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PRECAST CLADDING

ARCHITECTURAL AND STRUCTURAL CONSIDERATIONS

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ABSTRACT: Design considerations which should be followed to provide for the economical attachment of precast concrete cladding to a building structure are described. Panel configuration, production, transportation, erection, loading, and connection types are discussed for non-structural cladding. Finally, special considerations required of structural cladding and connections are reviewed.

Introduction

Architectural precast concrete cladding connections are generally designed to transfer cladding loads to the structure without affecting the response of the structure to vertical loads and lateral wind or seismic loads. Floor and roof members must be able to deflect and column drift must be accommodated without imposing loads on the cladding connections from the structure.

This can be accomplished by identifying and providing for the interrelated architectural, structural and cost requirements of the building design.

Cladding Panel Configuration

The architectural design of a precast building facade is usually enhanced by the use of real and false joints to create a pattern. The location of real joints between individual cladding panels must be carefully chosen.

Generally, the joints will create three types of panels: story height wall panels, horizontal spandrel panels and vertical column cover type of panels. See Figure 1.

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Next, we must consider the location, size and capacity of the building structure to support the loads from the cladding panel connections. Whenever possible, panel bearing connections should be located at the building columns. Column supported connections are more economical than beam bearing connections and provide stiffer resistance to the panel eccentric loads. Real vertical joints at column lines thus offer an advantage.

The overall size and weight of each individual panel can also be limited by the capacity of the local production facility, truck transportation legal limits, truck and crane access around the structure, and the available crane capacity.

Once the cladding panel sizes are established, the connection types and locations can be determined. See Figure 1.

Connection Types and Loads

Cladding panel connections must transfer gravity, wind and seismic loads from the panels to the structure. Generally they can be divided into three types:

* Bearing Connections ▼
* Lateral Load Connections ●
* Shear Load Connections ▬

Each panel may have one or two bearing connections, but never more than two. The panels are generally very stiff relative to the supporting structure so the use of more than two bearing points to support a panel creates unknown loads in each connection.

Bearing connections transfer panel gravity loads, wind and seismic loads perpendicular to the panel, and may also transfer seismic loads parallel to the panel. They are generally located near the ends of the panels to provide a stable base during panel erection.

Lateral load connections only transfer loads perpendicular to the panel. They are designed to permit the structure to move vertically and horizontally parallel to the panel while under perpendicular loading. They are located above or below the bearing connections and along the length of the panel as necessary to support the panel designed as a continuous beam for perpendicular loading.

Shear load connections transfer loads in all horizontal directions while permitting the structure to move up and down behind the panel. They are located near the middle of wall and spandrel panels and at one end of vertical column cover panels.

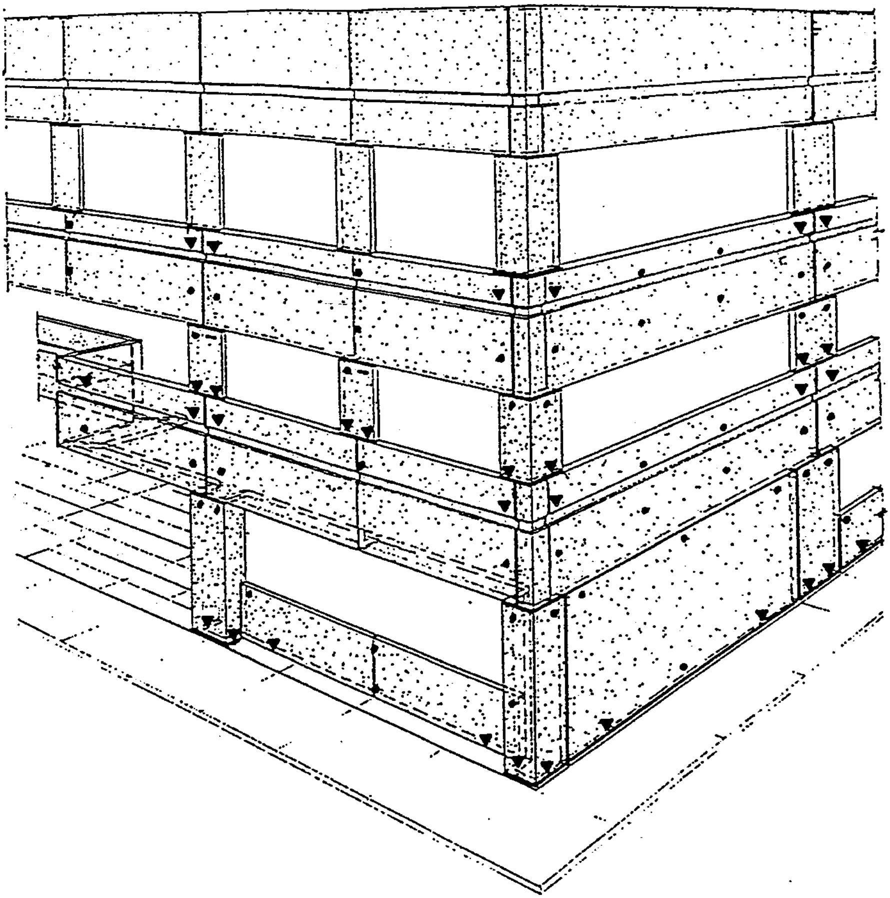


FIG 1

Typical Architectural Precast Concrete Panel Building Facade with Real Joints and Panel Connection Locations Shown.

First, the joints must permit the individual panels to move as required to follow the building drift under lateral loading. Each story should have at least one real horizontal joint continuous all the way around the building. This will permit the panels attached to one floor to move with that floor's drift relative to the panels above and below them which must move with their floor's drift.

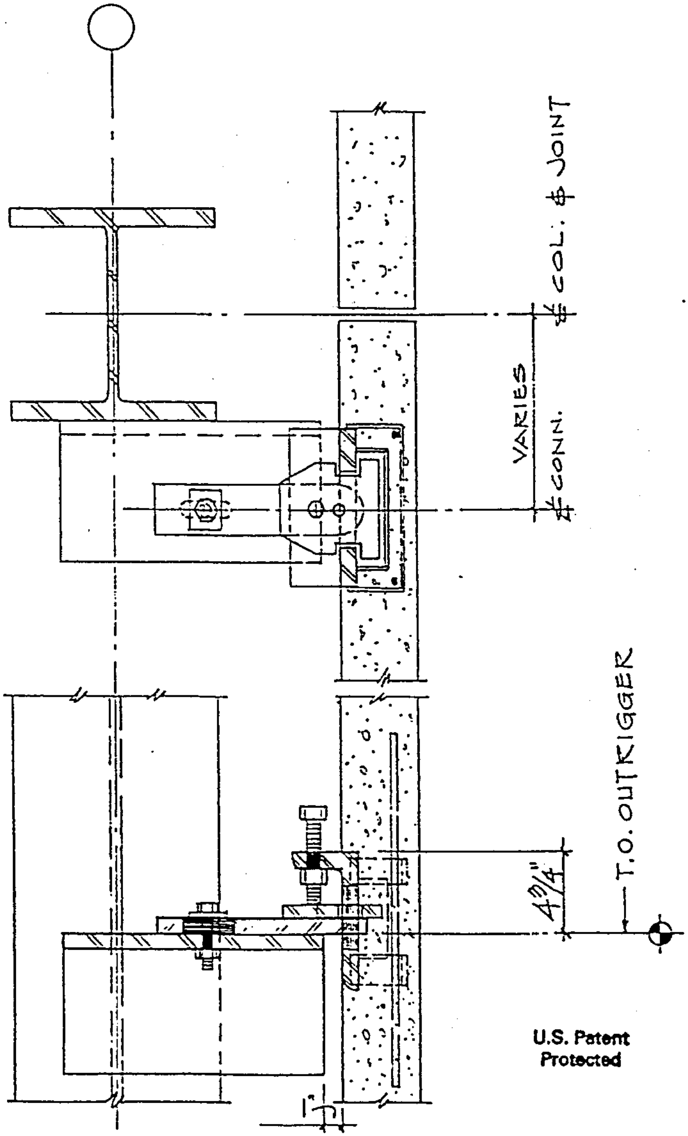


FIG 2

Bearing Connection At Column

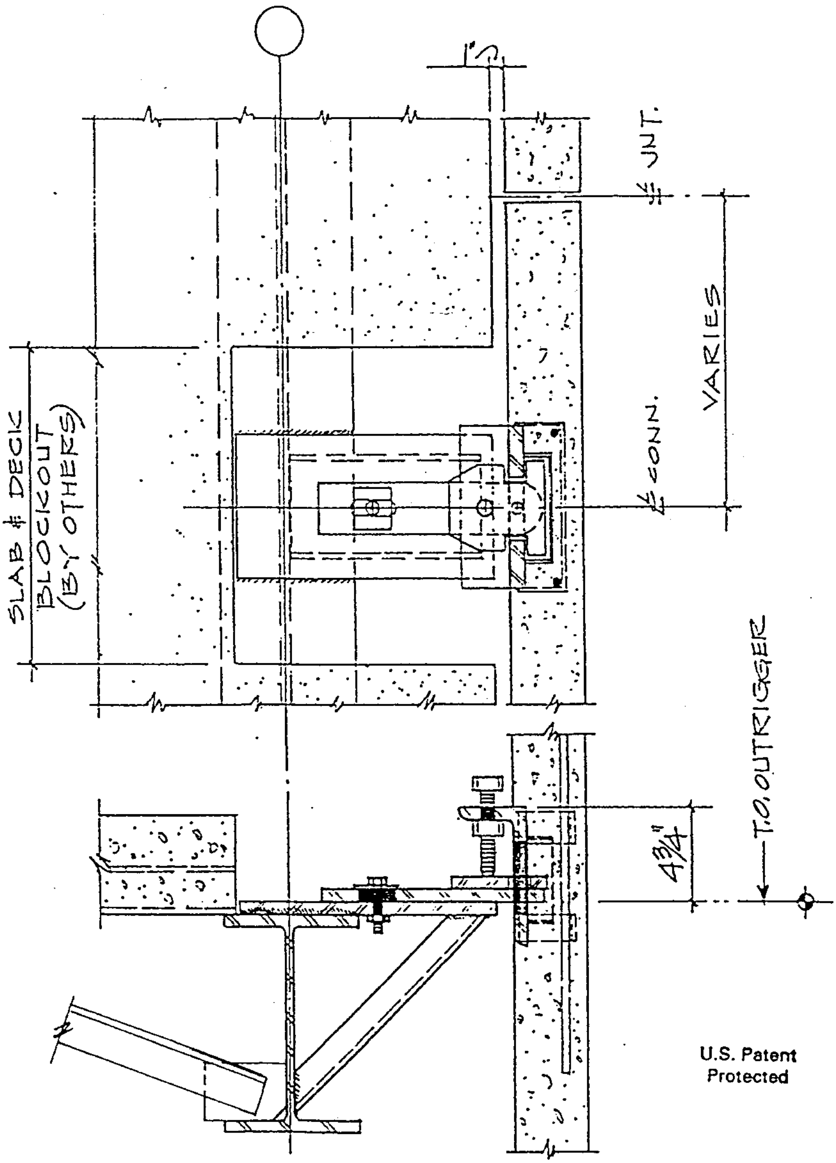


FIG 3

Bearing Connection At Beam

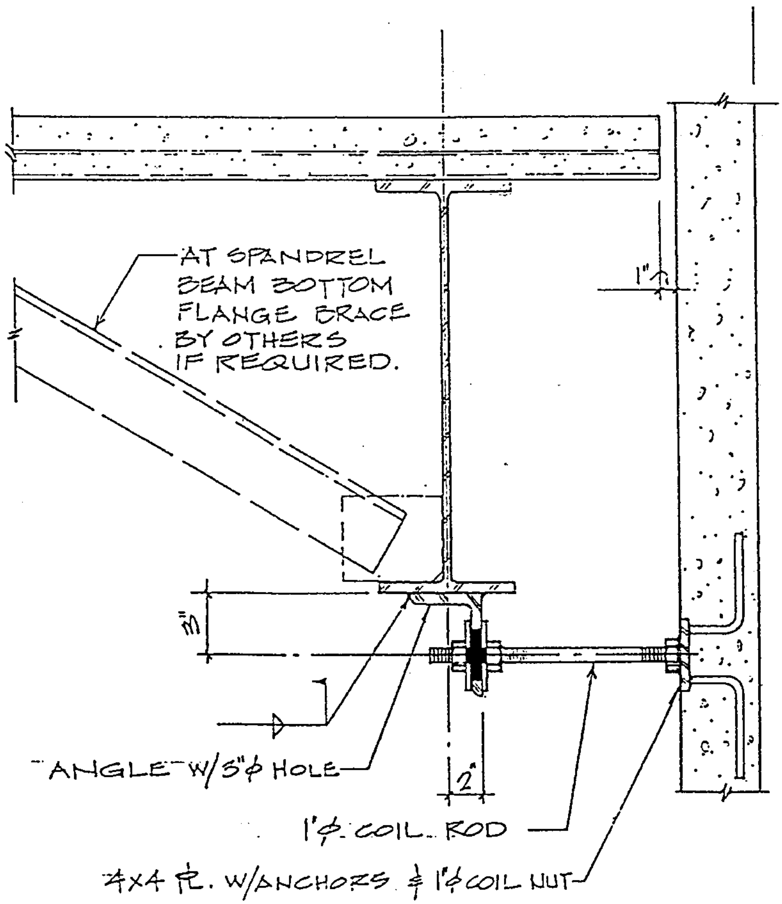


FIG 4

Lateral Connection To Beam Or Column

Panel Connection Design

The configuration and design of each type of panel connection must consider a number of important characteristics. Providing a safe, economical solution to supporting cladding panels on a building frame requires that the connections be designed:

* To transfer erection as well as final loads to the structure.
  A bearing connection may have to be designed for an eccentric load created by one panel in place before the adjacent panel is erected. Often, panels are placed on the structure in a temporary position and then finally aligned and secured days later. This may require moving the panel slightly with the connections supporting gravity loads.

* For ease of fabrication.
  These connections are generally required to develop large loads in thin concrete sections without distress. The cost of the connection hardware, placing it in the panel, and making the final connections in the field can have a large impact on the total building facade cost.

* To accommodate building construction tolerances.
  The exterior facade of the building must be aligned to a true vertical and horizontal plane regardless of the variations in alignment of the structure behind it. The connections must be capable of accommodating these expected variations without creating eccentricities or loading beyond their capacity.

* For economical panel erection.
  A field crew and crane can cost more than $10,000 a day. Connections which permit rapid, secure attachment of panels to the structure will dramatically reduce the per panel erection cost. See Figures 2 and 3 for a bearing connection which only requires the placement of one bolt before the crane is released to hoist another panel. This type of connection also permits later movement of the panel in all directions under load for final alignment.

* To permit the structure to move.
  The connections must be capable of carrying their design loads while the structure is deflecting due to gravity or lateral loading. This may be accomplished with slotted holes or bending of steel connection members. Two examples of lateral connections with this capability are illustrated in Figures 4 and 5.

* To fit within the architectural finish.
  Furring around columns and on the inside of the panels will quite often conceal and protect the connections. Connections exposed to the weather should be painted or galvanized to protect them from corrosion.

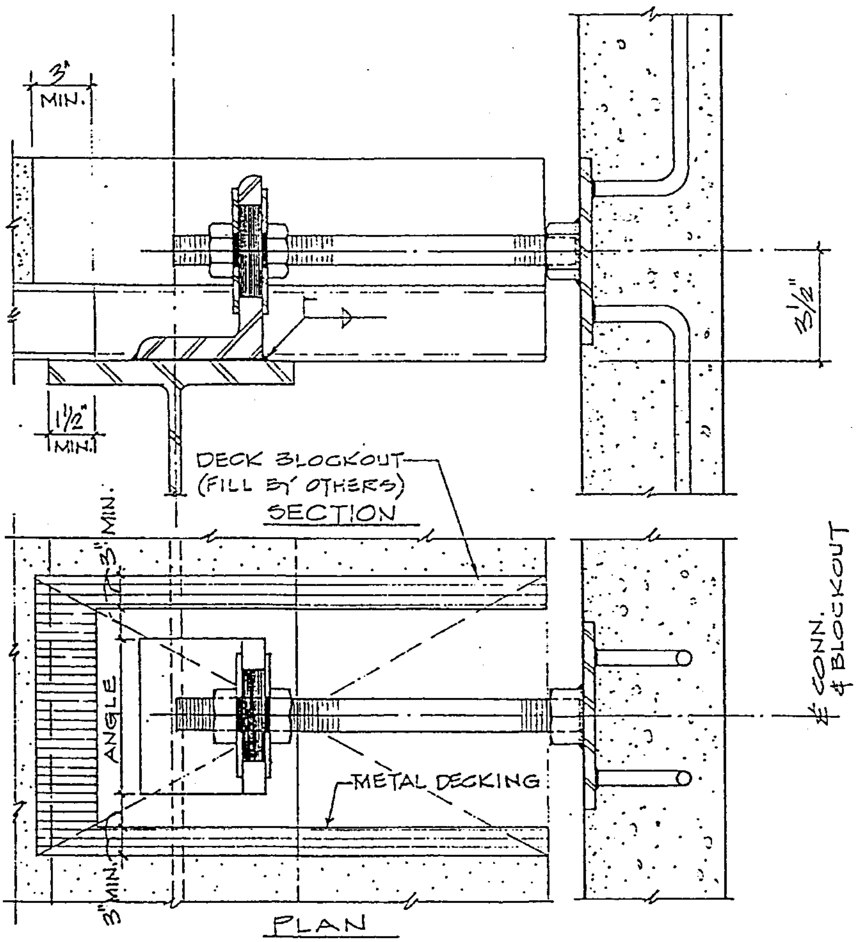


FIG 5

Lateral Connection To Floor

Structural Cladding and Connections

Precast cladding panels and their connections which are required to participate with the structure to transfer lateral wind and seismic loads must have some special characteristics such as the ability to:

* Carry loads after distortion and yielding due to building movement.

* Support multiple load reversals without failure.

* Develop strength with ductility.

The cost of structural cladding will surely be greater but may be partially offset by reduced structure cost and less architectural damage due to reduced story drift under seismic loading.

Figures 6 and 7 illustrate a precast ductile frame building system which can incorporate architectural panels into the exterior frames.

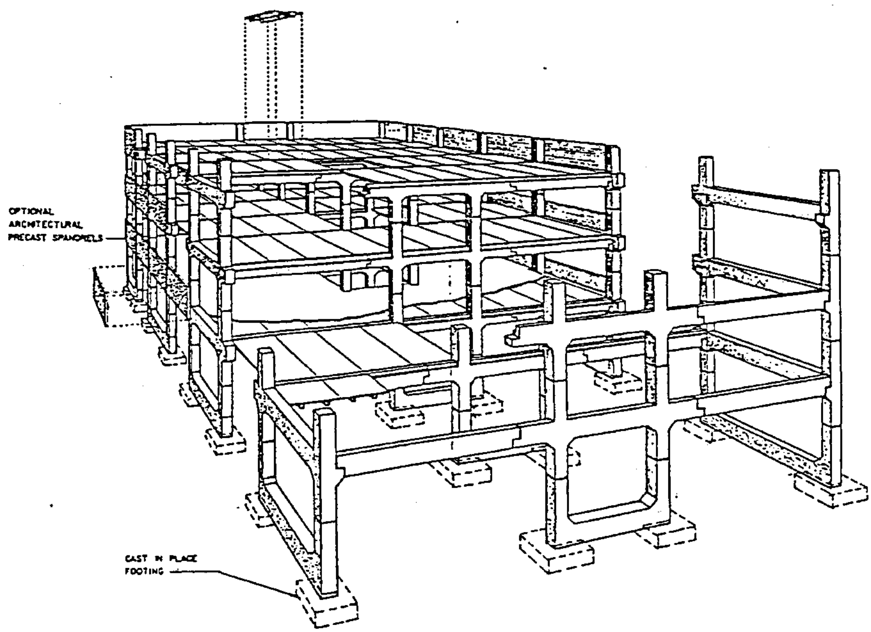


FIG 6

Precast Concrete Building Frame System

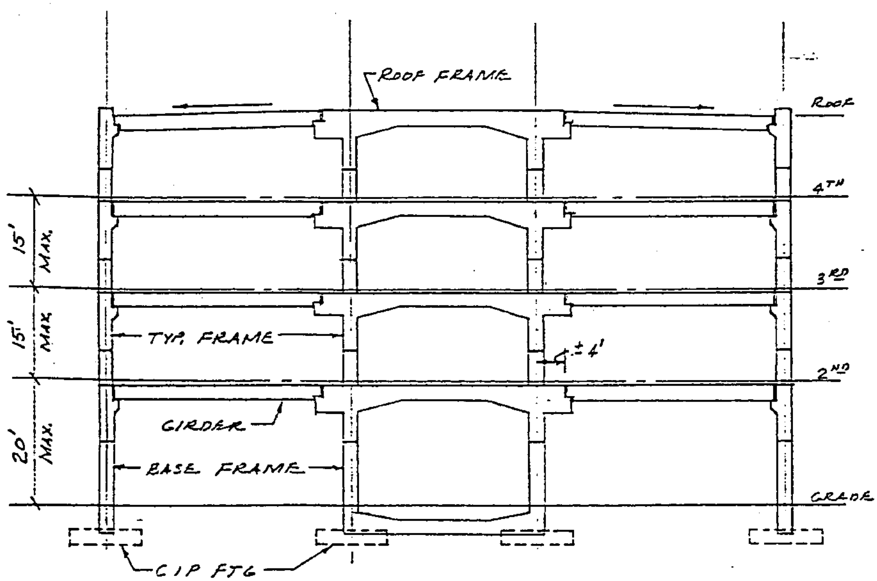
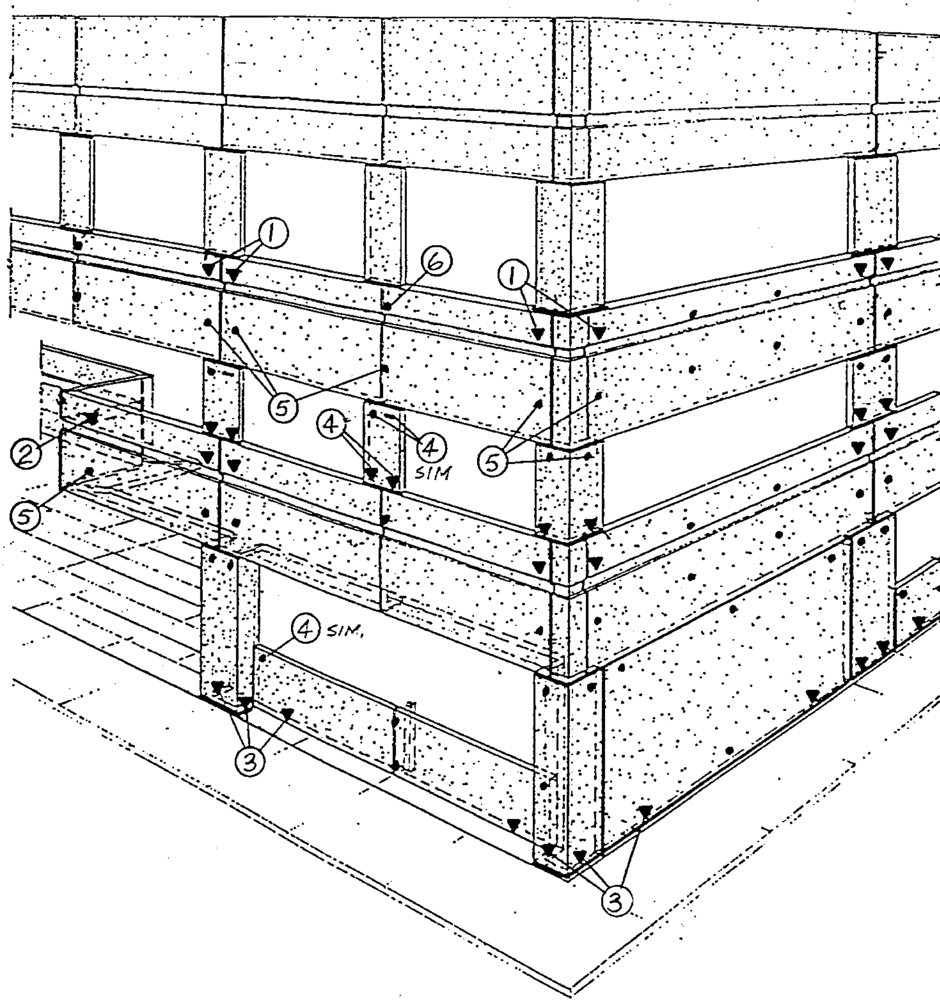


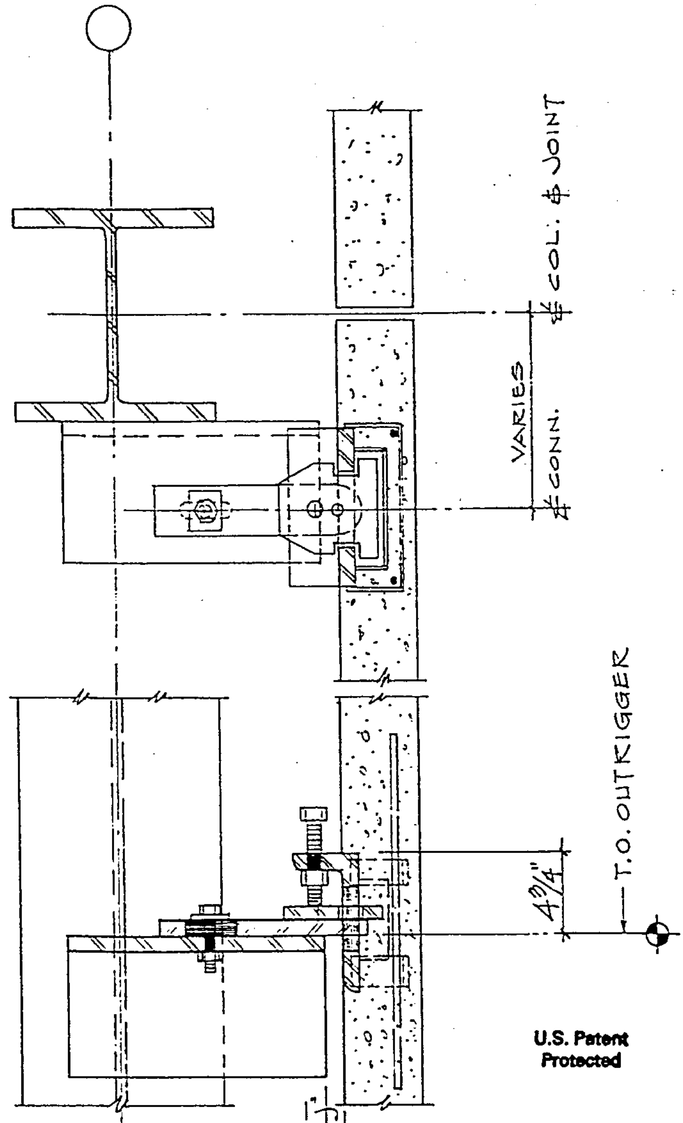
FIG 7

Building Frame System Cross Section



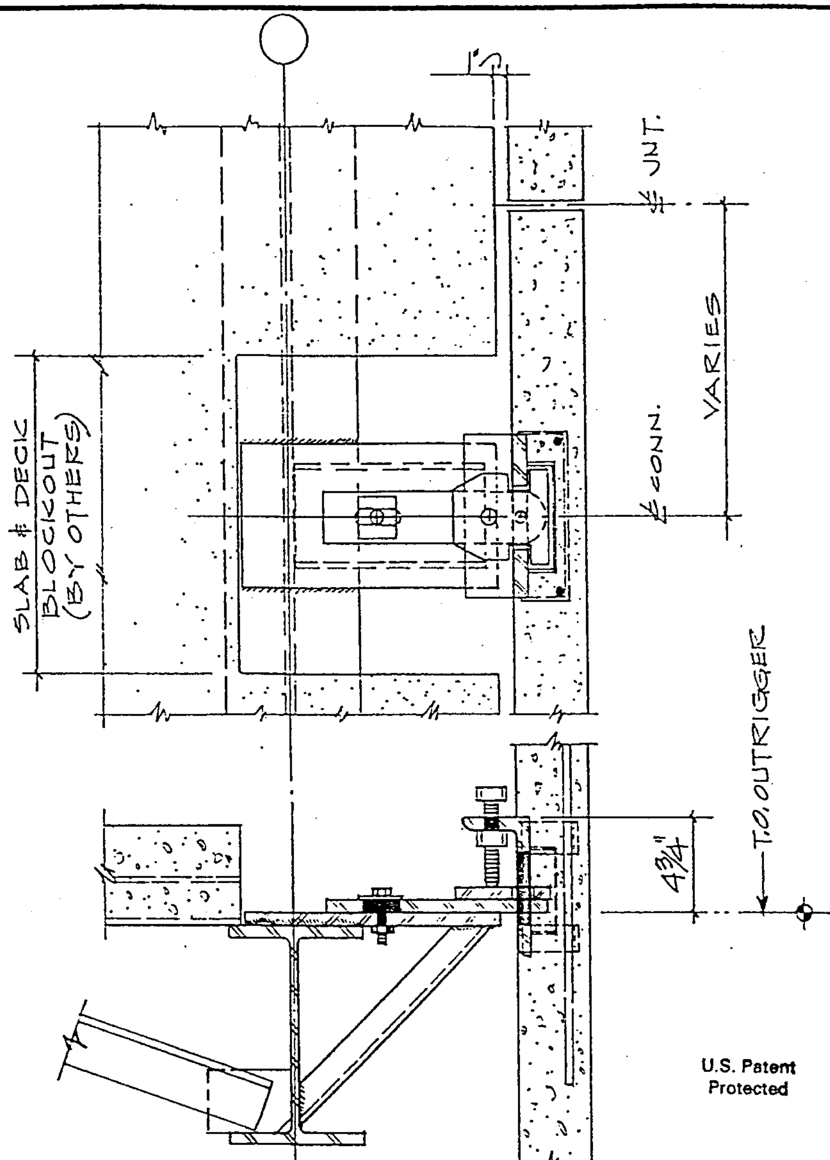
Panel Connections

1. Floor bearing - swing arm to column side
2. Floor bearing - swing arm to beam
3. Bearing - panel to grade slab
4. Bearing - panel to panel
5. In/out - panel to column/beam
6. In/out - panel to floor slab

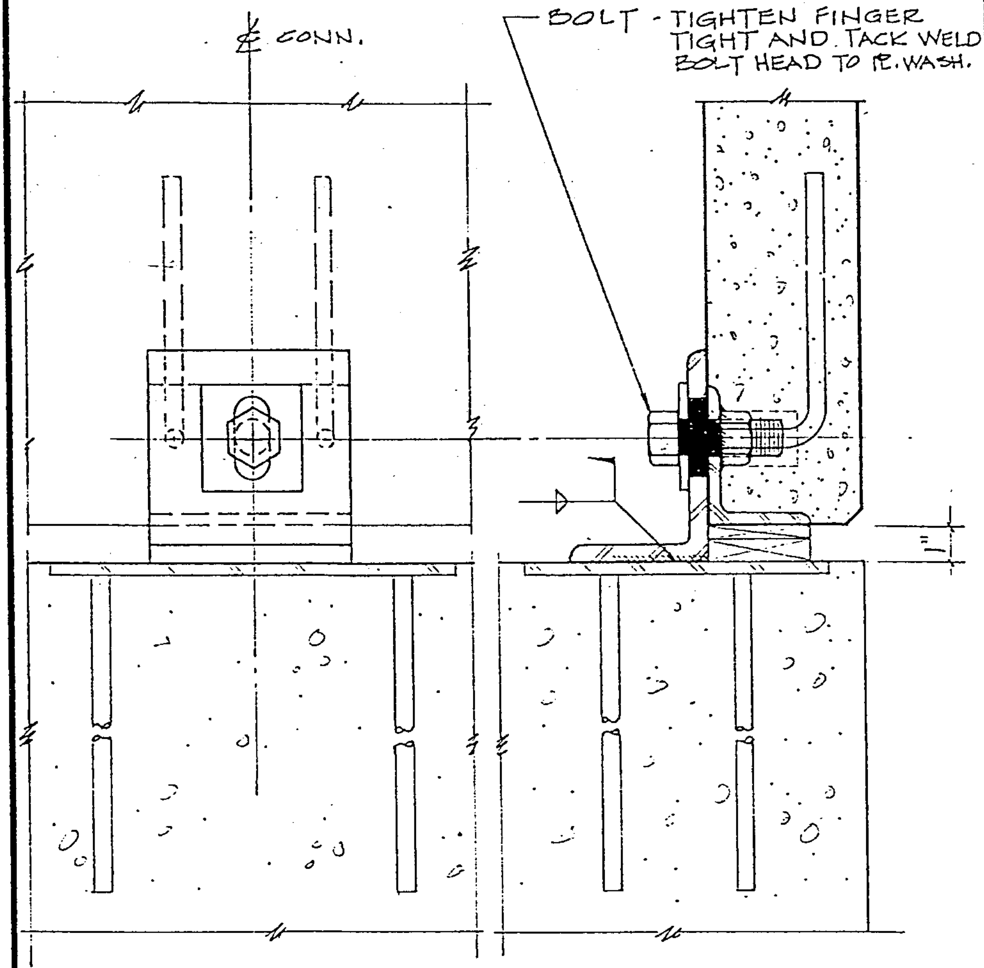


① DEAD LOAD BEARING CONNECTION

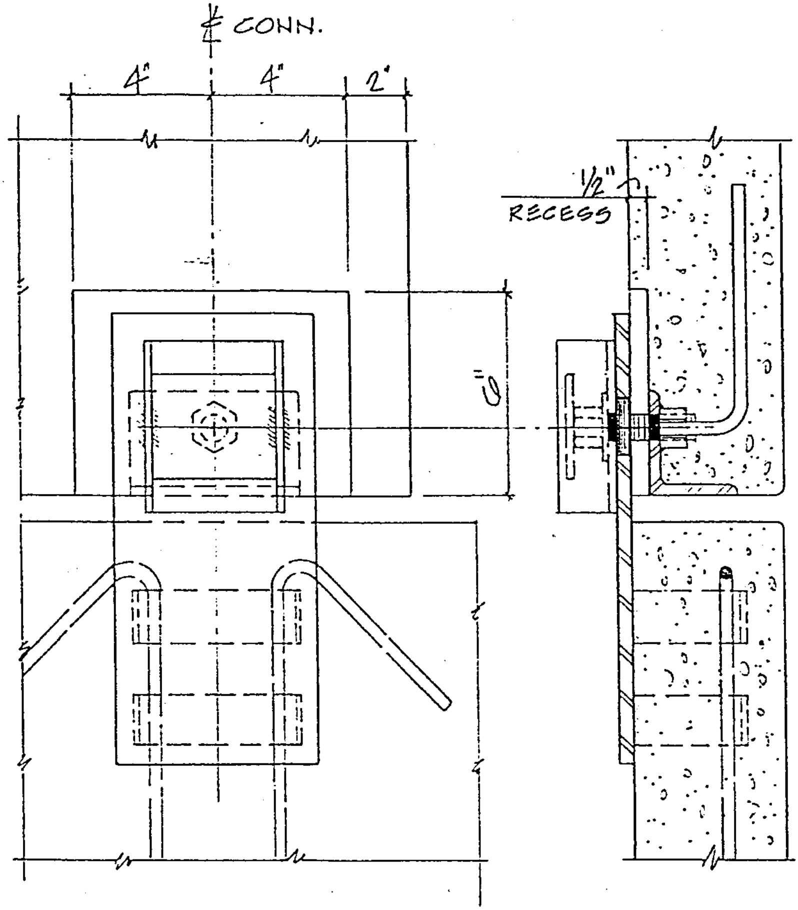
AT EACH SIDE OF COL.



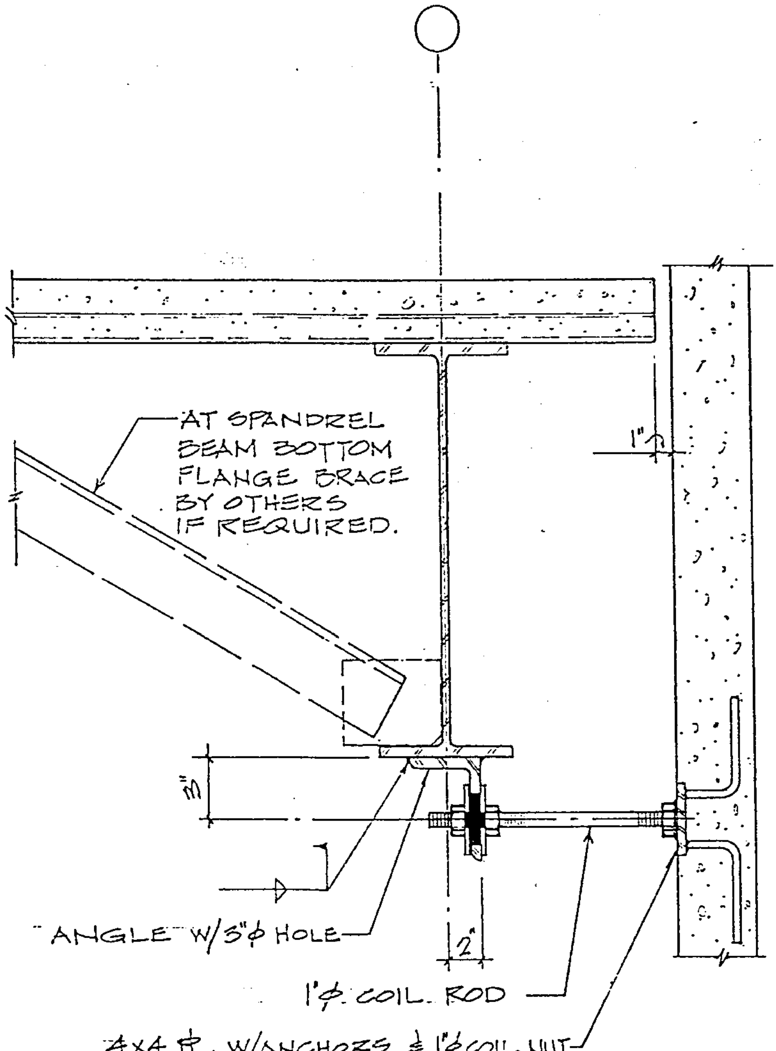
(2) DEAD LOAD BEARING CONN. AT BEAM



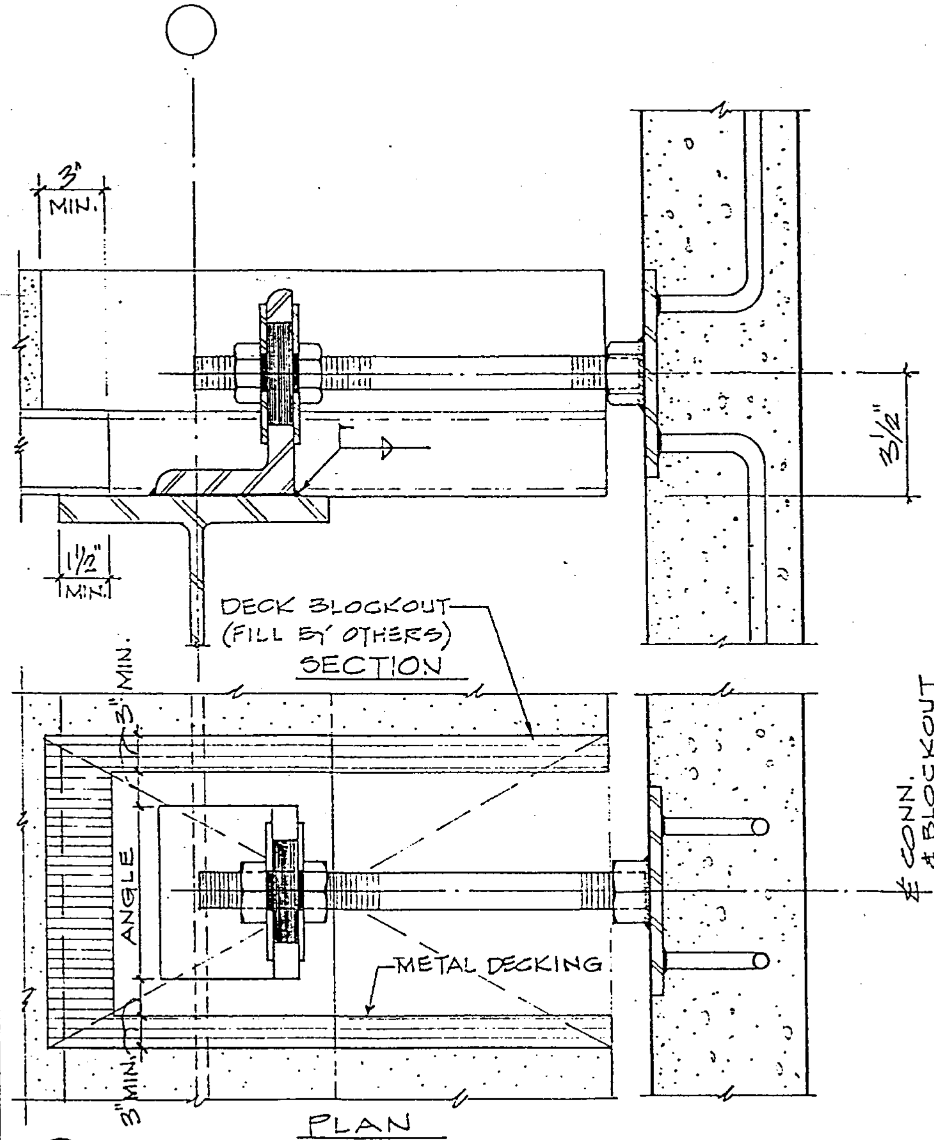
3 PANEL TO SLAB ON GRADE



(4) COL. COVER TO SPANDREL BEARING



5 IN-OUT CONNECTION AT BEAM OR COL. (SIM.)



6 IN-OUT CONNECTION AT SLAB EDGE