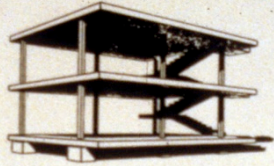




Precast and Prestressed Concrete

Arch 173: Building Construction 2
Winter 2022



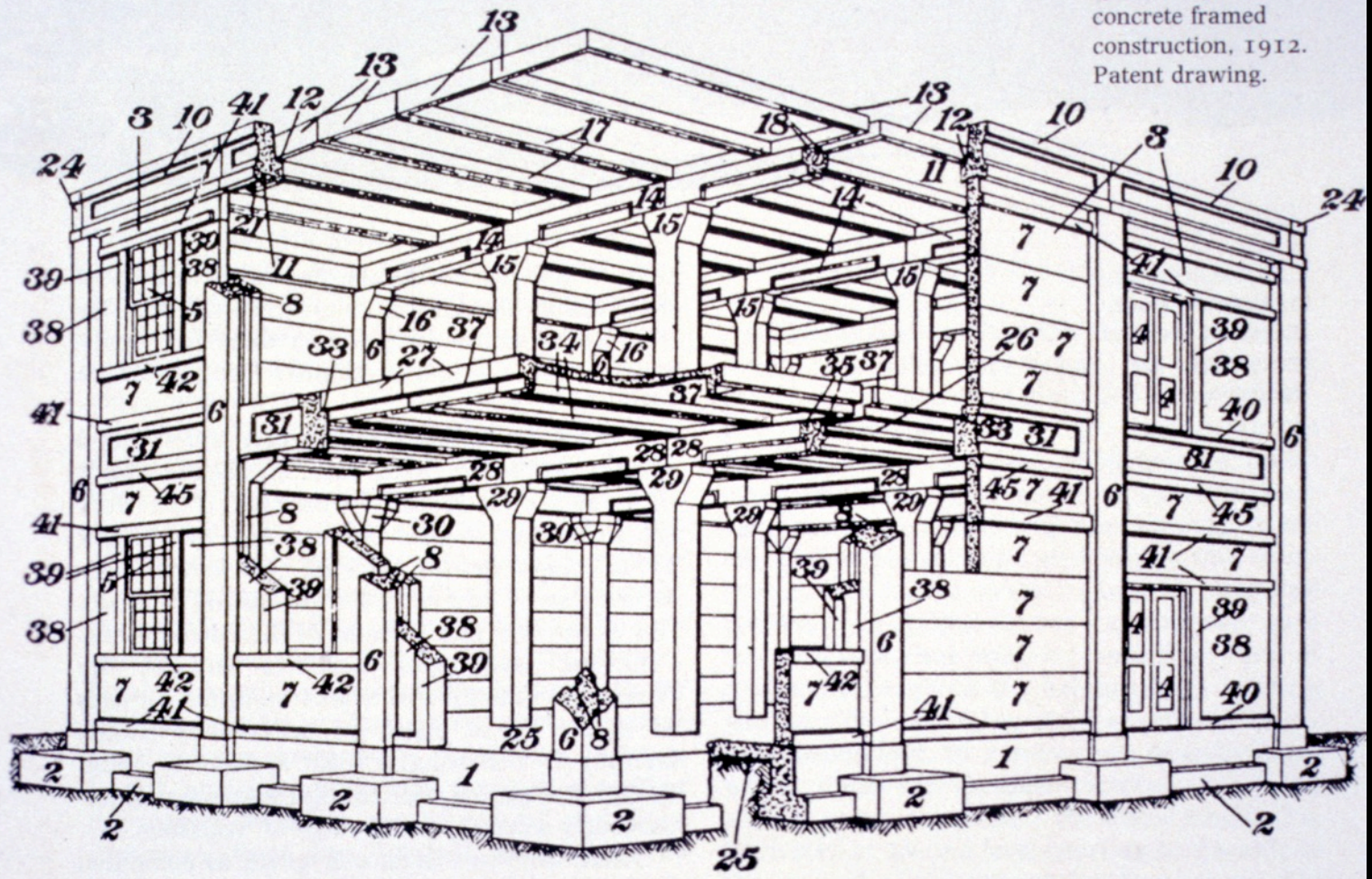
“In the next twenty years, big industry will have co-ordinated its standardized materials . . . technical achievements will have carried . . . methods of rational construction far beyond anything we are acquainted with.”

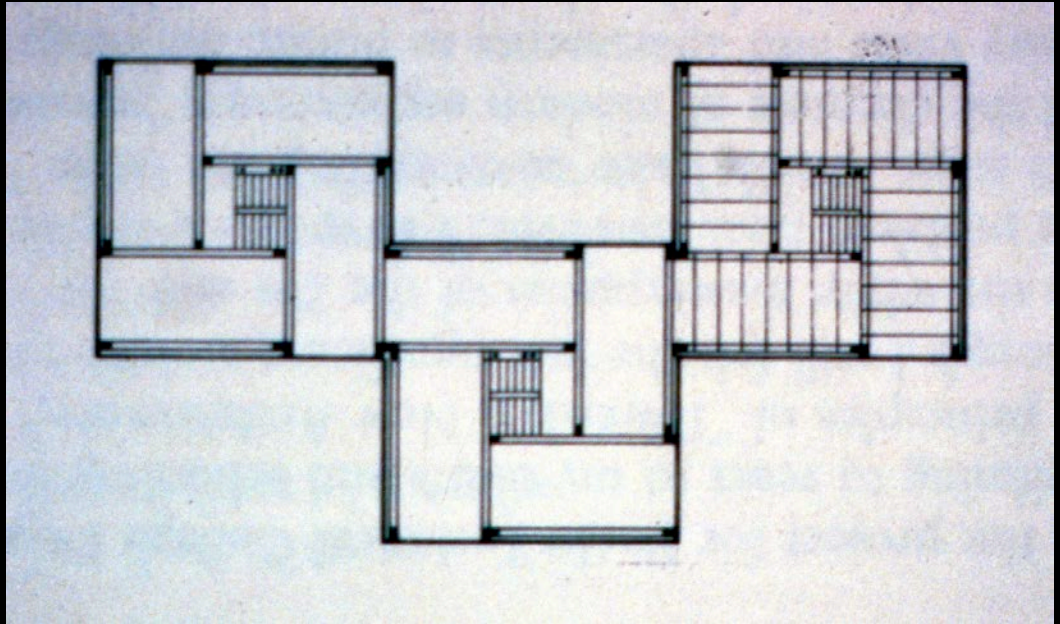
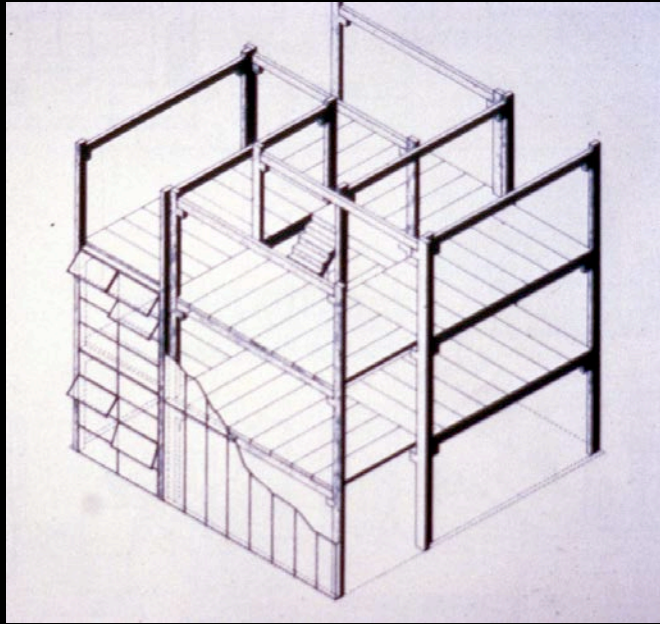
—Le Corbusier, 1914

Precast concrete came about in the early 1900s as a response to industrialization.

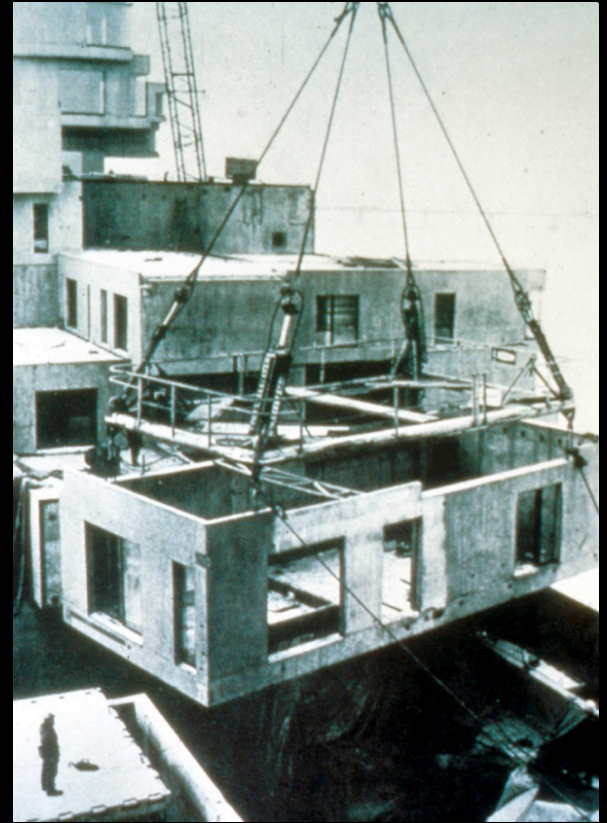
How could you use concrete but without on site wet processes?

4.10 Conzelman
system of precast-
concrete framed
construction, 1912.
Patent drawing.





Prototype for a precast concrete house system by James Stirling



Expo 1967, Montreal, Housing
Moshe Safdie

Precast Concrete Construction Basics

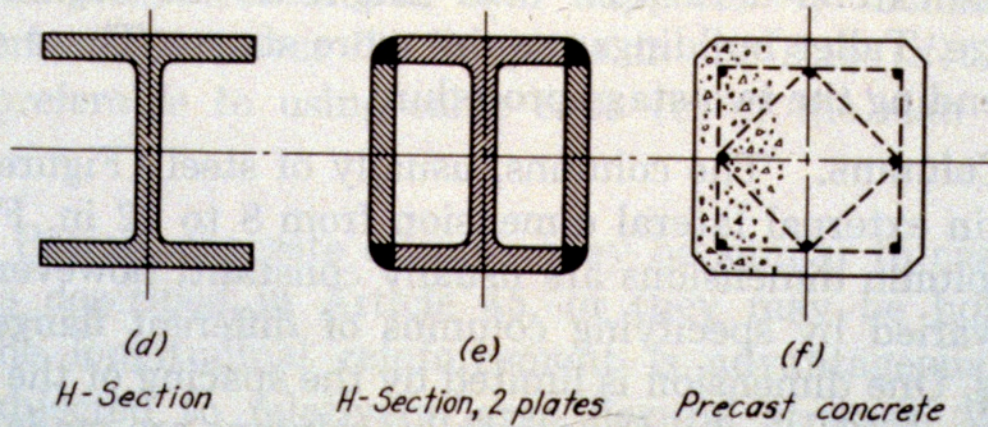
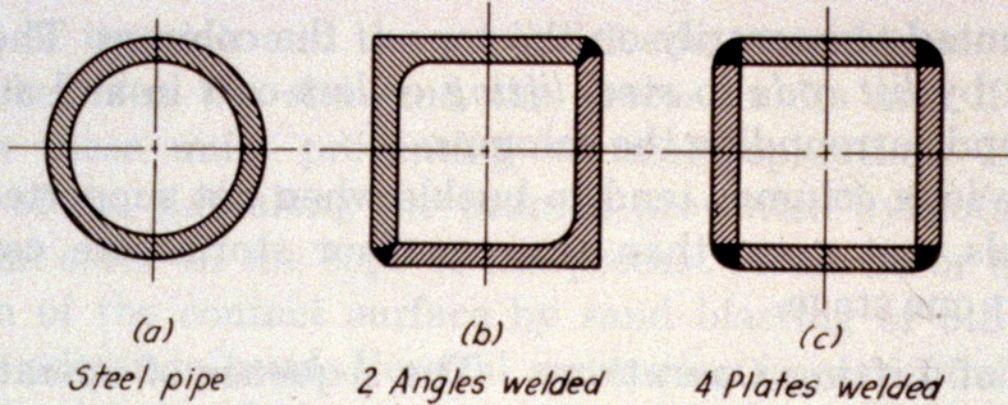
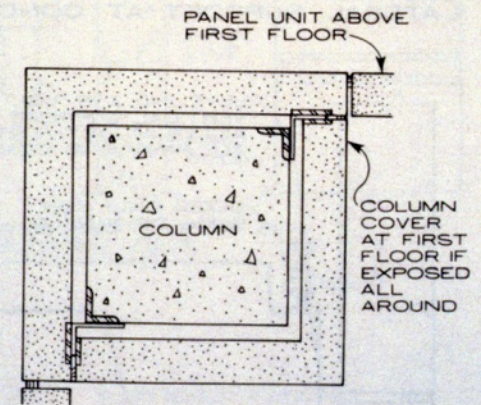
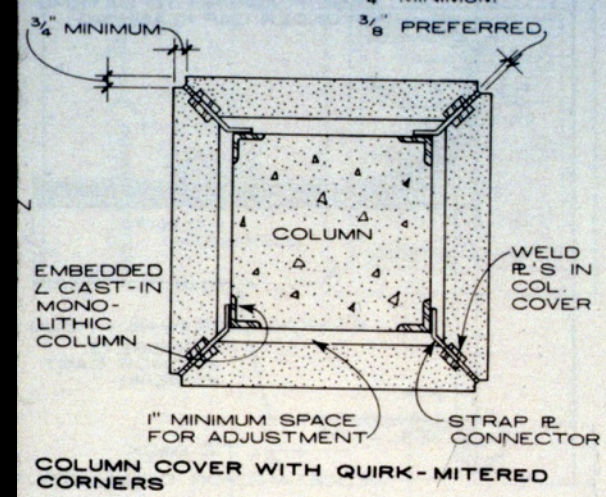
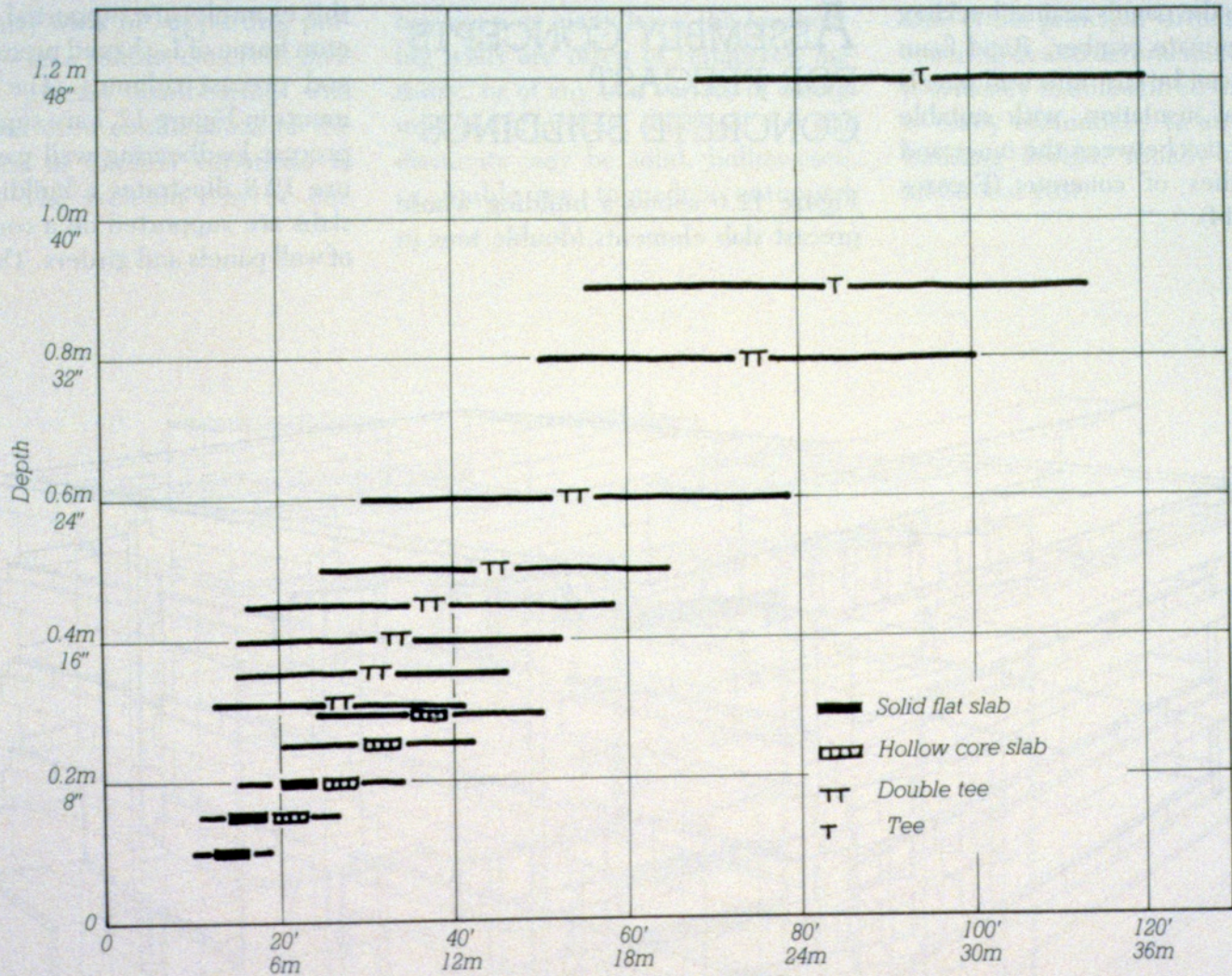


FIGURE 8.9 Types of columns.



ADVANTAGE IS COLUMN COVER CAN BE COMBINED WITH FASCIA PANELS WITH OPEN FIRST FLOOR AREA. ANCHORAGE SIMILAR TO QUIRK-MITERED CORNER



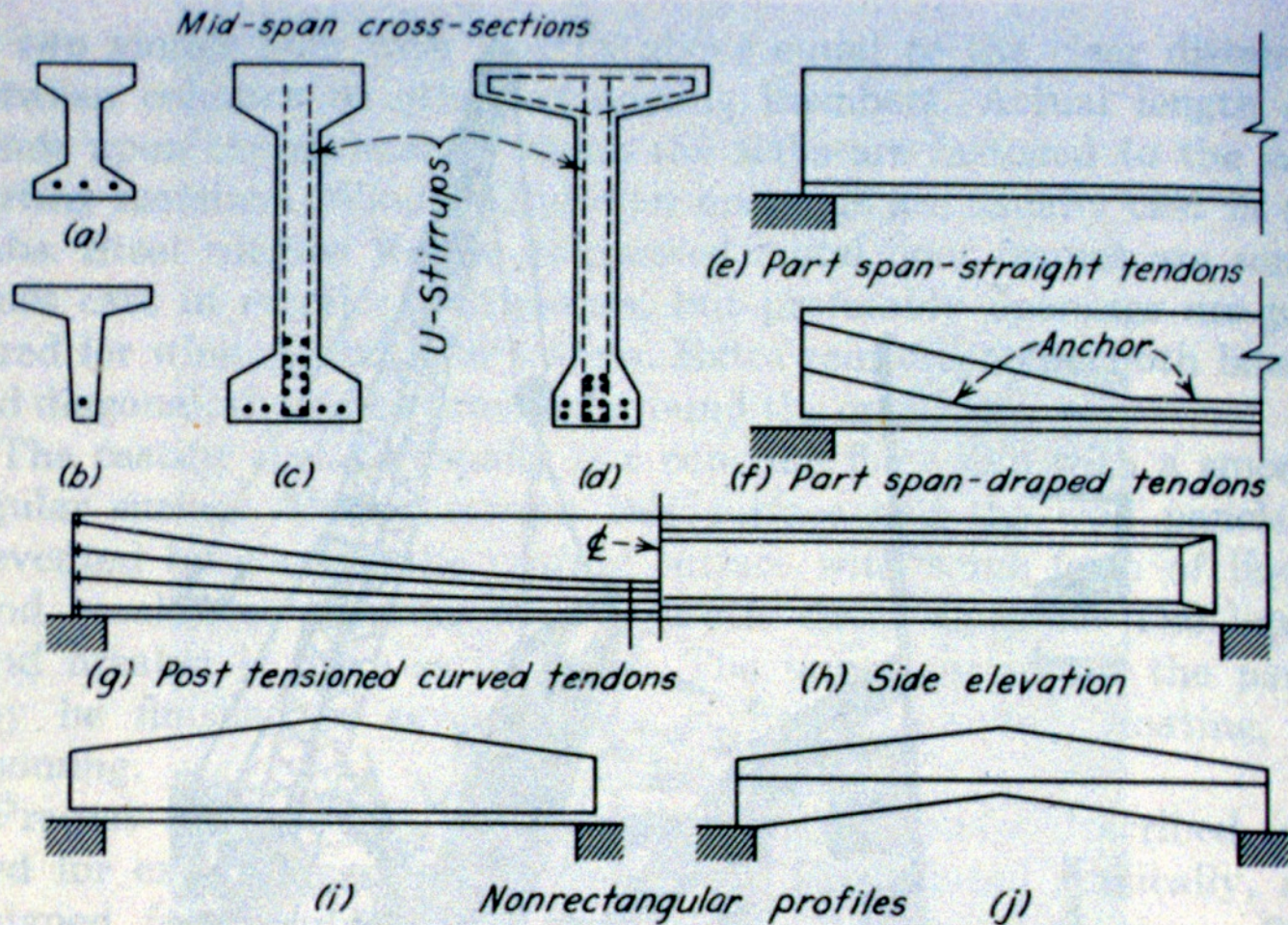
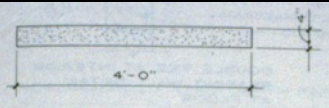
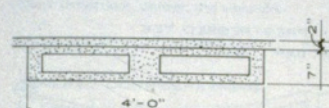


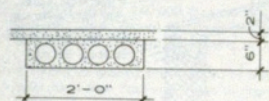
FIGURE 8.6 Precast and prestressed joints, beams, and girders.



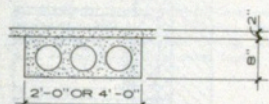
TYPE "A"



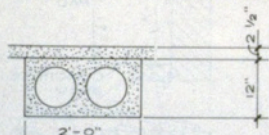
TYPE "B" WITHOUT TOPPING
TYPE "C" WITH 2" TOPPING



TYPE "D" WITHOUT TOPPING
TYPE "E" WITH 2" TOPPING



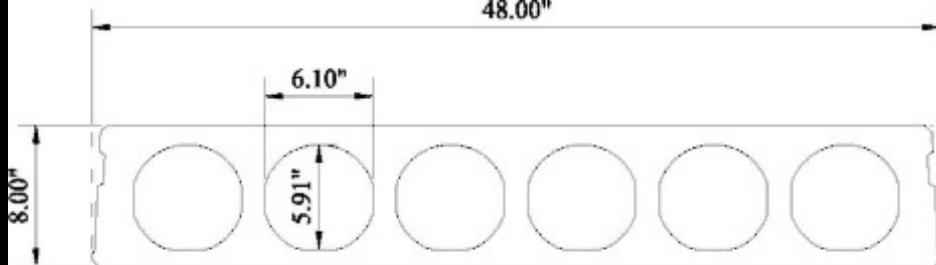
TYPE "F" - WITHOUT TOPPING
TYPE "G" - WITH 2" TOPPING



TYPE "H" - WITHOUT TOPPING
TYPE "J" - WITH 2 1/2" TOPPING

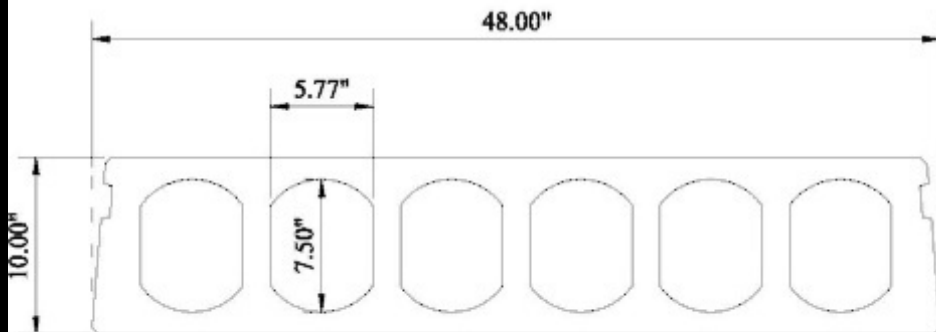


TYPE "K" - WITHOUT TOPPING
TYPE "L" - WITH 2" TOPPING



**8" x 48" PRESTRESSED CONCRETE
HOLLOW CORE SLAB**

| PROPERTIES | | | |
|----------------------|----------------------|----------------------|-----------|
| WITHOUT TOPPING | | | |
| A in ² | y _b in | I in ⁴ | wt pcf |
| 196 | 3.97 | 1580 | 51 |



**10" x 48" PRESTRESSED CONCRETE
HOLLOW CORE SLAB**

| PROPERTIES | | | |
|----------------------|----------------------|----------------------|-----------|
| WITHOUT TOPPING | | | |
| A in ² | y _b in | I in ⁴ | wt pcf |
| 249 | 5.00 | 3108 | 65 |

Tee spanning systems

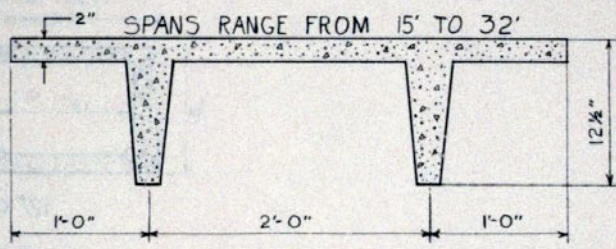
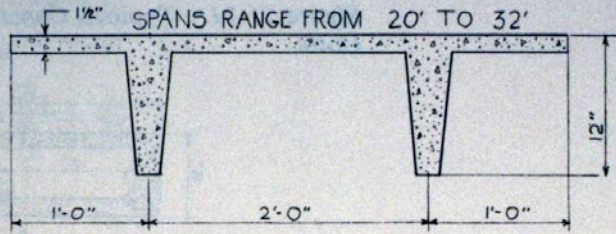
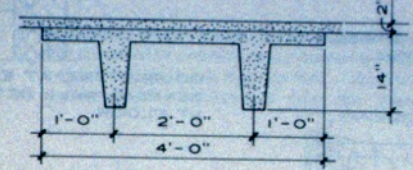
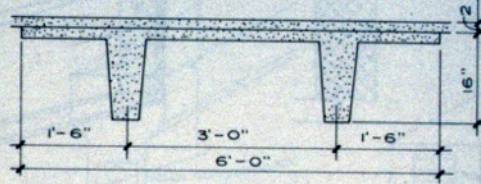


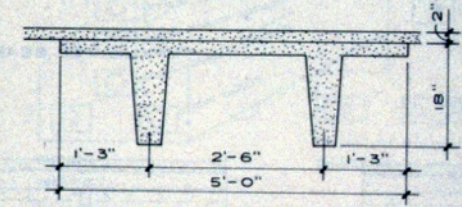
Figure 11-9. Double-Tee Floor and Roof Units



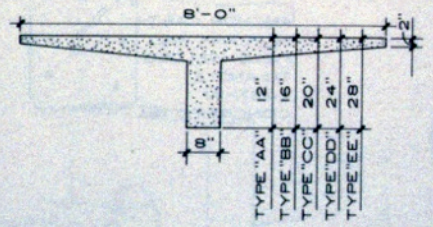
TYPE "M" - WITHOUT TOPPING
TYPE "N" - WITH 2" TOPPING



TYPE "Q" - WITHOUT TOPPING
TYPE "R" - WITH 2" TOPPING



TYPE "S" - WITHOUT TOPPING
TYPE "T" - WITH 2" TOPPING



TYPE "AA" THRU "EE" - AS NOTED

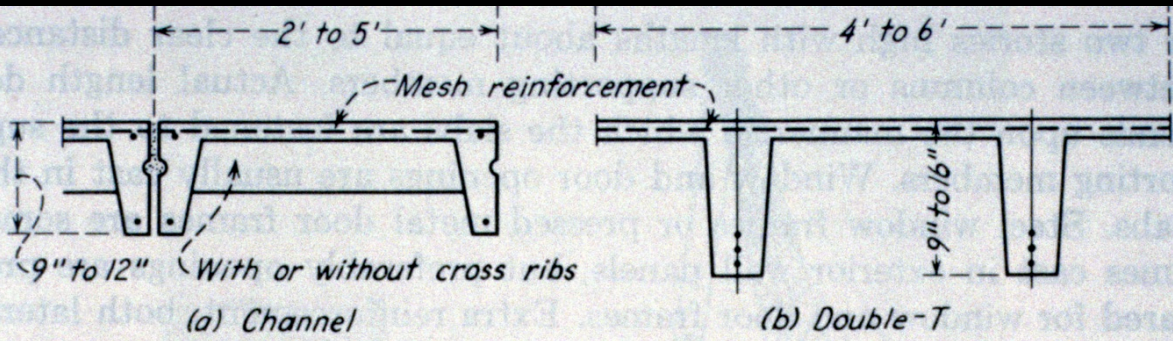


FIGURE 8.4 Channel and double-T decks.



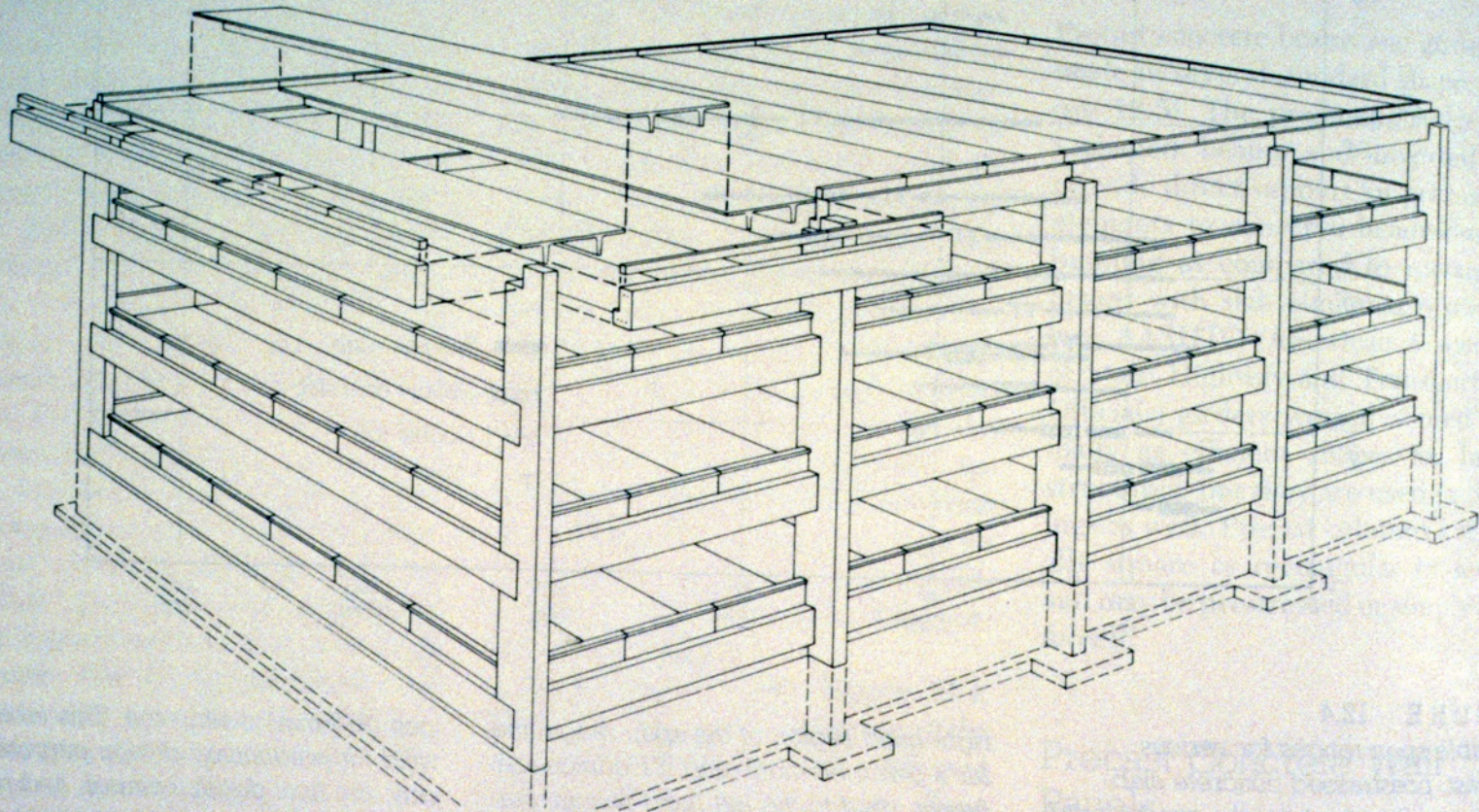


FIGURE 12.6

Double-tee slab elements supported on a frame of precast columns and L-shaped girders. (Courtesy of Prestressed Concrete Institute)

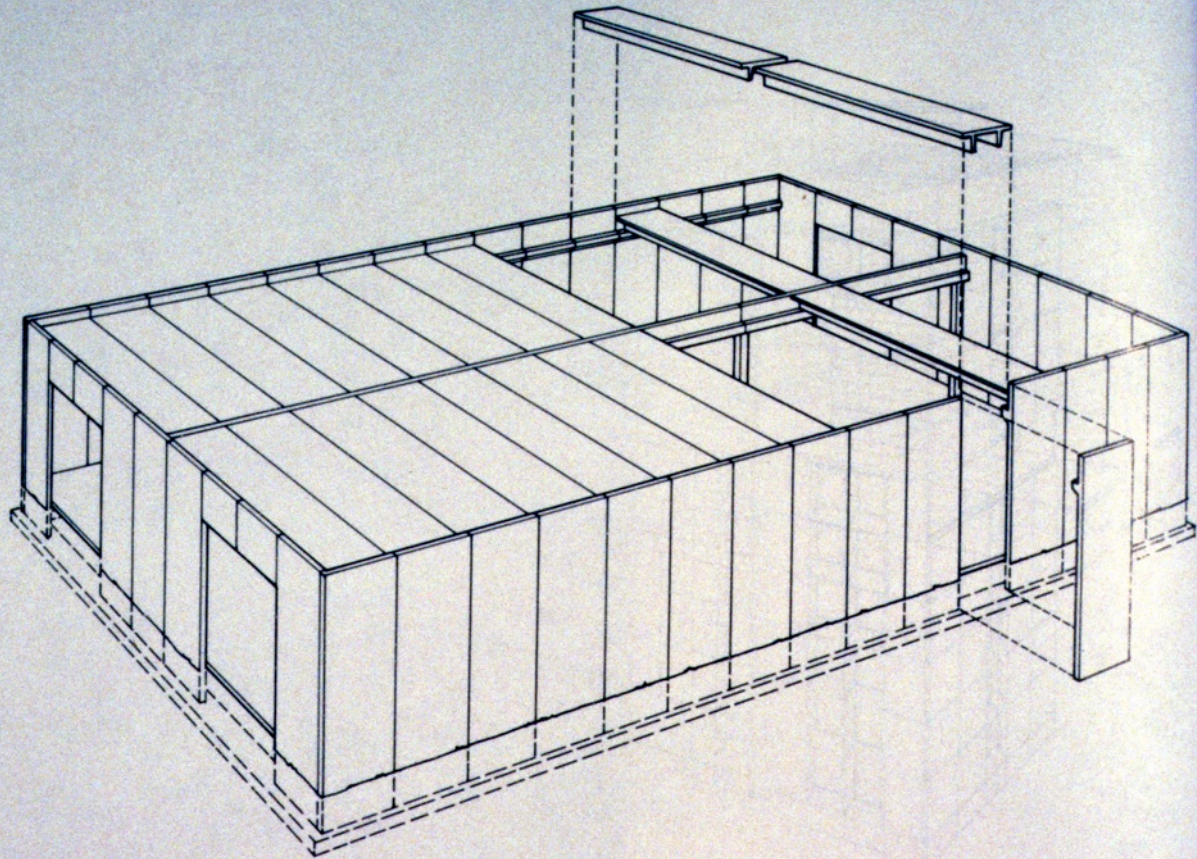


FIGURE 12.8

Double-tee slab elements supported on a perimeter of precast concrete loadbearing wall panels, and an interior structure of precast columns and girders. (Courtesy of Prestressed Concrete Institute)

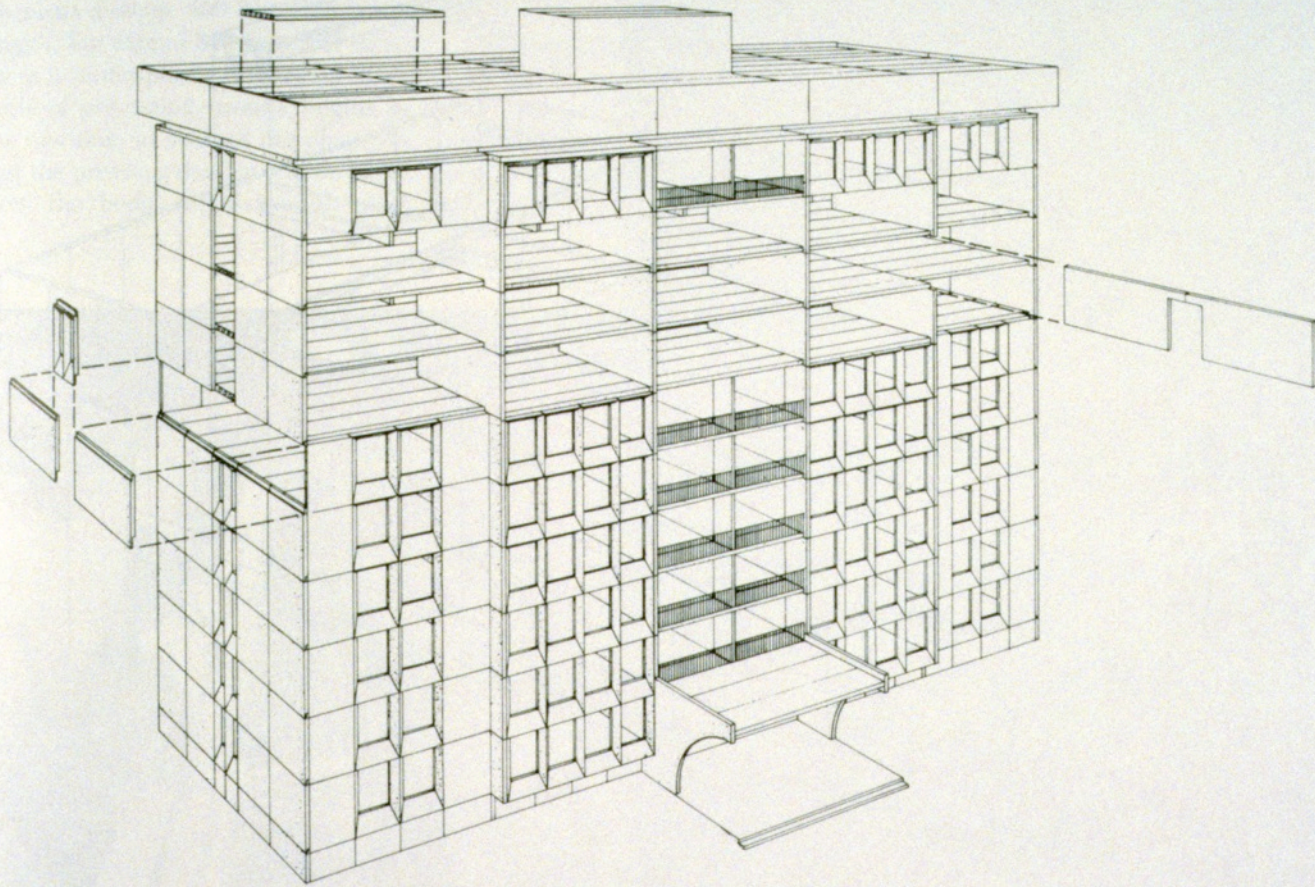


FIGURE 12.7

Hollow-core slab elements supported on precast concrete loadbearing wall panels. (Courtesy of Prestressed

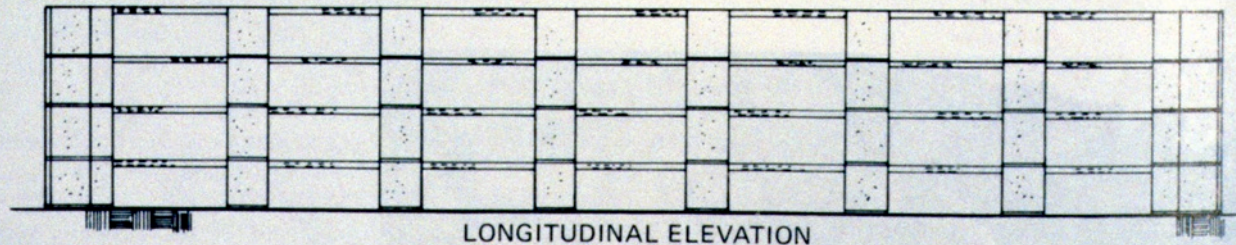
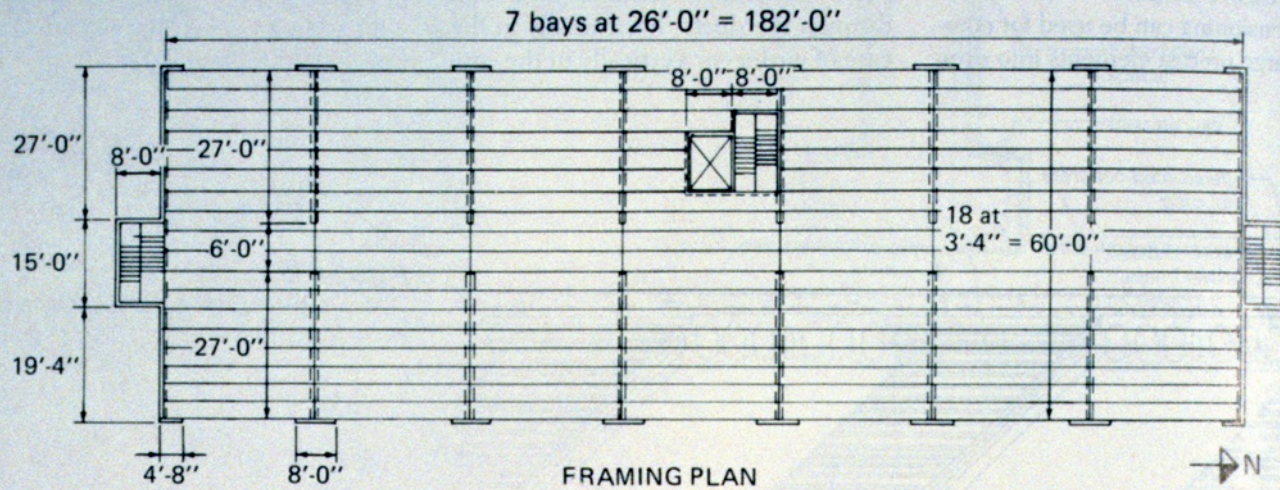


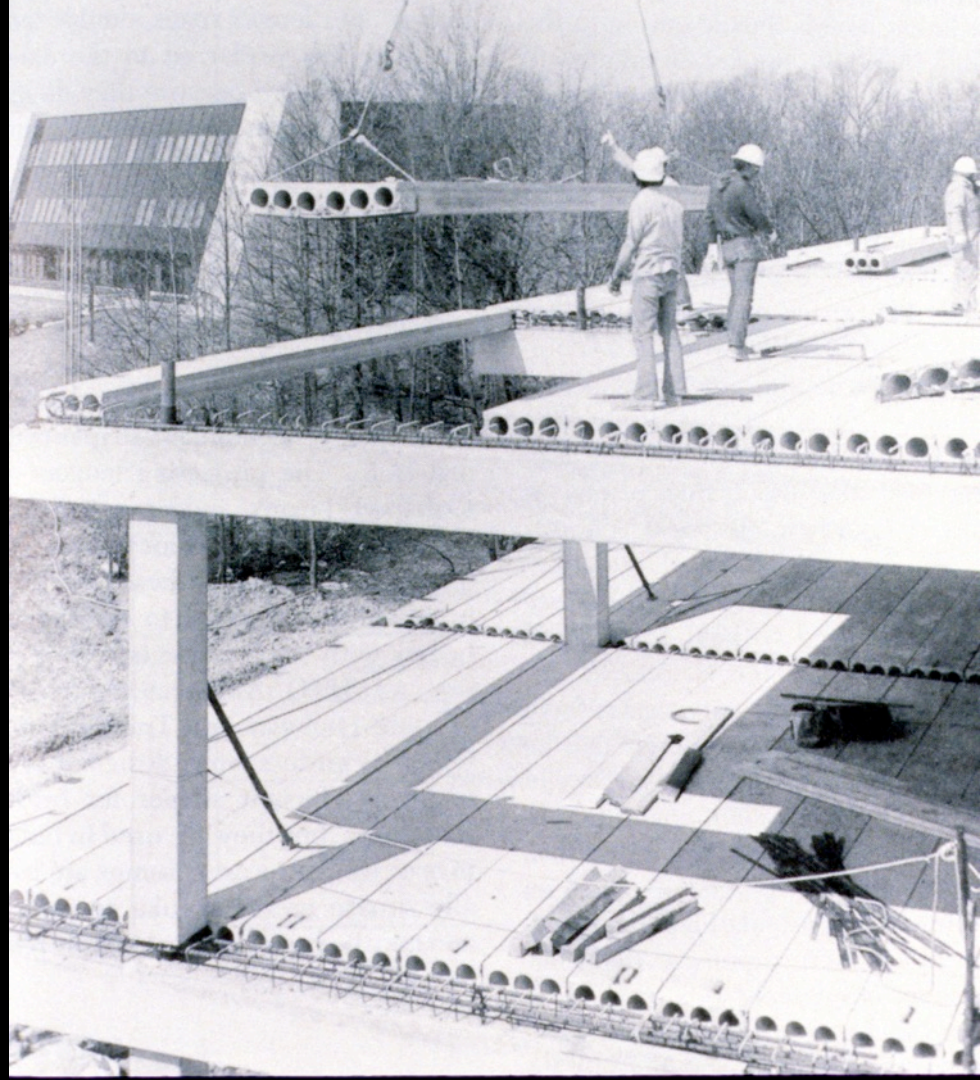
FIGURE 12.28

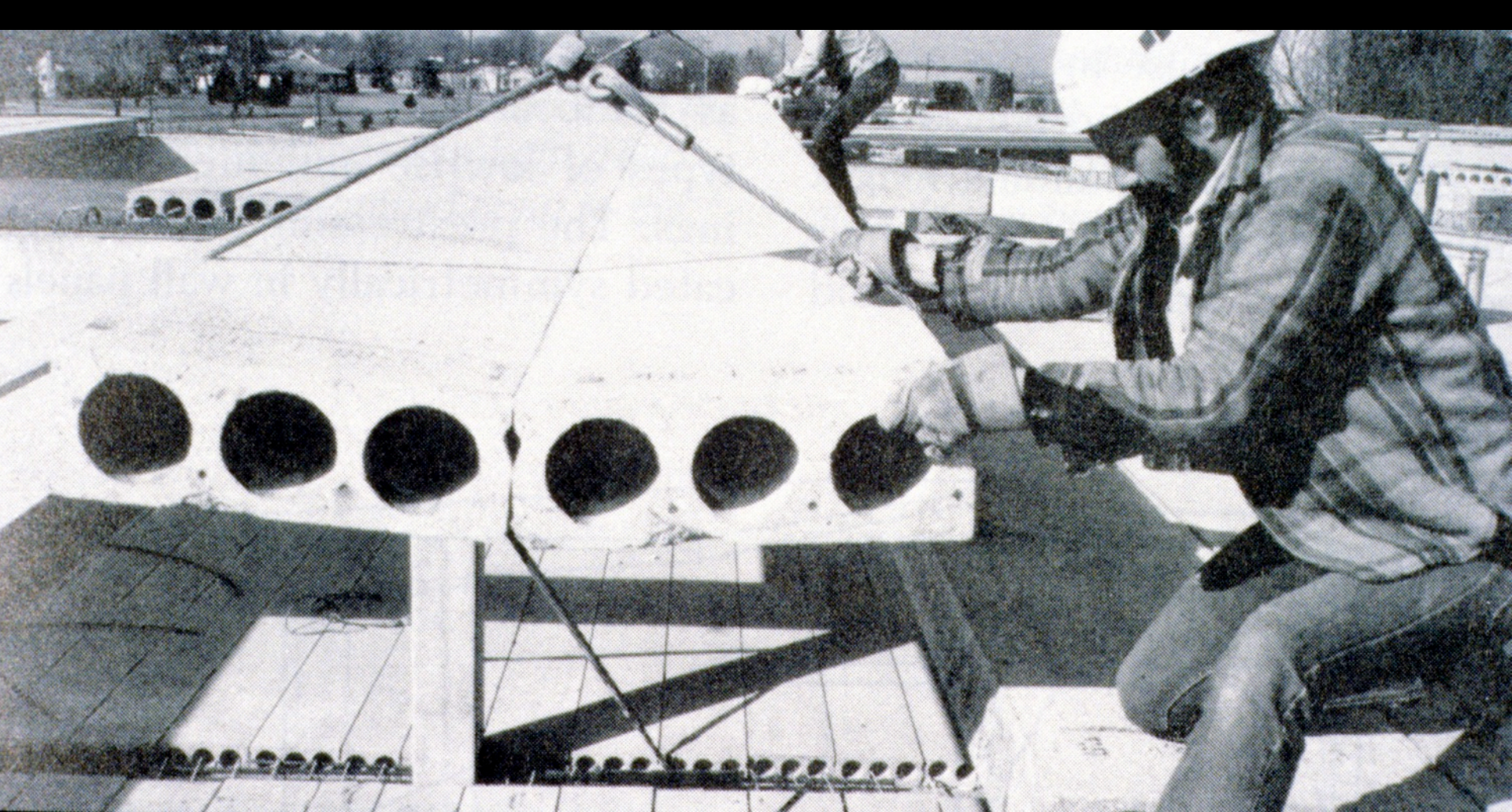
A framing plan and elevation of a simple four-story building made of loadbearing precast concrete wall panels and hollow-core slab elements. (Courtesy of Prestressed Concrete Institute)



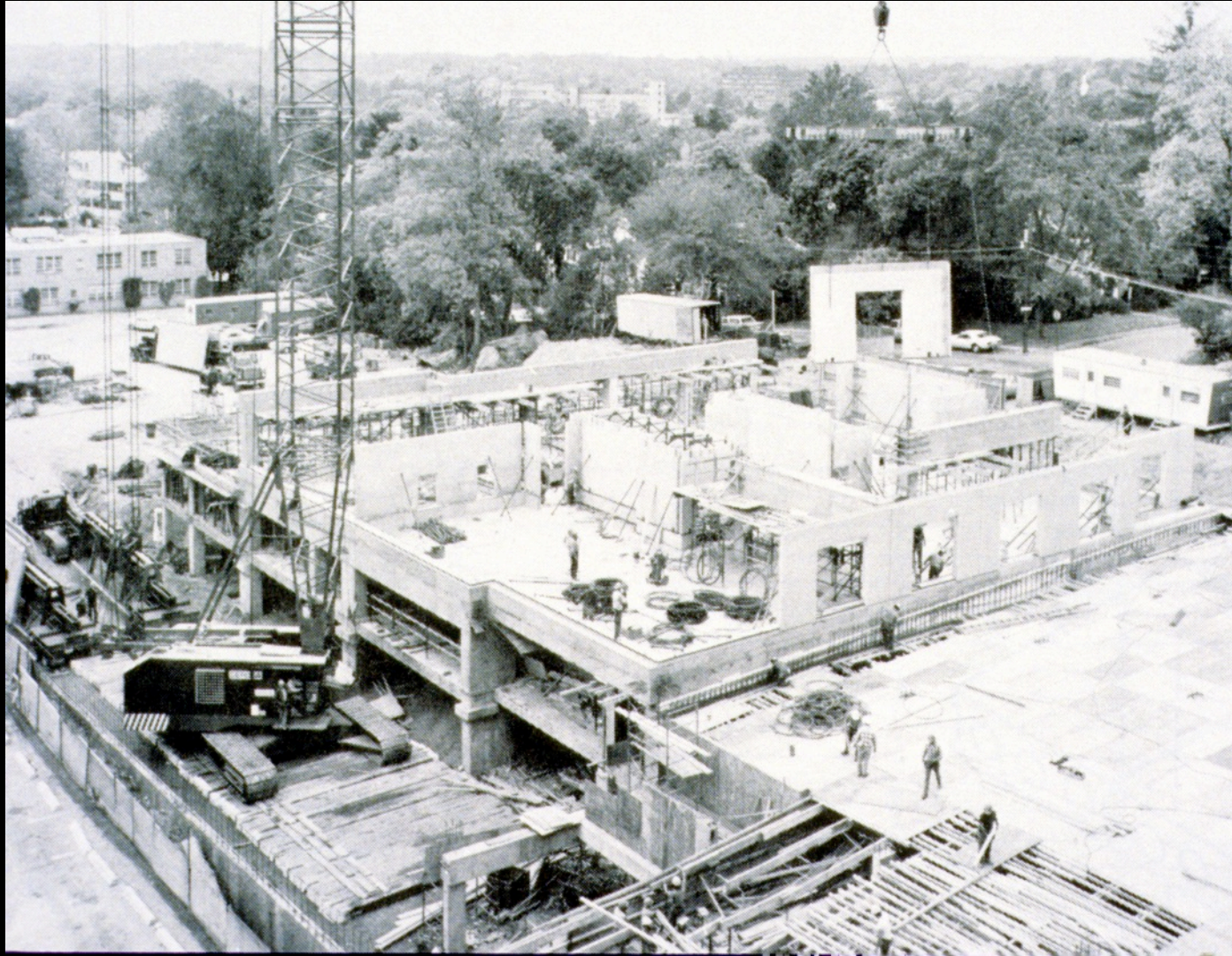




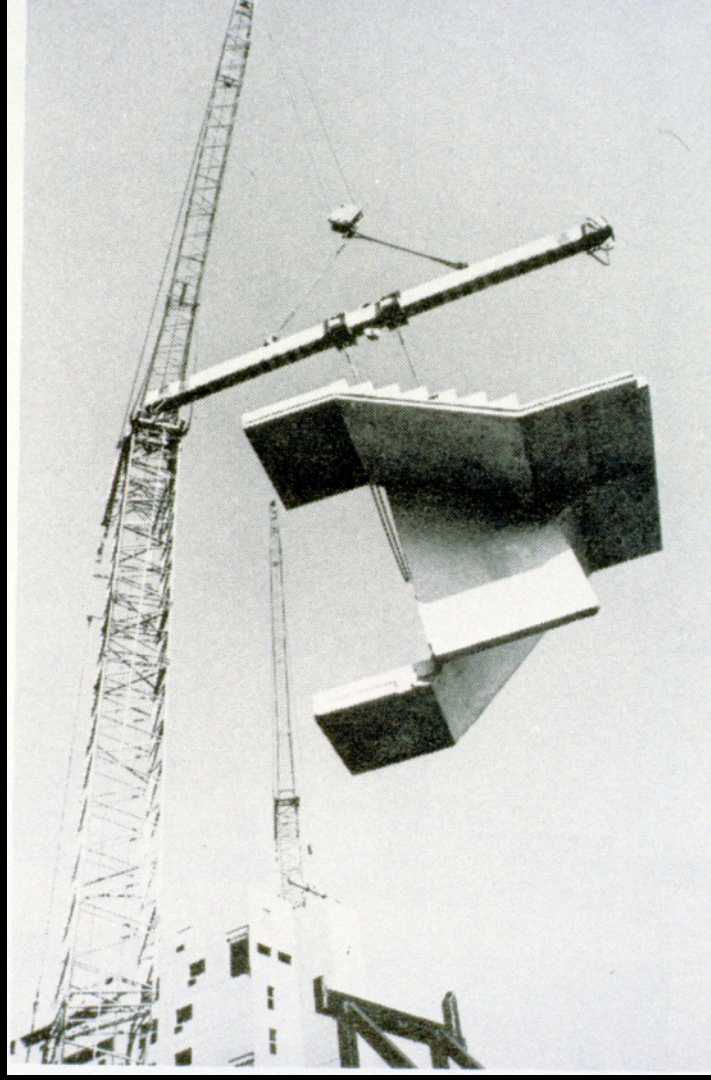
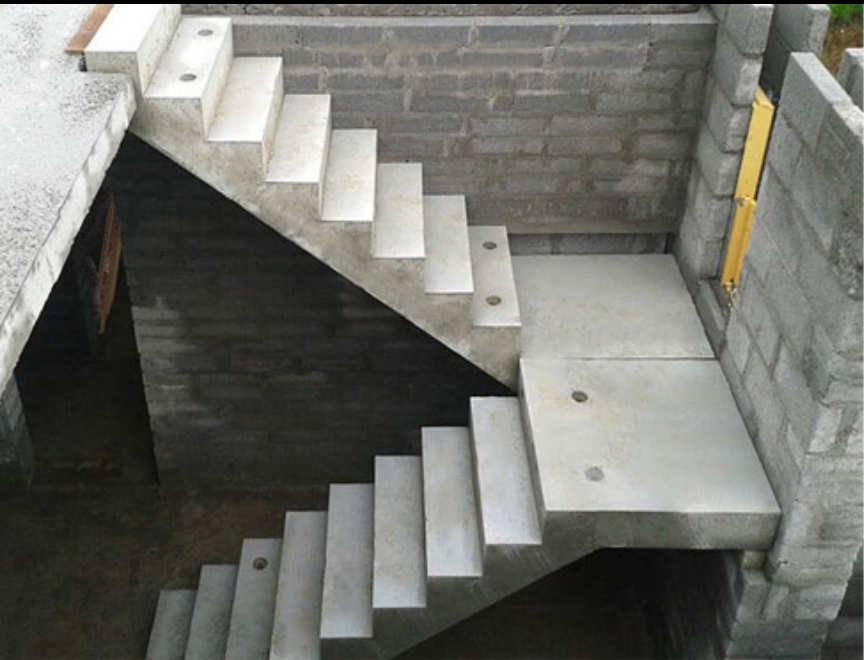


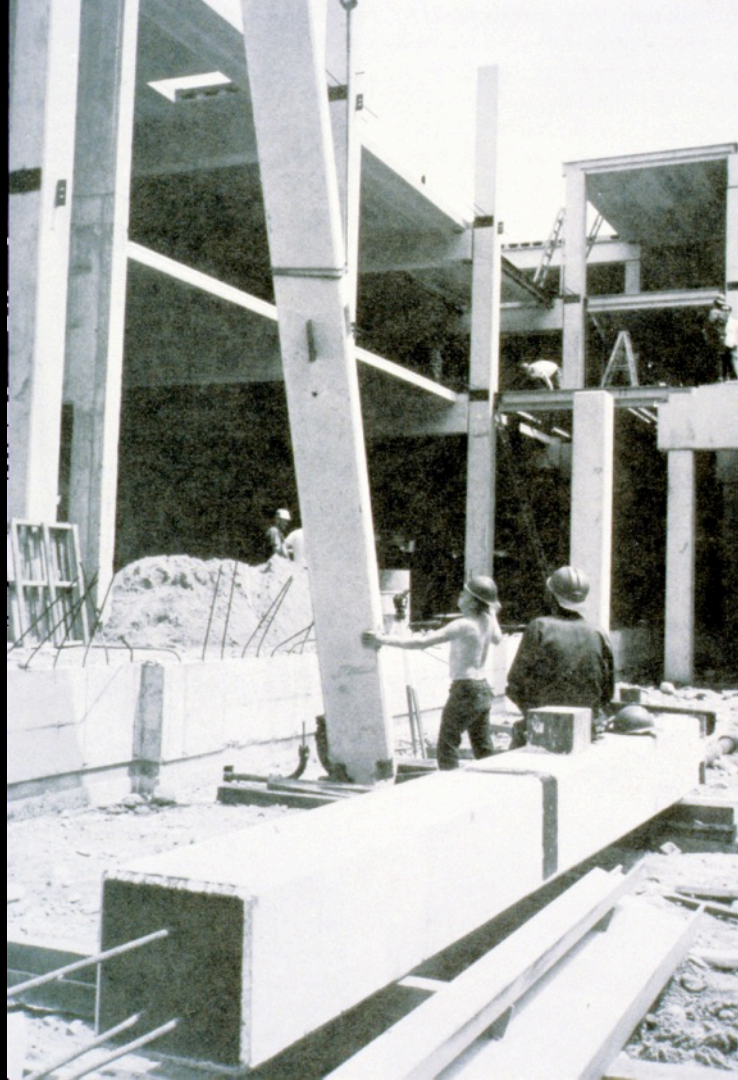
























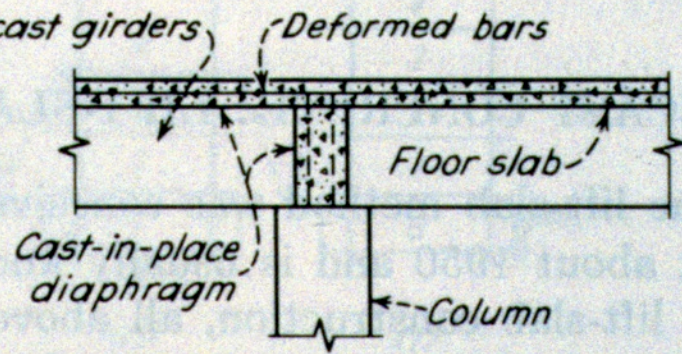
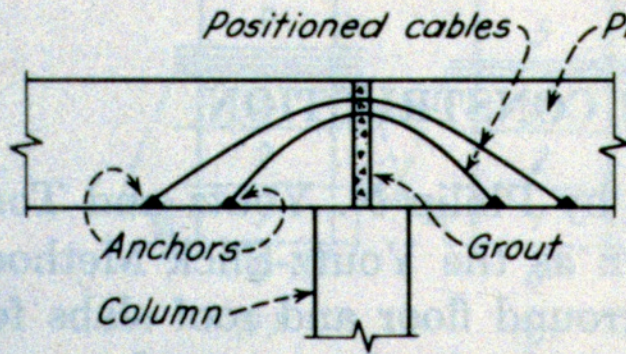
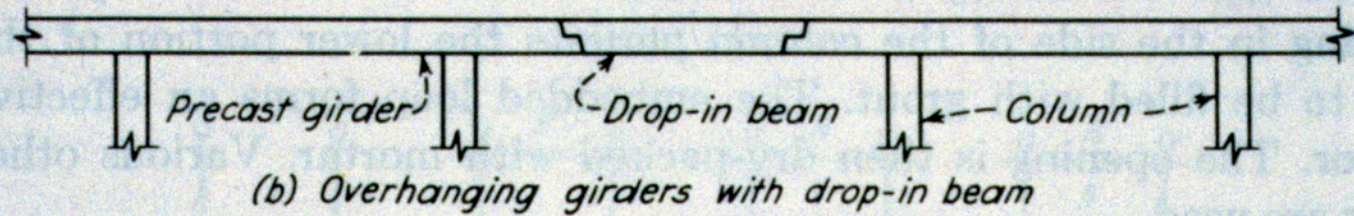
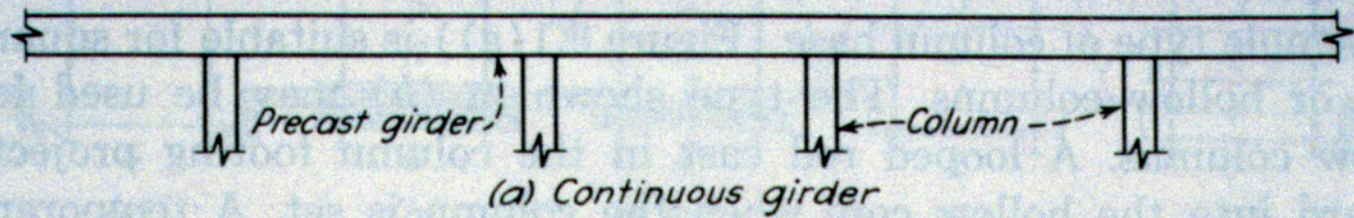
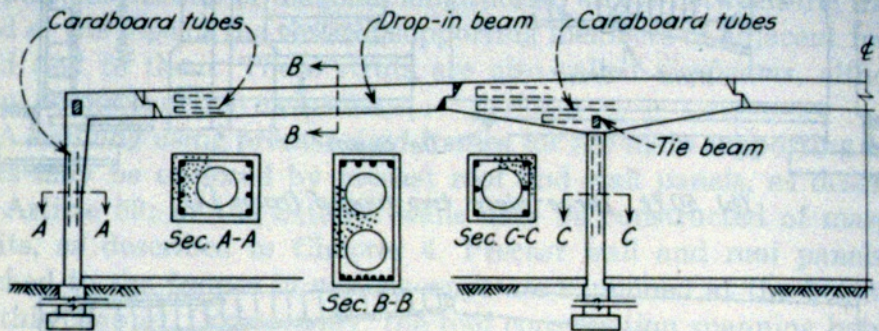
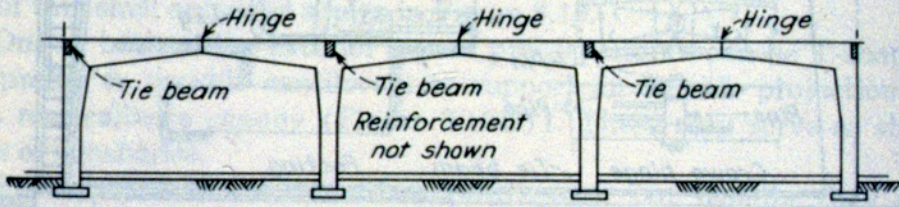


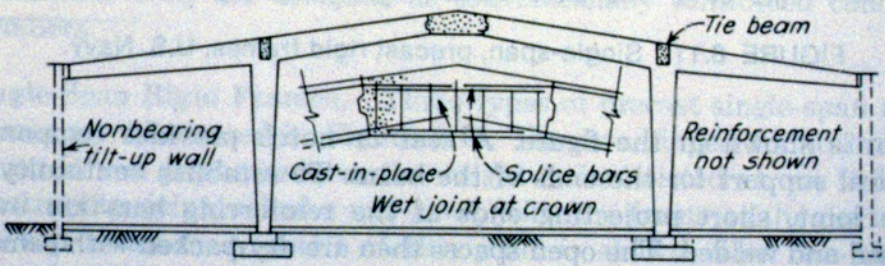
FIGURE 8.7 Overhanging girders and continuity connections.



(a) 200 ft. 3-span continuous frame with drop-in beams. U.S. Navy [4].

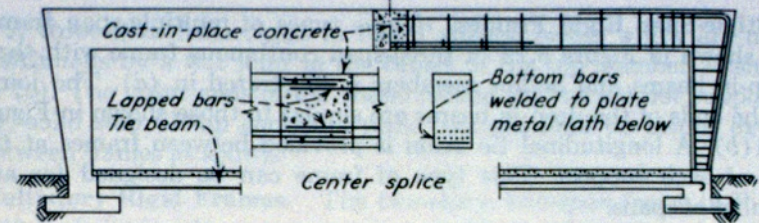


(b) 3-span rigid frame

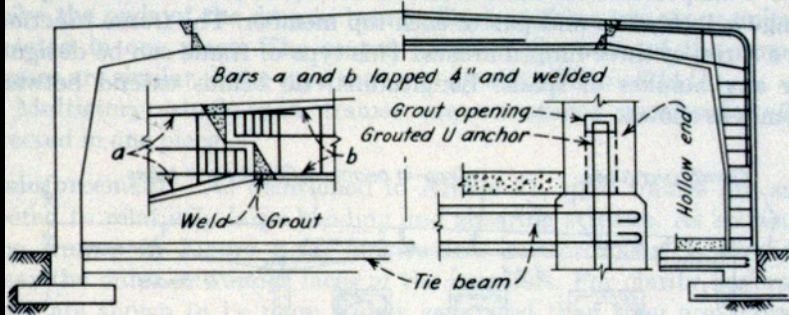


(c) 90 ft. 3-span rigid frame. U.S. Navy [4].

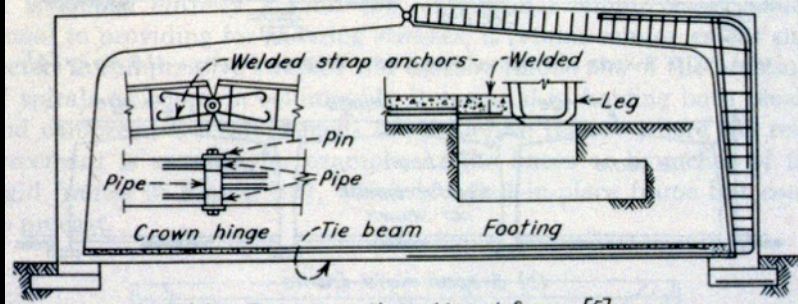
FIGURE 8.12 Three-span rigid frames. U.S. Navy.



(a) 60 ft. Two-piece two-hinged frame [4]



(b) 50 ft. Three-piece two-hinged frame [4]



(c) 64 ft. Two-piece three-hinged frame [5]

FIGURE 8.11 Single-span, precast rigid frames. U.S. Navy.

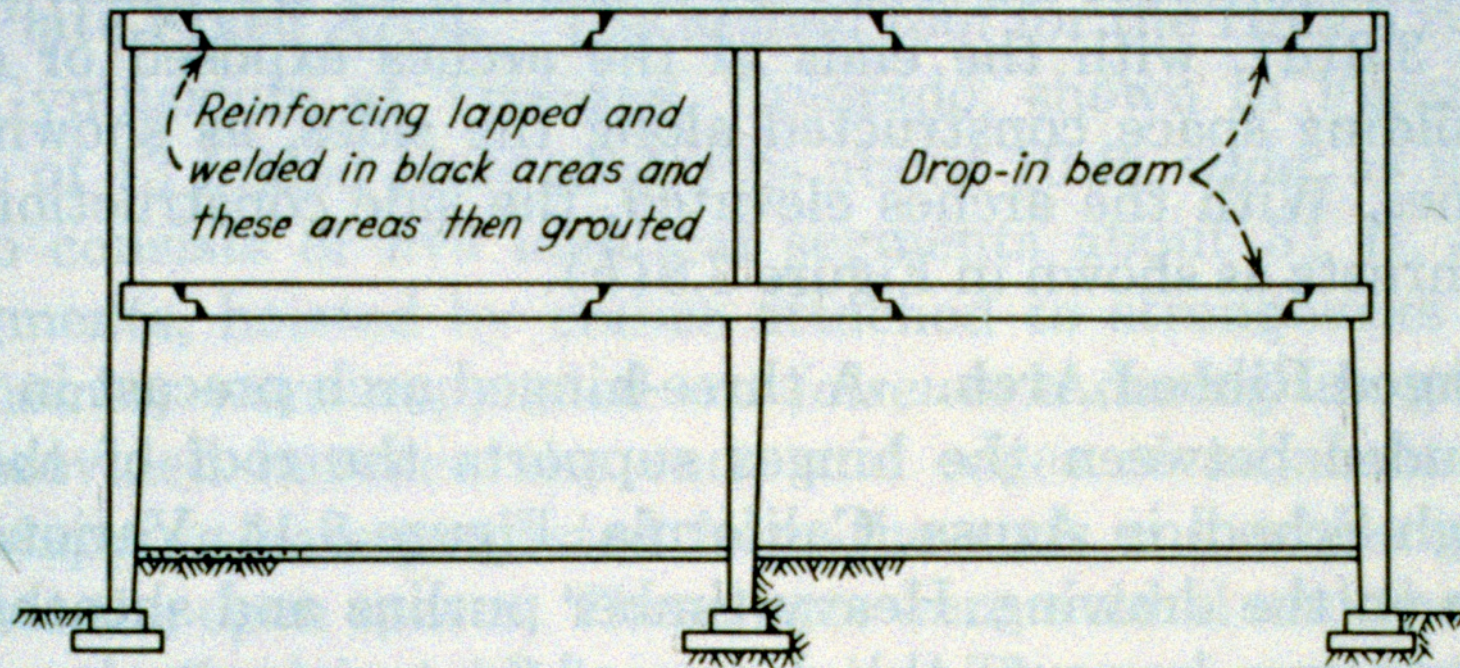
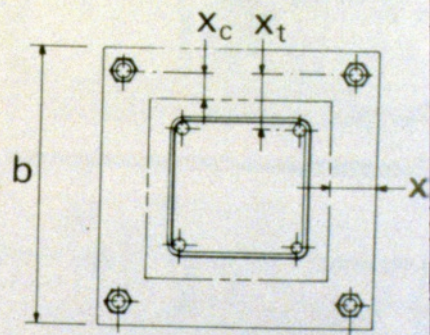
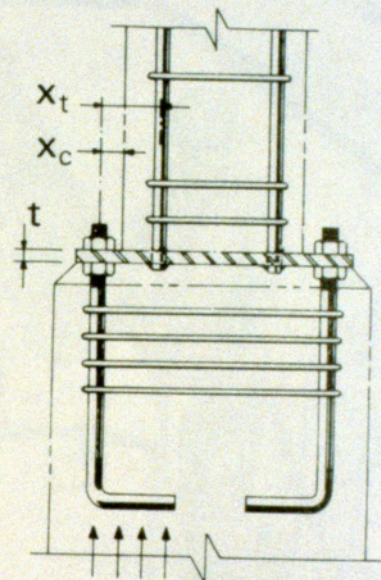
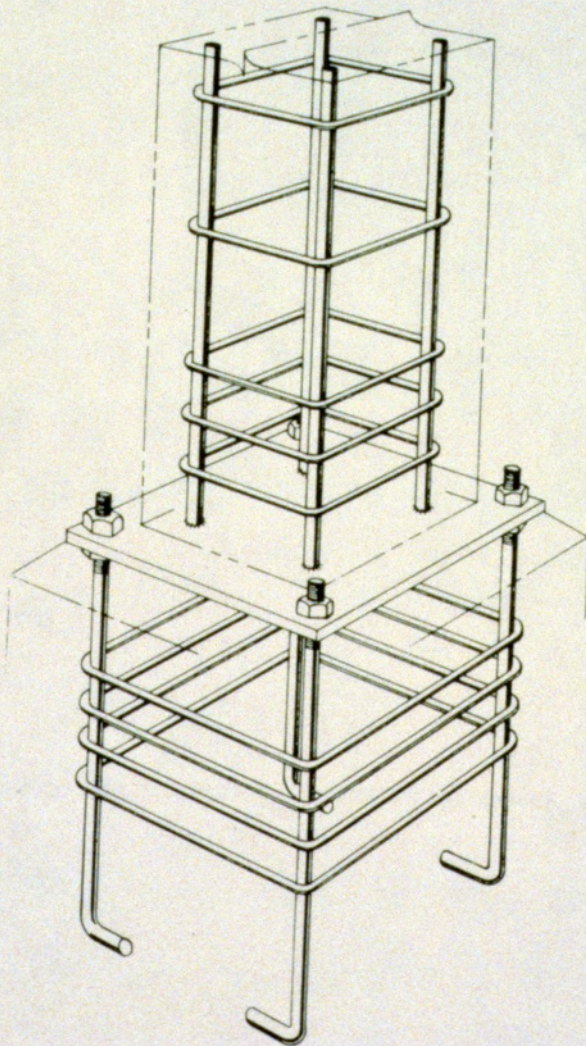
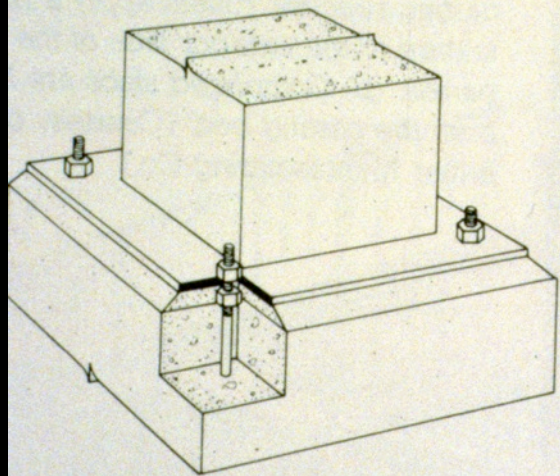
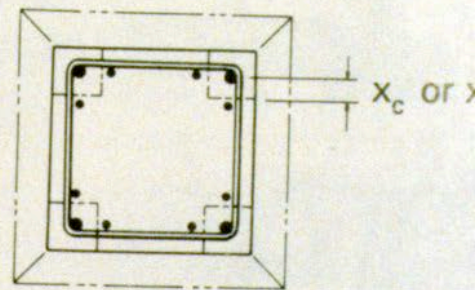
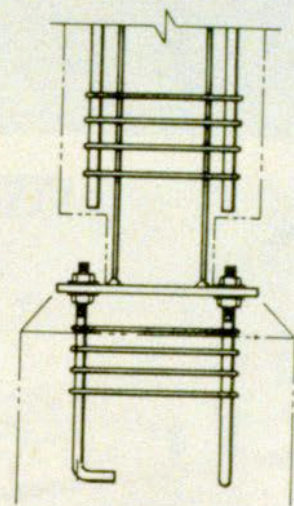
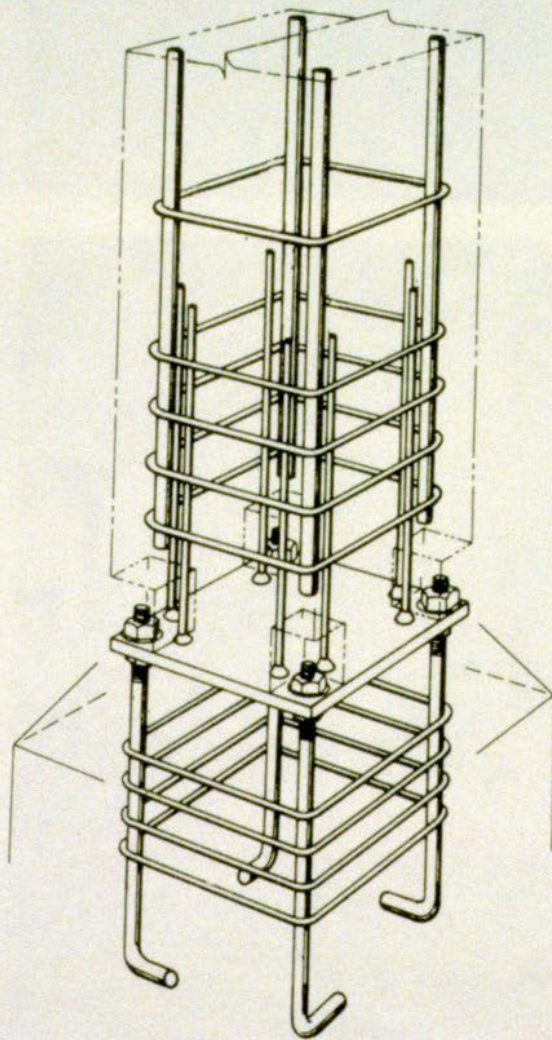
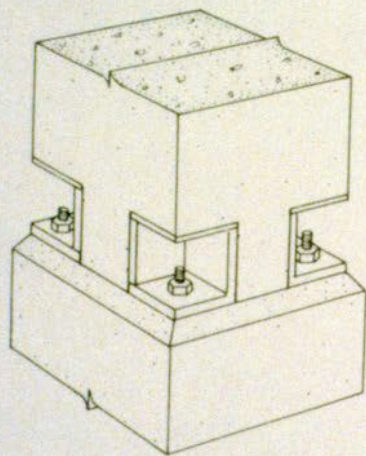


FIGURE 8.13 A 50-ft. two-span, two-story rigid frame with drop-in beam. Designed by Roberts and Schaefer for U.S. Air Force.





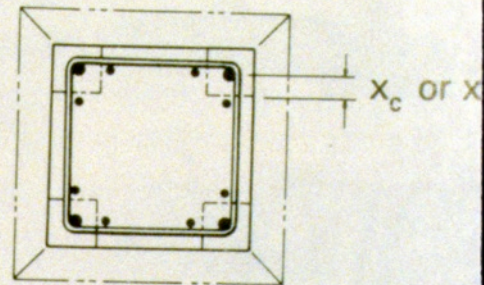
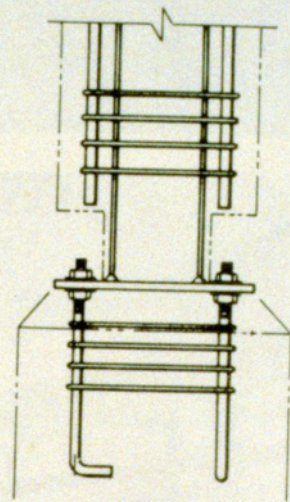
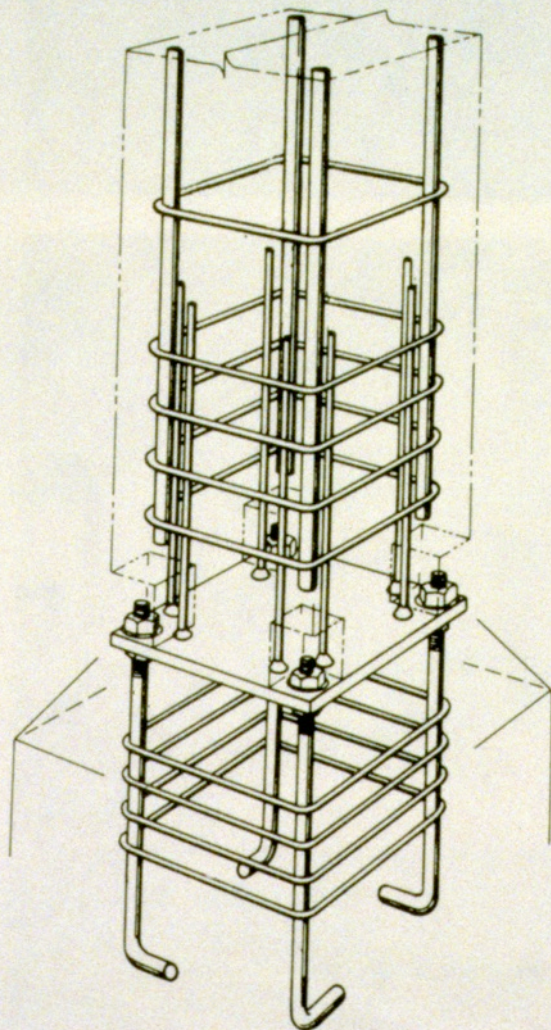
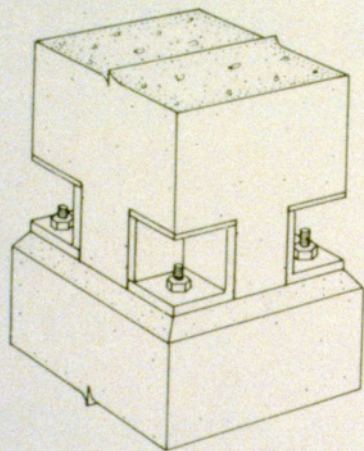
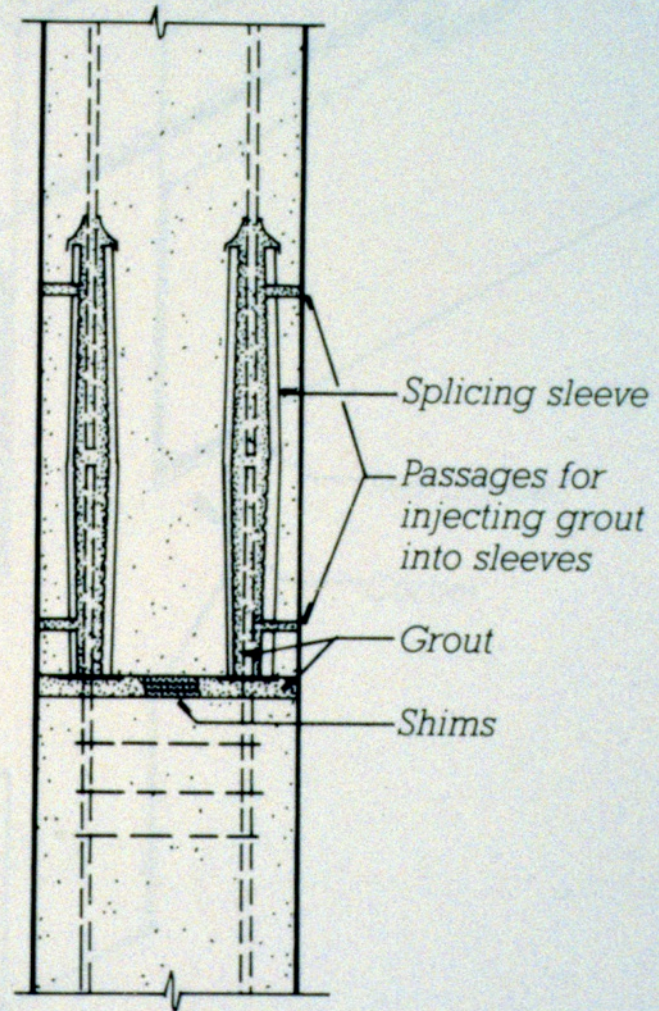
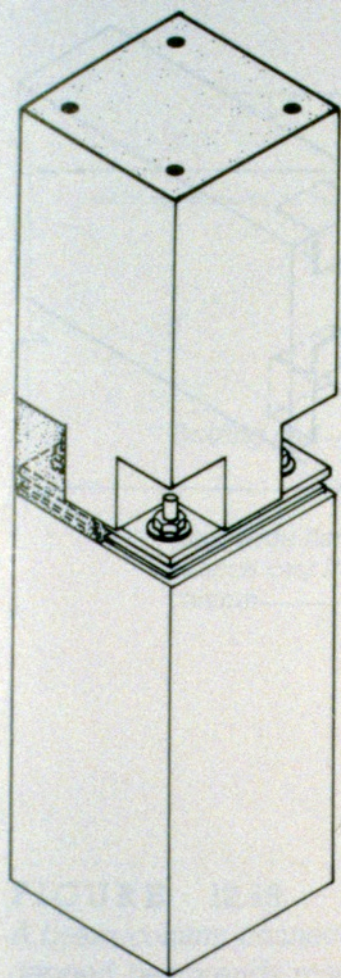


FIGURE 12.17

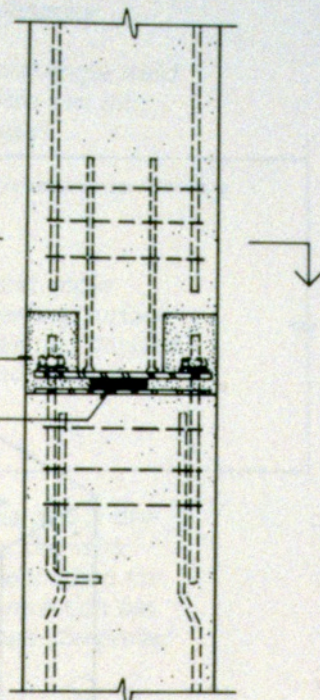
Section through a column-to-column connection using a proprietary sleeve that is cast into the column. Projecting reinforcing bars from the lower column section are inserted in the sleeves, where injected grout makes the connection.



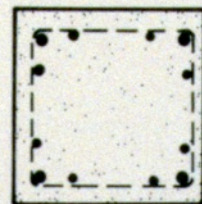


The entire joint is
dry-packed with
grout after
alignment

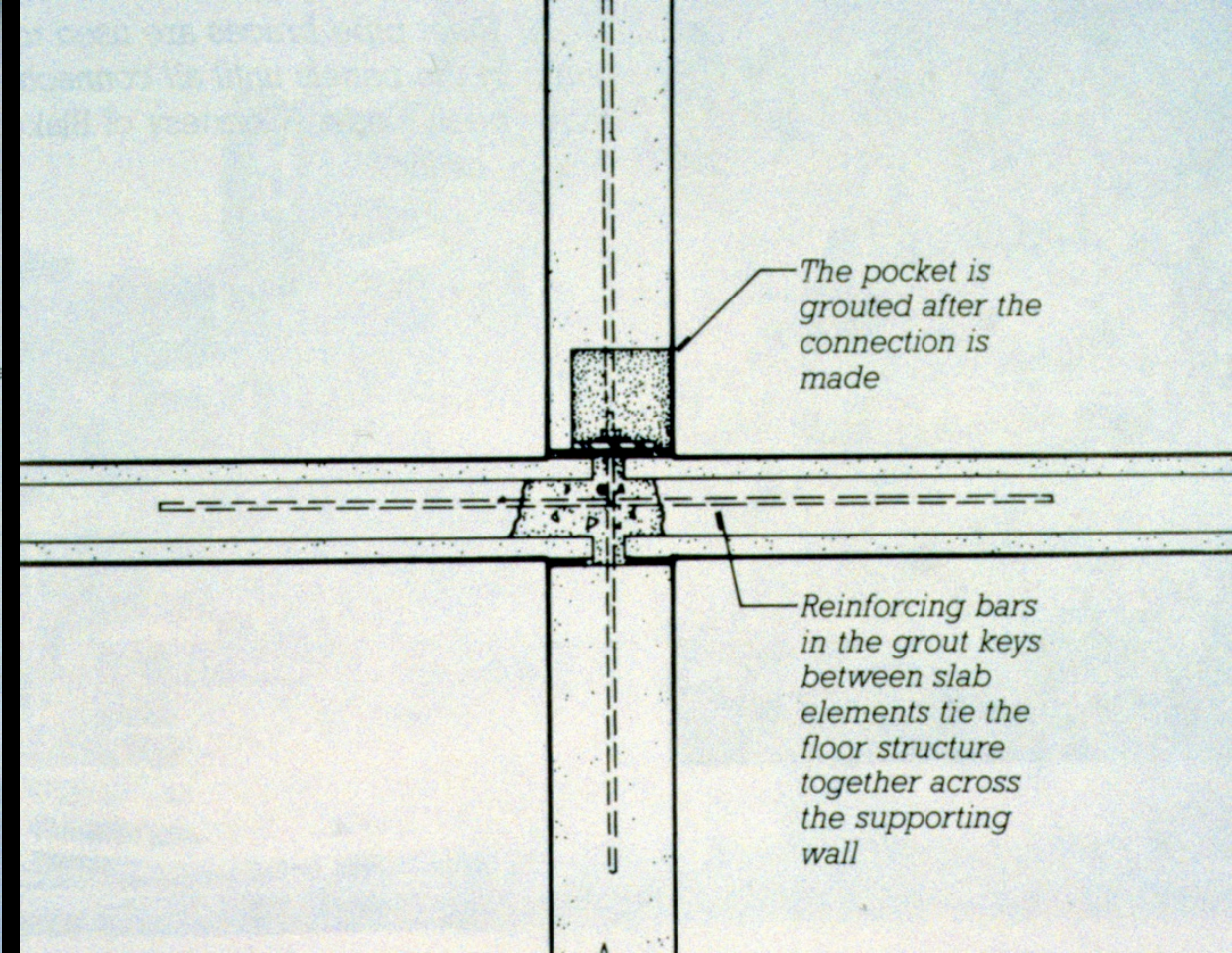
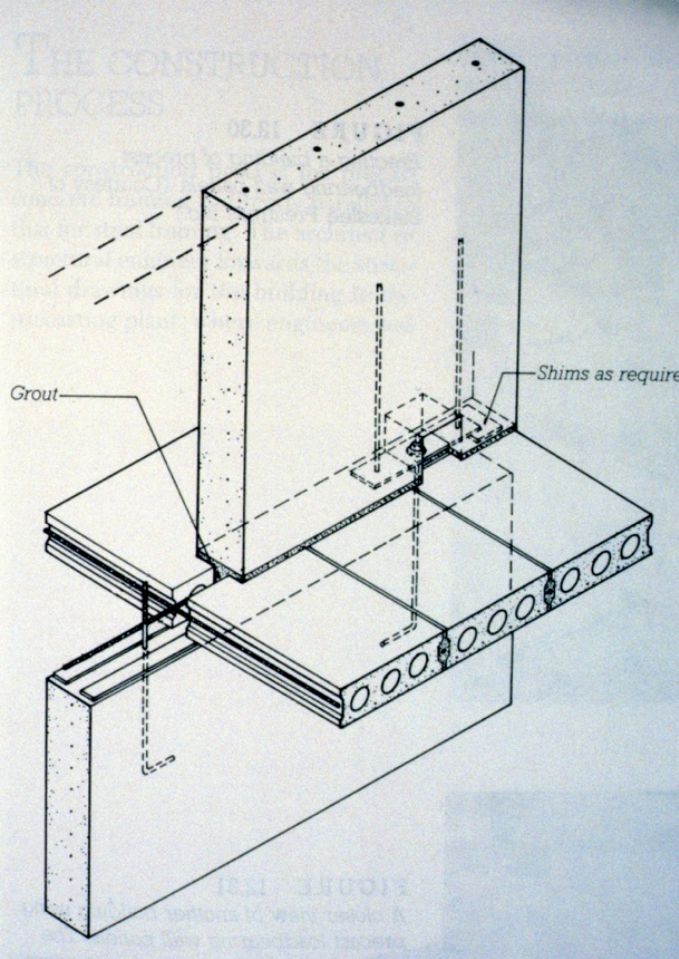
Shims

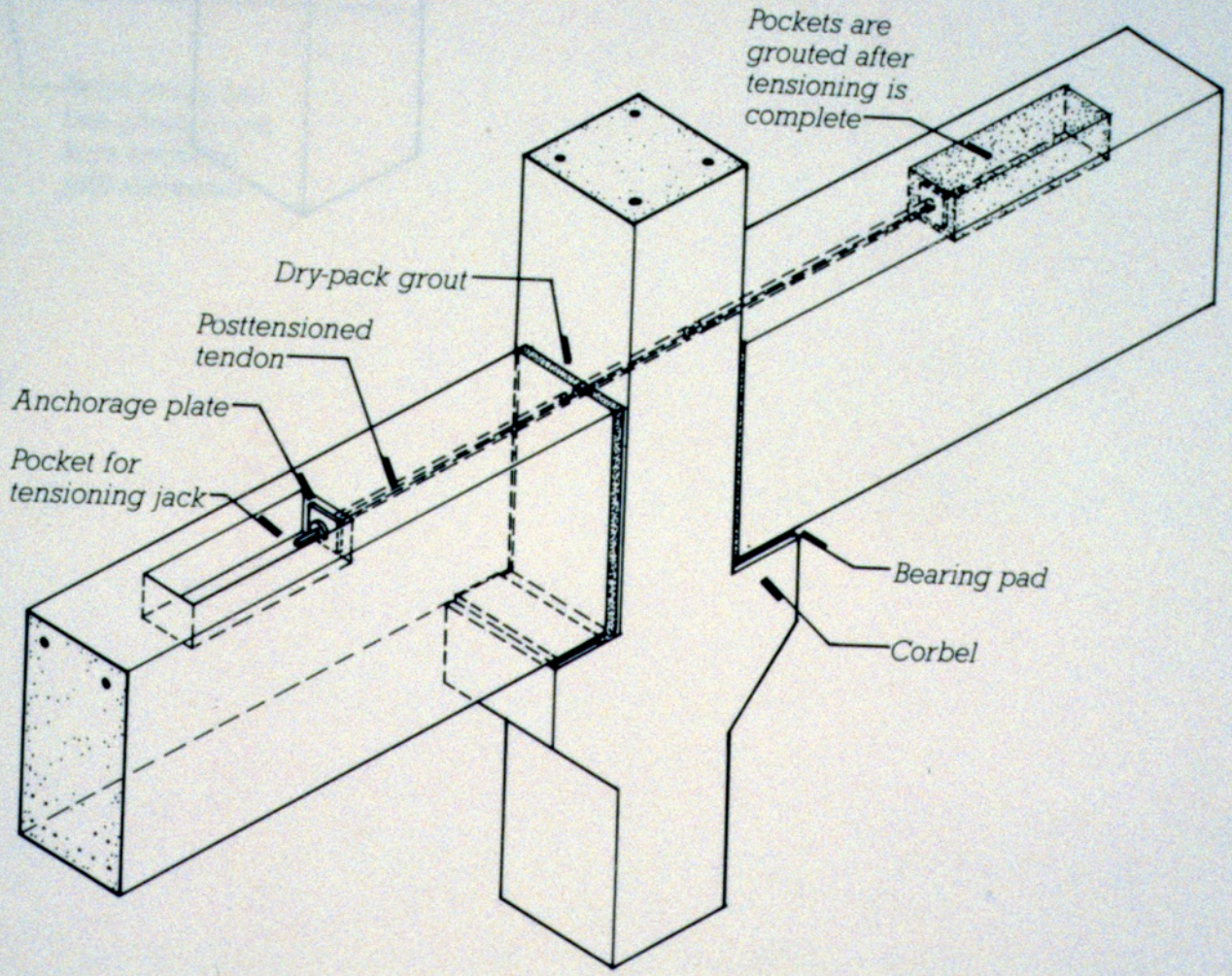


SECTION



PLAN





Pockets are grouted after tensioning is complete

Dry-pack grout

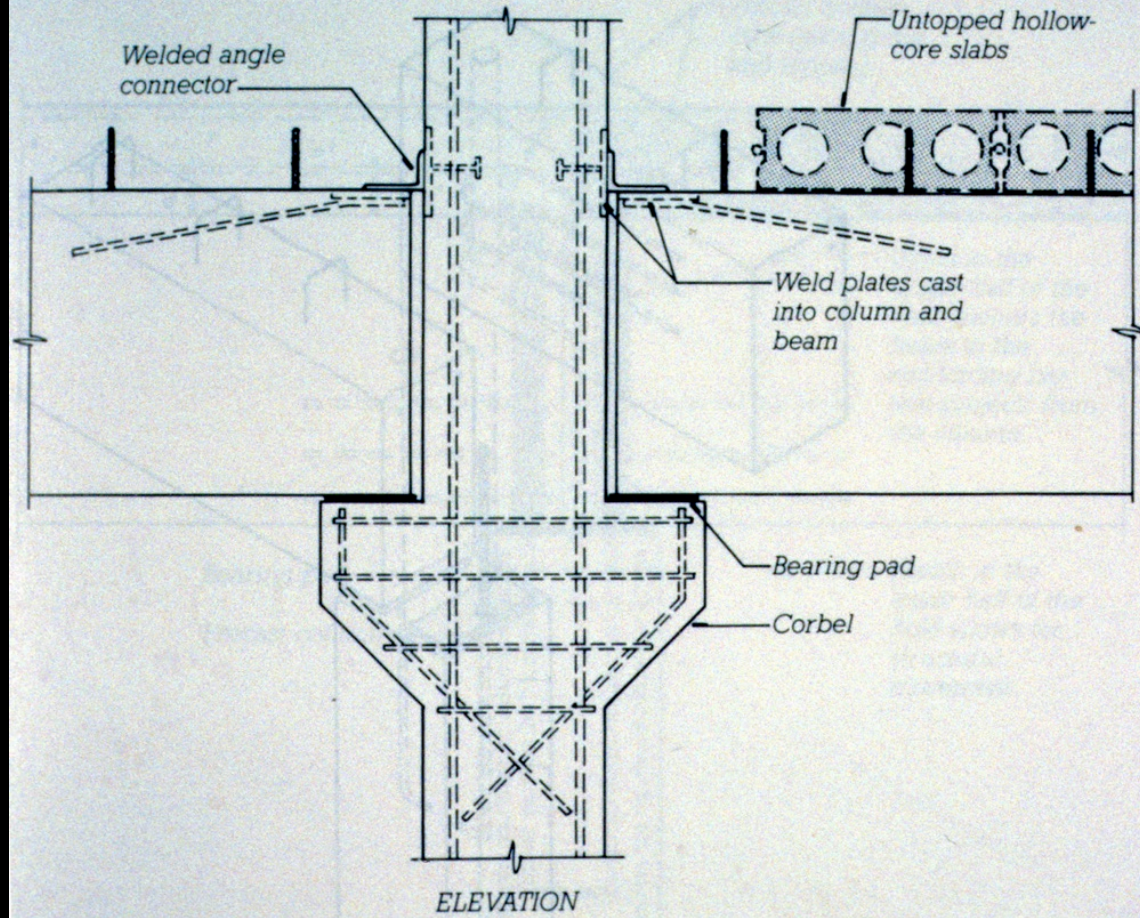
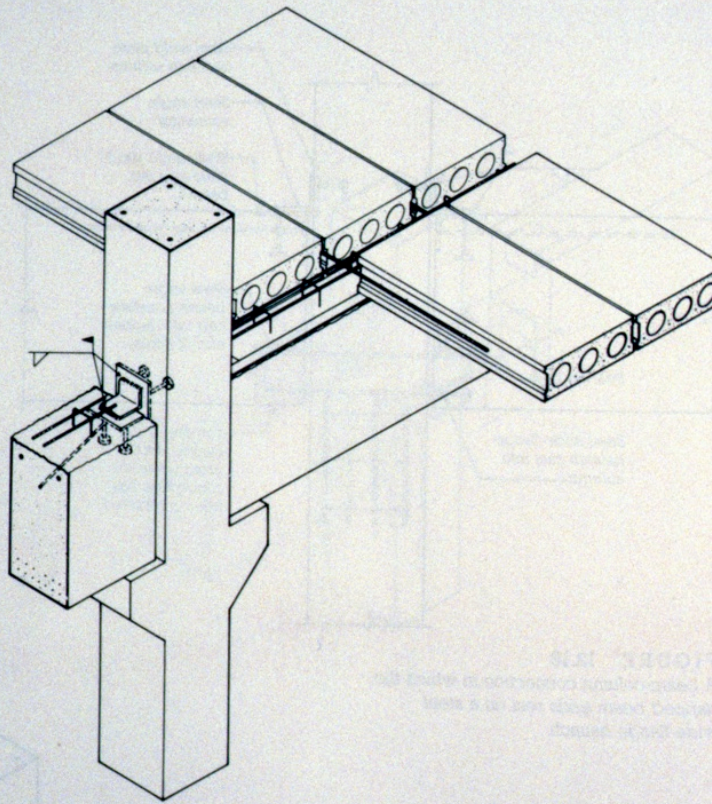
Posttensioned tendon

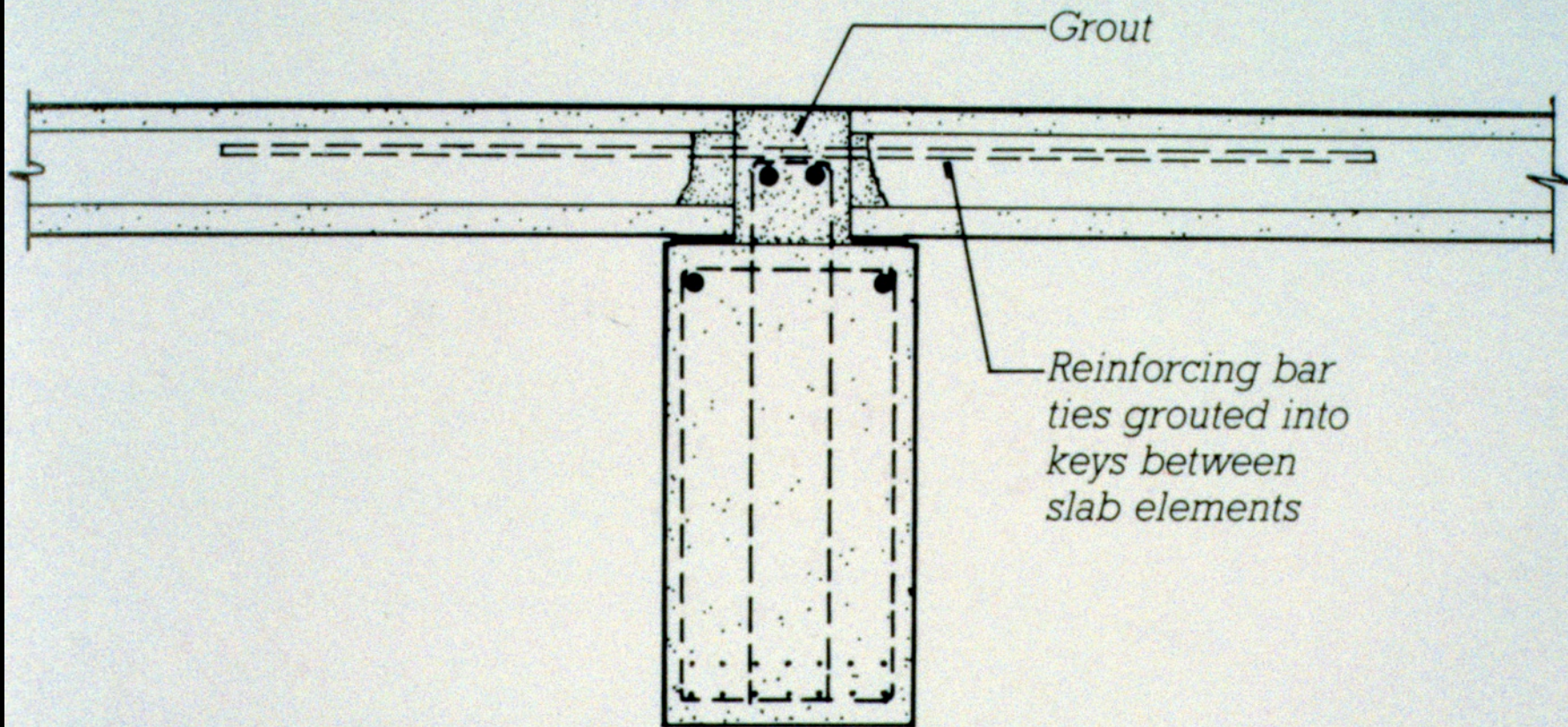
Anchorage plate

Pocket for tensioning jack

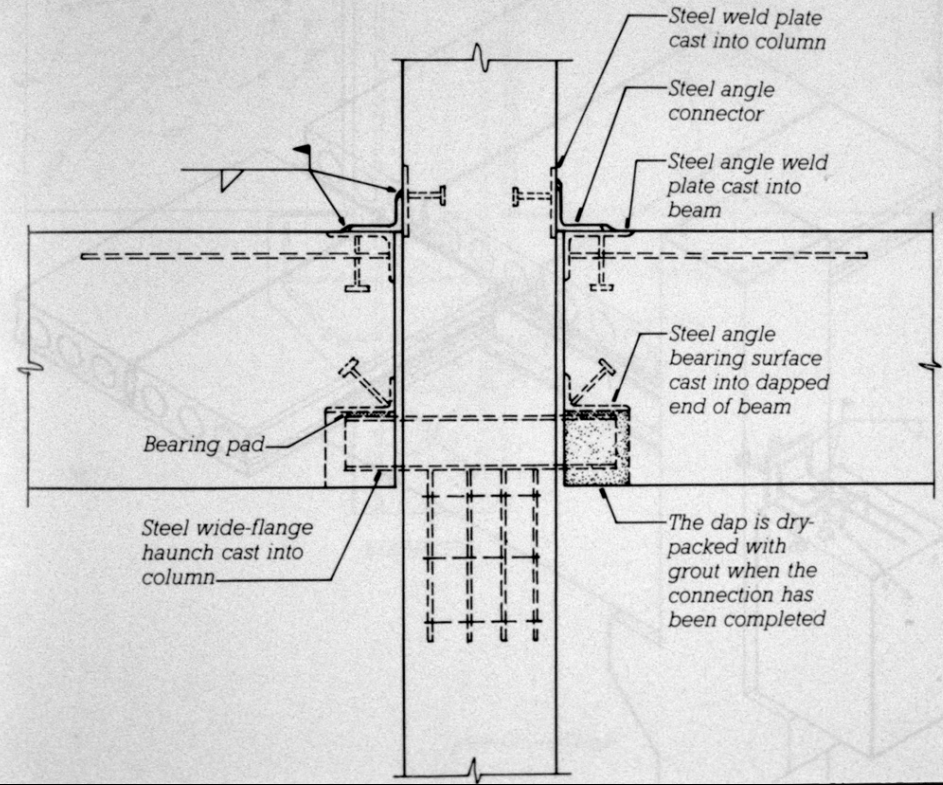
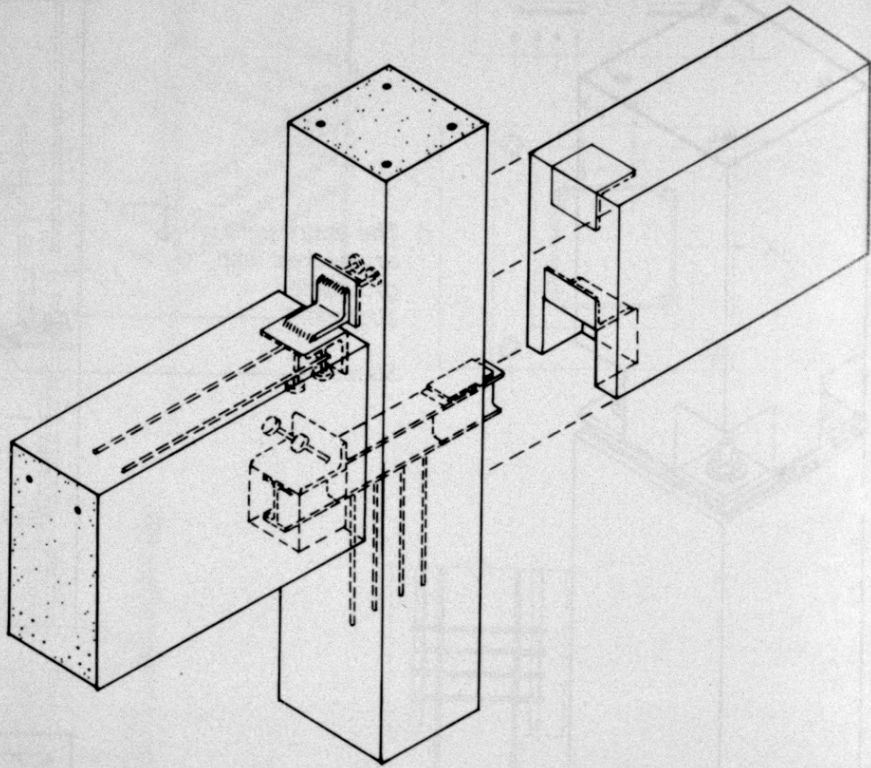
Bearing pad

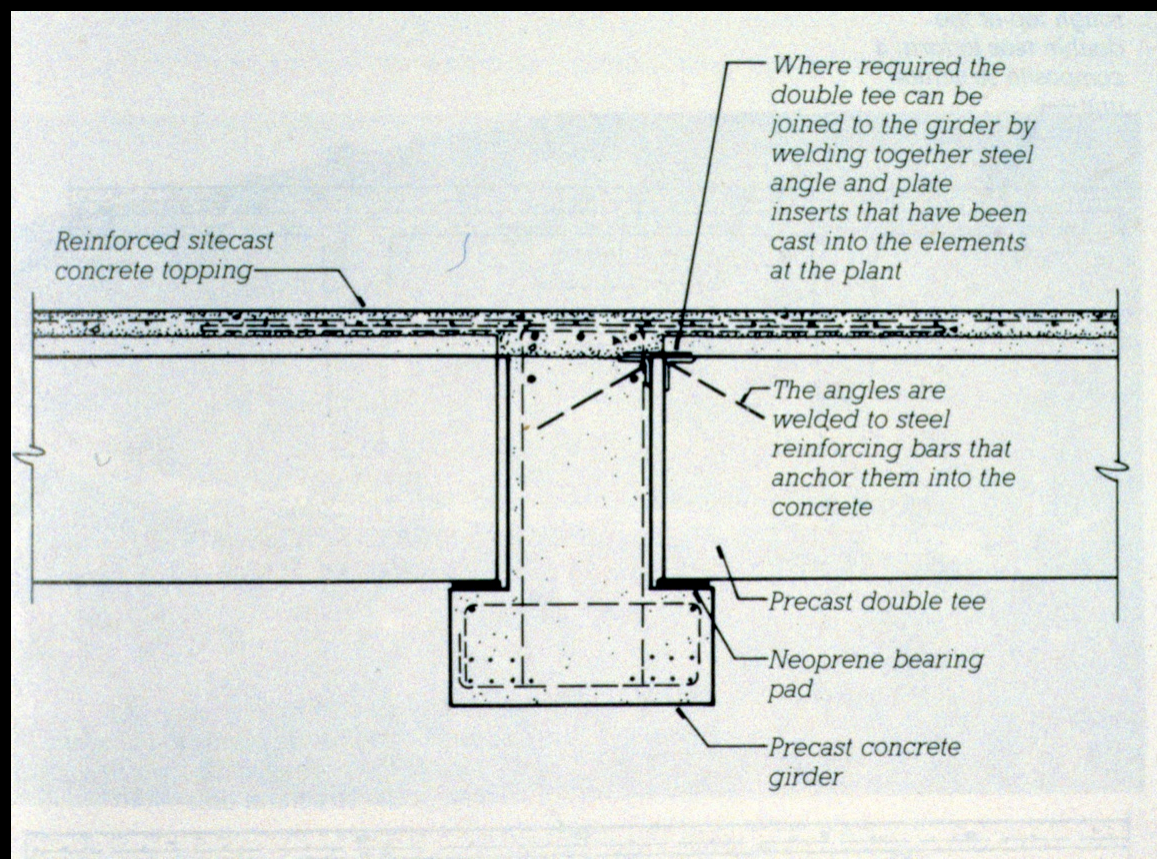
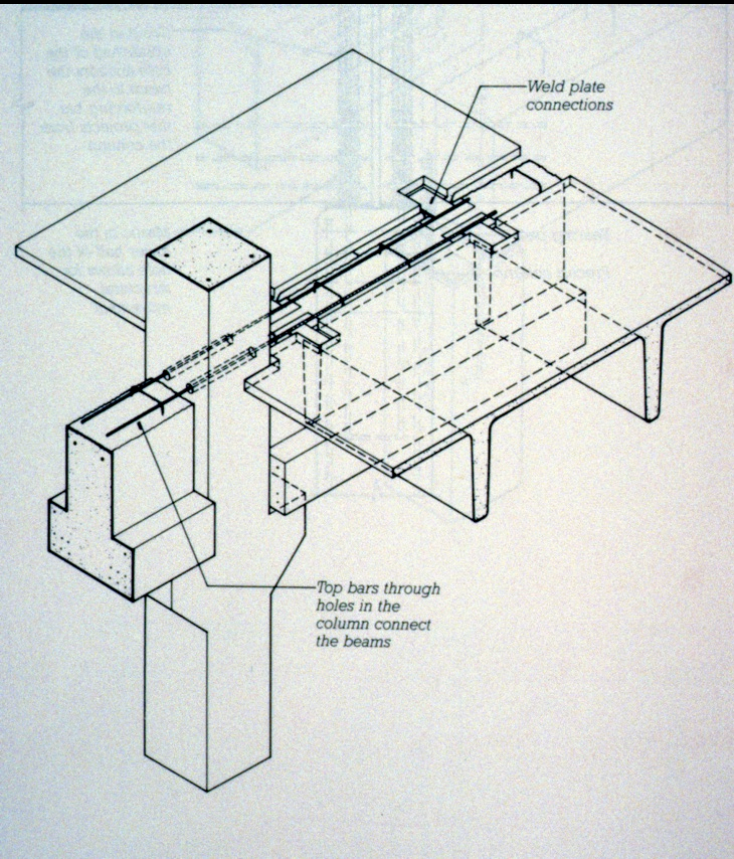
Corbel





SECTION
THROUGH BEAM





Lift Slab Construction

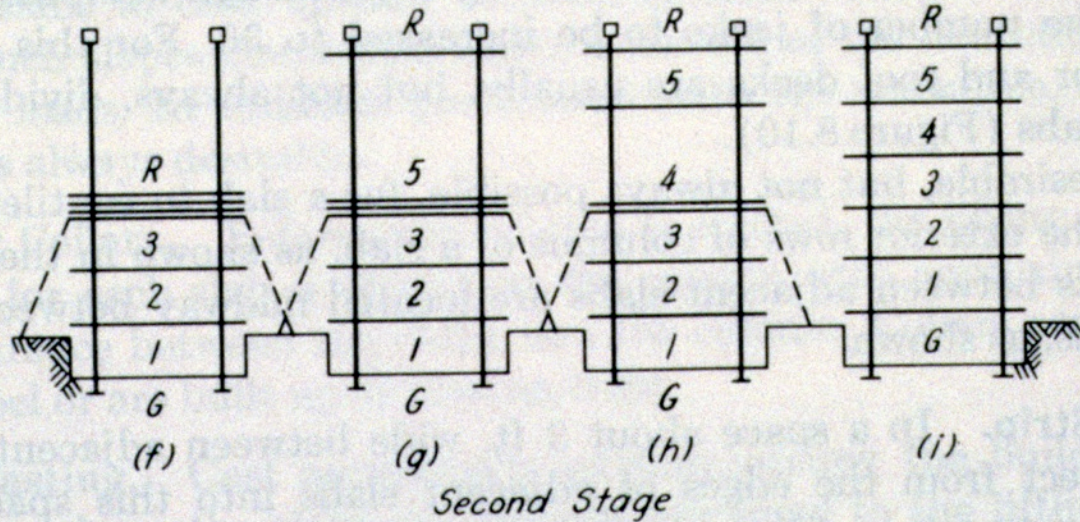
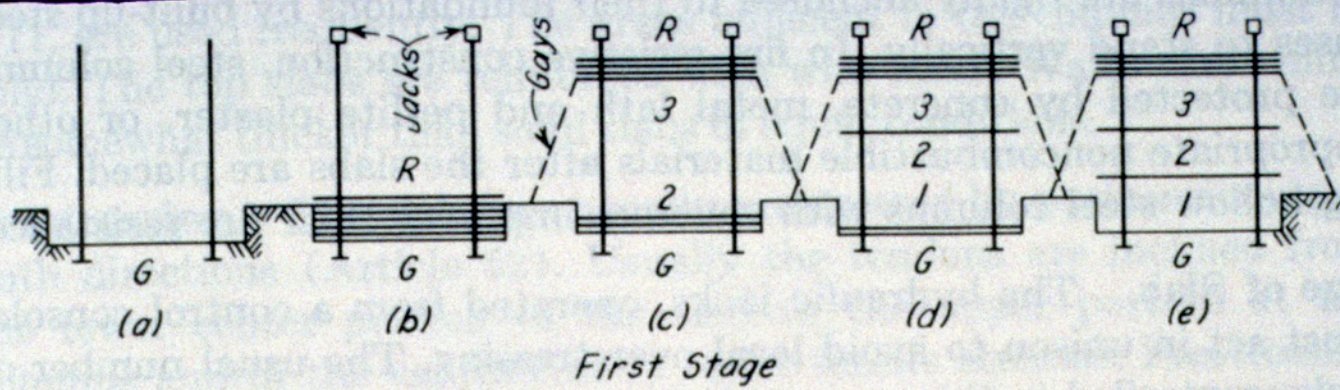
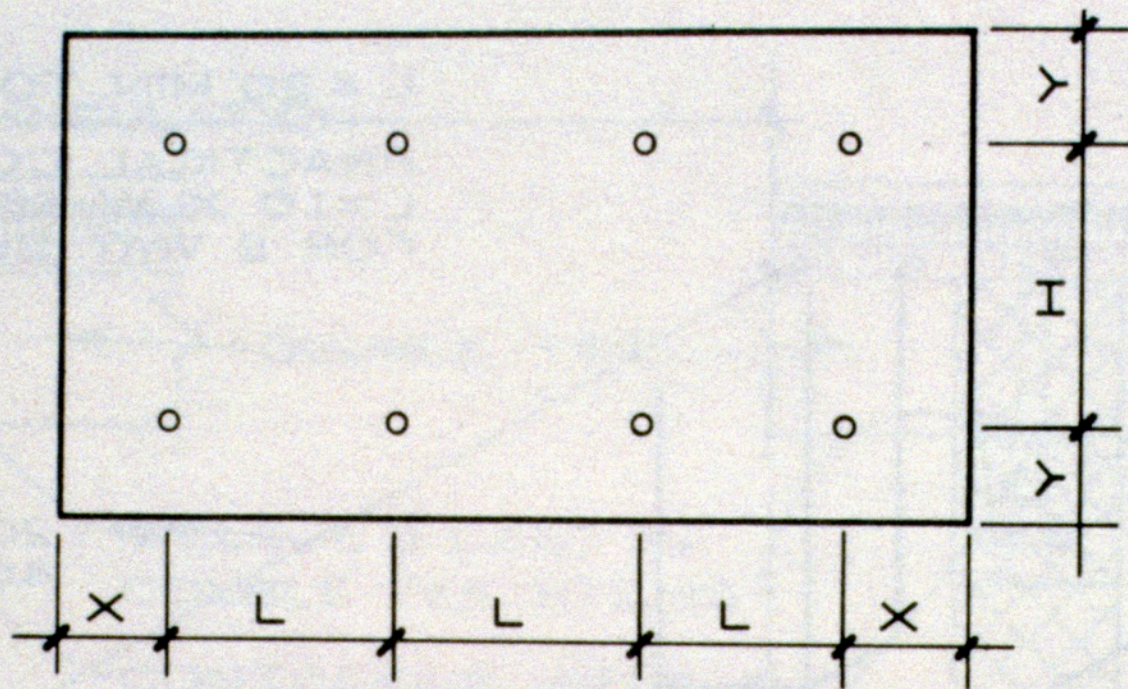


FIGURE 8.8 Sequence of lifting operations.

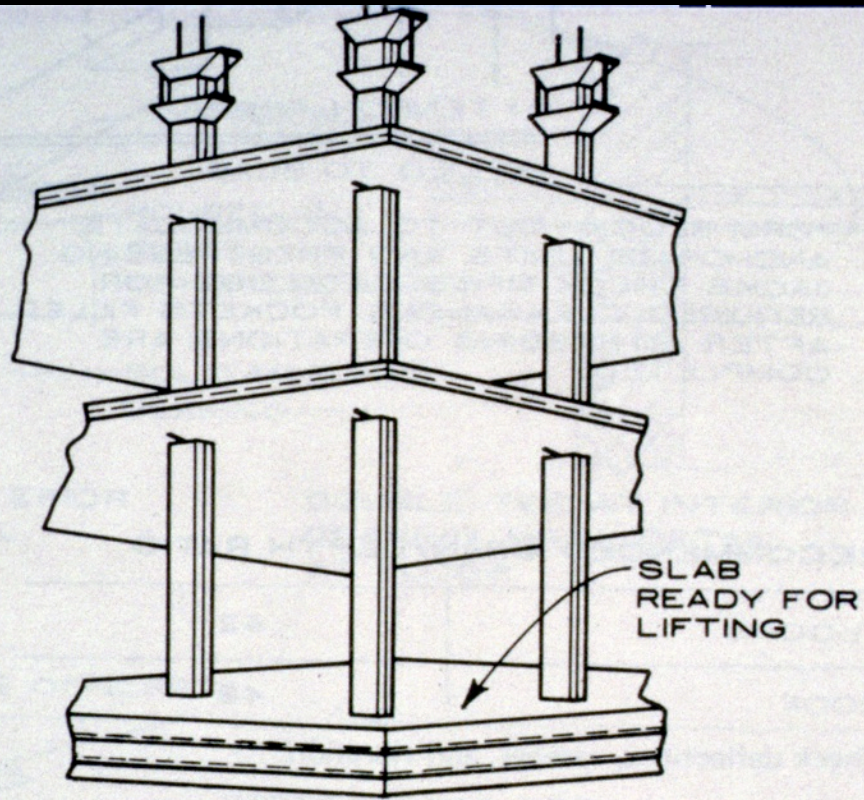


BEST RESULTS OCCUR WHEN
CANTILEVERS ARE PROPORTIONED
AS FOLLOWS:

$Y = 25\% H$ MIN; $40\% H$ MAX.

$X = 25\% L$ MIN; $40\% L$ MAX.

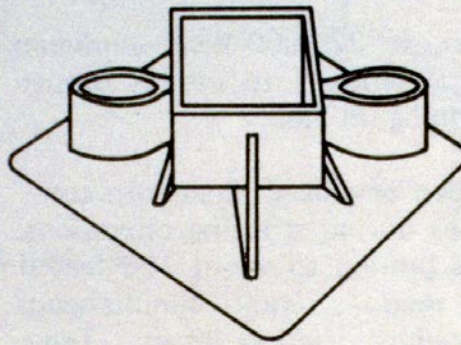
PLAN OF LIFT - SLAB



SCHEMATIC ISOMETRIC OF LIFT-SLAB METHOD

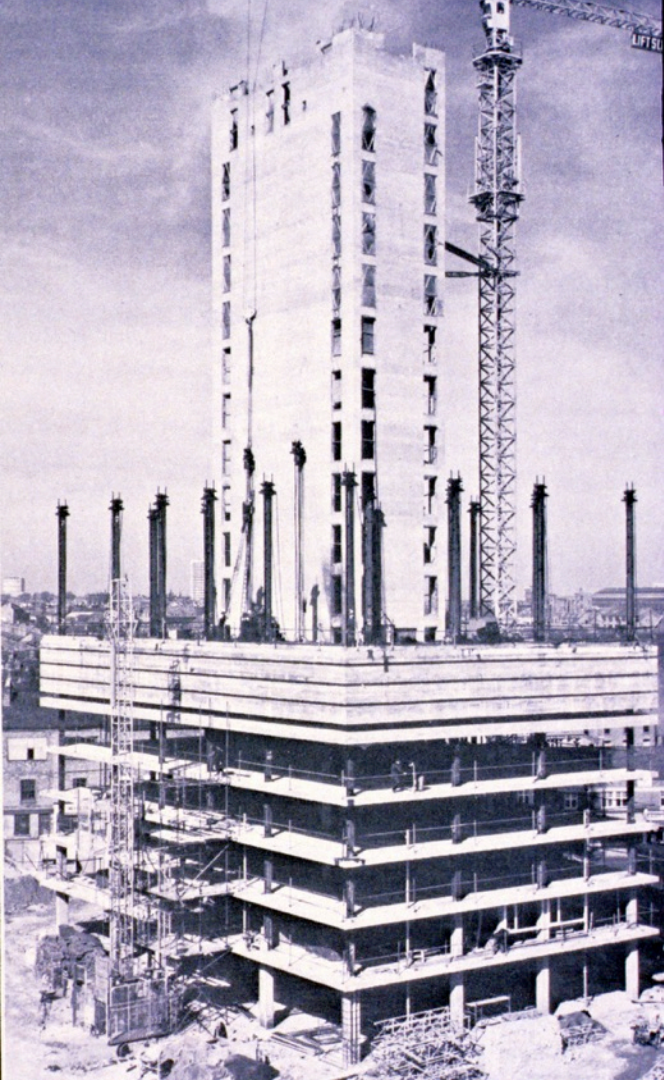
NOTE :

Schematic shows jacks at top of columns, lifting rods, shear bars under slabs. The slabs can be pre-stressed, post-tensioned, or reinforced concrete.



TYPICAL COLLAR USED IN LIFT - SLAB CONSTRUCTION

LIFT - SLAB CONSTRUCTION



<https://www.presconinc.com/prescon-technology/lift-slab/>



The lift slab method was fatefully implemented in the L'Ambiance Plaza development in Bridgeport, Connecticut. What was set to be a 16-storey residential project suddenly collapsed on April 23, 1987, killing 28 construction workers.

Precast Concrete Cladding Systems



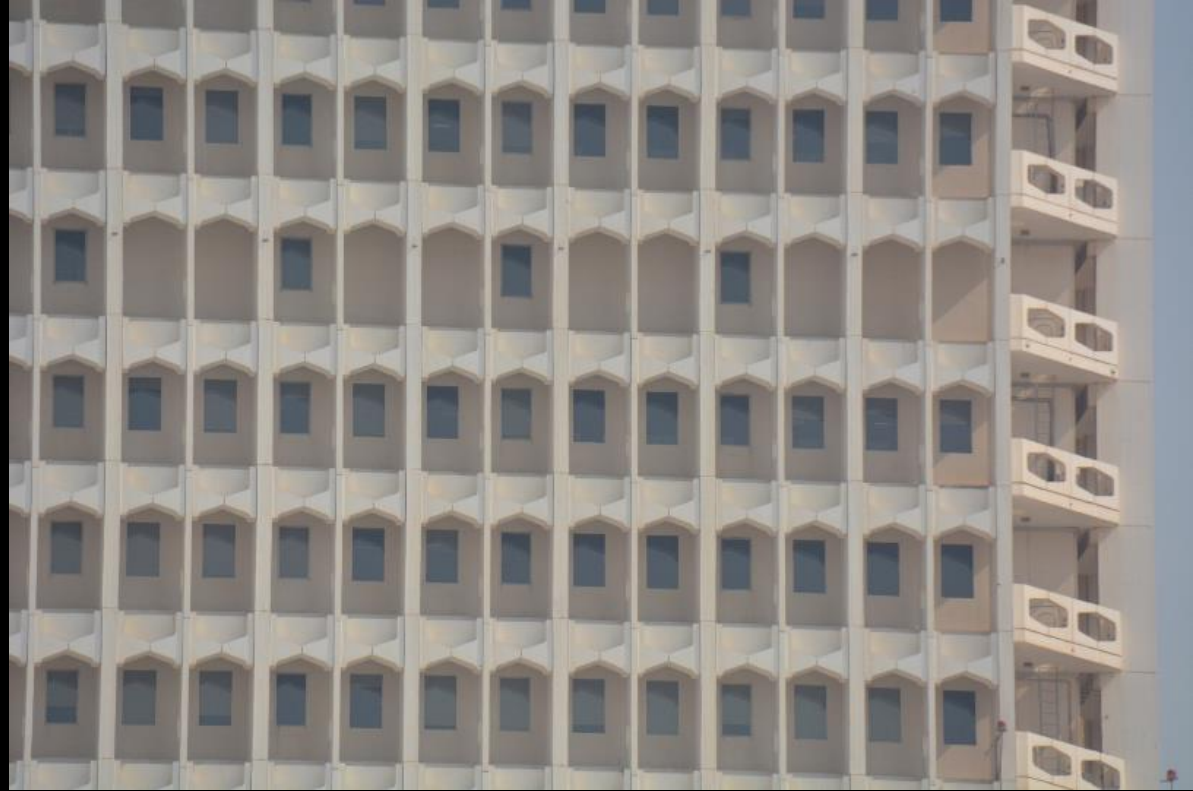
Transamerica Tower, San Francisco











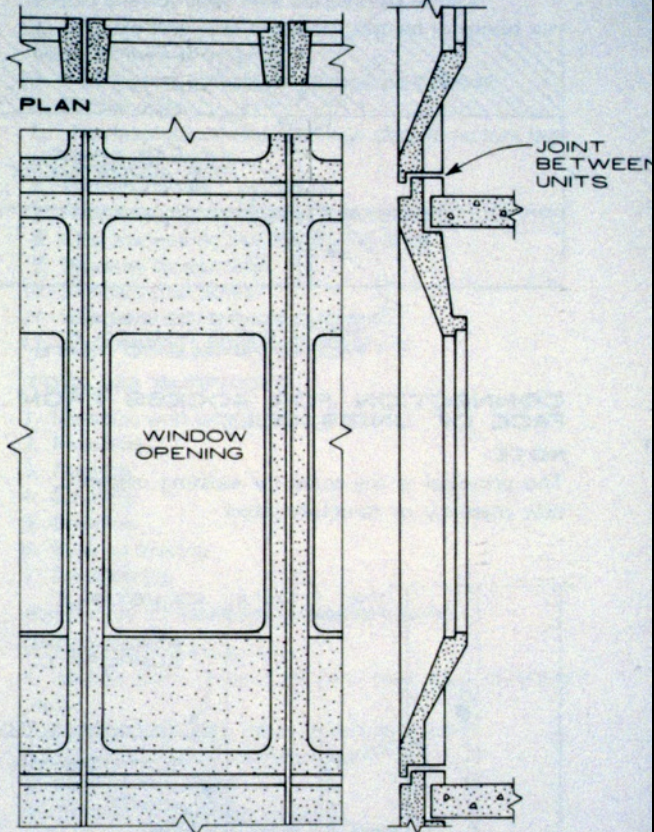
World Trade Center
Dubai, UAE
John R. Harris Associates
1979



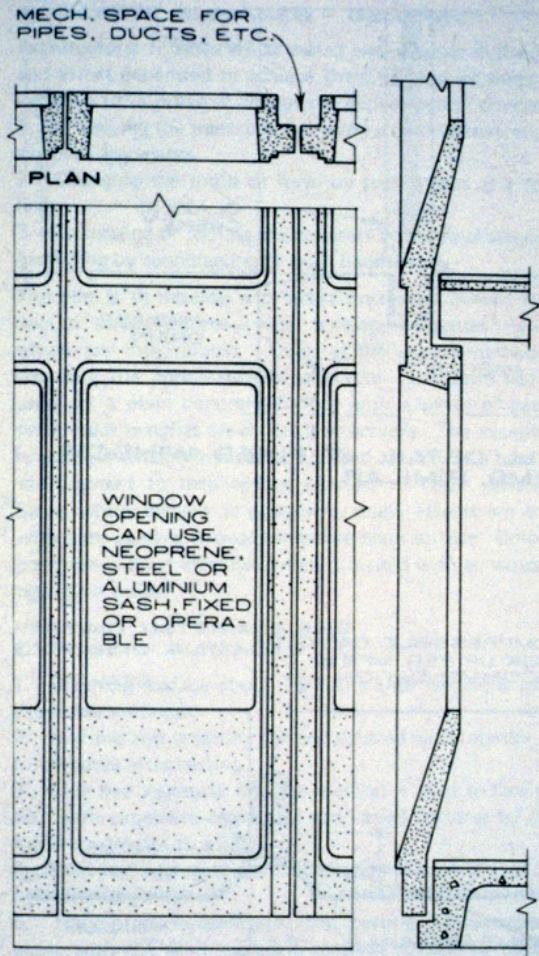


Washington, D.C.





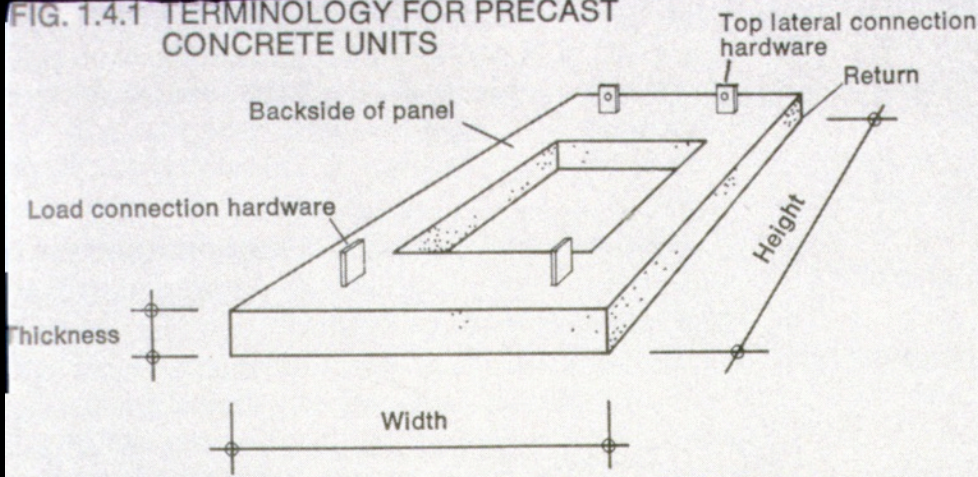
ELEVATION **SECTION**
SINGLE STORY FACING TYPE UNITS
 THIS UNIT HAS BOTH STRUCTURAL AND MECHANICAL USES



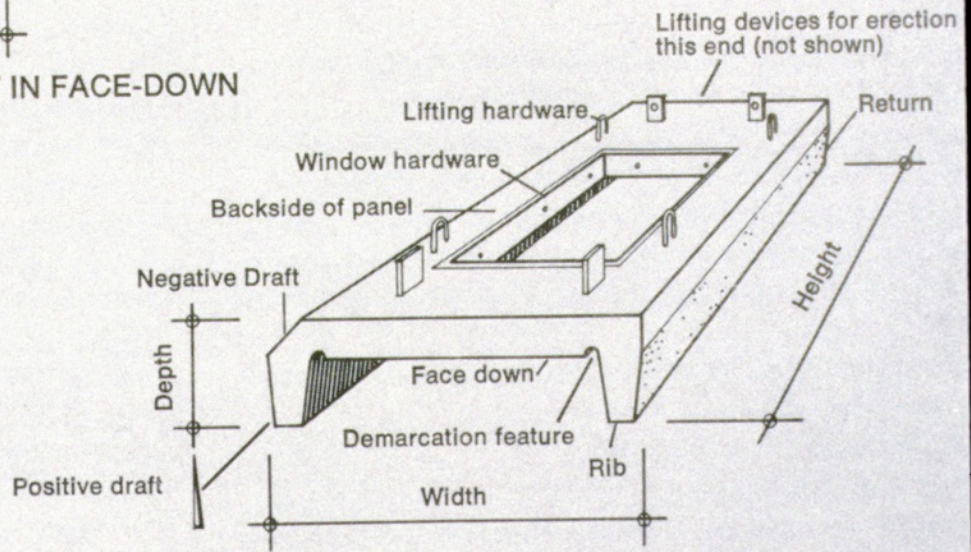
ELEVATION **SECTION**
MULTI-STORY FACING TYPE UNITS
 THIS UNIT HAS BOTH STRUCTURAL AND MECHANICAL USES



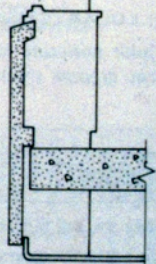
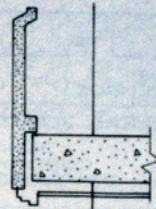
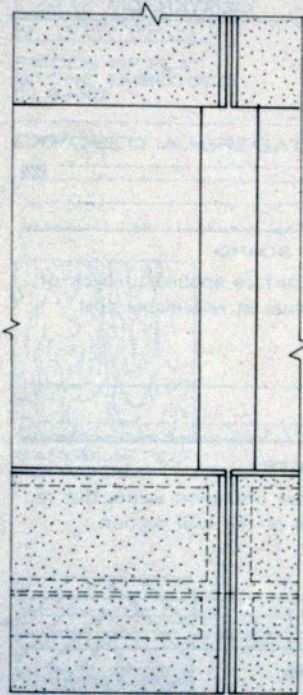
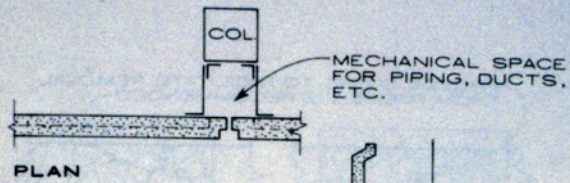
FIG. 1.4.1 TERMINOLOGY FOR PRECAST CONCRETE UNITS



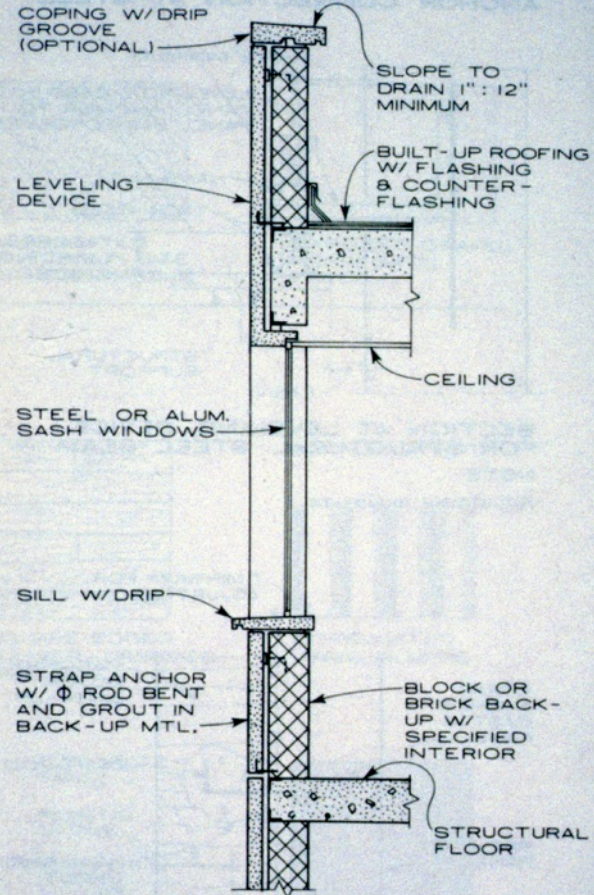
TYPICAL FLAT PANEL AS CAST IN FACE-DOWN POSITION



SCULPTURED PANEL AS CAST IN FACE-DOWN POSITION



SPANDREL FACING TYPE UNITS
 THESE ARE CANTILEVERED TO ALLOW MECHANICAL SPACE
BASIC TYPES



FLAT FACING UNITS WITH COPING-RETURN AT WINDOW HEAD-WINDOW SILL



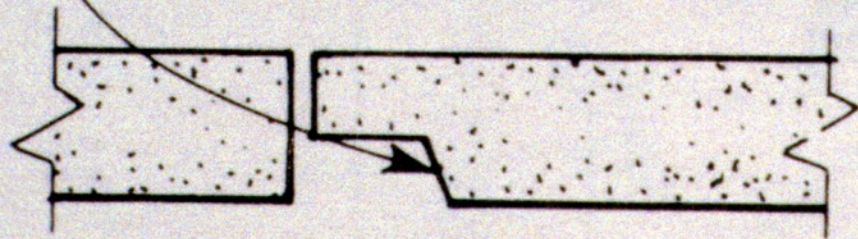




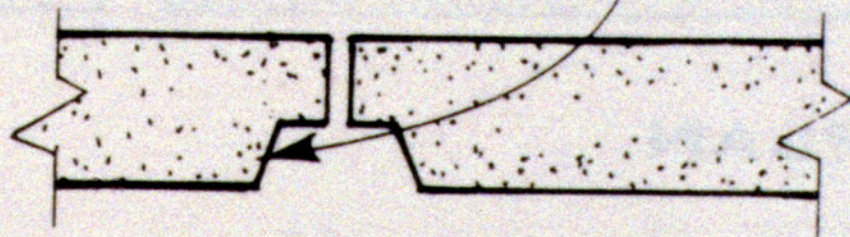




PROVIDE SLOPE TO FACILITATE REMOVAL
FROM FORMS, 1:12 RECOMMENDED



ONE SIDE

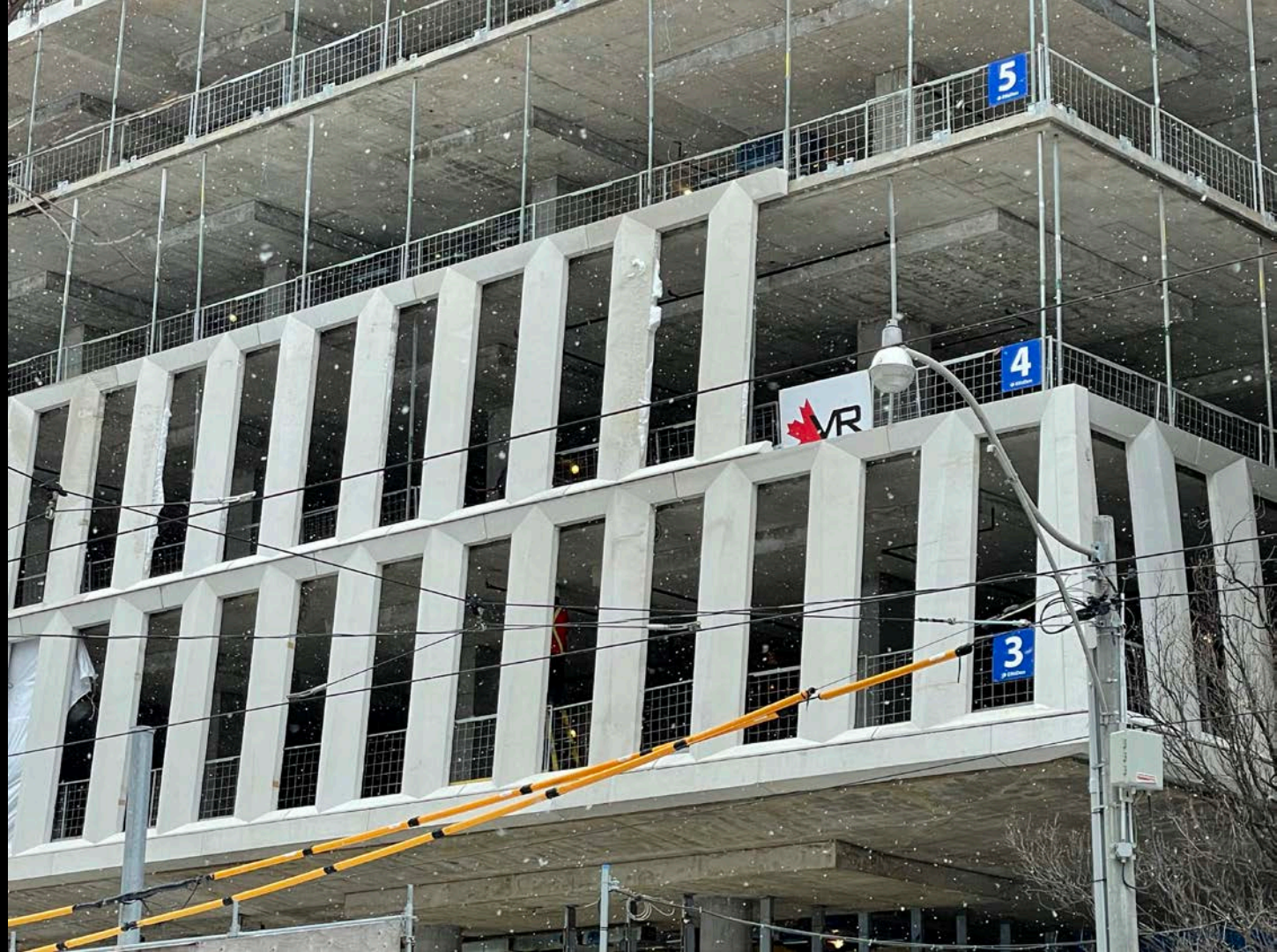


CENTERED

REVEAL JOINTS



College Street, Toronto, 2022



5

4

3

VR



Precast Concrete Cladding Types:

1. Old style uninsulated panel hung from the floor slabs
 - with steel stud back up and batt insulation (bad)
 - with steel stud back up and impermeable spray foam insulation (better)
 - better if also installed as a rain screen
2. Sandwich panel with impermeable insulation between
 - Best if accompanied by a rain screen drainage behind

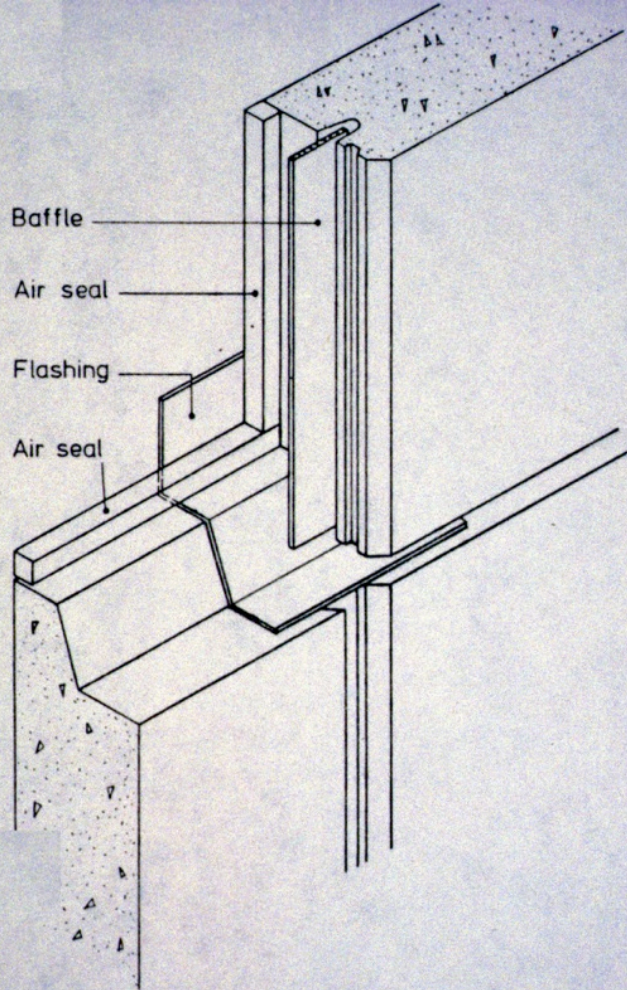
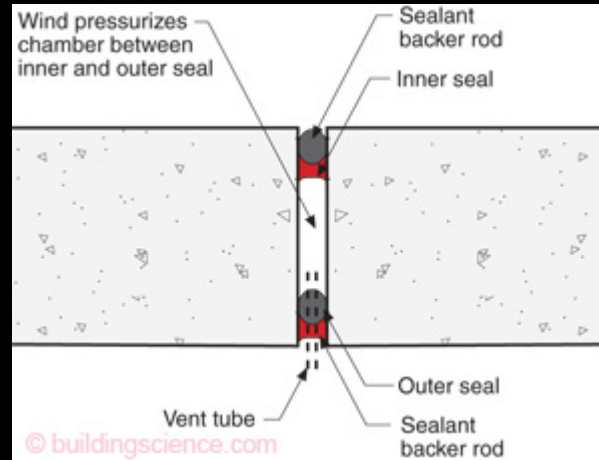
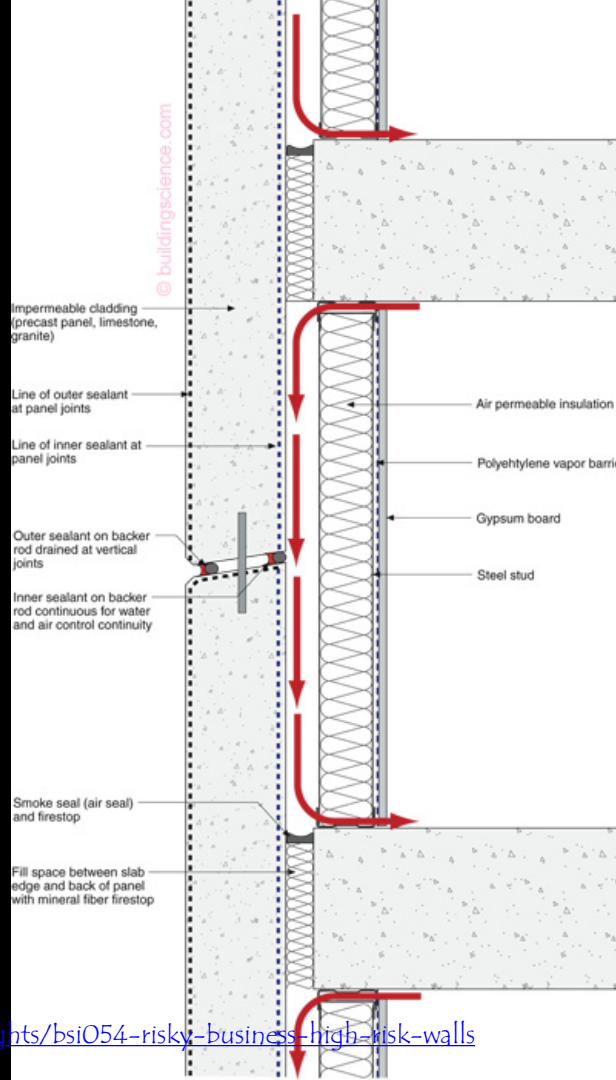
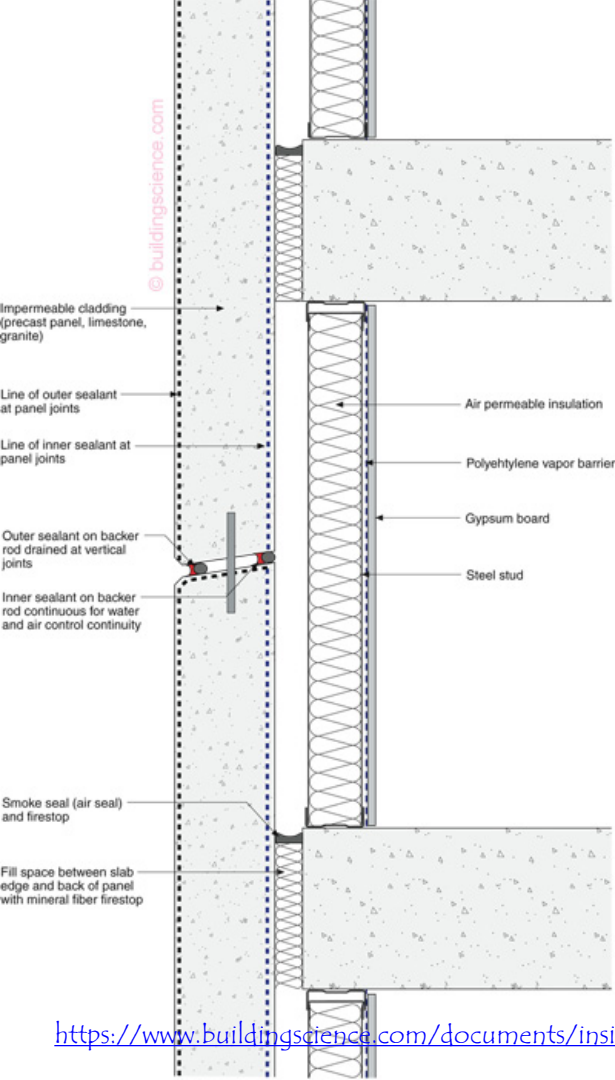


Figure 12. Intersection between horizontal and vertical two-stage joints in an external wall

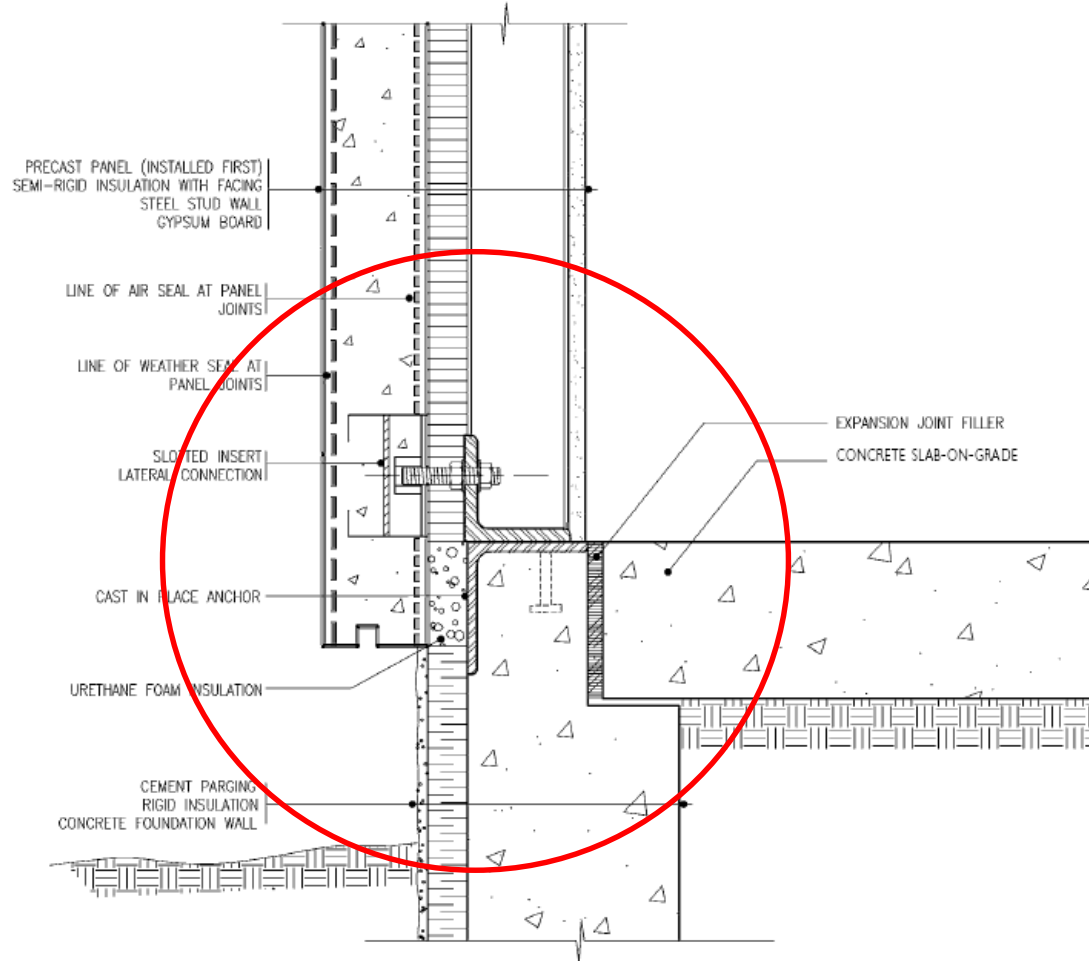


Two-Stage Joint—An inner and outer seal provide drainage at joints. The outer seal is exposed to the elements and gets trashed by the UV and heat and water but the assembly still works because of the interior protected seal. This interior seal is installed from the exterior for continuity reasons.

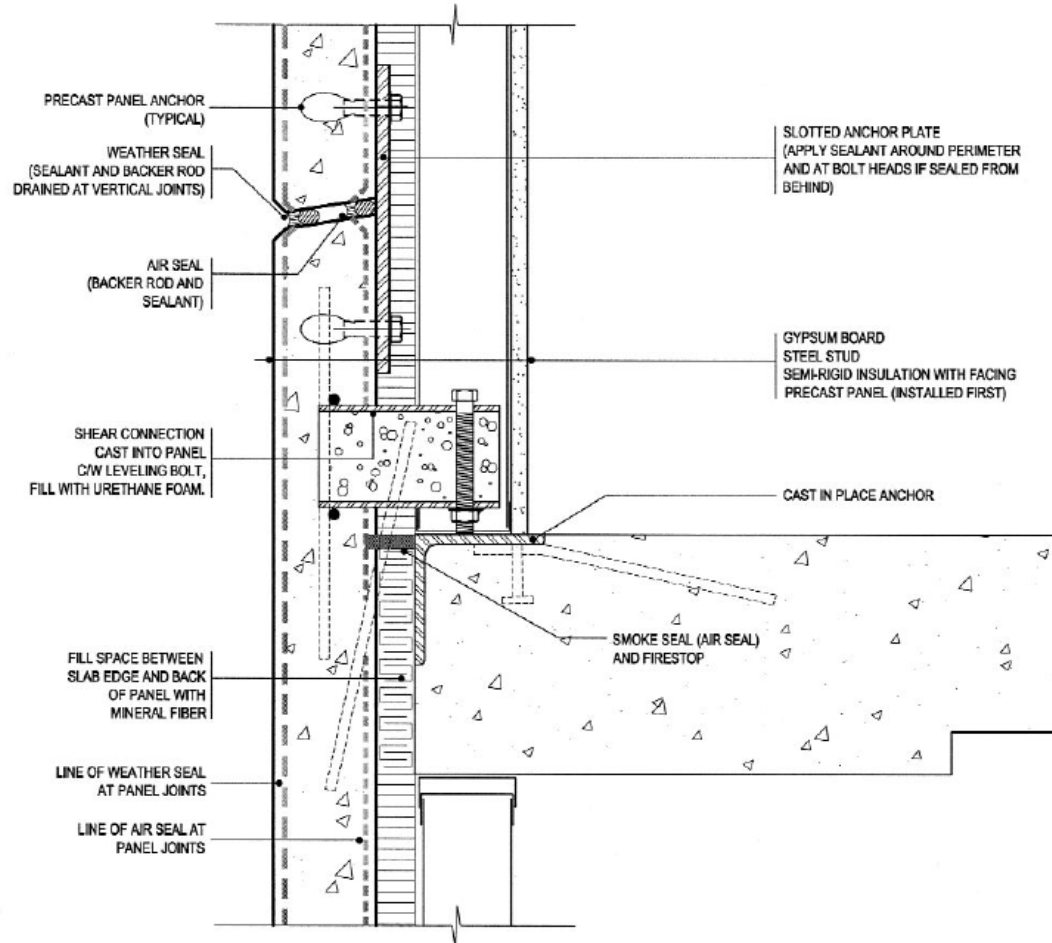


Face-sealed cladding (“perfect barrier”) that is impermeable to water vapor. It is insulated on the interior with air permeable insulation usually held in place between steel studs or impaled on pins protruding from the back of the cladding and covered by a vapor barrier.

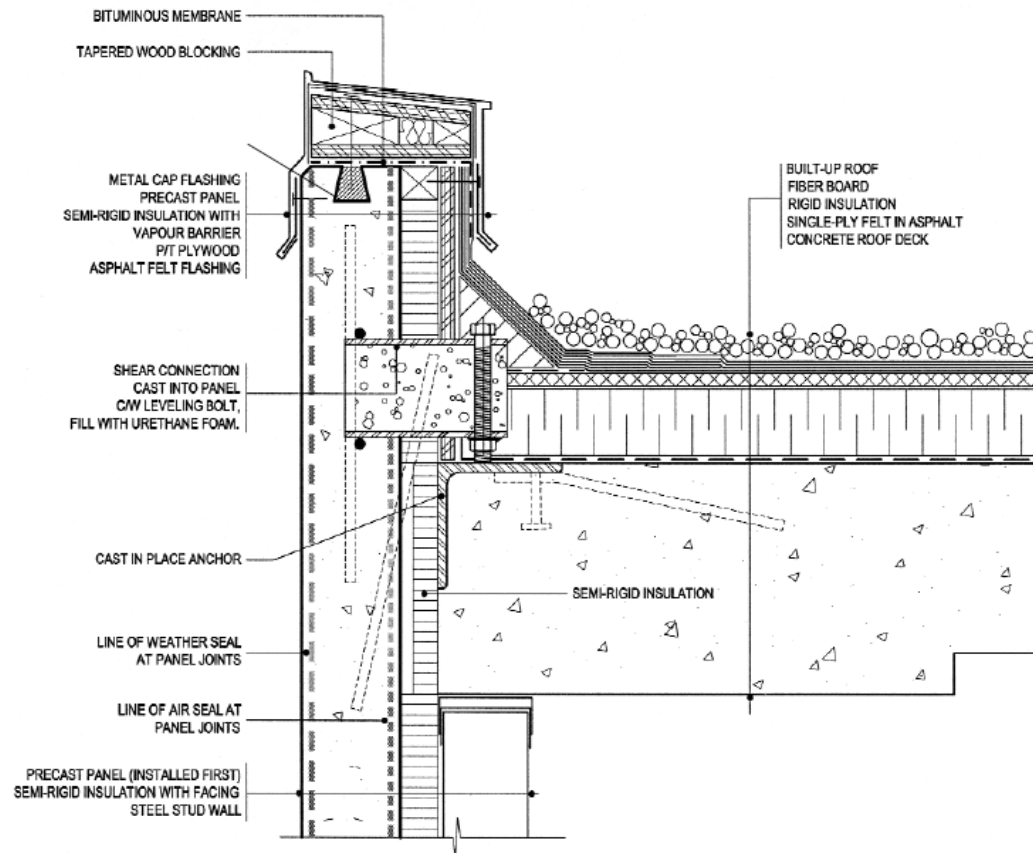
BAD DETAIL as the face seal is likely to fail and the cavity is not designed as a rain screen to drain.



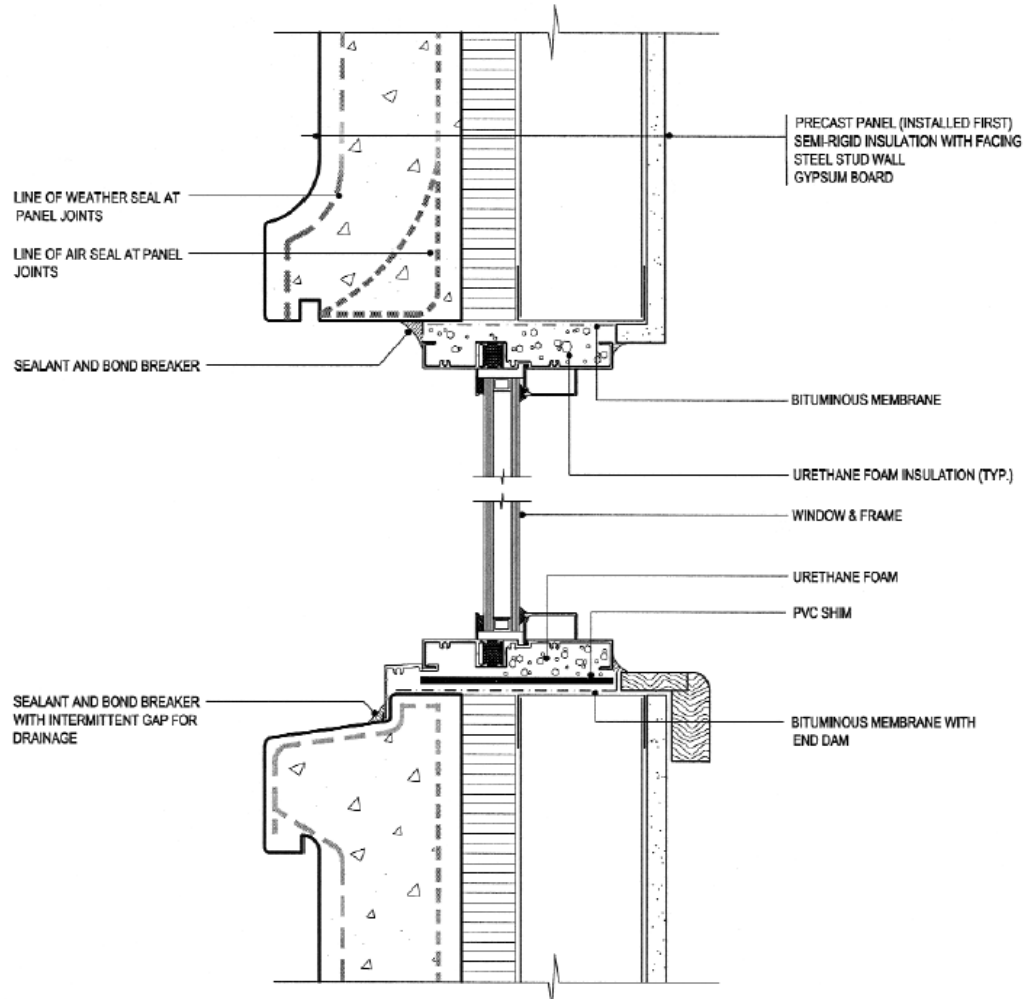
CONVENTIONAL PANEL
 LATERAL FOUNDATION CONNECTION



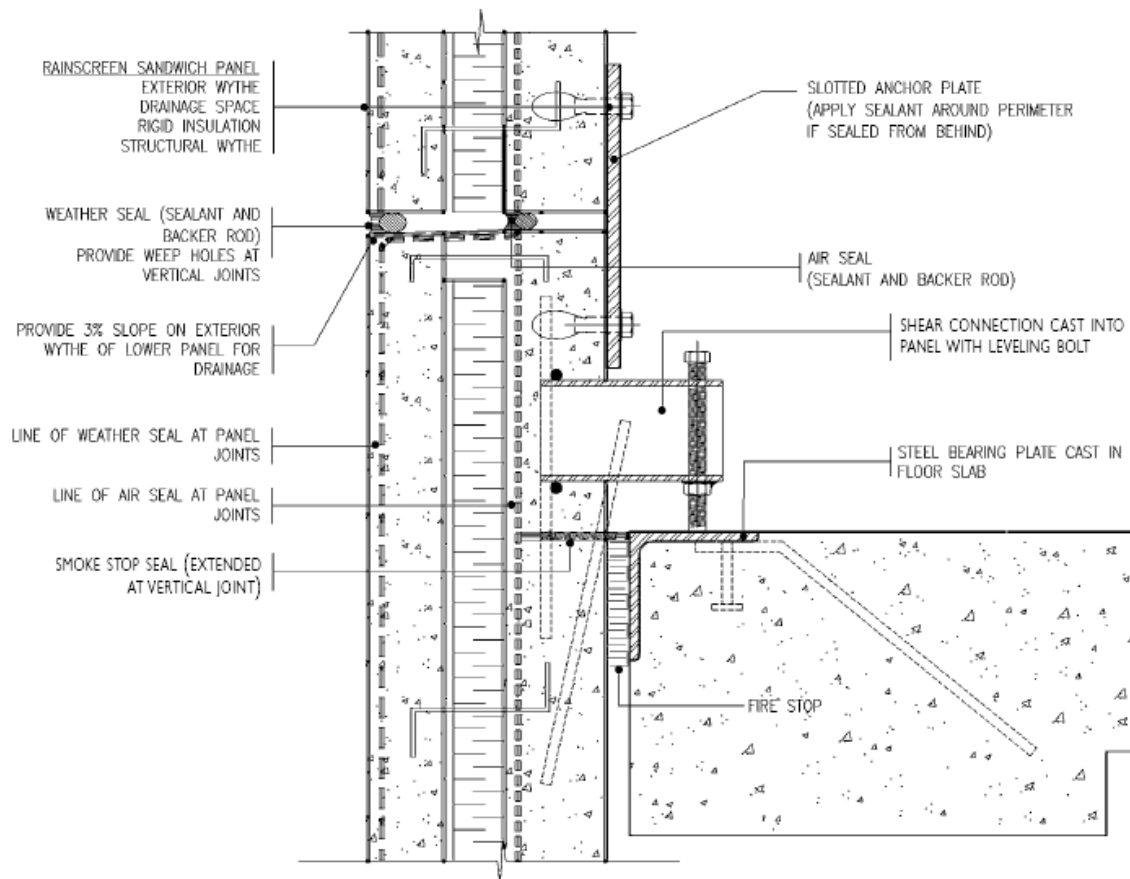
CONVENTIONAL PANEL
 SLAB BEARING CONNECTION



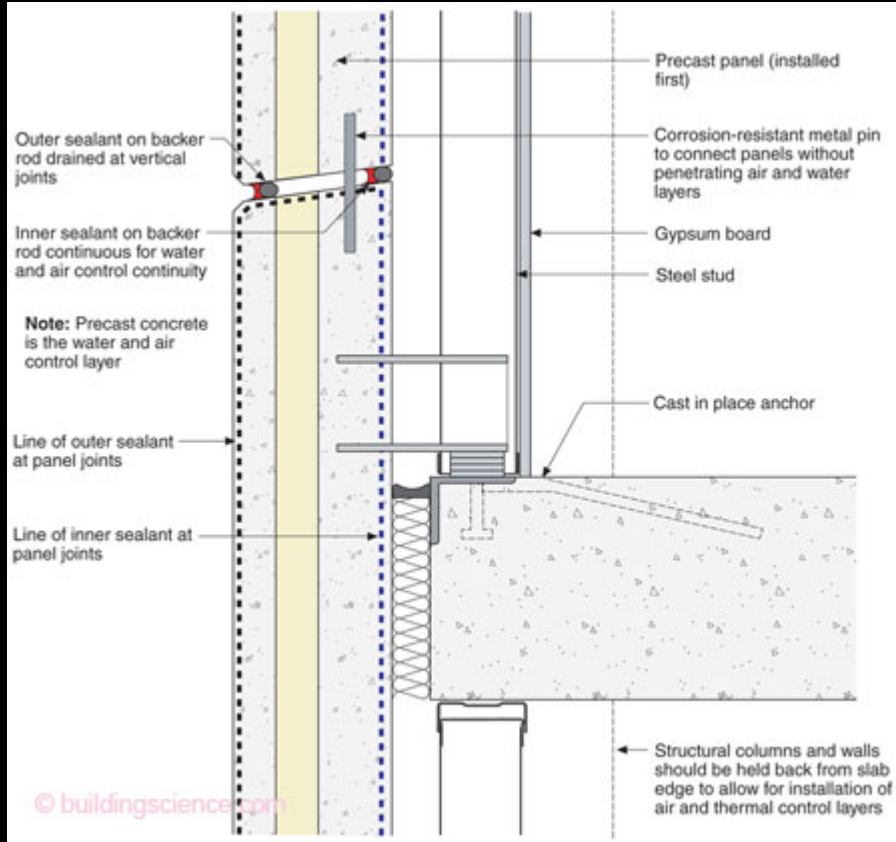
CONVENTIONAL PANEL
TOP HUNG PARAPET CONNECTION



CONVENTIONAL PANEL
 WINDOW HEAD/SILL CONNECTION



SANDWICH PANEL WITH RAINSCREEN
 BEARING CONNECTION TO SLAB EDGE



Sandwich Panel—Low risk preinsulated precast panel. Rigid insulation located between two layers of concrete that comprise the panel.



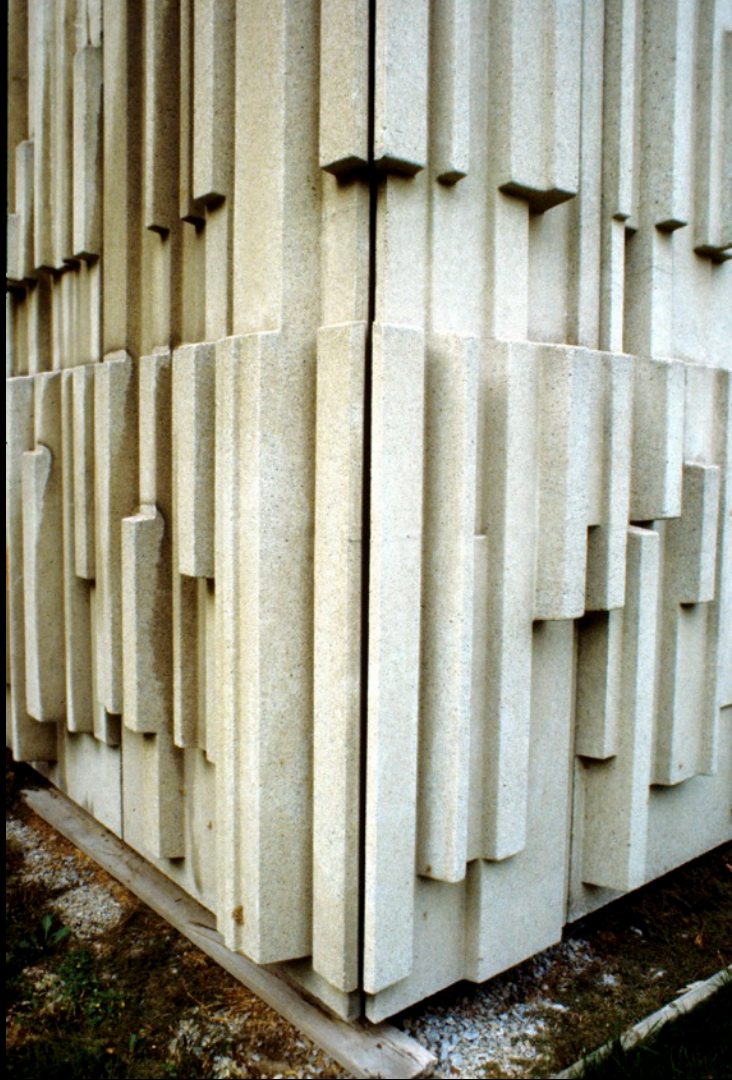
Weathering is a big issue in urban projects.

The rain washes down the building and deposits dirt as it slows down.

Worse on smooth finished precast.







Fabricating the Precast Elements





























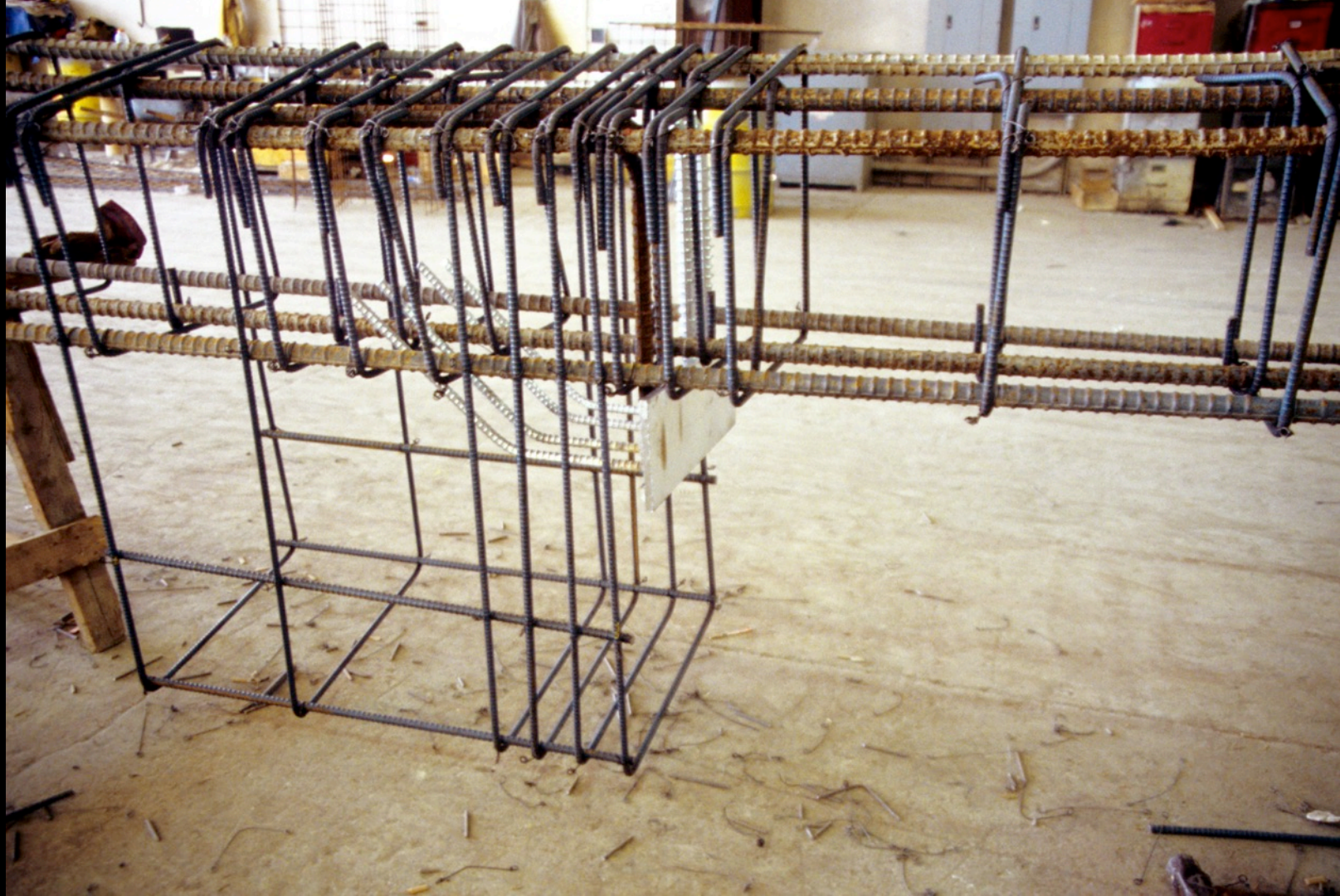












































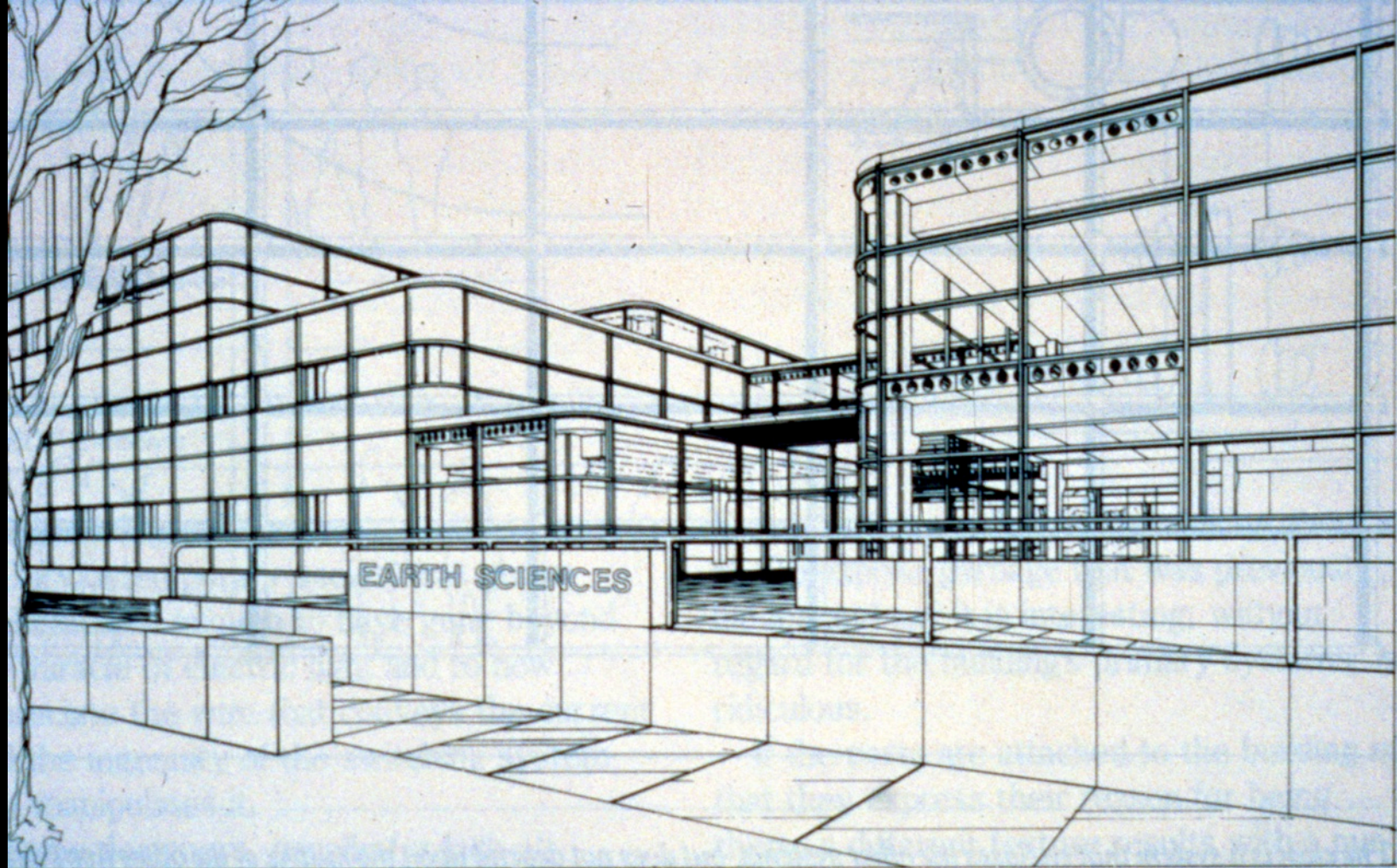




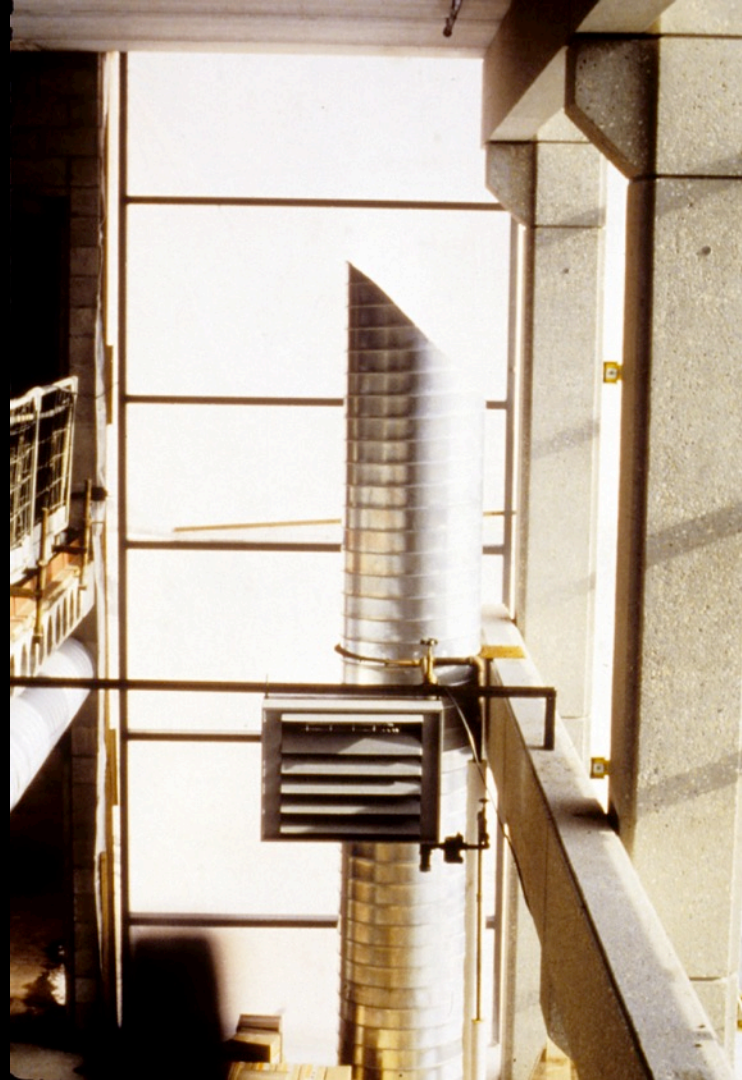
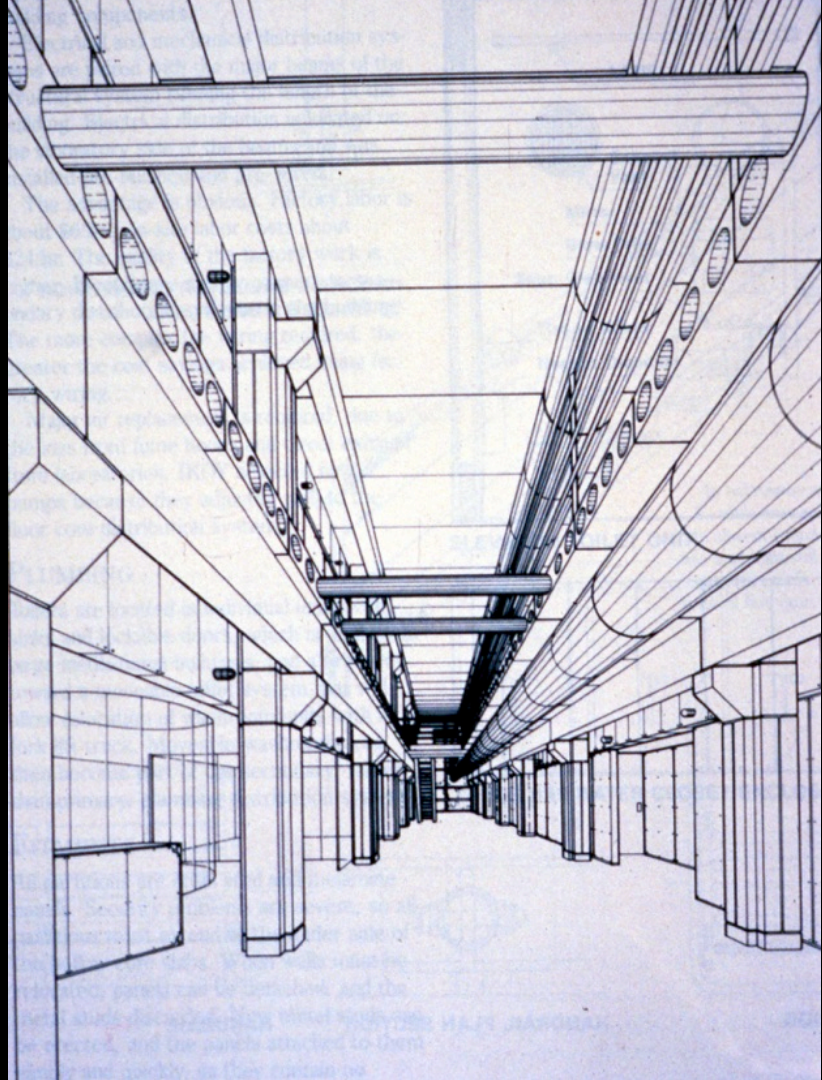




























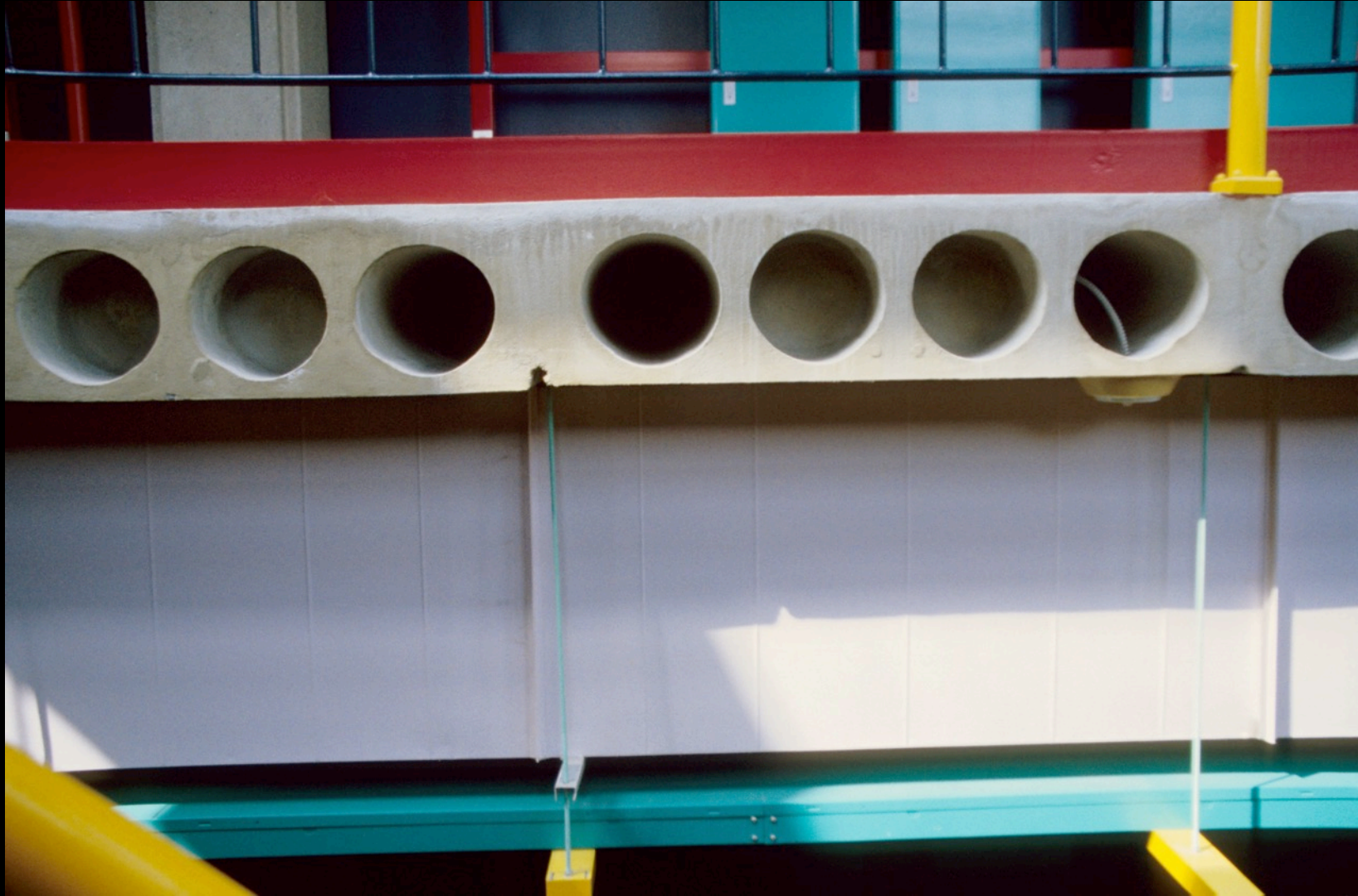










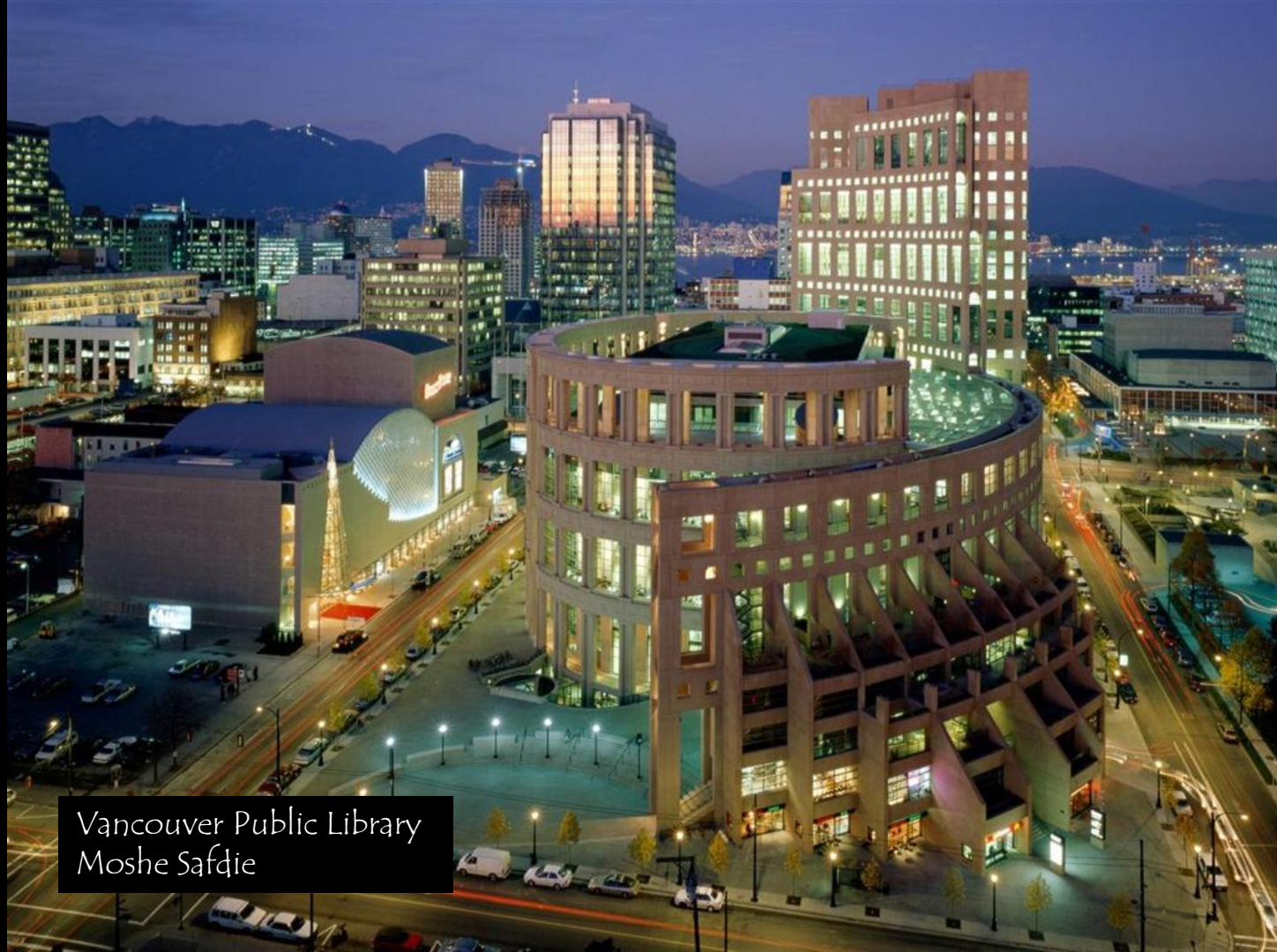












Vancouver Public Library
Moshe Safdie







Robson St

Homer St

Robson St

ARTS & CULTURE











Salt Lake City Public Library
Moshe Safdie













Skyscraper
Medellin, Colombia







AURORA MUNICIPAL JUSTICE CENTER

Aurora, Colorado

Architects / Engineers:

Skidmore, Owings & Merrill, Washington, D.C.

Robert P. Holmes, Design Partner

Ken Wiseman, Senior Designer

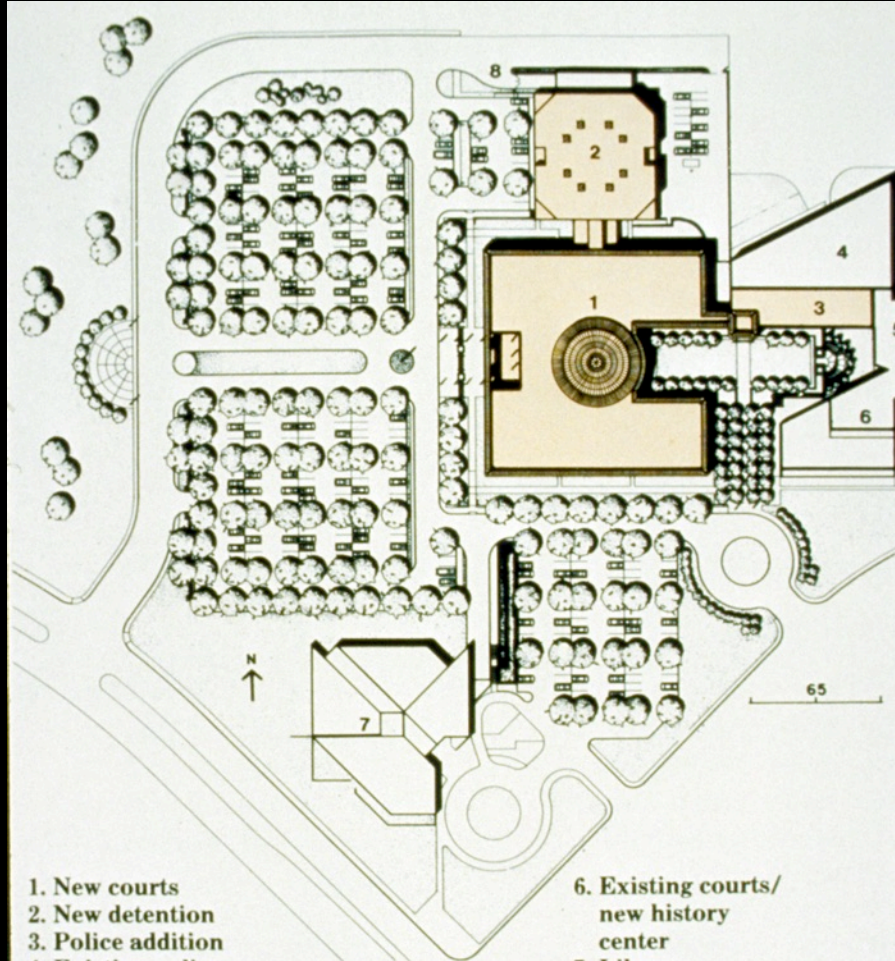
Ken Leibowitz, Structural Engineer

General Contractor: Weitz-Cohen Construction Co.

Precast / Prestressed Concrete Manufacturer:

Rocky Mountain Prestress, Inc. Denver, Colorado

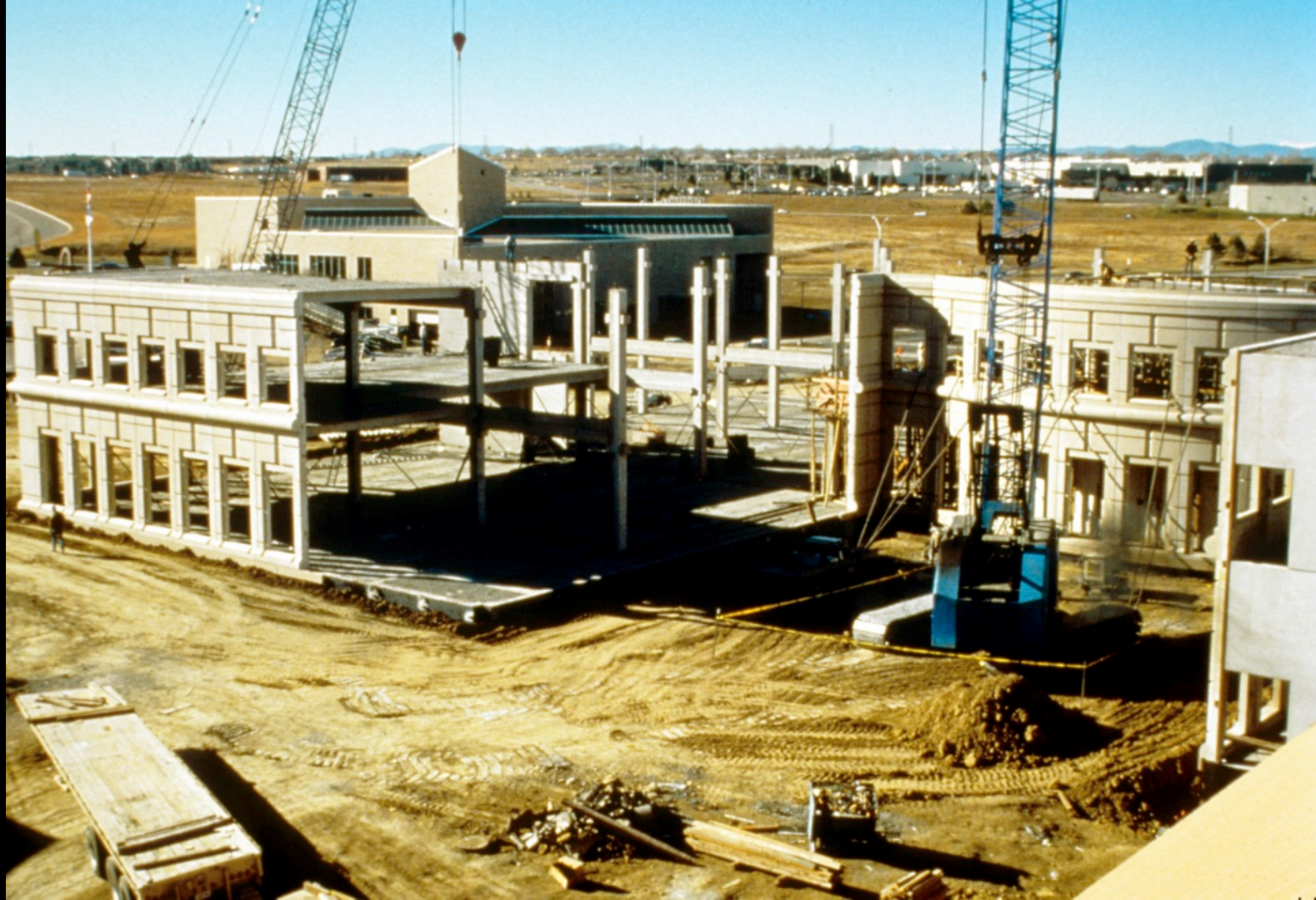




- 1. New courts
- 2. New detention
- 3. Police addition
- 4. Existing police
- 5. Existing detention
(to be removed)

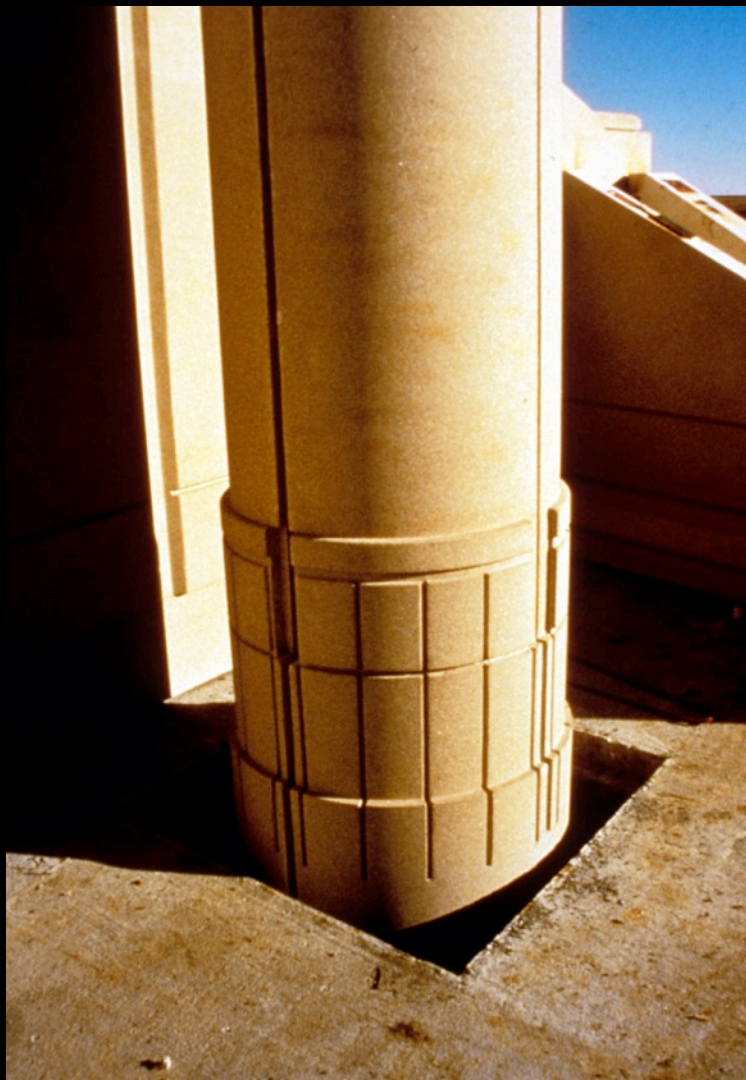
- 6. Existing courts/
new history
center
- 7. Library
- 8. Sallyport























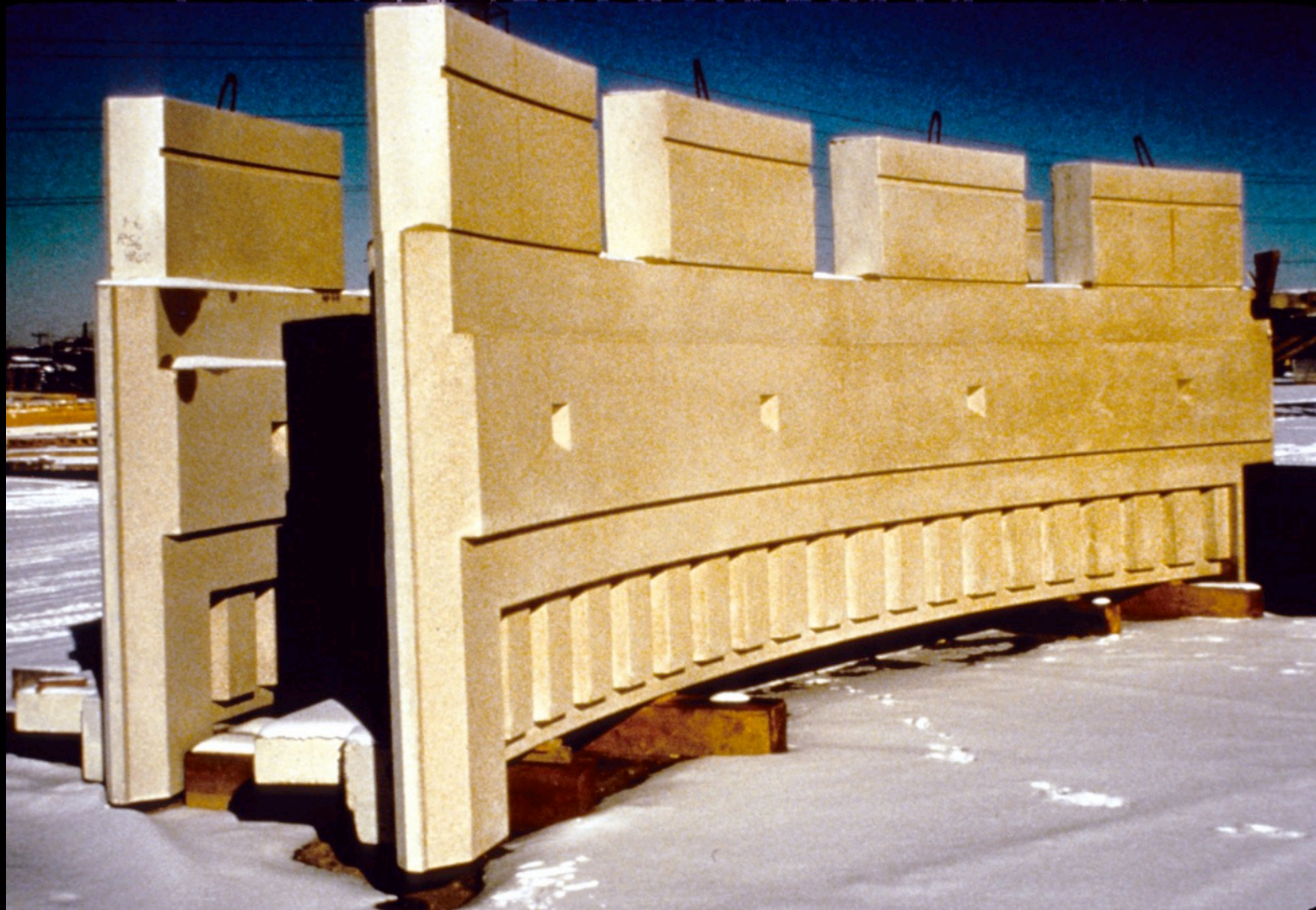














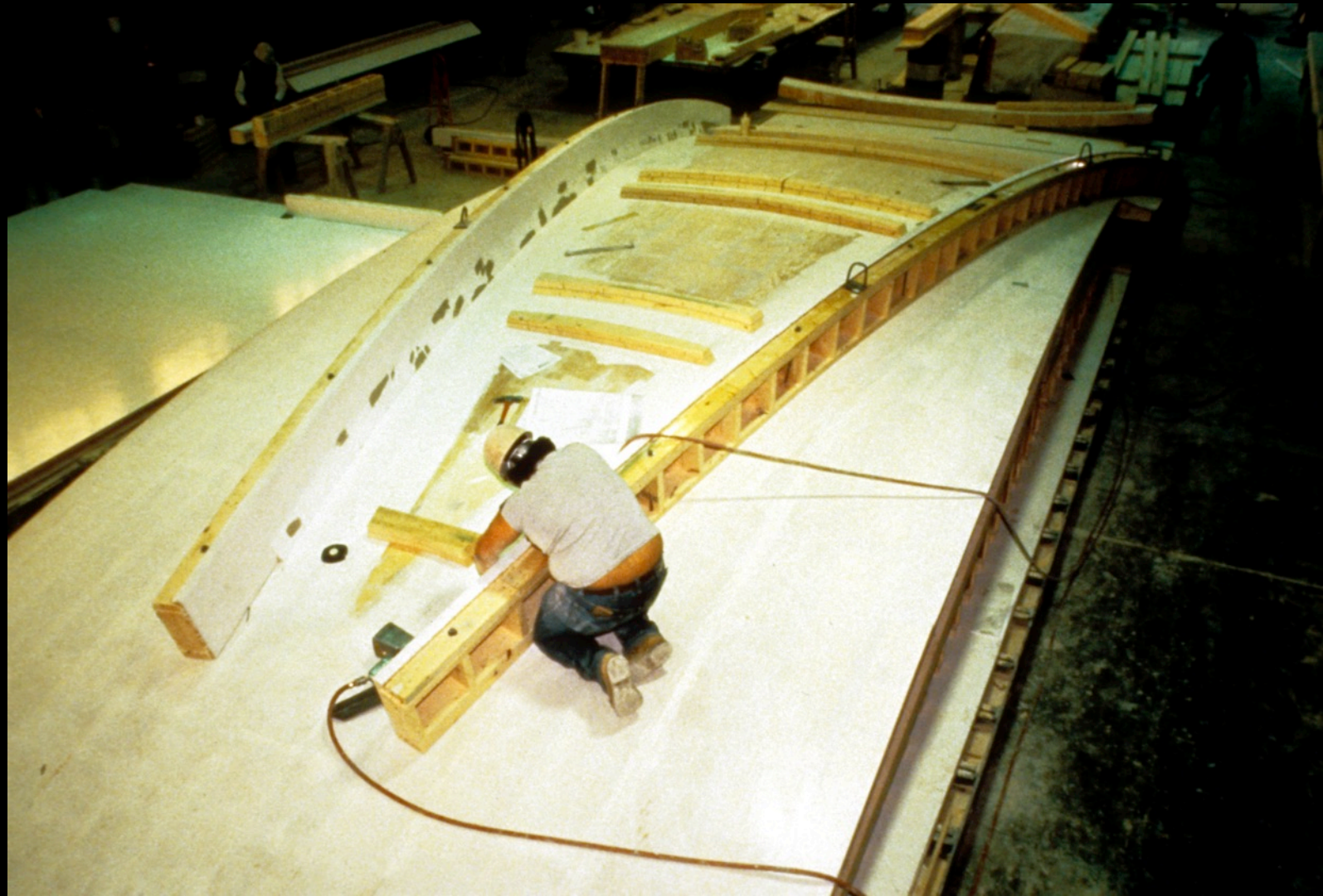








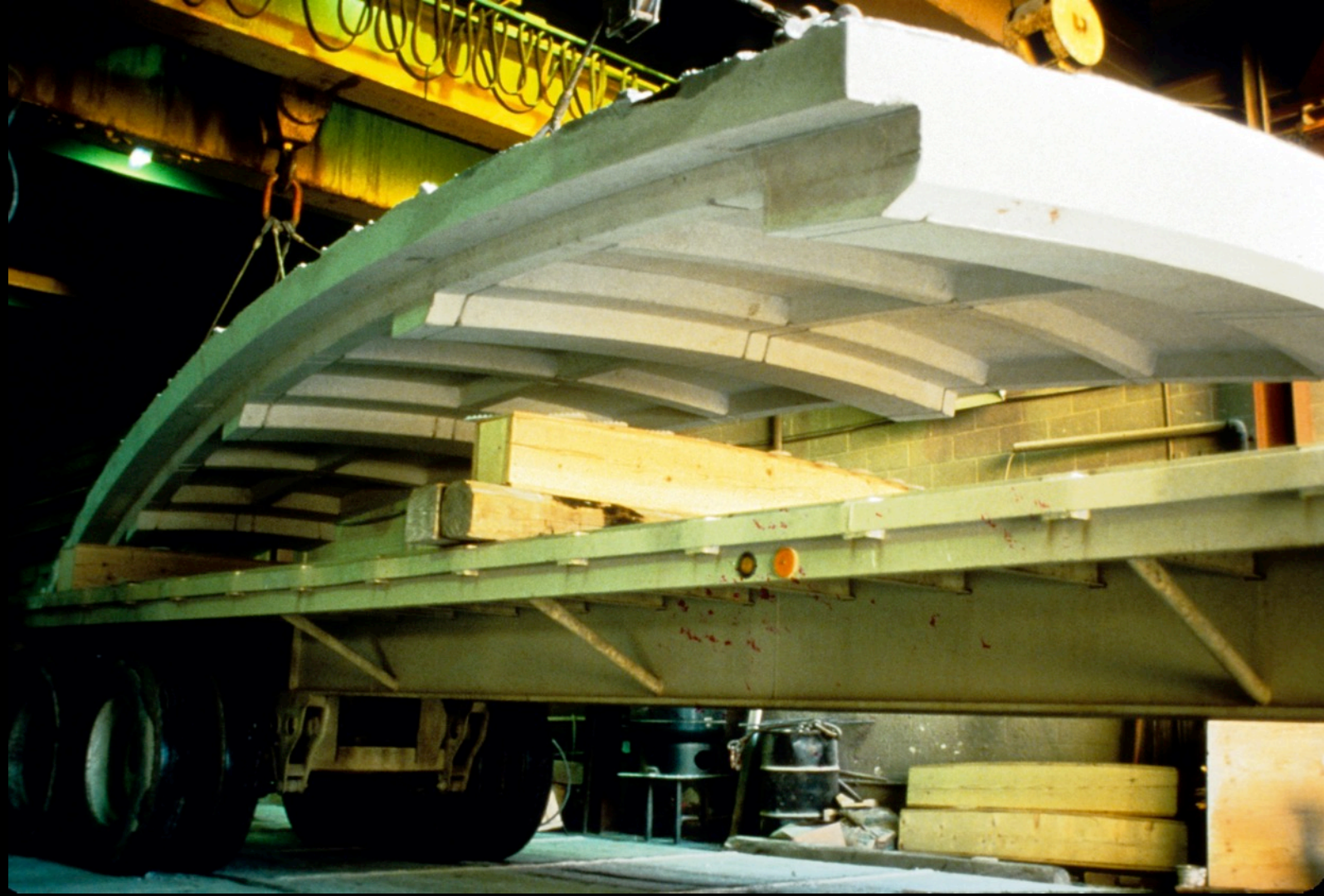












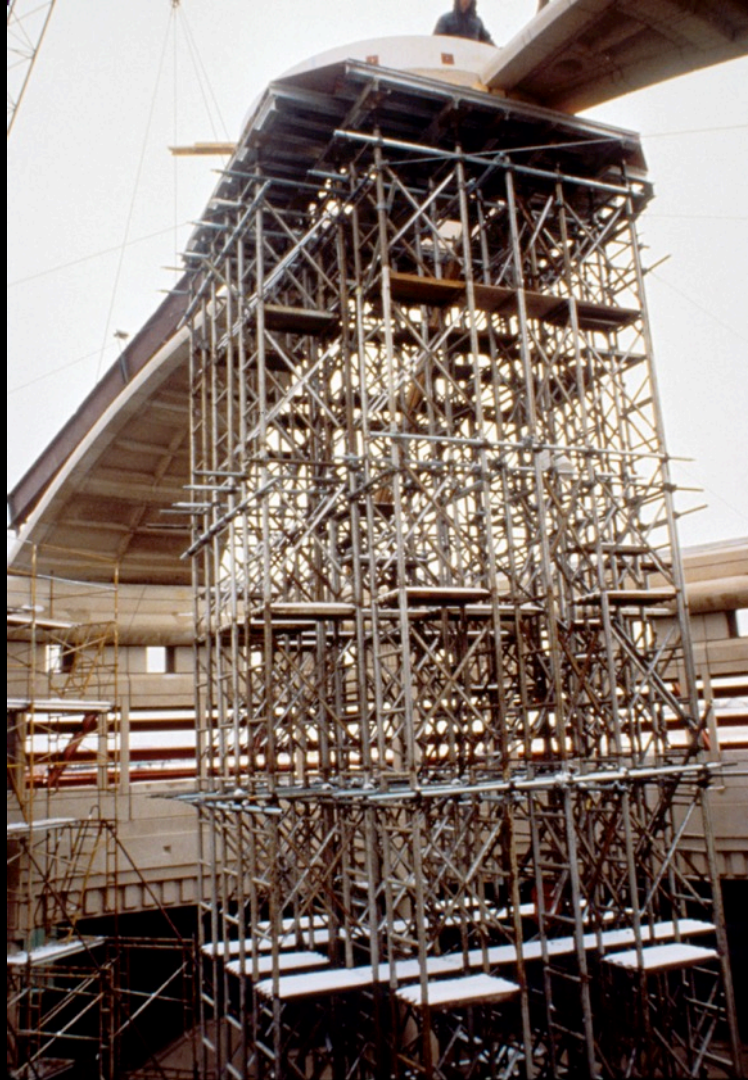


165th



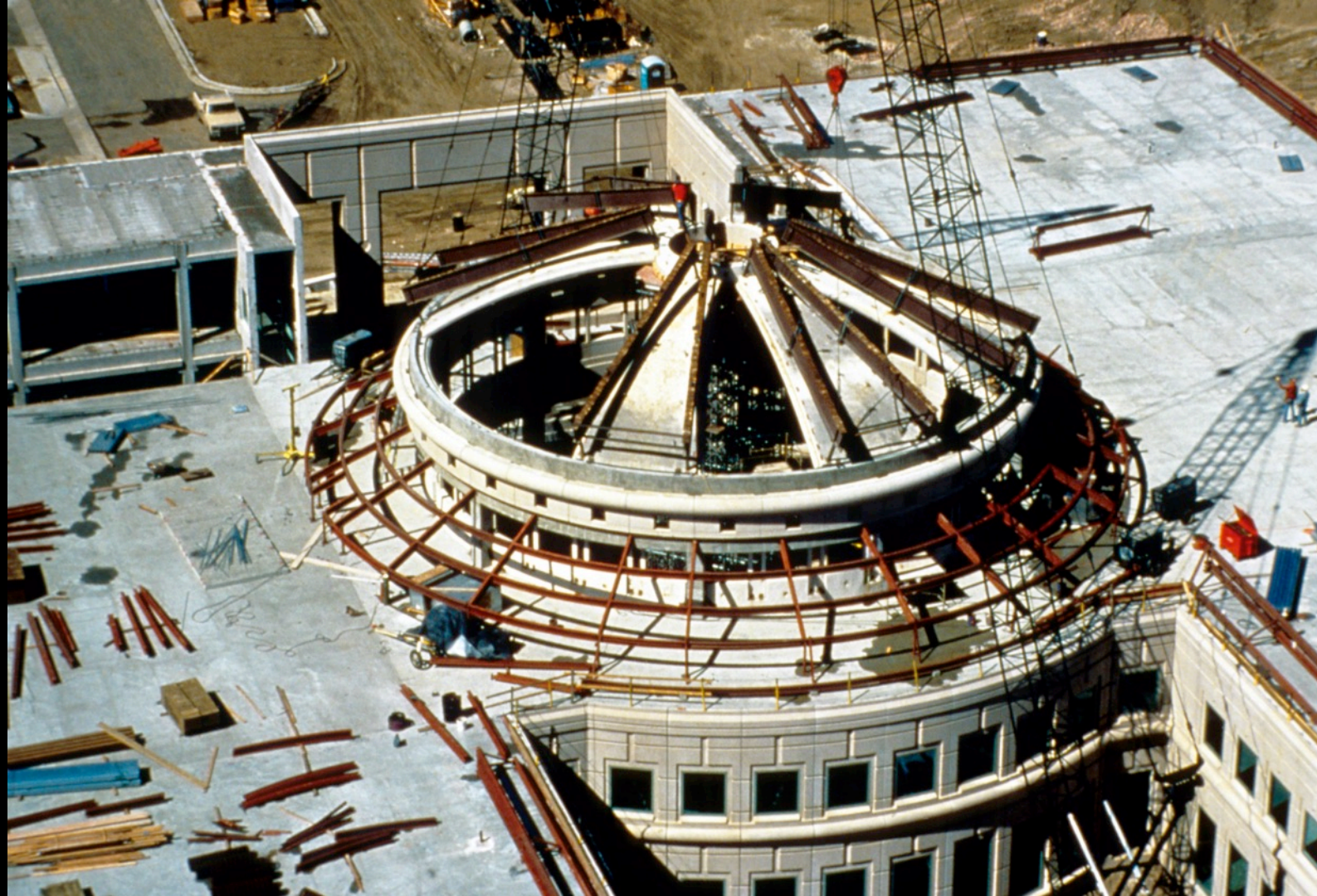


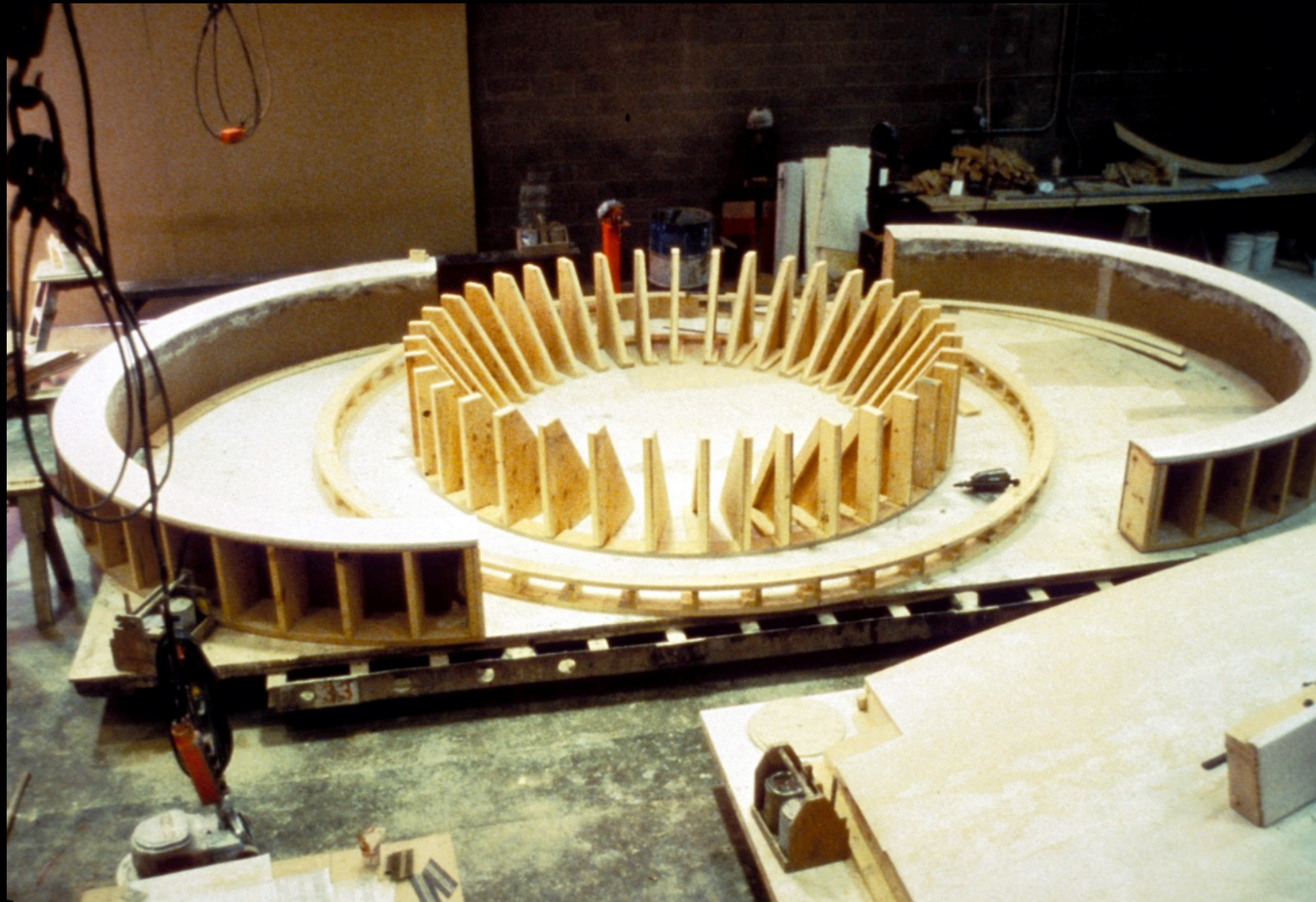


























Prestressed Concrete:

Prestressed is the general term referring to BOTH pre-tensioned and post-tensioned forms

Pre-tensioned concrete:

Where the steel tendons are inserted and stretched BEFORE the concrete is placed and has set

Post-tensioned Concrete:

Normally where conduits are positioned in the concrete forms, concrete is placed around and cured, THEN the steel tendons are inserted and stretched.

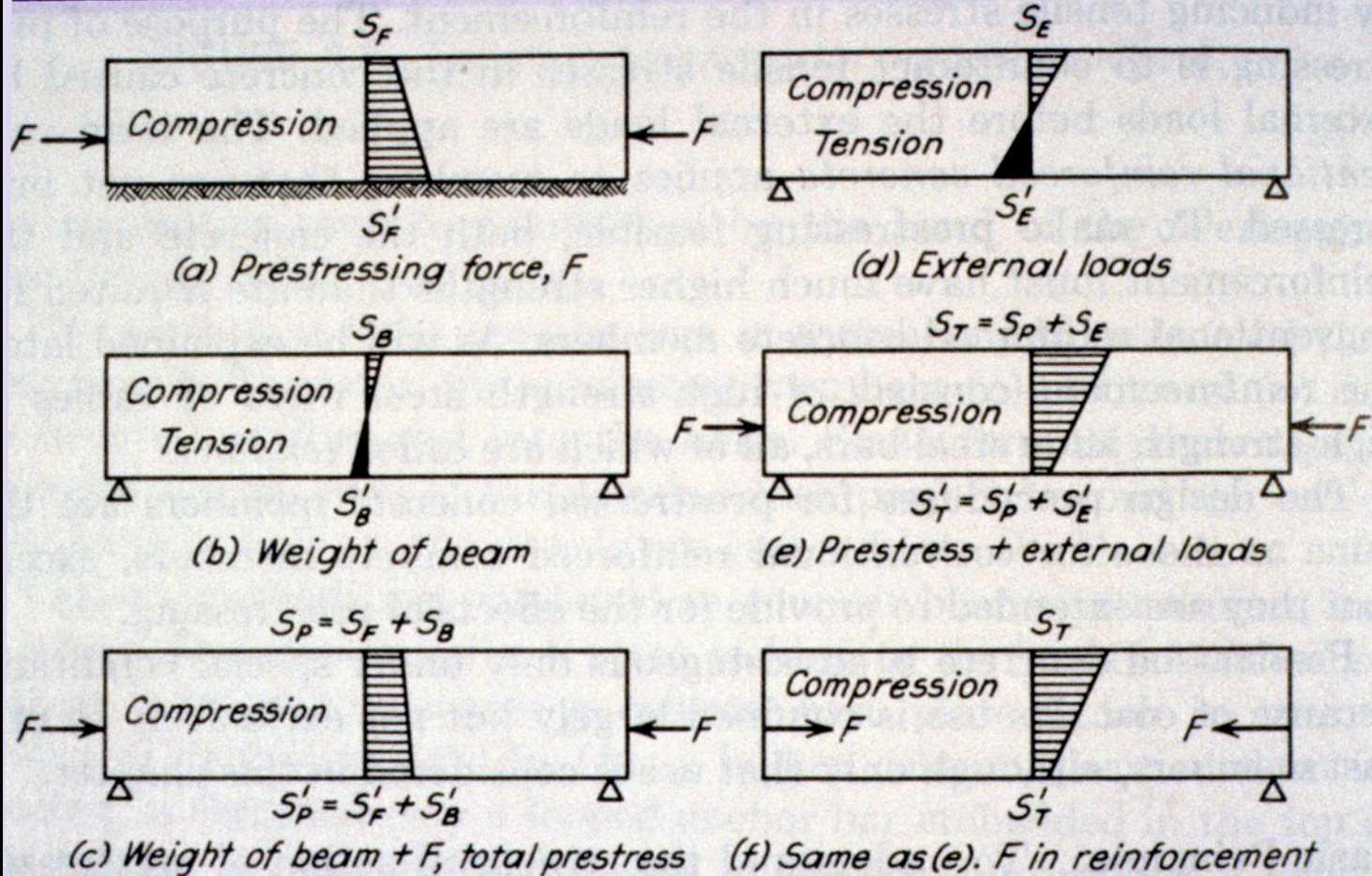
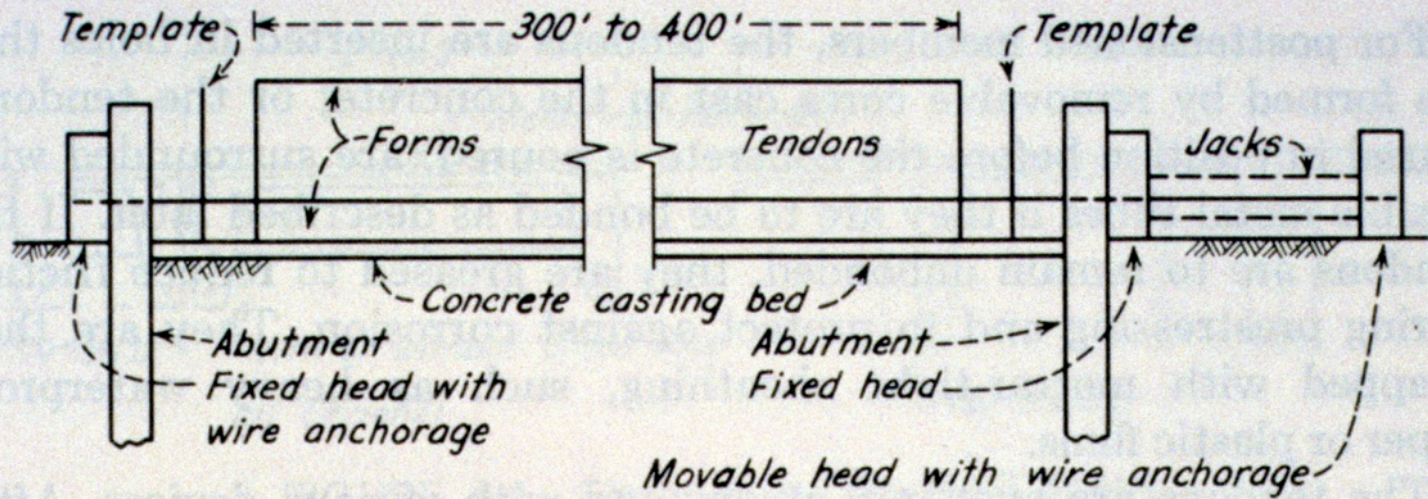
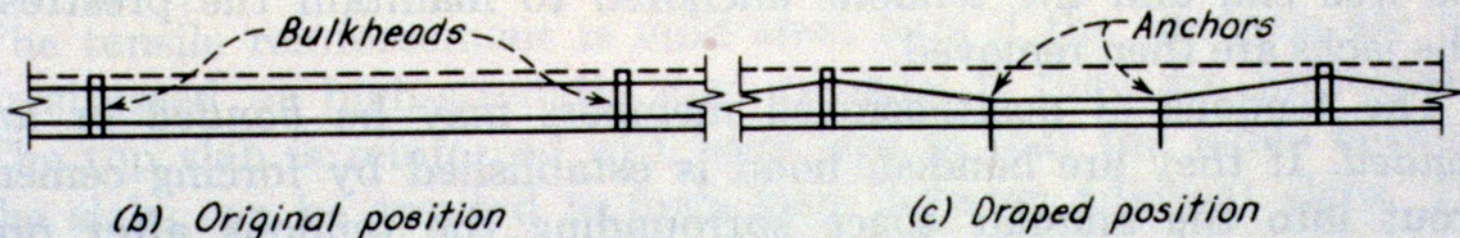


FIGURE 8.2 Fiber stresses caused by various loading conditions.



(a) Pretensioning bed for long-line process
 Arranged from Portland Cement Ass'n publication



(b) Original position

(c) Draped position

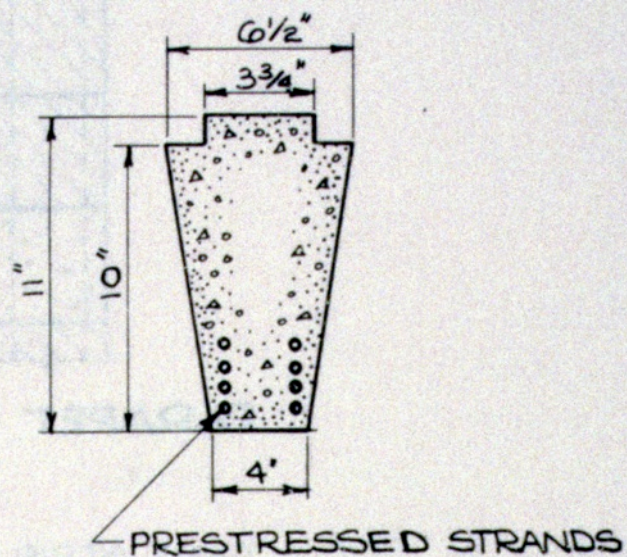
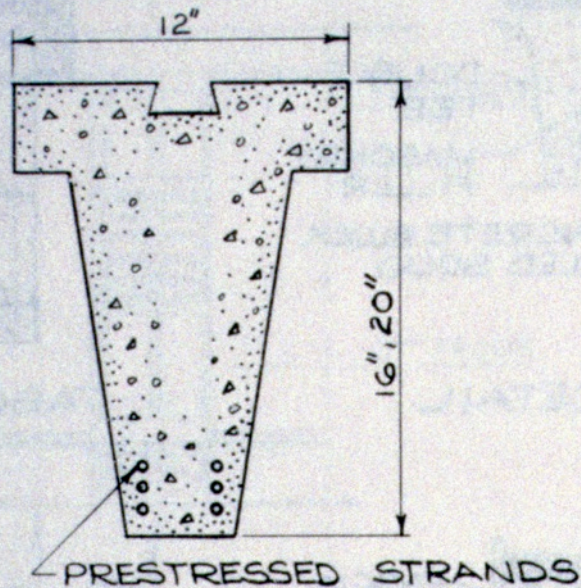
FIGURE 8.3 Pretensioning beds and draping of tendons.











| LOADS PER LINEAR FOOT FOR CONCRETE TEE JOISTS | | | |
|--|-----|-----|----|
| SPAN IN FT. | 20 | 45 | 64 |
| LB'S/LIN. FT. 16" | 584 | 128 | — |
| LB'S/LIN. FT. 20" | 873 | 293 | 82 |

PRESTRESSED REINFORCED
CONCRETE BEAMS—
SPANS FROM 16'-0" TO 32'-0"
IN INCREMENTS OF 2'-0"

Figure 11-7. Prestressed Concrete Beams for Floor and Roof Construction

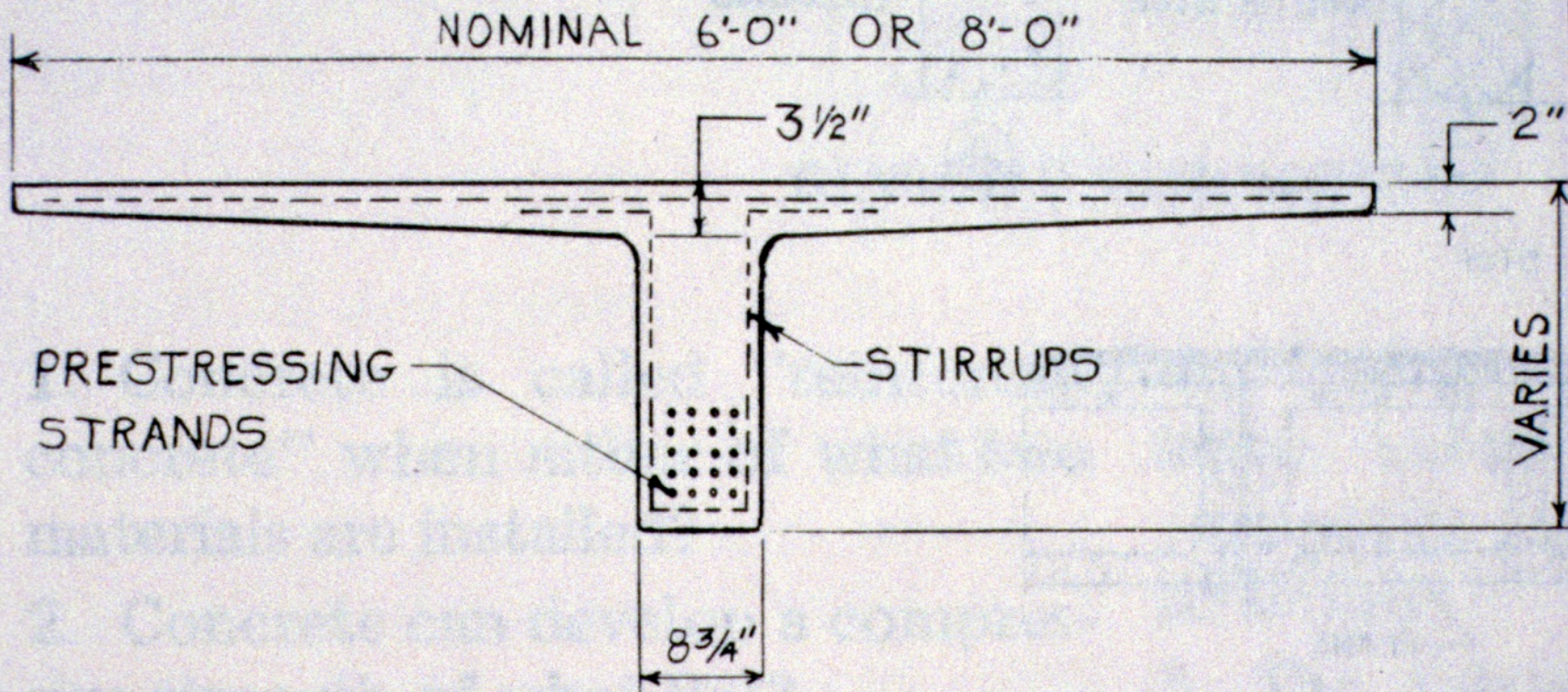


Figure 11-10. Typical Prestressed Tee Section

L = 20' MIN. TO 40' MAX.
 PRACTICAL COLUMN SPACINGS
 $L = 1.0 \times W$ TO $1.33 \times W$ BEST
 FOR 2 WAY SLABS.

W = 20' MIN. TO
 40' MAX.

INTERIOR SLAB BLOCK-OUT
 WITH CENTRAL STRESSING
 SYSTEM. TWO TENDONS STRESSED
 SIMULTANEOUSLY WITH SPECIAL
 JACK. EXTERIOR TENDON END
 ANCHORS ENCASED IN SLAB.
 ELIMINATES EXTERIOR FORM BLOCK-OUTS.

P = TENDON FORCE
 APPLIED TO SLAB

FORM BLOCK-OUT TO ACCOMMODATE
 ANCHORAGE UNITS AND PRESTRESSING
 JACKS. CHECK MFG'S. CATALOGS FOR
 REQUIRED CLEARANCES. POCKETS FILLED
 AFTER STRESSING OPERATIONS ARE
 COMPLETED.

CENTROID OF CONCRETE
 SECTION

t = SLAB
 THICKNESS

e_1 = ECCENTRICITY

e_2

Draped post-tension tendons pre-compress concrete to provide resistance to tensile stresses produced by flexural bending due to dead + live loads on floor. Maximum tendon spacing should not exceed 8 times slab thickness (t).

Practical solid slab thickness 6" min. to about 10" max. without drop panels. For long spans cast-in place (not lift slabs) haunched slabs or drop panels may be used. Hollow slabs or waffle slabs can also be used to reduce dead load on long spans.

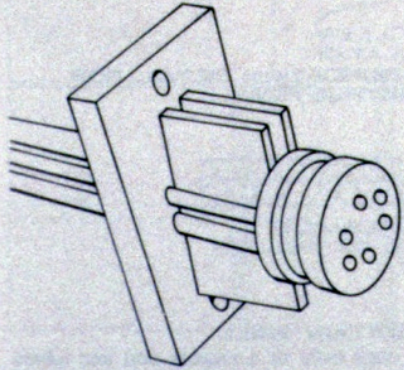
RECOMMENDED SPAN/DEPTH RATIO

| | |
|--------|----|
| FLOORS | 42 |
| ROOF | 48 |

Check deflections, camber, and vibration.

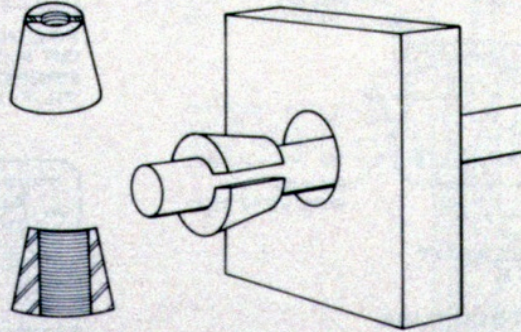




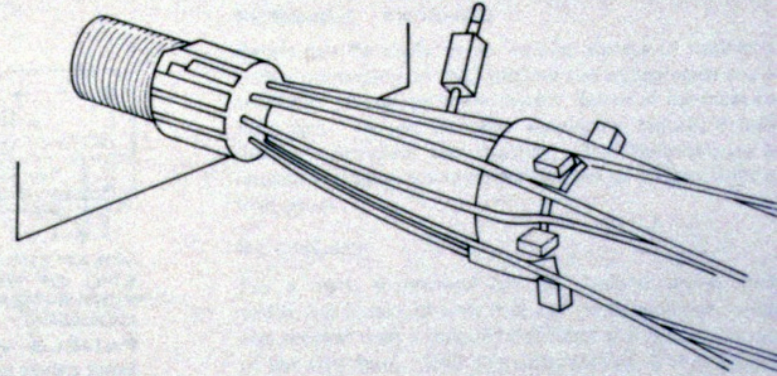


PRESCON ANCHORAGE

NOTE:



STRESSTEEL BAR ANCHORAGE

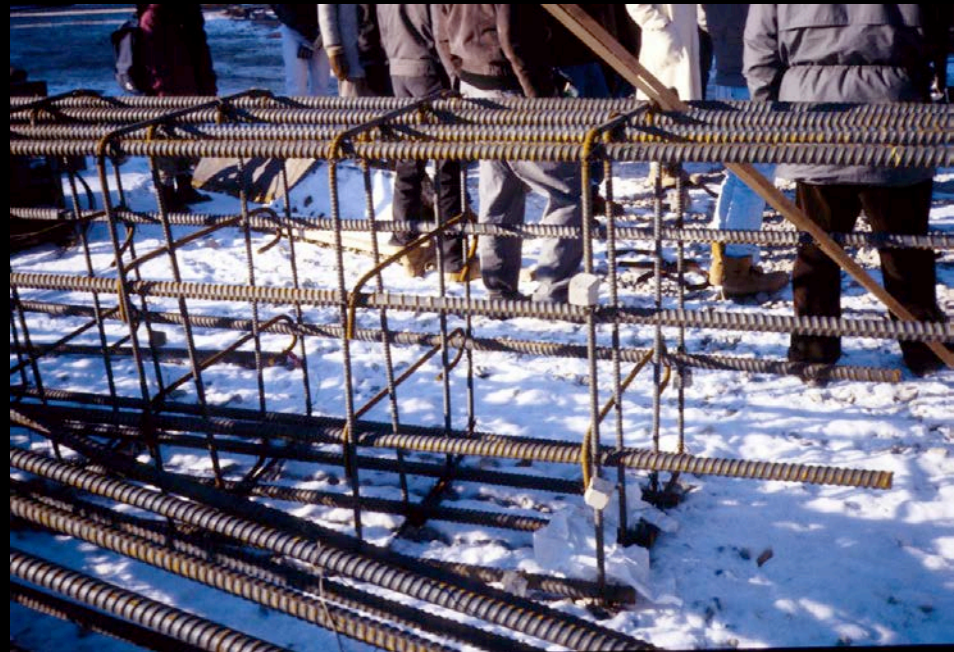


FREYSSINET WIRE ANCHOR AND JACK

Two-way post tensioned flat slabs average about 1 lb. of prestressing wire or strand per square foot for 24' to 28' bays. Additionally: at ordinary reinforcing steel runs about 0.5 lbs. per square foot



Construction of SkyDome (Rogers Centre) - 1987



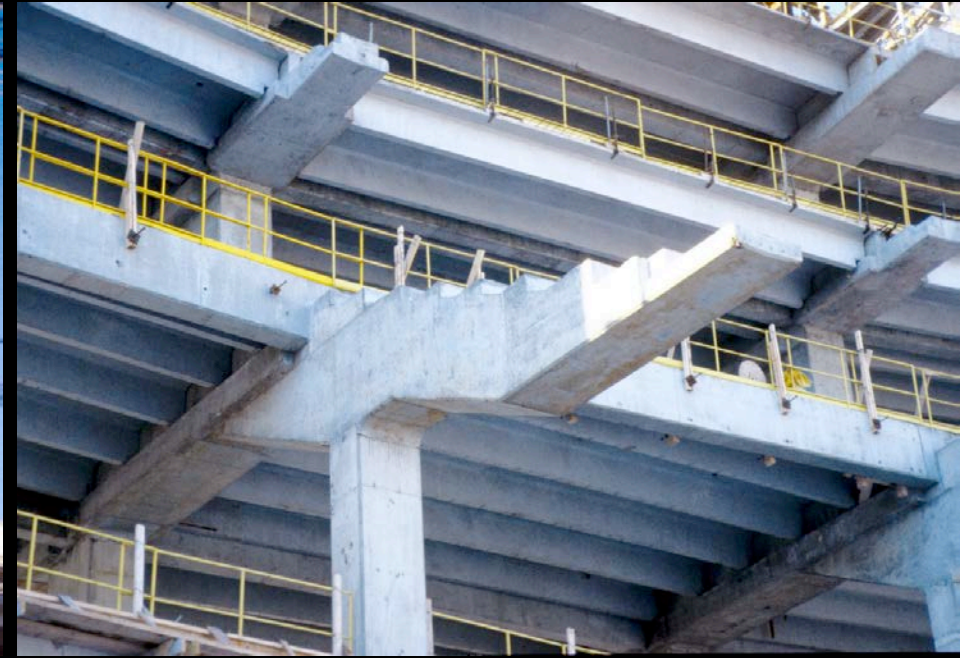


















ARATA ISOZAKI

"FOUR DECADES OF ARCHITECTURE"

MEMBER, ARCHITECTURAL INSTITUTE OF JAPAN

PRINCIPAL; ARATA ISOZAKI & ASSOCIATES

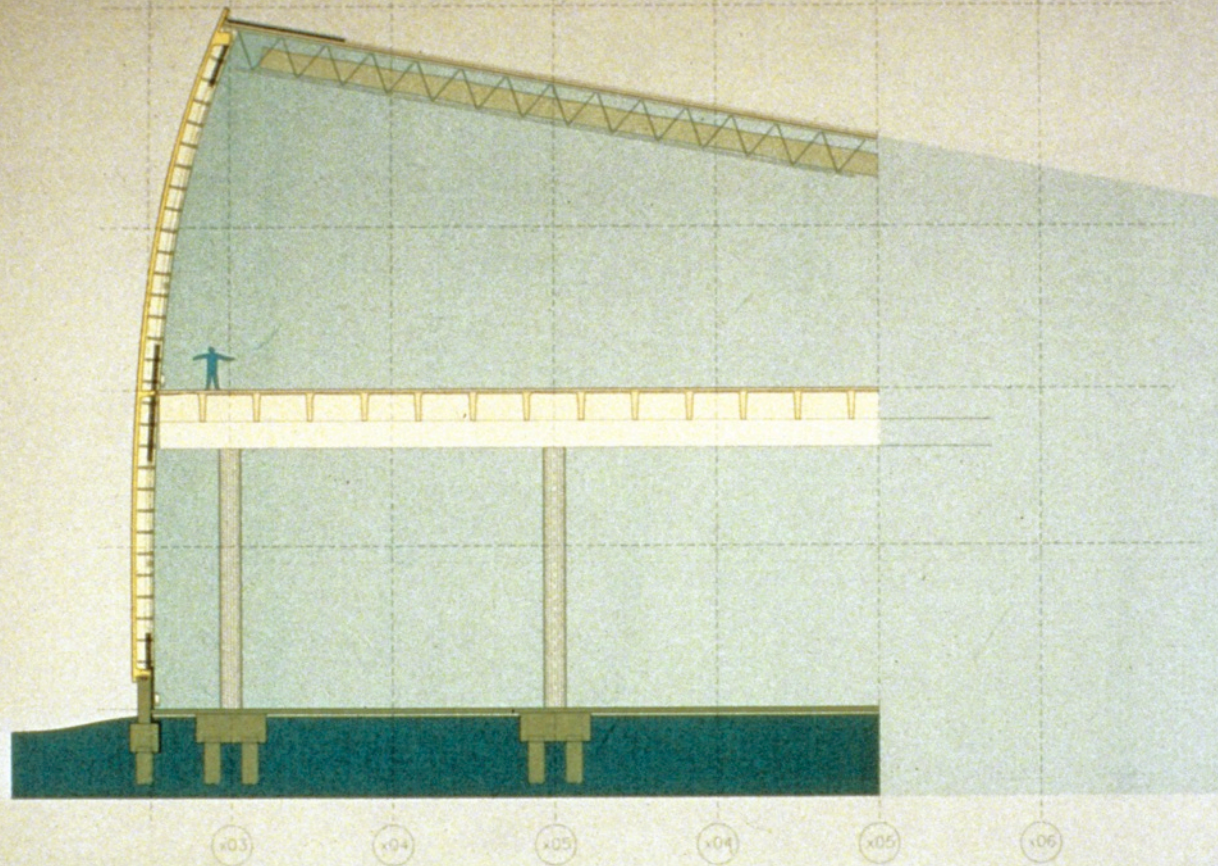
TOKYO, JAPAN

PRINCIPAL ARCHITECT: COSI-- COLUMBUS, OH









GREAT WALL SECTION







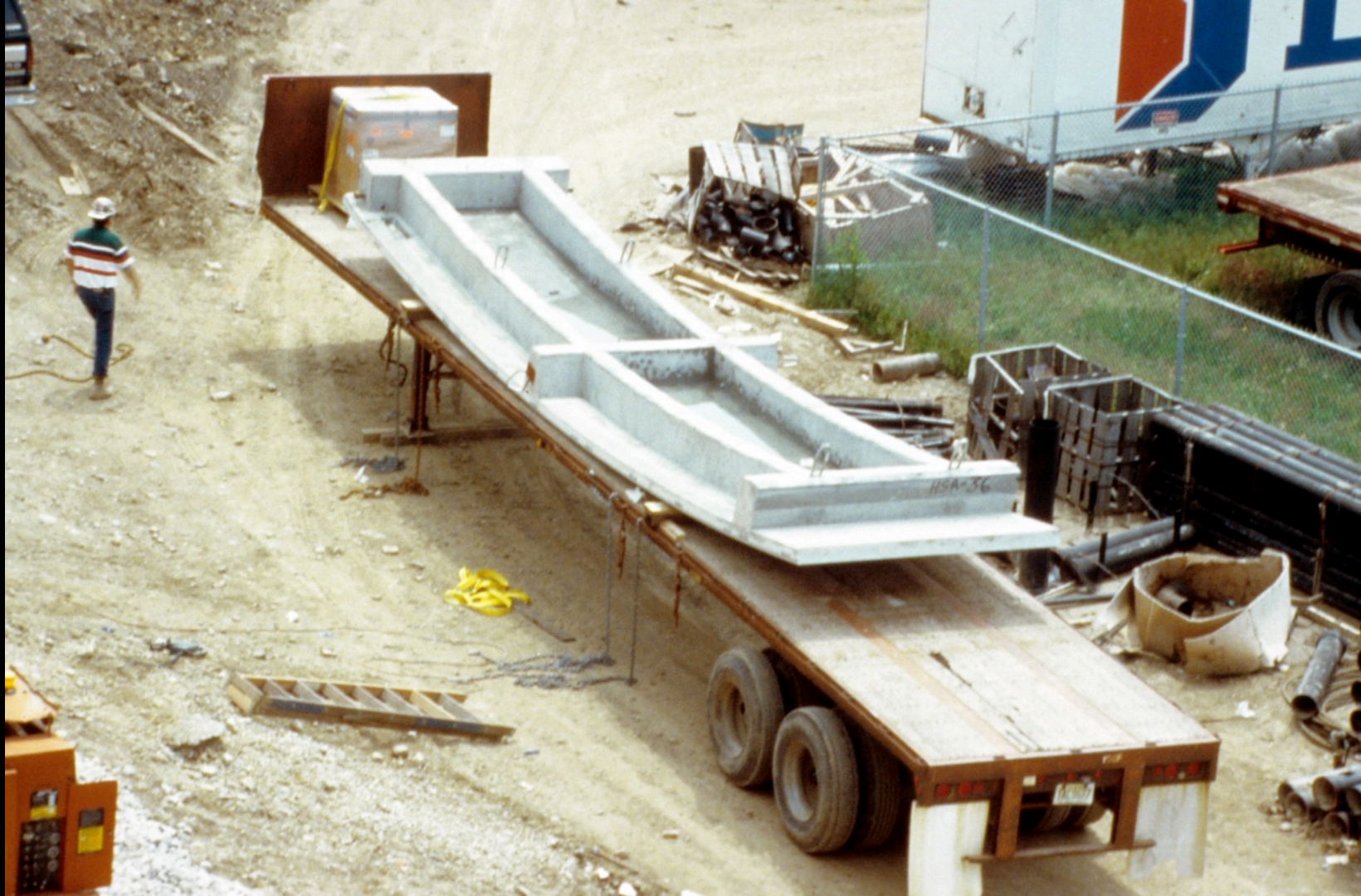


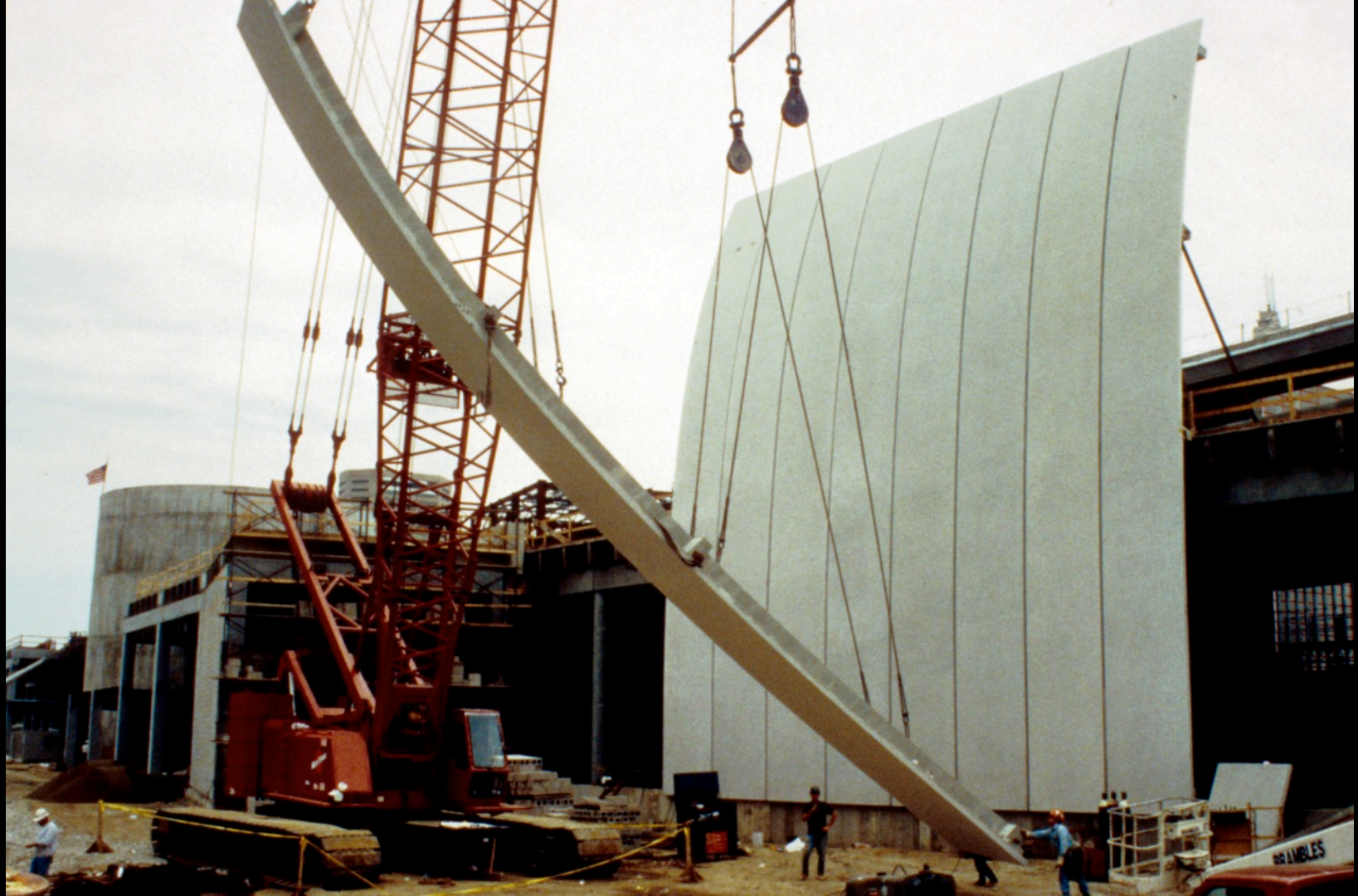






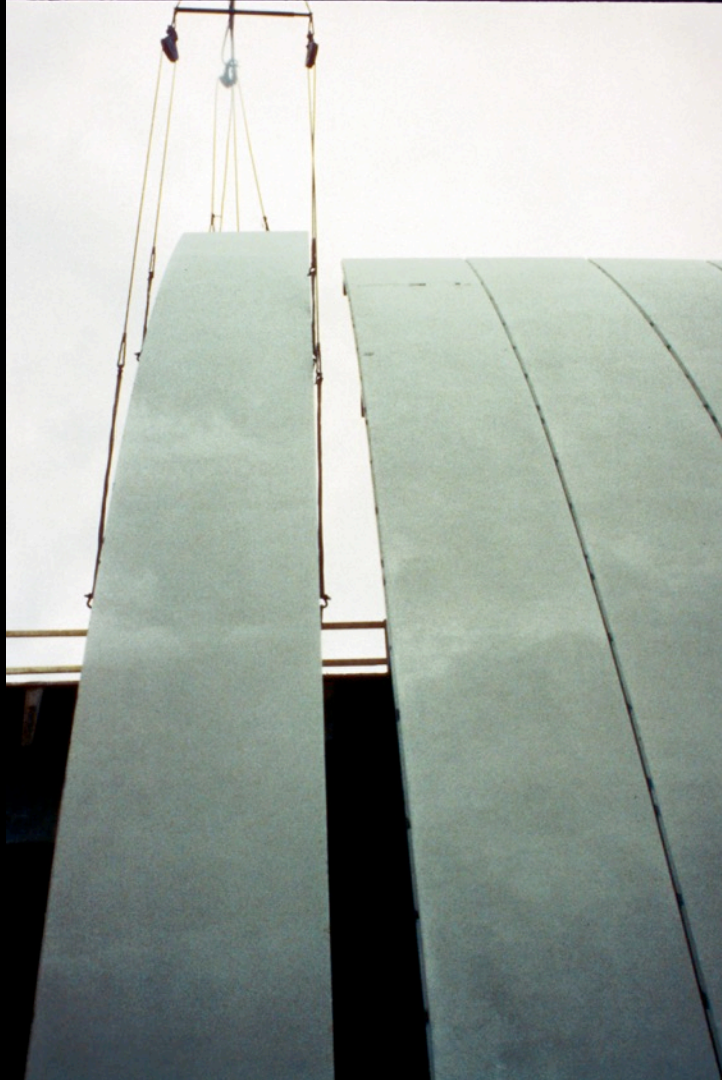


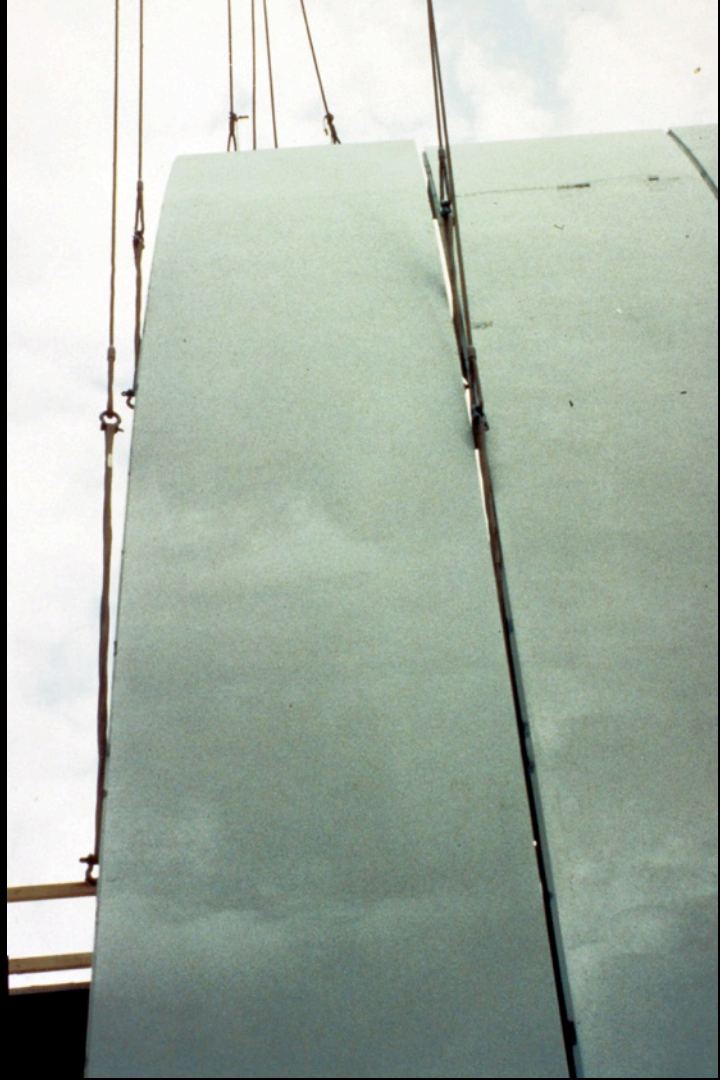


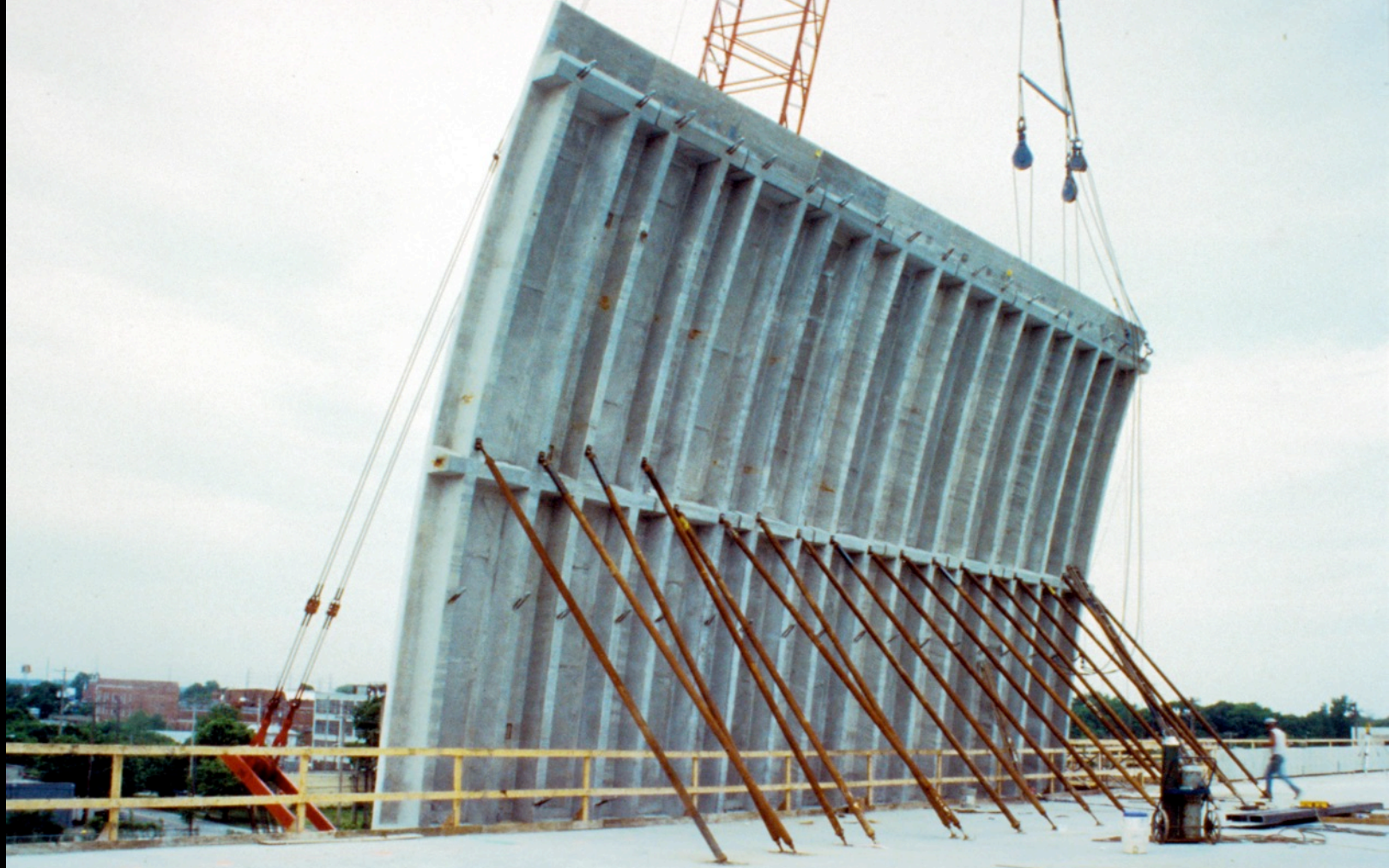


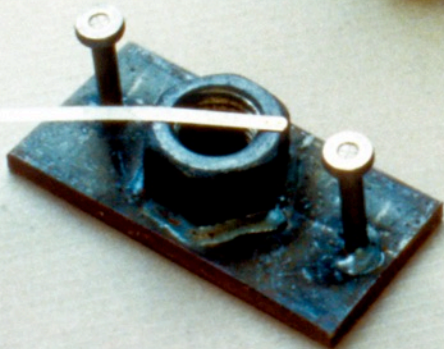
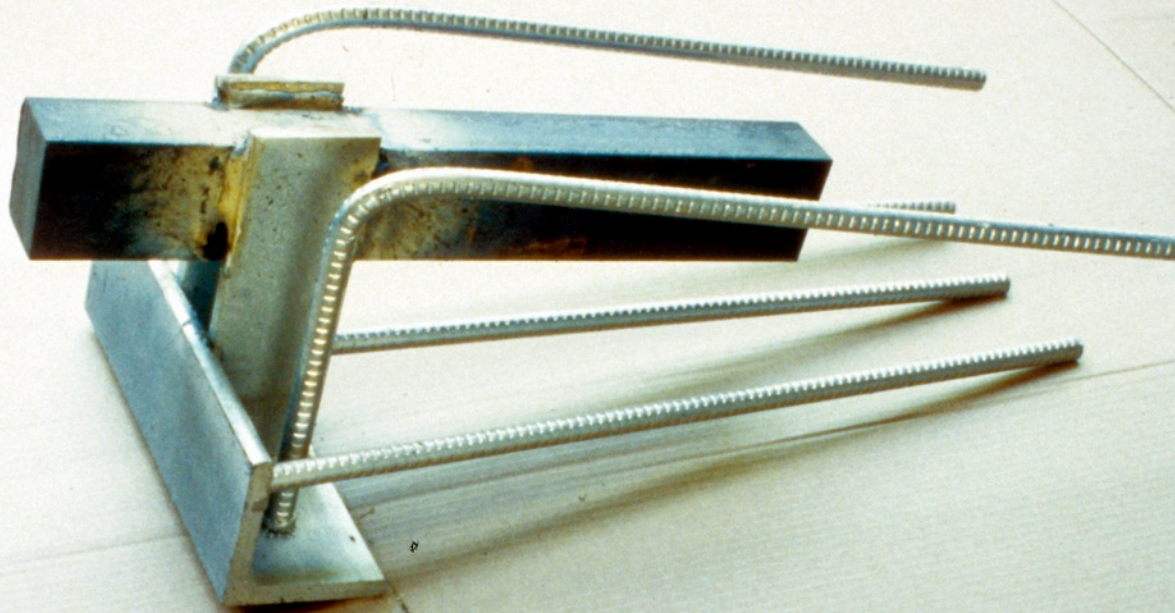


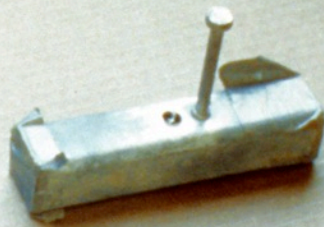
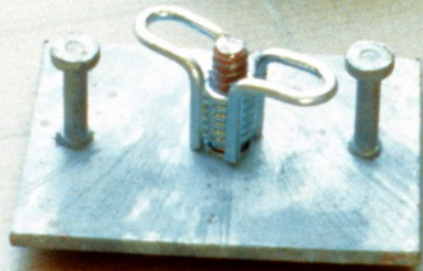
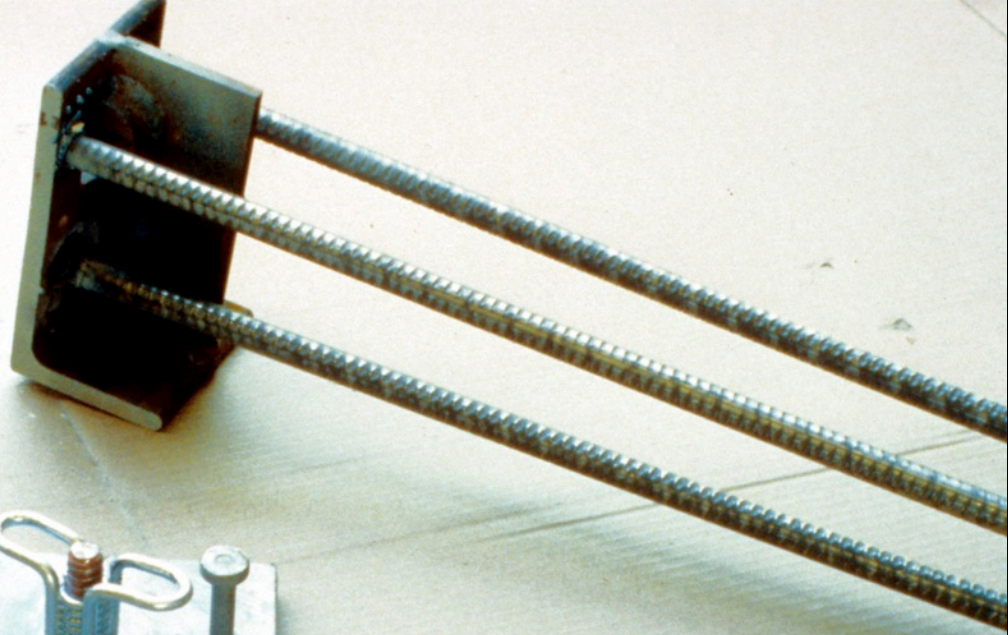










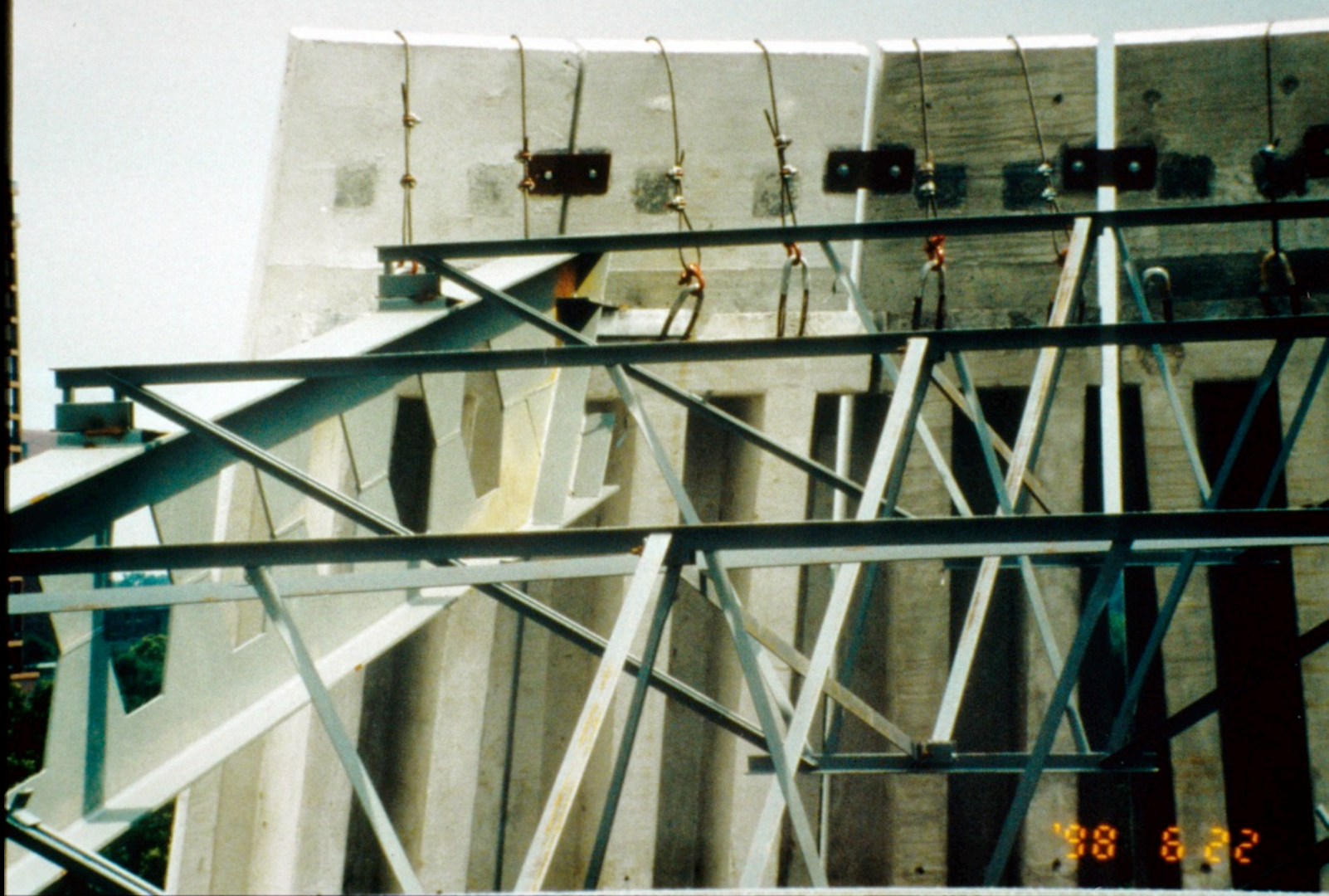




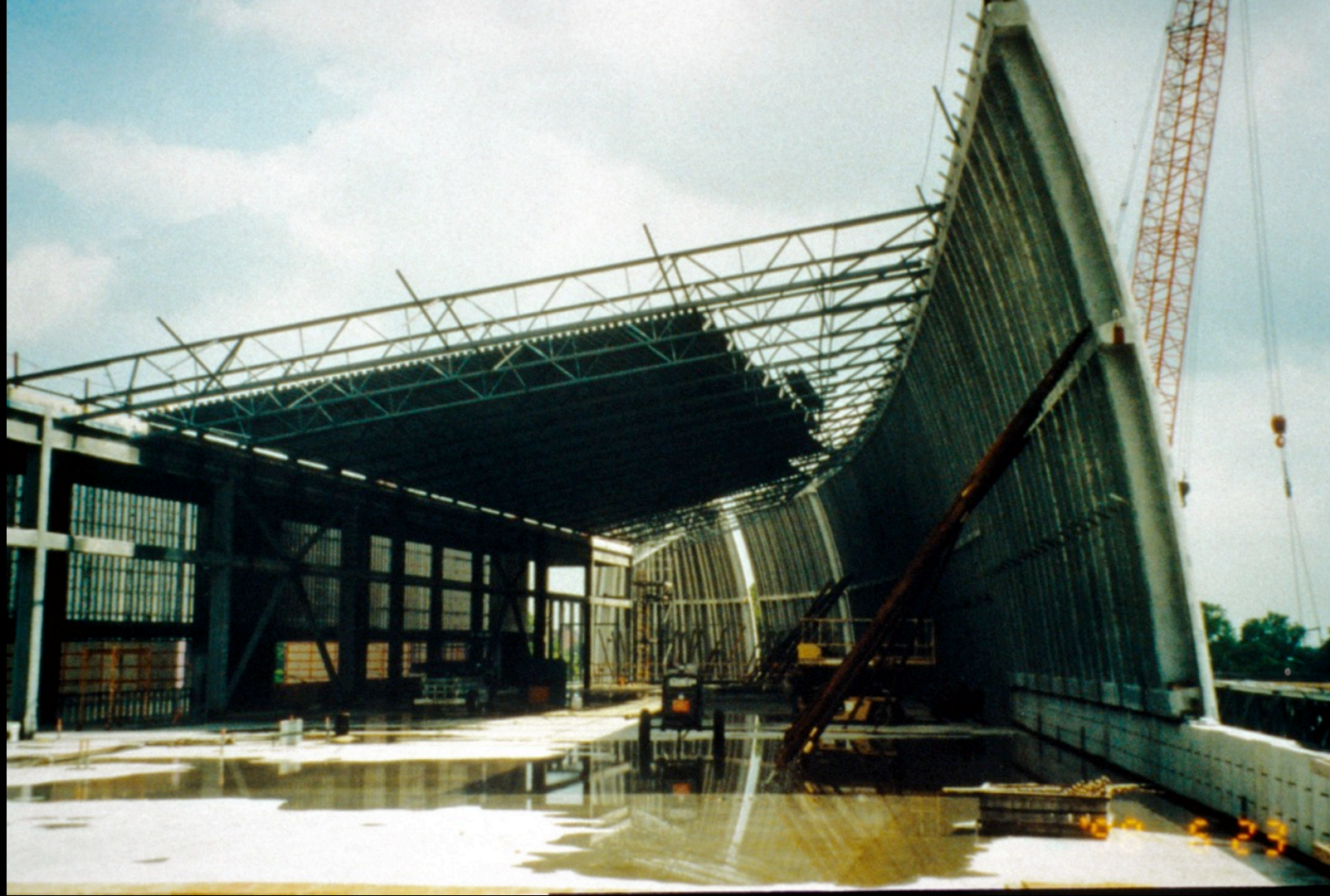








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