DETAILING MASONRY EXTERIOR WALLS

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VENEER WALLS

Masonry veneer walls are constructed of a thin (usually 4" thick) wythe of exposed masonry which is tied to a back-up wall. The back-up wall is designed to resist all structural loads. The back-up wall may be constructed of concrete block masonry (CMU), light-gage metal studs, or wood studs. In older buildings, solid brick masonry or hollow clay tile were also sometimes used for back-up wall construction.

WIND LOADS

For non-load bearing walls, wind loading is the dominant structural load which a back-up wall must be engineered to resist. For calculating the wind loads on *Components and Cladding*, the BOCA code references *ASCE 7-88 - Minimum Design Loads for Buildings and Other Structures*. The calculated wind loads are a function of the following variables:

basic wind speed
site wind exposure
building occupancy
distance from Atlantic Ocean coastline
building height
building shape

Example: 30 foot tall rectangular commercial building located in central Connecticut with basic wind speed of 80 mph. Positive wind pressure: 28 psf. Negative wind pressure (suction): 38 psf.

The back-up wall must be engineered to have not only sufficient strength to resist wind loads but also sufficient stiffness so that the veneer does not crack under high wind loads. Deflection of back-up walls should be limited to span/600.

METAL STUD BACK-UP WALLS

Light-gage metal studs are used for back-up wall systems for low-cost commercial buildings with a design service life of 30 years or less.

This type of construction first became popular in the 1970's. Many of the early metal stud installations have experienced failures resulting from a lack of understanding of the design requirements for a masonry back-up wall system. Contractors built metal stud back-up walls using details which they had become accustomed to using with interior metal stud partitions. Not surprisingly, many of these early walls did not perform well.

Metal stud size and gage are selected based on their structural properties. In resisting wind loads, stiffness usually controls rather than strength.

Metal studs should be spaced 16" on center. Although 3 5/8" studs may be used for short spans, 6" studs are more appropriate for most applications.

The minimum thickness of the studs should be 18 gage. This is necessary for the screws which fasten the masonry ties to have sufficient pull-out resistance.

Metal stud framing must be reinforced around window and door openings. Built-up members are usually required at heads, sills, and jambs of openings.

If all special metal stud framing conditions are not engineered and detailed on the working drawings, then the specifications should be require the Contractor to submit shop drawings and structural calculations for the metal stud framing.

Gypsum sheathing is normally used over metal stud framing. Gypsum sheathing is not a very durable material and will deteriorate if left exposed to the weather or a damp masonry cavity. The sheathing must be protected with a waterproof material. Traditionally, building paper has been used to protect the sheathing, however building paper will deteriorate with time. Tyvek is a more effective protection for the sheathing and also serves as an air infiltration barrier without trapping water vapor in the wall.

CMU BACK-UP WALLS

Concrete block masonry walls are the preferred back-up wall system for institutional buildings, schools, and other structures where a long service life and durability is desired.

CMU wall thickness must be calculated based on rational engineering analysis. Since a masonry back-up wall is significantly stiffer than the veneer wythe, strength rather than stiffness usually controls the wind load analysis.

Since buildings in Connecticut must be designed to resist seismic loads, the Building Code does not permit masonry to be designed by the empirical methods. The empirical height to thickness ratio of 18 is still a good guide for selecting wall thickness, however it must be substantiated with structural calculations. Back-up walls should be at least 8 inches thick.

CMU back-up walls will usually require vertical and horizontal reinforcing in order to satisfy the seismic design requirements. It is often cost effective to use the reinforced masonry walls as shear walls to resist lateral seismic and wind loads on the building. On one story buildings it is also often cost effective to use the exterior CMU walls as load-bearing walls to support the roof framing.

Joint reinforcing should be used in every second bed joint. When the wall has vertical reinforcing steel, ladder type joint reinforcing should be used rather than the truss type.

Exterior walls should be detailed to permit the placement of vertical reinforcing and grout in the wall. It is sometimes practical to offset perimeter steel beams off the column centerline to allow reinforcing and grout to be placed in the wall.

The outside face of the CMU back-up wall should be dampproofed with a troweled on bituminous dampproofing. Any structural steel exposed to the cavity or in contact with the masonry should also be dampproofed to protect it from corrosion.

If the CMU wall is to be exposed as the finished wall on the interior of the building, rigid insulation is usually required between the veneer and the back-up wall. This insulation should not fill the cavity. A 2 inch air space should be left between the insulation and the veneer wythe.

WOOD STUD BACK-UP WALLS

In residential construction wood stud walls are most commonly used as back-up walls. Detailing is similar to metal stud walls. Plywood is used as the sheathing rather than gypsum board.

Details must allow for the shrinkage of the framing lumber. This can be problematic at window trim and cornices.

CAVITY WALLS

It is unusual for a solid masonry wall or a single wythe masonry wall to not leak. A masonry wall contains miles of mortar joints, every inch of which is a potential source of water leakage. Water usually penetrates at cracks and incompletely filled head joints. Properly detailed and constructed cavities are the only proven effective method of building weathertight masonry walls.

Cavity walls have an unobstructed air space between the veneer wythe and the back-up wall. This air space permits air pressures to equalize and allows any water which penetrates the veneer to be directed back out of the wall through weep holes.

Weep holes are most commonly formed using plastic weep tubes embedded in head joints. Weep holes should be placed at the bottom of walls, at every floor level, over lintels, at window sills, and at any other locations where flashing is placed in the cavity. Weep holes are normally spaced 24 inches on center and should never be more than 32 inches on center. Weep holes will not function if the cavity is permitted to fill with mortar droppings.

A drainage material should be used in the cavity behind the weep holes to prevent mortar from blocking drainage. Pea gravel has often been used as a drainage material, however the weight of the pea gravel can sometimes tear the flashing. One company manufactures a plastic drainage network which can be placed at the bottom of the cavity.

The ideal thickness for a cavity is 2 inches. The cavity should never be less than 1 ½ inches or more than 4 inches. It is not possible for a mason to prevent mortar from falling into a cavity which is too narrow. Wall ties will not be able to effectively span a cavity which is two wide.

If rigid insulation is used in the cavity a 2 inch air space should be left between the insulation and the veneer wythe.

Flexible flashings are most commonly used in cavity wall construction. PVC flashings have performed poorly in the past since the material becomes brittle and deteriorates with age. PVC flashings should be avoided. Flashing is used to collect water in the cavity and direct it to weep holes. Where flashing is used it should extend through the cavity and be bonded to the sheathing of the back-up wall, or, where a CMU back-up wall is used, the flashing should terminate in a horizontal mortar joint. Joints in flashing and any reinforcing steel penetrations must be sealed. At the face of the wall, the flexible flashing should be bonded to rigid sheet metal flashing which forms a drip edge.

Copper and stainless steel are commonly used for the rigid flashing. Joints in sheet metal flashing should be soldered. While copper is easier to form in the field than stainless steel, copper is prone to staining the masonry. Lead coated copper will not stain masonry.

At ends of window sills and heads or at any termination of flashing, the flashing should be turned up into a head joint to form a dam.

With rubble stone veneer walls, it is not possible to construct a cavity. Since the thickness of each of the stones varies, it is necessary for the stone mason to fill the space between the back of each stone and the sheathing with mortar so that he has a base to set the next stone on. With rubble stone walls, the Tyvek or building paper is relied on to keep the wall watertight.

Glazed block does not perform well in Connecticut. Since the glazed face is impermeable, any moisture which gets behind the face becomes trapped and spalls the masonry when it freezes. A traditional cavity wall is not effective with glazed masonry. The manufacturers of the glazed block recommend that the mortar joints be raked and filled with an epoxy grout to prevent water from penetrating the wall.

TIES AND ANCHORS

The veneer wythe is anchored to the back-up wall with metal wall ties spaced 16 inches on center vertically and horizontally. Ties should be vertically adjustable to allow for misalignment of the masonry coursing and to permit differential volume change of the masonry.

For seismic resistance, ties should be used which engage horizontal joint reinforcement in the veneer.

For corrosion protection, ties should be either hot-dip galvanized or stainless steel. Mill galvanized ties should only be used in interior walls. Stainless steel ties should be a 300 series alloy. This type of stainless steel is not magnetic and can easily be identified with a pocket magnet. Galvanized and stainless steel elements should not be in contact with each other since this will result in galvanic corrosion.

The veneer wythe and masonry back-up walls should be anchored to the structural steel frame with masonry anchors. The most effective type of anchor are channel slot anchors. Since the channel slot is purchased by the structural steel fabricator, and the anchors are purchased by the mason, it is important to make sure that both are purchased from the same manufacturer since parts are not interchangeable.

SINGLE WYTHE WALLS

Single wythe CMU walls are popular for one story industrial or warehouse buildings. Often the walls are load-bearing and support the roof structure.

This type of construction is very susceptible to water leakage. When split-rib or split-face architectural blocks are used, it is difficult to properly tool the mortar joints. This increases the walls susceptibility to leakage.

Normal-weight architectural CMU have better resistance to water absorption than light-weight CMU. Specifying CMU with an integral water repellent admixture will also reduce absorption.

Through wall flashing and weep holes should be provided at the bottom of the wall and above any bond beam courses. The wall should be split with two thin wythes at the flashing unless special flashing blocks are used.

Often a sealer is applied to the exterior of the wall to reduce leakage. Sealers have a short service life and usually need to be reapplied every three years. Some sealers can trap moisture in the masonry wall result in spalling during cold weather.

RELIEVING ANGLES

Masonry relieving angles supported off of the structural frame are required for tall walls or where there is a continuous band of windows or masonry openings wider than the allowable span for loose lintels.

The Building Code permits a veneer wall to be constructed up to 30 feet above the foundation without a relieving angle. Support for the veneer must be provided at a height of 30 feet and at every floor above that.

Structural framing supporting relieving angles should be engineered to limit the deflection due to live loads and the dead load of masonry to span/600 or 3/8 inch. A compressible filler should be placed under relieving angles to allow for deflection of the structure. The horizontal joint should be caulked rather than filled with mortar. This joint will usually be wider than 3/8 inch.

Relieving angles as well as loose lintels should be hot-dip galvanized for corrosion protection.

PARAPET WALLS

Parapet walls are one of the most frequent sources of water penetration and structural masonry failures. They are exposed to rain and wind loads from both sides. They are exposed to wide temperature variations. They are not laterally braced at the top. The mortar bond is often broken by flashing. A falling section of parapet wall can have catastrophic results.

Parapet walls should be detailed so that they are well anchored to the building structure. Vertical reinforcing should be used and any through wall flashing must be sealed where the reinforcing penetrates. When the vertical reinforcing is welded to the structural steel framing, smooth rod should be used since reinforcing bars are rolled from a steel which is not weldable.

Precast concrete or stone copings should be anchored to the parapet wall. Rigid sheet metal flashing should be provided under copings.

VOLUME CHANGE

Control joints should be provided to allow for volume change of the masonry.

Clay brick has a tendency to expand with age. At the time a brick leaves the kiln, all moisture has been removed from the clay and the brick is the smallest dimension that it will ever be. With age, the clay will absorb moisture and expand. Brick control joints, consequently, are expansion joints and must be filled with a compressible material and caulked. If the joints are spaced too far apart, the compressible filler will be squeezed out of the joints.

If the bricks are dampened allowing the brick to expand prior to being laid in a wall, the finished wall will experience less volume change. For this reason, cutting bricks with a wet saw is acceptable.

Concrete masonry units have a tendency to shrink with age. From the time a concrete block is molded it begins to shrink as the concrete cures and loses moisture.

Concrete masonry units should not be laid in a wall until they are fully cured. CMU's stored on the site should be protected from rain with tarps and should be cut only with dry saws.

CMU control joints are contraction joints. The joints are sometimes filled with mortar. The mortar is raked back and the joint is caulked. The preferred method of forming a control joint is with a cruciform shaped neoprene gasket inserted into sash blocks. Joint reinforcing and bond beams must be terminated at control joints.

If a masonry wall has been engineered to span between vertical columns to resist wind loads, control joints should be positioned only at structural columns.

Control joints should usually be spaced at no more than 25 feet on center. It is desirable for control joints to divide walls into rectangular panels with an aspect ration which does not exceed 1:2.

Brick veneer walls should be tied to CMU back-up walls with adjustable anchors which will not restrain the differential volume change between the brick and concrete block. If the two wythes are tied with rigid anchors or bonded with brick header courses, the wall will have a tendency to bow outward.

INSPECTION

Without proper inspection, the best detailed set of drawings will not assure that the masonry walls will perform well.

Special Inspections of masonry are required for most masonry buildings. These inspections should not be delegated to Testing Laboratories. The Architect and Engineer should take an active role in inspecting the buildings which they design.

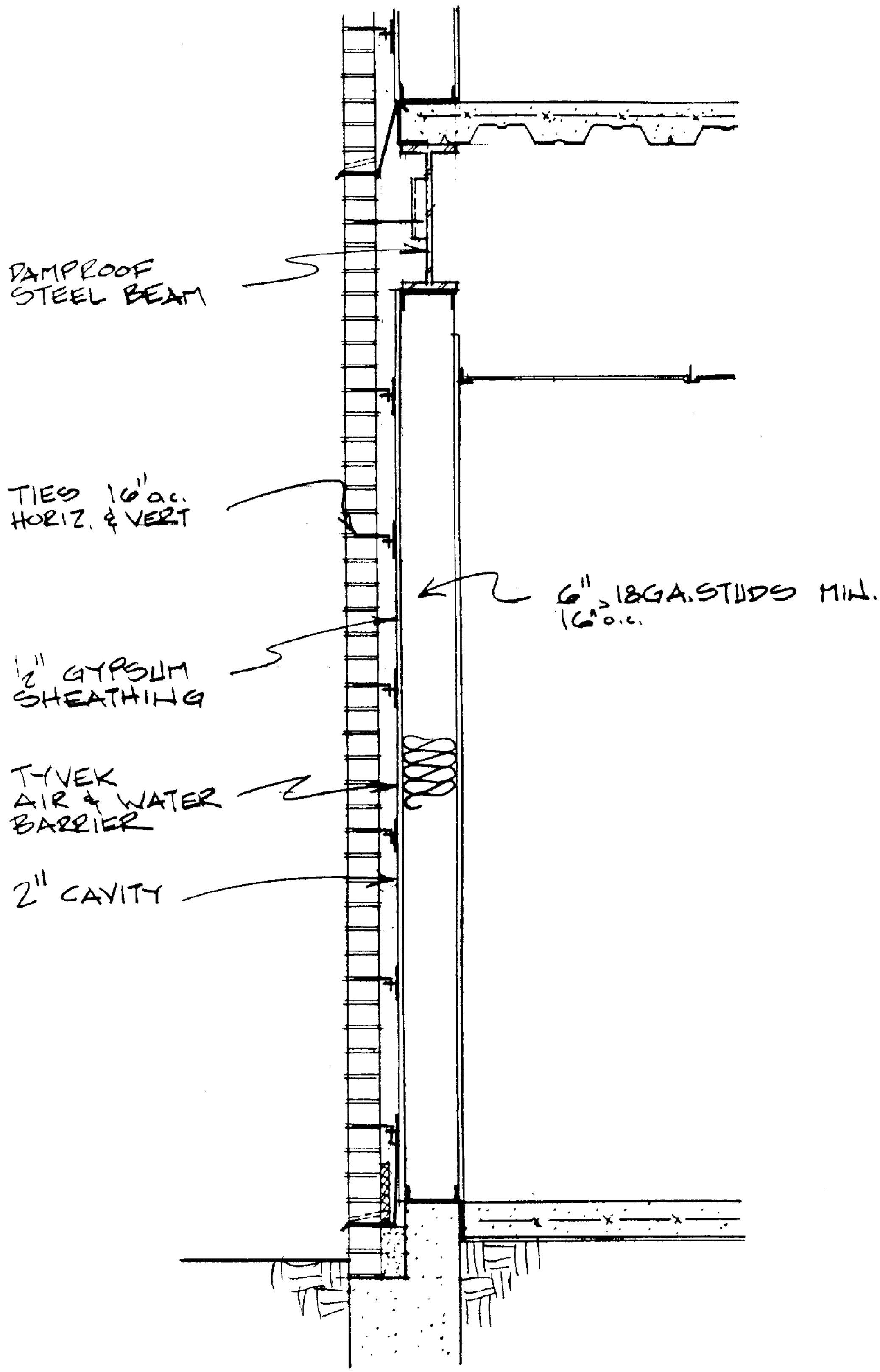

FIGURE 1 - veneer wall with metal stud back-up

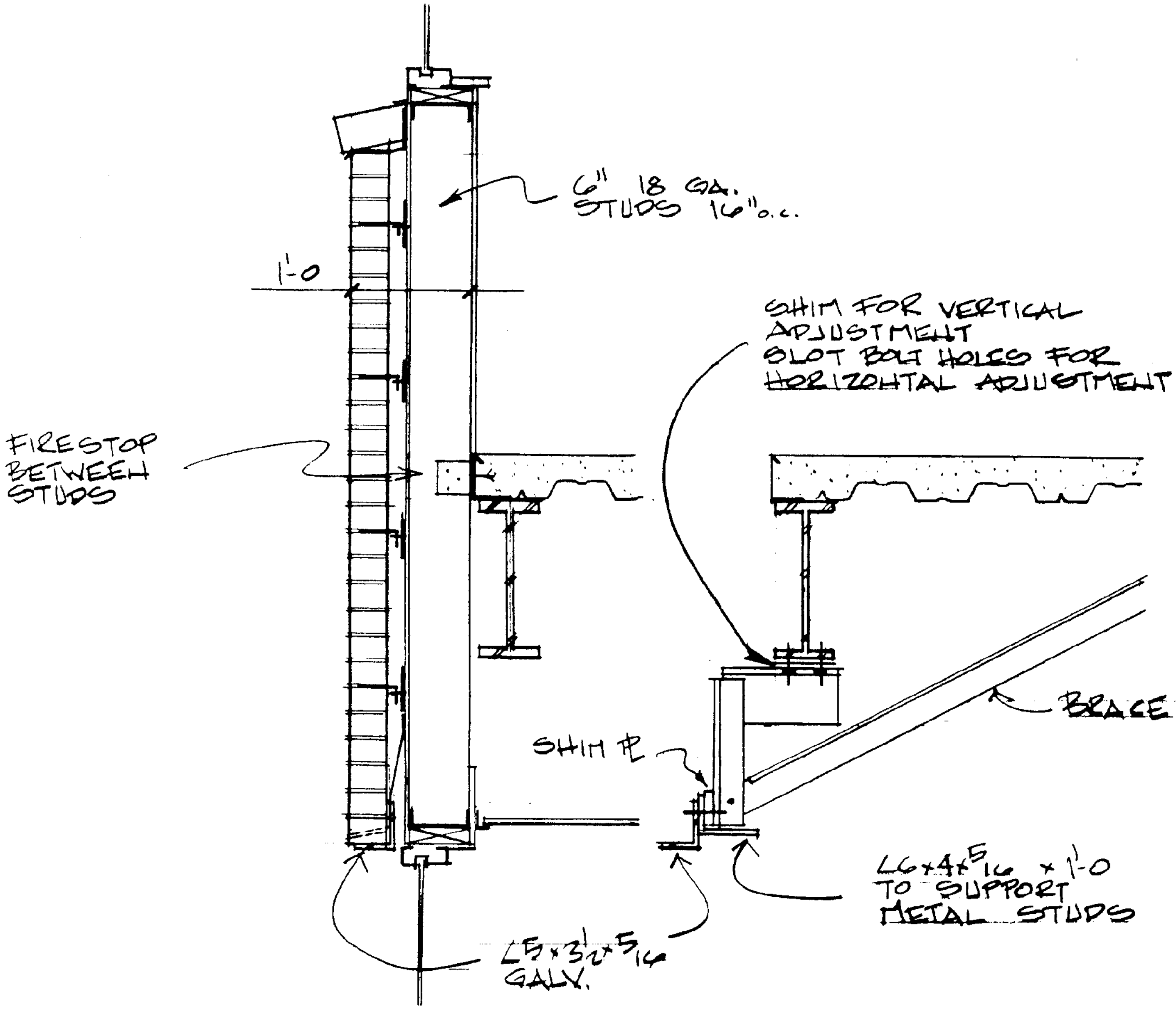

FIGURE 2 - veneer wall with metal stud back-up at continuous windows. Structural steel hung lintel detail shown at right.

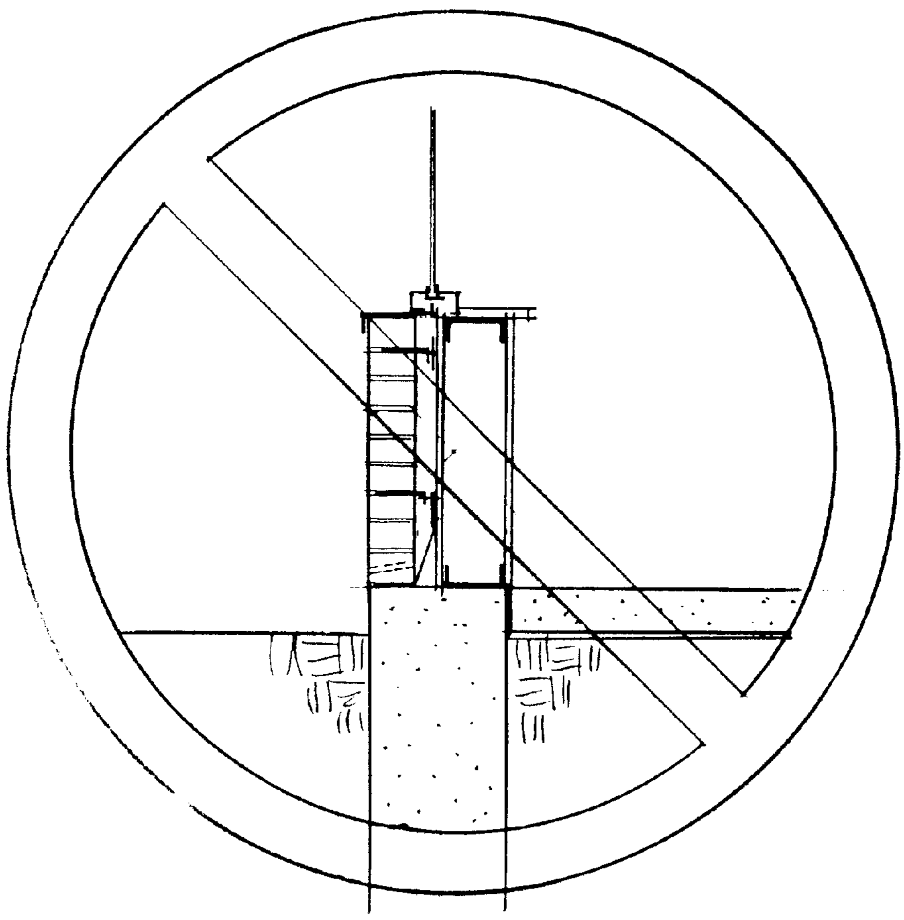

FIGURE 3 - laterally unstable metal stud back-up wall. Common error at storefronts.

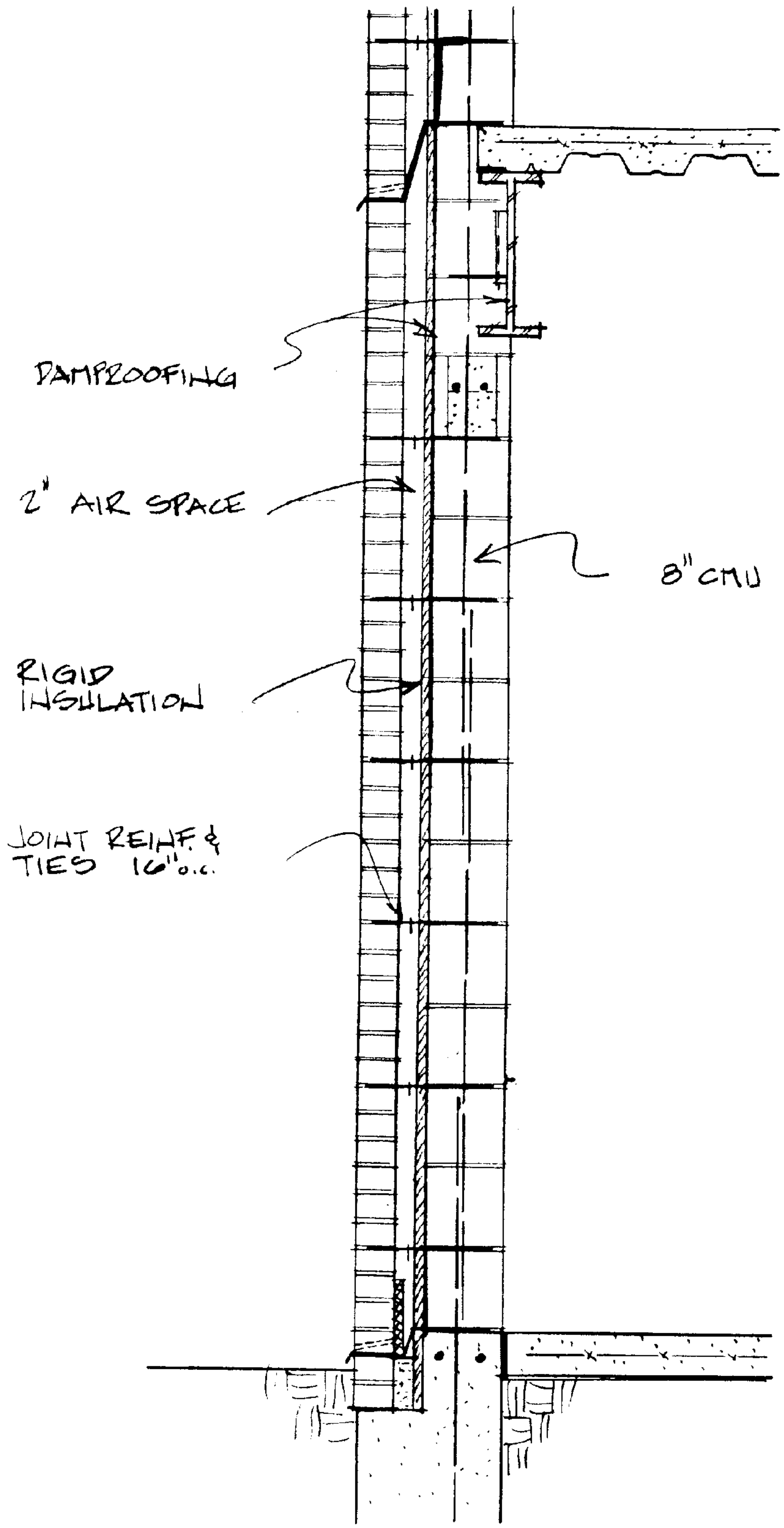

Figure 4 - veneer wall with CMU back-up

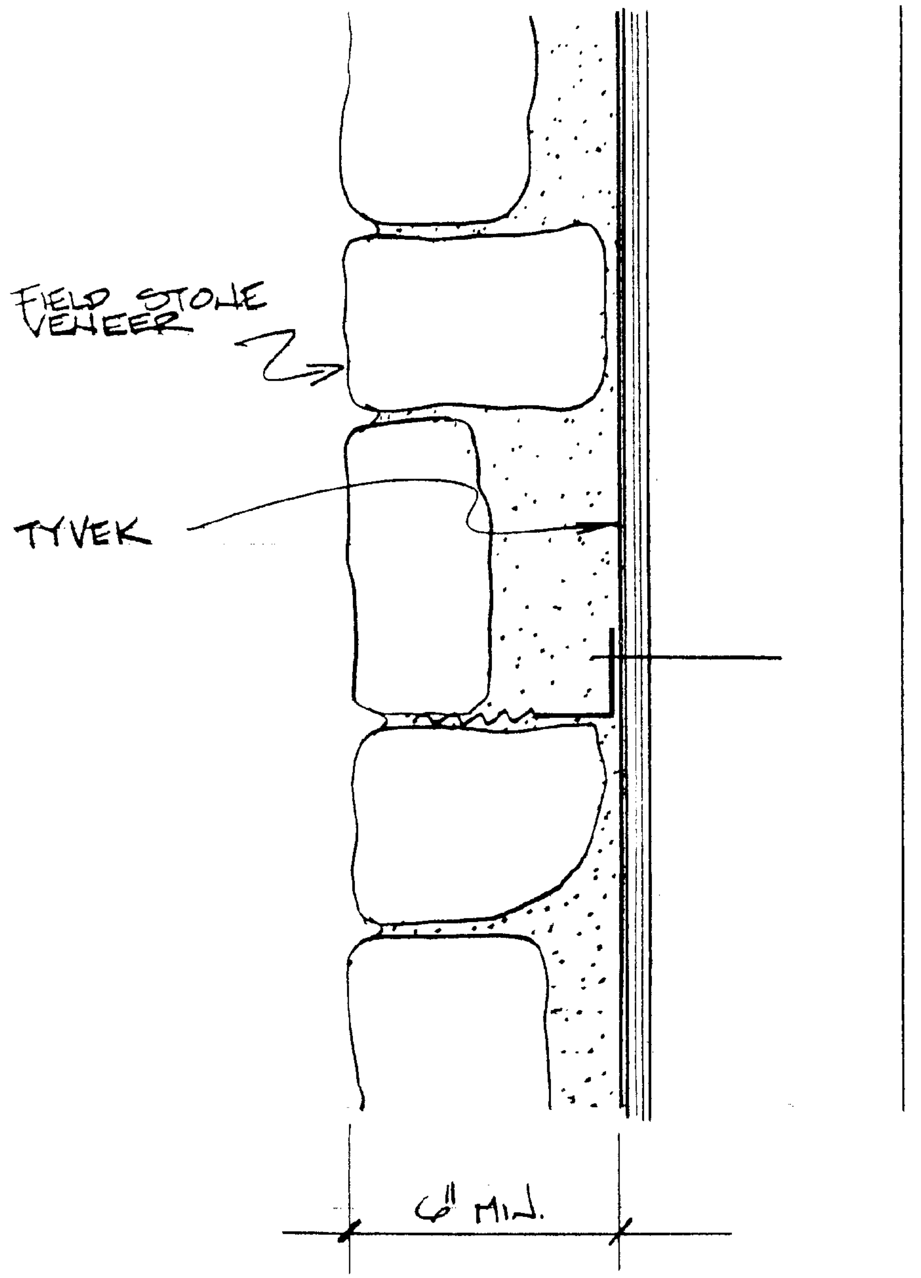

FIGURE 5 - rubble stone veneer wall

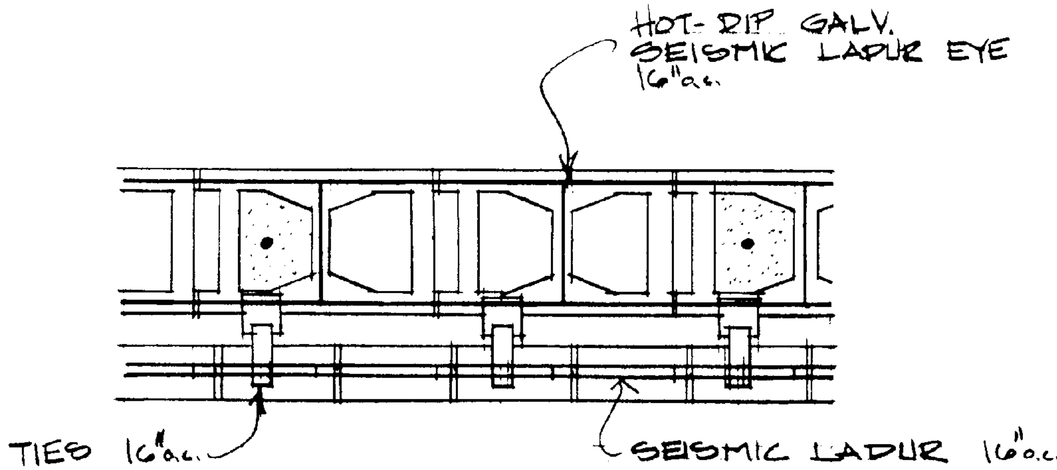

FIGURE 6 - cavity wall ties and joint reinforcing. Ties are required to engage horizontal joint reinforcing in the veneer per BOCA 1992 Supplement 1409.7.1.

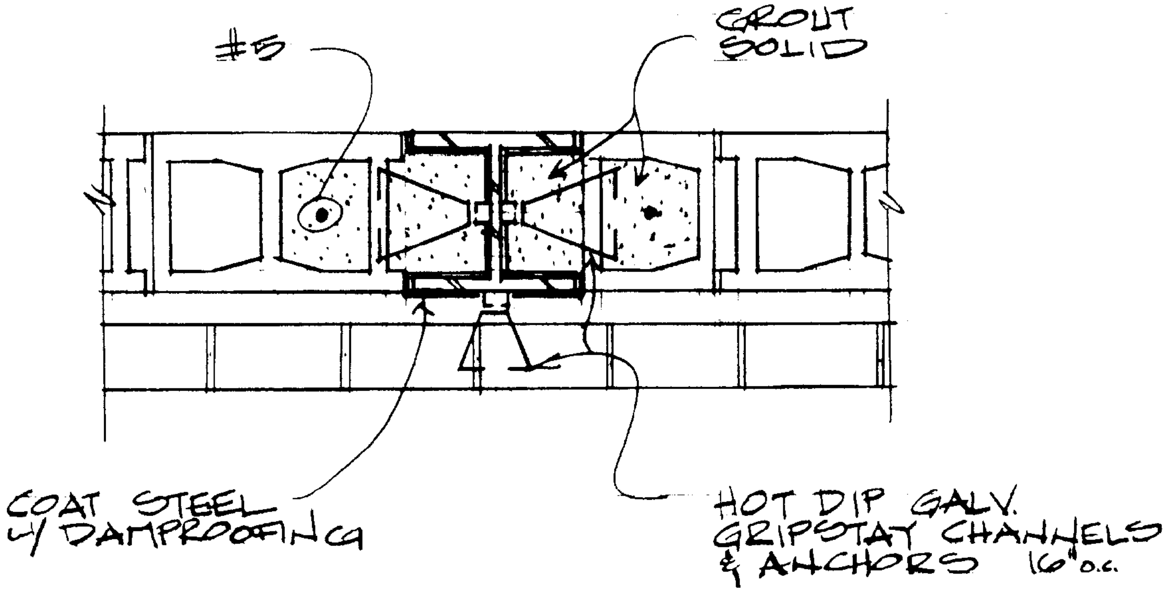

FIGURE 7 - Structural steel column anchors. Channel slot type anchors are preferred for anchorage of masonry to steel.

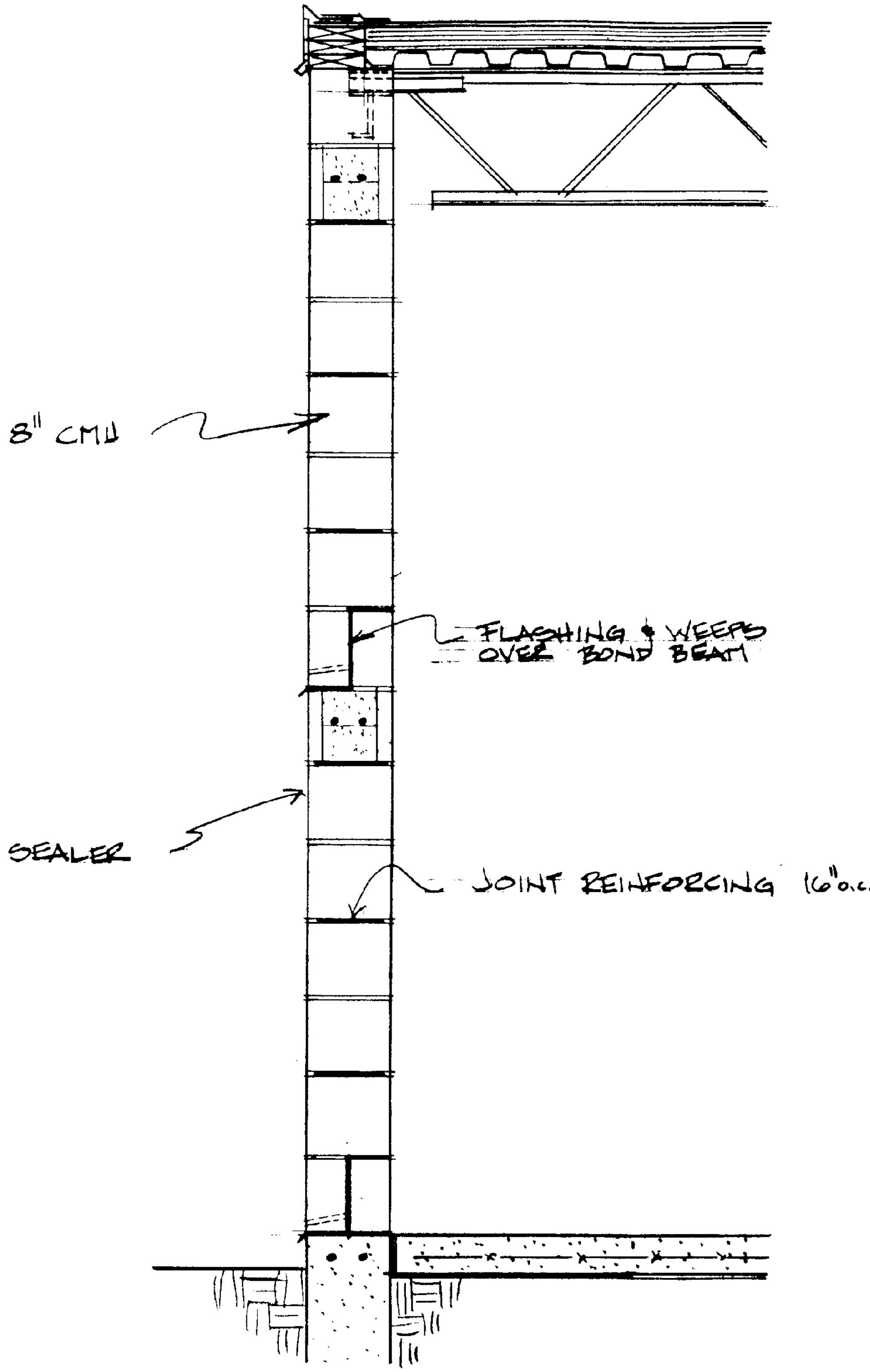

FIGURE 8 - single wythe CMU bearing wall

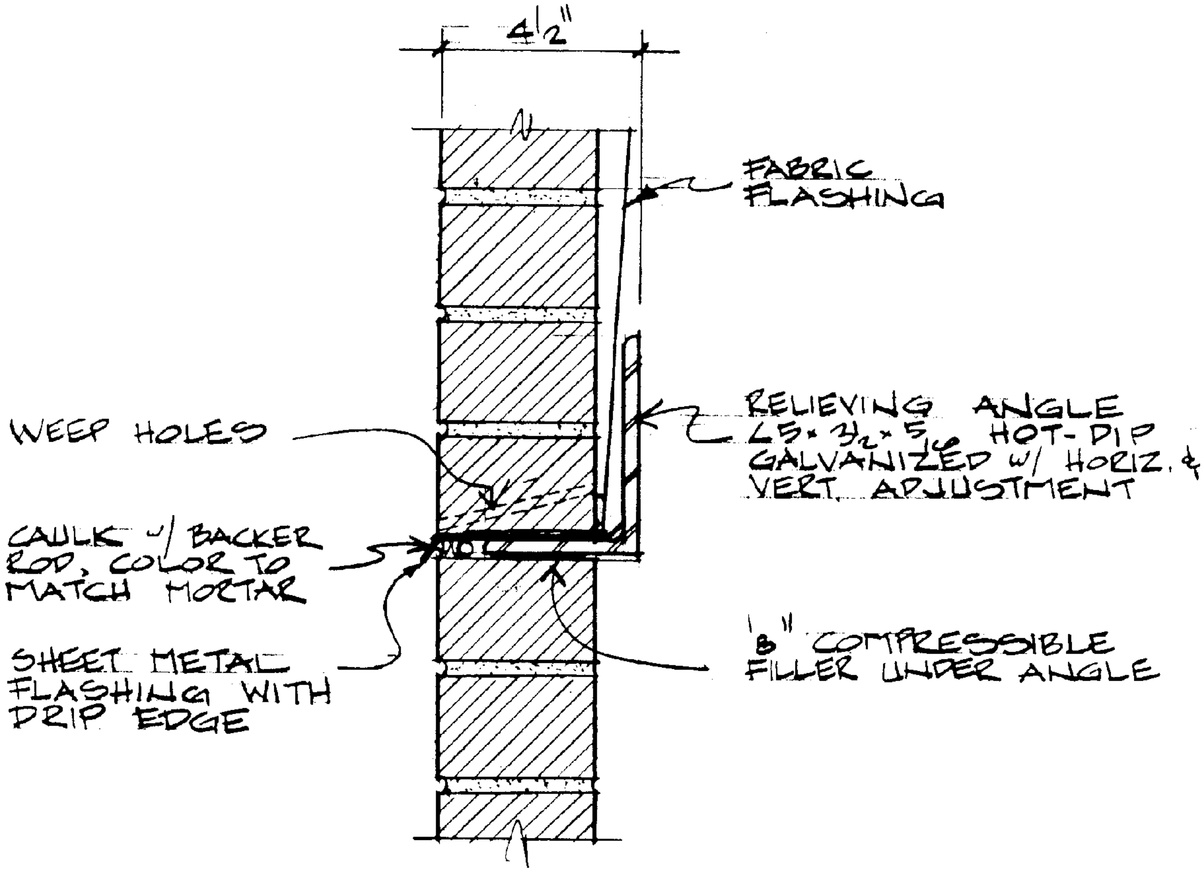

FIGURE 9 - brick relieving angle

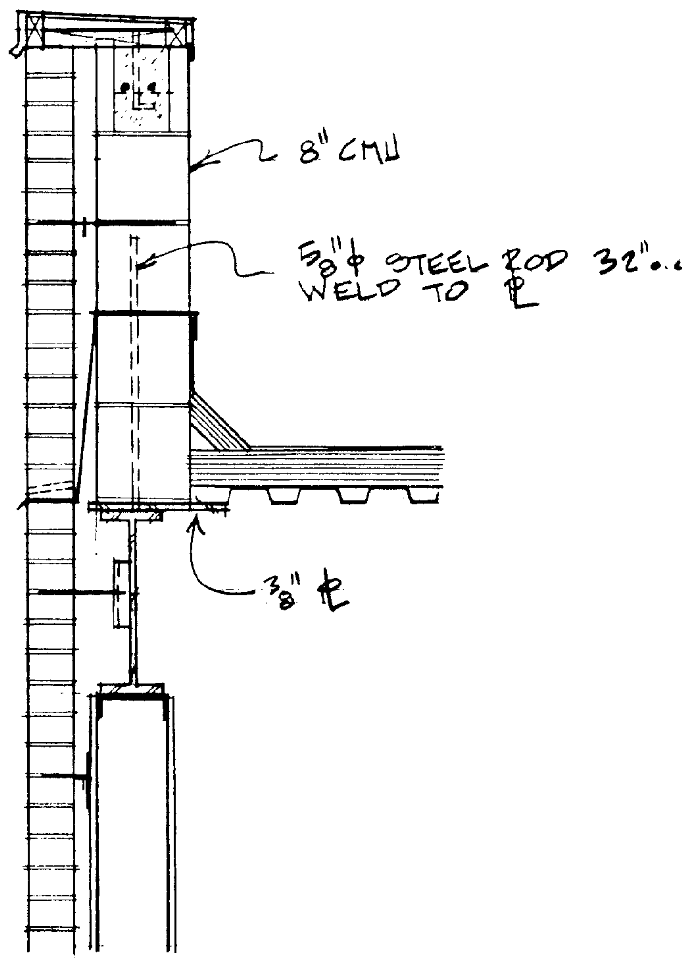

FIGURE 10 - parapet wall