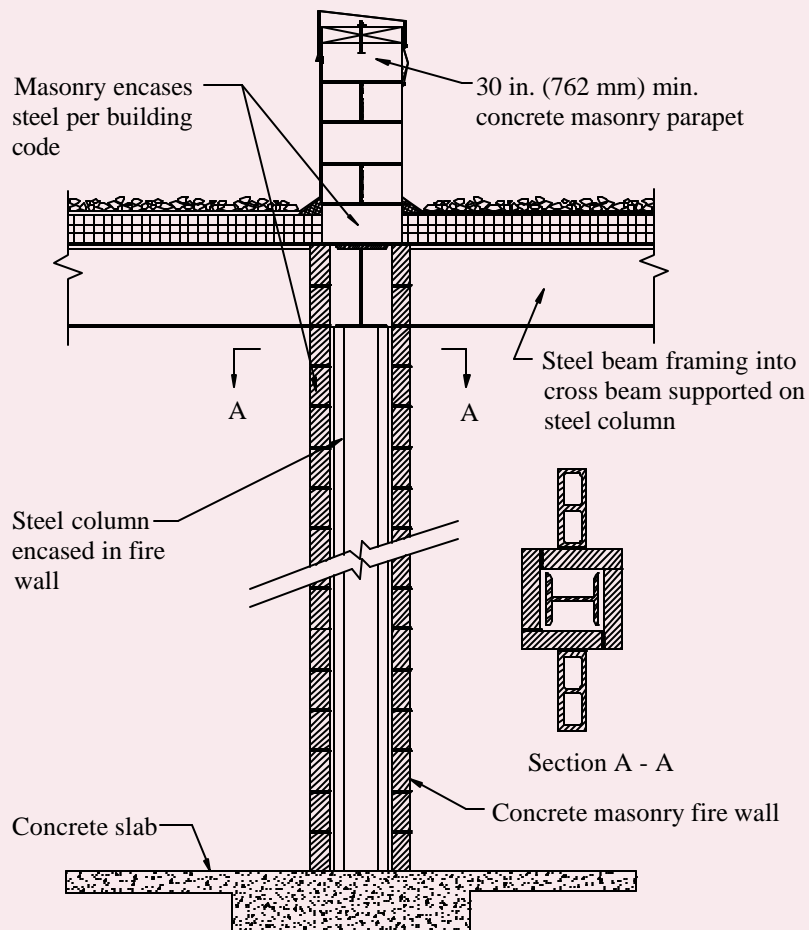


Figure 5c—Single Column Method

Figure 5—Tied Fire Walls (ref. 10)

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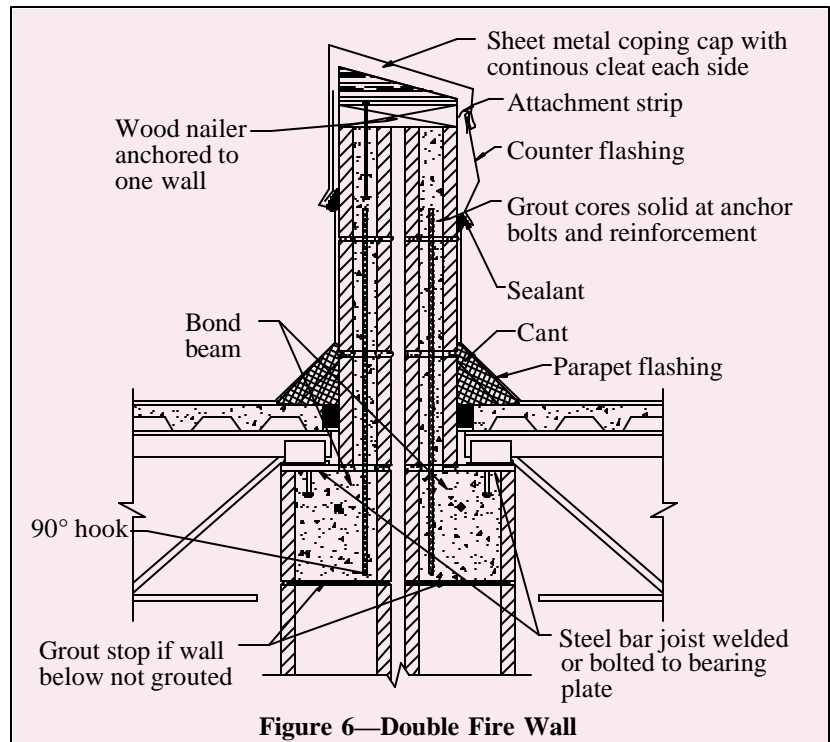


Figure 6—Double Fire Wall

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