Case study: One Tampa City Center

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Case Study: One Tampa City Center

Etude de cas: One Tampa City Center

Fallstudie: One Tampa City Center

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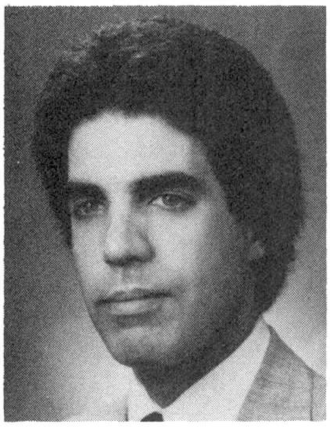

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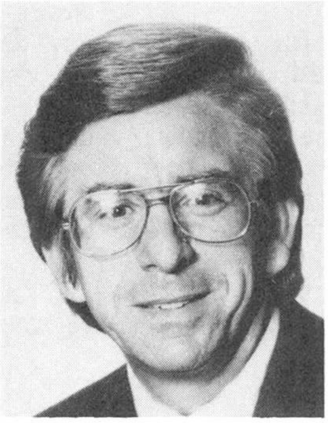

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SUMMARY

This paper presents a case study of One Tampa City Center, a 40-story office building located in Tampa, Florida, USA. Completed in 1982 as Florida's tallest building, the project utilizes composite steel-concrete construction for the primary structural system of the building, as well as composite subsystems and components. The composite structural system provided large clear-span areas as well as the required hurricane-wind resistance, all at minimum cost and within a tight construction schedule.

RÉSUMÉ

Cet article présente une étude de cas, le bâtiment administratif de 40 étages «One Tampa City Center», situé à Tampa. Achevé en 1982, il constitue le plus haut bâtiment de Floride. Les structures primaires et secondaires sont constituées d'éléments mixtes acier-béton. Ces structures mixtes permettent des grandes portées, assurent la résistance requise aux cyclones avec des coûts minimaux et nécessitent moins de dossiers et de plans de construction.

ZUSAMMENFASSUNG

Dieser Vortrag beinhaltet eine Fallstudie des One Tampa City Centers, eines 40stöckigen Geschäftshauses in Tampa, Florida, USA. Es wurde 1982 als Floridas höchstes Gebäude vollendet. Die primäre Tragkonstruktion sowie Tragwerksteile und Komponenten wurden in Stahl-Betonverbundbauweise ausgeführt. Mit dem Verbundtragwerk wurden grosse, frei überspannte Flächen wie auch die erforderliche Orkan-Widerstandsfähigkeit erreicht; dies alles zu minimalen Kosten und innerhalb eines gedrängten Bauprogramms.

1. GENERAL DESCRIPTION

One Tampa City Center is a 40-story office building located in Tampa, Florida, USA (Fig. 1). The building, sheathed in silver reflecting glass, has a height of 158 m and contains a gross area of 80,000 sq. m.

Completed in 1982 as Florida's tallest building, the project utilizes a composite steel-concrete structural system which consists of a slipformed concrete core in combination with structural steel framing outside the core (Fig. 2). All wind resistance is provided by the core, thus enabling the use of simple economical connections for the steel framing outside the core. The gross weight of structural steel for this project is only 39.6 kg/sq. m.

The composite structural system provides large 13.7-m clear-span areas as well as the required hurricane-wind resistance, all at minimum cost and within a tight construction schedule. Other structural systems which were evaluated during the preliminary design stage included a total structural steel frame, a post-tensioned concrete beam-and-slab system, and a prefabricated prestressed concrete joist system. It is estimated that the composite steel-concrete system resulted in overall savings to the project in excess of $1,000,000. In addition, the composite system expedited the fast-track construction schedule, allowing installation of elevators and mechanical risers in the core while the structural frame outside the core was being erected.

2. CONCRETE CORE

2.1 Design

The concrete core has a typical wall thickness of 406 mm and is stepped at the 12th and 20th Floors, corresponding to the exterior shape of the building (Fig. 3). In order to achieve the proper composite interaction of these stepped portions of the core, necessary for drift control of the building, built-up structural steel H-frames were placed in pairs within the concrete core walls at the 6th, 11th, 12th, 18th, 19th, and 20th Floors (Fig. 4).

A concrete mat having a thickness of 2.4 m forms the base of the core. Compacted soil-cement, in a unique application, transfers the mat foundation loads to limestone which lies approximately 10 m below the ground surface.

2.2 Analysis

The concrete core was analyzed utilizing a 3 dimensional finite element computer model comprised of combined membrane and beam elements. A total of 45 loading combinations were investigated, including pressure loading conditions obtained from wind tunnel testing.

Due to the fast-track nature of the project, and the lead time requirements for wind tunnel testing, the actual testing was performed subsequent to both the structural design of the building and the awarding of a contract for the structural steel work. However, since the structural steel design was essentially unaffected by the wind loading on the building, mill ordering and fabrication of the structural steel was able to proceed unhindered. The results of the wind tunnel testing indicated significant torsional effects, which were otherwise unpredictable, and required reanalysis of the core and modification of the core wall reinforcing in several localized areas.

3. STEEL FRAMING

3.1 Beams and Girders

A typical framing plan for the upper portion of the building is shown in Fig. 5. The steel specified for the beams and girders is ASTM A572 Grade 50, F_y = 35.2 kg/sq.mm. Beams and girders utilize 19-mm-diameter x 89-mm-long shear connectors to act compositely with the floor slabs. Since the entire lateral resistance is provided by the core, beam-to-beam and beam-to-column connections are generally simple shear connections (Fig. 6).

Temporary shoring was provided for the steel beams until the concrete gained sufficient strength, in lieu of providing heavier beams to control the deflection due to the weight of wet concrete. This approach enabled the use of relatively shallow beams for large spans, e.g., a 457-mm beam for the typical 13.7-m span, which reduced the floor-to-floor dimension and the total height of the building.

3.2 Columns

The steel specified for the columns is ASTM A572 Grade 50, F_y = 35.2 kg/sq.mm. Since the columns transmit only axial forces, simple base plate and column splice details are utilized (Fig. 7).

In order to compensate for the differential shortening of the concrete core and the steel columns under dead load, column length adjustments were specified in the design and incorporated into the fabrication process.

3.3 Connection to Concrete Core

A weld-plate detail is utilized for the connection between the steel beams and the concrete core (Fig. 8). During the slipform operation, the weld-plates are set at the required locations, with the outer surface of the weld-plate set flush with the wall surface. Anchorage of the weld-plate is achieved by shear connectors which are welded to the inner surface and become embedded in the core wall. The weld-plates were oversized in order to allow for placement tolerances.

Subsequently, structural steel tees were field-welded to the weld-plates. The outstanding stem of each structural tee contained slotted holes in order to provide increased erection tolerances. The beams were connected to the tee stems using high-strength friction bolts.

In order to avoid delays to the structural steel erection due to possible out-of-tolerance field conditions of weld-plates, several types of such conditions were anticipated prior to the start of steel erection. Standardized solutions for these conditions were developed and pre-approved so that they would be readily available to be implemented whenever an out-of-tolerance condition might arise during the steel erection.

4. FLOOR CONSTRUCTION

4.1 Outside Core

The floor system outside the core area, typically spanning 2.5 m between floor beams, utilizes composite steel decking having a depth of 51 mm and a thickness of 0.91 mm. A concrete fill of 64 mm thickness is placed above the decking, and welded wire fabric is placed within the concrete fill (Fig. 9). An electrified floor system is utilized for the 3rd through 17th Floors, and a nonelectrified system is utilized for the balance of the floors.

4.2 Within Core

The typical floor construction within the core consists of cast-in-place concrete beams and slabs, with the exception of the 11th, 19th, 30th, and 37th Floors which use structural steel framing with composite steel decking and concrete fill.

Each of the steel-framed core floors was constructed as soon as the slipform reached its corresponding level. This provided stiffening for the free-standing concrete core, and also provided a protective umbrella which enabled concrete floor slabs to be placed at the floors below while the slipform operation continued. Structural steel framing was used for these protection floors in lieu of concrete in order to minimize the shutdown time of the slipform operation while these floors were being constructed.

4.3 Connection to Concrete Core

At the connection between the floor slabs (both within and outside of the core) and the core walls, intermittent keyways were provided in the core walls (Fig. 10). This enables the transmission of lateral diaphragm forces from the floor system to the core. Keyway connections were also provided at stairs and stair platforms within the core in order to maintain the structural continuity of the core at the stair shaft openings.

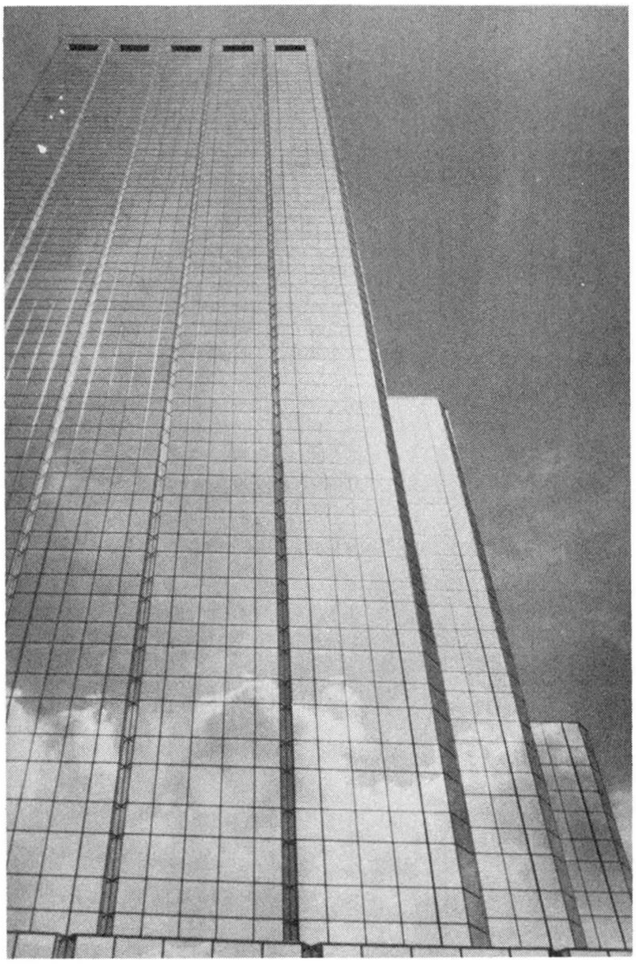


Fig.1 One Tampa City Center, Tampa, Florida, USA

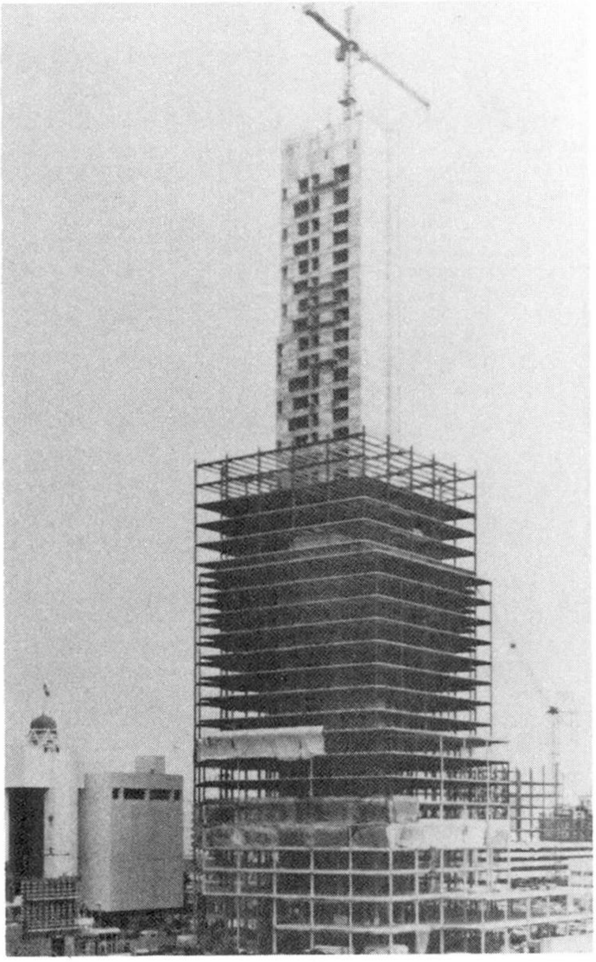
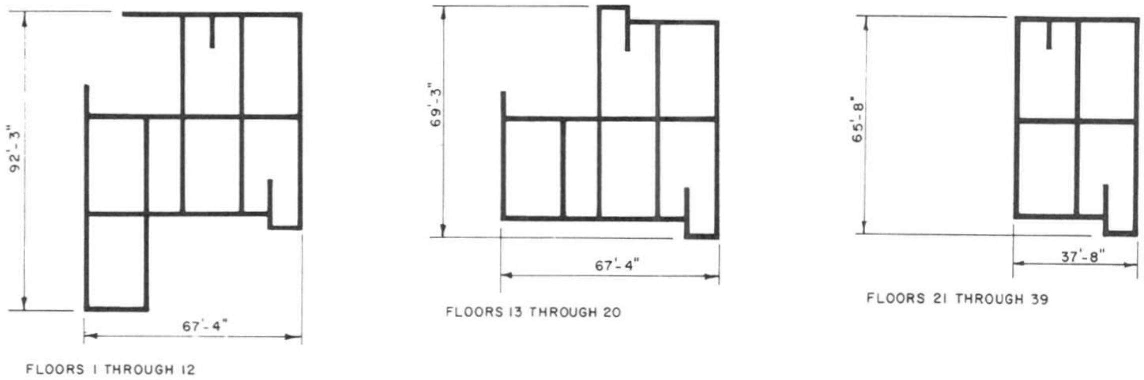


Fig.2 Composite Steel-Concrete Structural System

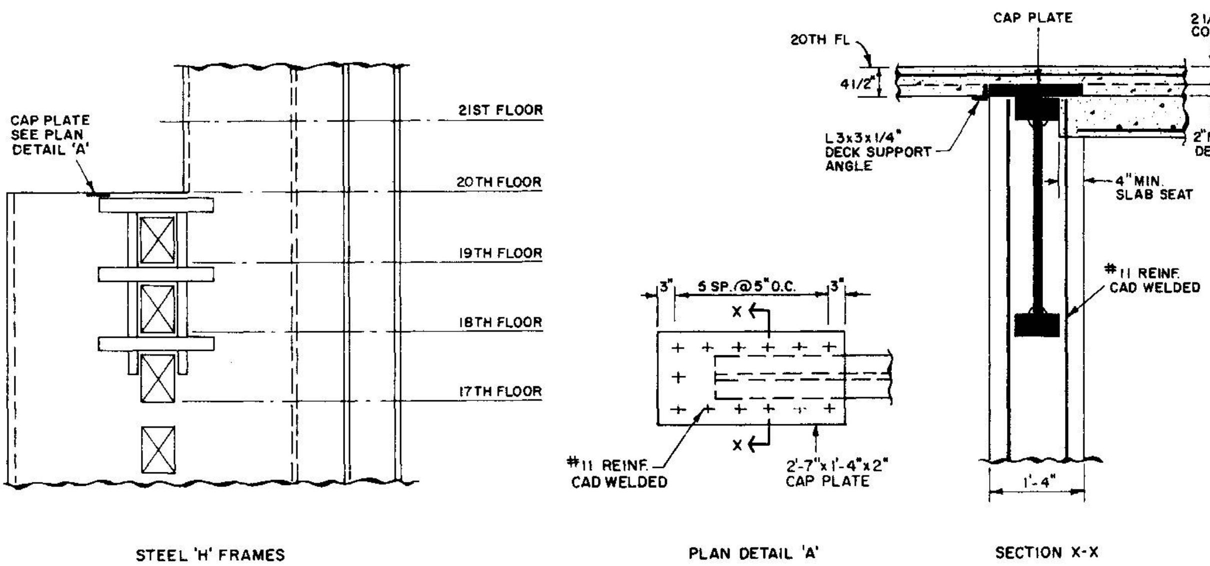


FLOORS 1 THROUGH 12

FLOORS 13 THROUGH 20

FLOORS 21 THROUGH 39

Fig.3 Concrete Core Configurations



STEEL 'H' FRAMES

PLAN DETAIL 'A'

SECTION X-X

Fig.4 Structural Steel H-Frames Placed in Concrete Core

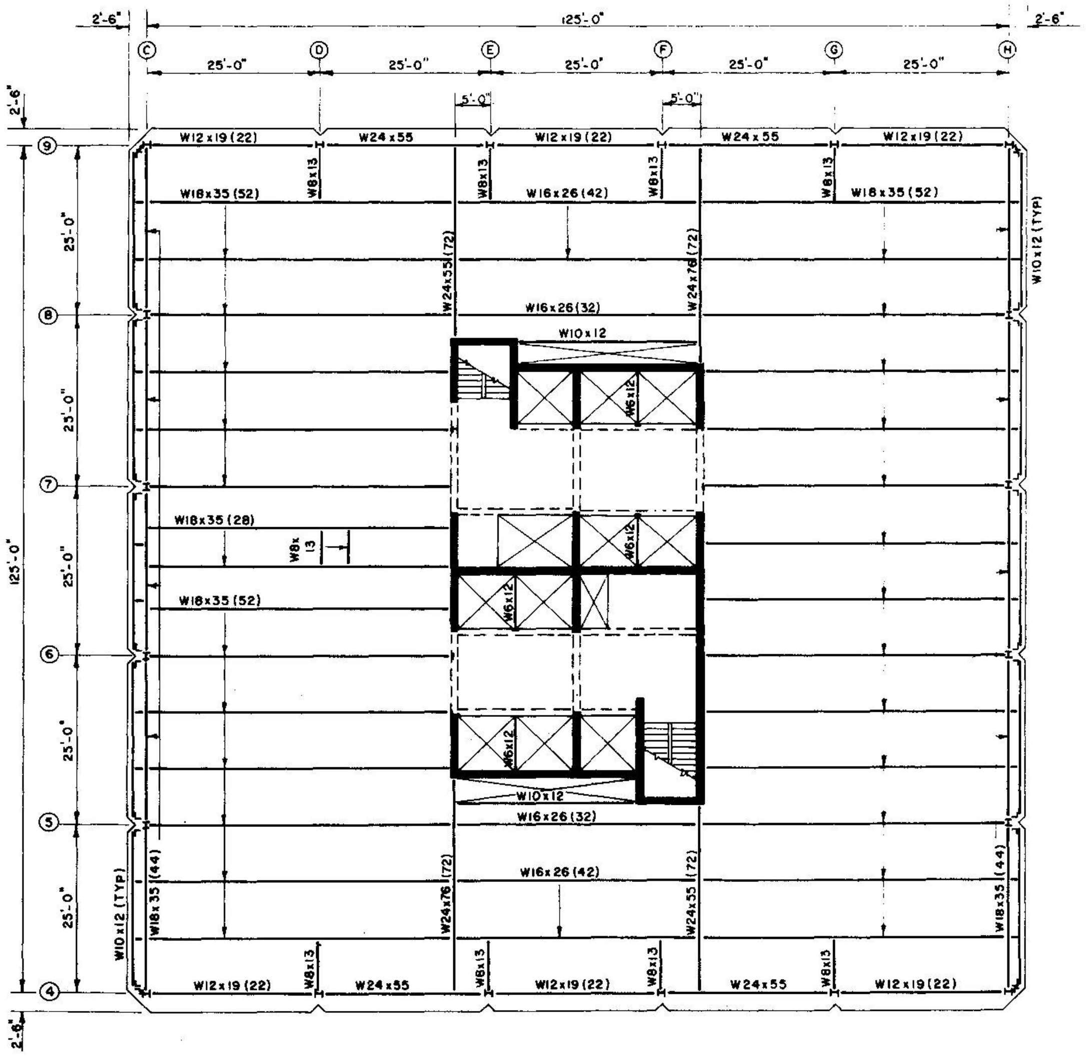


Fig.5 Typical Framing Plan

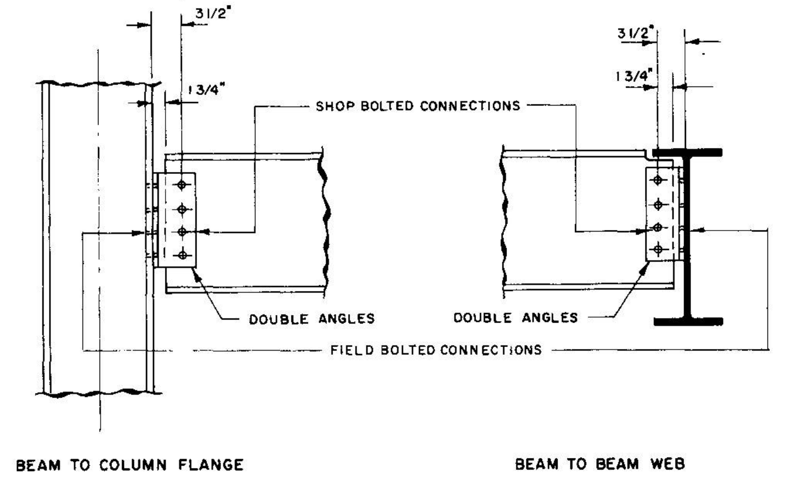


Fig.6 Typical Steel Framing Connections

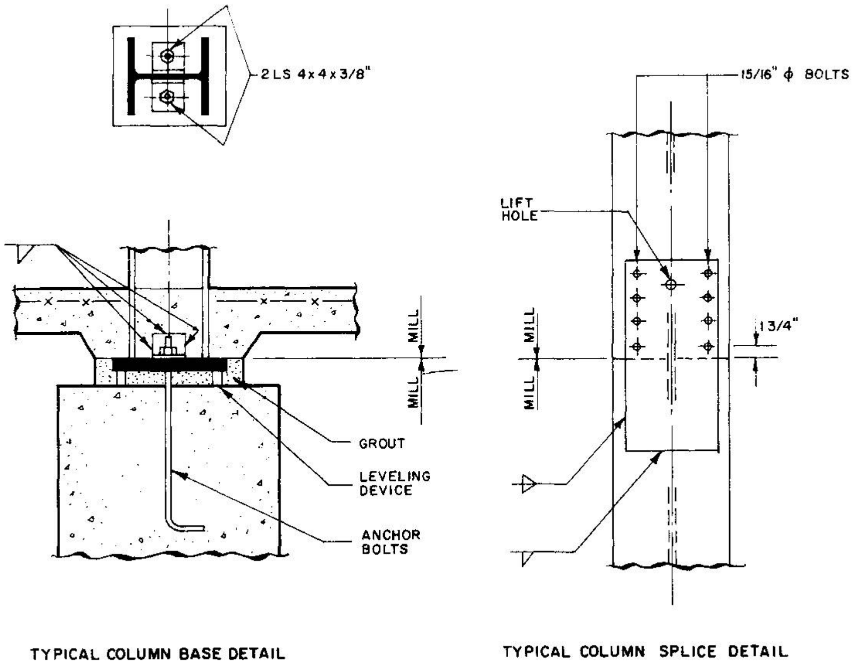


Fig.7 Typical Steel Column Details

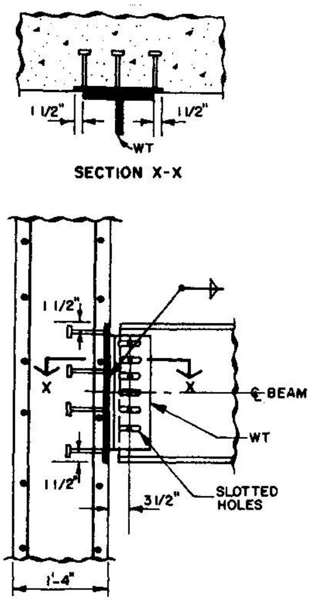


Fig.8 Typical Connection of Steel Beam to Concrete Core Wall

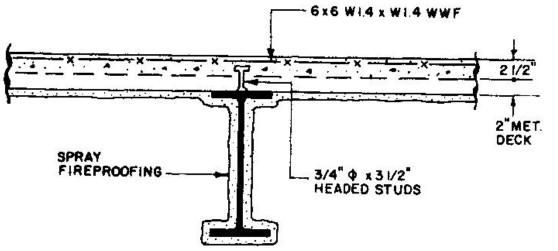
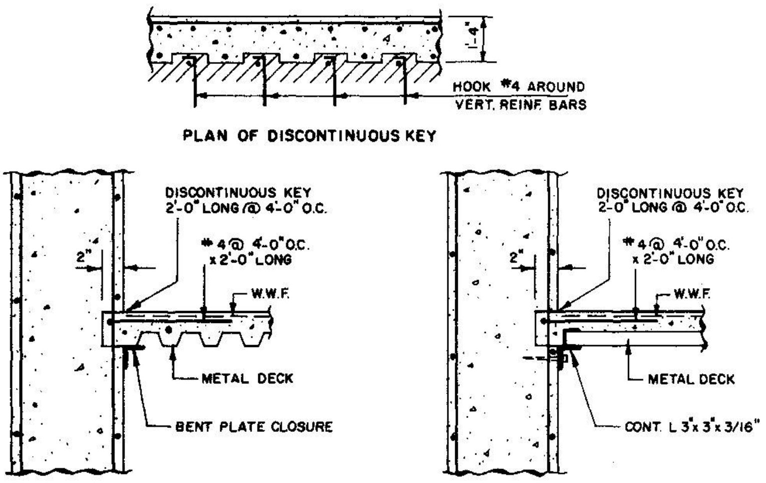


Fig.9 Typical Floor Construction Outside Core



DECK PARALLEL TO WALL DECK PERPENDICULAR TO WALL

Fig.10 Typical Connection of Floor Slab to Core Wall