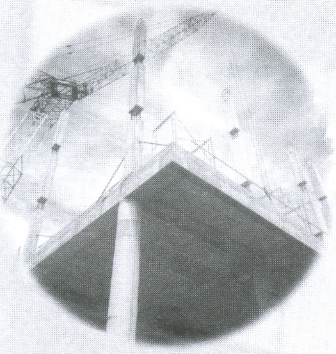


CHAPTER 5

PRECAST CONCRETE ASSEMBLY

Chapter 5 PRECAST CONCRETE ASSEMBLY

5.1 General

A complete statical evaluation of prefabricated buildings includes the following phases:
1. load assessments
2. formulation of a model of the main structural system
3. description of load paths
4. design of structural members
5. design of connections

Construction drawings for a prefabricated building project will normally consist of architectural sketches, modular details, general modular drawings, production drawings and assembly details.

For designers not familiar with prefabicated building designs, there will be considerable confusion with the selection of the appropriate methods of jointing and connections of precast components. With the exception of some common ones, the development of connection details is often on a project to project basis. Even the same details may be subjected to various modifications as dictated by the different structural and architectural requirements.

Despite the different manners in which a connection detail may be executed, the type of joint details must fulfil the following requirements:
1. compatibility with adjoining structural members
2. economy of materials
3. manufacturing and erection techniques
4. ease of assembly and speed of construction
5. final aesthetic joint appearances

There are basically three different types of connections used in precast concrete structures, namely, the cast in-site joint including grouted pipe sleeves, mechanical joint by bolting or welding, or a combination of both. Generally, the cast in-site type is the cheapest and it fits well into the craftsmanship already available on the building site. Bolted connections are easy to execute with both skilled and unskilled labour, whereas welding operations call for skilled labour or specialists. In terms of execution, bolted and welded joints normally need closer supervision and higher quality control.

This chapter presents an overview of the various jointings and connections of precast components which may assist the designer and architect in the design of prefabricated buildings. The details represent a cross-section of some of the proven techniques used locally in residential buildings, public housing, commercial and industrial buildings. As the local construction industry is relatively new to precast construction techniques, a selection of connection details from overseas are also included to provide readers with a wider spectrum of the connection techniques.

The details should be used a guide instead of as a design manual. It must be emphasised that the responsibility for a proper connection fulfilling all relevant performance requirements rests with the structural designer and the architect working often in close consultation with the precaster and contractor in an integrated approach during the design, development, fabrication and construction of the precast buildings.

5.2 Joints Used In Singapore Projects

The table below shows a compilation of connection and jointing details commonly used in Singapore. These details have been used in various projects such as private residential buildings, public housing, commercial and industrial buildings.

Types Of Joints Used Locally	Column	Beam	Slab/Plank	Wall	Stump	Precast Panel/Façade	Staircase
Column	5.9, 5.11, 5.12	5.9, 5.11, 5.12		5.17, 5.18	5.9, 5.10		
Beam			5.1, 5.3, 5.4, 5.5, 5.6, 5.8, 5.14	5.20			
Slab/Plank			5.1, 5.2	5.7, 5.8, 5.15, 5.16, 5.20		5.7, 5.16	5.27, 5.28, 5.29, 5.30, 5.31
Wall				5.21, 5.22, 5.23, 5.24, 5.25, 5.26			

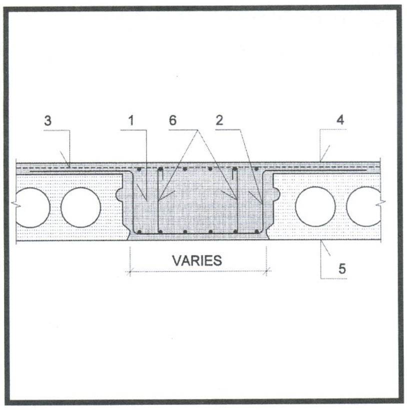


Figure 5.1 Tie Strip Between Hollow Core Slabs

1. Tie beam
2. Links
3. Steel mesh
4. Concrete topping
5. Hollow core slab
6. Shear links (if structurally required)

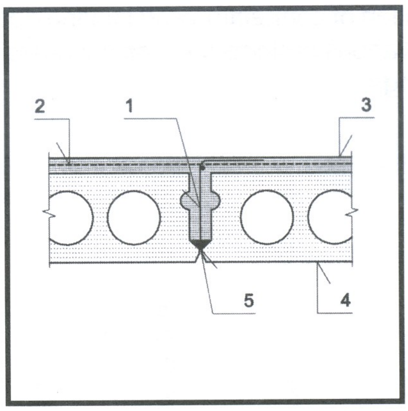


Figure 5.2 Hollow Core Slab to Slab Joint Detail

1. L shape T10 or R10 at 600c/c
2. Steel mesh
3. Concrete topping
4. Hollow core slab
5. Foam or cement/sand block-out

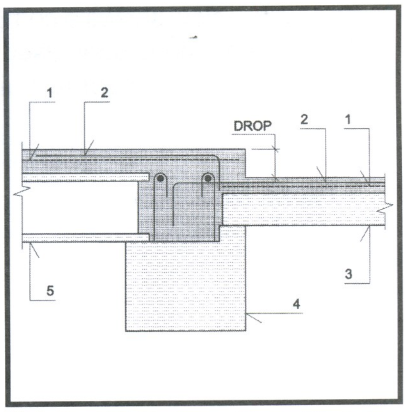


Figure 5.3 Hollow Core Slab / Beam/ Plank Connections With Drop

1. Steel mesh
2. Reinforcement to engineer's design
3. Plank
4. Beam
5. Hollow core slab

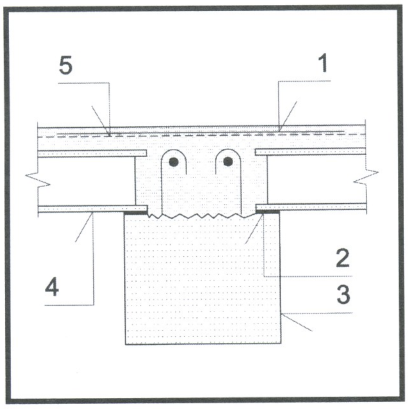


Figure 5.4 Hollow Core Slab Seating

1. Reinforcement to engineer's design
2. Neoprene strip
3. PC/RC beam
4. Hollow core slab
5. Steel mesh

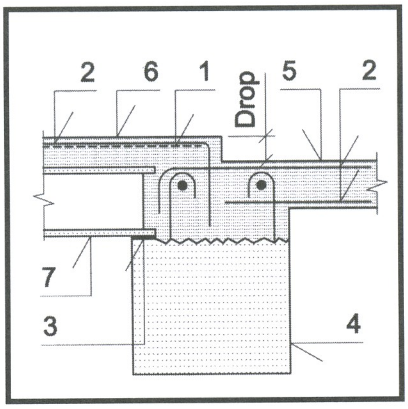


Figure 5.5 Beam/Hollow Core Slab/In-Situ Slab

1. Steel mesh
2. Reinforcement to engineer's design
3. Neoprene strip
4. PC/RC beam
5. RC slab
6. Concrete topping
7. Hollow core slab

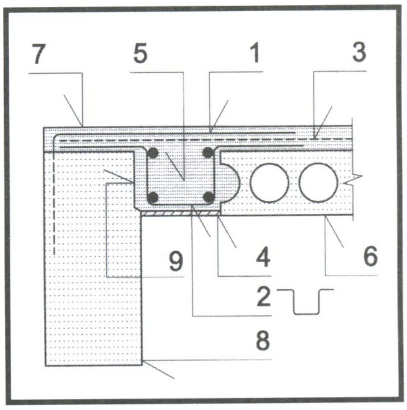
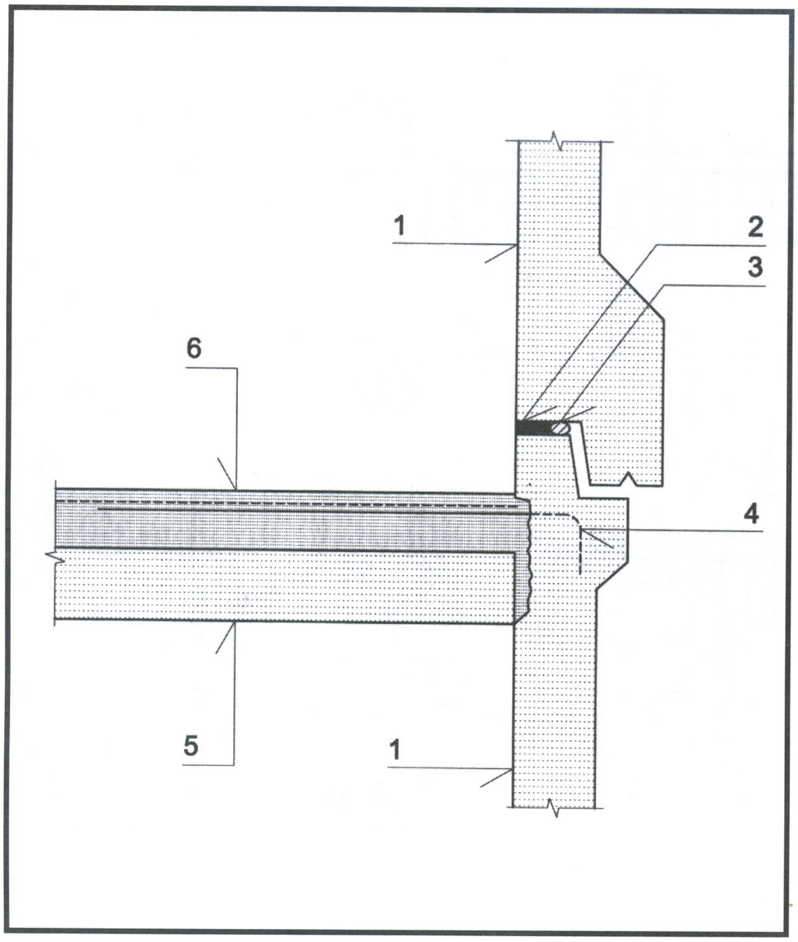


Figure 5.6 In-Situ Strip In Hollow Core Slab With Beam

1. Reinforcement to engineer's design
2. Shear links
3. Steel mesh
4. Plastering
5. Reinforcement in pour strip
6. Hollow core slab
7. Concrete topping
8. PC/RC beam
9. 20mm recess in beam lab



1. PC external wall
2. 20mm dry pack under external wall
3. Backer rod
4. Reinforcement (from PC wall)
5. Plank
6. In-situ topping

Figure 5.7 Plank And External PC Wall Panel

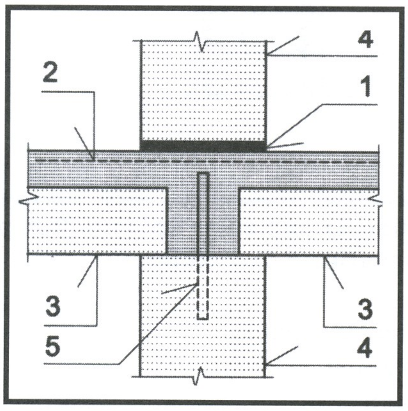


Figure 5.8 Plank And Wall

1. Sand/cement mortar or grouting
2. Steel mesh
3. Plank
4. PC beam / wall
5. Dowel bars

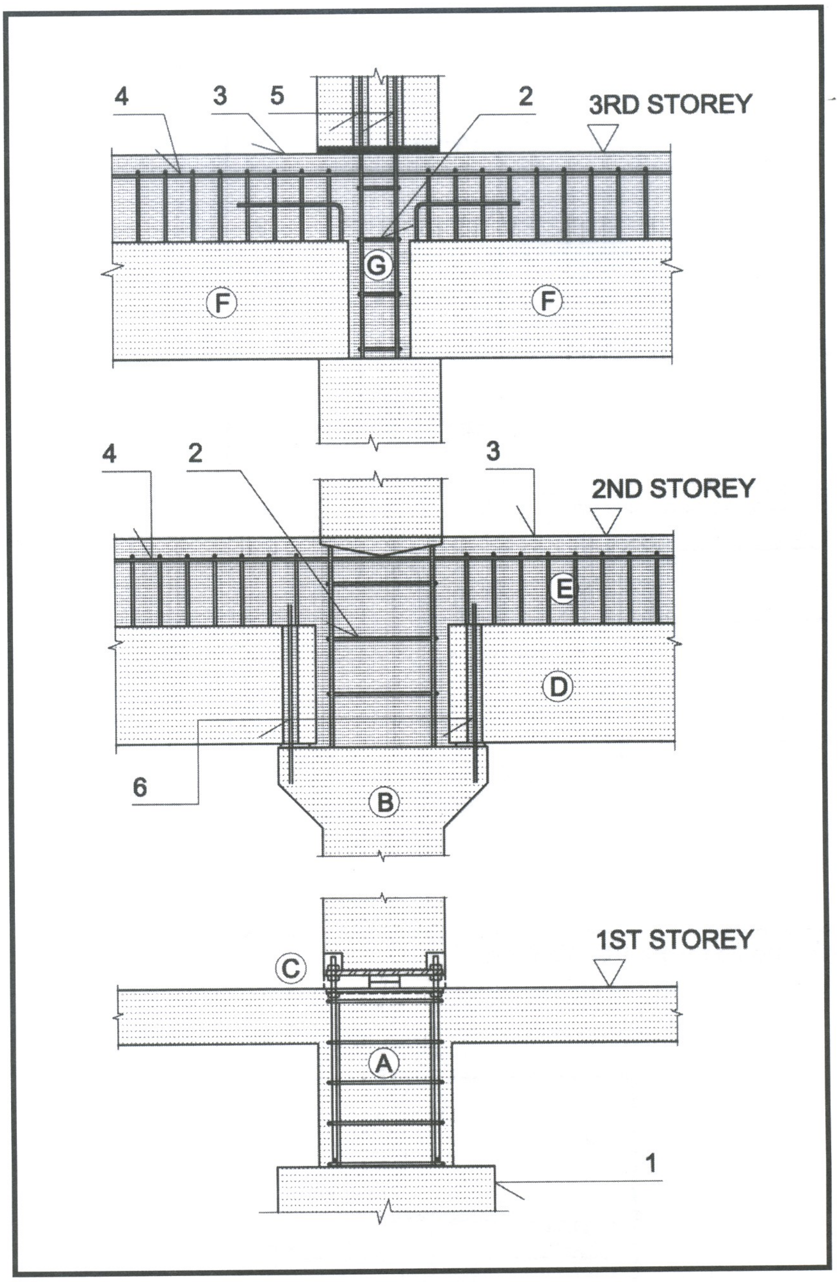


Figure 5.9 Illustration Example For Column/Stump, Column/ Column And Column/Beam Connection

1. Pilecap
2. Links loop round steel bars
3. Cast in-situ concrete
4. In-situ beam bars
5. Column steel bars to extend above floor for grouted pipe sleeve column connection
6. Steel dowel for site safety

Stages of Construction

A. Construct foundation and 1st storey RC work
B. Erect precast columns
C. Grouting of column base
D. Launch precast beams and floor slab elements
E. Cast in-situ RC work
F. Launch precast beams and floor slab elements
G. Cast in-situ RC work

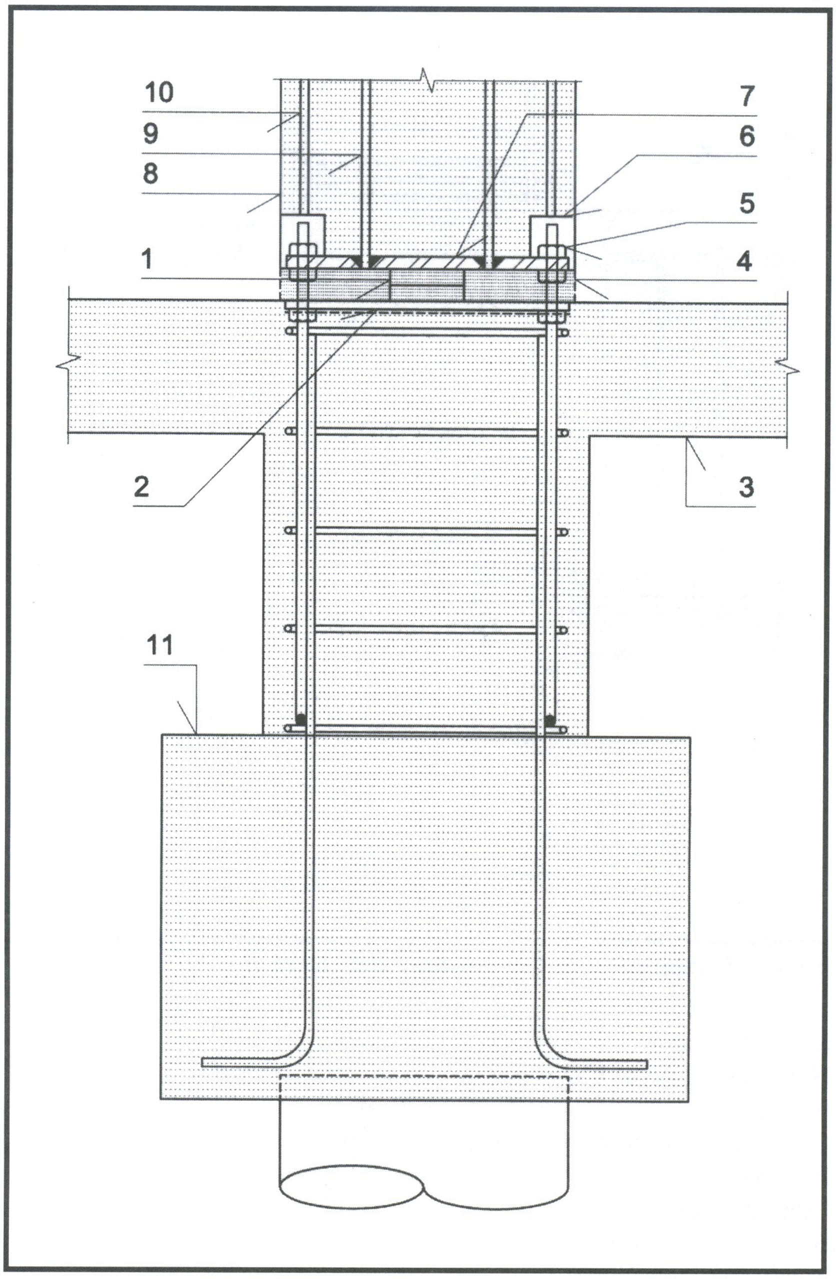


Figure 5.10 Bolted Column Base Connection

1. The gap is to be formed by seating precast column onto shimming plates (with the adjusting bolts screwed down to the lowest position).
2. Template to position bolts
3. Ground slab
4. Grouting
5. Nuts and washer plates
6. Base angle
7. Base plate (recessed from column faces)
8. Precast column
9. Bars welded to base plate
10. Column bars
11. Pilecap

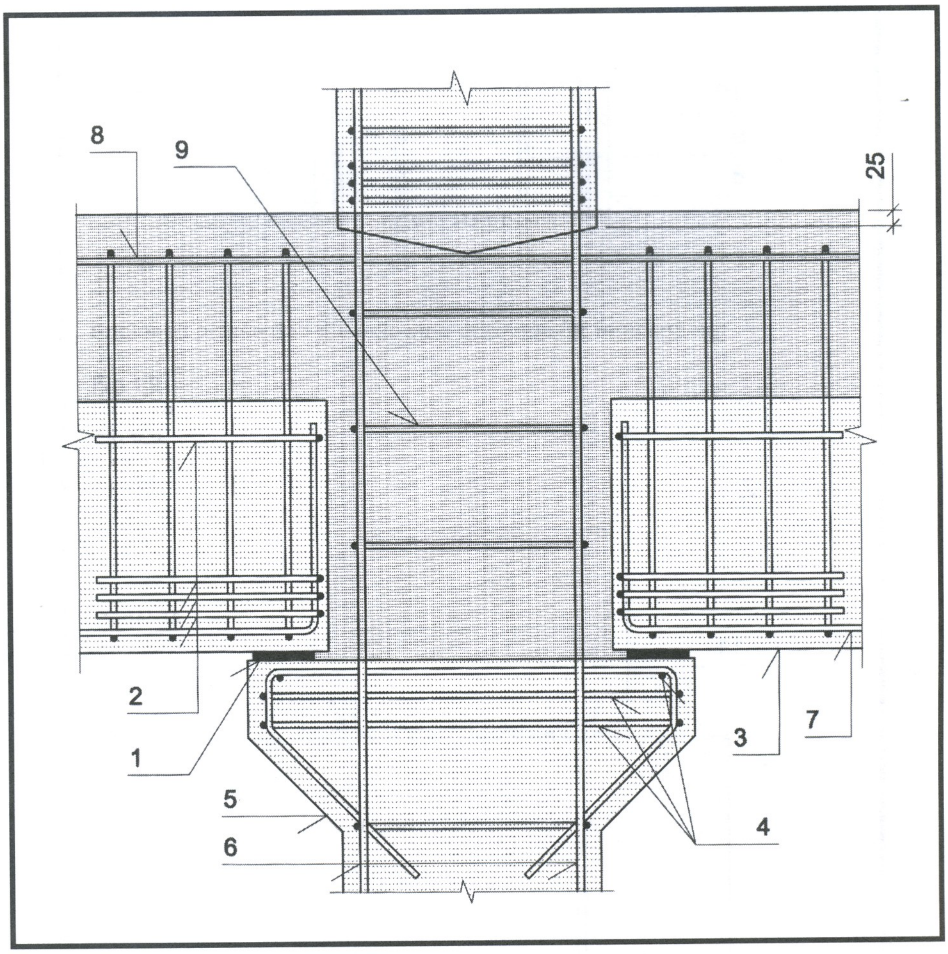


Figure 5.11 Column/Beam Connection With Corbel

1. Neoprene strip
2. Horizontal loop at beam ends
3. PC beam
4. Corbel reinforcement to engineer's design
5. PC column
6. Column bars
7. Bend-up beam reinforcement
8. In-situ reinforcement
9. Column links

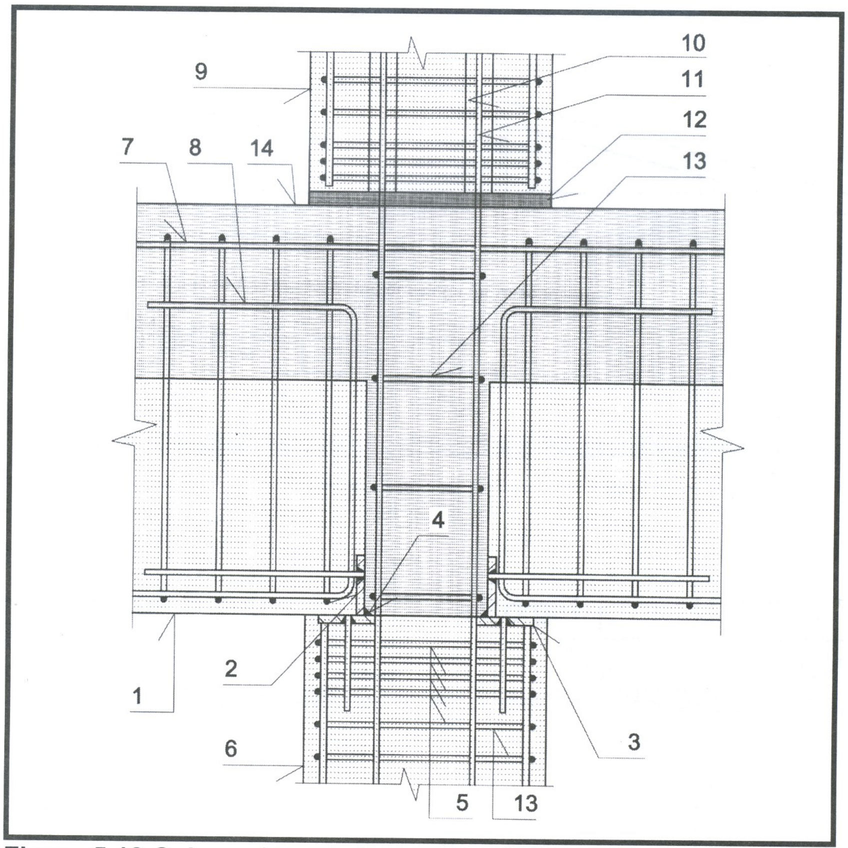


Figure 5.12 Column / Beam Connection Without Corbel

1. Precast beam
2. Cast-in end plate with horizontal welded bars in PC beam
3. Cast-in steel plate with vertical welded bars at column face
4. Site welding to prevent beam toppling
5. Shear friction steel
6. Precast column
7. In-situ placed reinforcement
8. Bend up beam reinforcement
9. Upper floor precast column
10. Pipe sleeve
11. Starter column bars from lower precast column
12. 25 thick non-shrink grout
13. Column links
14. In-situ concrete

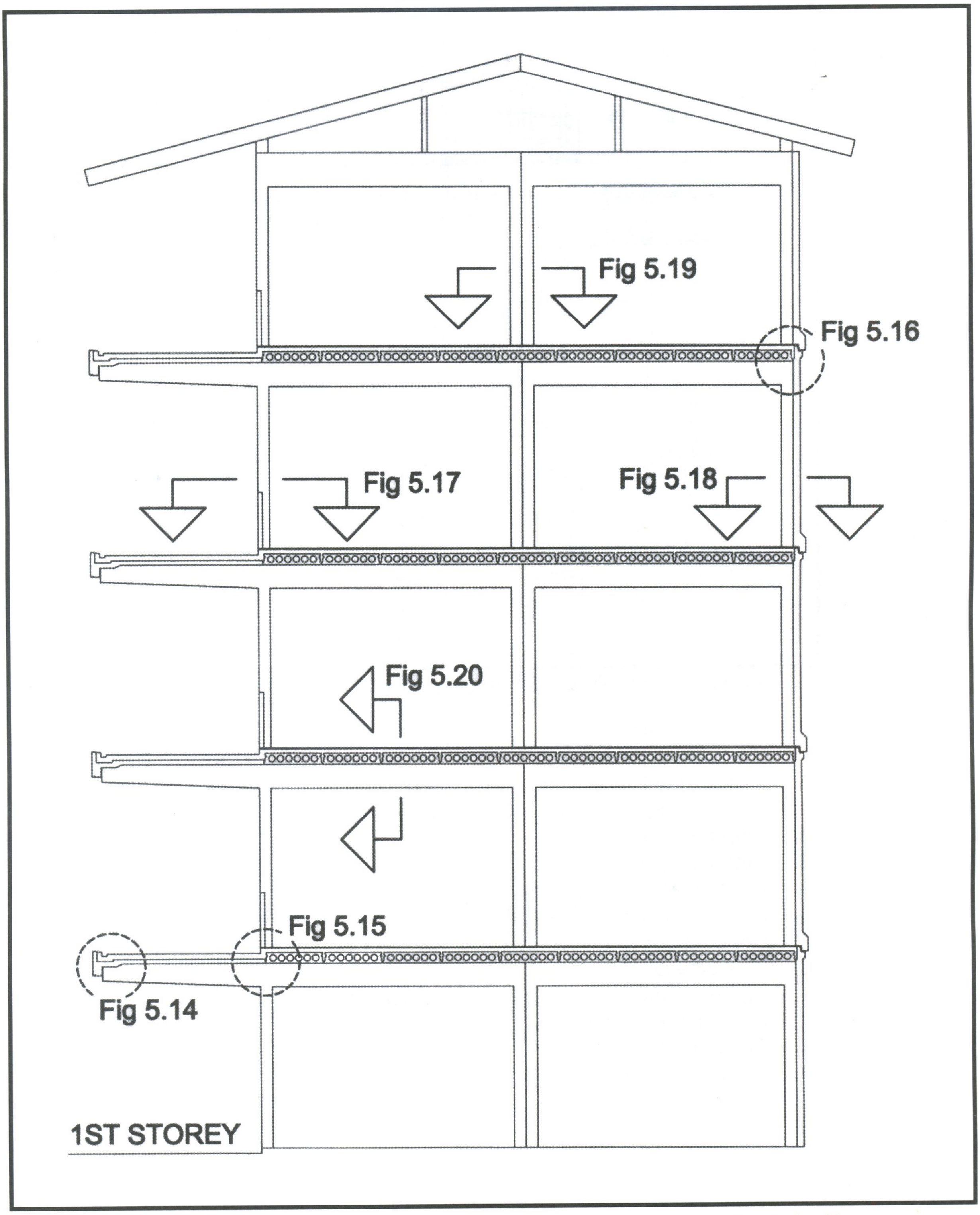
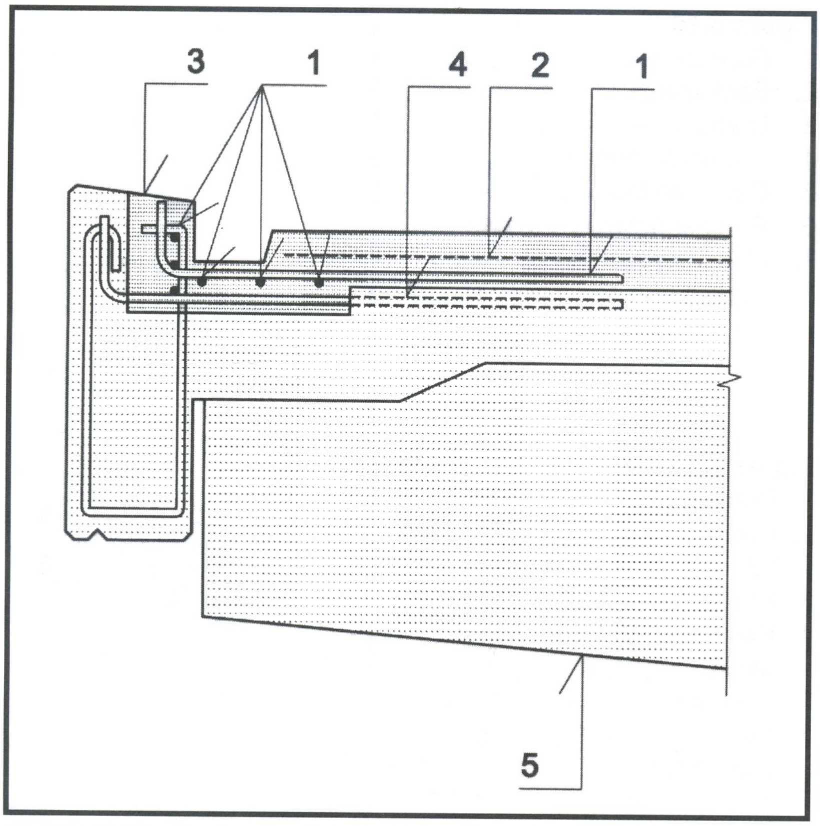


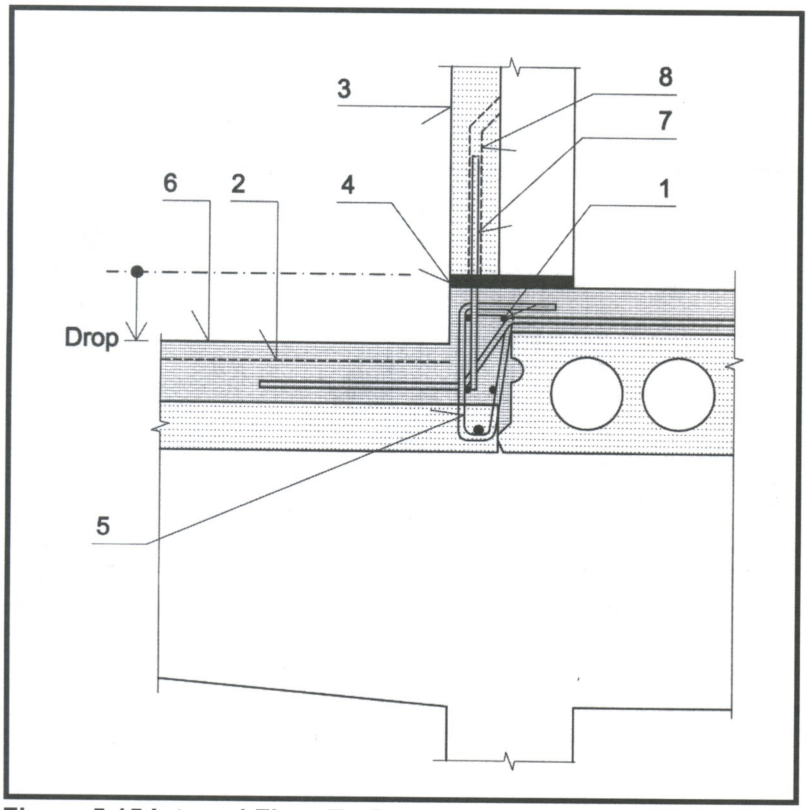
Figure 5.13 Typical Section Of A Precast Building (Section And Details To Refer To Figures 5.14 To 5.20)

This is a typical section of a precast concrete structure for a dormitory. The precast members consist of single storey high column and beam with integrated partition walls. A cantilever beam is incorporated in the outer frame at the corridor which is column free. Hollow core slabs are used as internal floor structure and profiled precast planks incorporating perimeter beams are used at the corridor. All internal and external walls are precast with architectural features of window sills, copings, drips etc. The precast components are simple pin-connected both vertically and horizontally with either cement/sand mortar or grouted joints. An in-situ 75mm thick concrete topping throughout the floor will bind all members together to provide the necessary structural action to resist horizontal forces.



1. Reinforcement added on site
2. Steel mesh
3. Cast in-situ concrete
4. Rebar from precast plank
5. Cantilever beam from precast frame

Figure 5.14 Perimeter Beam And Plank With Surface Scupper Drain



1. Reinforcement added on site
2. Steel mesh
3. Precast wall
4. Drypack cement mortar
5. Reinforcement to engineer's design
6. Concrete topping (75mm - 100mm)
7. Dowel bar
8. Corrugated pipe sleeve (to be grouted)

Figure 5.15 Internal Floor To Corridor And Partition Wall Connection To Floor

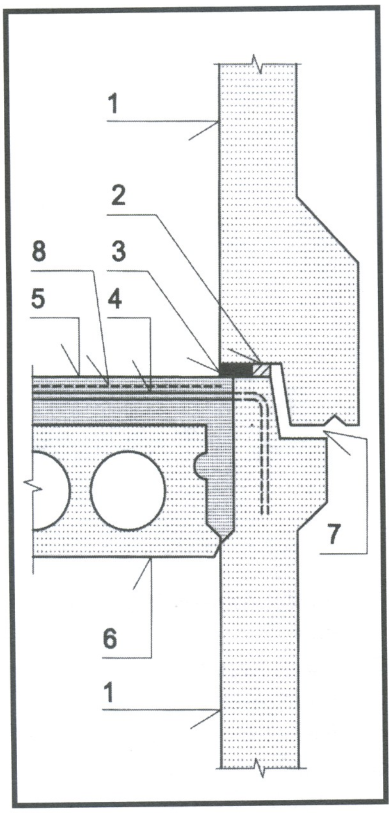


Figure 5.16 Floor To External Wall Connection

Figure 5.16
1. Precast wall
2. Backer rod
3. Drypack cement mortar
4. Reinforcement
5. Concrete topping
6. Precast hollow core slab
7. Open horizontal joint
8. Steel mesh

Figure 5.17
1. Precast wall
2. Cottering reinforcement (placed on site)
3. Precast column
4. Reinforcement to engineer's design
5. Plastering
6. Column and wall joint to be cast in-situ
7. Recess in wall for plastering

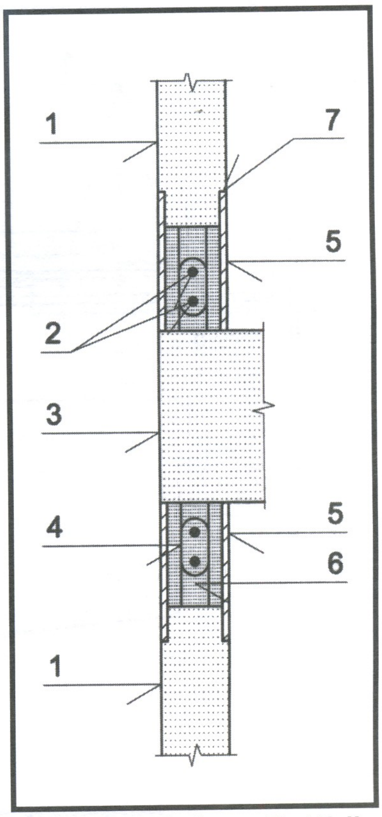


Figure 5.17 Column To Wall Connection

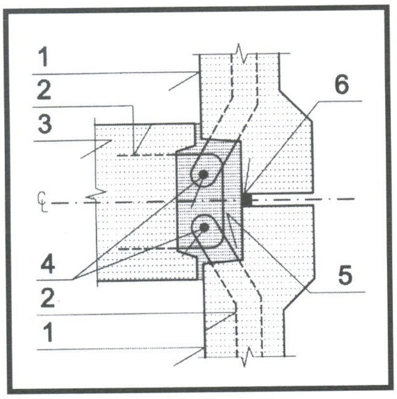


Figure 5.18 Column/External Wall Connection

1. Precast wall
2. Reinforcement to engineer's design
3. Precast column
4. Cottering reinforcement (placed on site)
5. Column and wall joint to be cast in-situ
6. Backer rod

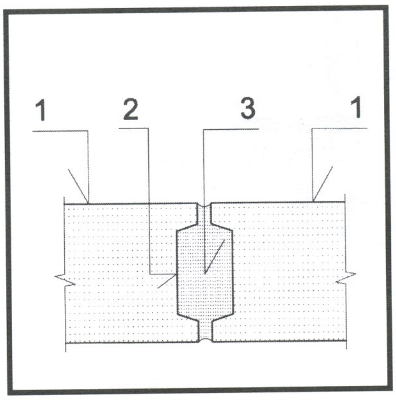


Figure 5.19 Column To Column Vertical Joint

1. Column
2. Vertical castellations
3. Grouting

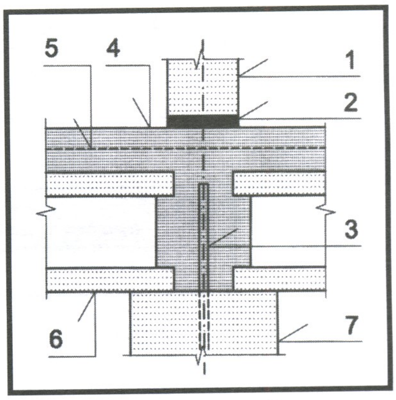
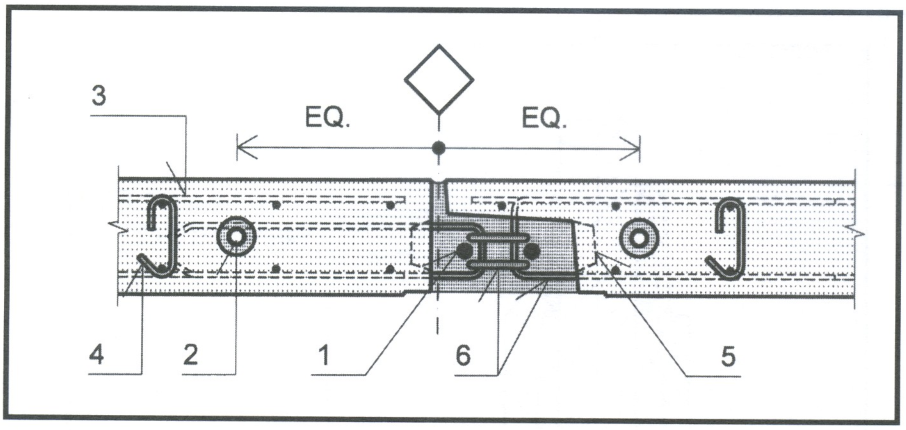


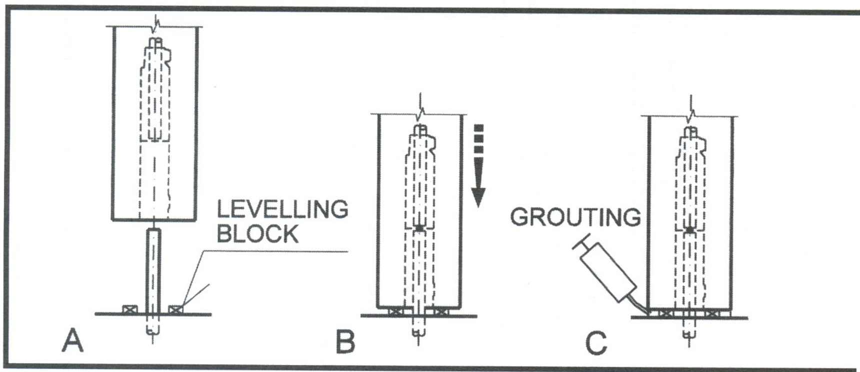
Figure 5.20 Hollow Core Slabs Beam/Wall Connection

1. Precast wall
2. Drypack cement mortar
3. Dowel reinforcement to engineer's design
4. Concrete topping
5. Steel mesh
6. Hollow core slab
7. Precast beam



1. Joint rebar
2. Pipe sleeve
3. Steel mesh
4. Space bar
5. Edge castellation
6. Reinforcement

Figure 5.21 Wall-Wall Cast In-Situ Vertical Joint



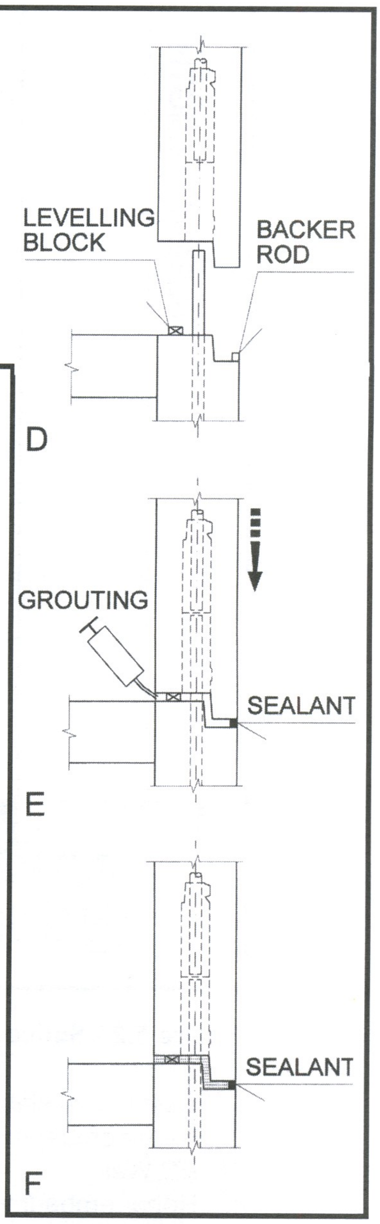


Figure 5.22 Installation Of Wall With Spliced Sleeve Connection

Procedures for connecting internal walls using pipe sleeves

A. Levelling blocks are placed
B. Lower the upper member into position
C. Grouting of horizontal joint

Procedures for connecting external walls using pipe sleeves

D. Levelling block is placed
E. Lower the upper member into position
F. Grouting of horizontal joint

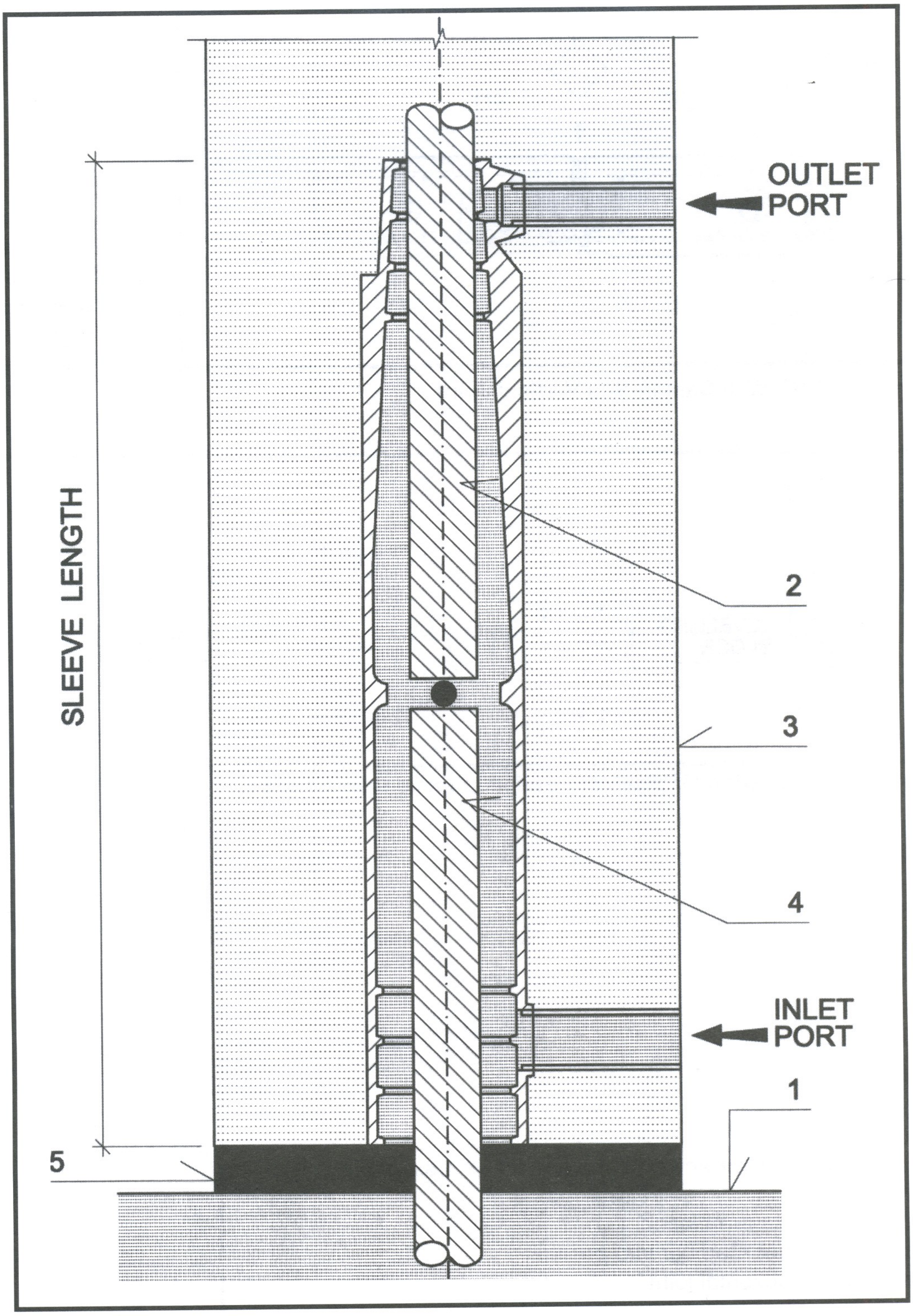


Figure 5.23 Spliced Sleeve Connection In Walls

1. Cast in-situ slab
2. Rebar embedment; dowel installed in factory
3. PC Wall
4. Rebar embedment; dowel installed in factory
5. Grouting

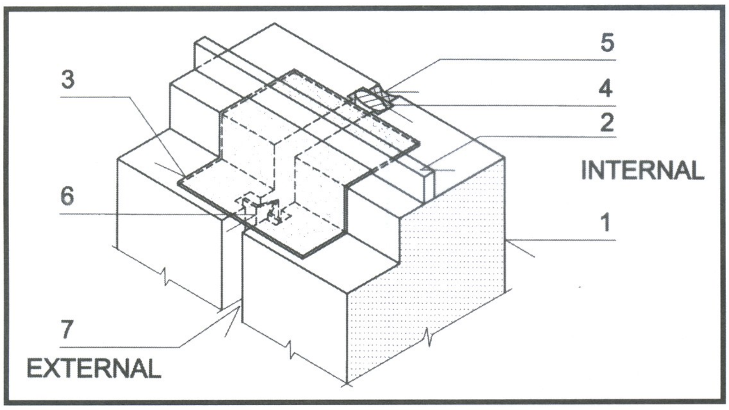


Figure 5.24 Joint Details Of Abutting External PC Wall

1. PC wall panel
2. Watertightness sealing strip
3. Aluminium or stainless steel flashing
4. Backing
5. Sealant or mortar
6. Baffle strip
7. Design gap

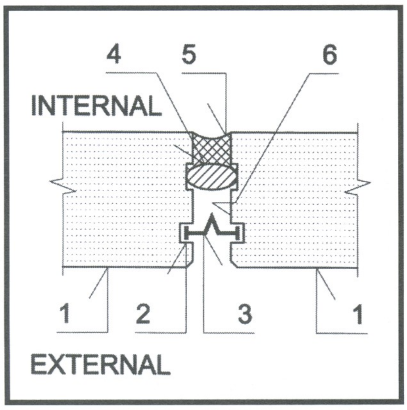


Figure 5.25 Open Drained Joint

1. PC wall panel
2. Recess profile for baffle strip
3. Baffle strip
4. Backing
5. Sealant or mortar
6. Drained and ventilated air space

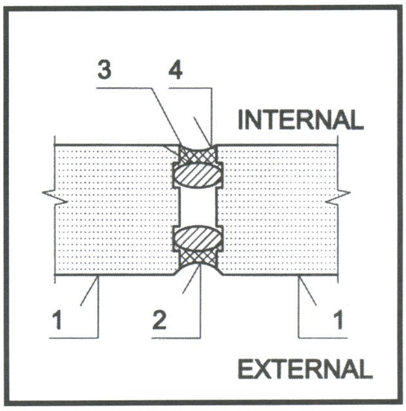


Figure 5.26 Closed Joint

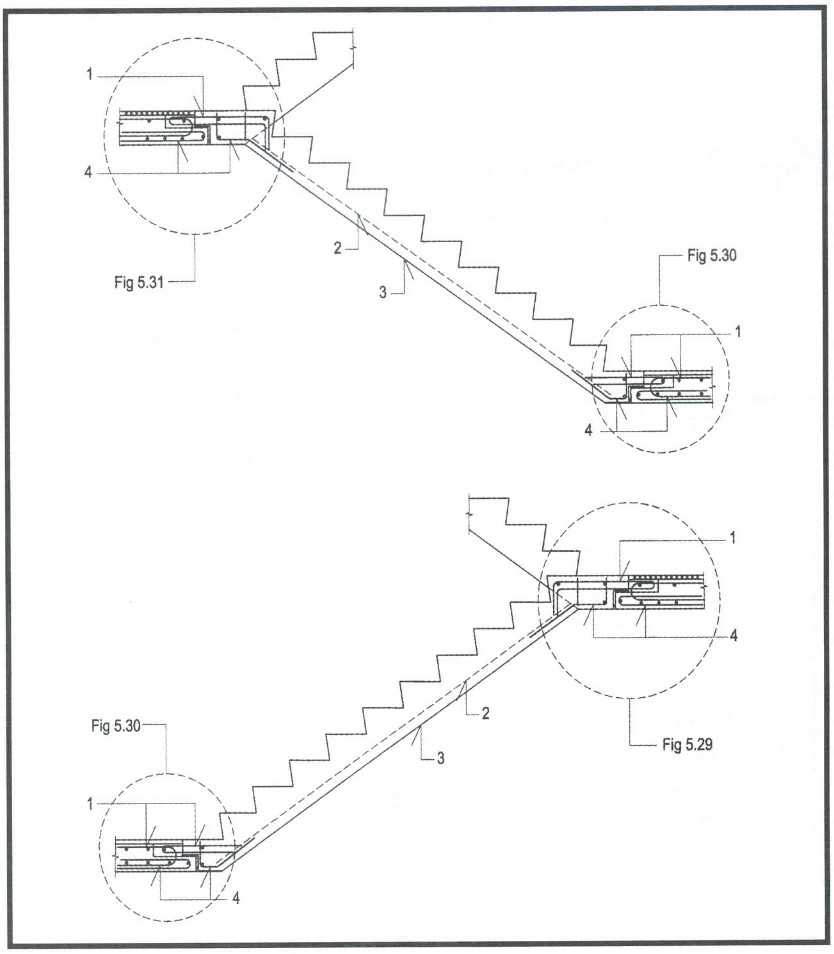
The close and open joints have both been successfully used to ensure watertightness in the joints of precast wall panels.

The close joint adopts a single stage sealing using either polysulphide mastic or silicone sealants to prevent the penetration of air and water. The open joint has a 2-stage sealing feature namely a front protection baffle and a rear air-tight seal. Water penetrating the front baffle will be drained away in the airspace between the 2 seals.

Most failures in close joints involve aging, loss of surface adherence or elasticity of the sealant material. For good performance, it is necessary, therefore, to note the followings:

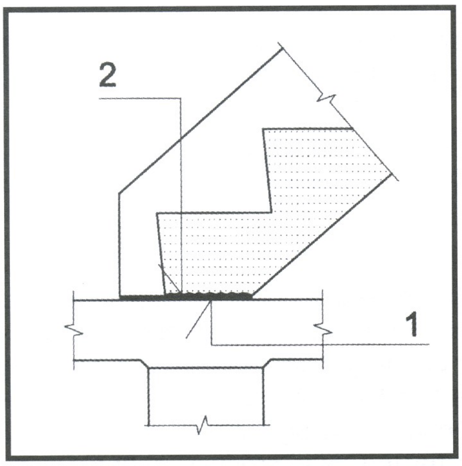
1. good workmanship preferably by specialists
2. good sealant material with correct proportioning or resin and inert materials
3. sufficient joint dimensions with enough width and depth for proper joint filling
4. regular and plain joint edges to ensure good surface adherence
5. seal should be set back in the joint for protection from weather elements

The watertightness of open joint depends critically upon the effectiveness of the air-tight seal at the rear of the joint. Damages to the seal may be due to the movement of the wall panels, loss of adherence of air-tight sealant or dropping off of the mortar or grouting. The loss of front baffle may arise from inadequate end stoppages which cause the baffle to fall out of the joint or from simple vandalism. Compared with close joint, the placement of open joint sealing features is carried out during the erection of the panels. It is thus necessary to check that the insert grooves for baffle in the adjoining panels run relatively parallel to each other at the joint. A further disadvantage of the open joint is that it is difficult to inspect and maintain the joint particularly at the intersections of the horizontal and vertical joints. Repair of leaking joints is also difficult. Despite these shortcomings, the open joints are less exposed to the weather than close joint and movement of the panels does not generally affect the effectiveness of the joints. Most open joints are found to give little trouble in service.



1. Nib reinforcement
2. Welded wire
3. Precast staircase
4. Hanger steel

Figure 5.27 Typical Staircase Sections



1. Cement mortar (10 - 15mm thick)
2. Roughened contact faces

Figure 5.28 Floor Slab & Staircase Flight

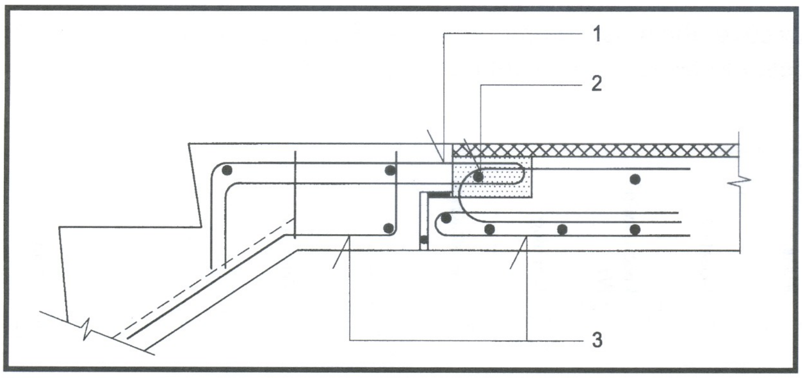


Figure 5.29 Landing Slab And Staircase Flight

1. Nib reinforcement
2. T13 cottering bar
3. Hanger steel

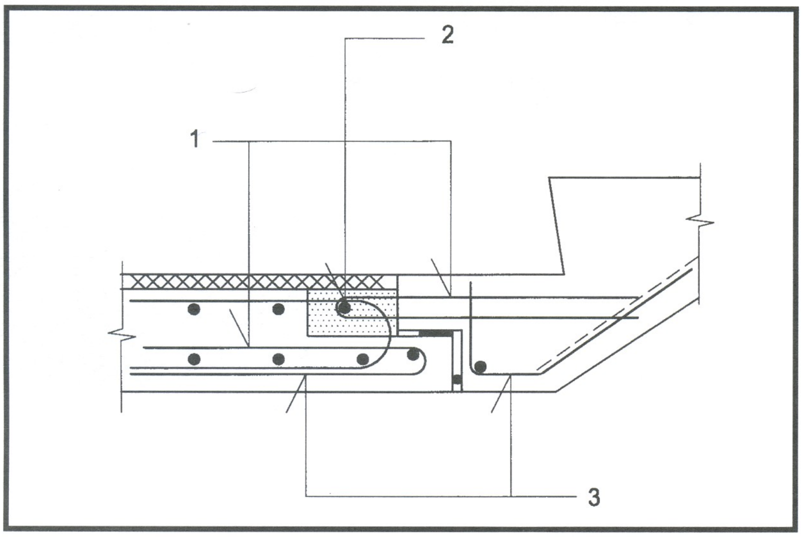


Figure 5.30 Landing Slab And Staircase Flight

1. Nib reinforcement
2. T13 cottering bar
3. Hanger steel

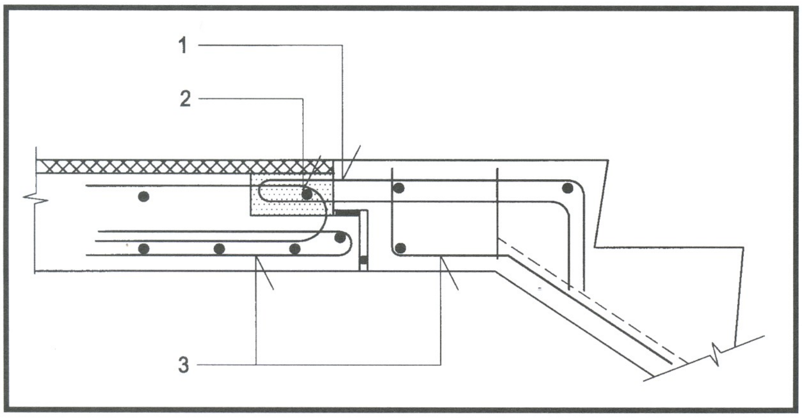


Figure 5.31 Landing Slab And Staircase Flight

1. Nib reinforcement
2. T13 cottering bar
3. Hanger steel

5.3 Joints Used In European Countries

The details indicated in the table below cover the most commonly adopted structural joints in European countries. For external joints in facades, the two-step open joint principle is chosen.

Types of Joints Used In European Countries	Column	Beam	HC Slab	Plank	Double T	Load Bearing Wall	Cladding	Panel/Façade	Frame	Balcony Slab	Balcony Parapet	Staircase	Column Socket
Column	5.32 to 5.37	5.38 to 5.45		5.115			5.116 to 5.117	5.118		5.119			5.135 to 5.138
Beam		5.46 to 5.49	5.50 to 5.54	5.55 to 5.56	5.57 to 5.59	5.60 to 5.62	5.63 to 5.66	5.67 to 5.69	5.101 to 5.103	5.120		5.131 to 5.134	
HC Slab			5.70 to 5.72	5.73 to 5.75	5.76 to 5.77	5.78 to 5.79	5.80	5.81	5.104 to 5.106	5.121 to 5.122			
Plank				5.82 to 5.83	5.84	5.85	5.86	5.87	5.107	5.125			
Double T					5.88	5.89	5.90	5.91	5.108				
Load Bearing Wall						5.92 to 5.95	5.96 to 5.97	5.98	5.109	5.123 to 5.124, 5.126		5.129 to 5.130	
Cladding							5.99		5.110 to 5.111				
Façade								5.100	5.112				
Frame									5.113 to 5.114				
Baloony Slab										5.127	5.128		

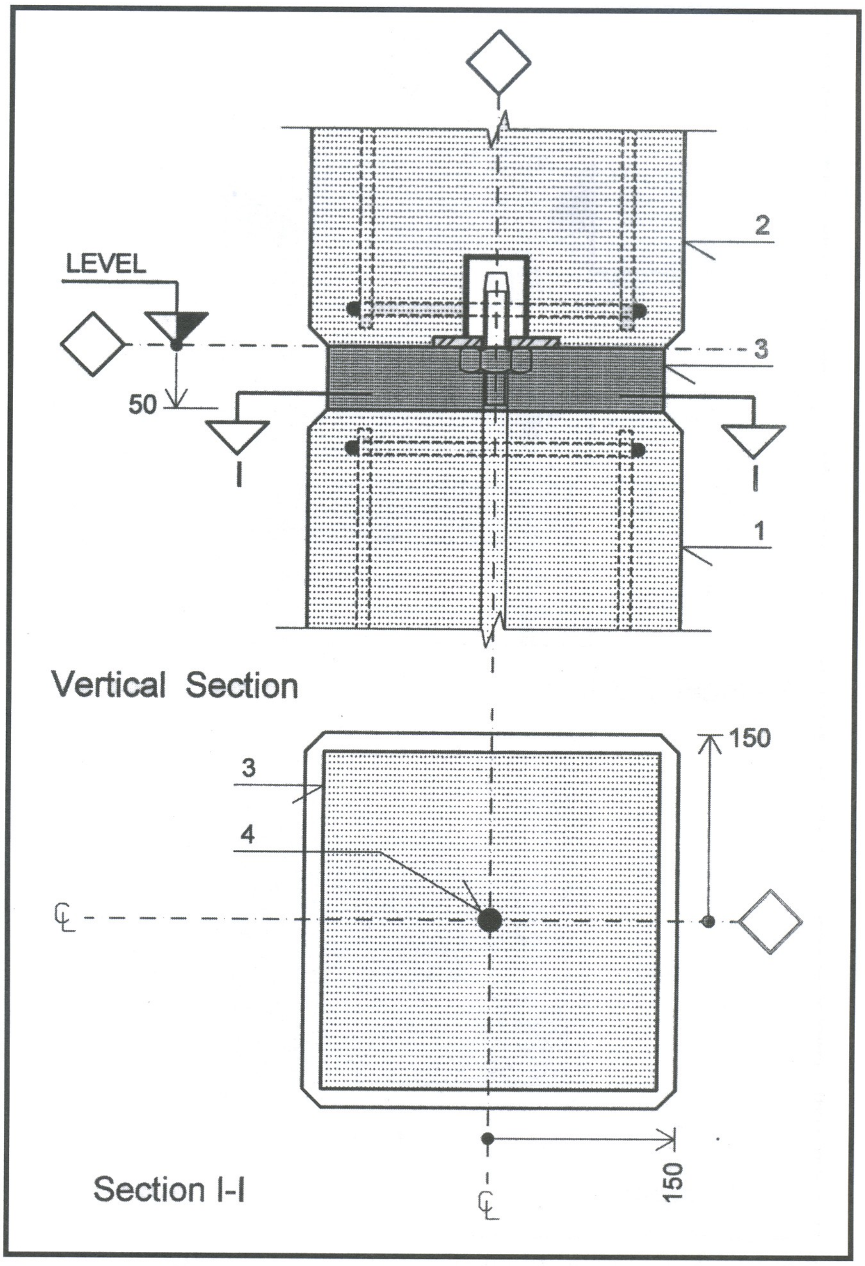
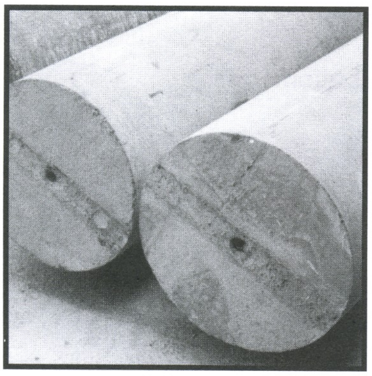


Figure 5.32 Column/Column Dowel Connection



1. Column with cast-in assembly bolt at the top
2. Column with cast-in steel plate and recess at the bottom
3. Grouting with cement mortar
4. Assembly bolt with nut

The simply supported column is temporarily placed on the assembly bolt. The grout will transmit the compression force.

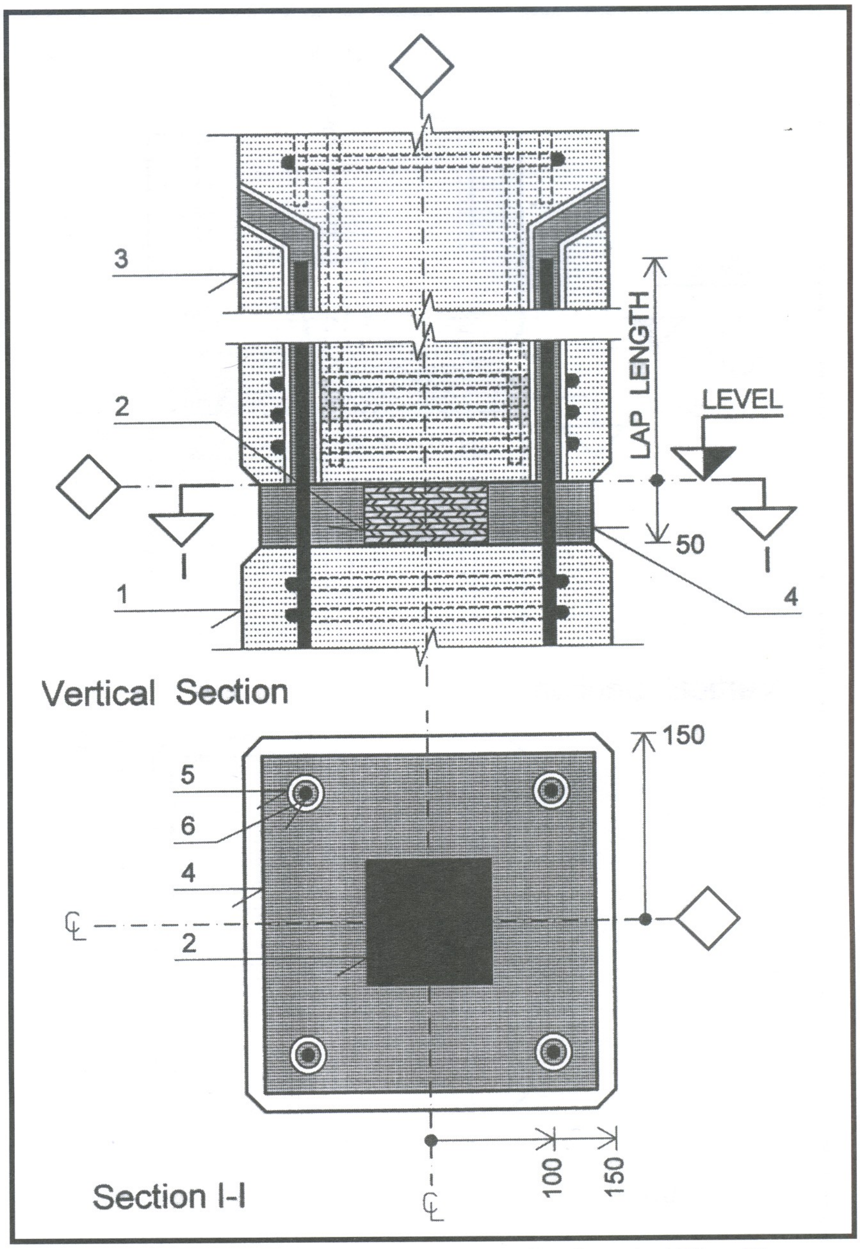
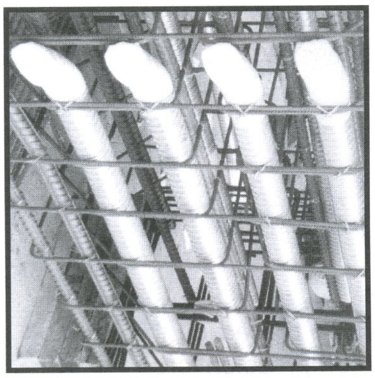


Figure 5.33 Column/Column Connection By Grouted Pipe Sleeves



1. Column with protruding rebars at the top
2. Support shims
3. Column with corrugated pipes at the bottom
4. Grouting with cement mortar
5. Corrugated pipe
6. Protruding reinforcement bar

The column is temporarily supported by the shims. After finishing the joint, the column can be considered as restrained.

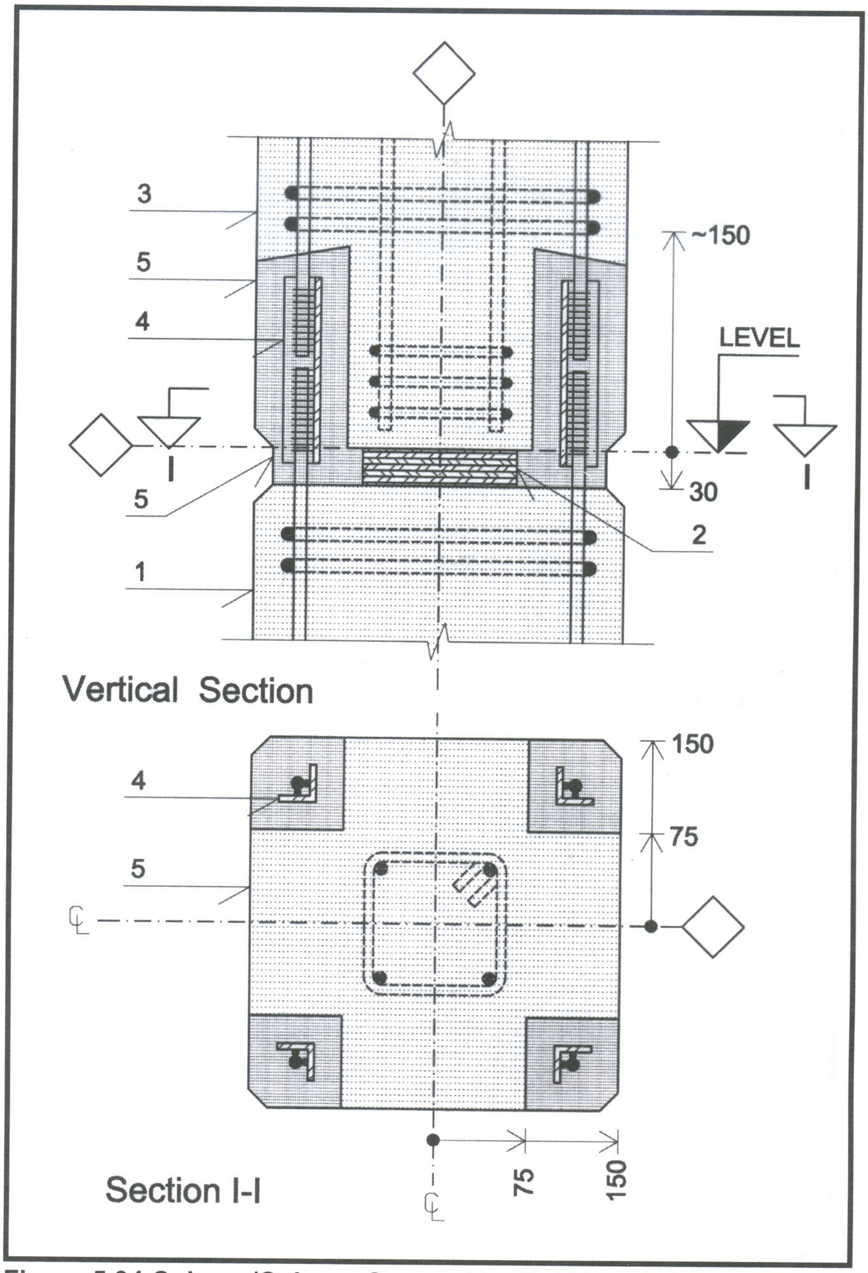
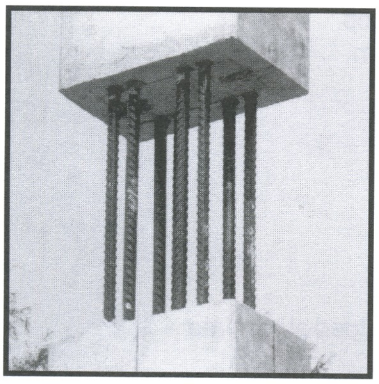


Figure 5.34 Column/Column Connection By Welded Angles



1. Column with protruding rebars at the top
2. Support shims
3. Column with protruding rebars at the bottom
4. Steel angle welded to rebars protruding from columns
5. Grouting with cement mortar

As the main reinforcement bars are welded together, the column acts as fixed-ended.

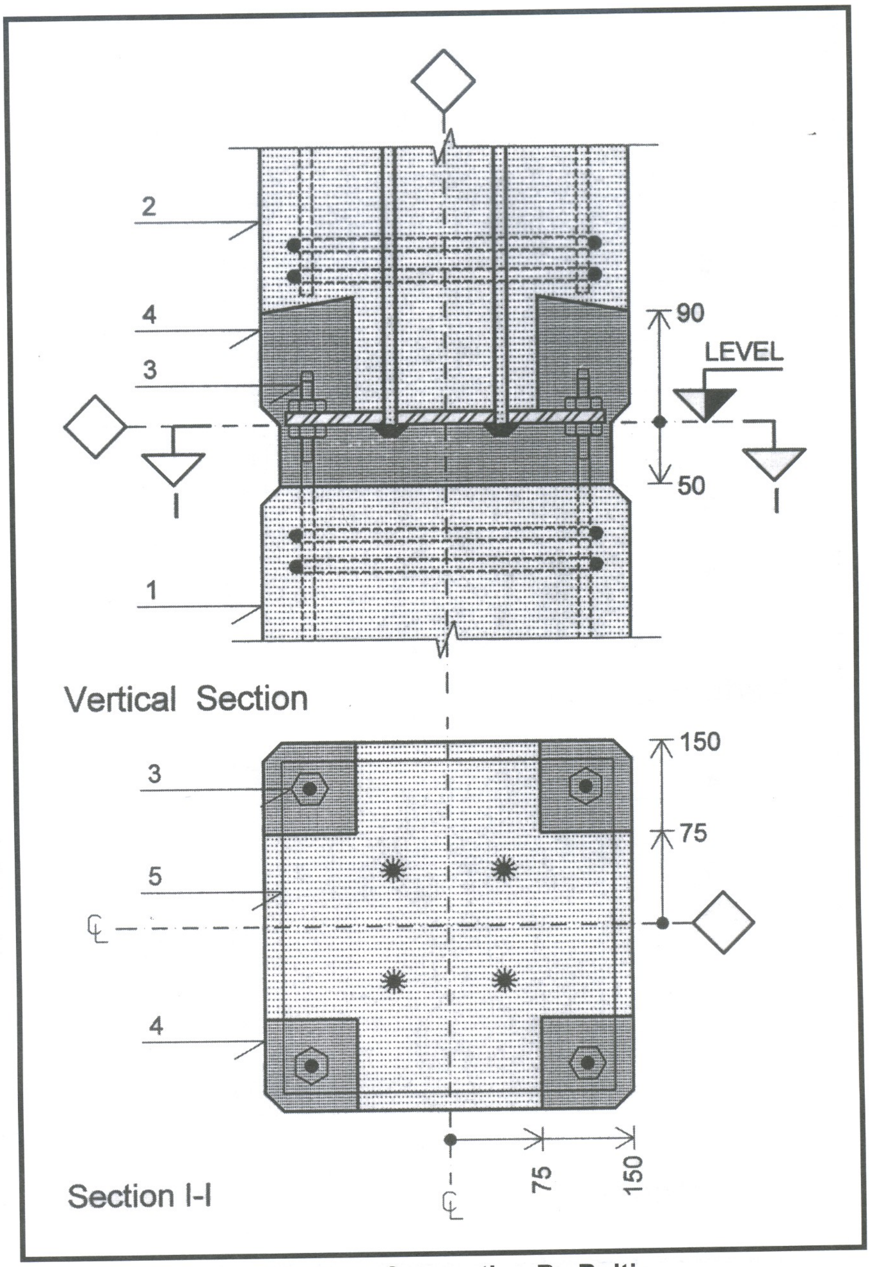
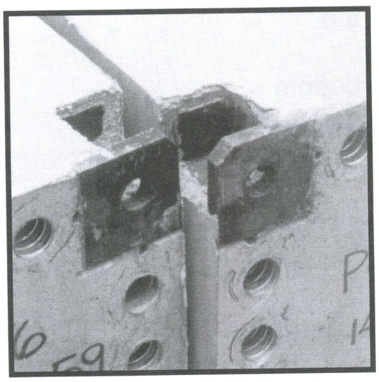


Figure 5.35 Column/Column Connection By Bolting



1. Column with assembly bolts at the top
2. Column with steel plate at the bottom
3. Bolts fastened to steel plate
4. Grouting with cement mortar
5. Steel plate welded to column bars

The four assembling bolts and the embedded steel plate form a fixed-ended column.

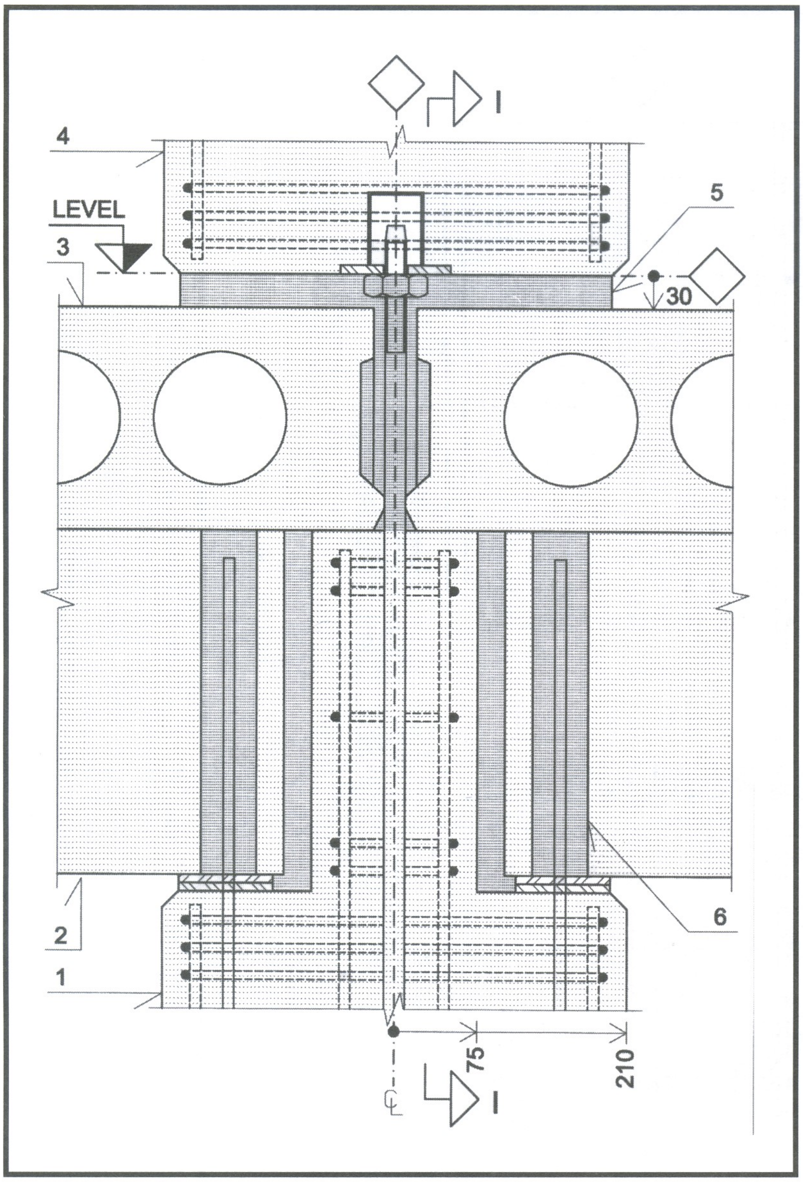


Figure 5.36 Column/Beam/Floor Pinned Connection

1. Column with assembly bolt at the top
2. Precast beam
3. Hollow core slab
4. Column with steel plate support and recess
5. Grouting with cement mortar
6. Dowel-hole connection

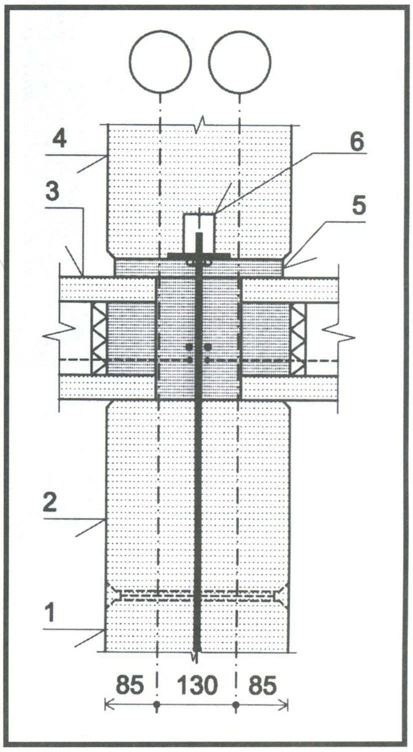


Figure 5.37 Section I-I

1. Column with assembly bolt
2. Beam component
3. Hollow core slab
4. Column in the next storey
5. Grouting
6. Recess for assembly bolt

Section I-I shows vertical forces being transmitted via the cast in-situ zone.

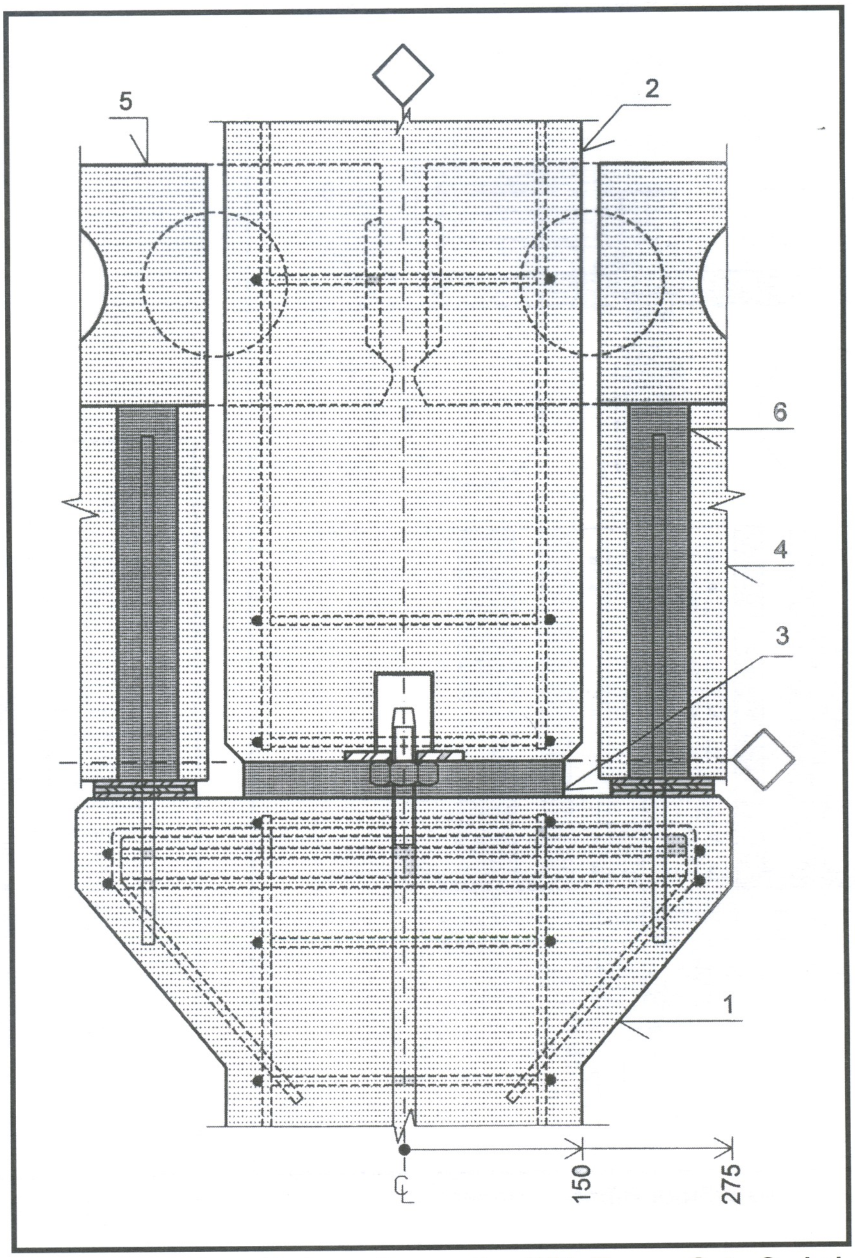
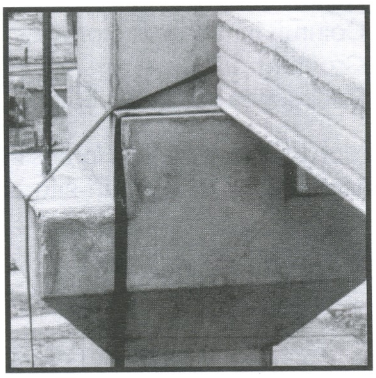


Figure 5.38 Column/Column Connection With Beams Onto Corbel



1. Column with corbels and assembly bolt
2. Column with steel plate and recess
3. Grouting with cement mortar
4. Precast beam
5. Hollow core slab
6. Dowel-hole connection

The assembly detail shows a normal column-to-column joint and two simply supported beams.

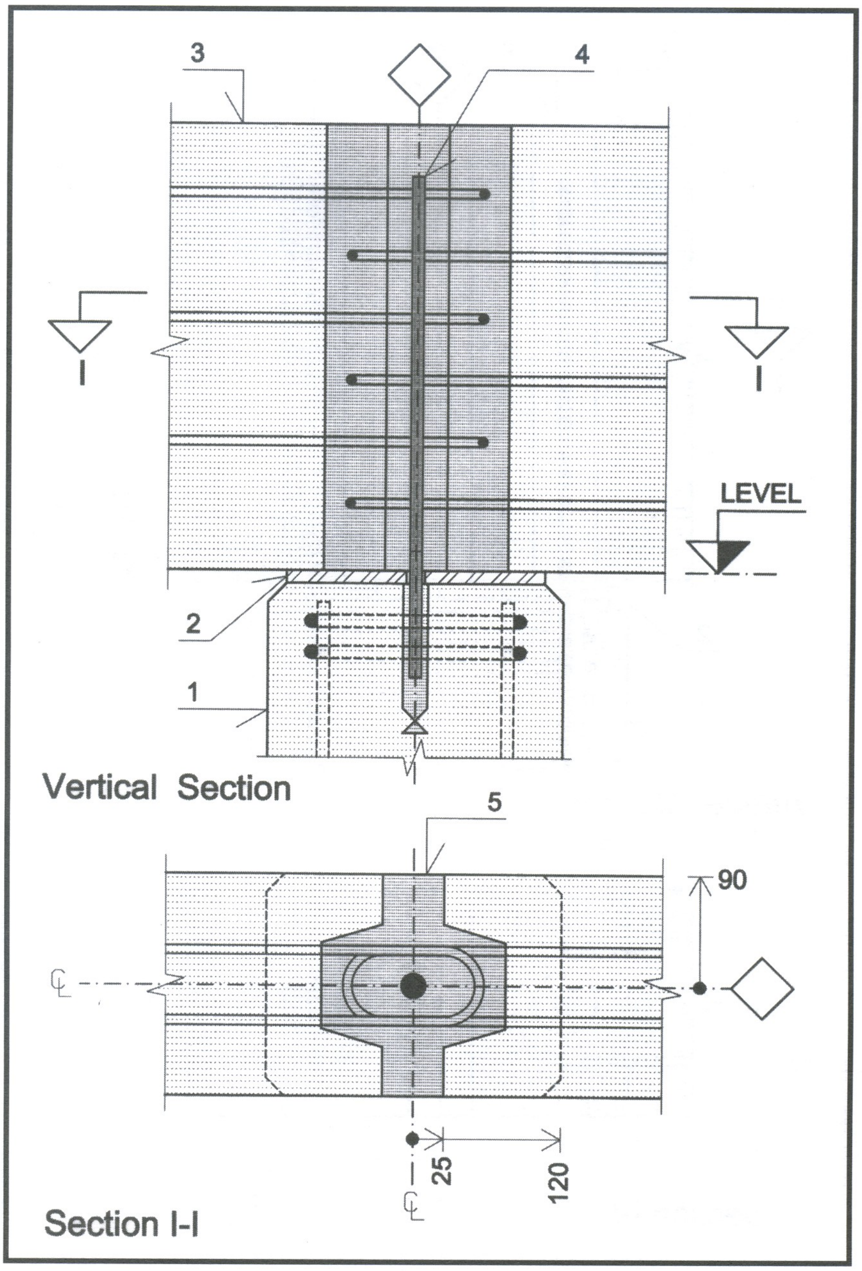
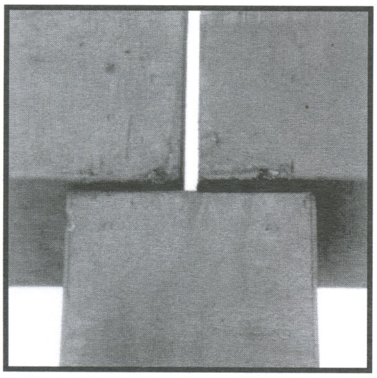


Figure 5.39 Column/Beam Connection With In-Situ Jointing And Looped Bars



1. Column with anchor insert at the top
2. Steel plate as support
3. Precast beam with protruding stirrups
4. Dowel screwed into insert
5. In-situ concrete or grouting

The two beams are restrained by the use of protruding stirrups and locking dowel.

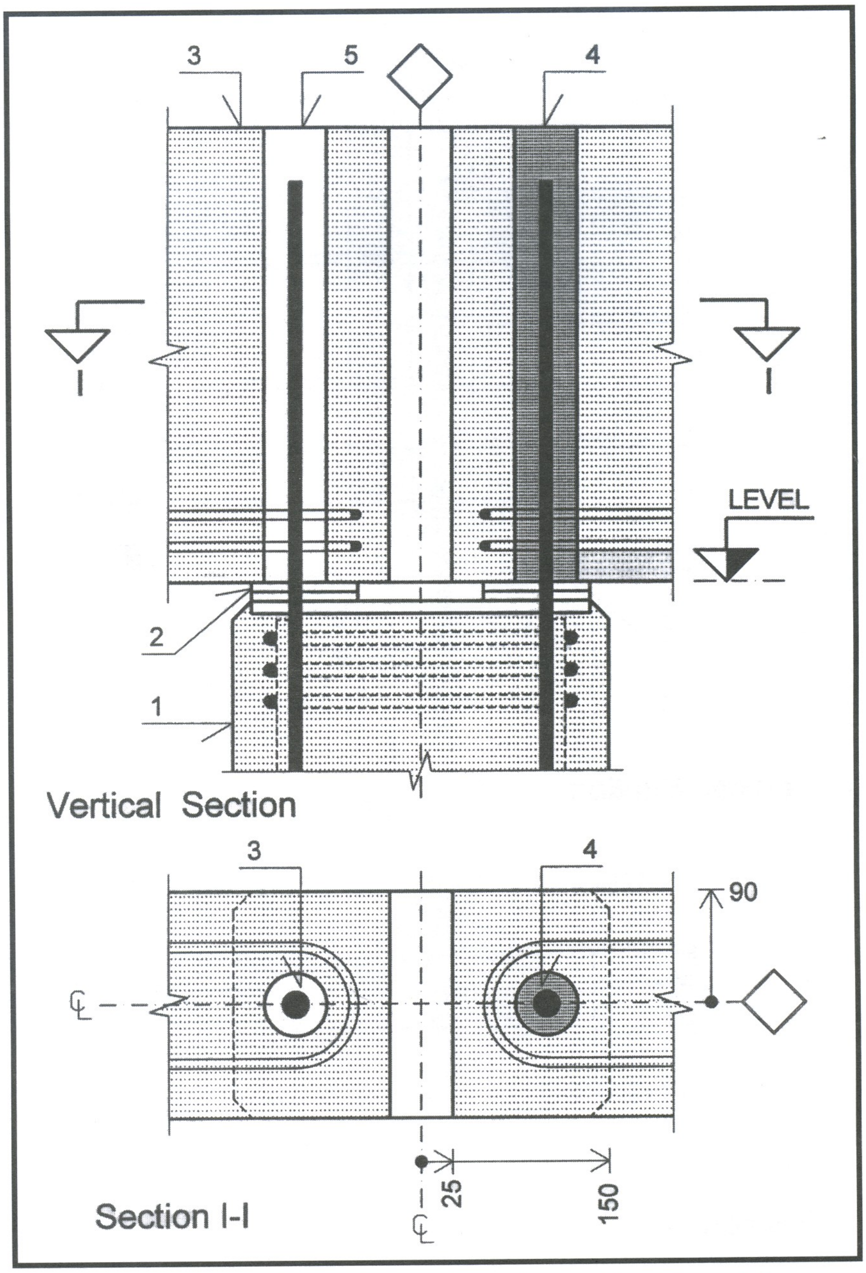
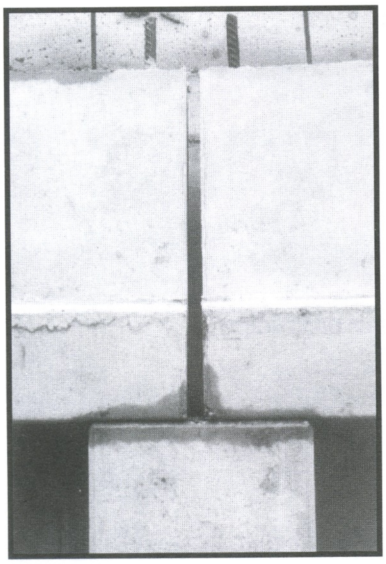


Figure 5.40 Column/Beam Connection With Vertical Dowel Bars



1. Column with cast-in steel plate and protruding dowels at the top
2. Reinforced neoprene rubber bearing
3. Beam with dowel holes
4. Grouted dowel-hole connection
5. Non-grouted connection

To the left, a movable bearing is shown; to the right, a fixed bearing is used.

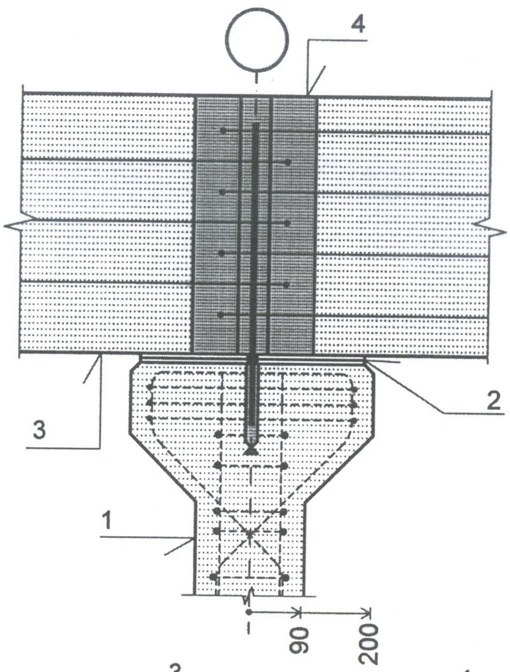


Figure 5.41

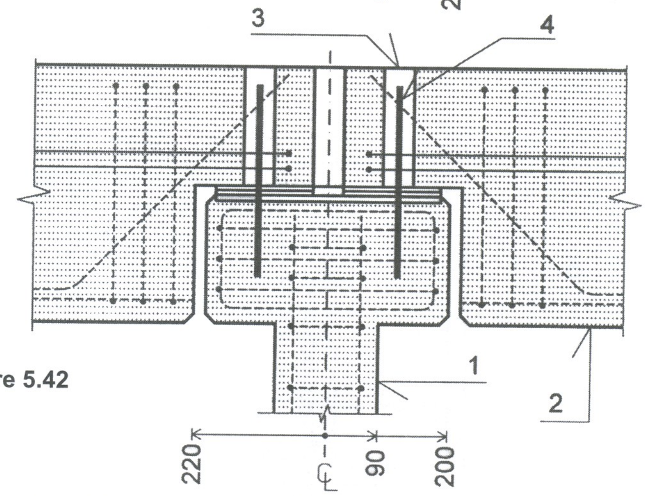


Figure 5.42

Figure 5.41 : Connection Similar to 5.39
Figure 5.42 : Connection Similar to 5.40

Figure 5.41 Column-Beam

1. Column with corbels and anchor insert with dowel
2. Bearings: steel or neoprene
3. Beam with stirrups
4. Column-beam joint cast in-situ

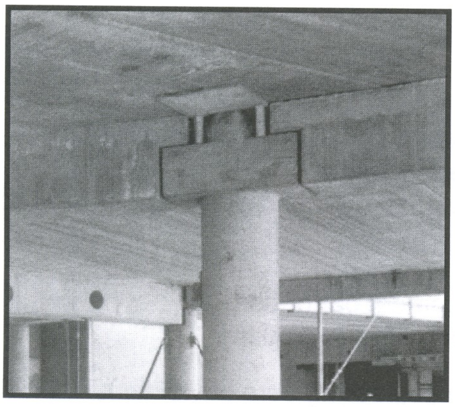


Figure 5.42 Half Joint Column/Beam Connection

1. Column with corbels and cast-in dowels
2. Precast beam with half joint
3. Grouted dowel-hole connection
4. Dowel protruding from column

In Figure 5.42, the components are placed on top of each other. Using a beam with half joint, the corbels can be hidden and the structural height can be reduced as shown in Figure 5.42.

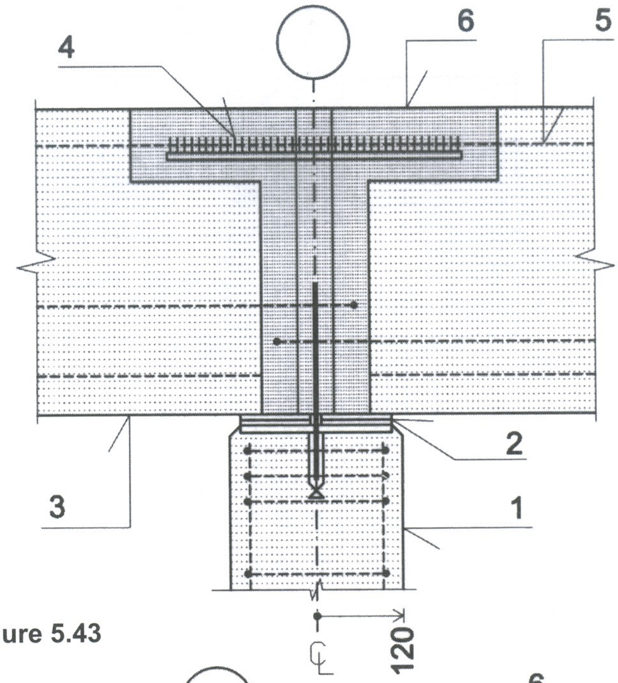


Figure 5.43

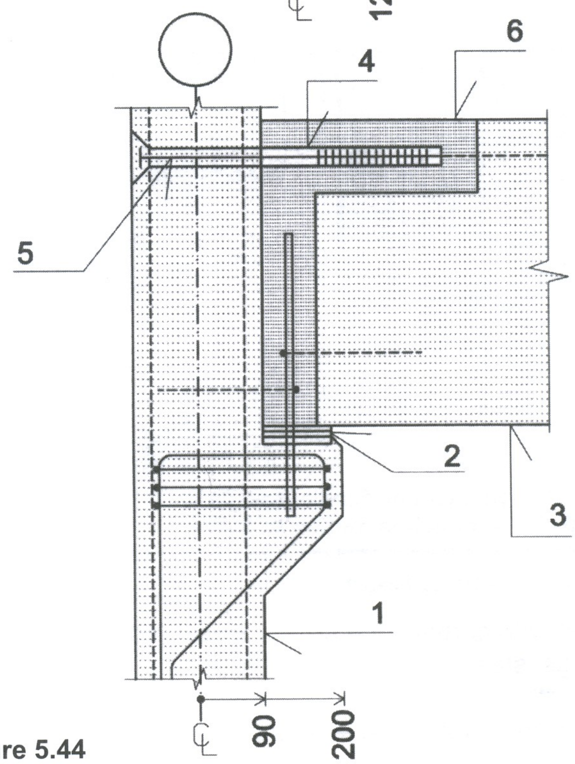


Figure 5.44

Figure 5.43 Column-Beam With Moment And Shear Continuity

1. Column with anchor insert
2. Steel bearing plate
3. Beam with protruding stirrups and rebars at the top
4. Welded connection using steel angle
5. Reinforcement bar
6. In-situ concrete or grouting

Figure 5.44 Edge Column/Beam Connection With Moment And Shear Continuity

1. Column with corbel and cast-in dowel
2. Steel bearing plate
3. Beam with stirrups and protruding rebars at the top
4. Welded connection
5. Reinforcement bar or bolt
6. In-situ concrete or grouting

The beams can be connected to both the bottom and top by stirrups, locking bars or welding.

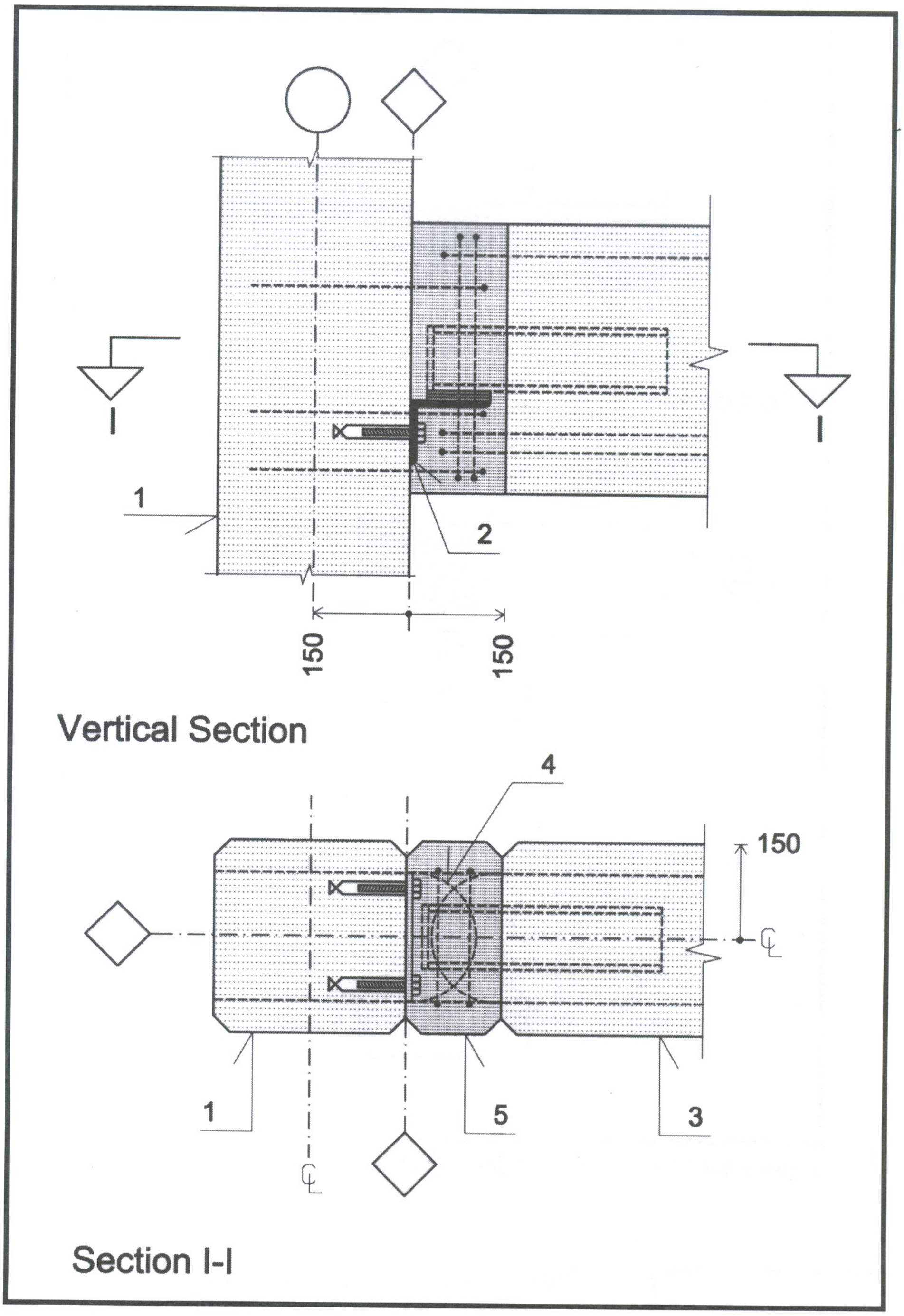


Figure 5.45 Column/Beam Connection With Temporary Steel Section Supports

1. Column component with anchor insert
2. Steel angle bolted to column
3. Beam with embedded steel section
4. Connection using protruding stirrups and reinforcement placed on site
5. Casting on site

In Figure 5.45, a combination of a temporary and a permanent column-beam support is shown. First the embedded steel profile acts as support, later the stirrups and locking bars take over.

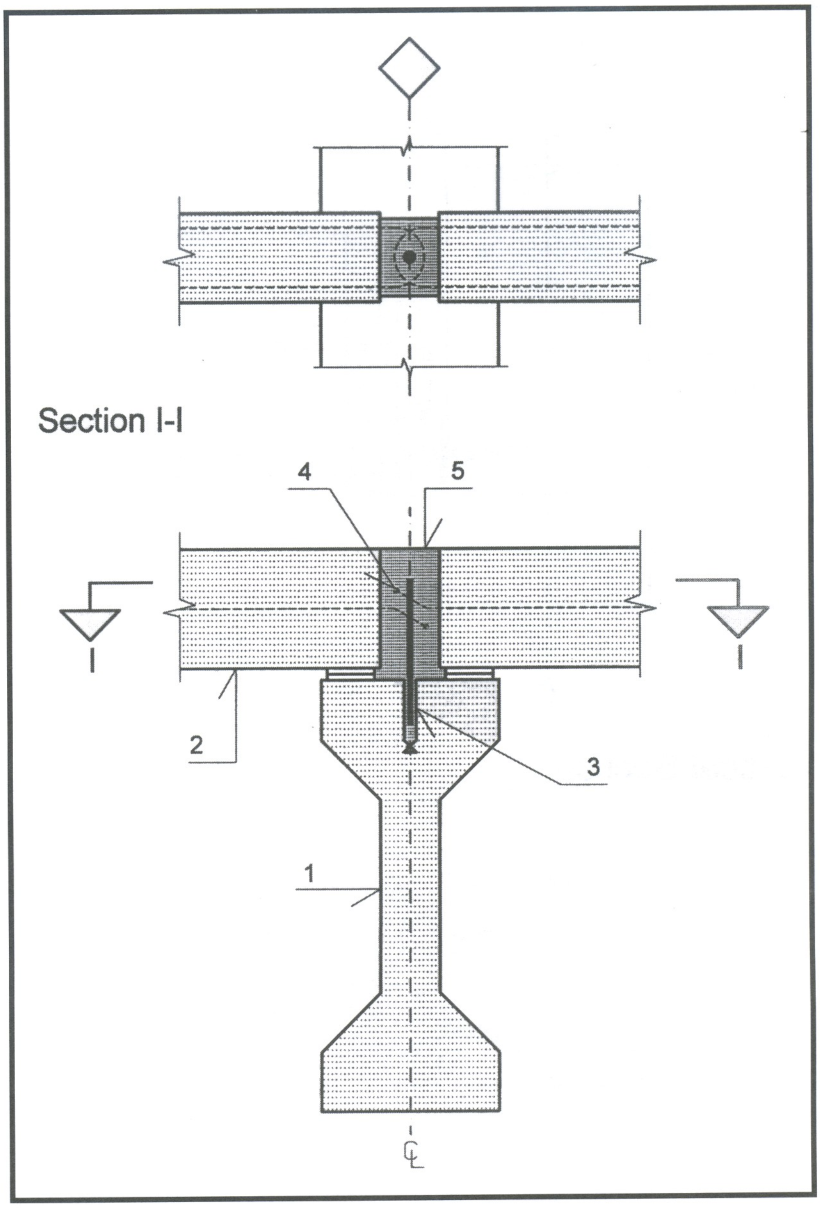
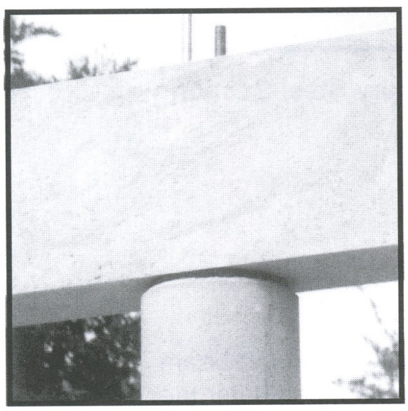
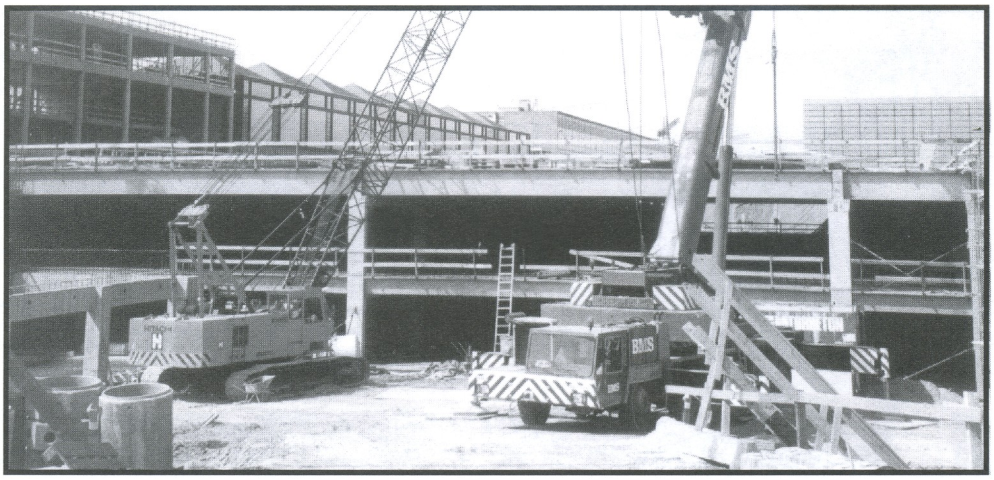


Figure 5.46 Secondary To Main Beam Connection



1. Prestressed main beam with anchor inserts at the top
2. Secondary beam or purlin with protruding stirrups
3. Dowel screwed into insert
4. Stirrup-dowel connection
5. Cast in-situ joint

The connecting detail is simple, cheap and easy to execute.



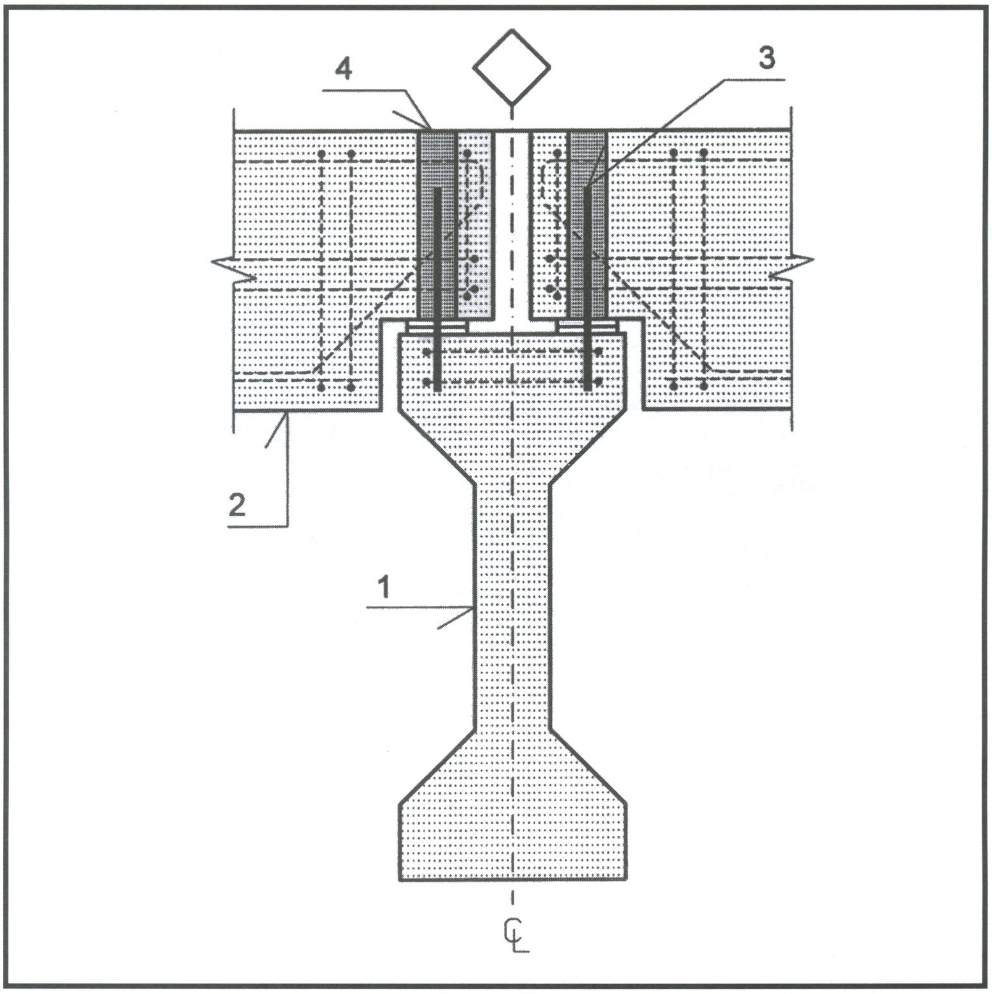
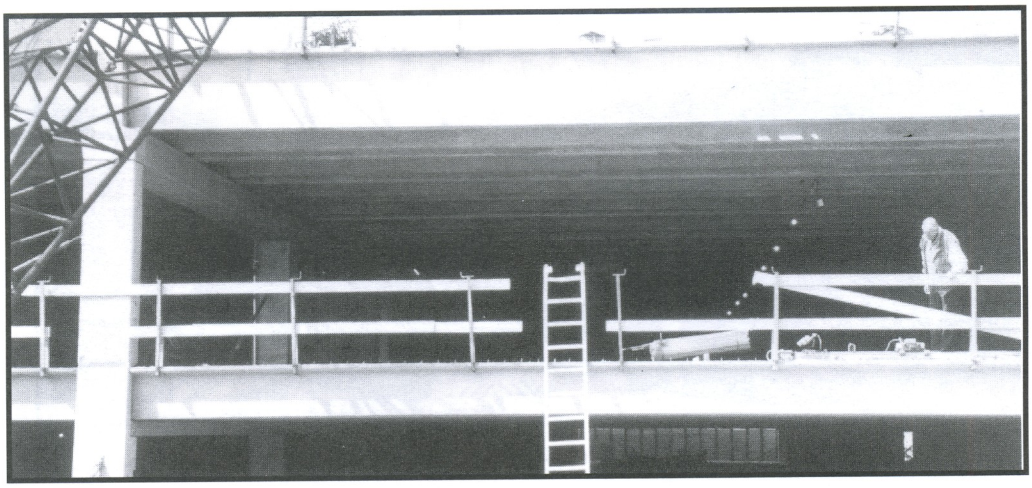


Figure 5.47 Secondary To Main Beam Half-Joint Connection

1. Prestressed beam
2. Secondary beam
3. Dowel protruding from beam
4. Grouted dowel-hole connection

With the use of beam half joints, a more aesthetic solution has been obtained.



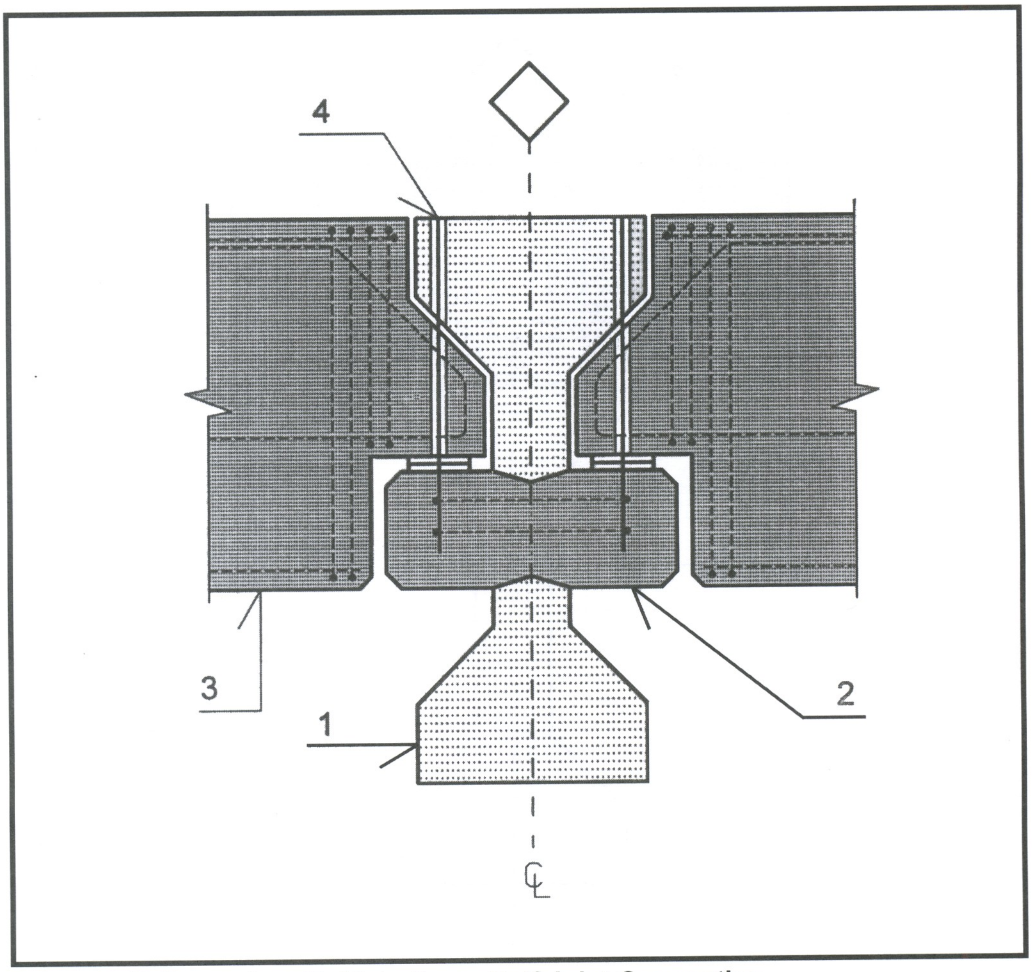


Figure 5.48 Secondary To Main Beam Half Joint Connection

1. Prestressed main beam
2. Transverse beam as double corbel
3. Secondary beam with half joint
4. Dowel-hole connection

To decrease the total construction height, double corbels can be used.

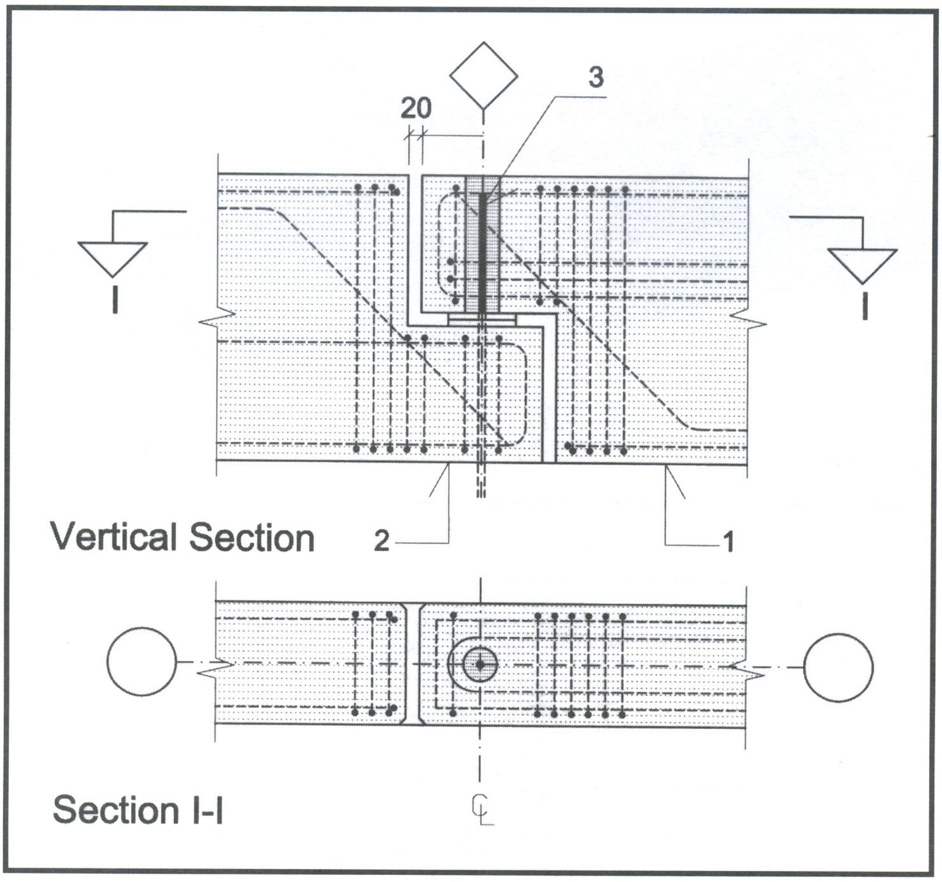
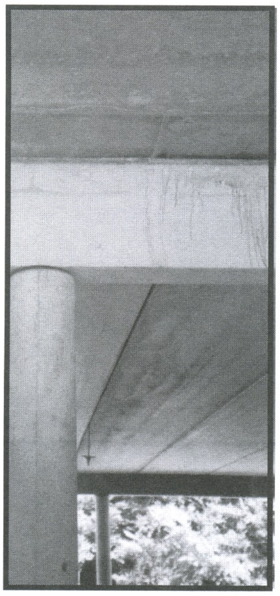
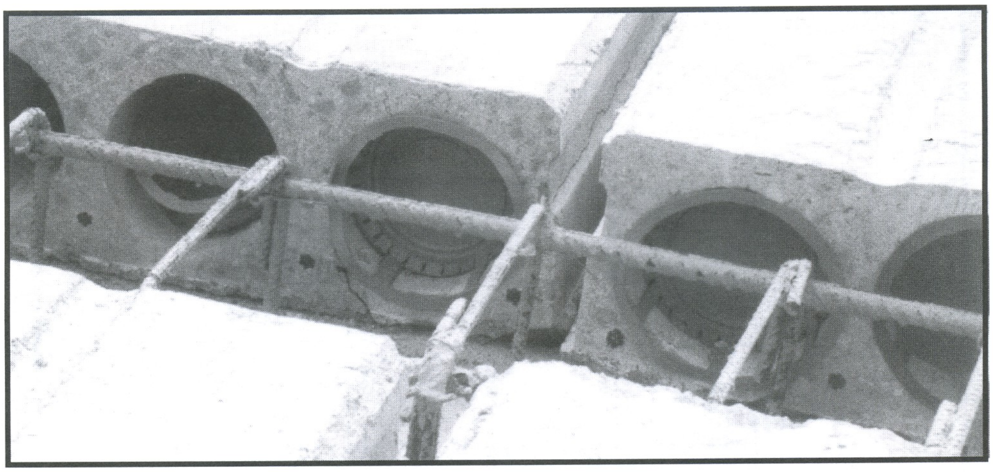


Figure 5.49 Half Joint Connection In Beams



1. Beam with half joint
2. Cantilevered beam
3. Dowel-hole connection, half-beam joint

Two half-beam joints have to be considered.



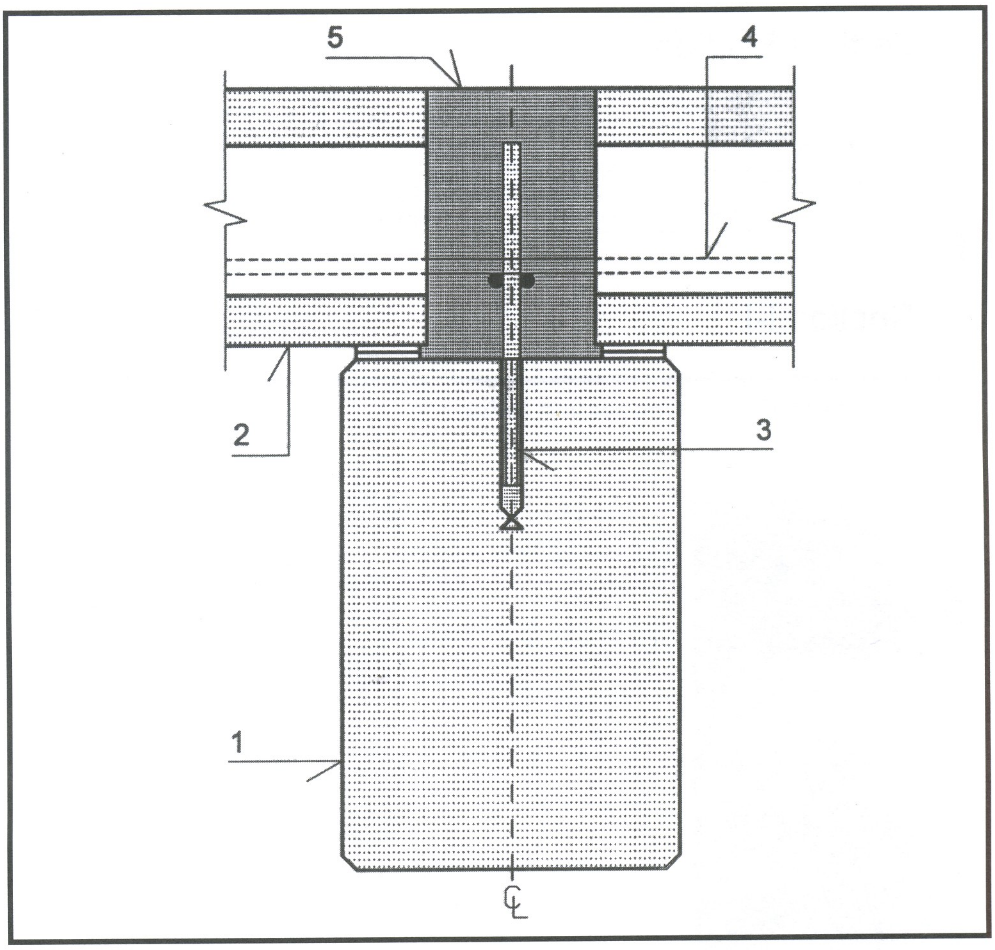


Figure 5.50 Beam And Hollow Core Slab Connection

1. Beam with anchor inserts at the top
2. Hollow core slab
3. Dowel screwed into insert
4. Reinforcement in slab joint
5. In-situ concrete or grouting

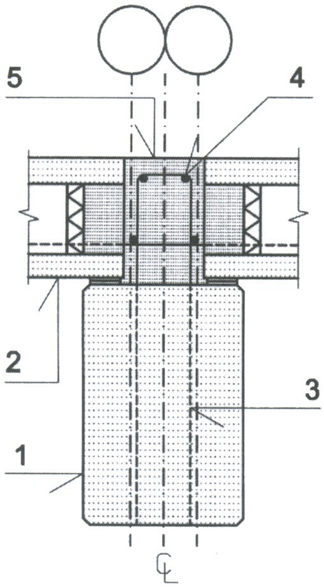


Figure 5.51

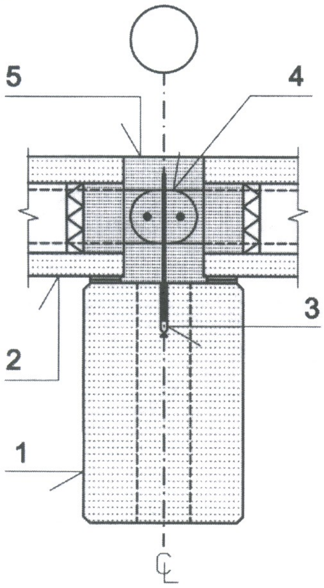


Figure 5.52

Figure 5.51 Beam-H.C.Slab

1. Precast beam
2. Hollow core slab
3. Stirrups protruding from the top of beam
4. Joint reinforcement
5. Casting on site

Figure 5.52 Beam-H.C.Slab

1. Precast beam
2. Hollow core slab
3. Dowel in insert
4. Joint reinforcement
5. Casting on site

Figure 5.53 Beam-H.C.Slab

1. Precast beam
2. Hollow core slab
3. Dowel in insert
4. Locking stirrups
5. Casting on site

Figure 5.51 shows modular slabs and a neutral zone; Figure 5.52 uses non-modular slabs. Both solutions result in a wider cast-on-site joint.

Figure 5.54 Beam-H.C.Slab

1. Precast beam: half inverted T
2. Hollow care slab
3. Anchor insert
4. Joint reinforcement screwed into insert
5. Casting on site

It is important to anchor the joint reinforcement to, for instance, edge beams.

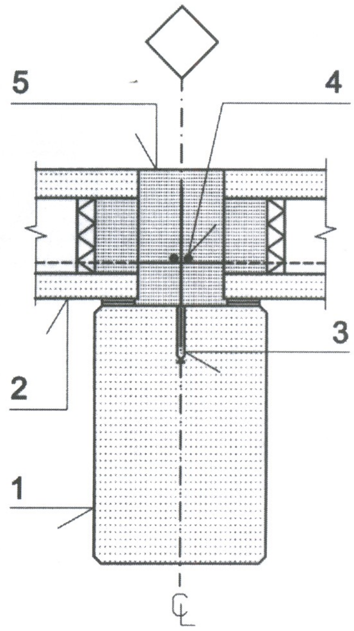


Figure 5.53

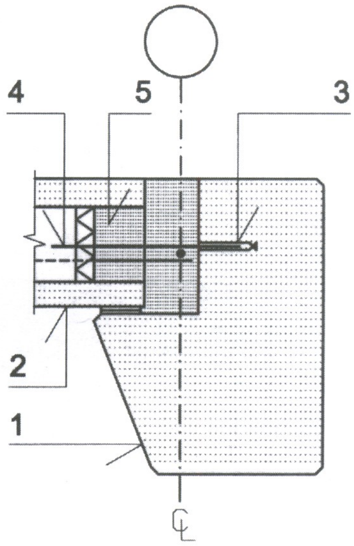
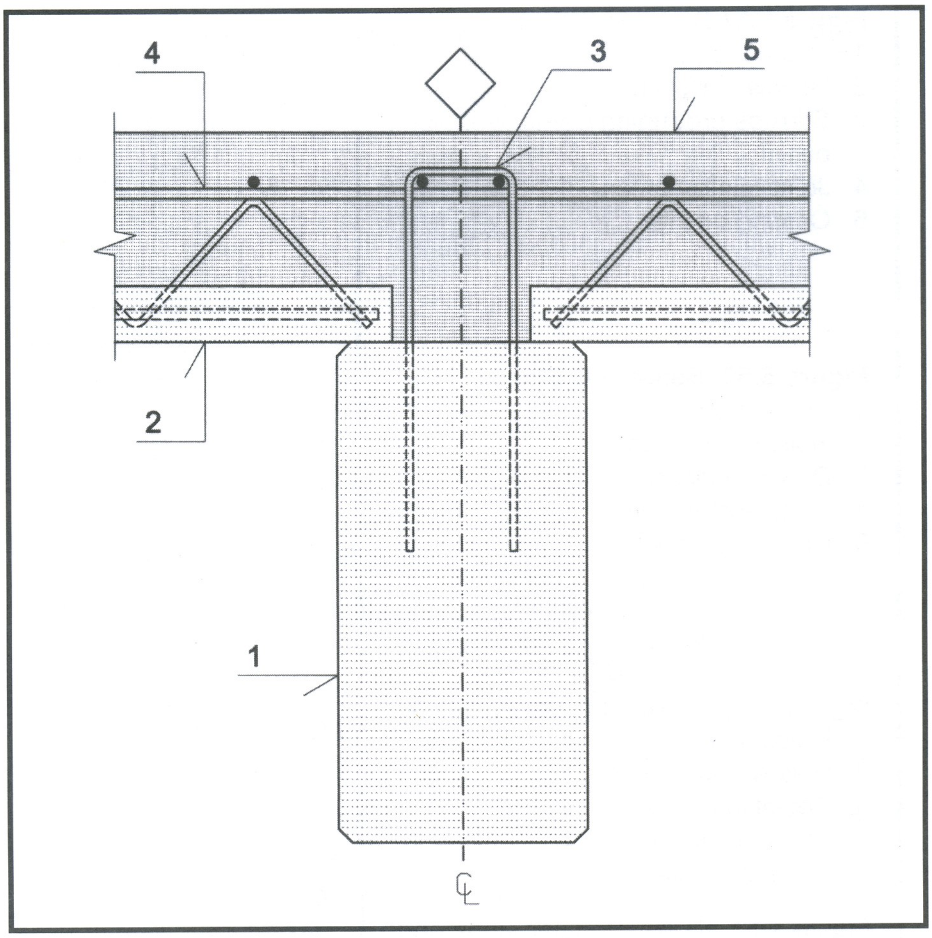
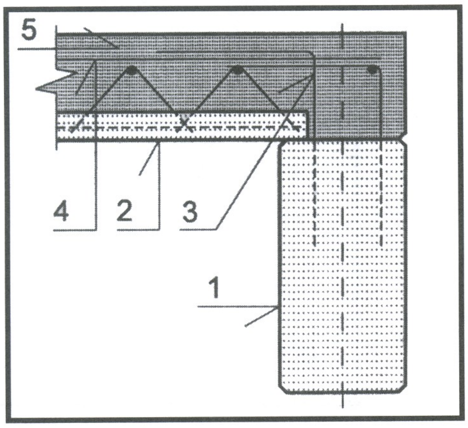


Figure 5.54



1. Precast beam
2. Plank
3. Stirrups protruding from beam
4. Reinforcement placed on site
5. Cast in-situ structural topping

Figure 5.55 Beam-Plank



1. Precast beam
2. Plank
3. Reinforcement protruding from beam
4. Reinforcement placed on site
5. Cast in-situ structural topping

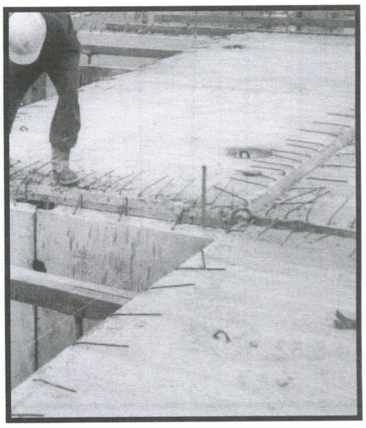
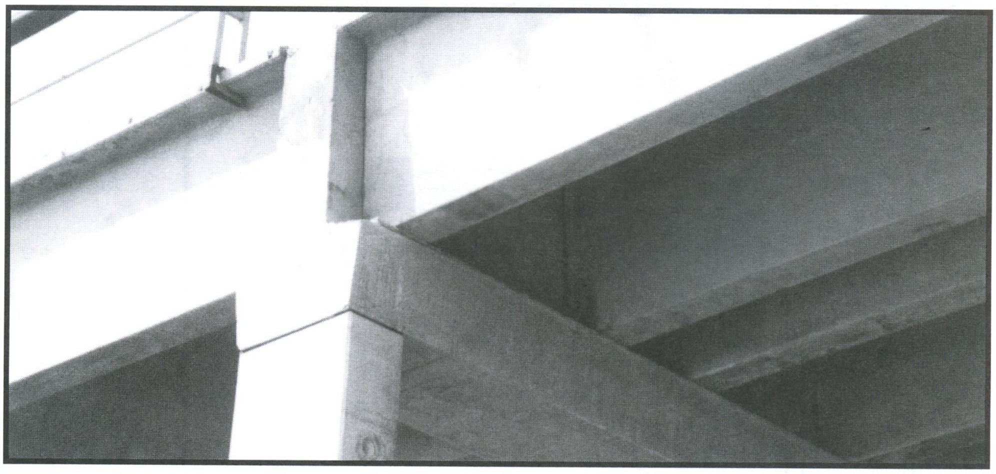


Figure 5.56 Beam-Plank

The combination of precast and cast in-situ structures gives good opportunities for the transmission of forces in the main structural system.



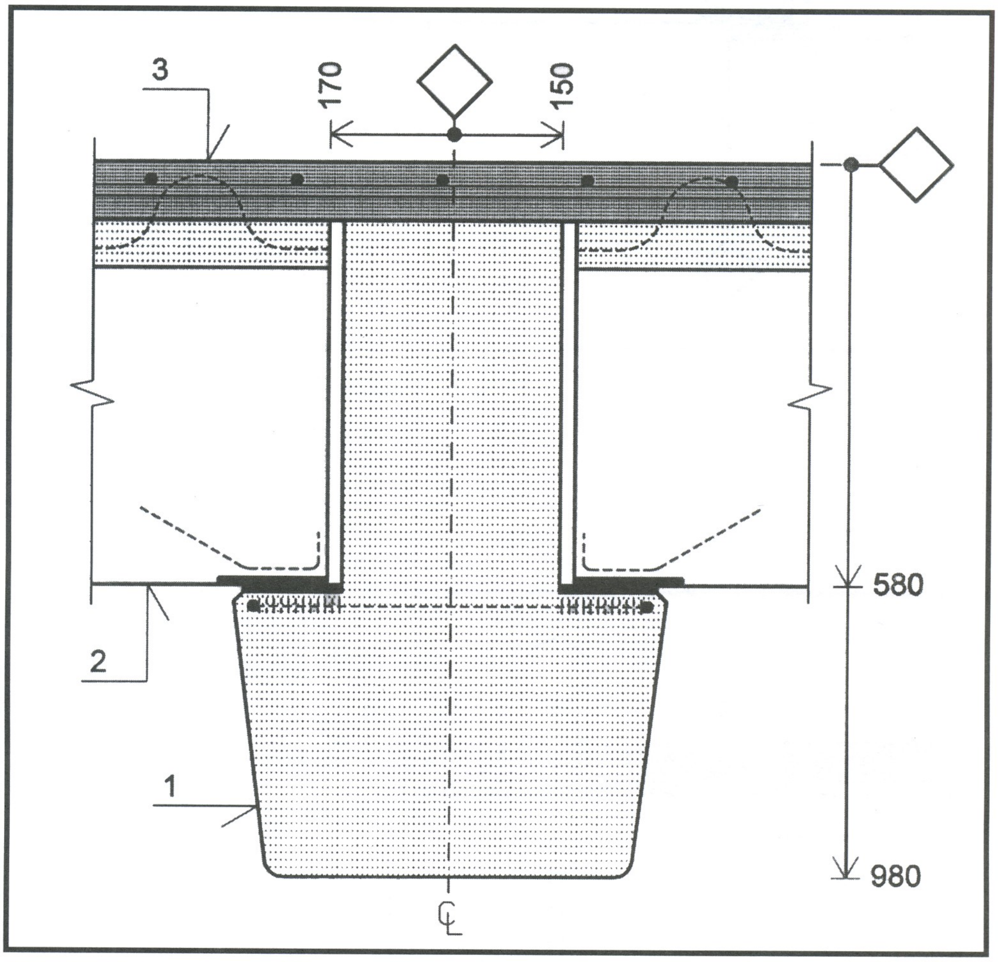


Figure 5.57 Beam And Double T

1. Beam: inverted T
2. Double T-slab
3. Structural topping

Normally the double T-slabs are produced with cast-in steel plates in the ribs for a welded support, and with protruding stirrups in the plate for the cast in-situ structural topping.

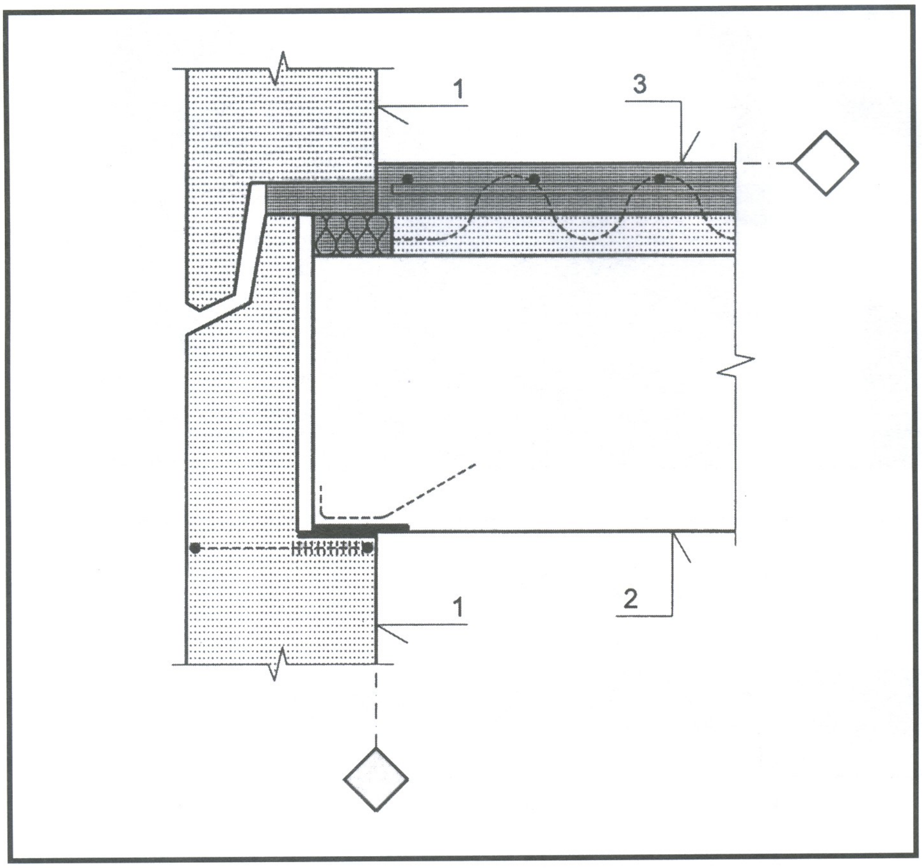


Figure 5.58 Beam-Double T

1. Facade beam (or frame or facade)
2. Double T-slab
3. Structural topping

As double T's are normally long-spanning components, moments and movements in the joints have to be considered in the structural design.

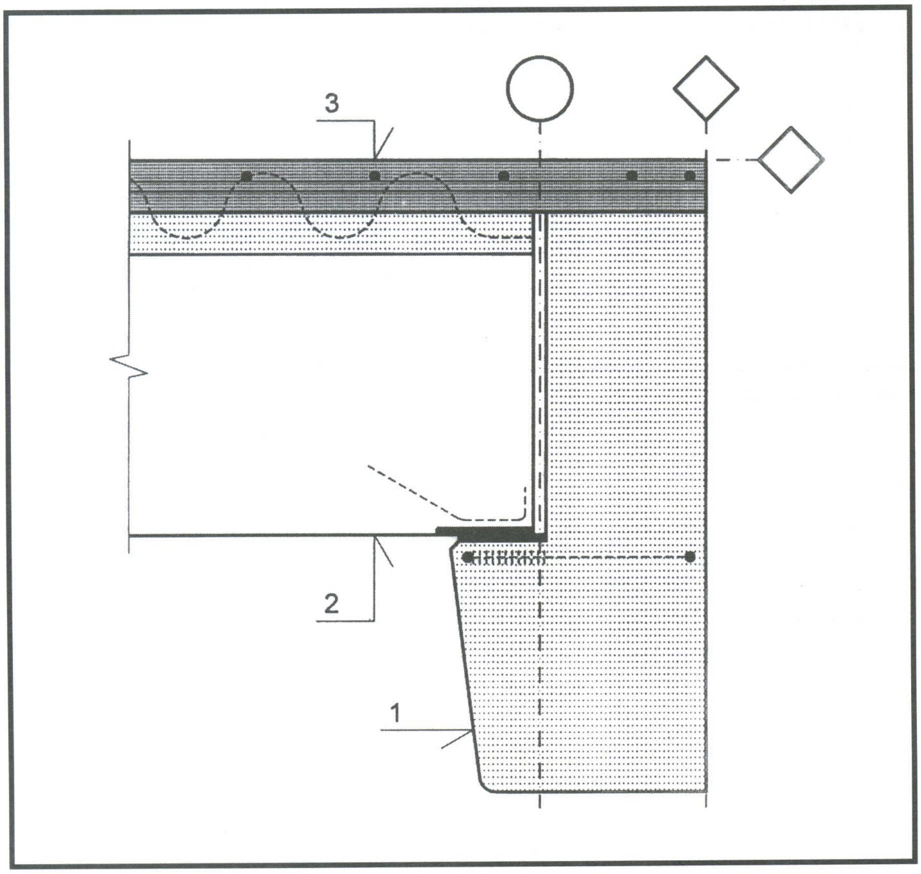


Figure 5.59 Beam-Double T

1. Beam, half inverted T
2. Double T-slab
3. Structural topping

Steel studs at the top of the edge beam could provide a better anchorage of the structural topping.

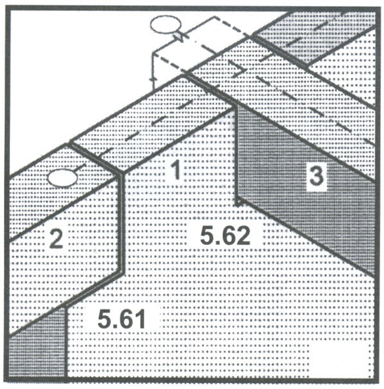
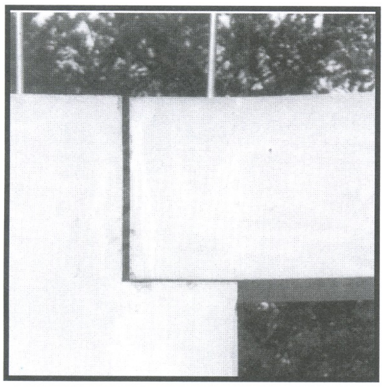


Figure 5.60 Beam-Wall Connections

1. Wall
2. Beam placed in the wall plane of symmetry
3. Beam placed perpendicular to the wall



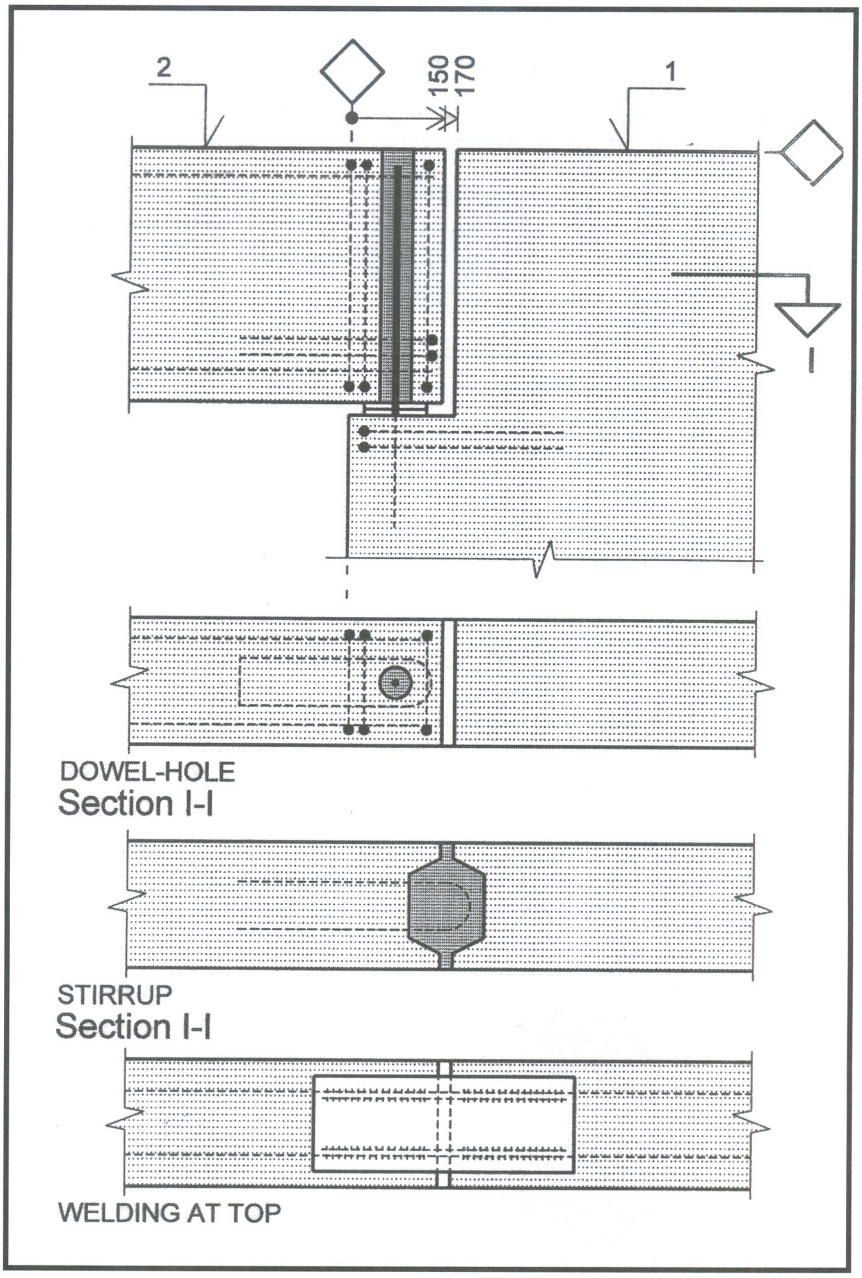
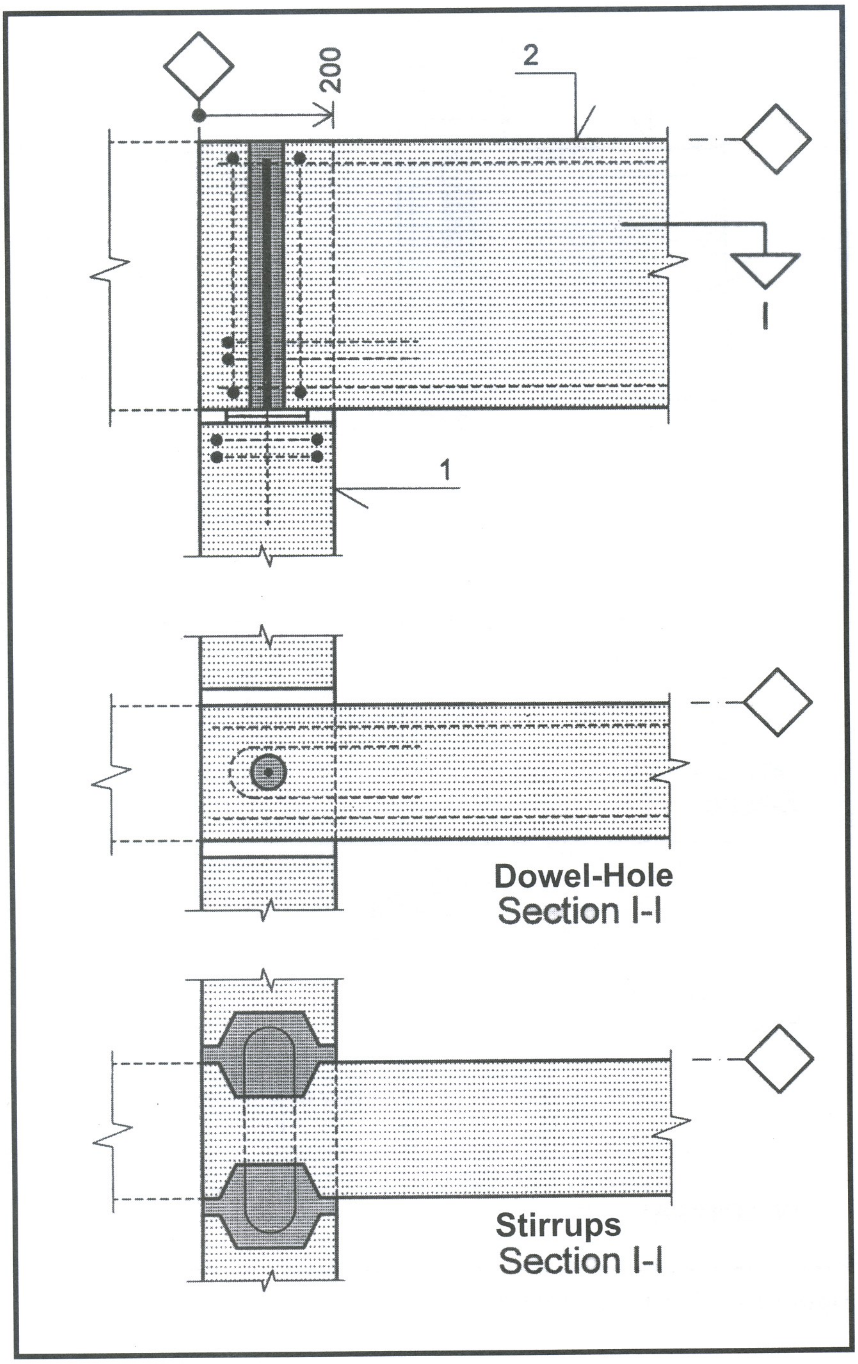


Figure 5.61 Beam-Load Bearing Wall

1. Wall
2. Beam

The beam-wall assembly could consist of either a dowel-hole, or stirrup or a welded connection as shown in Section I-I.



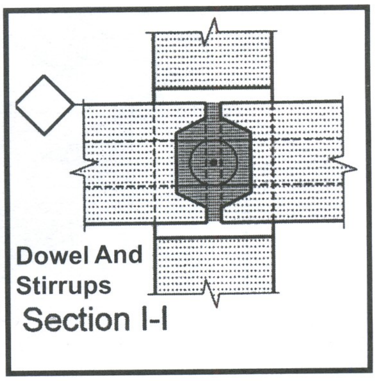


Figure 5.62 Beam-Load Bearing Wall

1. Wall
2. Beam

As shown in Section I-I, assembly could be done using a dowel-hole connection or protruding stirrups in cast in-situ joints.

Figure 5.63

1. Edge beam
2. Plank
3. Cladding
4. Structural topping

The cladding is fixed using dowel-hole connections which are locked to the structural topping.

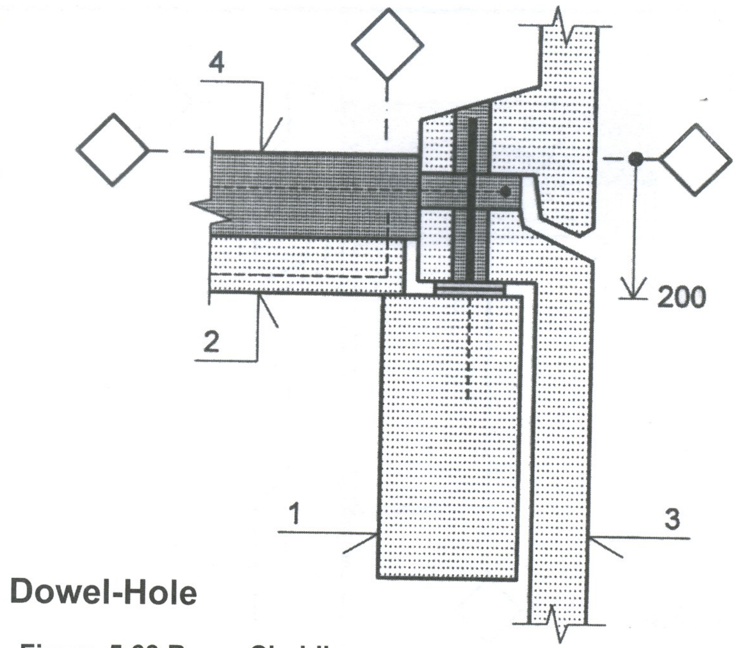


Figure 5.63 Beam-Cladding

Figure 5.64

1. Edge beam
2. Plank
3. Cladding
4. Structural topping

The cladding is fixed using embedded steel profiles and via placed-on-site steel angles.

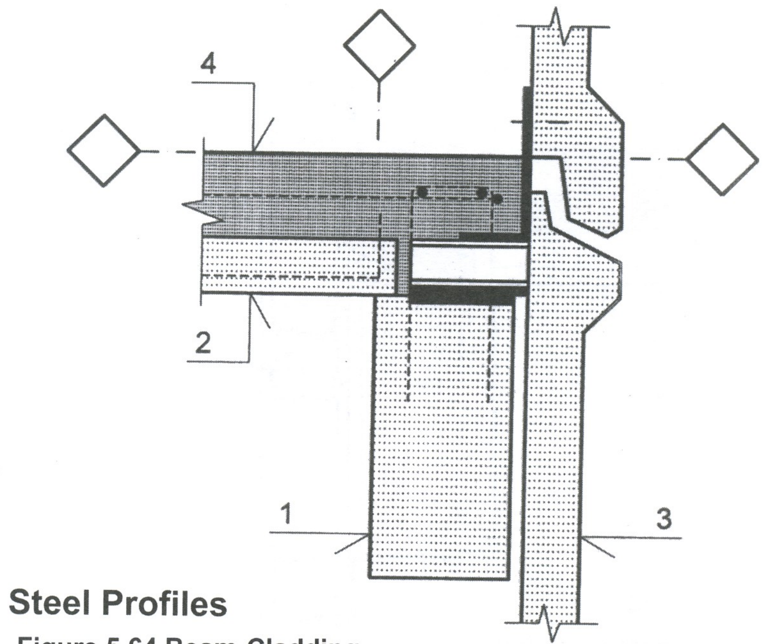
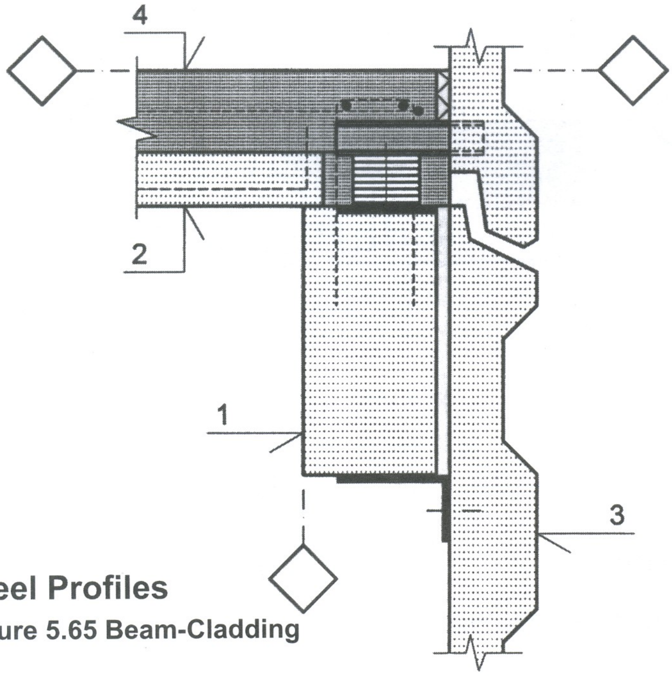
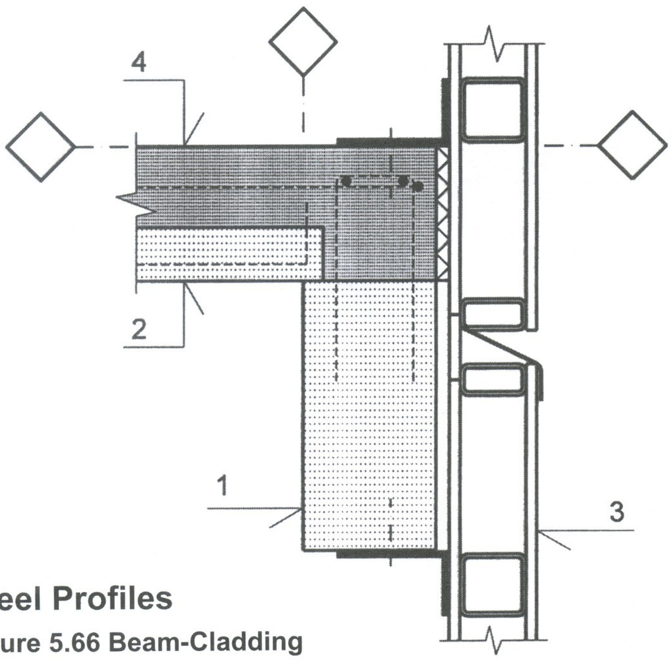


Figure 5.64 Beam-Cladding



Steel Profiles

Figure 5.65 Beam-Cladding



Steel Profiles

Figure 5.66 Beam-Cladding

Figure 5.65

1. Edge beam
2. Plank
3. Cladding
4. Structural topping

The cladding components are fixed to the beam by steel angles and to the floor slab using embedded steel sections locked to the structural topping.

Figure 5.66

1. Edge beam
2. Plank
3. Cladding
4. Structural topping

The lightweight cladding shown can be fastened to the beam and finished floor slab using steel angle profiles.

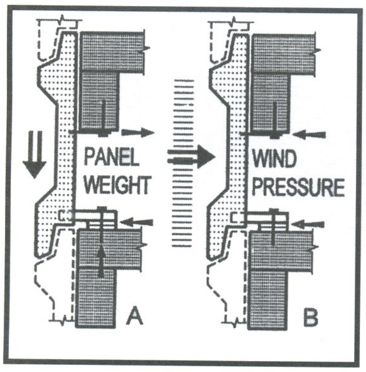


Figure 5.67 Beam-Panel Connections

Statically determinate connections should be chosen if possible. Load reactions are shown as a response to panel weight and to wind pressure.

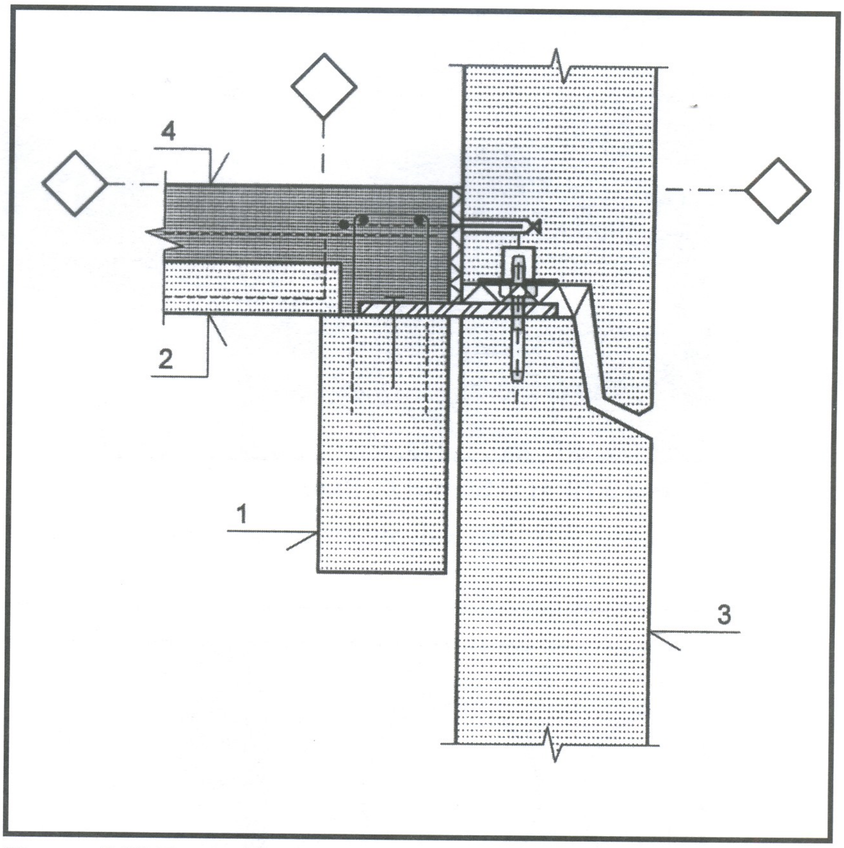


Figure 5.68 Beam-Facade

1. Edge beam
2. Plank
3. Facade
4. Structural topping

Vertical forces are transmitted through the horizontal joint. Horizontal forces are carried by the steel plate and reinforcement anchorage.

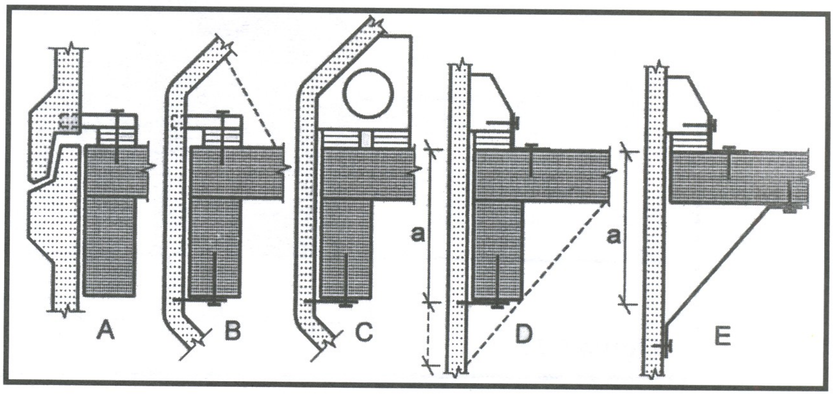


Figure 5.69 Beam-Panel Supports

Schematic solutions for positioning of joints.

A. Panels are fastened to floor slab
B. Joints are placed at floor slab and beam
C. Cross walls on panel plus beam joint
D. Corbels on panel plus beam fixing
E. Corbels on panel plus steel bracing

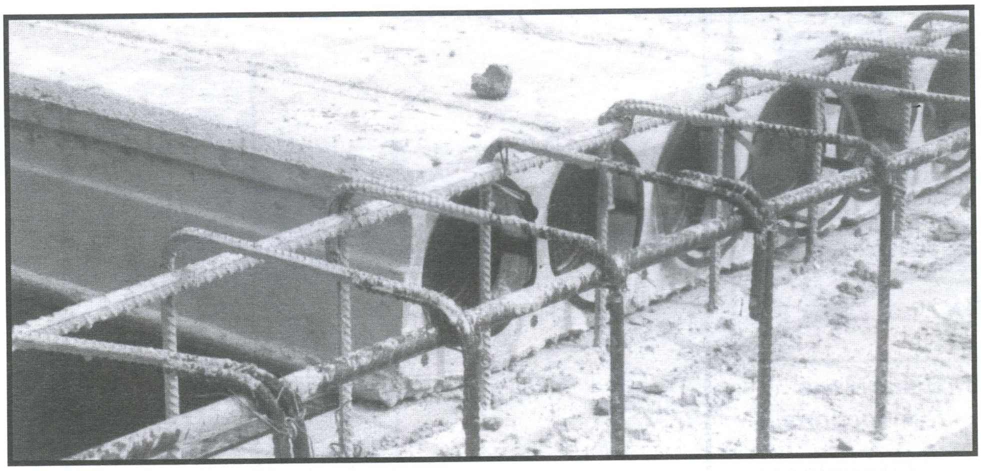


Figure 5.70 H.C.Slab-H.C. Slab

1. Hollow core slab with reinforcement bar placed in joint

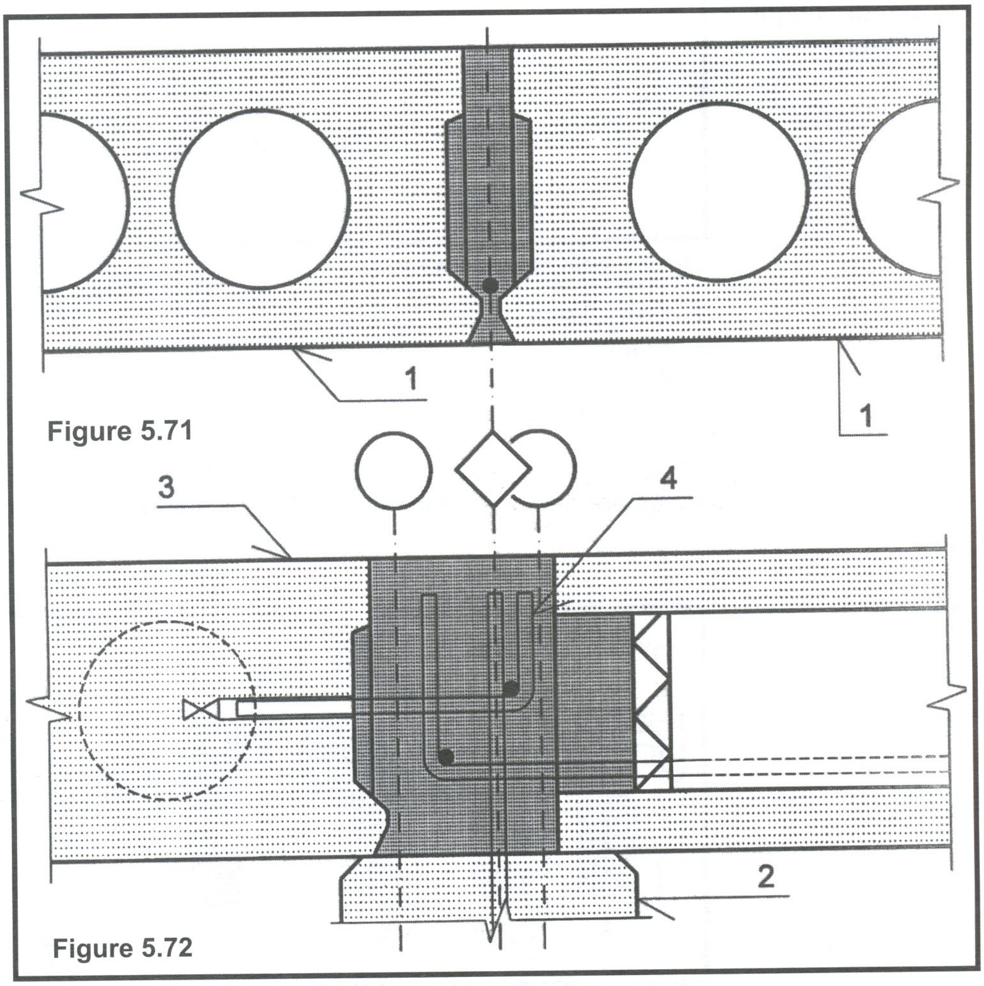


Figure 5.71

Figure 5.72

Figure 5.71 And 5.72: H.C.Slab-H.C.Slab

2. Beam, wall or frame
3. Edge of HCS without void
4. Locking rebars and dowels in joint

It is important to reinforce structural joints, for instance as shown with interaction between dowel in beam, reinforcement from slab joint and locking bar screwed into insert.

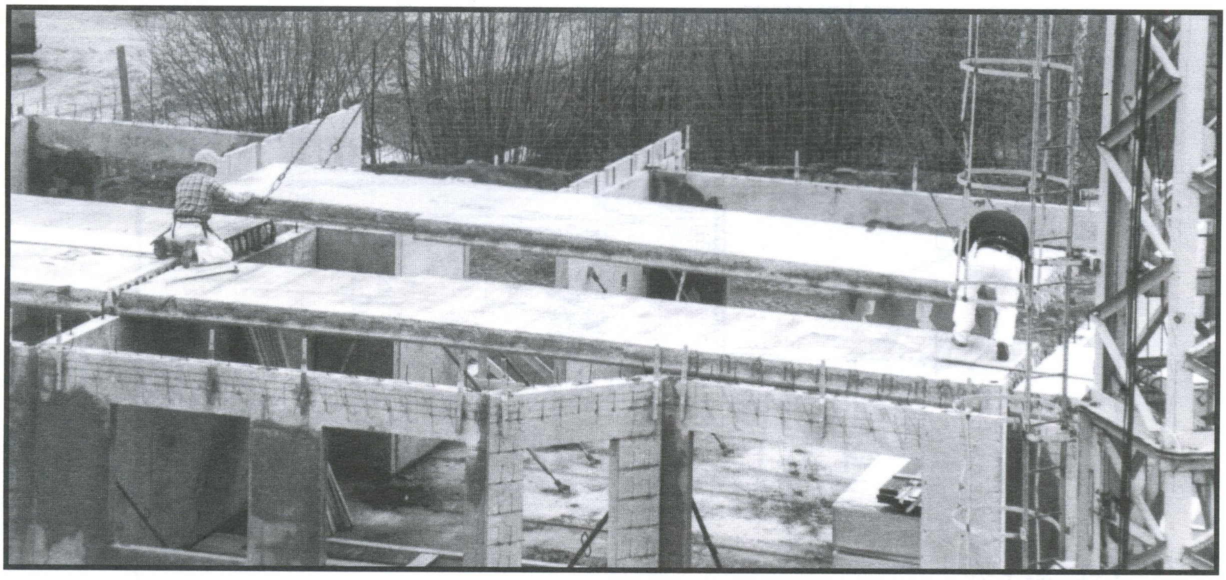
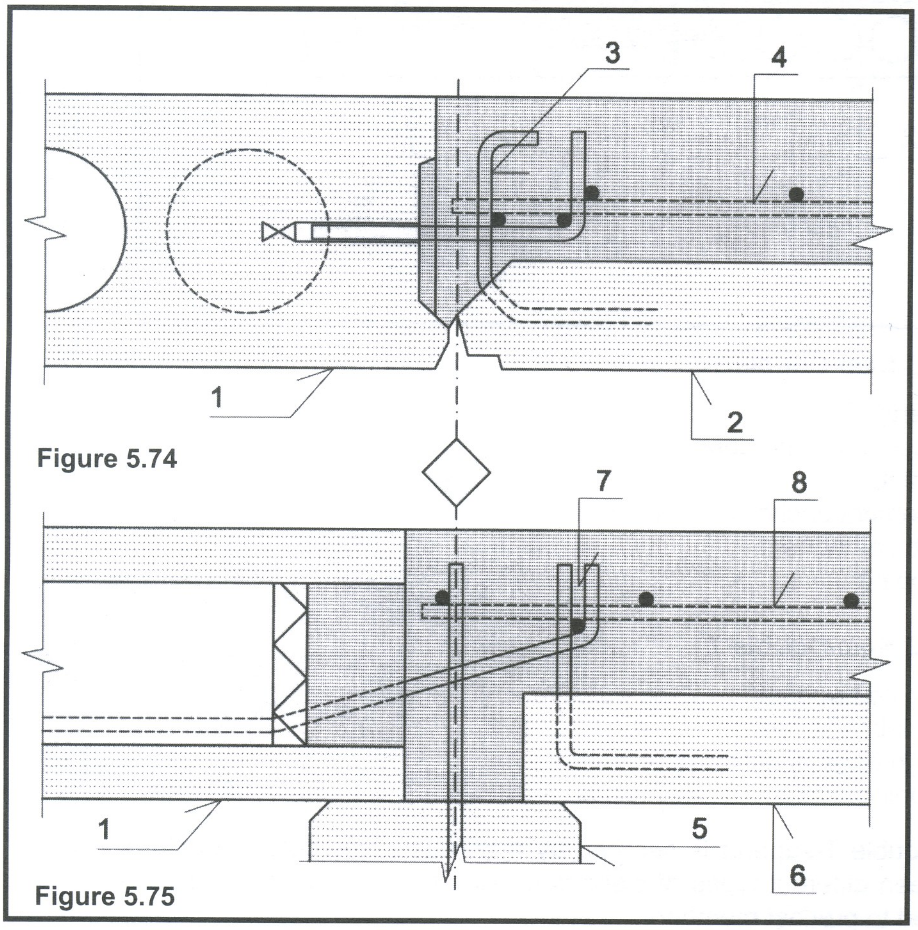


Figure 5.73 H.C.Slab-Plank



Figures 5.74 And 5.75 H.C.Slab-Plank

1. Hollow core slab
2. Plank
3. Locking reinforcement system
4. Reinforcement in structural topping

To create structural continuity in the floor slab system, it is important to anchor joint reinforcement in all adjoining members.

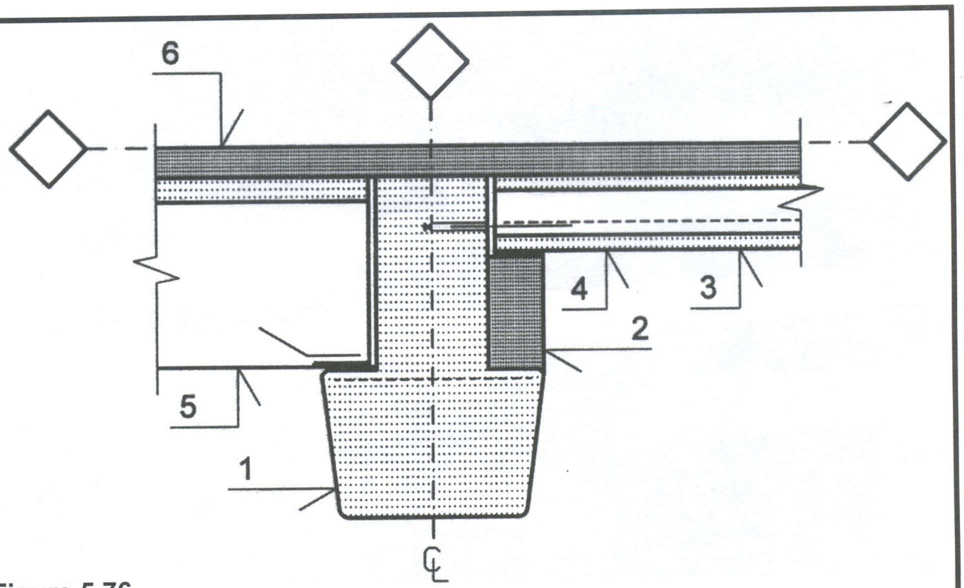


Figure 5.76

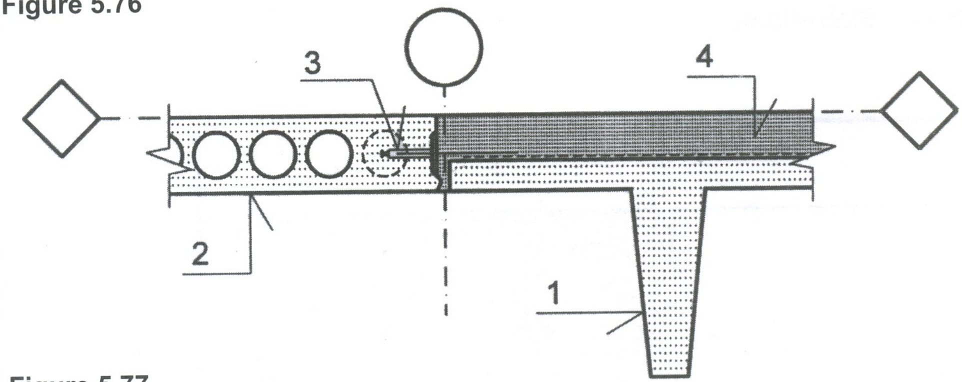


Figure 5.77

Figure 5.76 H.C.Slab-Double T

1. Beam as inverted T
2. Precast or cast in-situ members
3. Hollow core slab
4. Joint reinforcement anchored to insert
5. Double T-slab component
6. Structural topping

Figure 5.77 H.C.Slab-Double T

1. Double T-slab component
2. Hollow core slab
3. Steel anchor in edge of hollow core slab
4. Structural topping

Normally, the double T-support is secured by a welded connection. Structural continuity between different types of slabs is obtained by cast in-situ structural topping anchored to precast members.

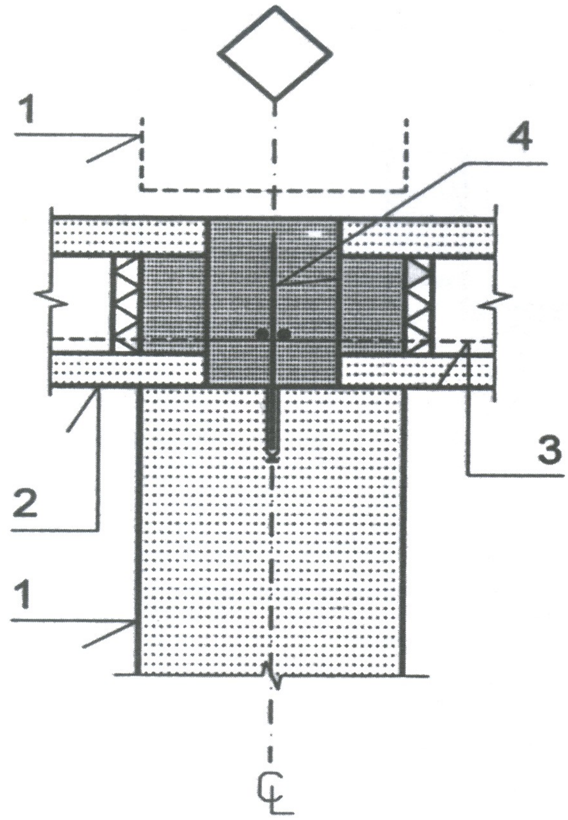


Figure 5.78

Figure 5.78 H.C.Slab-Load Bearing Wall
1. Load bearing wall
2. Hollow core slab, load bearing support
3. Slab joint reinforcement
4. Dowel screwed into steel insert

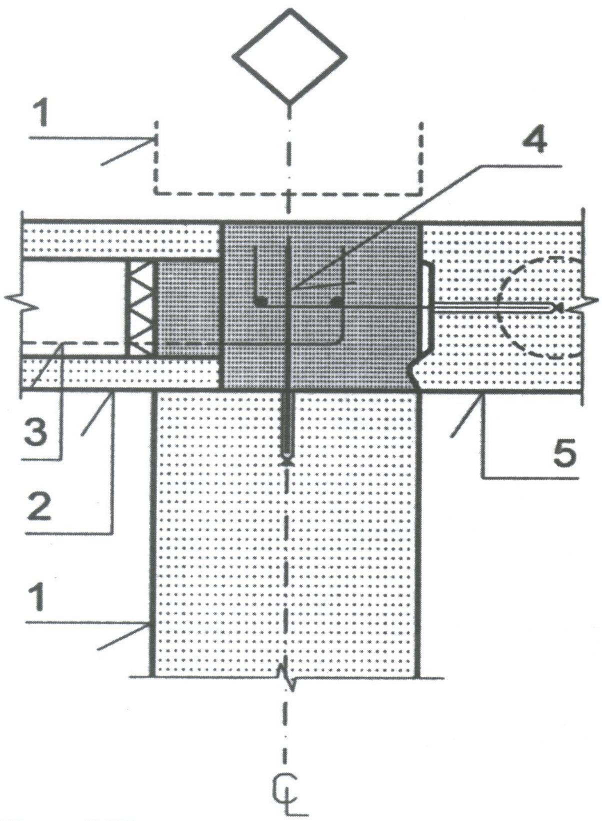


Figure 5.79

Figure 5.79 H.C.Slab-Load Bearing Wall
1. Load bearing wall
2. Hollow core slab, load bearing support
3. Slab joint rebar to be locked in wall joint
4. Dowel screwed into steel insert
5. Hollow core slab, non-load bearing support

Crossing reinforcement bars are locked together in the wall-slab joint. Wall in next storey (if any) is shown dotted.

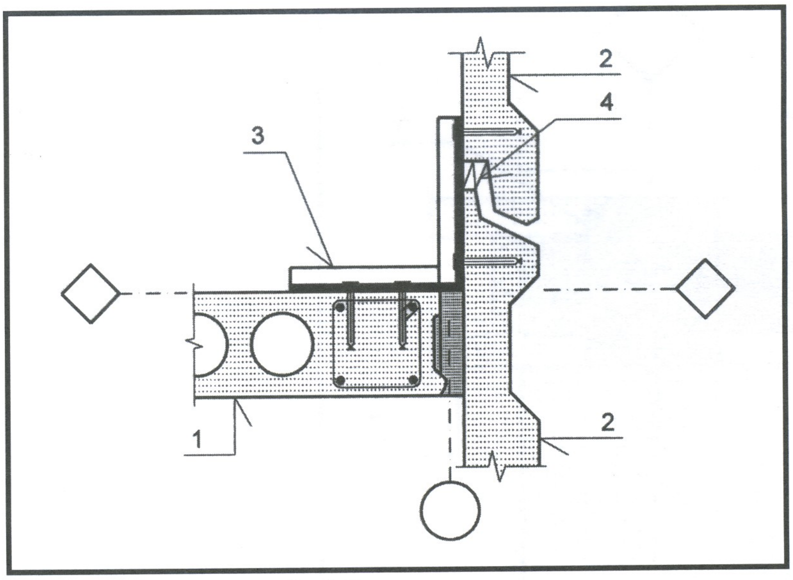


Figure 5.80 H.C.Slab-Cladding

1. Hollow core slab, non-load bearing edge
2. Cladding component
3. Steel angle bolted to hollow core slab and cladding
4. Joint material

The slab component has been reinforced along the edge to absorb vertical as well as horizontal forces from the cladding.

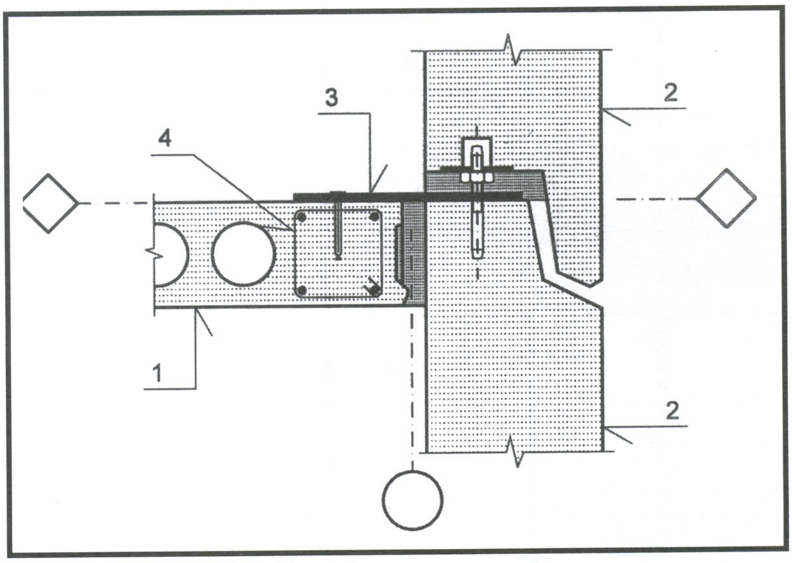


Figure 5.81 H.C.Slab-Facade

1. Hollow core slab, non-load bearing edge
2. Facade
3. Steel anchor plate
4. Edge beam reinforcement in hollow core slab

Facade weight is transmitted via the horizontal facade joint. The facade is anchored for horizontal forces using a steel plate bolted to the floor slab structure.

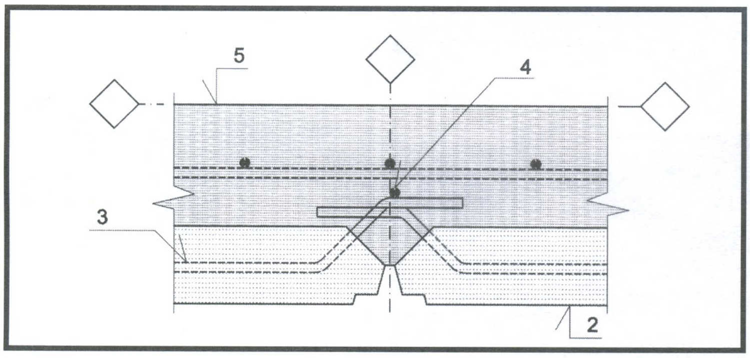


Figure 5.82 Plank-Plank

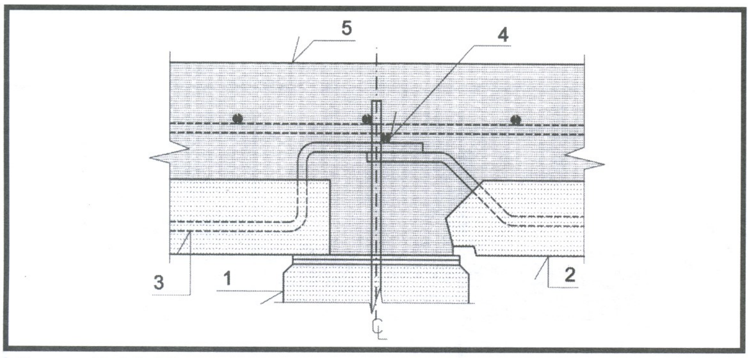


Figure 5.83 Plank-Plank

Figures 5.82 And 5.83

1. Supporting wall or beam
2. Plank
3. Reinforcement protruding from plank
4. Locked bar in joint
5. Structural topping

Figure 5.82 shows the connection along the non-load bearing edge while Figure 5.83 the connection between planks and supporting member. Protruding reinforcement bars from the planks are to be connected and locked in a joint cast in-situ together with the structural reinforced topping.

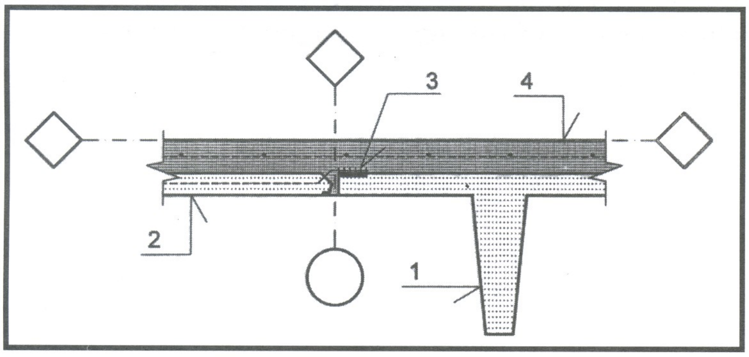


Figure 5.84 Plank-Double T

Figure 5.84

1. Double T-slab
2. Plank
3. Welded connection
4. Structural topping

Normally, steel plates are cast-in per 1.2 rib along the edge of double T's. Protruding rebars from planks could be welded to the plates and covered by the topping.

Figure 5.85

1. Supporting wall
2. Plank
3. Structural topping
4. Joint reinforcement locked to assembly bolt

Protruding rebars from planks are locked using joint reinforcement and assembly bolts from the wall.

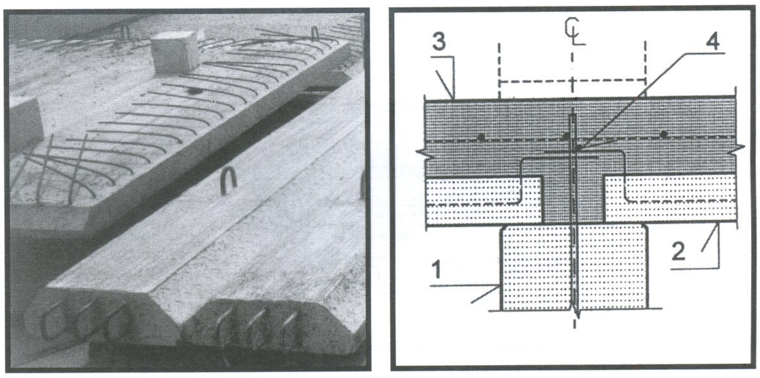


Figure 5.85 Plank-Load Bearing Wall

Figure 5.86

1. Structural topping on planks
2. Cladding component
3. Steel angle bolted to plank and cladding

As the cladding is lightweight, the steel angle must be designed to transmit vertical as well as horizontal forces.

Figure 5.87

1. Structural topping on planks
4. Facade component

Vertical forces are transmitted from facade to facade whereas horizontal loads go from assembly bolt via cast-in steel insert to reinforcement in the structural topping.

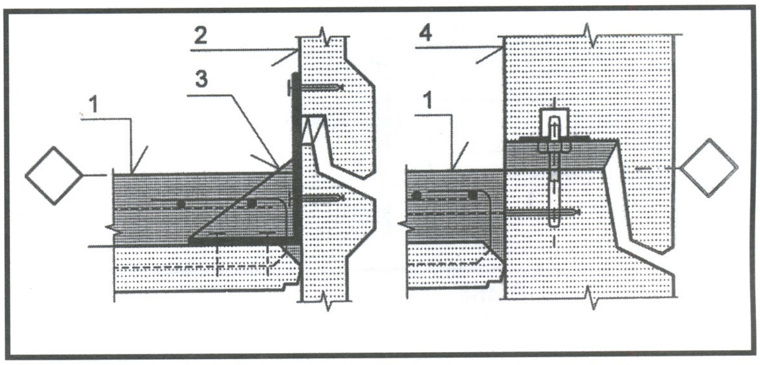


Figure 5.86 Plank-Cladding **Figure 5.87 Plank-Facade**

Figure 5.88

1. Double T-slab
2. Cast-in steel plate
3. Protruding stirrups
4. Connecting steel plate
5. Structural topping

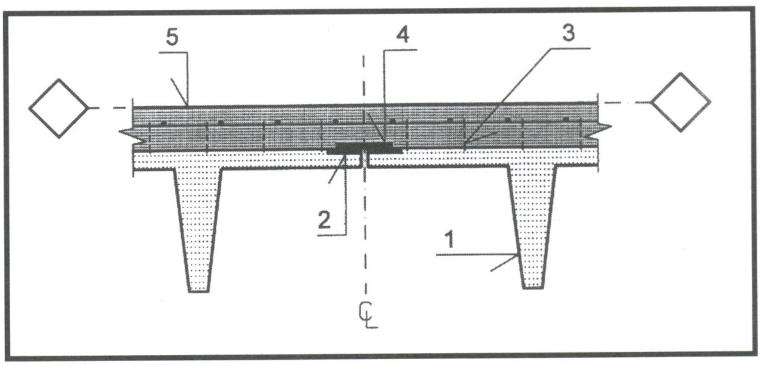


Figure 5.88 Double T

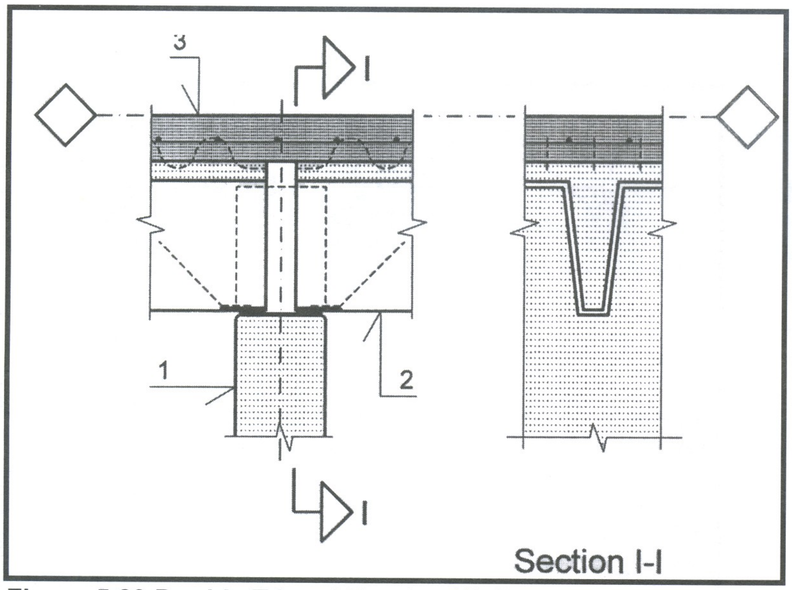


Figure 5.89 Double T-Load Bearing Wall

Figure 5.89

1. Supporting Wall
2. Double T, the rib
3. Structural topping

Welded connection between wall and ribs together with the structural topping locked to the plate create continuity in the floor slab structure.

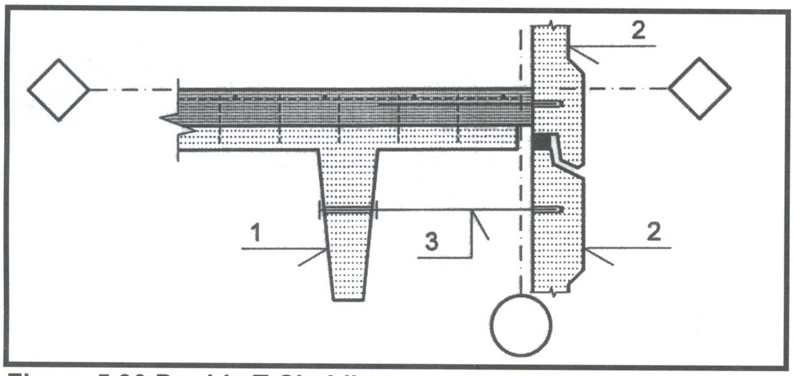


Figure 5.90 Double T-Cladding

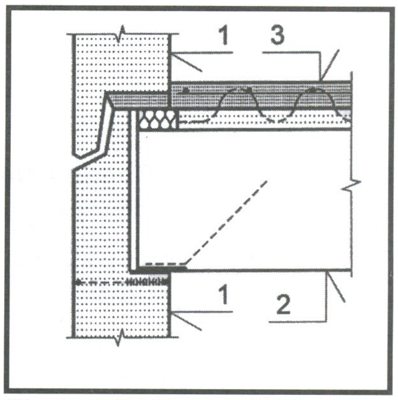


Figure 5.91 Double T-Facade

Figure 5.90

1. Double T, the rib
2. Cladding components
3. Connecting steel bar

The cladding components are placed on top of each other, horizontal forces are transmitted to the floor slab structure via steel anchors.

Figure 5.91

1. Facade components
2. Double T, the rib
3. Structural topping

The rib-facade joint is welded. A recess in the plate over the ribs allows the double T to rotate at the support.

Figure 5.92

1. Solid precast wall
2. Cast in-situ joint
3. Reinforced cast in-situ joint

Sketch A shows the standardised vertical joint between two wall components with castellated vertical edges. Sketch B shows a T-shaped wall connection which is normally reinforced like the L-shaped wall connection shown in Sketch C.

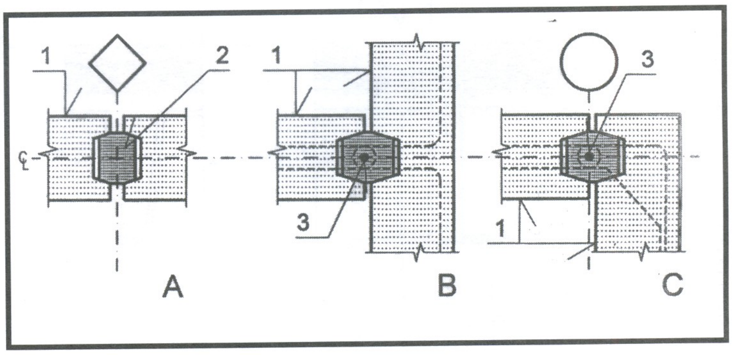


Figure 5.92 Load Bearing Wall-Loading Bearing Wall

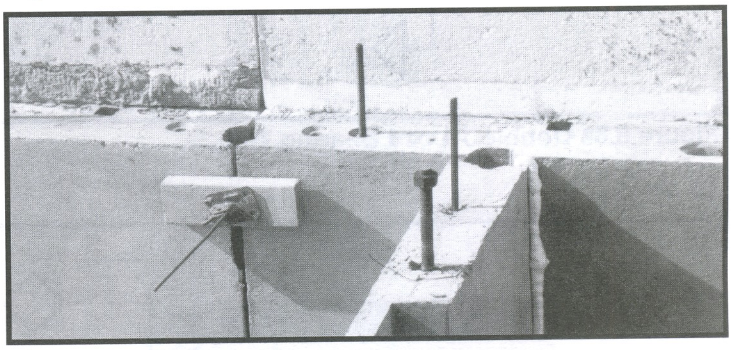


Figure 5.93 Load Bearing Wall-Load Bearing Wall

1. Standardised wall component
2. Grouting with cement mortar

The horizontal wall-to-wall joint is shown as a simple concrete joint with assembly bolts.

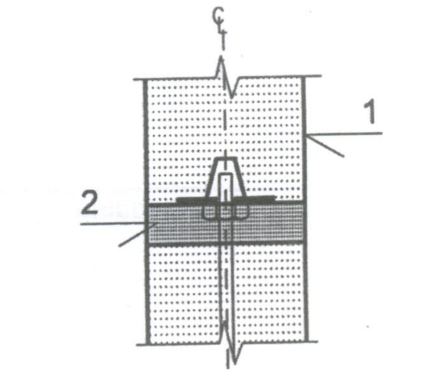


Figure 5.93

Figure 5.94 Load Bearing Wall-Load Bearing Wall

1. Standardised wall components
2. Hollow core slab
3. Plank
4. Structural topping

The wall-to-wall joint is often connected to slab structures as well. Reinforcement bars from adjoining members are locked using the structural topping.

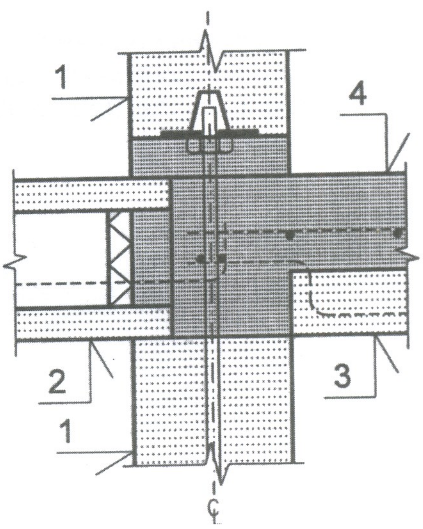


Figure 5.94

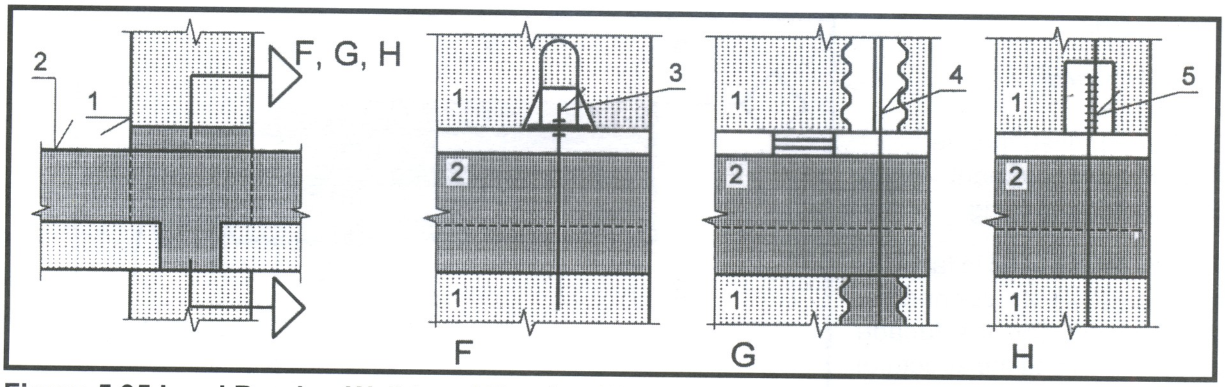
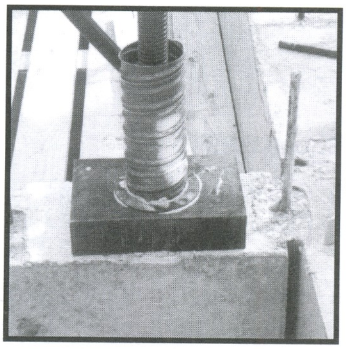


Figure 5.95 Load Bearing Wall-Load Bearing Wall, Tensile Joints

1. Load bearing and bracing walls
2. Concrete joint between walls and floor slabs
3. Bolted connection
4. Cast-in reinforcement bars
5. Welded connection



In Sketch F, the assembly bolt forms the tensile connection to the next wall. Sketch G shows reinforcement bars placed-on-site in corrugated pipes. Protruding rebars are welded together in Sketch H allowing tensile forces to be transmitted from wall to wall.

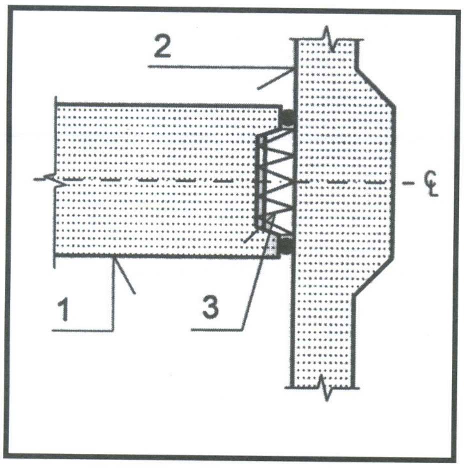


Figure 5.96 Load Bearing Wall-Cladding

Figure 5.96

1. Wall component
2. Cladding
3. Non-load bearing joint

As cladding components are normally fastened to floor slabs, the joint must be designed to resist sound and fire.

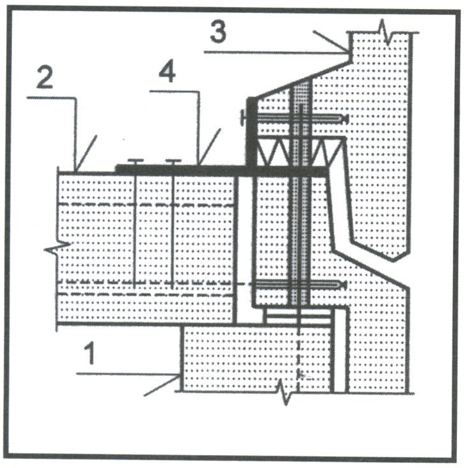


Figure 5.97 Load Bearing Wall-Cladding

Figure 5.97

1. Facade wall
2. Floor slab structure
3. Cladding
4. Steel angle to fix the cladding

Vertical forces are absorbed in a locked dowel-hole connection at the top of the cladding. Horizontal forces are transmitted to the floor slab via a steel anchor.

Figure 5.98

1. Facade wall
2. Plank
3. Standardised facade
4. Joint reinforcement
5. Structural topping

The assembly bolts in facades and walls act as connecting devices between the facade components and the structural topping.

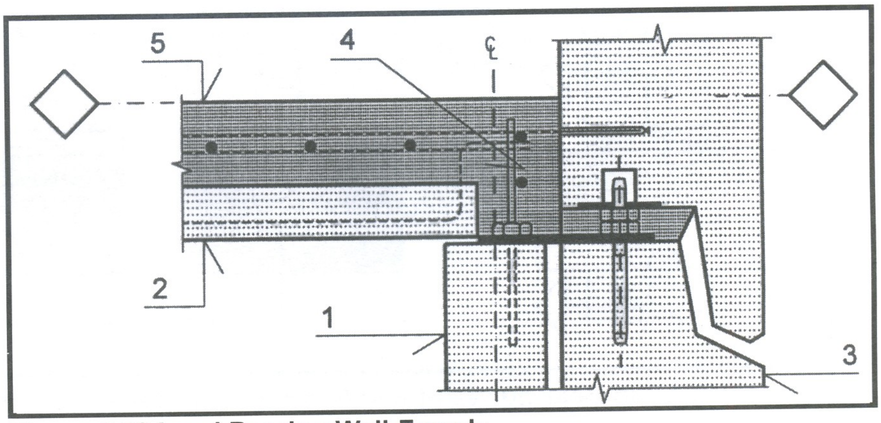


Figure 5.98 Load Bearing Wall-Facade

Figure 5.99

1. Cladding components
2. Fixing points, if any
3. Soft airtight joint
4. Partly open cladding joint
5. Soft airtight joint

When designing the joints between cladding components, it is important to know prevailing climatic conditions and movements in the cladding.

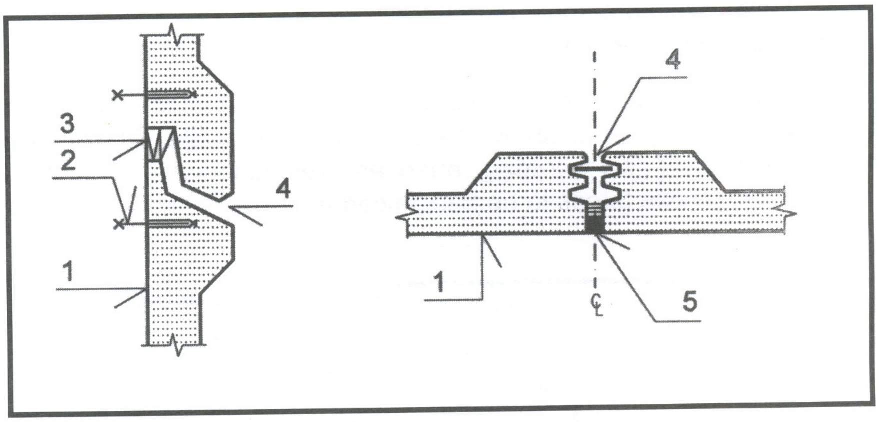


Figure 5.99 Cladding-Cladding

Figure 5.100

1. Facade component
2. Fixing point, if any
3. Grouting with cement mortar
4. Partly open facade joint
5. Reinforced castellated concrete joint

Normally, the facade-joint is designed according to the two-step principle: Airtightness inside and watertightness outside. Figure 5.100 shows a concrete joint inside and an open joint or a neoprene strip as an outside protection against the rain.

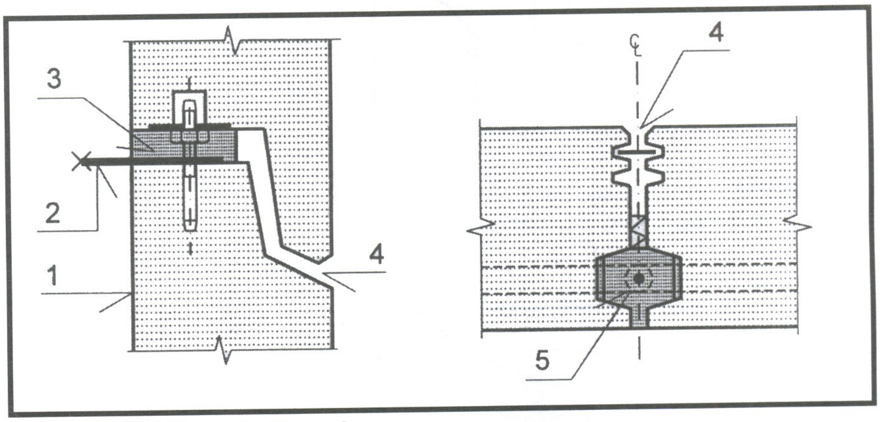


Figure 5.100 Facade-Facade

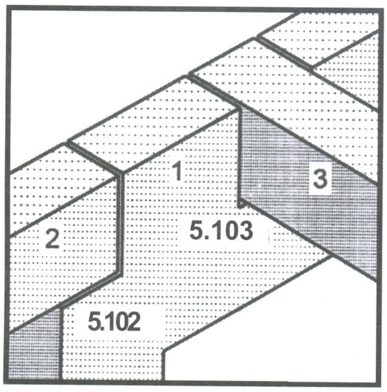


Figure 5.101 Beam-Frame Connections

Figure 5.101

1. Frame
2. Beam placed in frame plane of symmetry
3. Beam placed perpendicular to frame

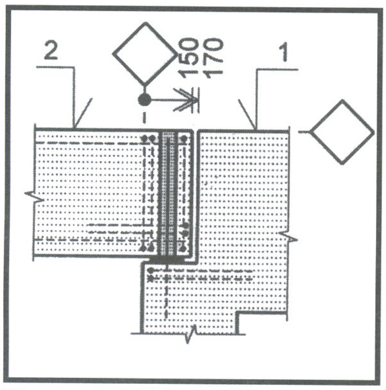


Figure 5.102 Beam-Frame

Figure 5.102

1. Frame
2. Beam

A normal dowel-hole solution is shown with reinforcing stirrups near the narrow support area.

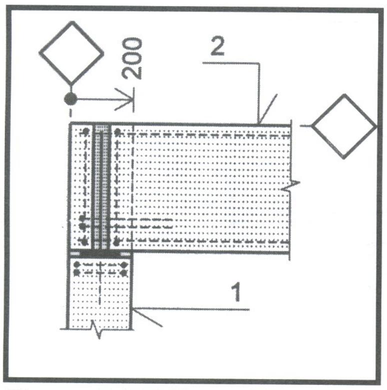


Figure 5.103 Beam-Frame

Figure 5.103

1. Frame
2. Beam

To get the components flushed, the whole width of the frame is used as supporting area. A dowel-hole connection is chosen.

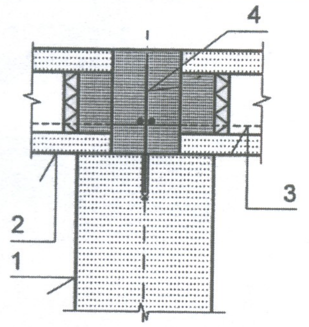


Figure 5.104

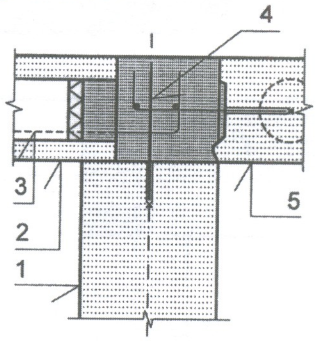


Figure 5.105

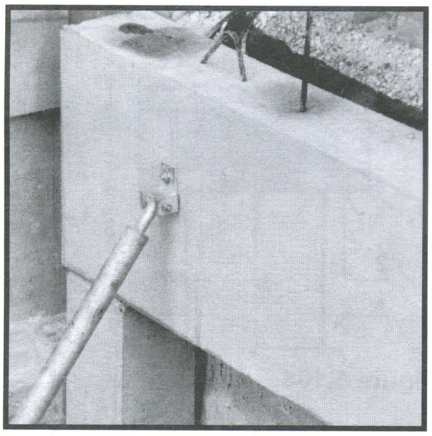
Figure 5.104 H.C.Slab-Frame

1. Frame
2. Hollow core slab
3. Reinforcement in slab joint
4. Dowel screwed into insert and grouted

Figure 5.105 H.C.Slab-Frame

1. Frame
2. Hollow core slab
3. Reinforcement in slab joint
4. Grouted joint with locking dowel and bars
5. HCS, non-load bearing edge

The two vertical sections in Figure 5.104 and Figure 5.105 show how continuity from slab to slab is obtained using joint reinforcement or protrusion of components.



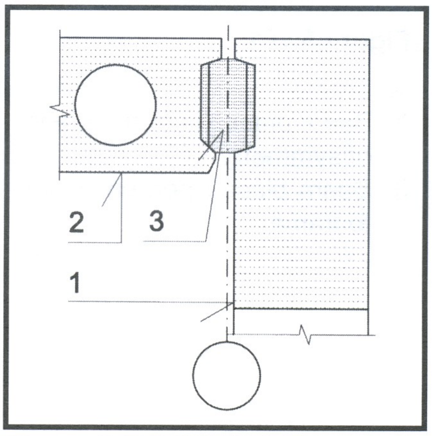


Figure 5.106 H.C.Slab-Frame

1. Frame
2. Hollow core slab
3. Cast in-situ castellated joint

A rough joint is able to absorb horizontal as well as vertical shear.

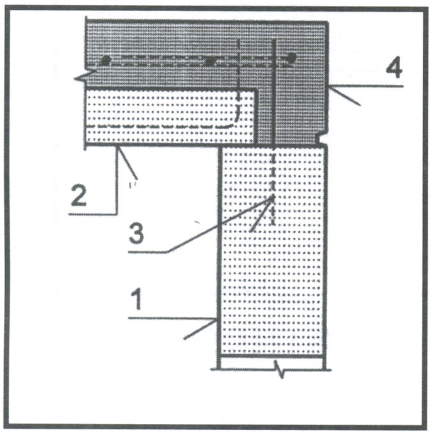


Figure 5.107 Plank-Frame

1. Frame
2. Plank
3. Protruding rebar
4. Casting on site

The connection is able to support the plank and absorb horizontal shear as well.

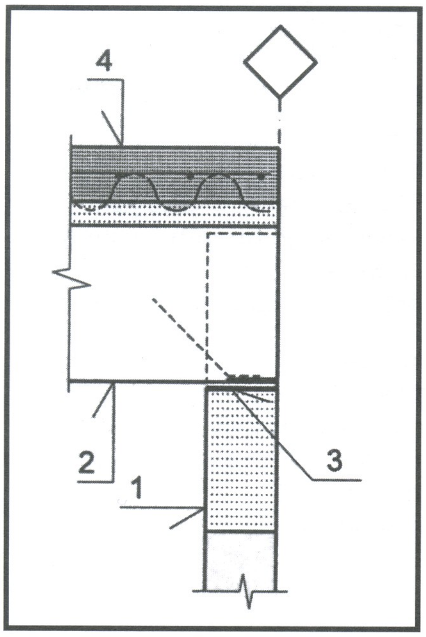


Figure 5.108 Double T-Frame

1. Frame
2. Double T-slab
3. Welded connection
4. Structural topping

Cast-in steel plates in frame and in ribs make it possible to execute a welded supporting connection.

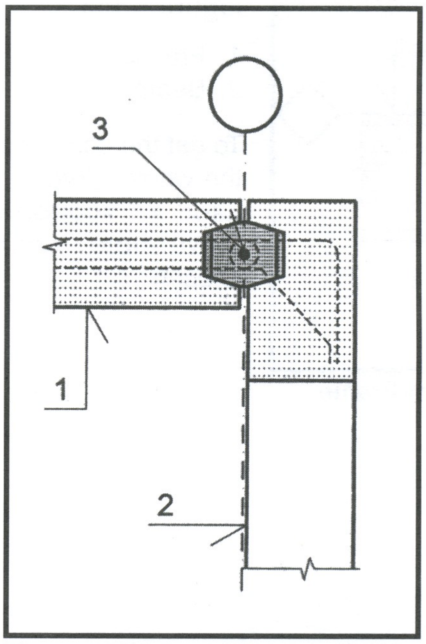


Figure 5.109 Load Bearing Wall-Frame

1. Standardised wall component
2. Frame, beam and column
3. Reinforced castellated joint

This horizontal section shows the use of a normal rough vertical joint in both the wall and frame column.

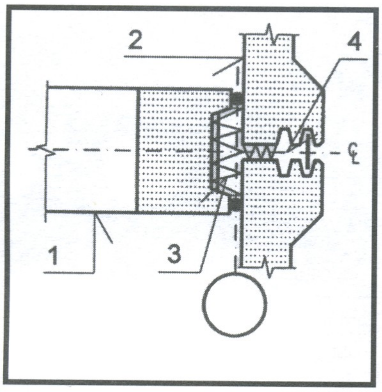
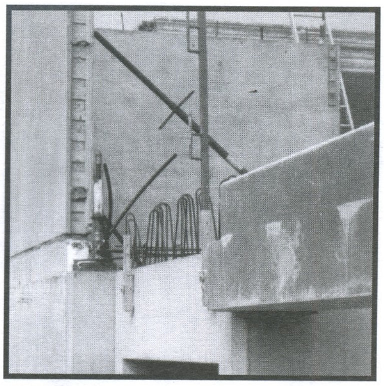


Figure 5.110 Cladding-Frame

Figure 5.110

1. Frame, beam and column
2. Cladding component
3. Soft joint material
4. Ventilated space/neoprene strip

The connection is considered only as a climatic joint. All forces are transmitted to the floor slab structure.



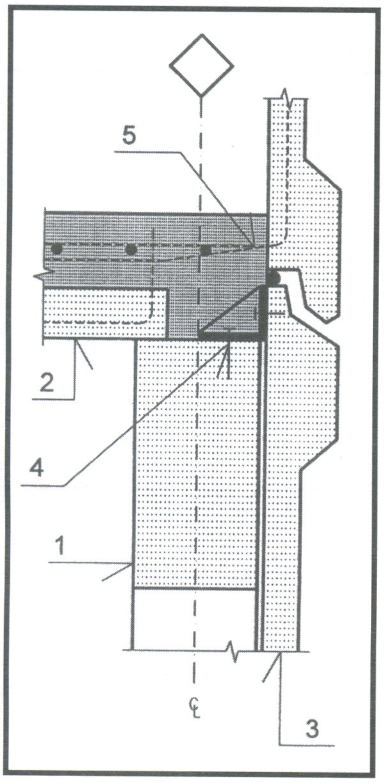


Figure 5.111 Cladding-Frame

Figure 5.111

1. Frame component
2. Plank
3. Cladding
4. Steel angle
5. Rebar protruding from cladding

The cladding is fastened at the top using a steel angle device and, at the bottom using rebars to be cast into the structural topping.

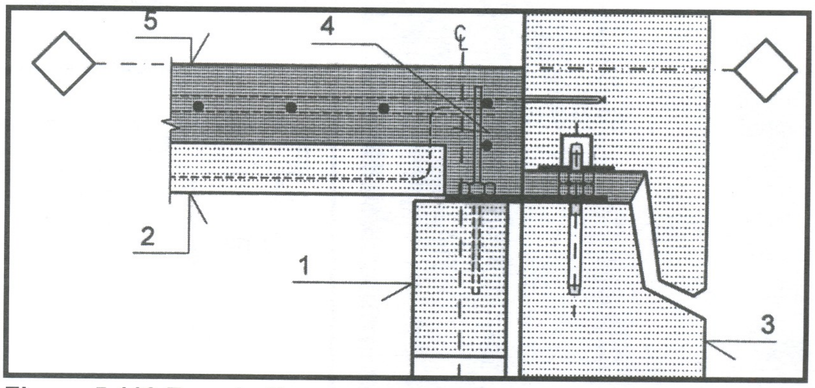
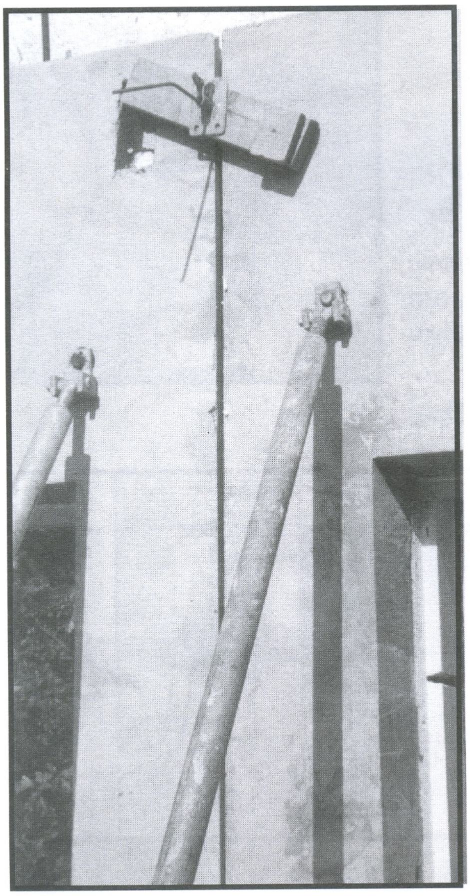


Figure 5.112 Facade-Frame

Figure 5.112

1. Frame component
2. Plank
3. Facade
4. Cast in-situ joint
5. Structural screed

Self weight from facade components is transmitted direct from facade to facade. Horizontal forces go to the floor slab structure using assembly bolt, steel plate and dowel.



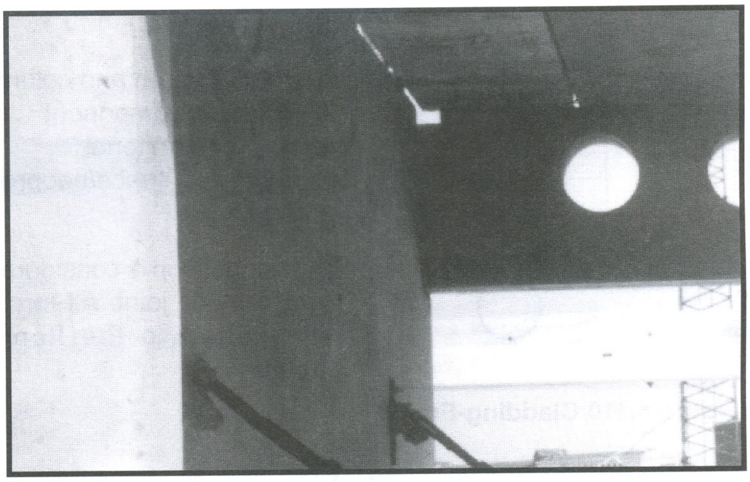


Figure 5.113 and 5.114 Frame-Frame

1. T-shaped frame
2. V-shaped frame

A two-dimensional load-bearing and bracing frame system can be created by using T- and V-shaped frame components. The T-shaped frames are placed longitudinally while the V-shaped frames are placed in the transverse direction.

Figure 5.113 shows the reinforced and rough joint between T-components while Figure 5.114 features the narrow bearing support between the two frame types. These bearings are reinforced by cast-in steel plates.

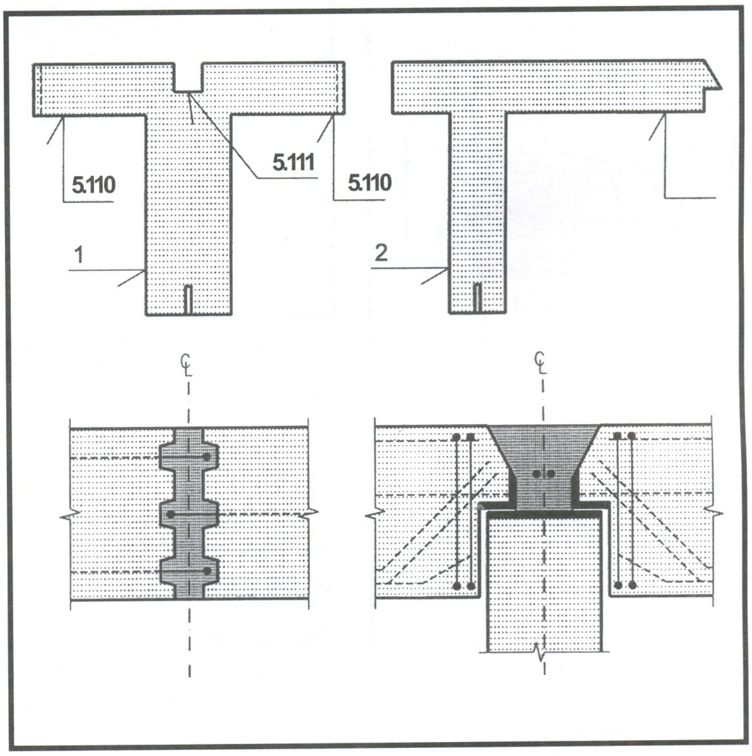
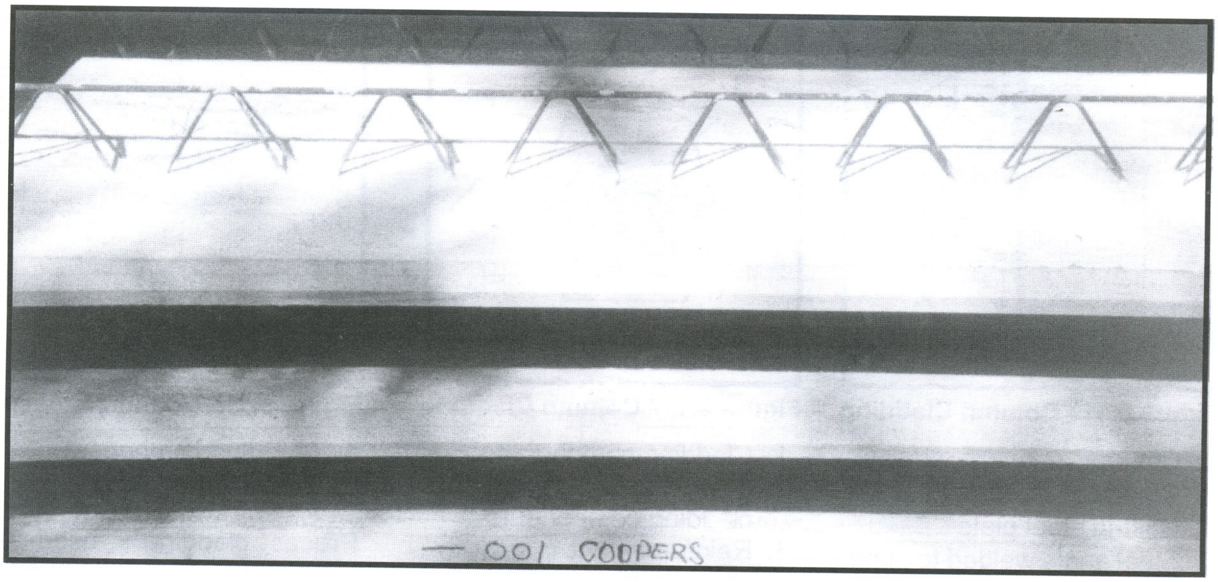


Figure 5.113 **Figure 5.114**



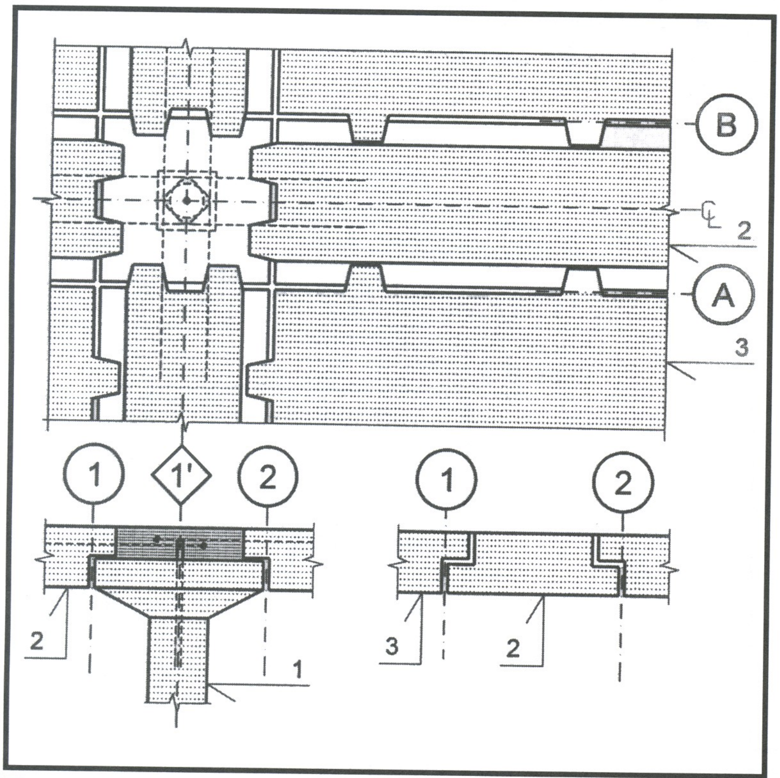
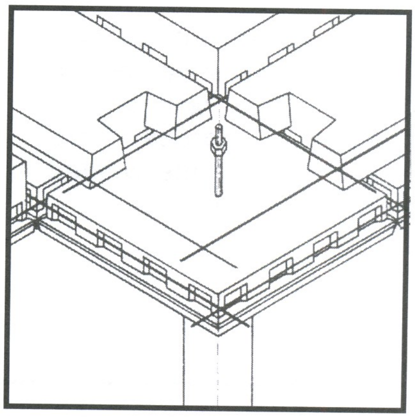


Figure 5.115 Column-Plank



1. Column with column head
2. Narrow planks or slabs
3. Planks or floor slabs

Precast building systems without beams may create problems due to very small support areas between slabs and columns.

Figure 5.115 provides a solution to this: A column head supports the narrow slabs, which are, in turn, supported by the main floor slabs.

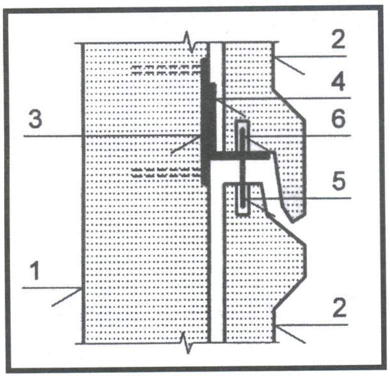


Figure 5.116 Column Cladding

1. Column
2. Cladding
3. Cast-in steel plate
4. Steel angle welded to plate
5. Dowel-hole connection
6. Dowel as assembly bolt

Vertical movement can take place at the top of the cladding components. Vertical and horizontal forces are transmitted via the welded steel connection.

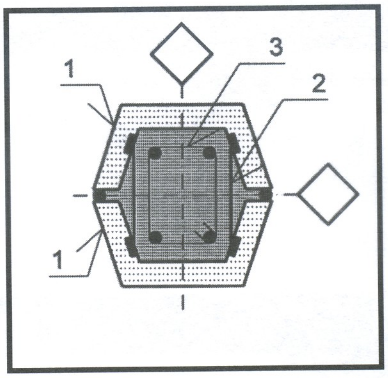


Figure 5.117 Column Cladding

1. Cladding components
2. Steel bar welded to the cladding components
3. Reinforcement in cast in-situ column

Precast cladding components are used as a finished surface and a form panel for cast in-situ structures.

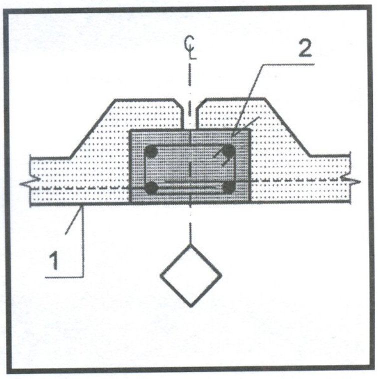


Figure 5.118 Column Facade

1. Cladding component
2. Cast in-situ column

Precast cladding is used as shuttering in a skeleton main structure.

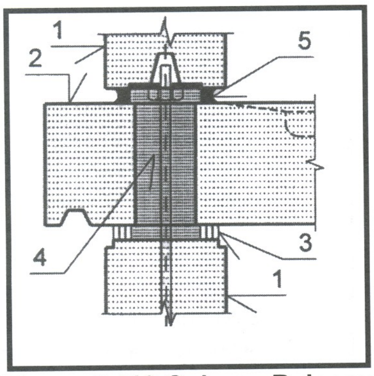


Figure 5.119 Column Balcony Slab

1. Column components
2. Balcony slab
3. Soft packing
4. Joint cast in-situ
5. Mastic joint

The designer must ensure a sound transfer of the vertical load and check on temperature movements in the balcony structure.

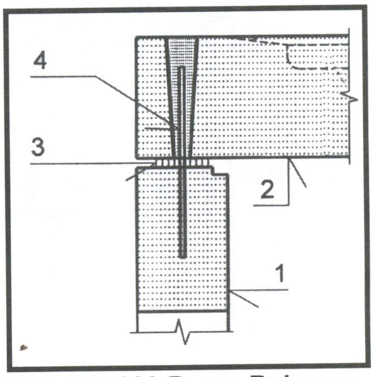


Figure 5.120 Beam-Balcony Slab

1. Beam or frame
2. Balcony slab
3. Soft bearing, for instance, neoprene
4. Dowel-hole connection

Temperature movements between beam and slab have to be considered.

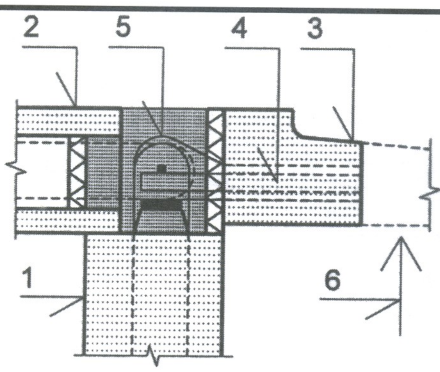


Figure 5.121 H.C.Slab-Balcony Slab

1. Beam, frame or wall
2. Hollow core slab
3. Balcony slab
4. Embedded steel section
5. Locking stirrups protruding from slabs
6. Vertical support

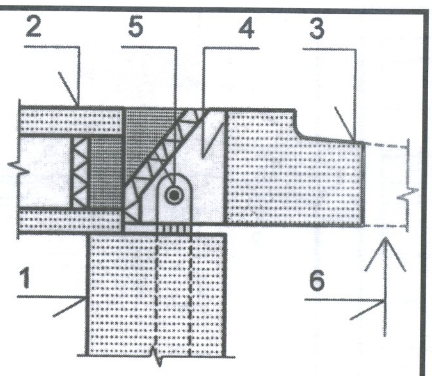


Figure 5.122 H.C.Slab-Balcony Slab

1. Beam, frame or wall
2. Hollow core slab
3. Balcony slab
4. Support cam or nib
5. Dowel in nib plus locking stirrup
6. Vertical support

Figures 5.121 and 5.122 have been designed to eliminate coldbridges and to allow temperature movements to take place.

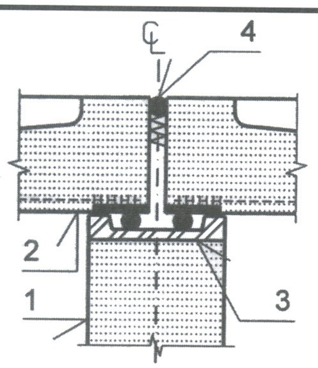


Figure 5.123 Load Bearing Wall-Balcony Slab

1. Wall
2. Balcony slab
3. Cast-in steel plate
4. Soft joint material

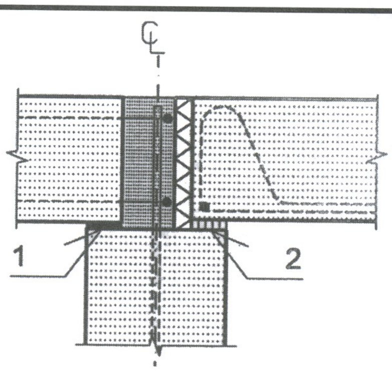


Figure 5.124 Load Bearing Wall-Balcony Slab

1. Balcony slab with fixed support
2. Balcony slab with movable support

Figure 5.123 shows two movable supports in a wall-balcony connection, whereas Figure 5.124 shows one fixed and one movable joint.

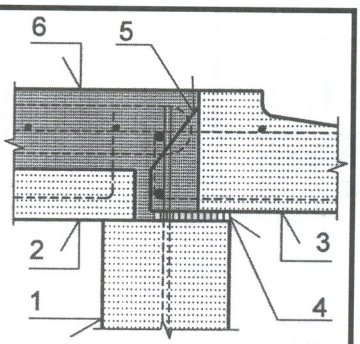


Figure 5.125 Plank-Balcony Slab

1. Beam, frame or wall
2. Plank
3. Balcony slab with nibs
4. Bearing, for instance, neoprene
5. Nib with protruding reinforcement
6. Structural topping

The balcony slab is considered as fixed-ended in Figure 5.125

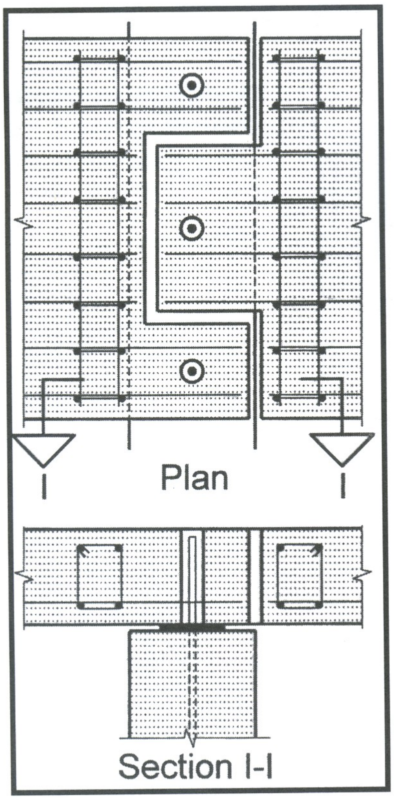


Figure 5.126 Load Bearing Wall- Balcony Slab

The assembly in Figure 5.126 shows how two balcony slabs can share the support area on top of a wall, each having the full width.

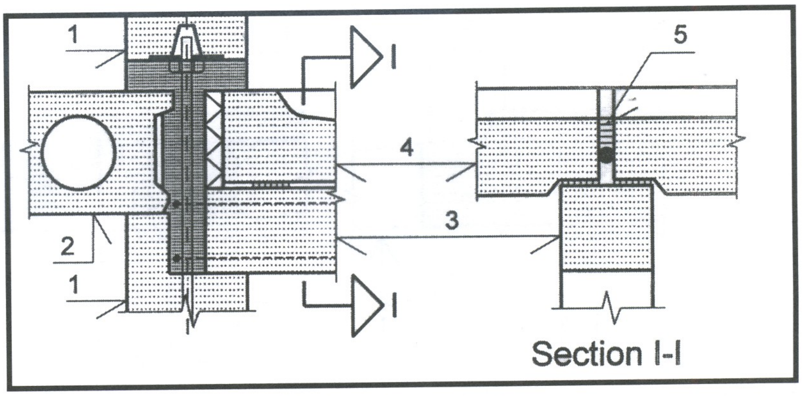


Figure 5.127 Balcony Slab-Balcony Slab

1. Facade wall
2. Hollow core slab
3. Balcony frame
4. Balcony slab

The balcony slabs are simply supported on the frame which is locked to the assembly bolt in the facade.

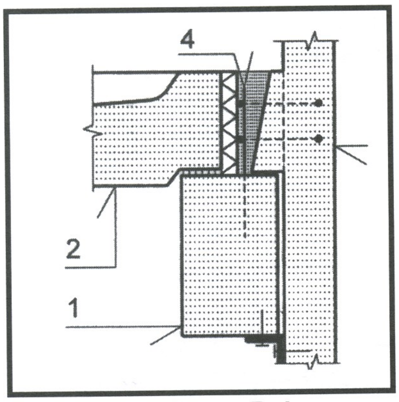
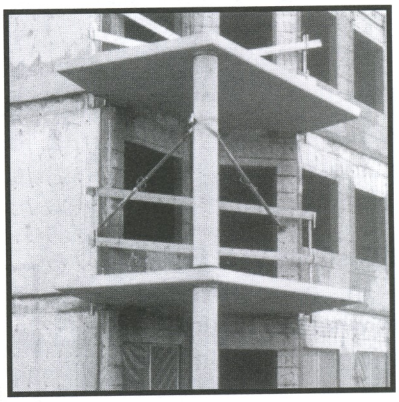
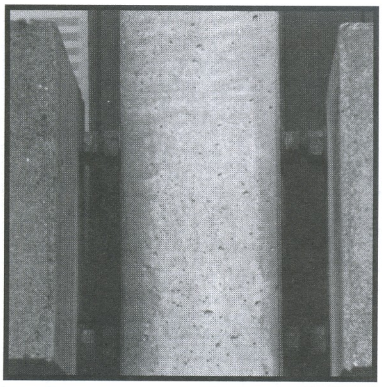


Figure 5.128 Beam-Balcony Parapet



1. Balcony beam
2. Balcony slab
3. Balcony parapet
4. Stirrup-dowel connection

The parapet is fastened to the top and bottom of the beam component.



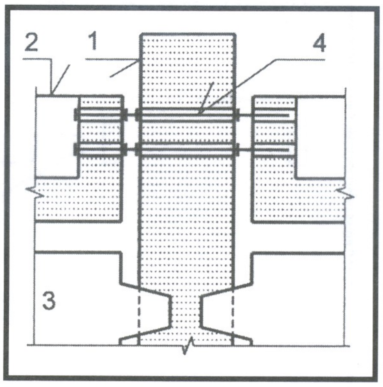


Figure 5.129 Load Bearing Wall Balcony Parapet

1. Load bearing wall
2. Balcony parapet
3. Balcony slab
4. Assembly bolts

The assembly bolts with nuts allow temperature movements from the right hand parapet to take place, but do not allow movements from the parapet to the left.

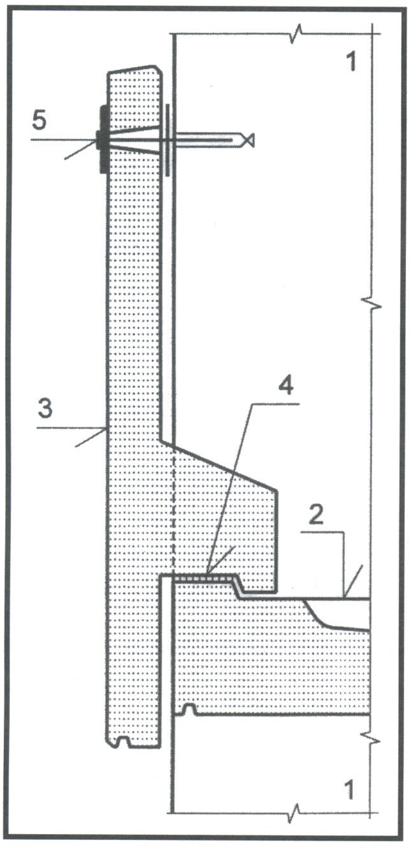
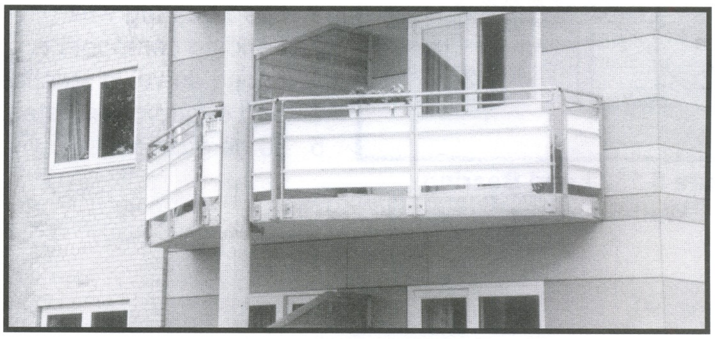


Figure 5.130 Balcony Slab-Balcony Parapet

1. Load bearing wall
2. Balcony slab
3. Balcony parapet
4. Neoprene bearing
5. Bolt into cast-in steel insert

Temperature movements in the parapet have to be considered before designing the parapet joint.



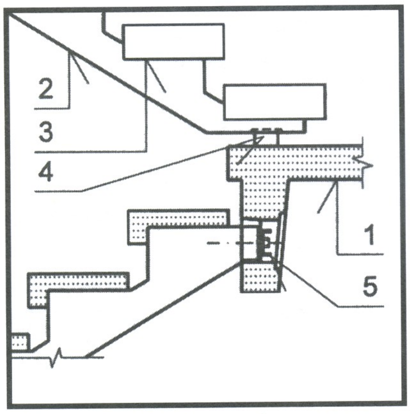
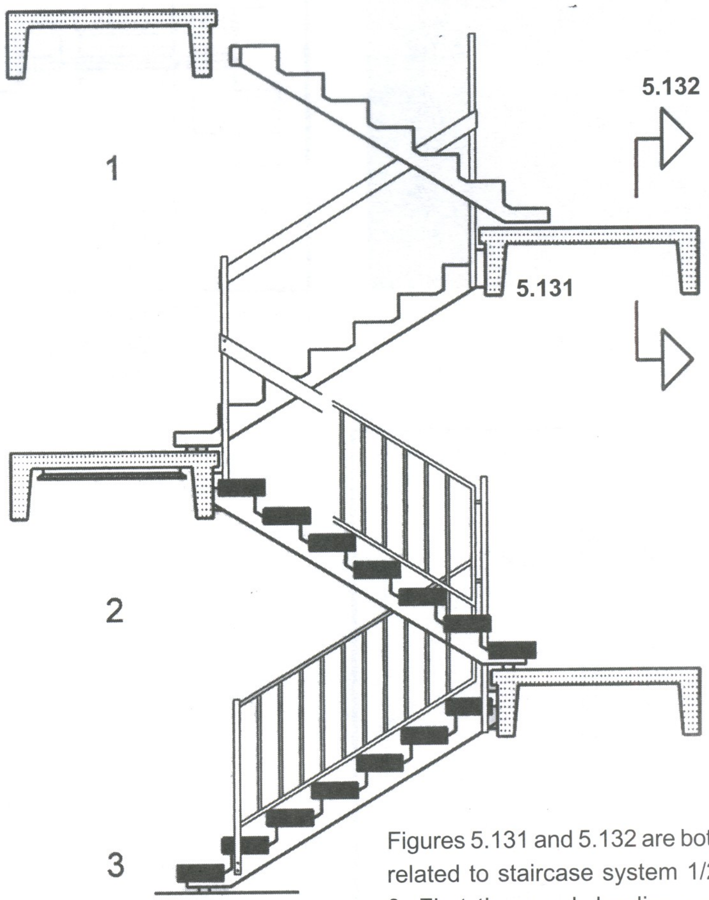


Figure 5.131 Beam-Staircase

1. Landing component
2. Flight component
3. Loose steps
4. Supporting steel studs
5. Bolted connection between flight and landing



Figures 5.131 and 5.132 are both related to staircase system 1/2/3. First the rough landing and flight components are placed; later when the building is completed the final step and railing are installed.

Staircase System 1/2/3

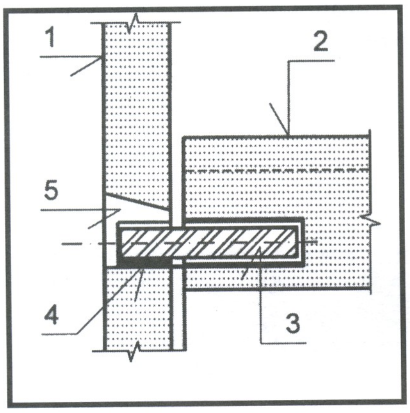
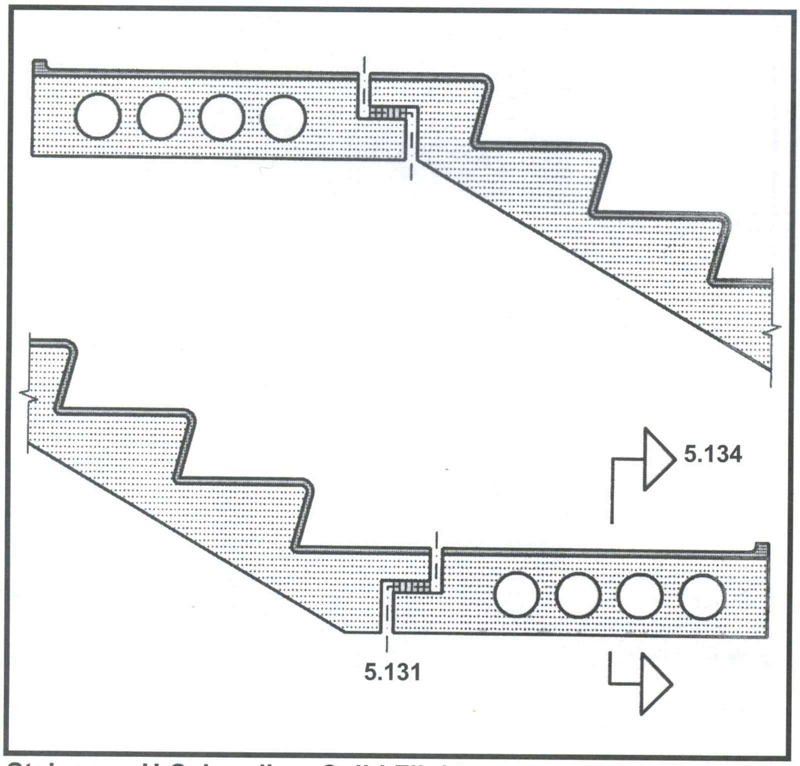


Figure 5.132 Load Bearing Wall-Staircase

1. Load bearing wall
2. Landing component
3. Loose dowel in steel section socket
4. Soft support, for instance, neoprene
5. To be grouted



Staircase: H.C. Landing, Solid Flights

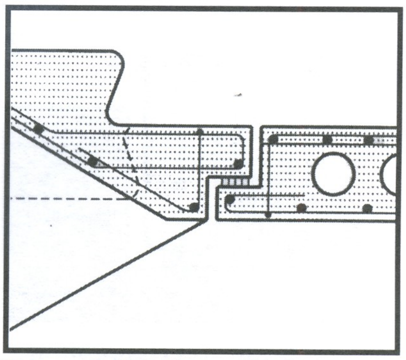


Figure 5.133 Beam-Stair

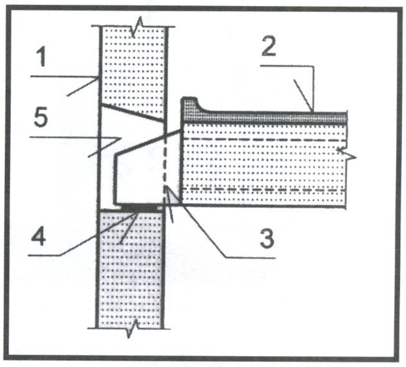


Figure 5.134 Load Bearing Wall-Staircase

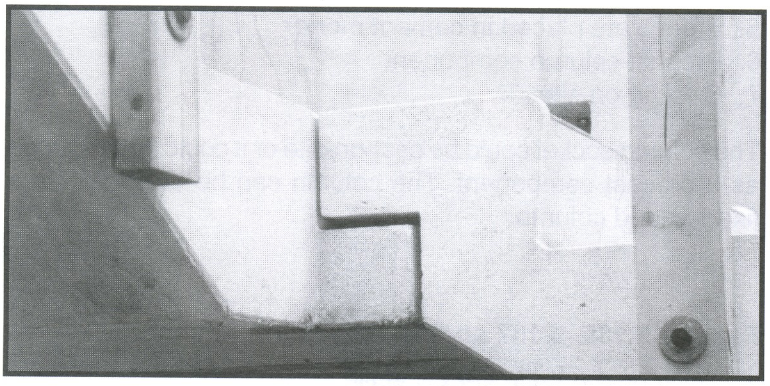


Figure 5.133

Half-beam joints are used between landings and flights.

Figure 5.134

1. Load bearing wall
2. Landing component
3. Support nib
4. Soft material, for instance, neoprene
5. To be grouted

Figures 5.133 and 5.134 are both related to the staircase system shown here which uses a hollow core slab as landing and a normal solid plate as flight component.

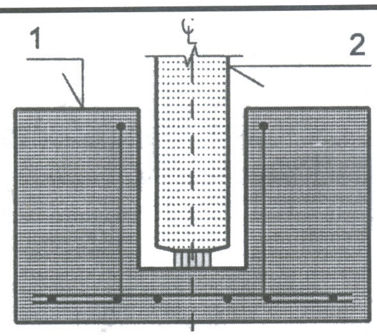


Figure 5.136 1st Generation

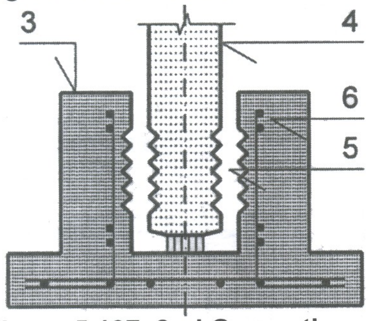


Figure 5.137 2nd Generation

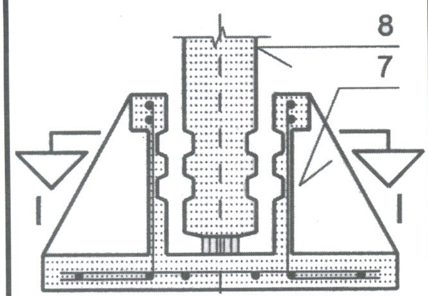
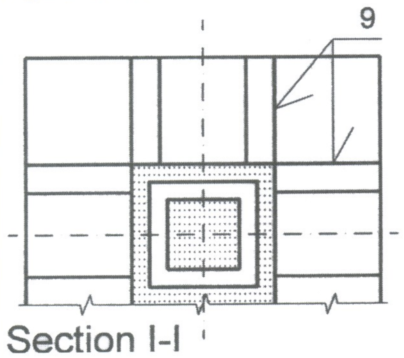


Figure 5.138 3rd Generation



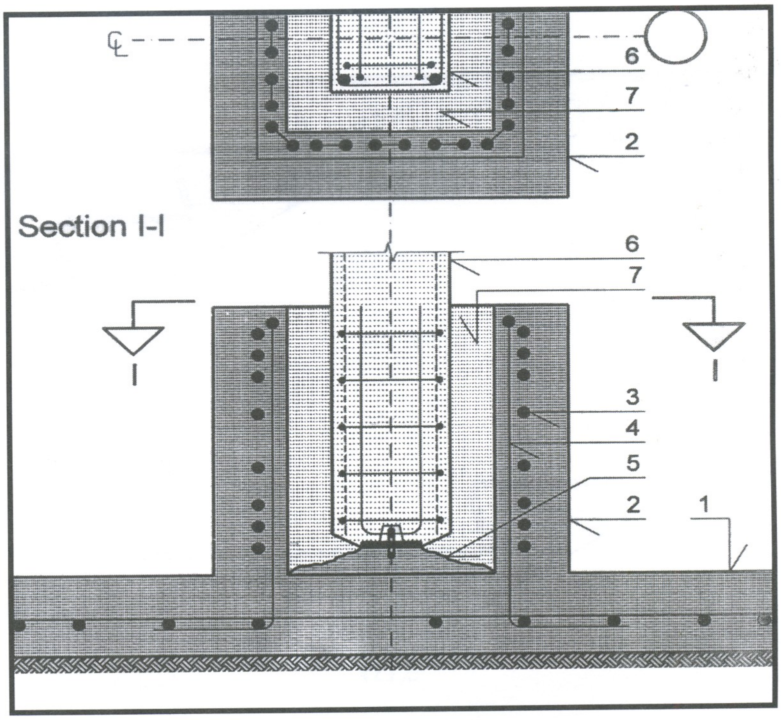


Figure 5.135 Column-Column Socket

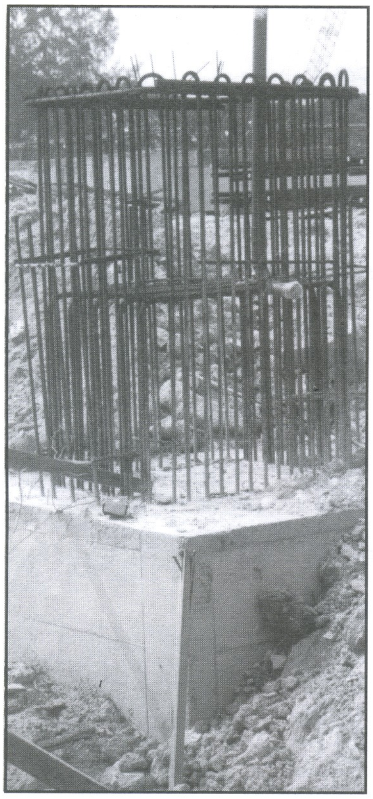
1. Bottom plate
2. Socket wall
3. Ring reinforcement
4. Vertical stirrups
5. Steel plate placed in cement mortar
6. Precast column component
7. Casting on site

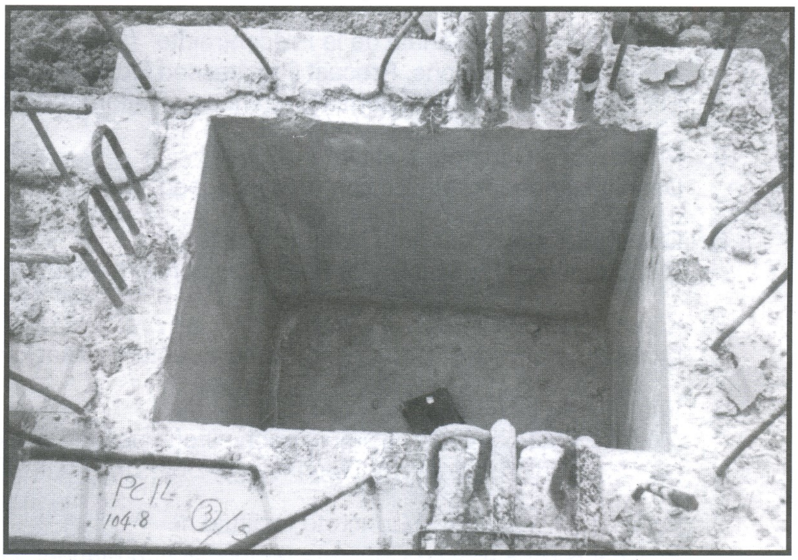
The column socket could be cast-on-site or it could be produced as a precast component. The column can be designed as a fixed-ended column.

Figures 5.136, 5.137 and 5.138 Column Sockets

1. Thick cast-on-site socket walls
2. Precast column
3. Thin cast-on site socket wall with rough surfaces
4. Precast column with rough surface
5. Cast-in-situ rough joint
6. Ring reinforcement and stirrups
7. Precast column socket with very thin walls and fins
8. Precast column with castellated surface

Figures 5.136, 5.137 and 5.138 show the development of the column socket from very solid concrete boxes cast in-situ to more light precast structures with thin walls supported by fins.

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