CONCRETE MASONRY &
HARDSCAPES ASSOCIATION

Provided By:

HYBRID CONCRETE MASONRY CONSTRUCTION DETAILS

INTRODUCTION

Hybrid masonry is a structural system that utilizes reinforced masonry walls with a framed structure. While the frame can be constructed of reinforced concrete or structural steel, the discussion here includes steel frames with reinforced concrete masonry walls. The reinforced masonry infill participates structurally with the frame and provides strength and stiffness to the system. It can be used in single wythe or cavity wall construction provided the connections and joints are protected against water penetration and corrosion. The hybrid walls are constructed within the plane of the framing. Depending on the type of hybrid wall used, the framing supports some or all of the masonry wall weight.

Hybrid masonry/frame structures were first proposed in 2006 (ref. 1). There are several reasons for its development but one primary reason is to simplify the construction of framed buildings with masonry infill. While many designers prefer masonry infill walls as the backup for veneers in framed buildings, there is often a conflict created when structural engineers design steel bracing for the frame which interferes with the masonry infill. This leads to detailing and construction interferences trying to fit masonry around braces. One solution is to eliminate the steel bracing and use reinforced masonry infill as the shear wall bracing to create a hybrid structural system.

The concept of using masonry infill to resist lateral forces is not new; having been used successfully throughout the world in different forms. While common worldwide, U.S. based codes and standards have lagged behind in the establishment of standardized means of designing masonry infill.

The hybrid masonry system outlined in this TEK is a unique method of utilizing masonry infill to resist lateral forces. The novelty of the hybrid masonry design approach relative to other more established infill design procedures is in the connection detailing between the masonry and steel frame, which offers multiple alternative means of transferring loads into the masonry—or isolating the masonry infill from the frame.

Prior to implementing the design procedures outlined in this TEK, users are strongly urged to become familiar with the hybrid masonry concept, its modeling assumptions, and its limitations particularly in the way in which inelastic loads are distributed during earthquakes throughout the masonry and frame system. This system, or design methods, should not be used in Seismic Design Category D and above until further studies and tests have been performed; and additional design guidance is outlined in adopted codes and standards.

CLASSIFICATION OF WALLS

There are three hybrid wall types, Type I, Type II and Type III. The masonry walls are constructed within the plane of the framing. The classification is dependent upon the degree of confinement of the masonry within the frame.

Type I walls have soft joints (gaps that allow lateral drift at the columns or vertical deflection at the top) at the columns and the top of the wall. The framing supports the full weight of the masonry walls and other gravity loads.

Type II walls have soft joints at the columns and are built tight at the top of the wall.

Type III walls are built tight at the columns and the top of the wall.

For Type II and III walls, the masonry walls share the support of the vertical loads, including the wall weight, with the framing.

CONSTRUCTION

Type I Hybrid Walls

Practically speaking, the concept of Type I walls is that the masonry wall is a nonloadbearing shear wall built within the frame which also supports out-of-plane loads (see Figure 1). The details closely match those for current cavity wall construction where the infill masonry is within the plane of the frame, except that the vertical reinforcement must be welded to the perimeter framing at supported floors.

Since the walls are generally designed to span vertically, the walls may not have to be anchored to the columns. The engineer's design should reflect whether anchors are required but only for out-of-plane loads. The masonry does have to be isolated from the columns so the columns do not transmit loads to the walls when the frame drifts.

In multi-story buildings, each wall is built independently. Walls can be constructed on multiple floors simultaneously. Because the steel framing is supporting the entire wall weight, Type 1 walls are more economical for lower rise buildings. It is possible with Type 1 walls to position the walls outside the framing so they are foundation supported as in caged construction (ref. 1), providing a more economical design for the framing.

Type II Hybrid Walls

With Type ll walls, the masonry wall is essentially a loadbearing shear wall built within the frame: it supports both gravity and out-of-plane loads (see Fig. 1).

There are two options: Type IIa and Type IIb. The engineer must indicate which will be used. For Type IIa walls, the vertical reinforcement (dowels) must be welded to the perimeter framing to transfer tension tie-down forces into the frame. The vertical dowels also transfer shear. For Type IIb walls, vertical reinforcement only needs to be doweled to the concrete slab to transfer shear forces because tie-down is not required. This simplifies the construction of multi-story buildings.

The top of the masonry wall must bear tight to the framing. Options include grouting the top course, using solid units, or casting the top of the wall. The top connectors must extend down from the framing to overlap with the vertical wall reinforcement.

Since the walls generally span vertically, the engineer must decide whether column anchors are needed similar to Type I walls. These anchors only need to transmit out-of-plane loads.

The design must take into account the construction phasing. In multi-story buildings, each wall may be structurally dependent on a wall from the floor below which is very similar to a loadbearing masonry building.

Type III Hybrid Walls

This wall type is fully confined within the framing—at beams and columns. Currently, there are no standards in the United States that govern Type III design. Standards are under development and research is underway to help determine structural and construction requirements. Therefore, no details are provided at this time.

DETAILS

Sample construction details were developed in conjunction with Concrete Masonry & Hardscapes Assocaition, International Masonry Institute (IMI), and David Biggs. They are hosted on the CMHA website at www.masonryandhardscaps.org and the IMI website at www.imiweb.org. Alternate details for hybrid construction are continually under development and will be posted on the web sites. There are several key details that must be considered, including: the wall base, the top of the wall, at columns, and parapets.

Base of Wall

As previously noted for Type I and Type IIa walls, vertical reinforcement must be anchored to either foundation or frame to provide tension-tie downs for the structure. Figure 2 shows the reinforcement anchored to the foundation with a tension lap splice, and also shows the reinforcement anchored at a floor level and tension lap spliced.

For Type IIb walls, the vertical reinforcement does not have to be anchored for tension forces because it only transfers shear forces. Figure 3 shows the reinforcement anchored to the foundation. Figure 4 shows the reinforcement anchored at a floor level. The designer must determine if the dowel can be effectively anchored to the slab for shear or if it must be welded to the framing as shown for Type I and Type IIa walls.

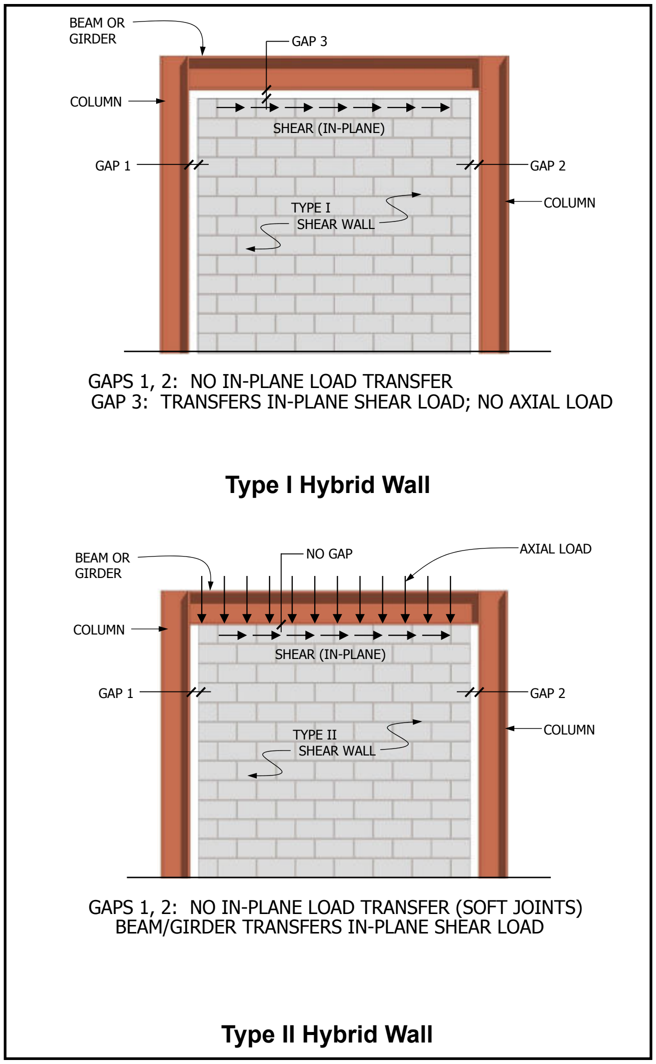


Figure 1—Hybrid Wall Types I and II

Top of Wall

For all wall types, the top of the wall must be anchored to transfer in-plane shear loads from the framing to the wall. It also accommodates out-of-plane forces. This is accomplished by a connector. Figures 5 and 5A show an example with bent plates and slotted holes. For Type I walls, the gap at the top of the wall must allow for the framing to deflect without bearing on the wall or loading the bolts. For Type II walls, the gap is filled tight so the framing bears on the wall.

The vertical reinforcement must overlap with the connectors at the top of the wall. Since the top course could be a solid unit, the connector should extend down to a solid grouted bond beam.

Top of wall construction raises the most concern by designers. Constructability testing by masons has been successfully performed. The design concept for the connectors is:

1. Determine the out-of-plane loads to the wall top.
2. Design the top bond beam to span horizontally between connectors. Connector spacing is a designer's choice but is generally between 2 and 4 ft (6.09 and 1.22 m) o. c.
3. Using the in-plane loading, analyze the connector and design the bolts.
4. If the design does not work, repeat using a smaller connector spacing.

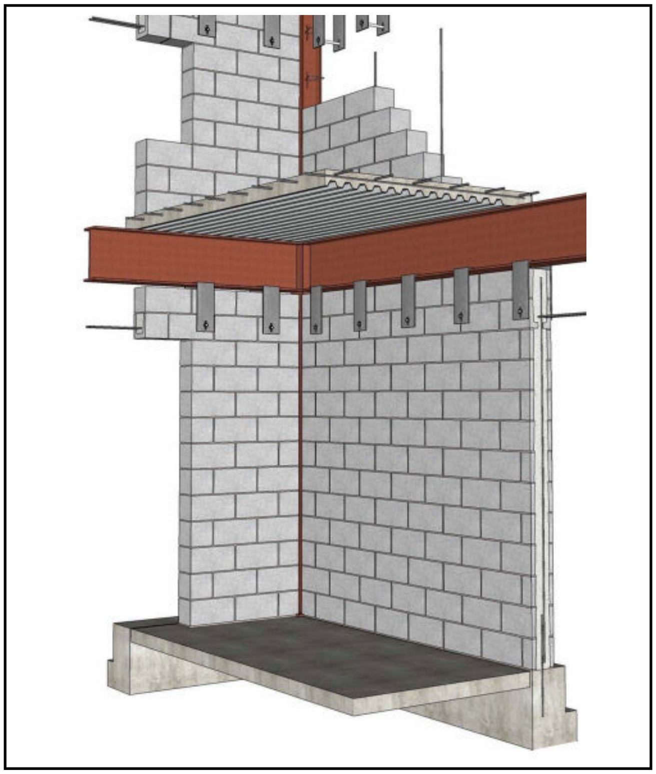


Figure 2—Type I and IIa Foundation and Floor Detail

The steel framing is affected by out-of-plane load transfer to the beam's bottom flange. Beam analysis and flange bracing concerns for the steel are identical to those for any infill wall.

Column

For Type I and IIa walls, the wall must be kept separated from the columns so that when the frame drifts it does not bear on the wall. Lightweight anchors can be used to support out-of-plane loads if desired. Figure 6 shows a possible anchor.

Parapet

Parapets can be constructed by cantilevering off the roof framing. Details vary depending on the framing used but are

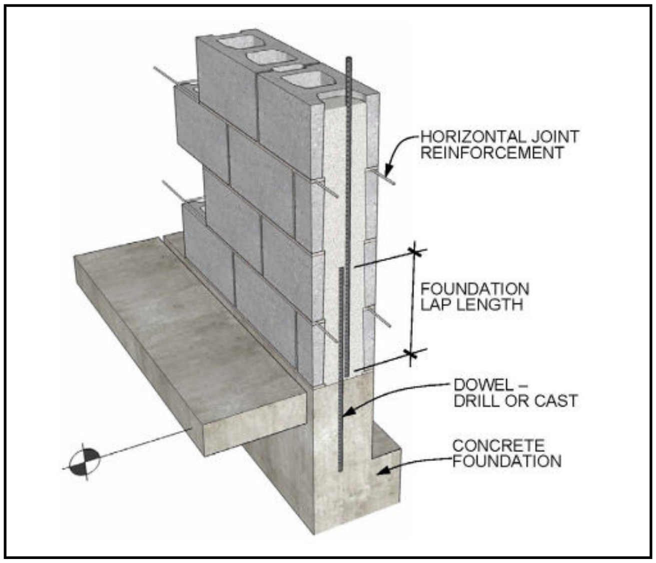


Figure 3—Type IIb Foundation Detail

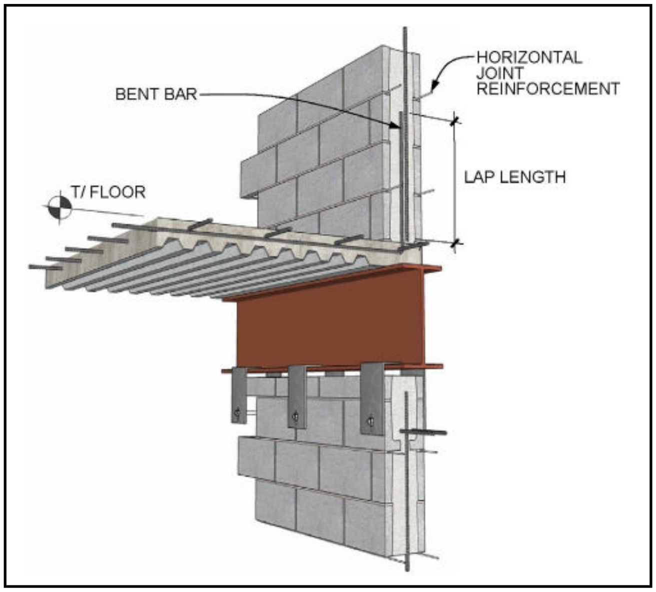
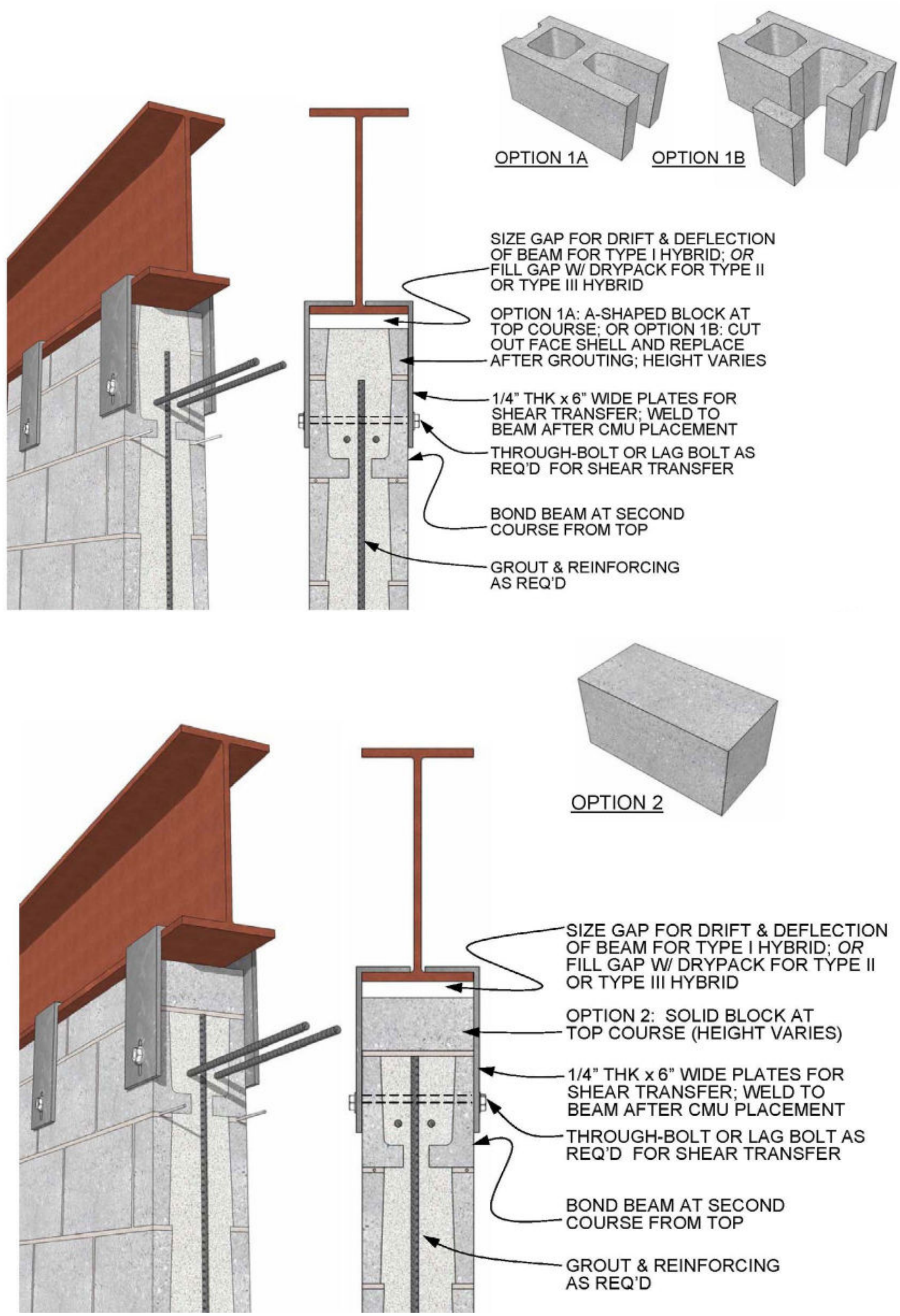


Figure 4—Type IIb Floor Detail



Note: For Type I walls, provide soft joint (gap to allow for movement. For Type II walls, fill gap tight.

Figure 5—Top of Wall Details

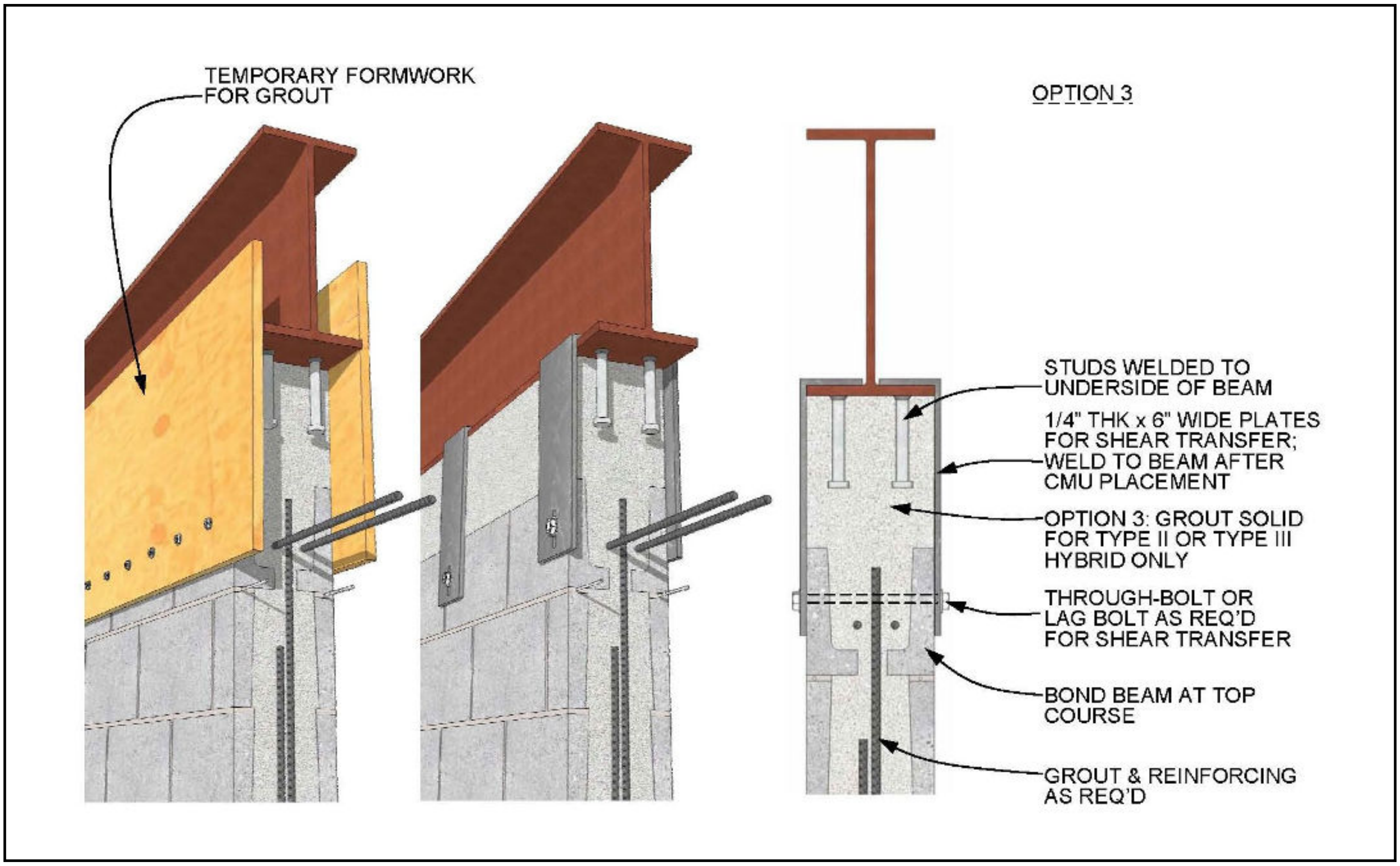


Figure 5—Top of Wall Details (continued)

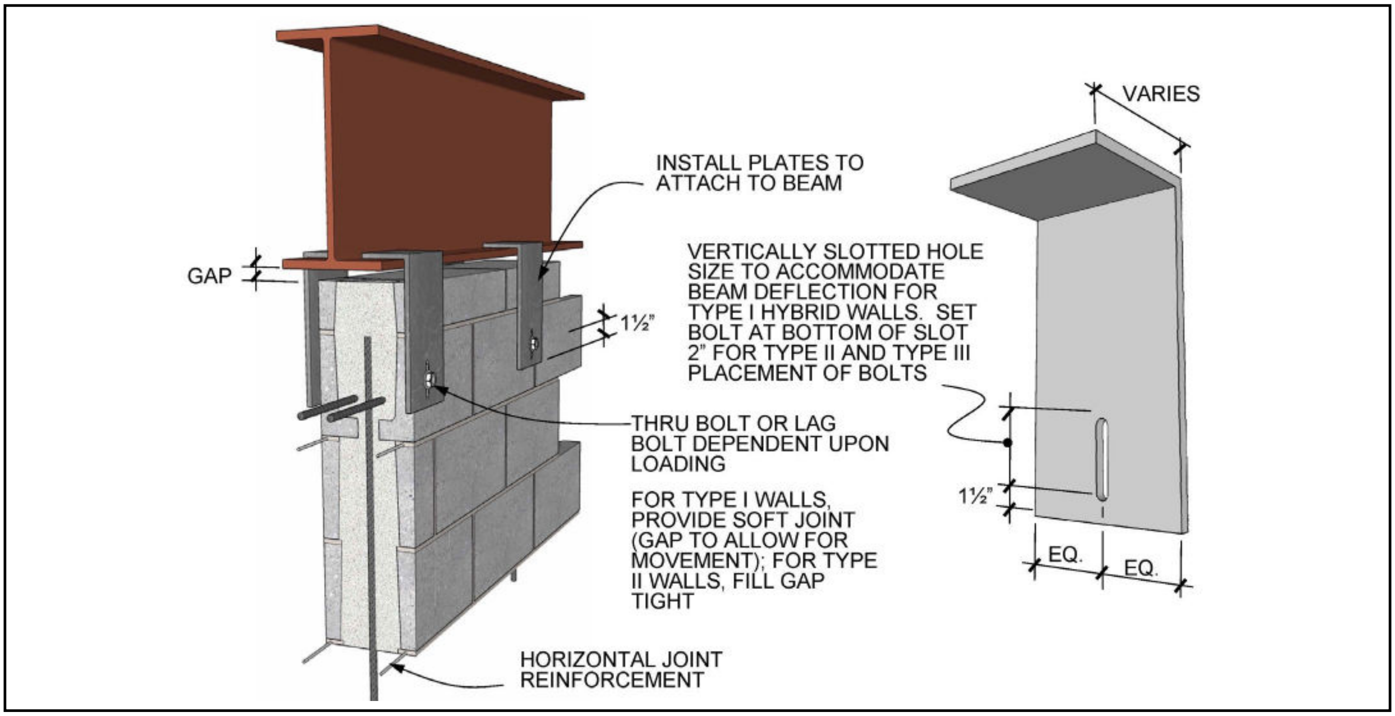


Figure 5A—Connector Plate Detail

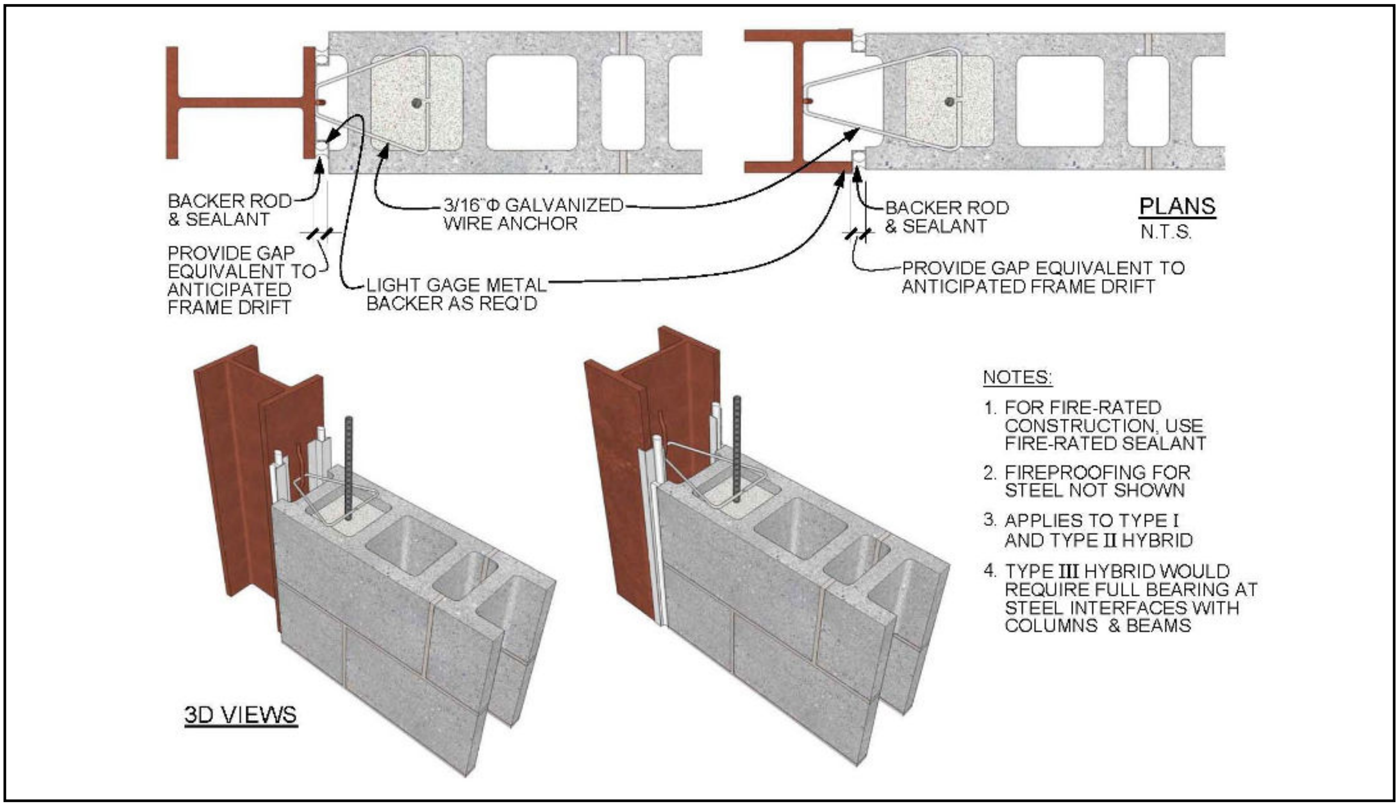


Figure 6—Column Details

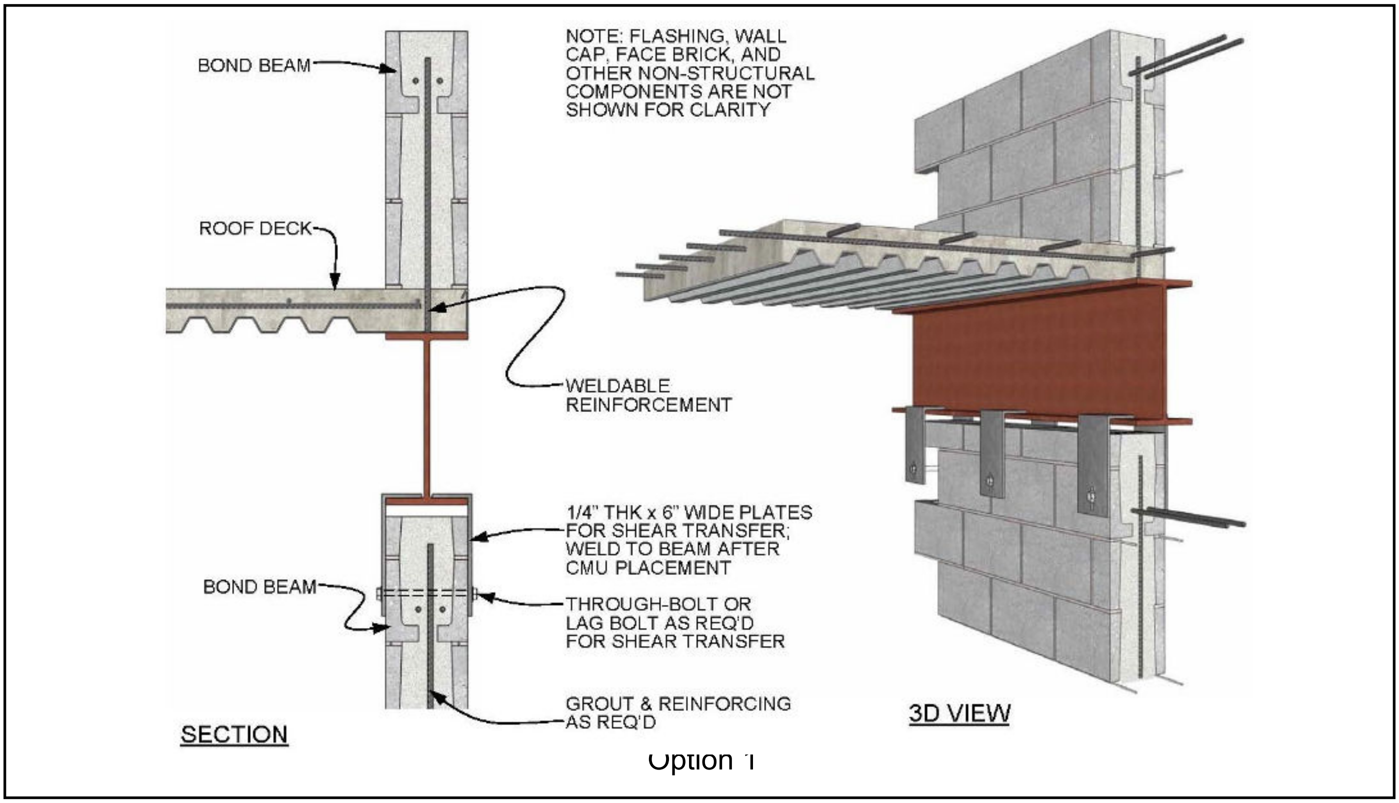
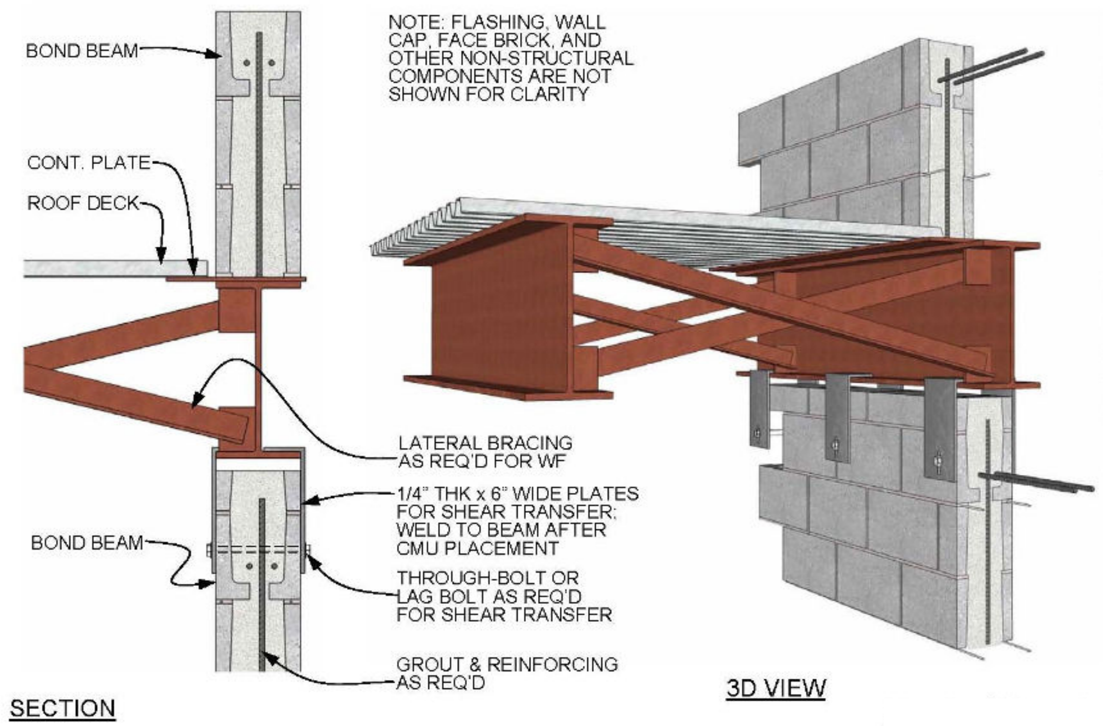
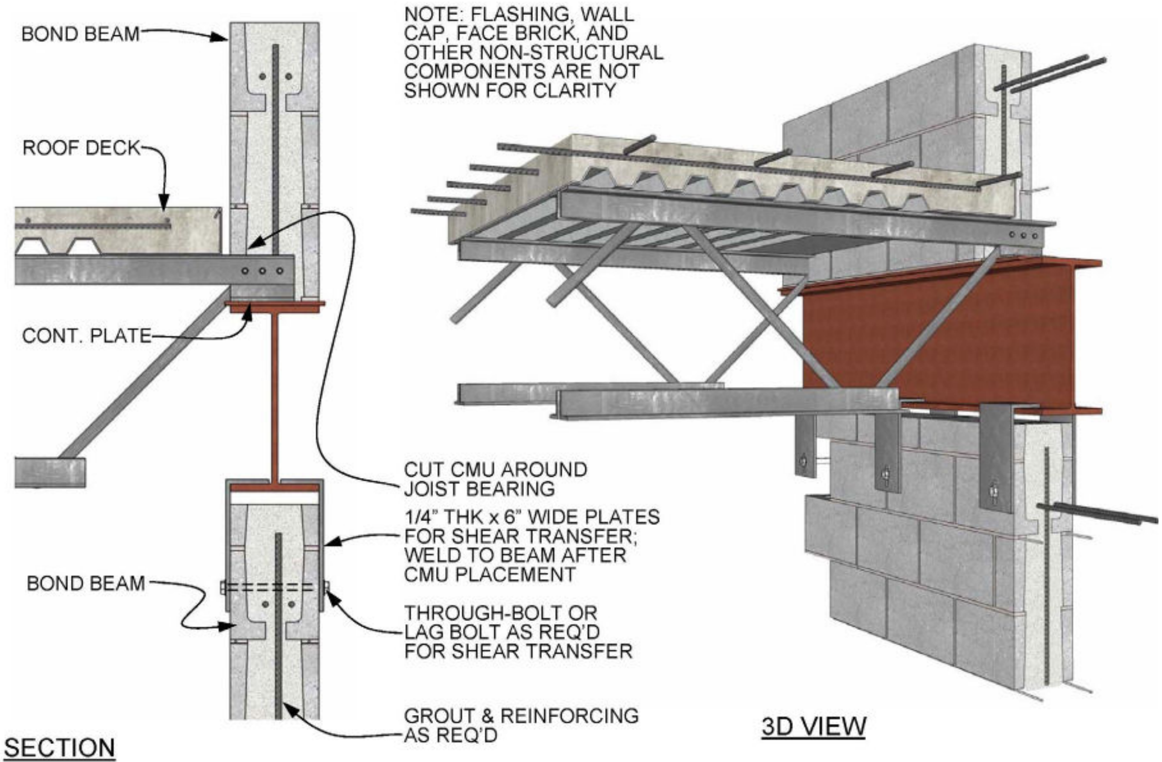


Figure 7—Parapet Details



Option 2



Option 3

Figure 7—Parapet Details (continued)

similar to Figure 2. Figure 7 shows three variations for: concrete slab, wide flange framing, and bar joist framing. There is a plate on the beam's top flange for the bar joist and wide flange framing options.

QUALITY ASSURANCE

Special inspections should be an essential aspect of the quality assurance plan. Besides verifying the vertical reinforcement is properly installed as required by *Building Code Requirements for Masonry Structures* (ref. 2), the connector must be checked as well. If Type I walls are used, the bolts from the connector to the wall must allow for vertical deflection of the framing without loading the wall.

CONCLUSIONS

Hybrid masonry offers many benefits and complements framed construction. By using the masonry as a structural shear wall, the constructability of the masonry with the frames is improved, lateral stiffness is increased, redundancy is improved, and opportunities for improved construction cost are created.

For now, Type I and Type II hybrid systems can be designed and constructed in the United States using existing codes and standards. Criteria for Type III hybrid systems are under development.

Design issues for hybrid walls are discussed in TEK 14-09A and IMI Tech Brief 02.13.01 (refs. 3, 4).

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