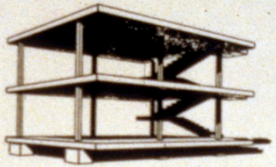
Precast and Prestressed Concrete

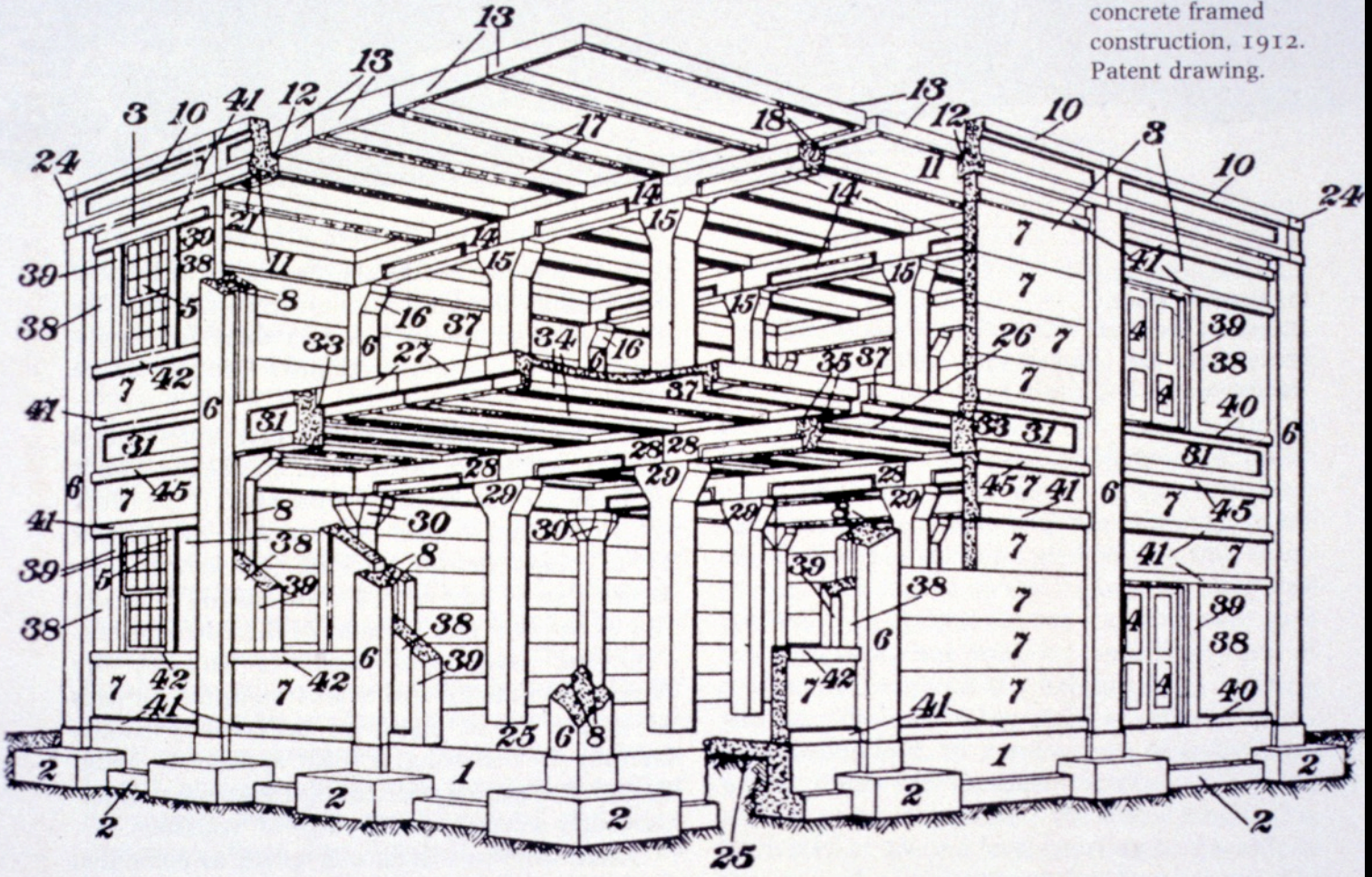
Arch 173: Building Construction 2
Winter 2025



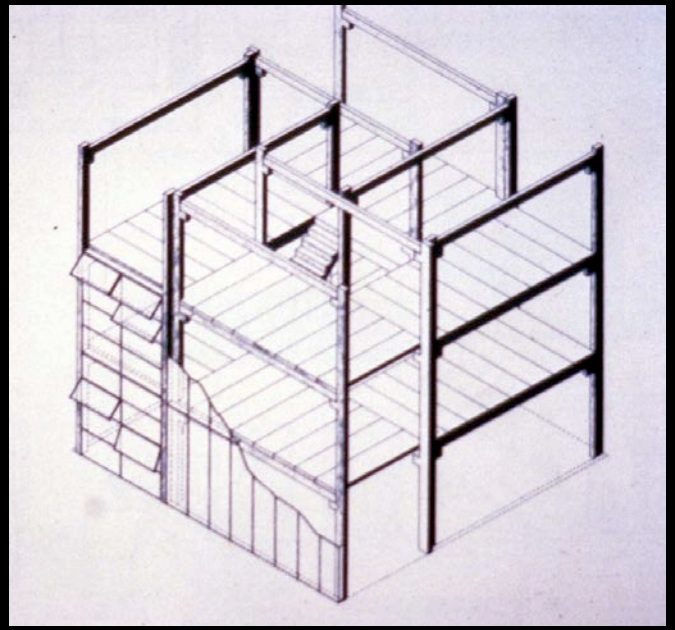
"In the next twenty years, big industry will have co-ordinated its standardized materials . . . technical achievements will have carried . . . methods of rational construction far beyond anything we are acquainted with."
—Le Corbusier, 1914

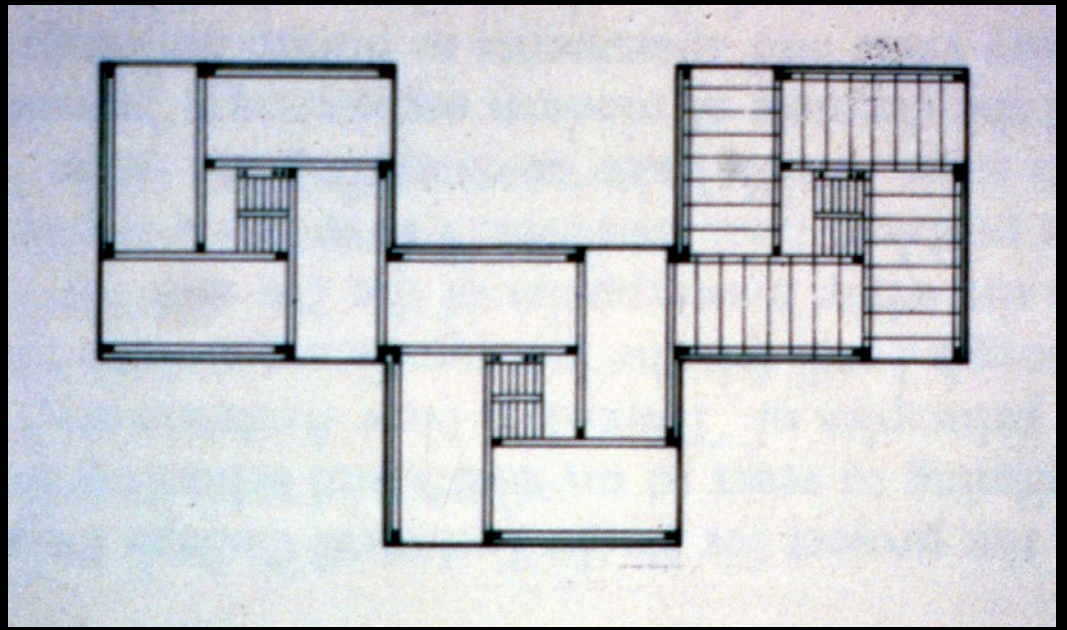
Precast concrete came about in the early 1900s as a response to industrialization.

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

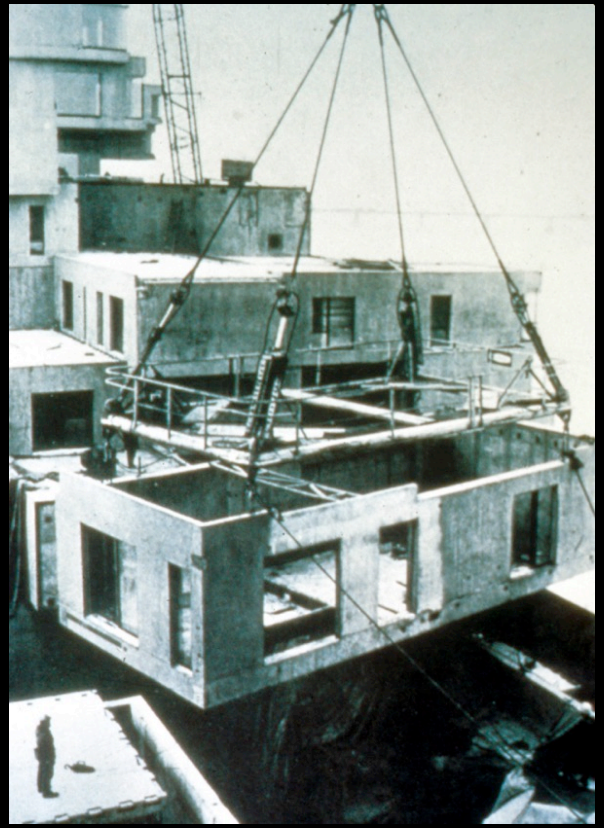


4.10 Conzelman system of precast-concrete framed construction, 1912. Patent drawing.





Prototype for a precast concrete house system by James Stirling



Expo 1967, Montreal, Housing
Moshe Safdie

Precast Concrete Construction Basics

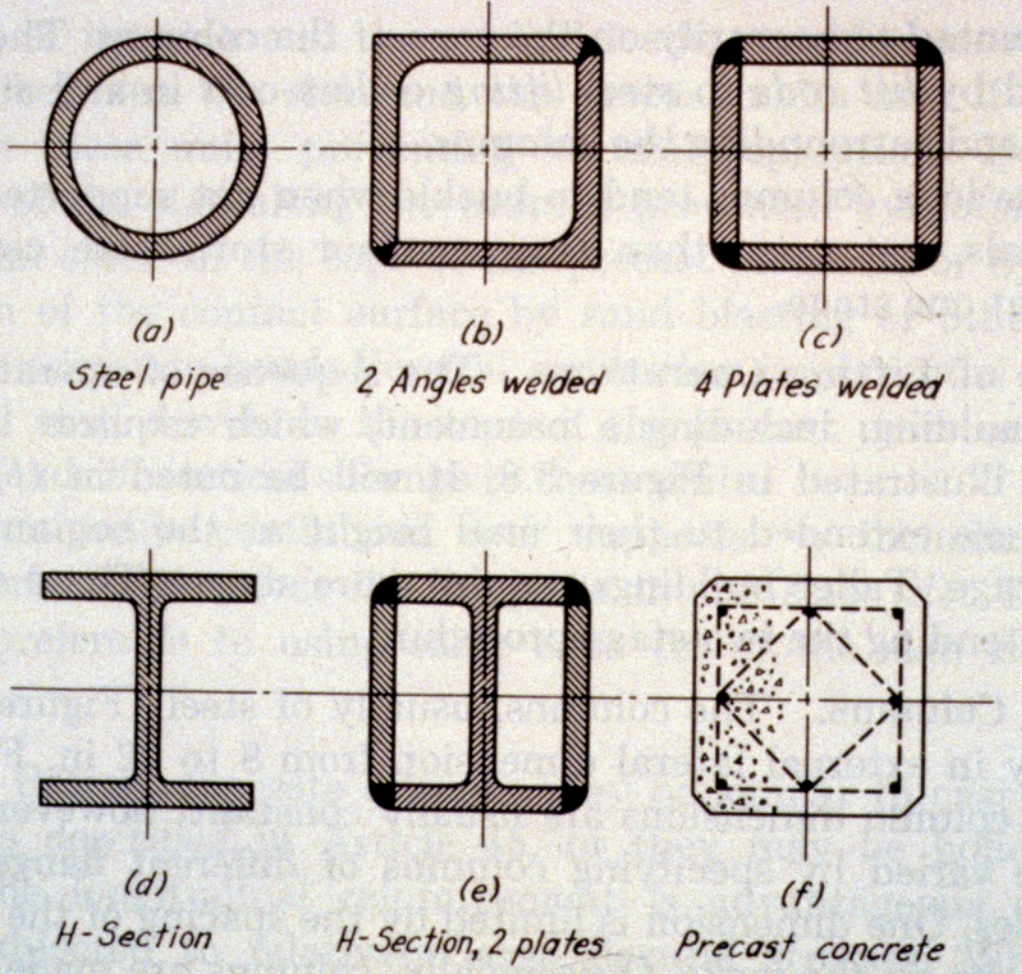
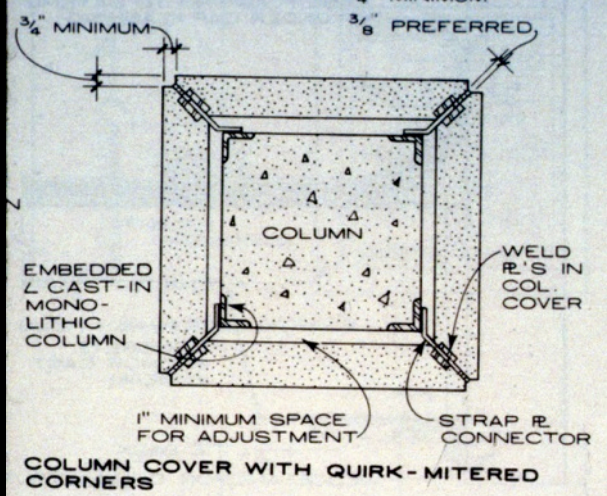
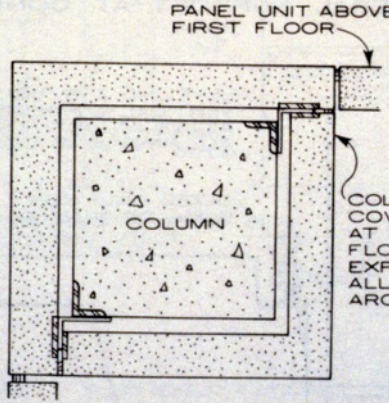


FIGURE 8.9 Types of columns.

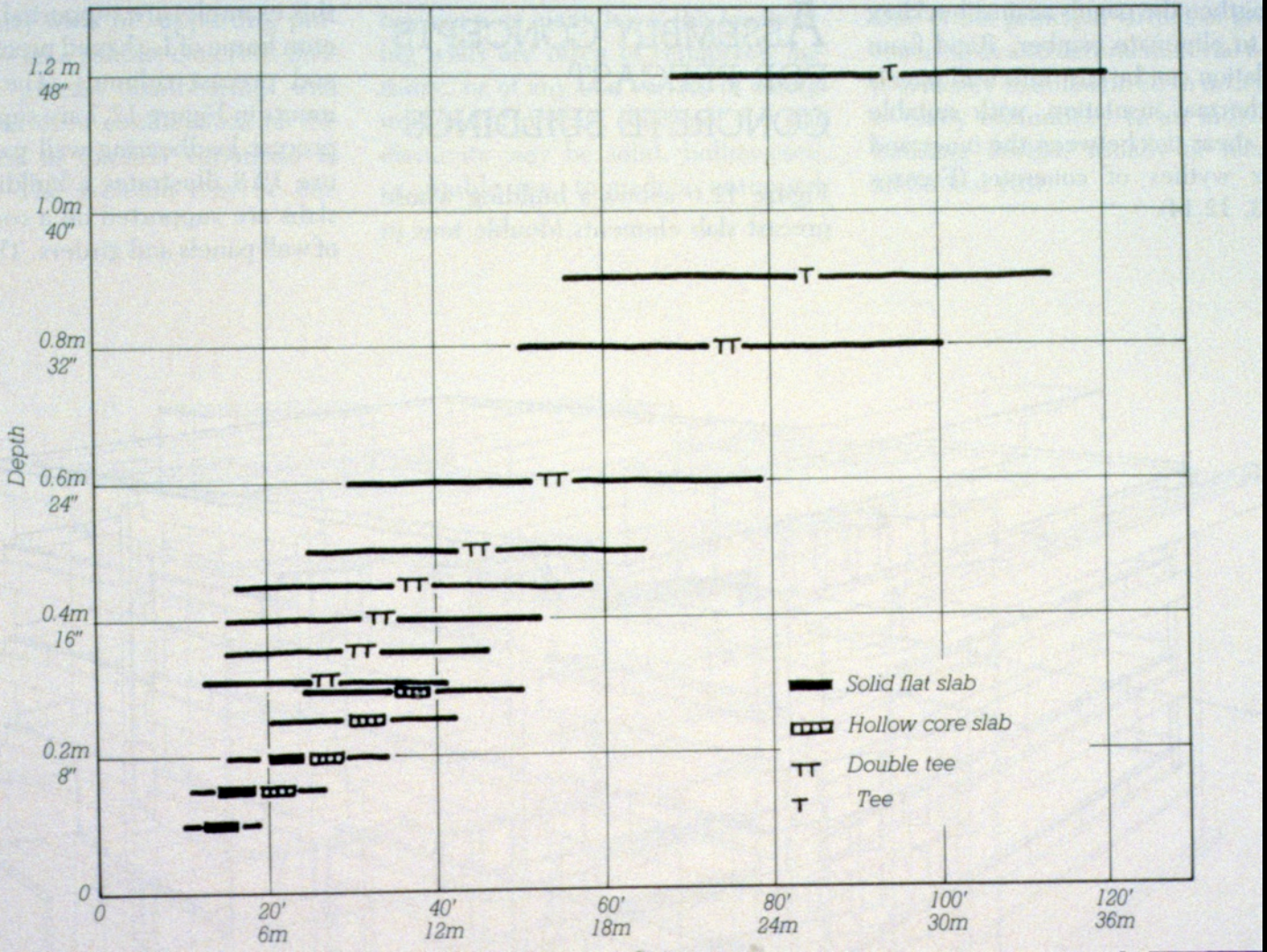


COLUMN COVER WITH QUIRK-MITERED CORNERS



COLUMN COVER WITH BUTT JOINT CORNERS

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


Depth
1.2 m
48"
1.0m
40"
0.8m
32"
0.6m
24"
0.4m
16"
0.2m
8"
0
0
20'
6m
40'
12m
60'
18m
80'
24m
100'
30m
120'
36m
T
T
TT
TT
TT
TT
TT
TT
TT
Solid flat slab
Hollow core slab
TT Double tee
T Tee

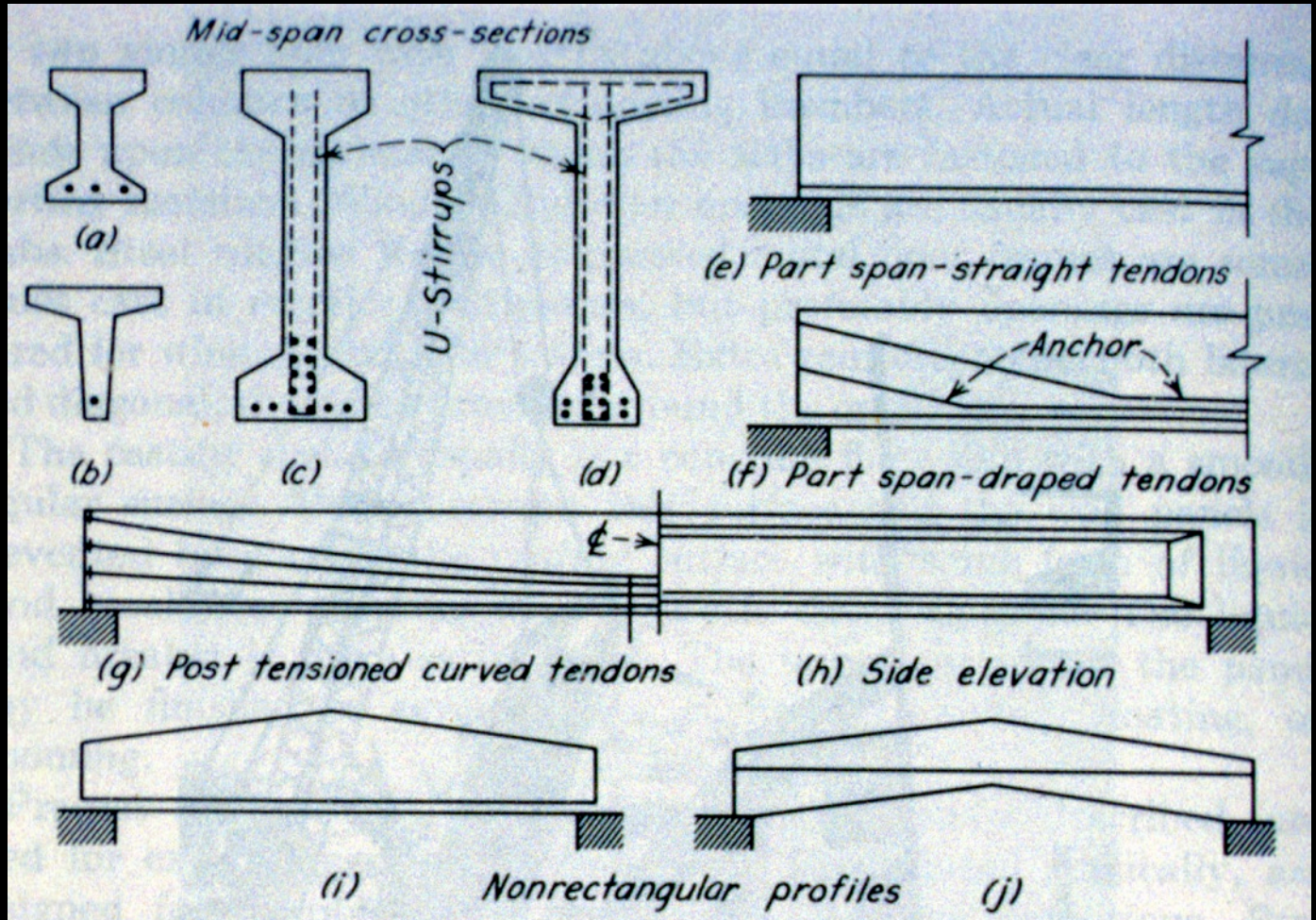
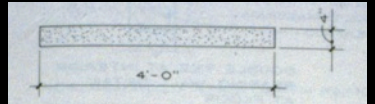
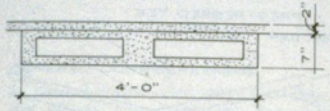


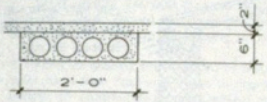
FIGURE 8.6 Precast and prestressed joints, beams, and girders.



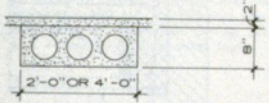
TYPE "A"



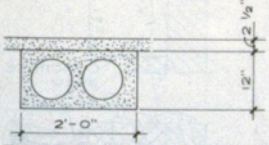
TYPE "B" WITHOUT TOPPING
TYPE "C" WITH 2" TOPPING



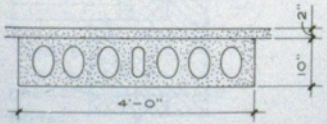
TYPE "D" WITHOUT TOPPING
TYPE "E" WITH 2" TOPPING



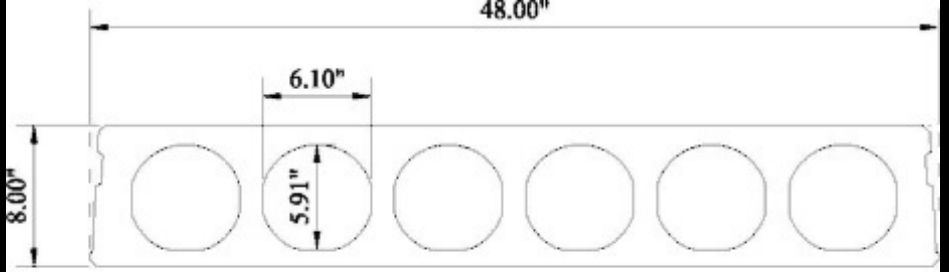
TYPE "F" - WITHOUT TOPPING
TYPE "G" - WITH 2" TOPPING



TYPE "H" - WITHOUT TOPPING
TYPE "J" - WITH 2½" TOPPING



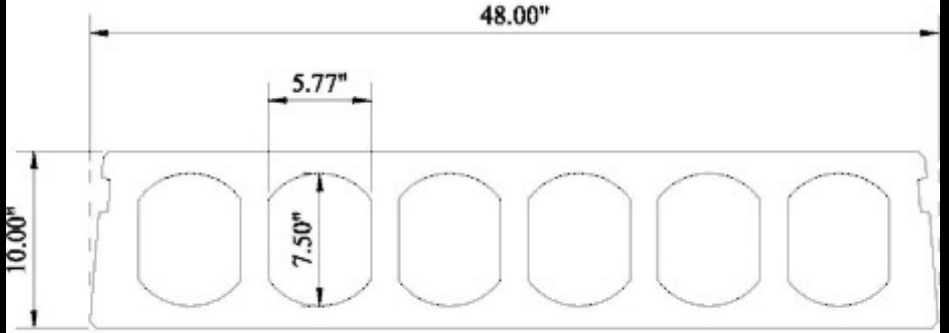
TYPE "K" - WITHOUT TOPPING
TYPE "L" - WITH 2" TOPPING



PROPERTIES			
WITHOUT TOPPING			
A in^2	yb in	I in^4	wt plf
196	3.97	1580	51

8" x 48" PRESTRESSED CONCRETE

HOLLOW CORE SLAB



PROPERTIES			
WITHOUT TOPPING			
A in^2	yb in	I in^4	wt plf
249	5.00	3108	65

10" x 48" PRESTRESSED CONCRETE

HOLLOW CORE SLAB

Tee spanning systems

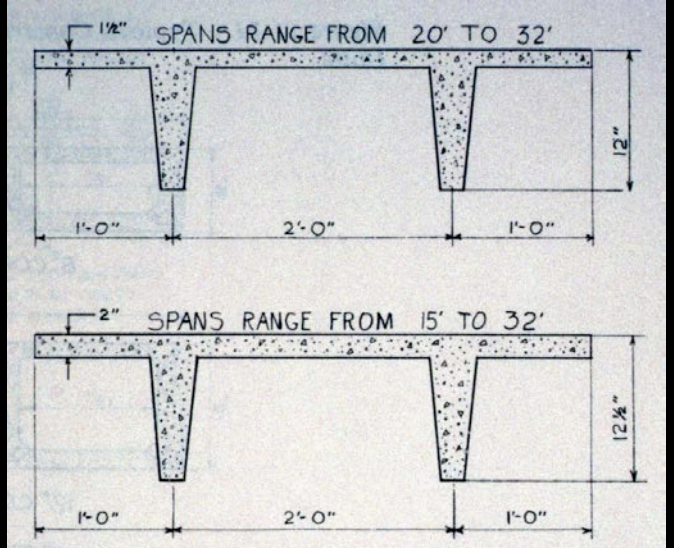


Figure 11-9. Double-Tee Floor and Roof Units

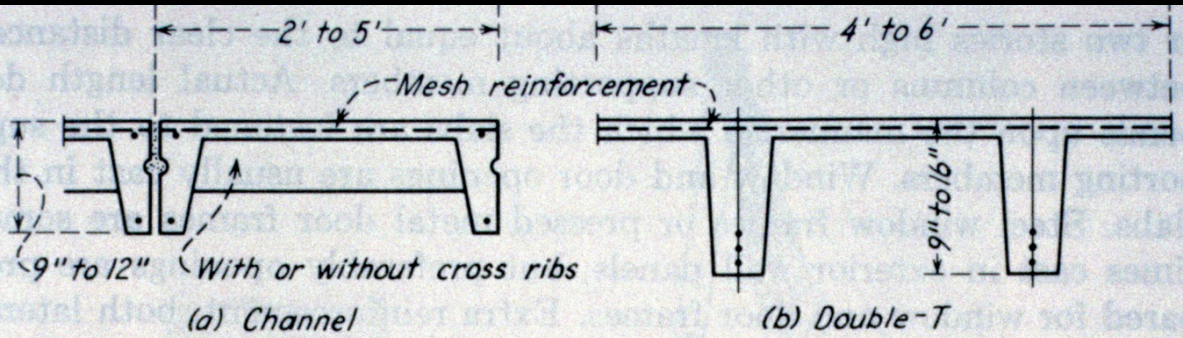
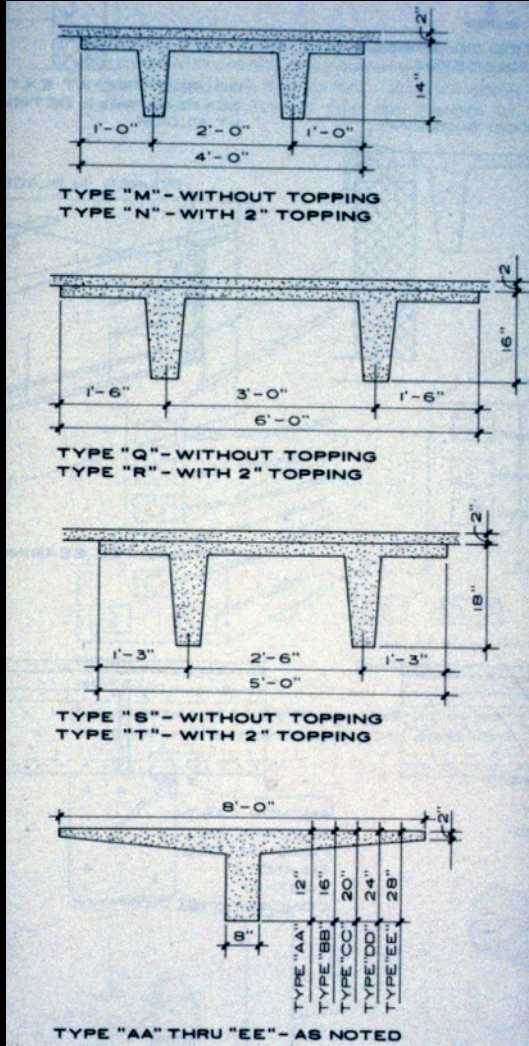


FIGURE 8.4 Channel and double-T decks.



Paul Kane Collection

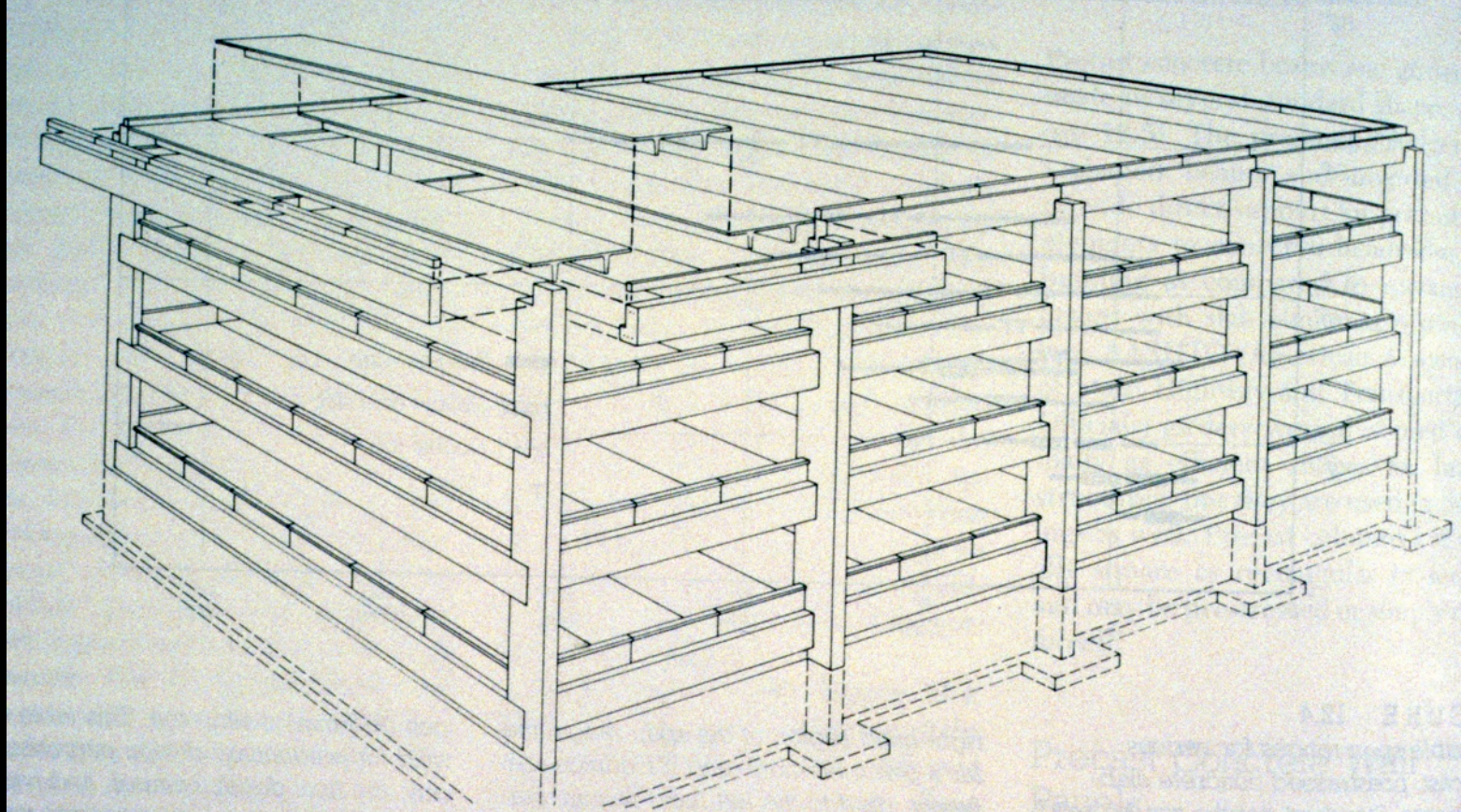


FIGURE 12.6
Double-tee slab elements supported on a frame of precast columns and L-shaped girders. (Courtesy of Prestressed Concrete Institute)

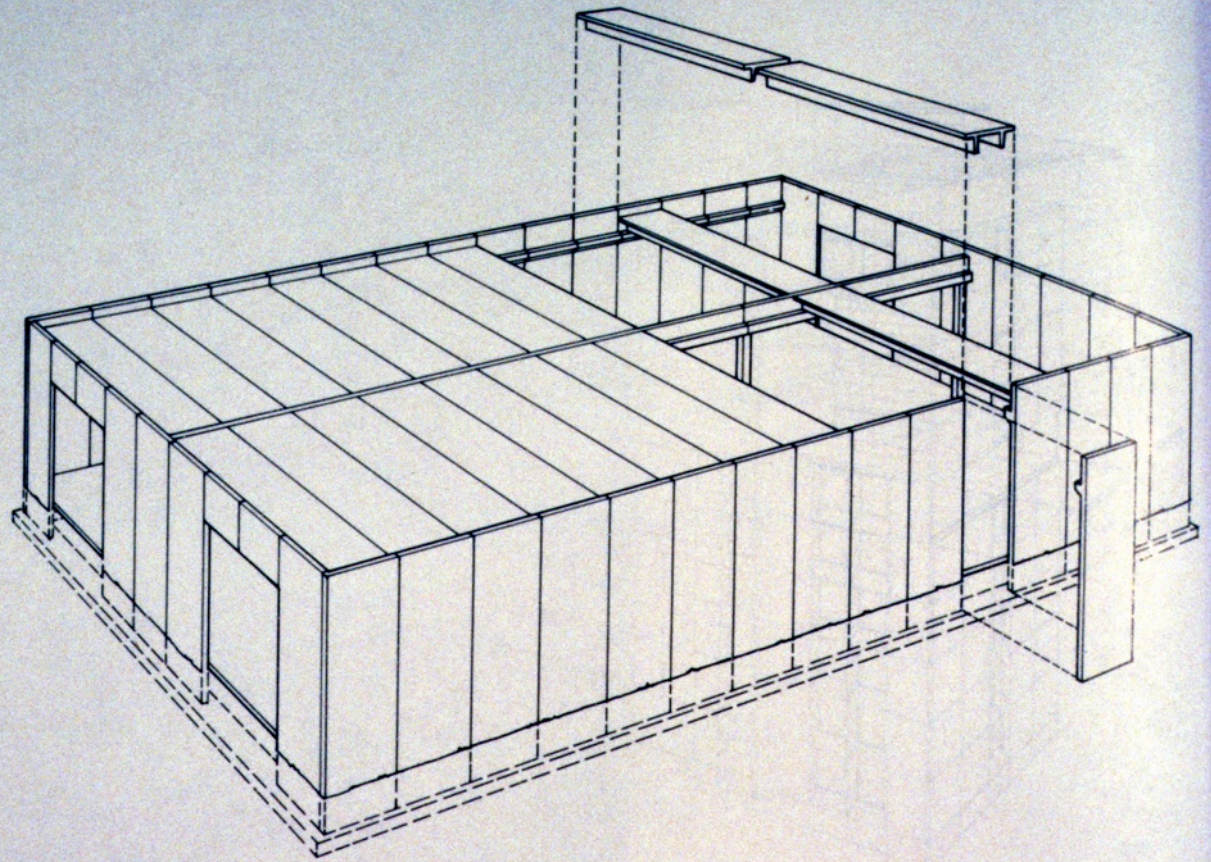


FIGURE 12.8
Double-tee slab elements supported on a perimeter of precast concrete loadbearing wall panels, and an interior structure of precast columns and girders. (Courtesy of Prestressed Concrete Institute)

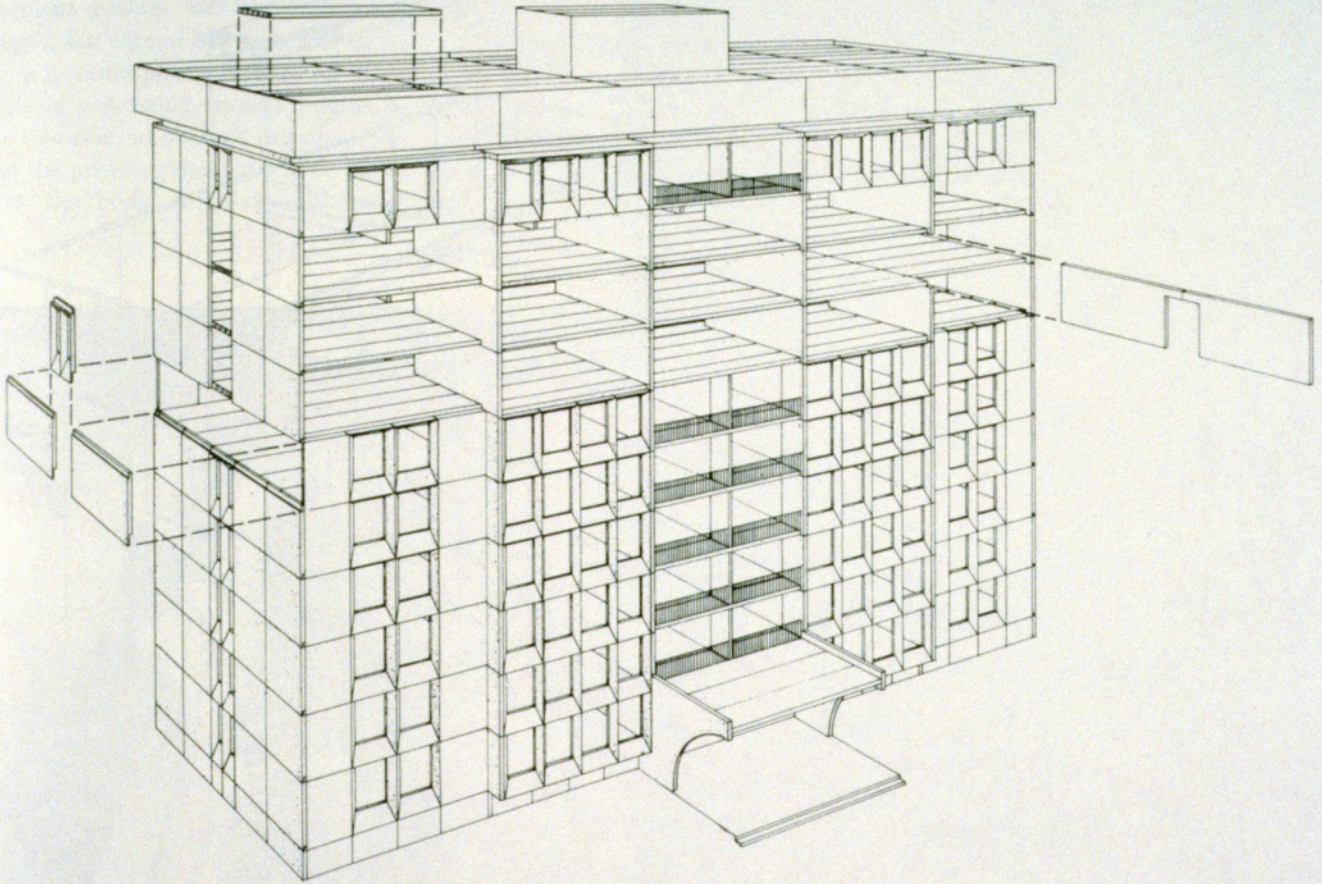
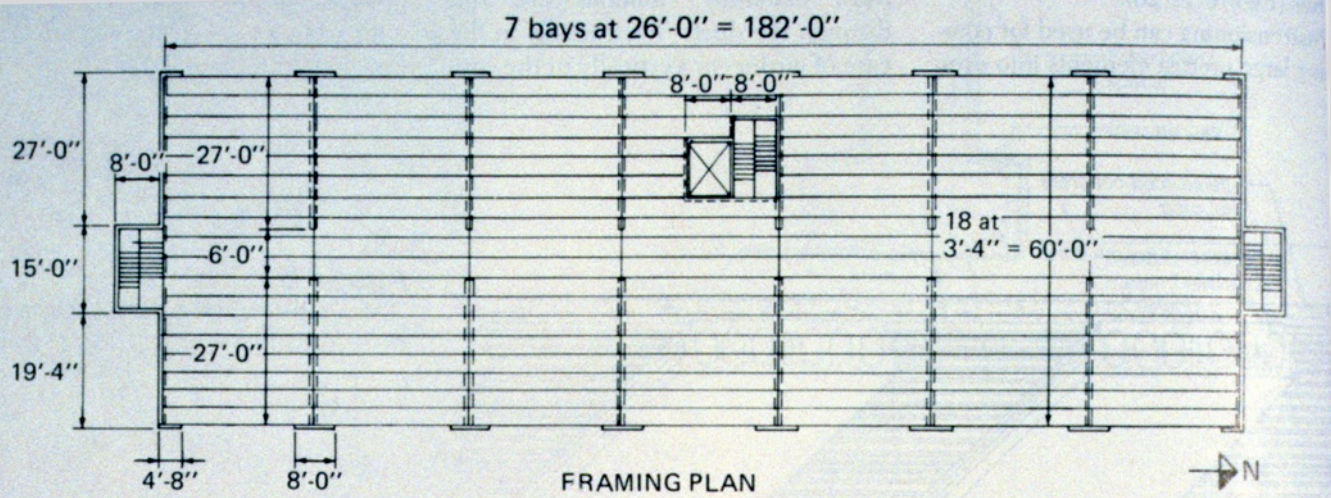
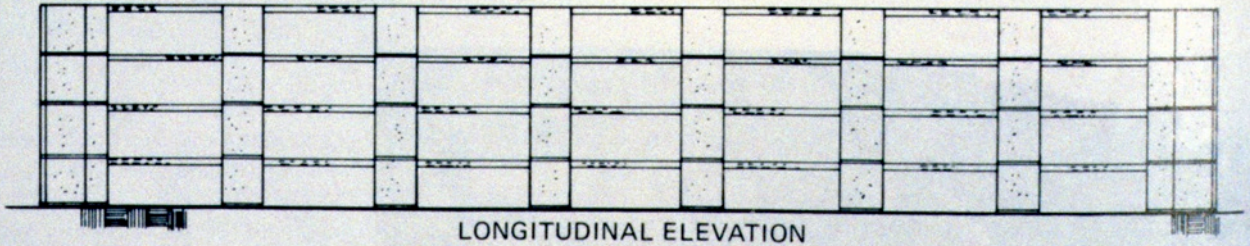


FIGURE 12.7
Hollow-core slab elements supported on precast concrete loadbearing wall panels. (Courtesy of Prestressed

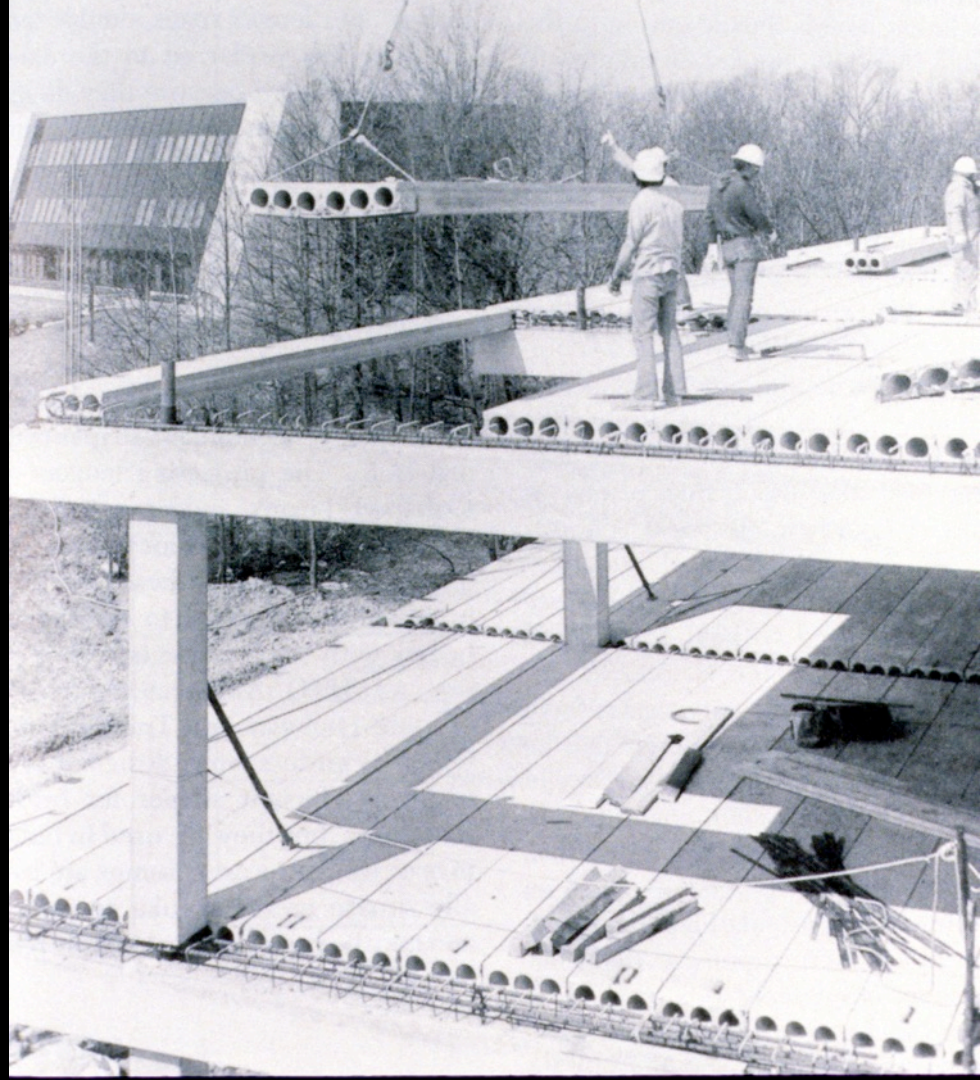


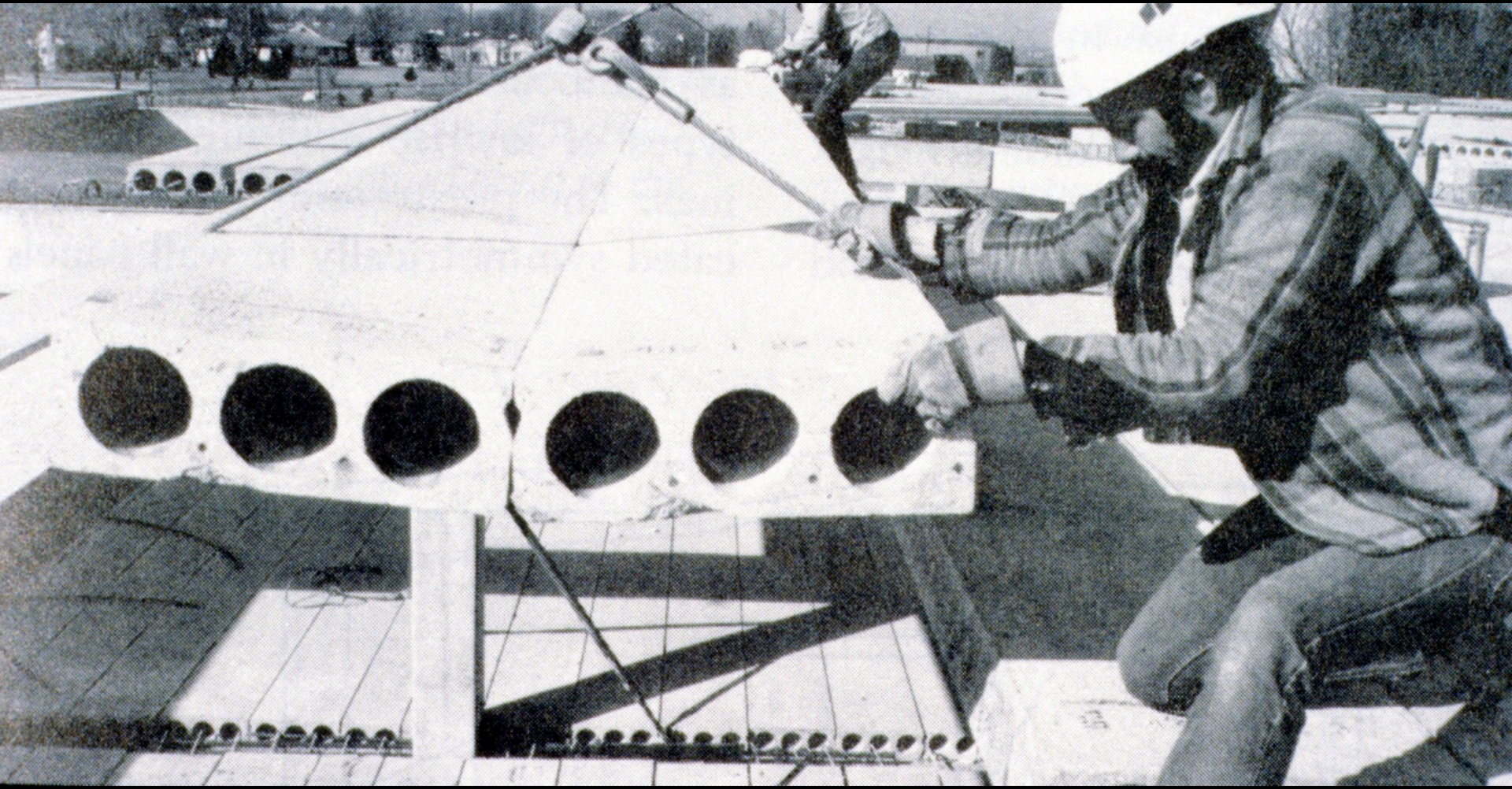


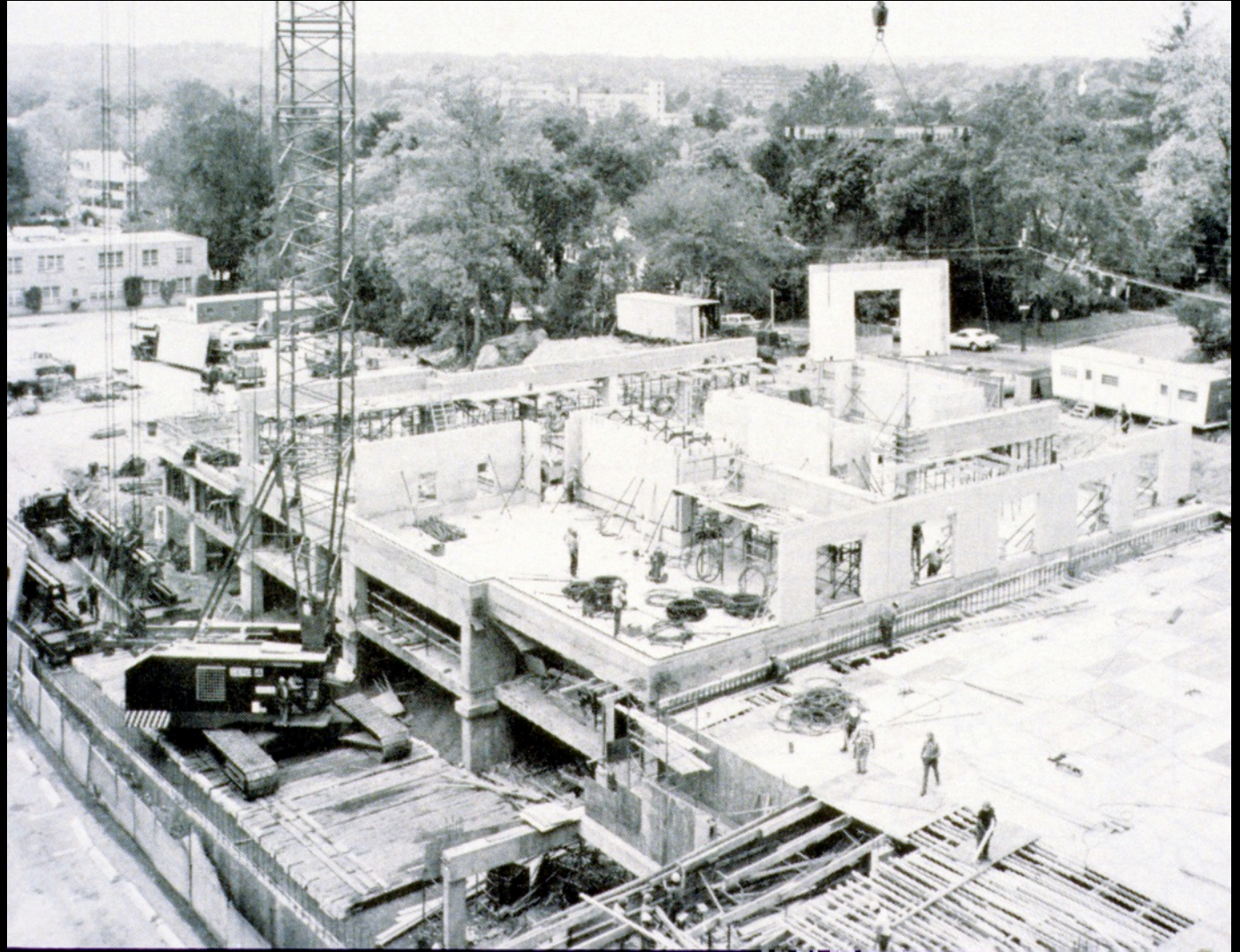
LONGITUDINAL ELEVATION

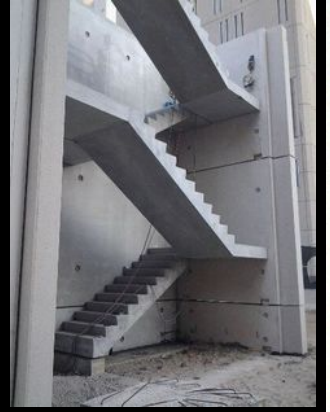
FIGURE 12.28

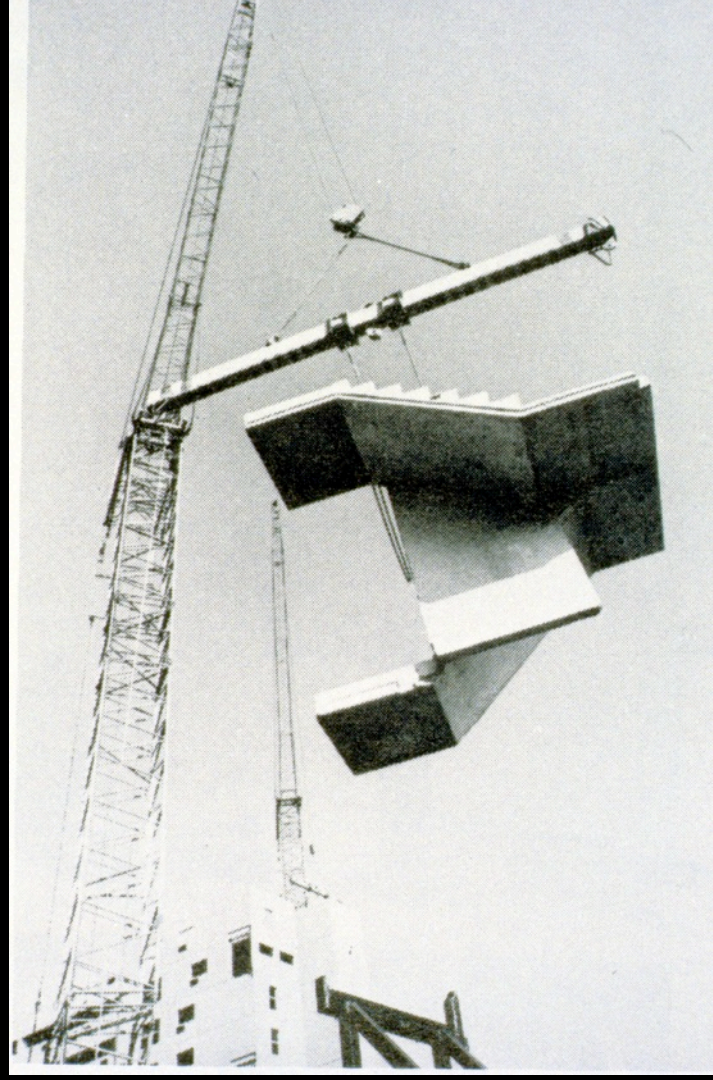
A framing plan and elevation of a simple four-story building made of loadbearing precast concrete wall panels and hollow-core slab elements. (Courtesy of Prestressed Concrete Institute)

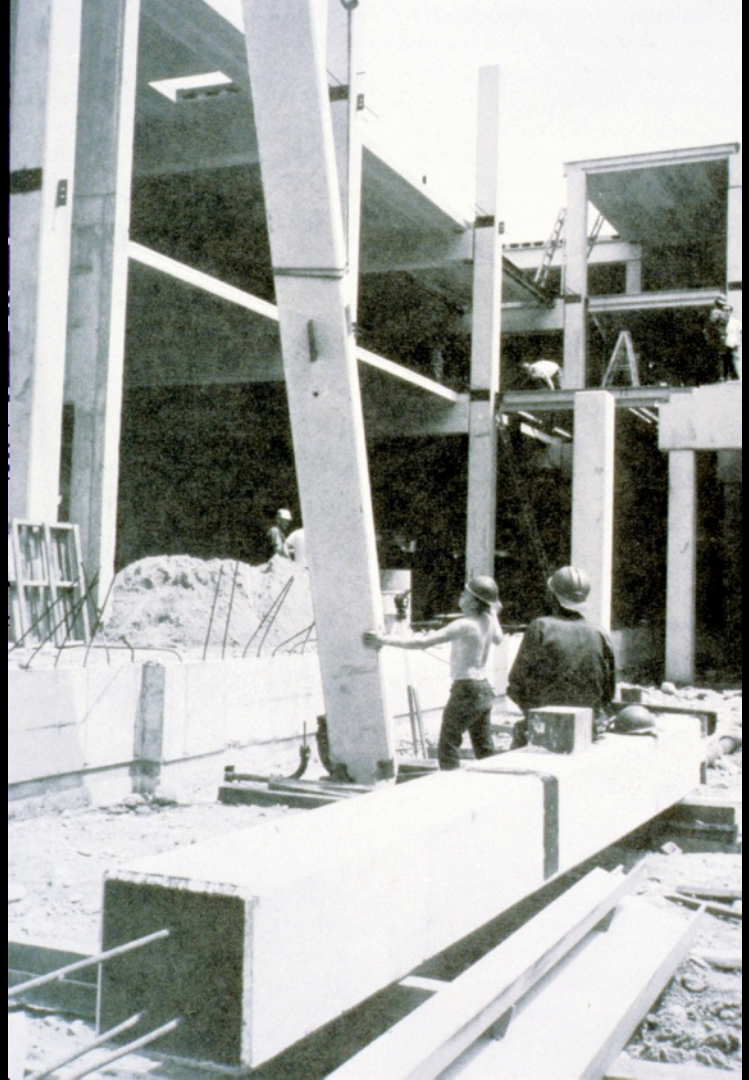


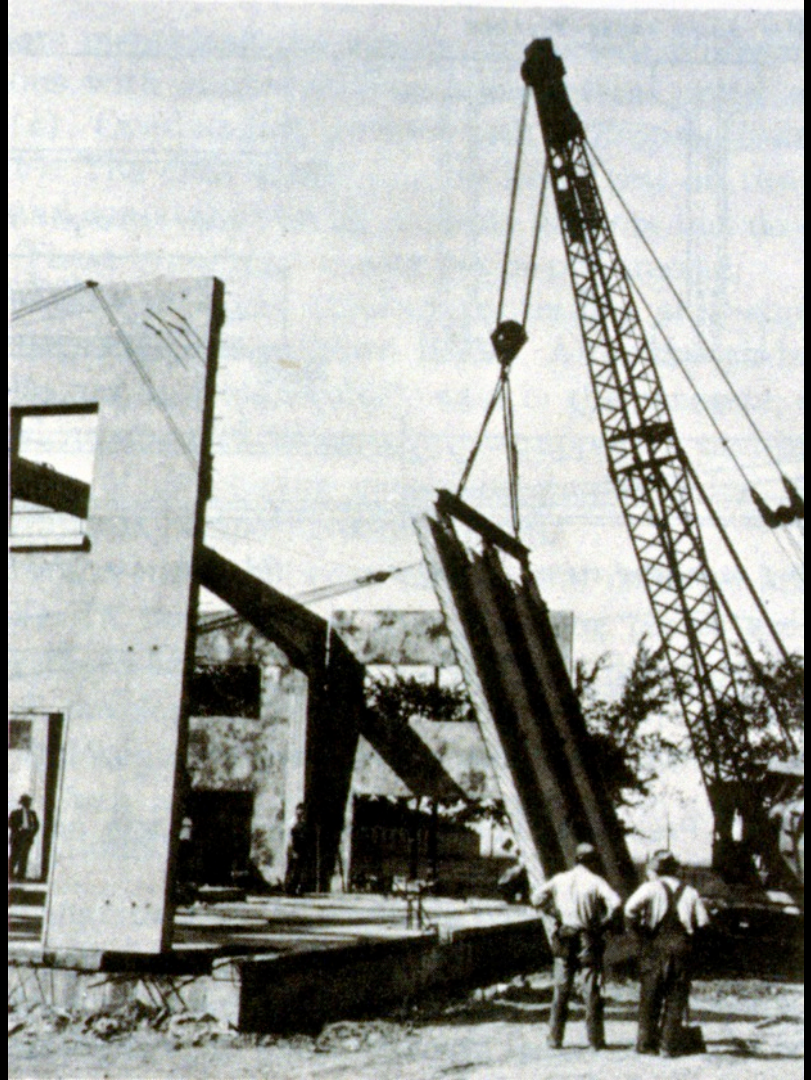


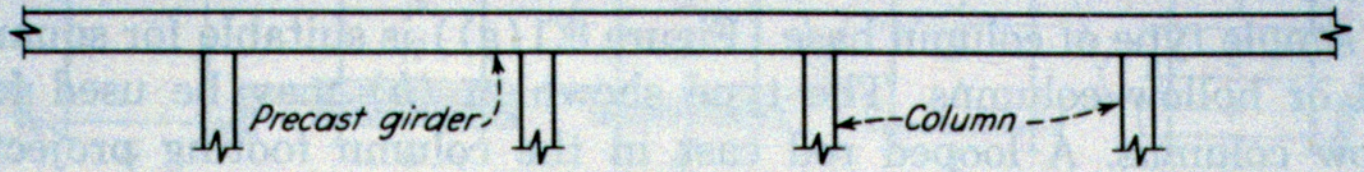




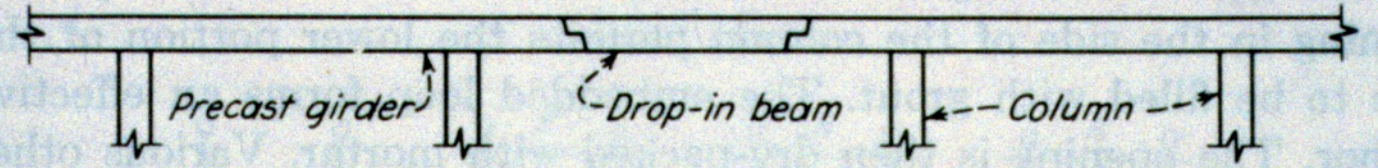




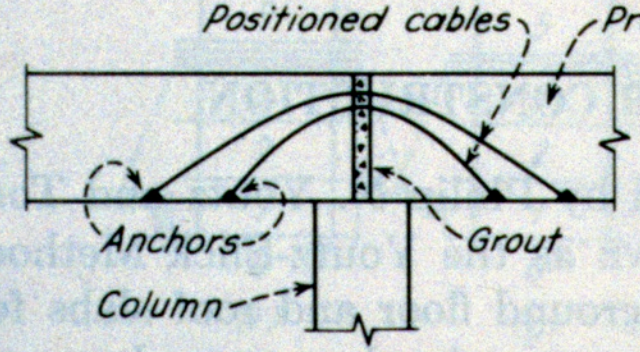




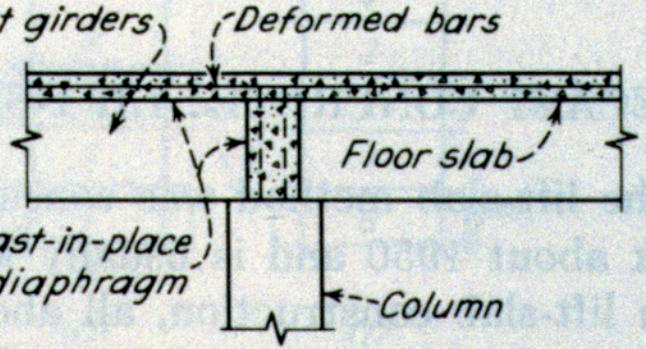
(a) Continuous girder



(b) Overhanging girders with drop-in beam

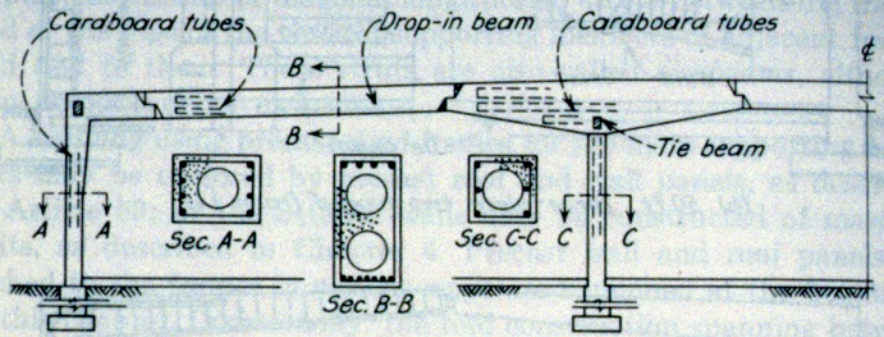


(c) Continuity with cap cables

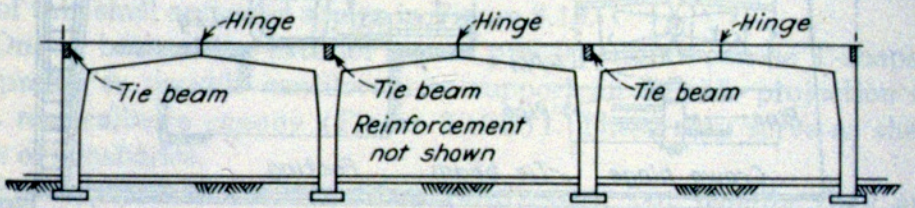


(d) Continuity in composite construction

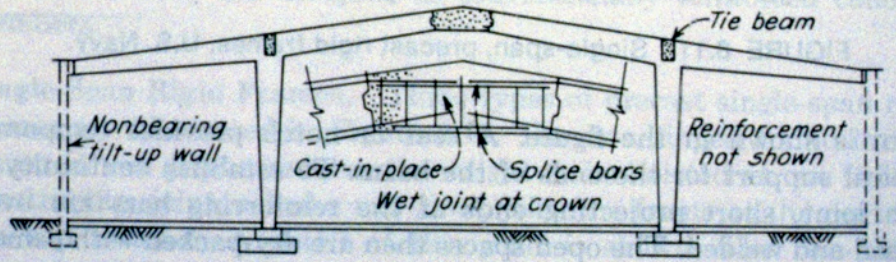
FIGURE 8.7 Overhanging girders and continuity connections.



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

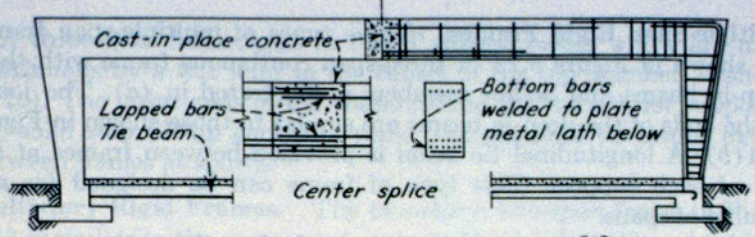


(b) 3-span rigid frame

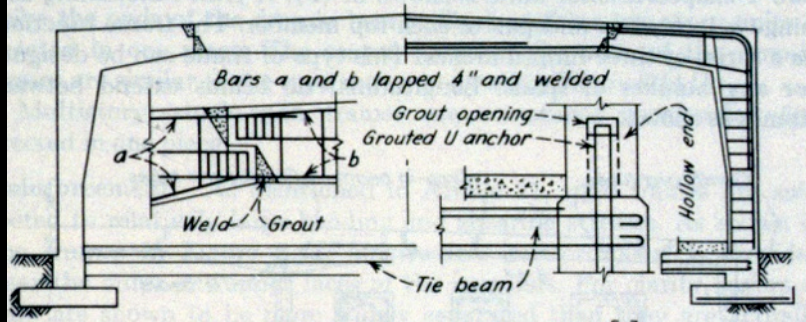


(c) 90 ft. 3-span rigid frame. U.S. Navy [4].

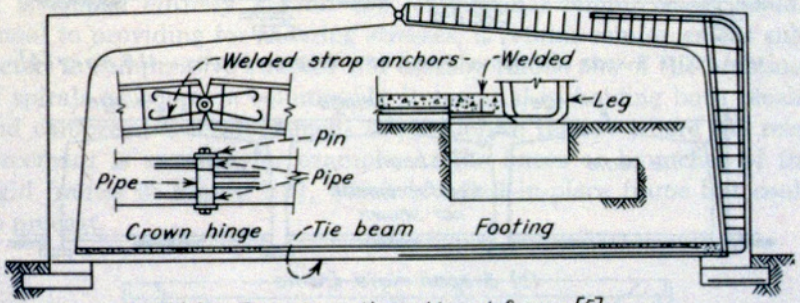
FIGURE 8.12 Three-span rigid frames. U.S. Navy.



(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.

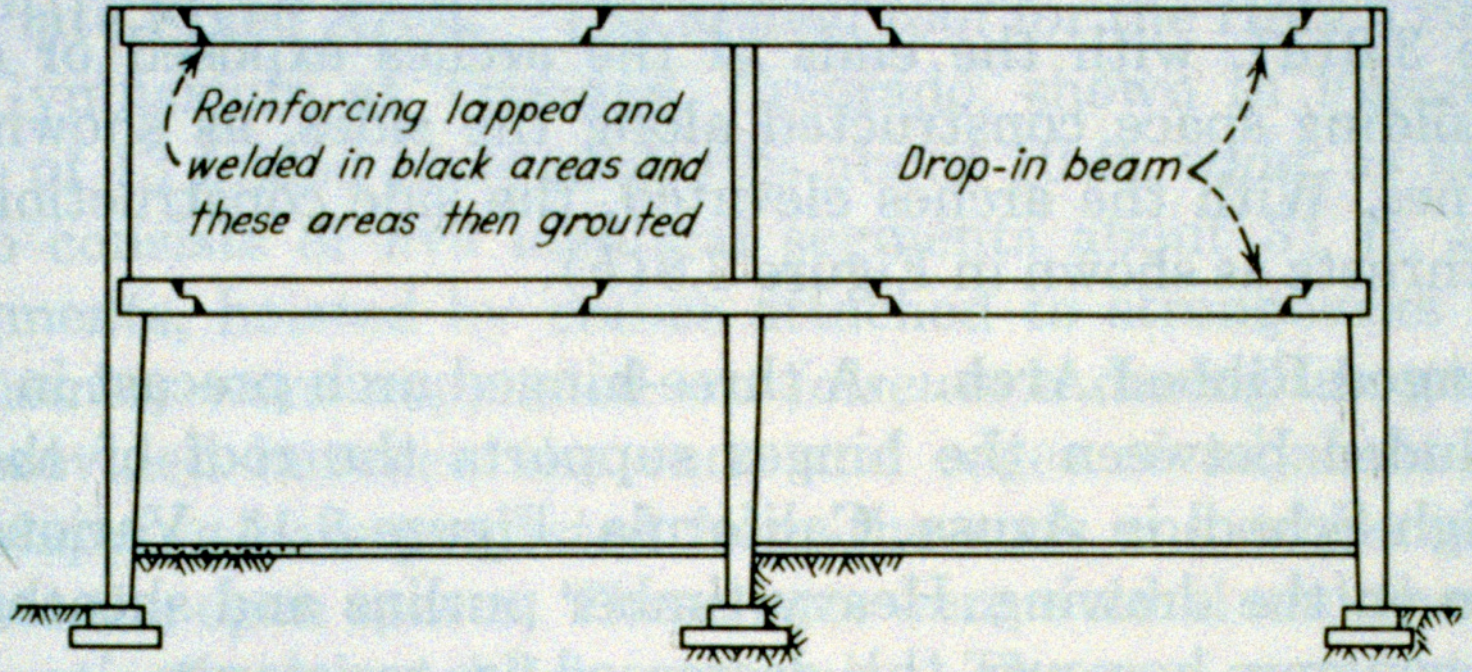
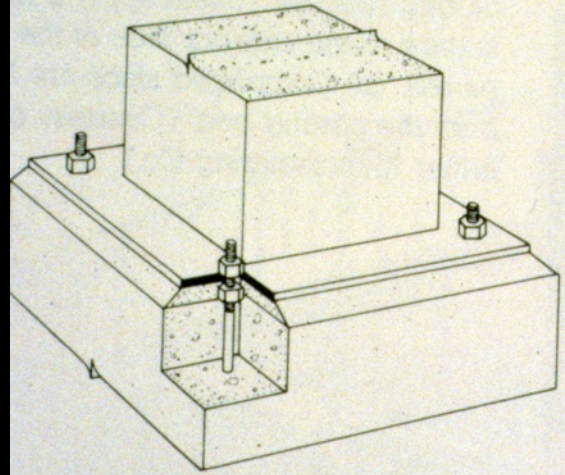
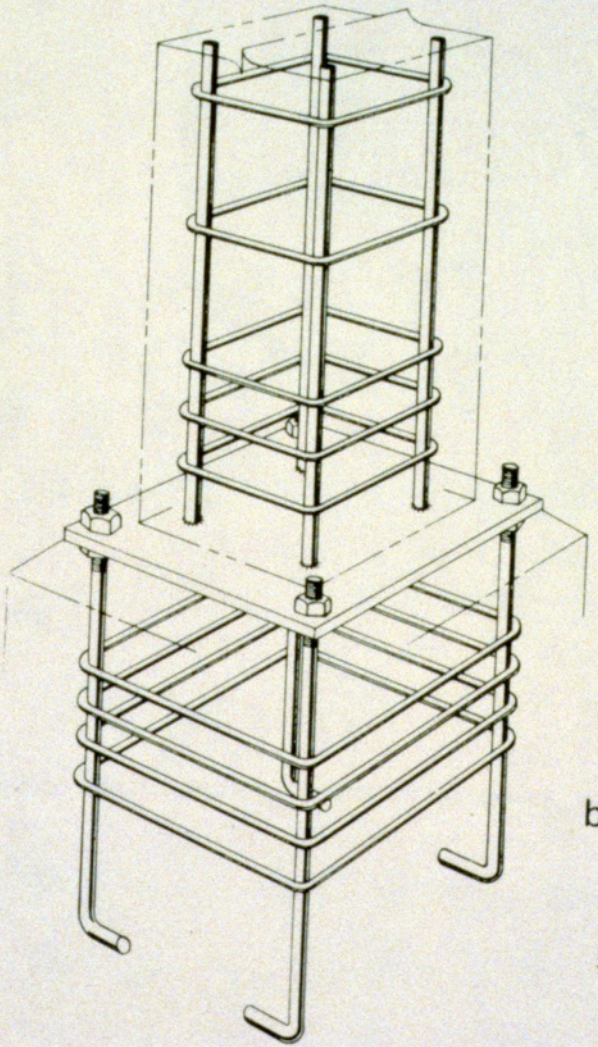
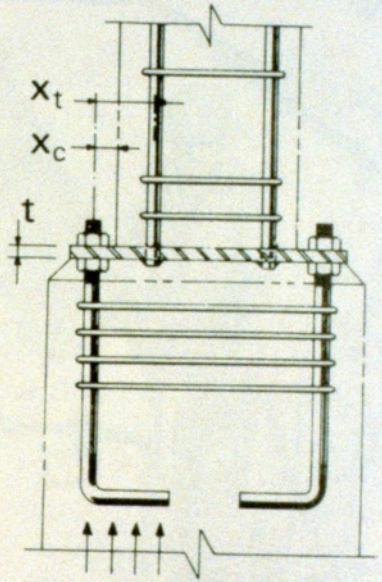
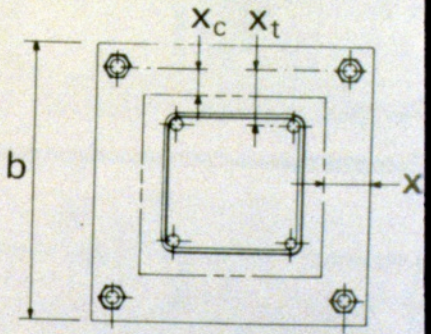


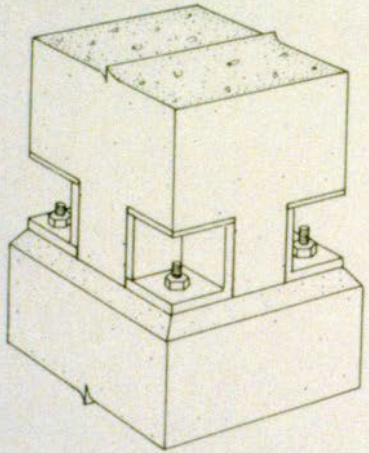
FIGURE 8.13 A 50-ft. two-span, two-story rigid frame with drop-in beam
Designed by Roberts and Schaefer for U.S. Air Force.

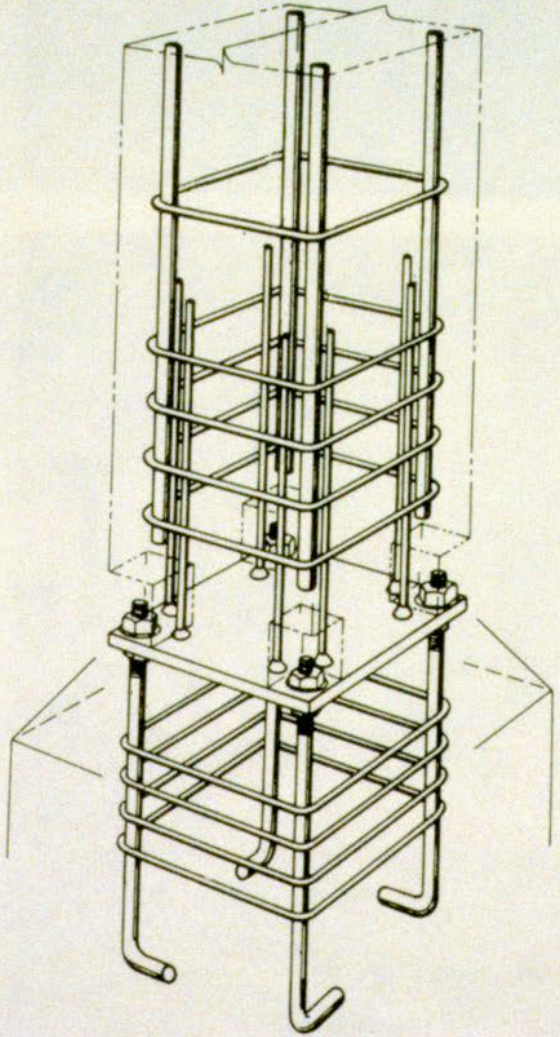


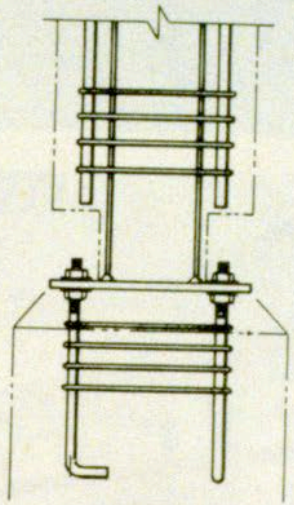


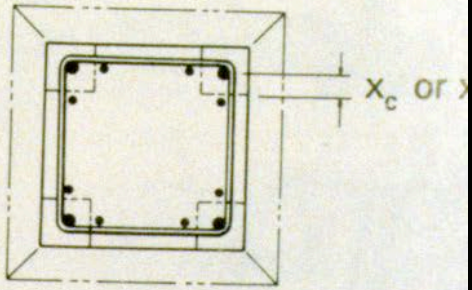

x_t
x_c
t

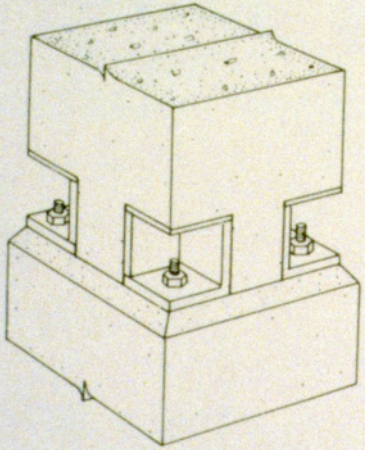

x_c
x_t
b
x

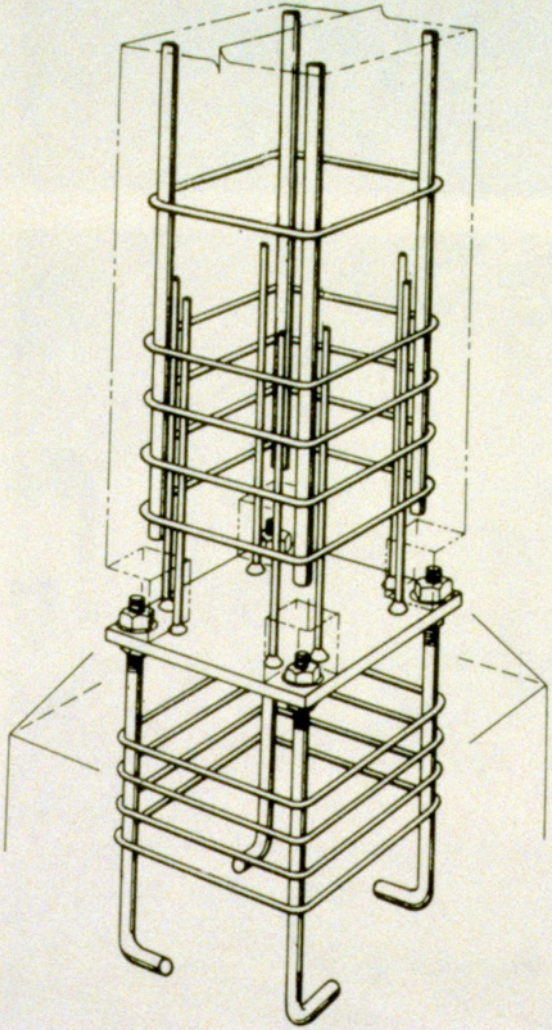


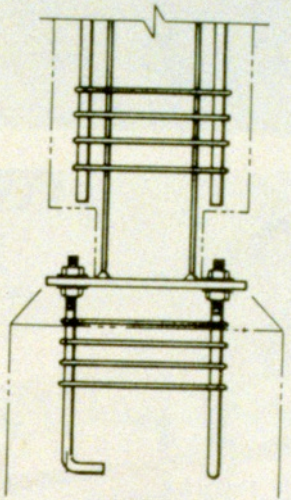





x_c or x







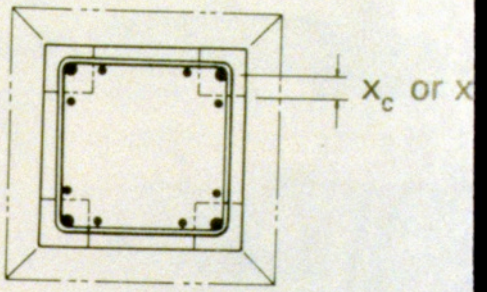
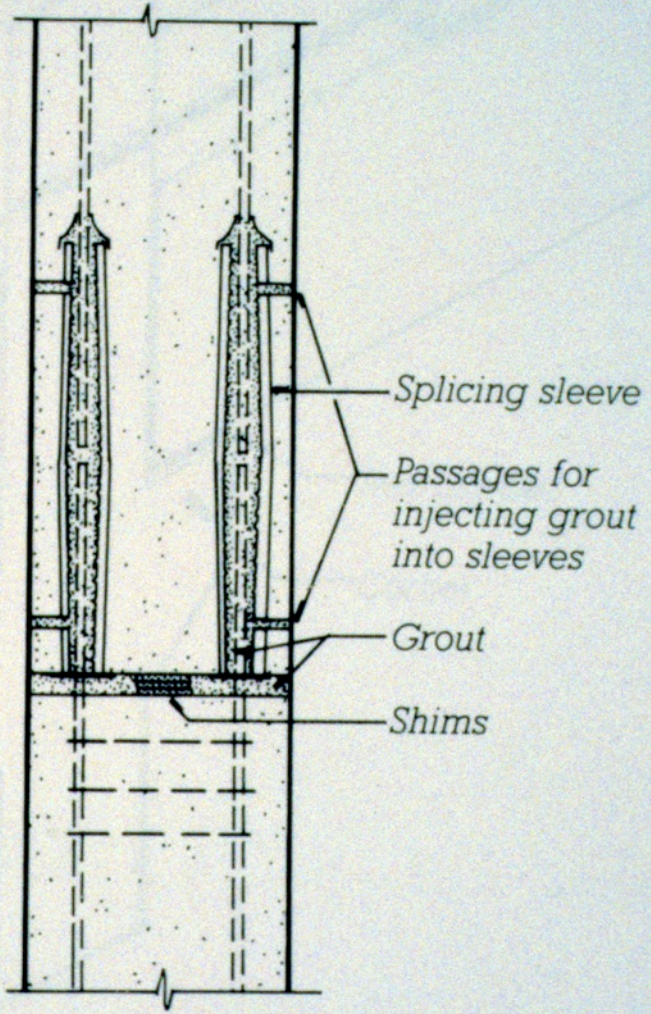
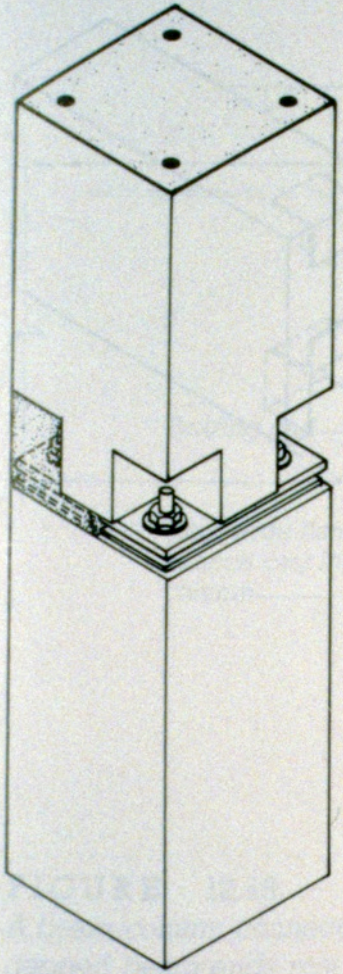
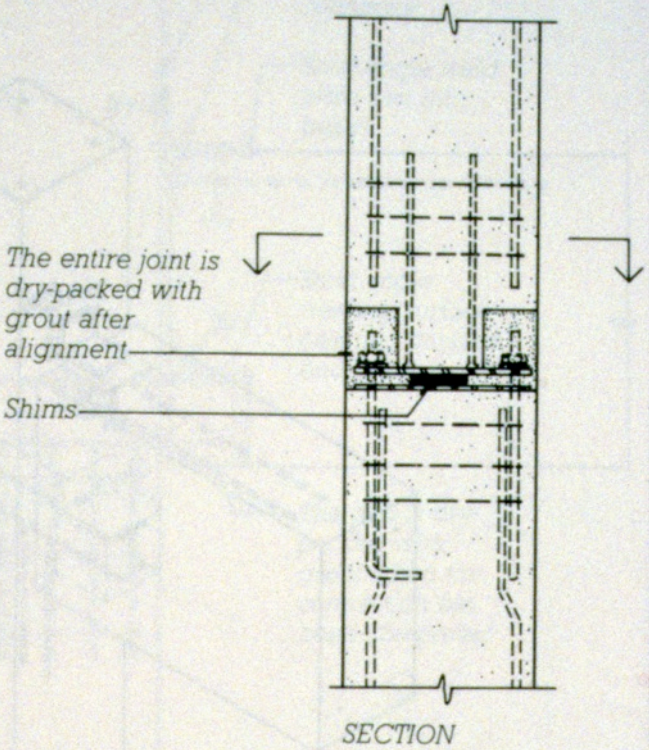

x_c or x

FIGURE 12.17

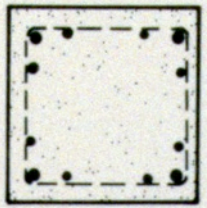
Section through a column-to-column connection using a proprietary sleeve that is cast into the column. Projecting reinforcing bars from the lower column section are inserted in the sleeves, where injected grout makes the connection.



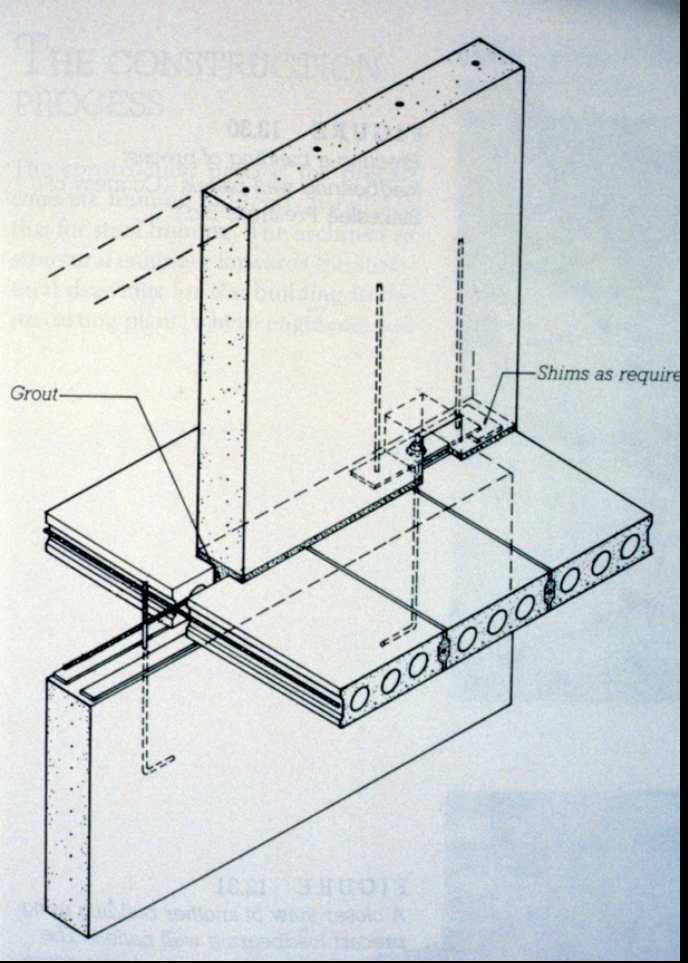


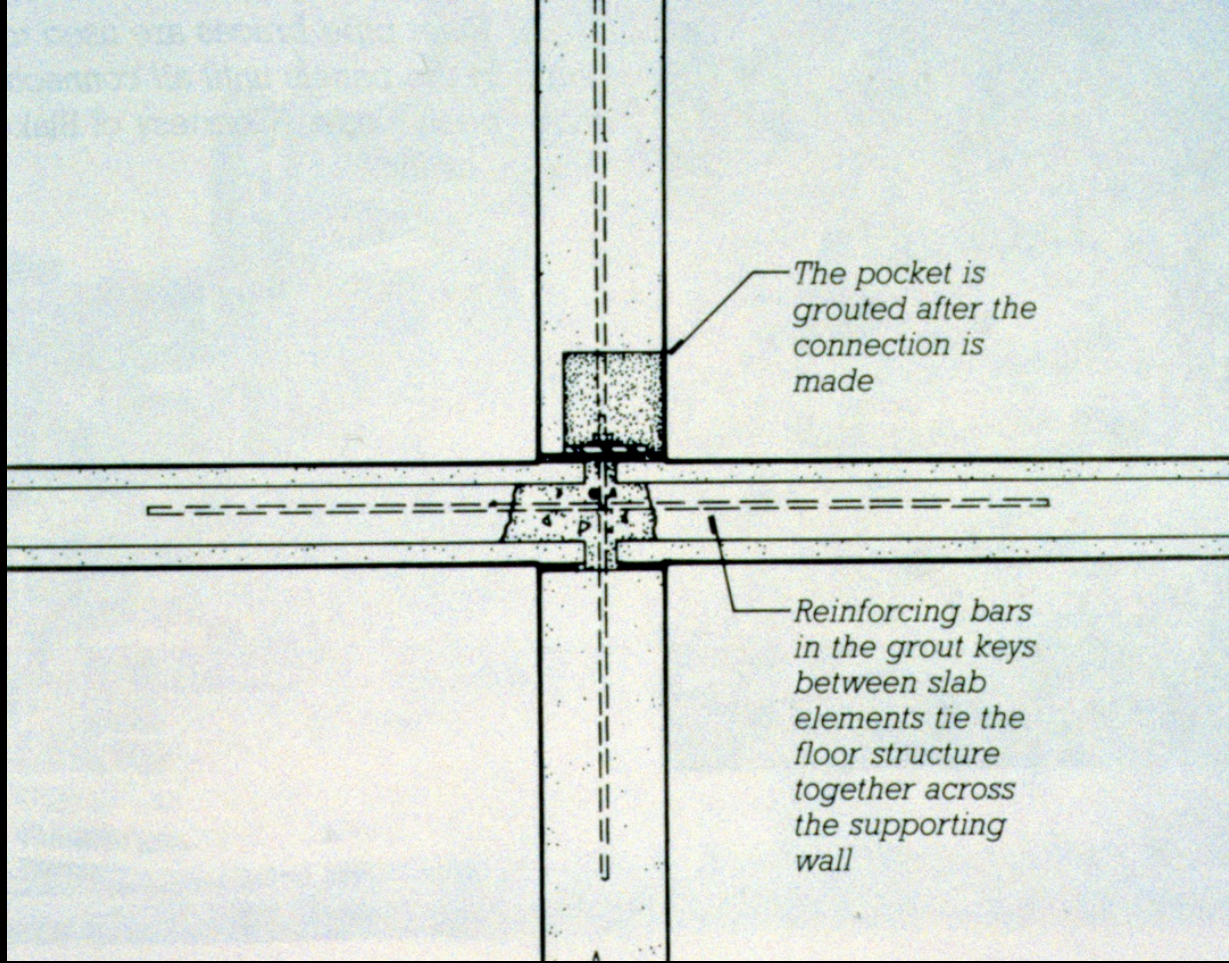


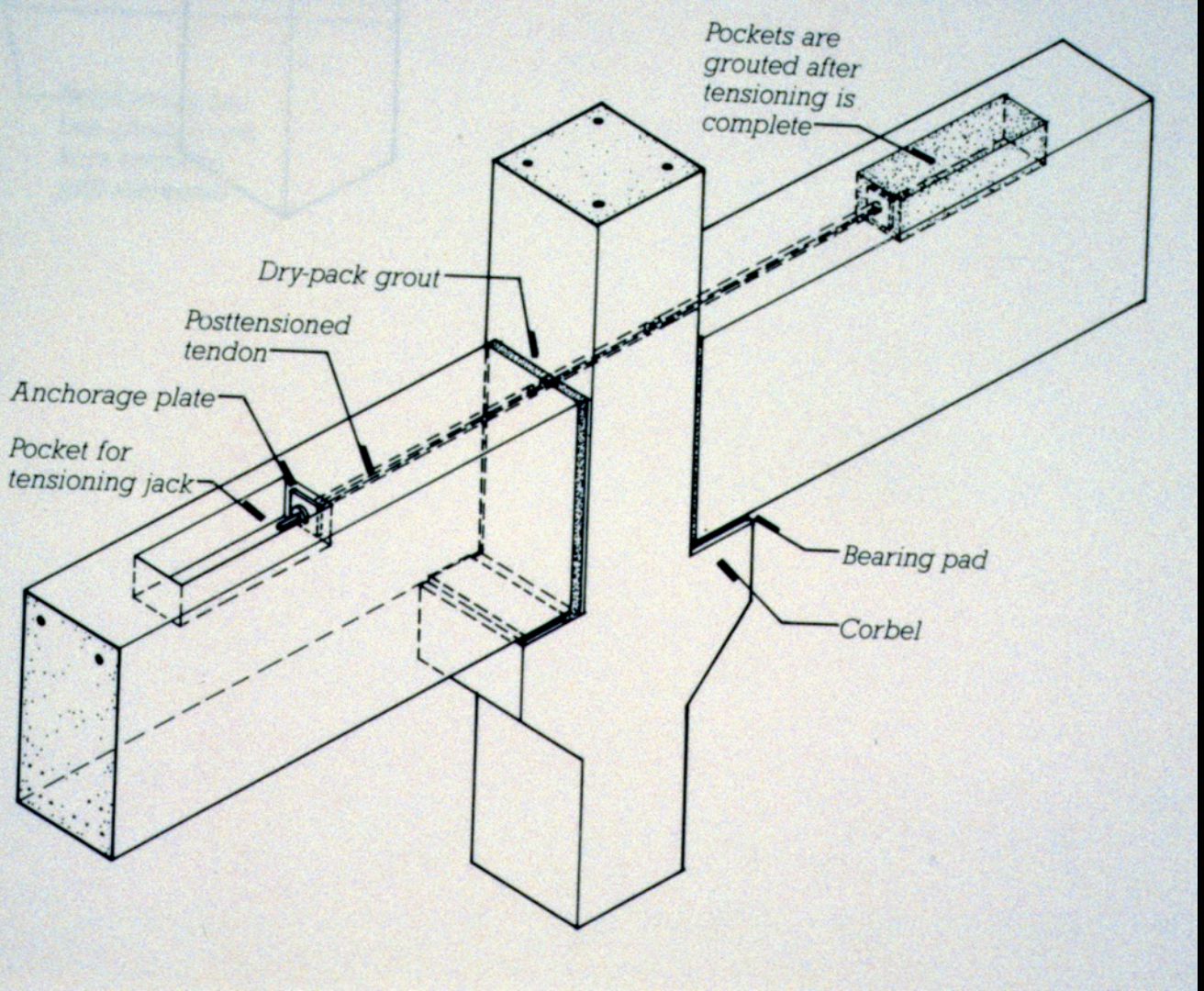
SECTION

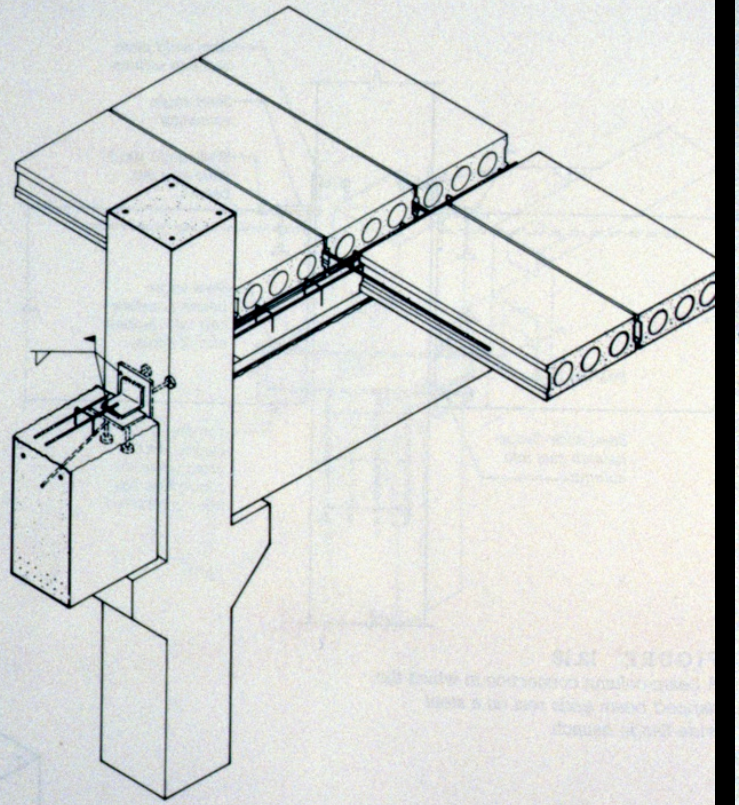


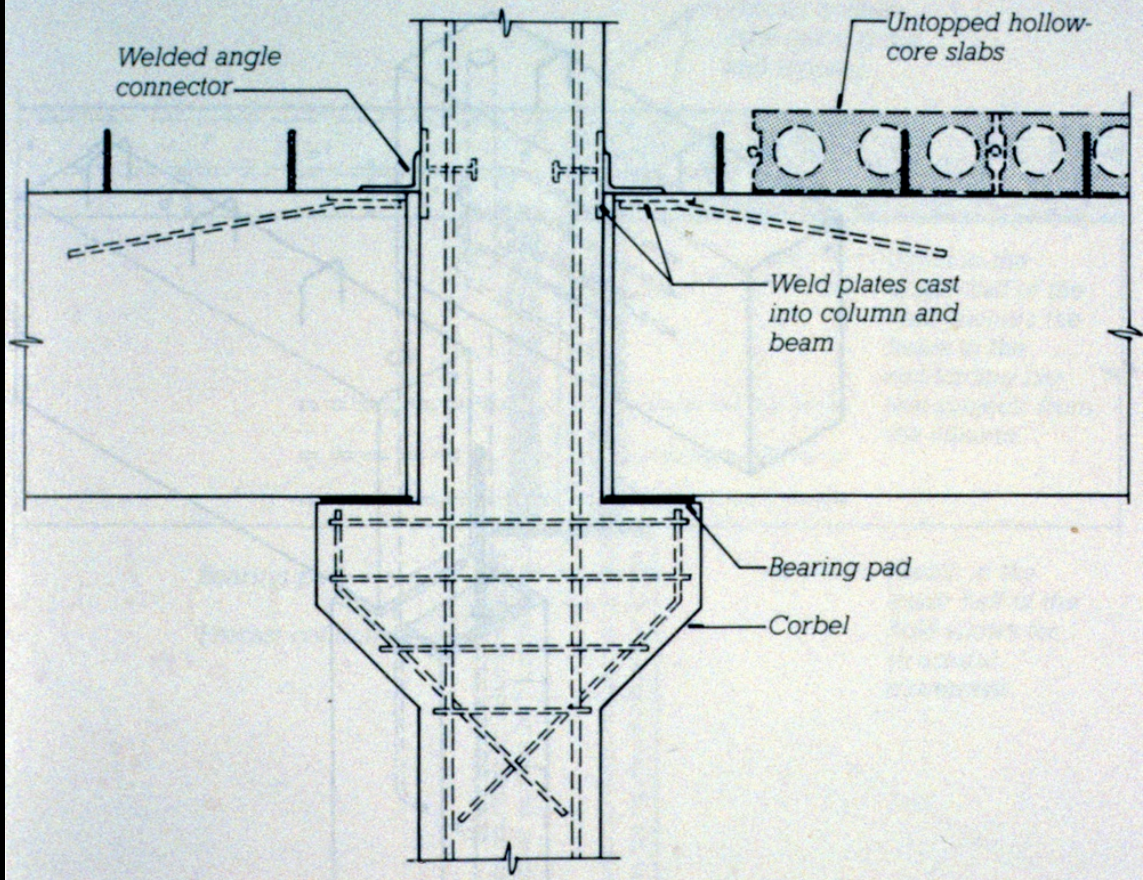
PLAN


Grout
Shims as required

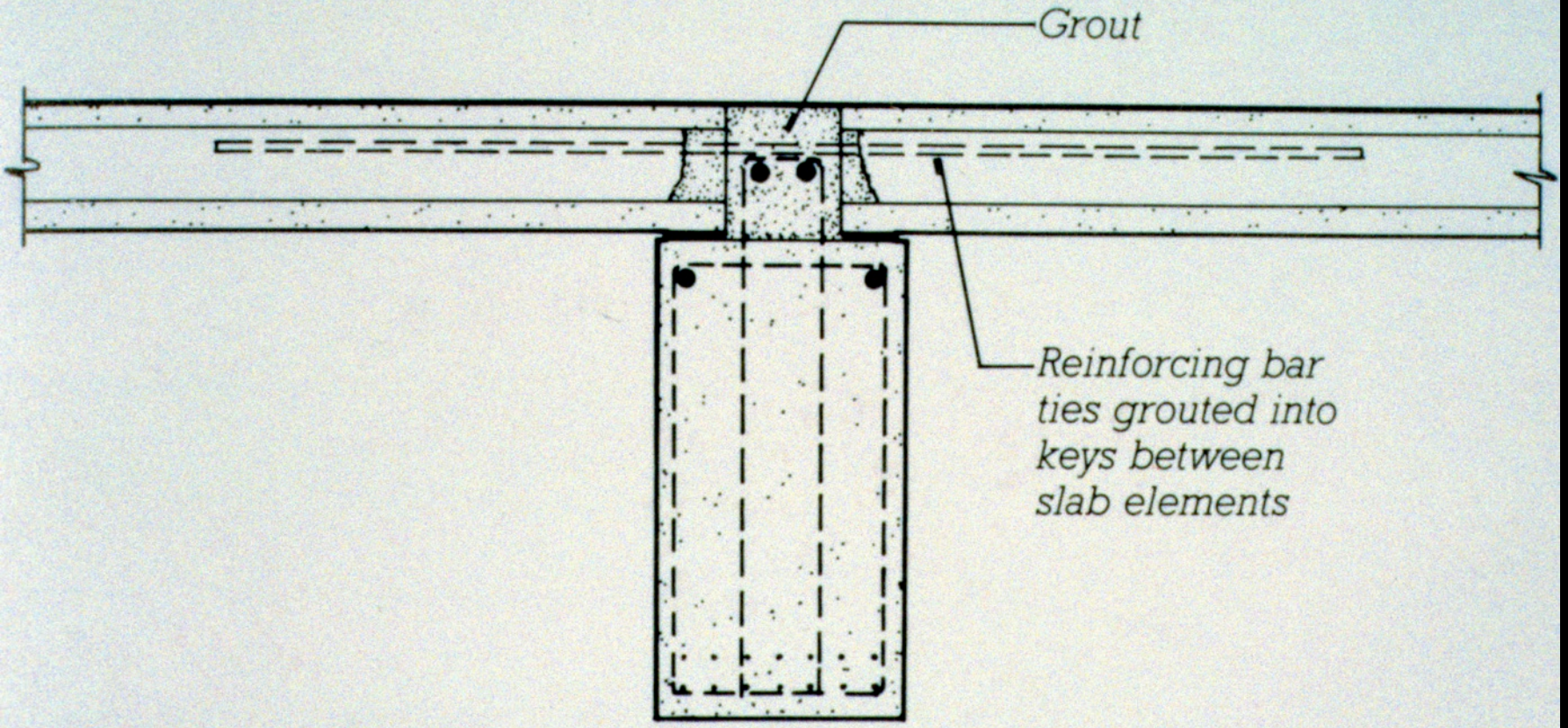

The pocket is grouted after the connection is made
Reinforcing bars in the grout keys between slab elements tie the floor structure together across the supporting wall


Pockets are grouted after tensioning is complete
Dry-pack grout
Posttensioned tendon
Anchorage plate
Pocket for tensioning jack
Bearing pad
Corbel

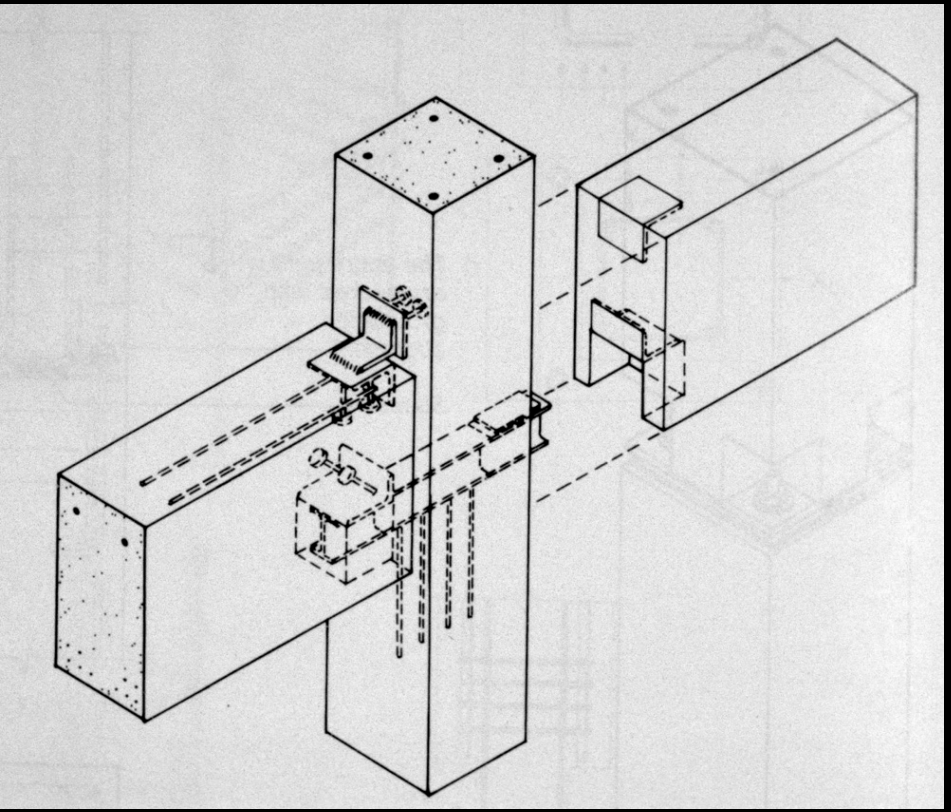


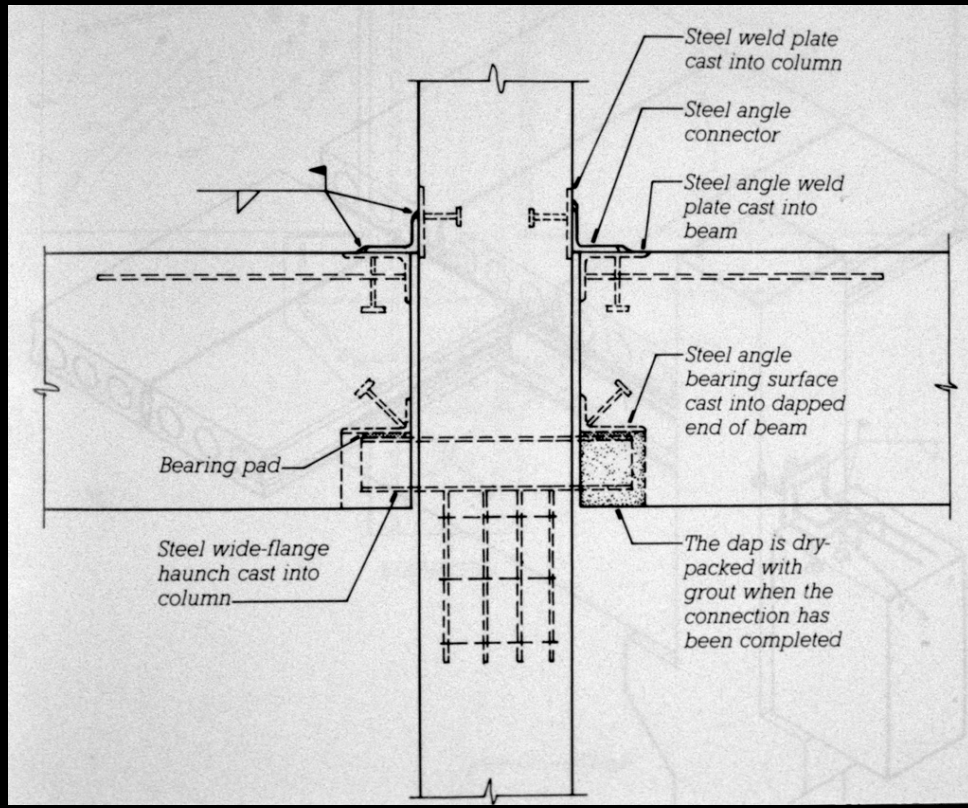

Welded angle connector
Untopped hollow-core slabs
Weld plates cast into column and beam
Bearing pad
Corbel

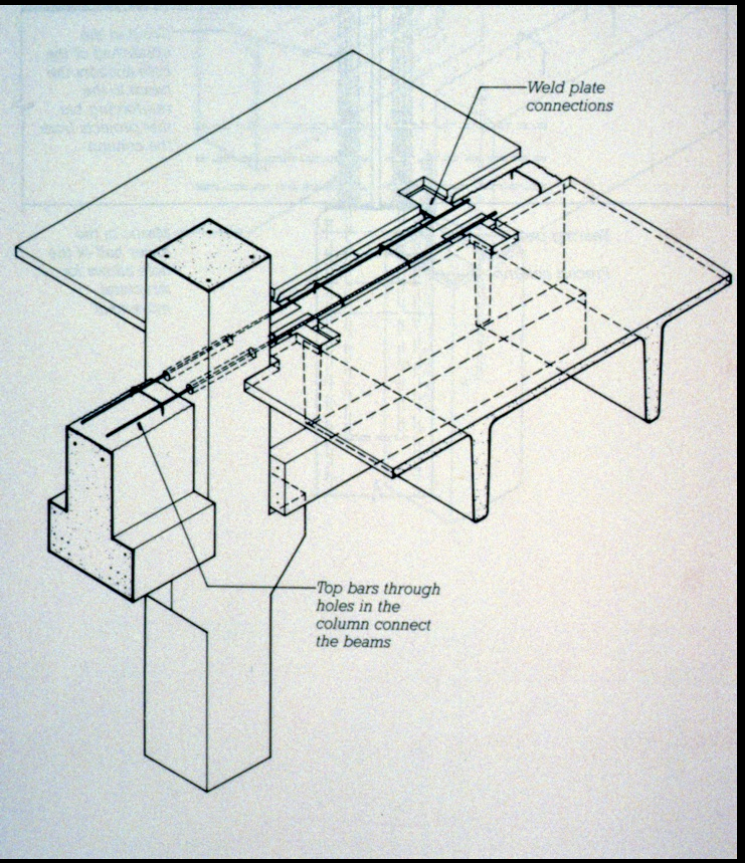
ELEVATION

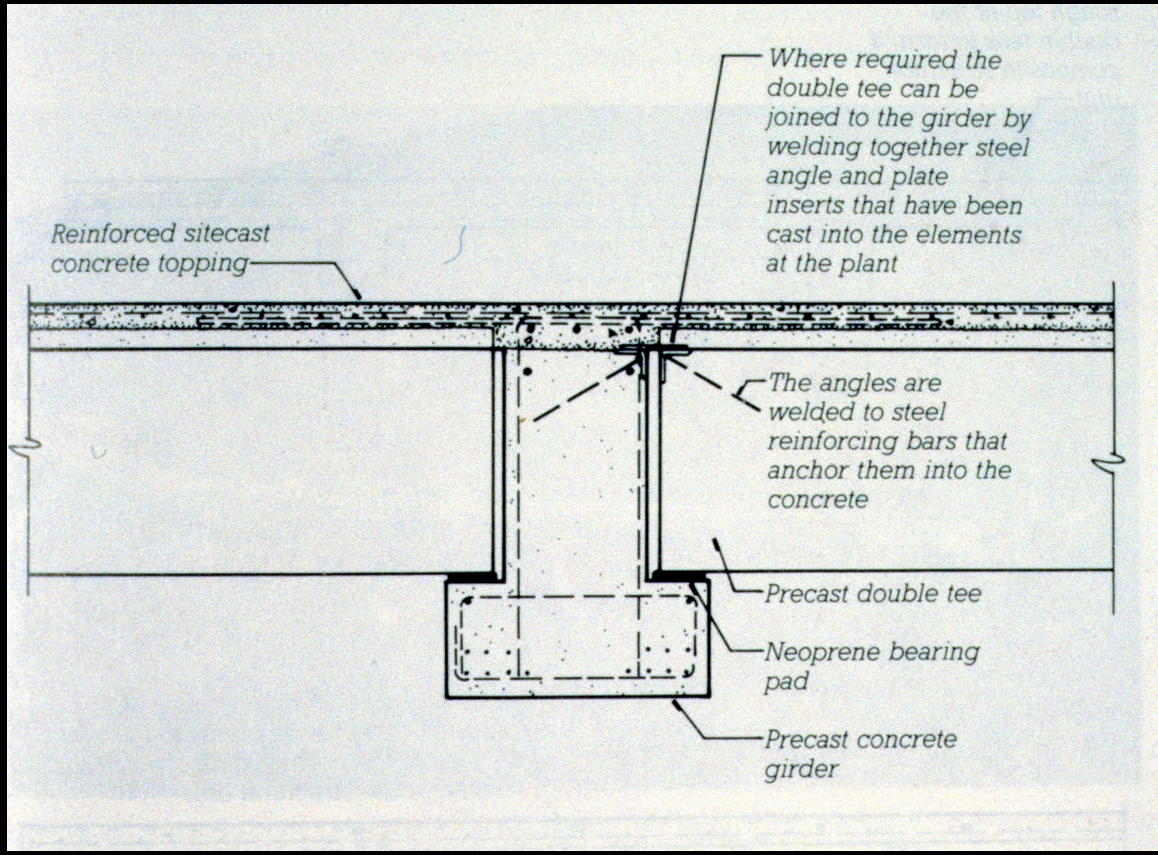


SECTION THROUGH BEAM




Steel weld plate cast into column
Steel angle connector
Steel angle weld plate cast into beam
Steel angle bearing surface cast into dapped end of beam
Bearing pad
Steel wide-flange haunch cast into column
The dap is dry-packed with grout when the connection has been completed


Weld plate connections
Top bars through holes in the column connect the beams


Where required the double tee can be joined to the girder by welding together steel angle and plate inserts that have been cast into the elements at the plant
Reinforced sitecast concrete topping
The angles are welded to steel reinforcing bars that anchor them into the concrete
Precast double tee
Neoprene bearing pad
Precast concrete girder

Lift Slab Construction

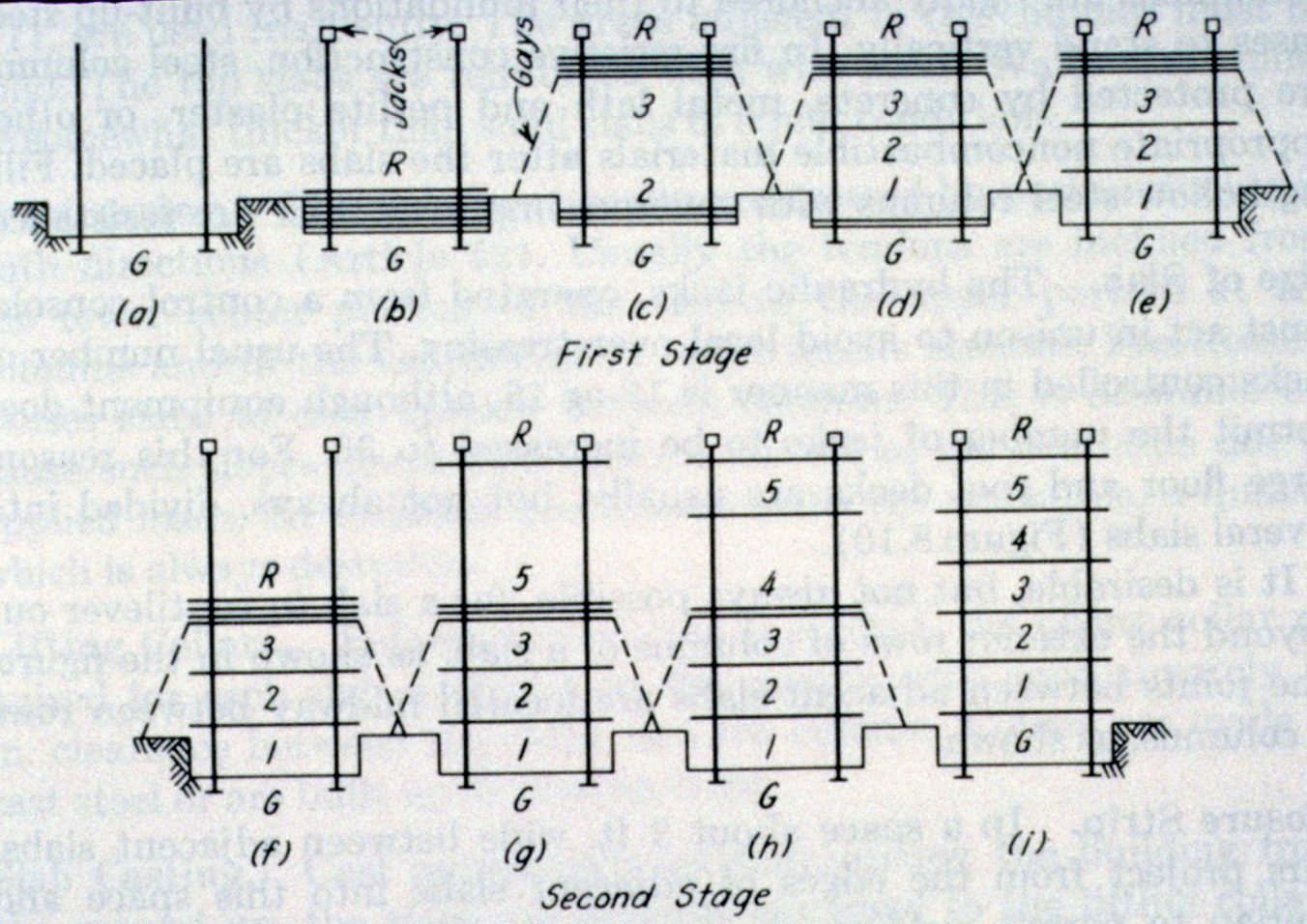
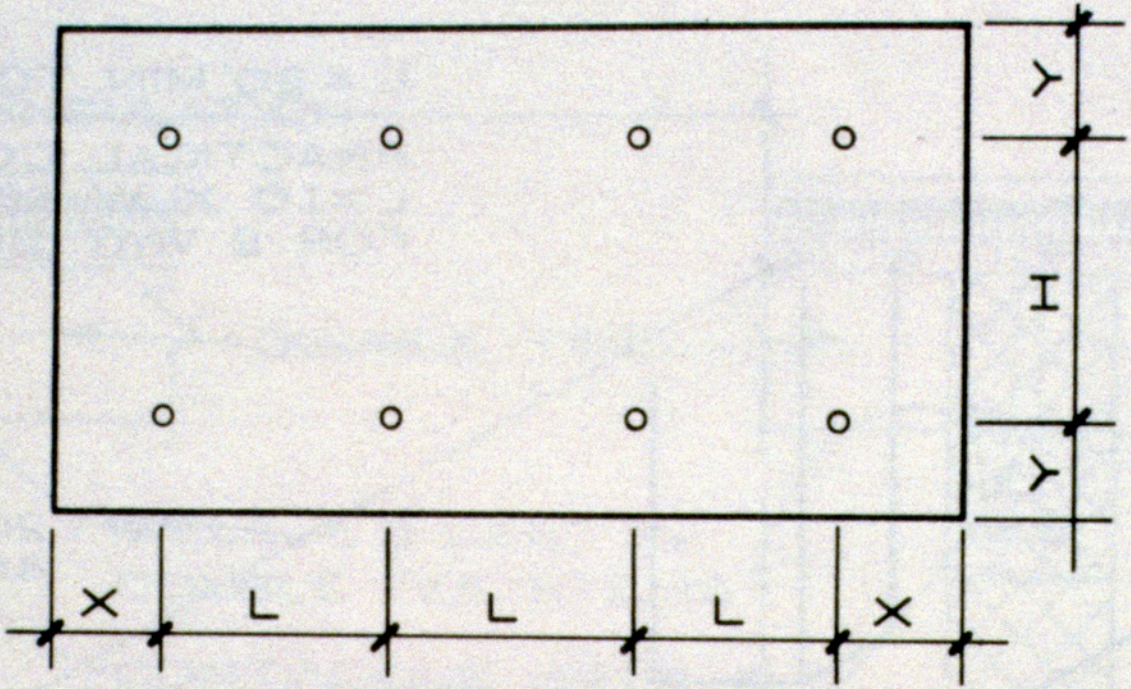


FIGURE 8.8 Sequence of lifting operations.

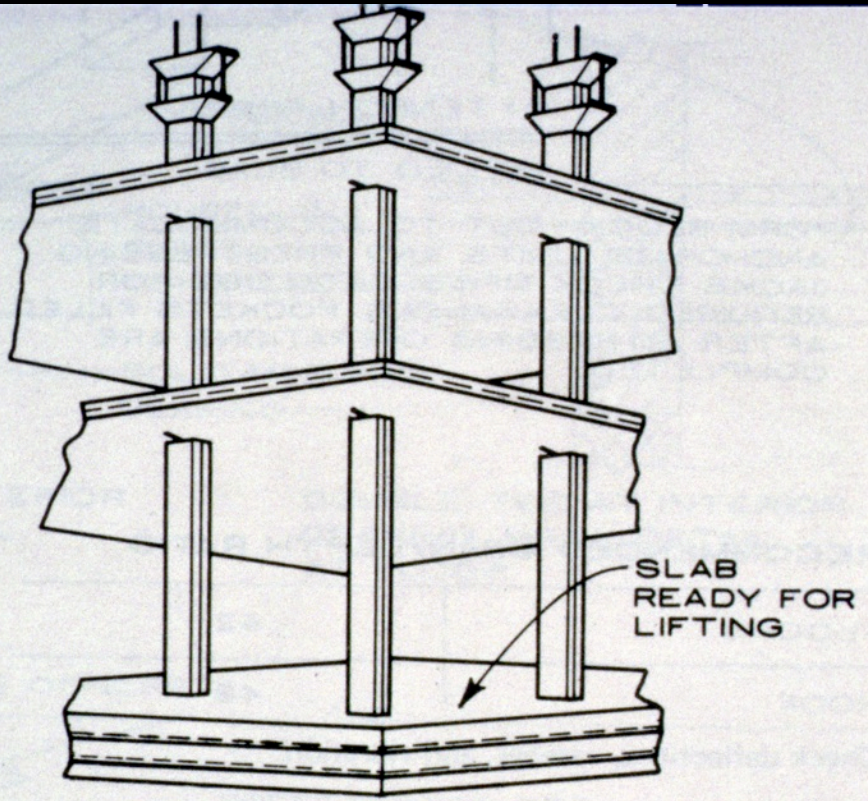


BEST RESULTS OCCUR WHEN CANTILEVERS ARE PROPORTIONED AS FOLLOWS:

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

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

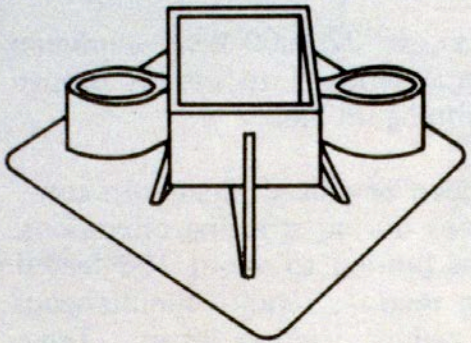
PLAN OF LIFT-SLAB



SCHEMATIC ISOMETRIC OF LIFT-SLAB METHOD

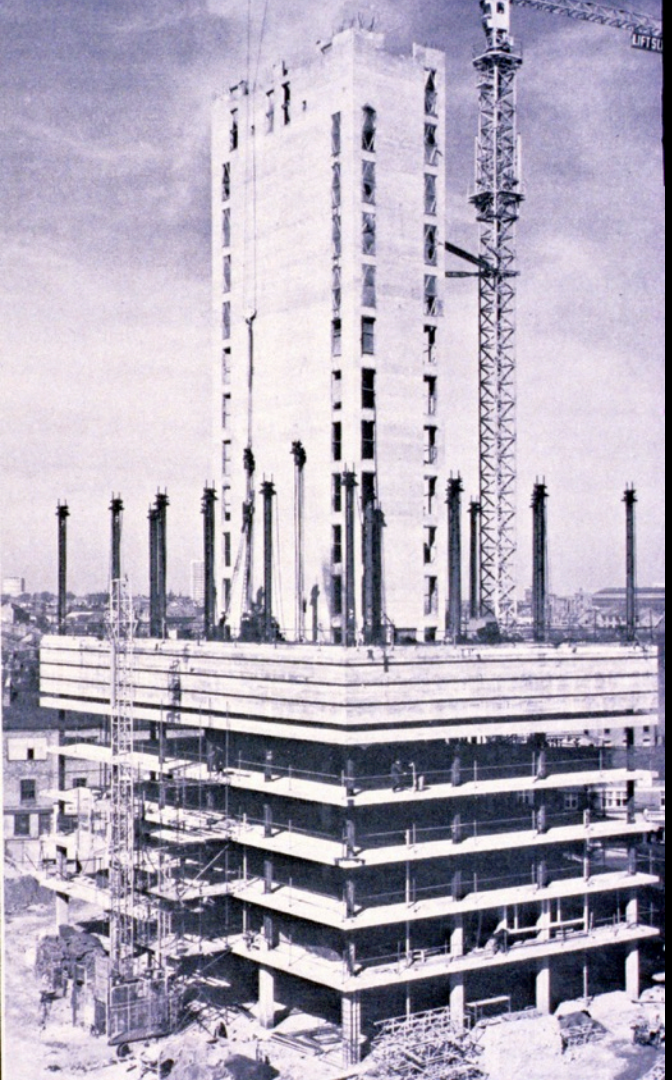
NOTE:

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/

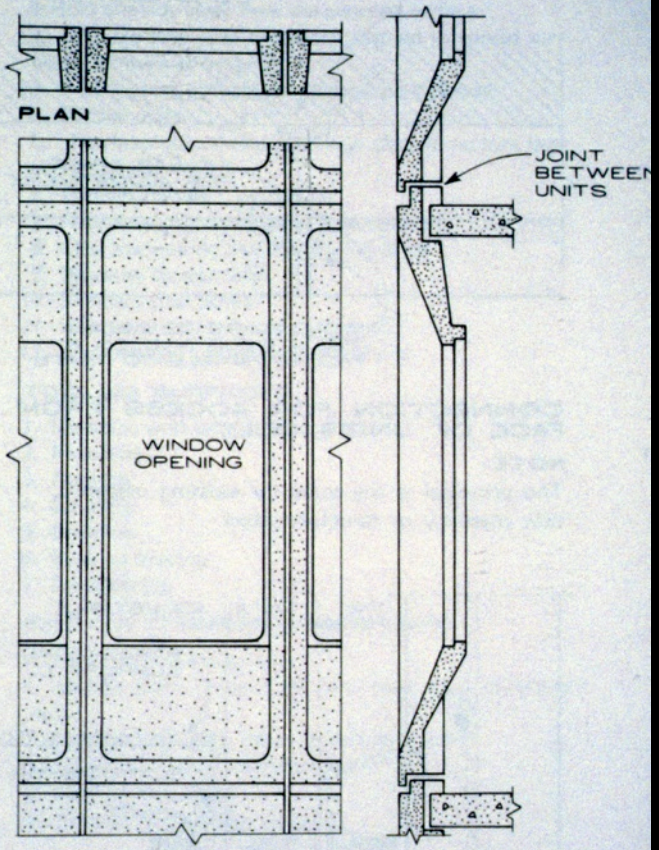
The lift slab method was fatefully implemented in the L'Ambiance Plaza development in Bridgeport, Connecticut. What was set to be a 16-storey residential project suddenly collapsed on April 23, 1987, killing 28 construction workers.

Precast Concrete Cladding Systems

Transamerica Tower, San Francisco

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

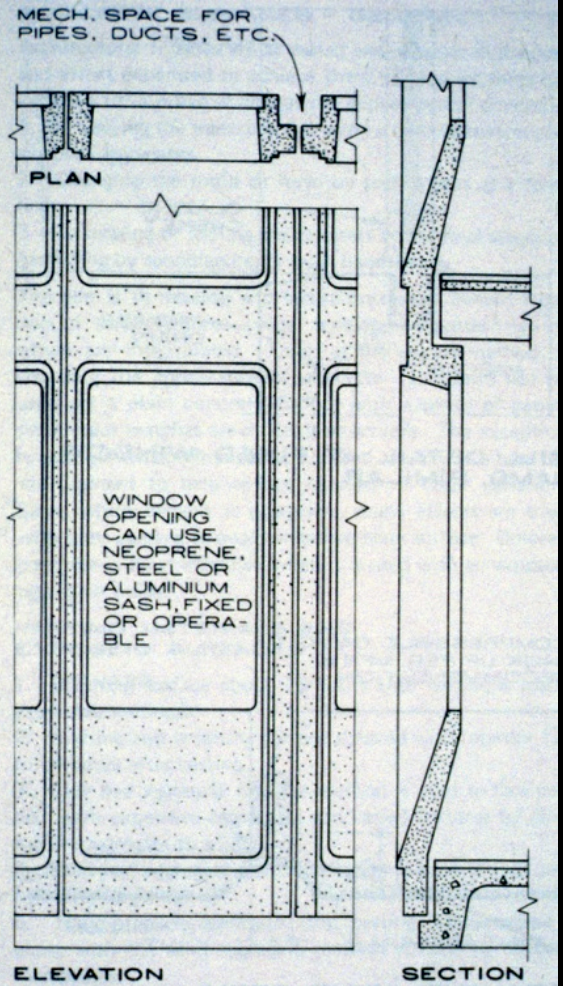
Washington, D.C.



ELEVATION SECTION

SINGLE STORY FACING TYPE UNITS

THIS UNIT HAS BOTH STRUCTURAL AND MECHANICAL USES

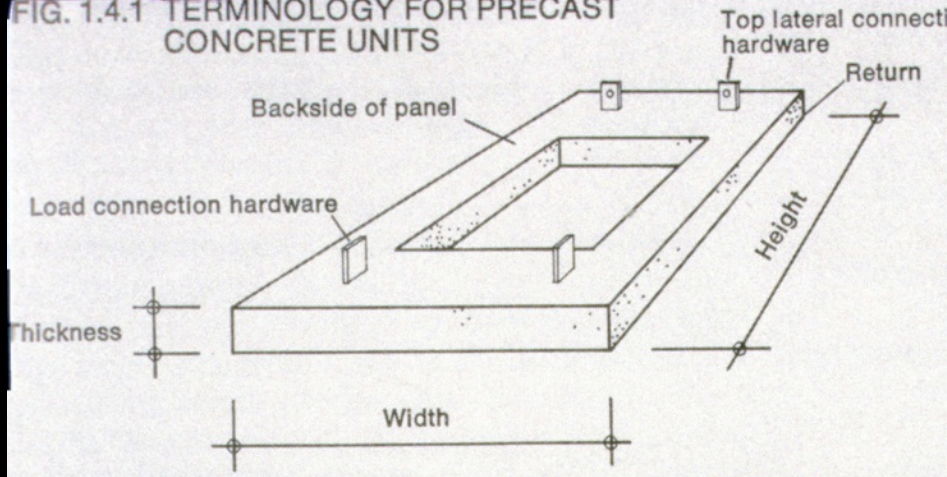


ELEVATION SECTION

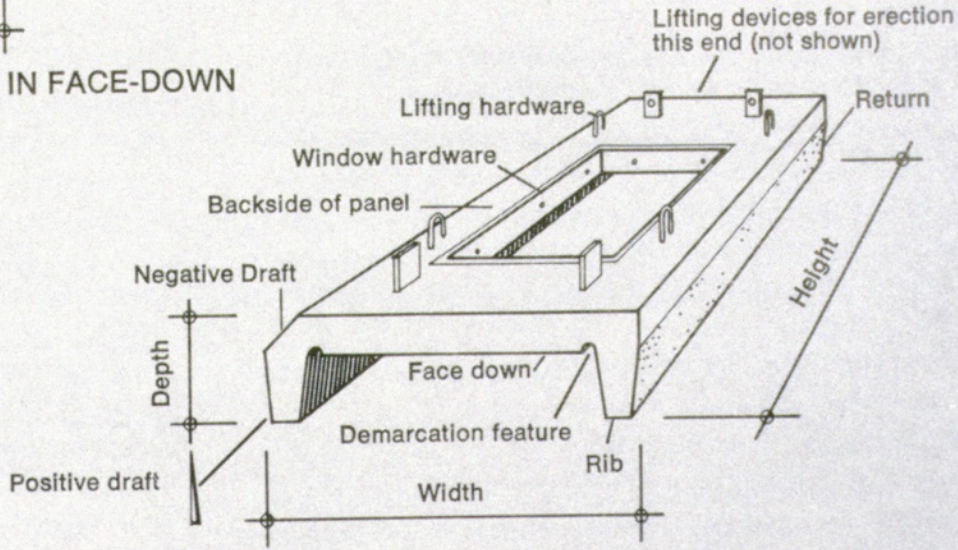
MULTI-STORY FACING TYPE UNITS

THIS UNIT HAS BOTH STRUCTURAL AND MECHANICAL USES

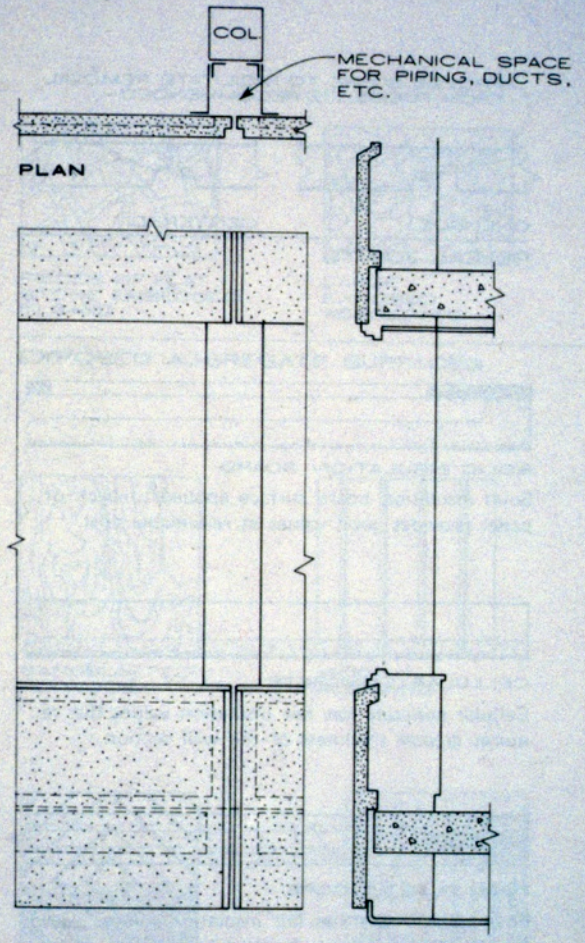
FIG. 1.4.1 TERMINOLOGY FOR PRECAST CONCRETE UNITS



TYPICAL FLAT PANEL AS CAST IN FACE-DOWN POSITION



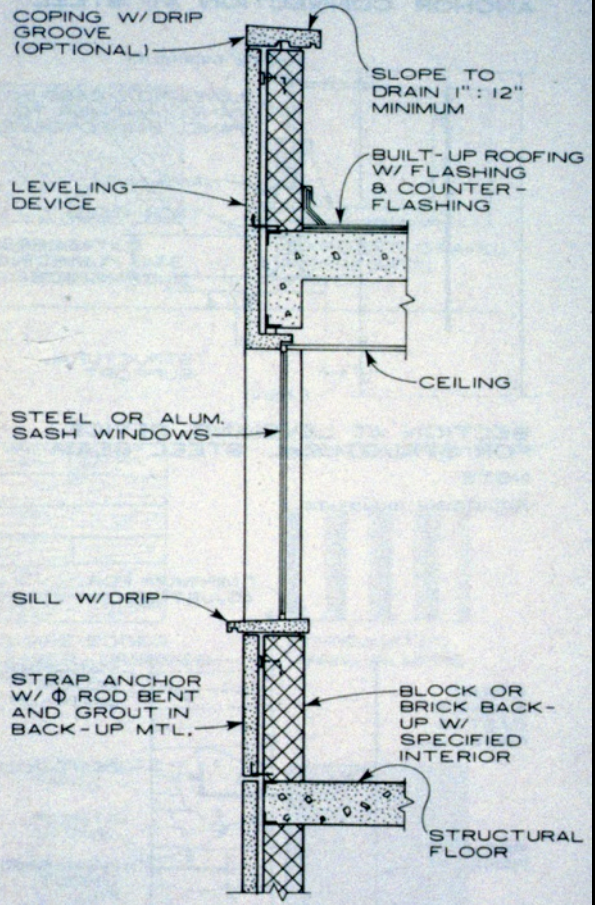
SCULPTURED PANEL AS CAST IN FACE-DOWN POSITION



SPANDREL FACING TYPE UNITS

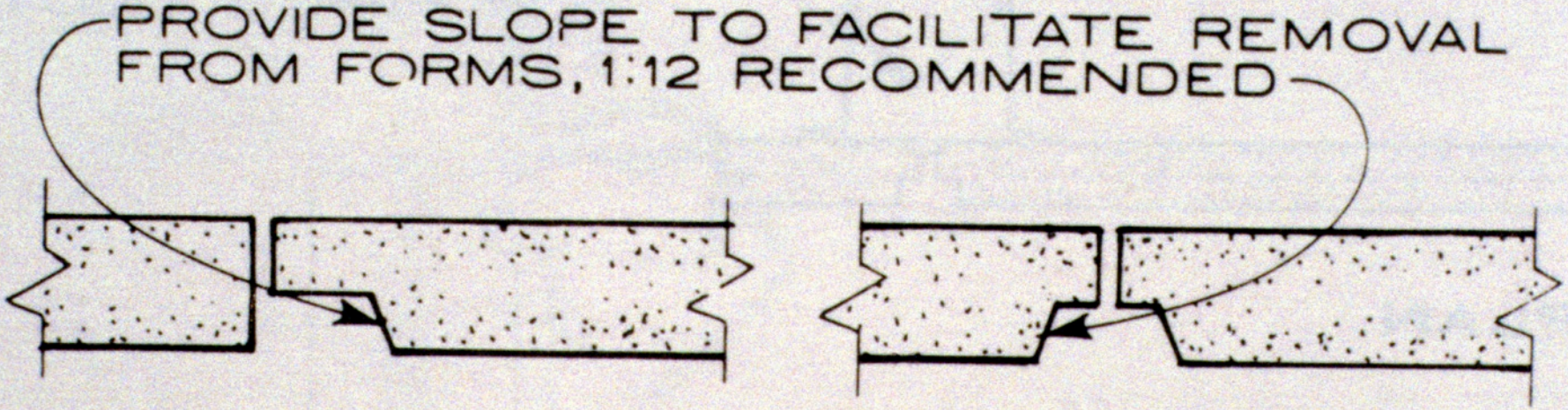
THESE ARE CANTILEVERED TO ALLOW MECHANICAL SPACE

BASIC TYPES



SECTION

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



REVEAL JOINTS

College Street, Toronto, 2022


5
4
VR
3

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

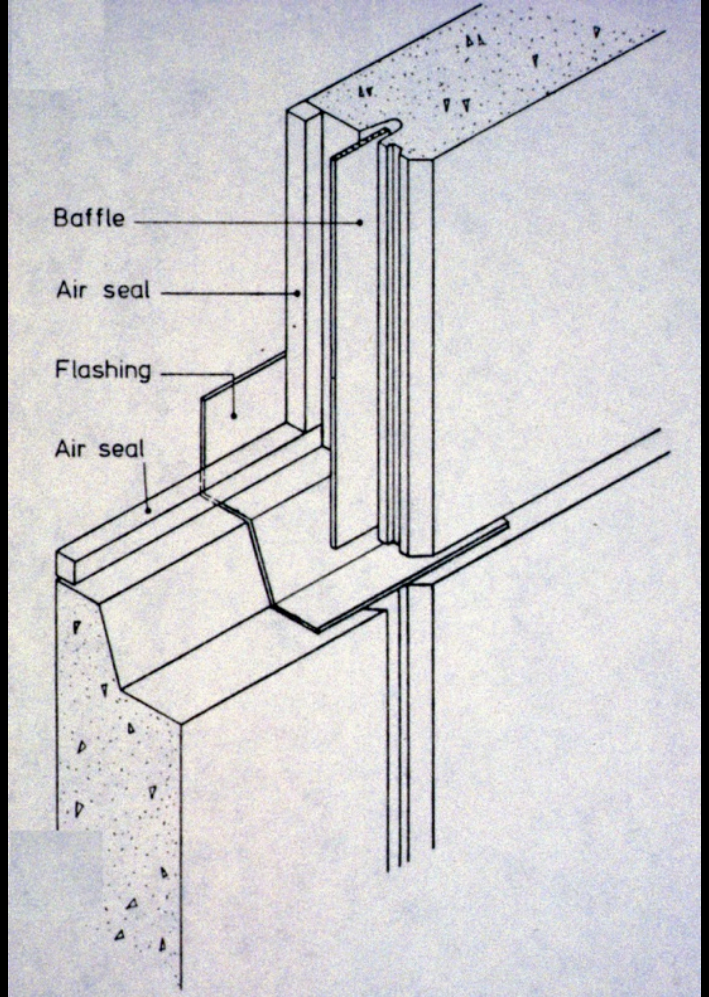
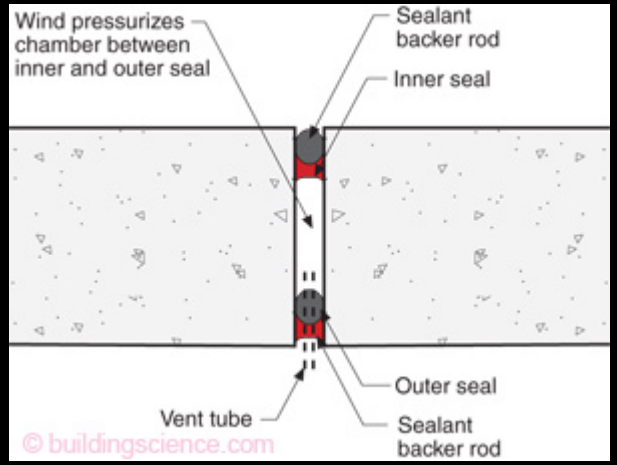
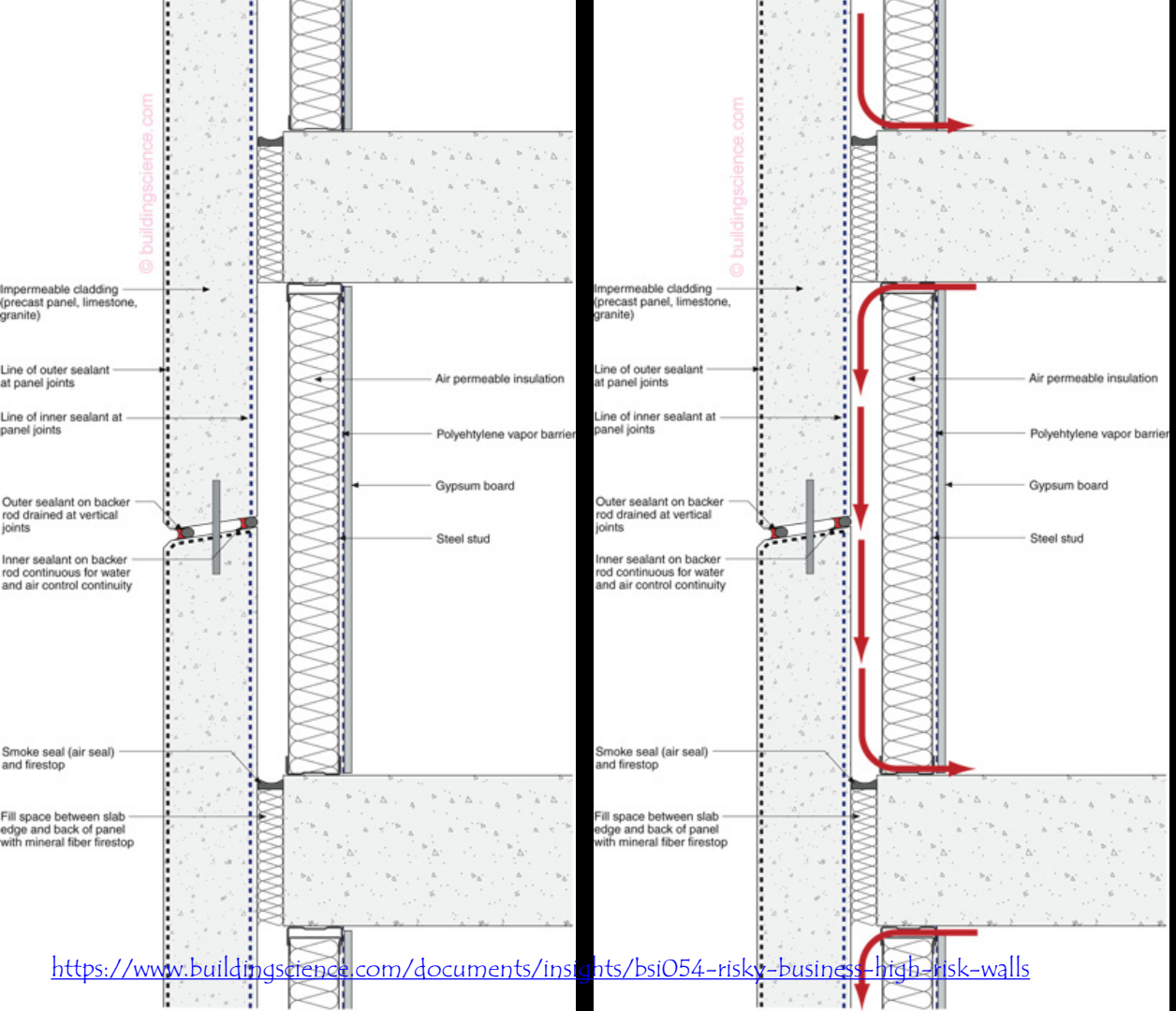


Figure 12. Intersection between horizontal and vertical two-stage joints in an external wall



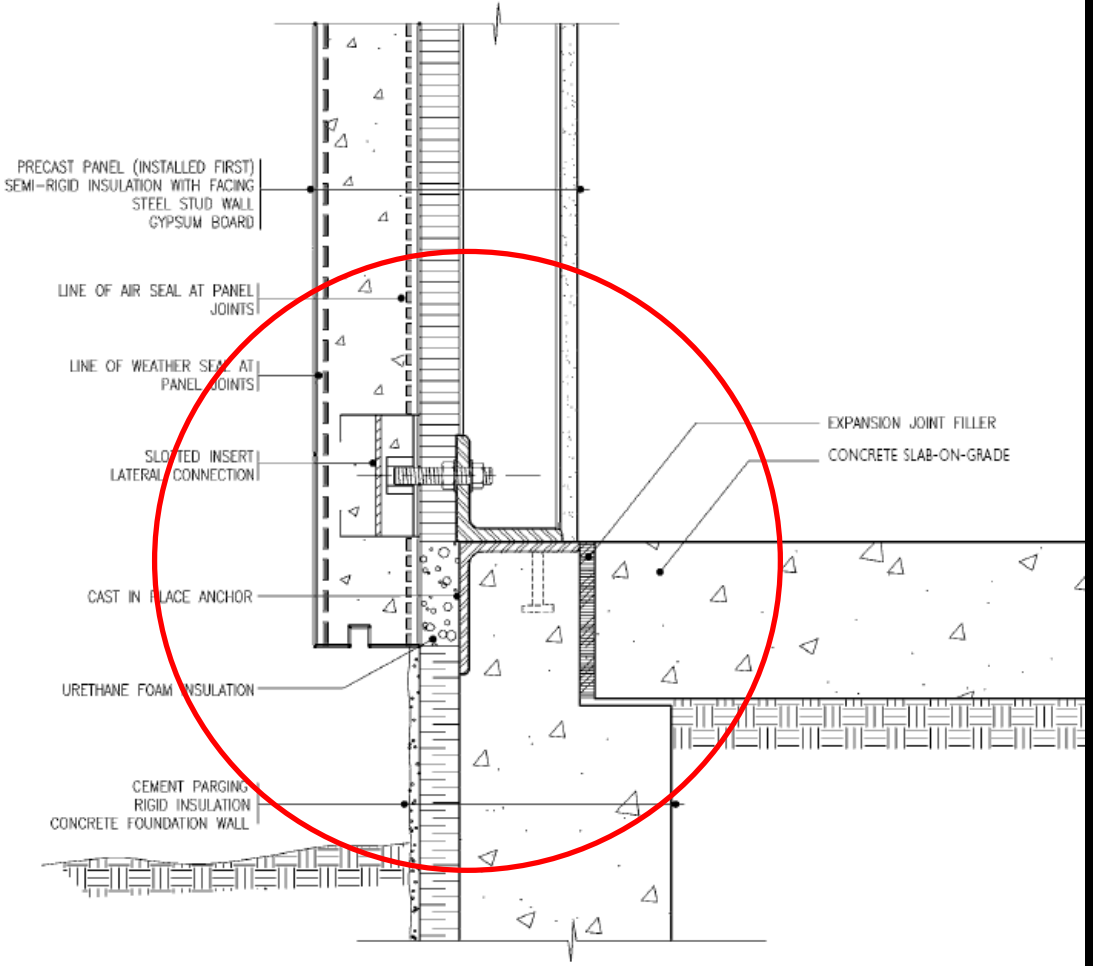
Two-Stage Joint—An inner and outer seal provide drainage at joints. The outer seal is exposed to the elements and gets trashed by the UV and heat and water but the assembly still works because of the interior protected seal. This interior seal is installed from the exterior for continuity reasons.



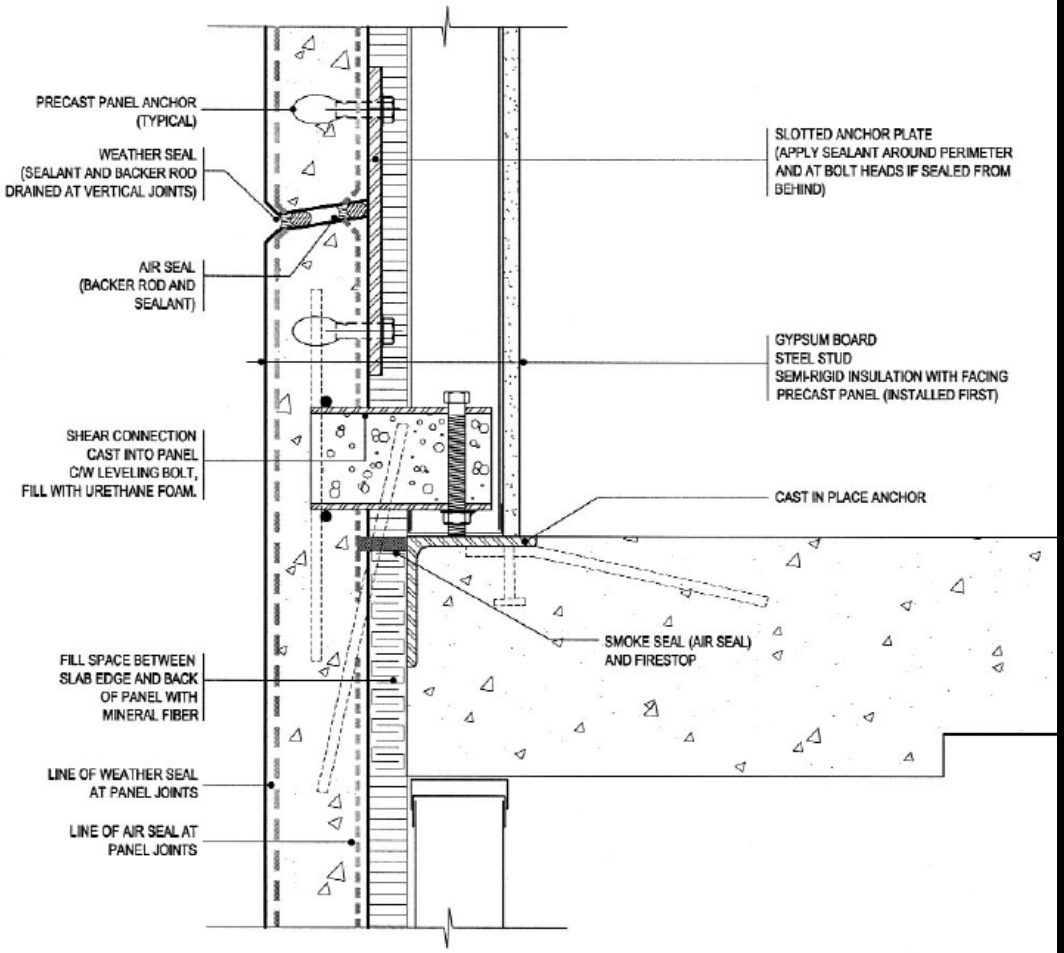
Face-sealed cladding (“perfect barrier”) that is impermeable to water vapor. It is insulated on the interior with air permeable insulation usually held in place between steel studs or impaled on pins protruding from the back of the cladding and covered by a vapor barrier.

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

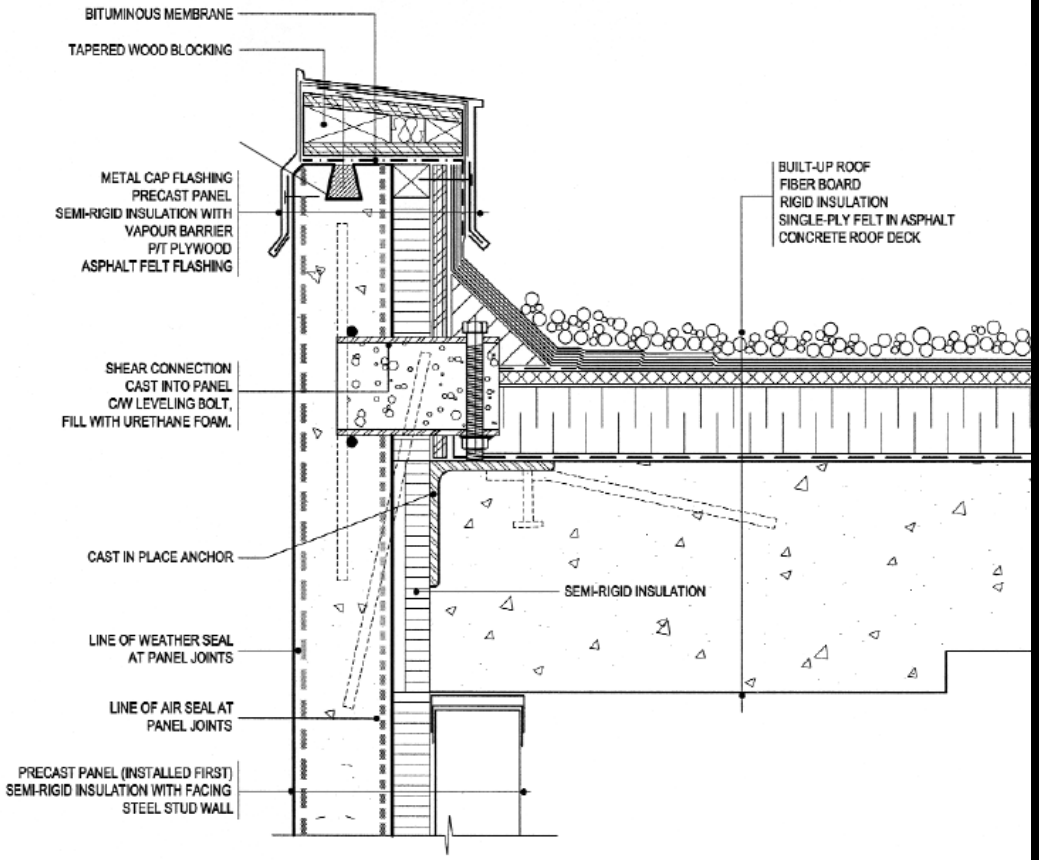
https://www.buildingscience.com/documents/insights/bsi054-risky-business-high-risk-walls



CONVENTIONAL PANEL
LATERAL FOUNDATION CONNECTION

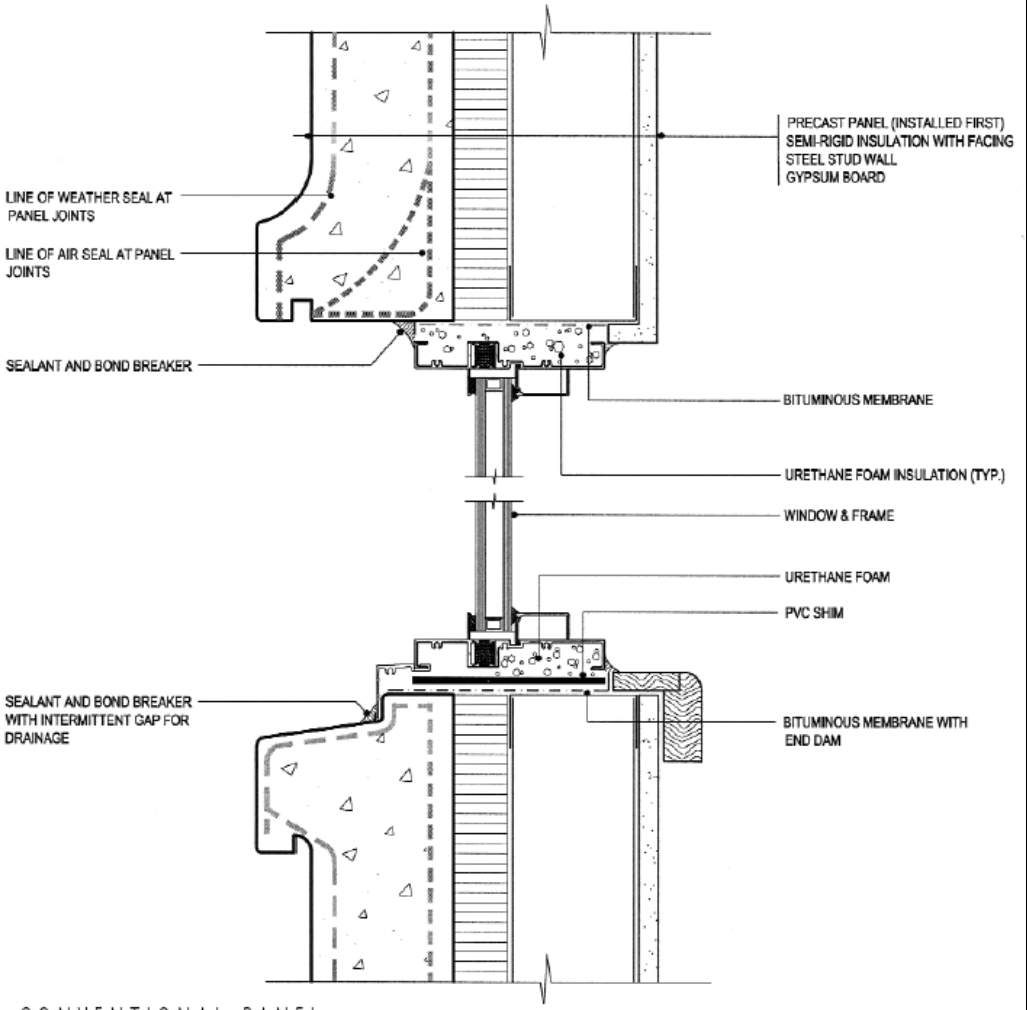


CONVENTIONAL PANEL
SLAB BEARING CONNECTION

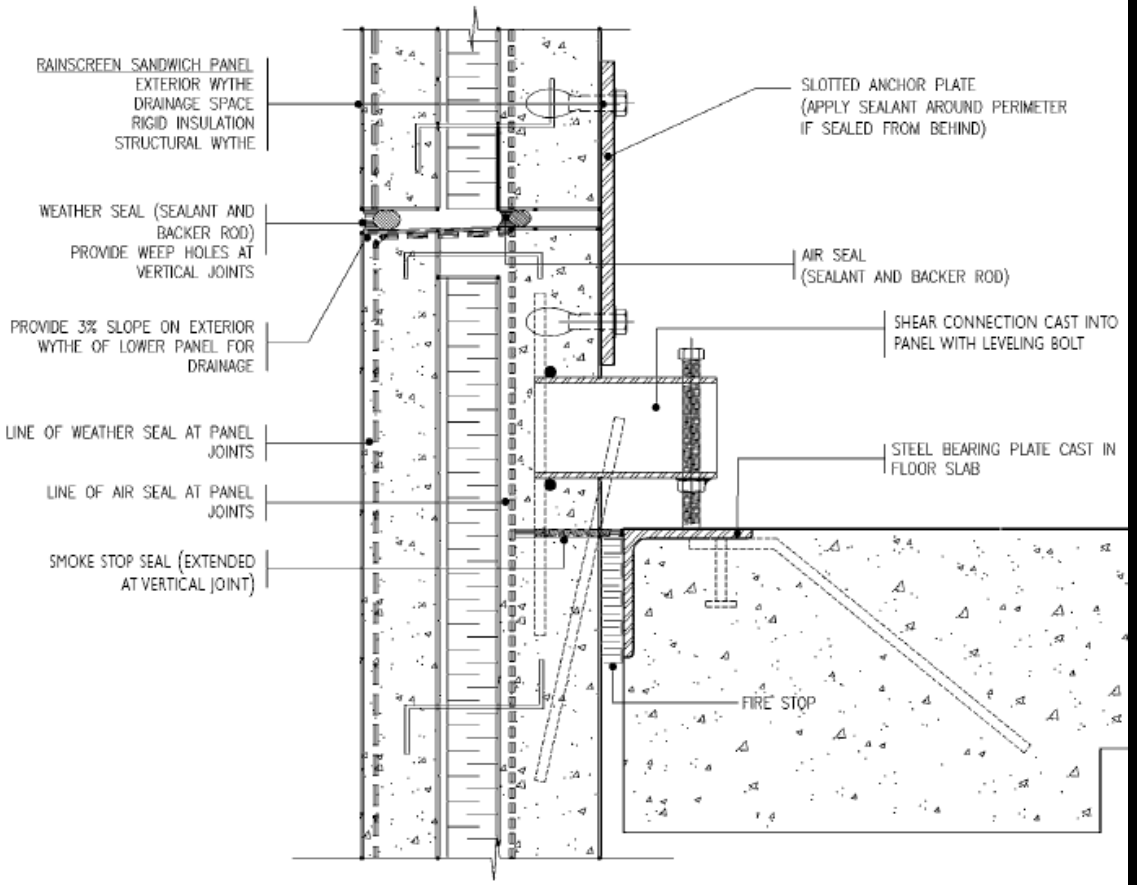


CONVENTIONAL PANEL

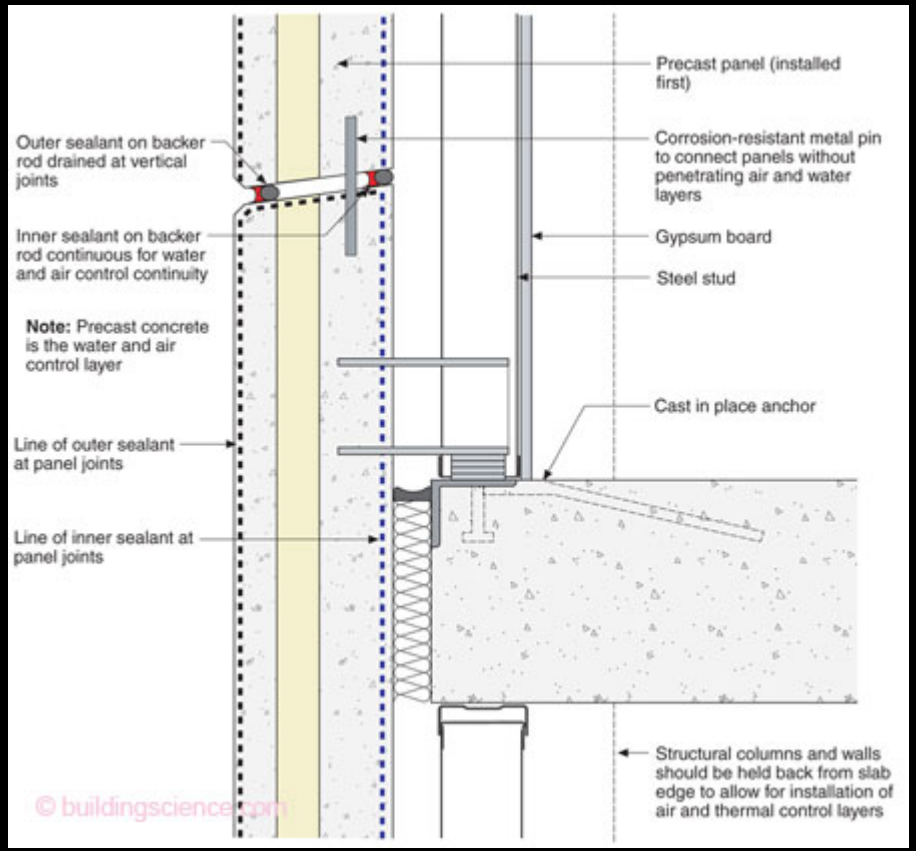
TOP HUNG PARAPET CONNECTION



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.

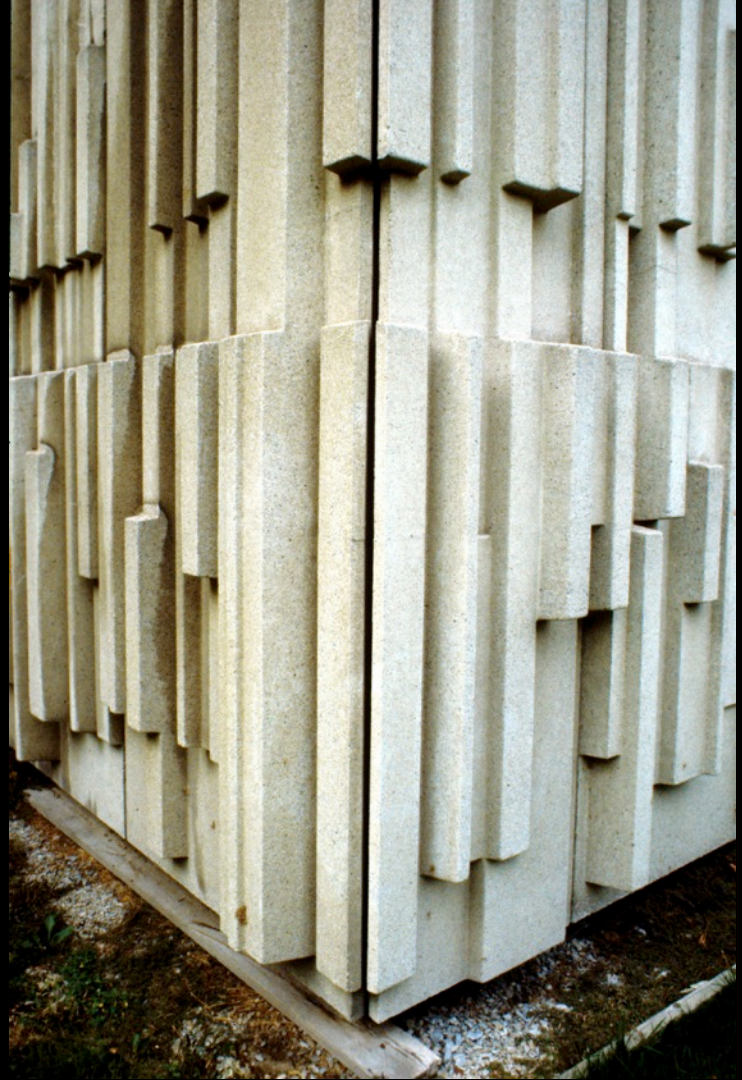
https://www.buildingscience.com/documents/insights/bsi054-risky-business-high-risk-walls

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.


FORD
836

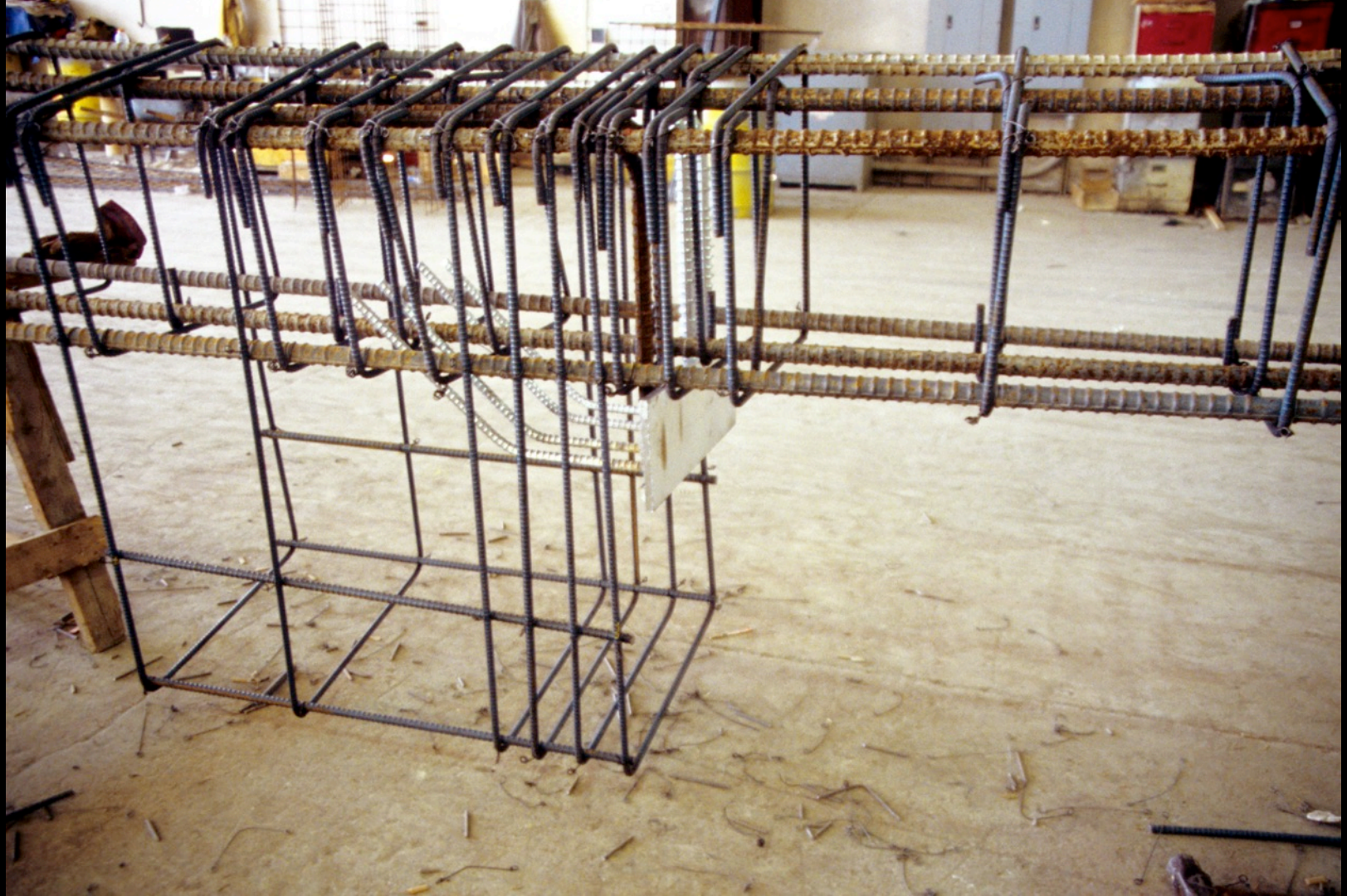


Fabricating the Precast Elements


1010 C307 (J) 212


0101 C421 (16) 7-12


C421 (18) 7-12



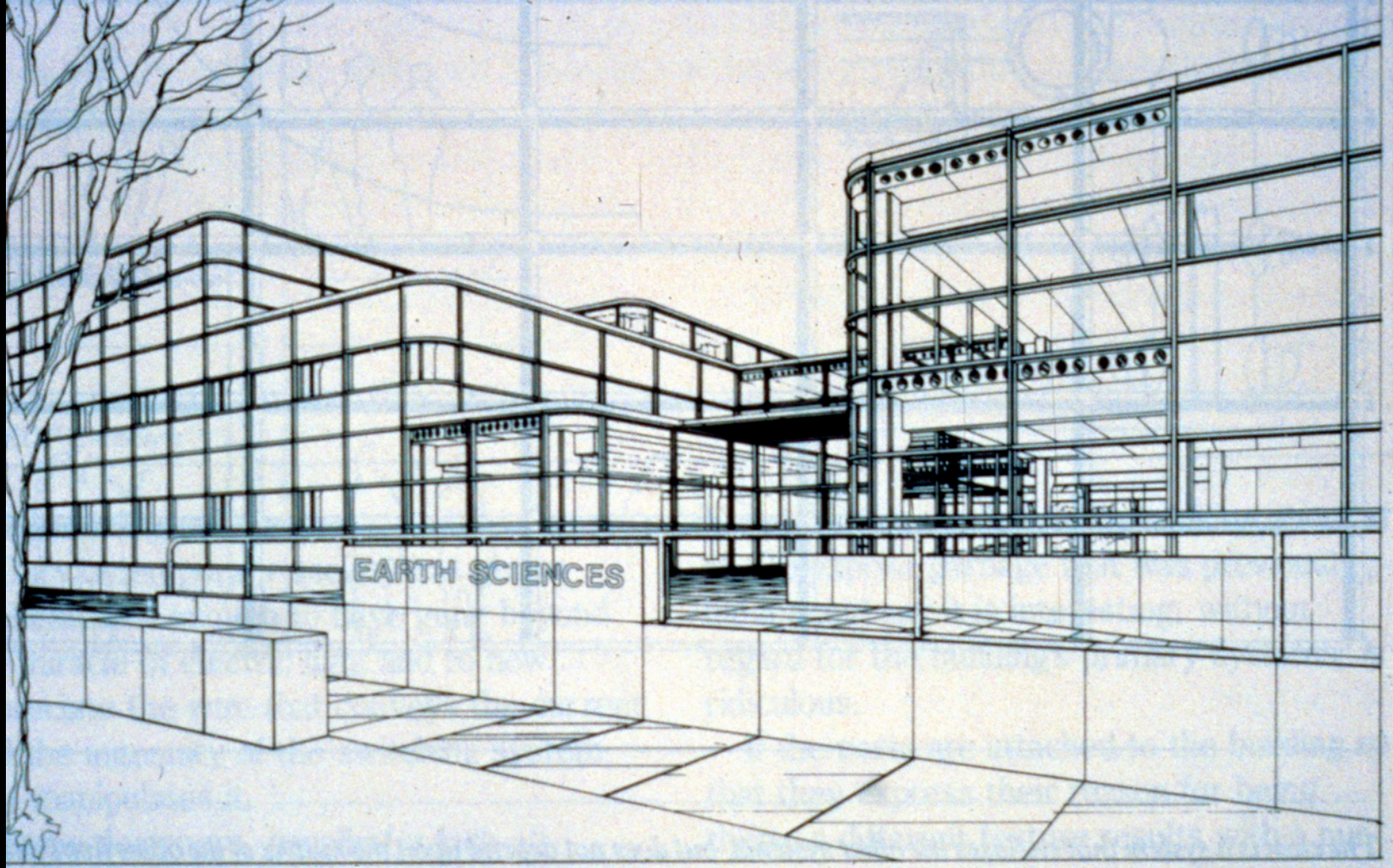

D103
C105
(2) 614


JLG

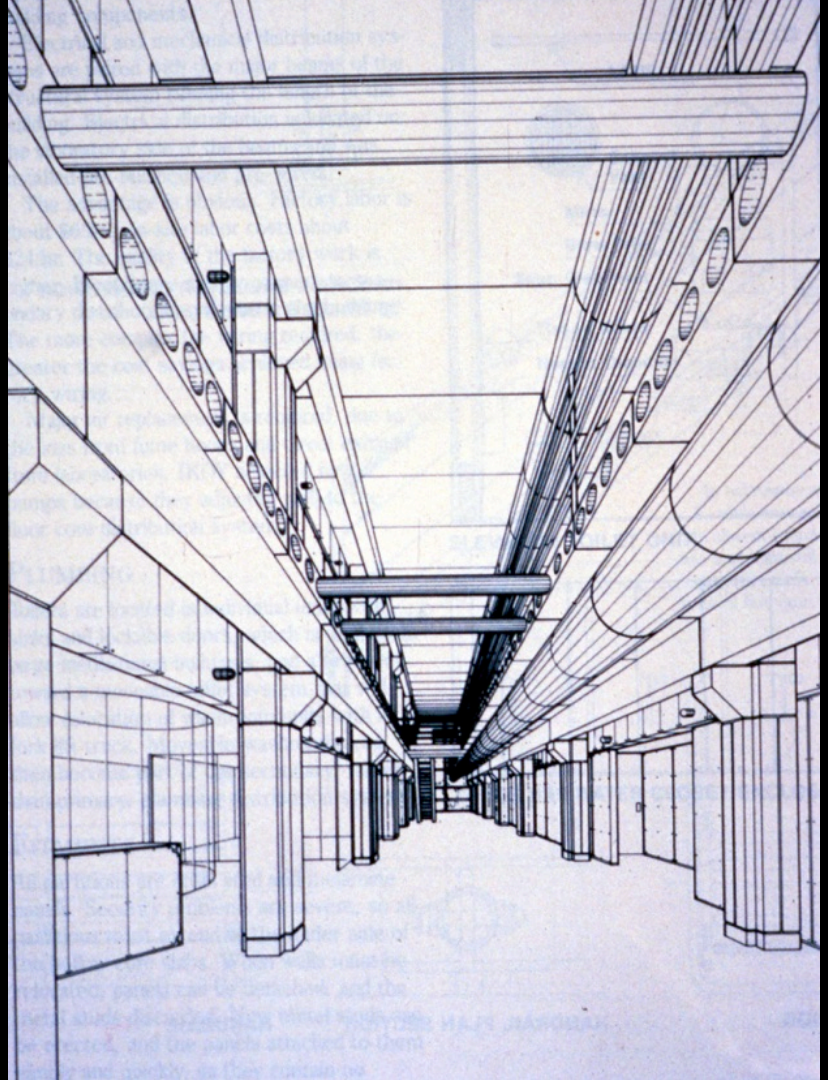

HOCKEY

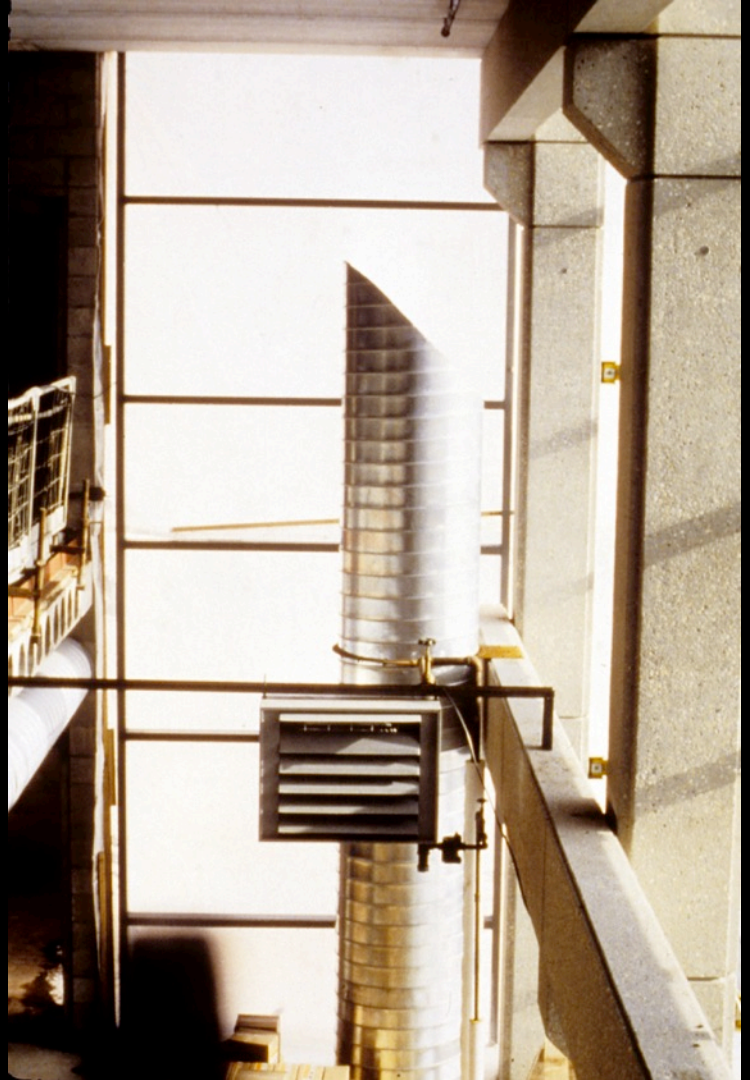

DEMAG

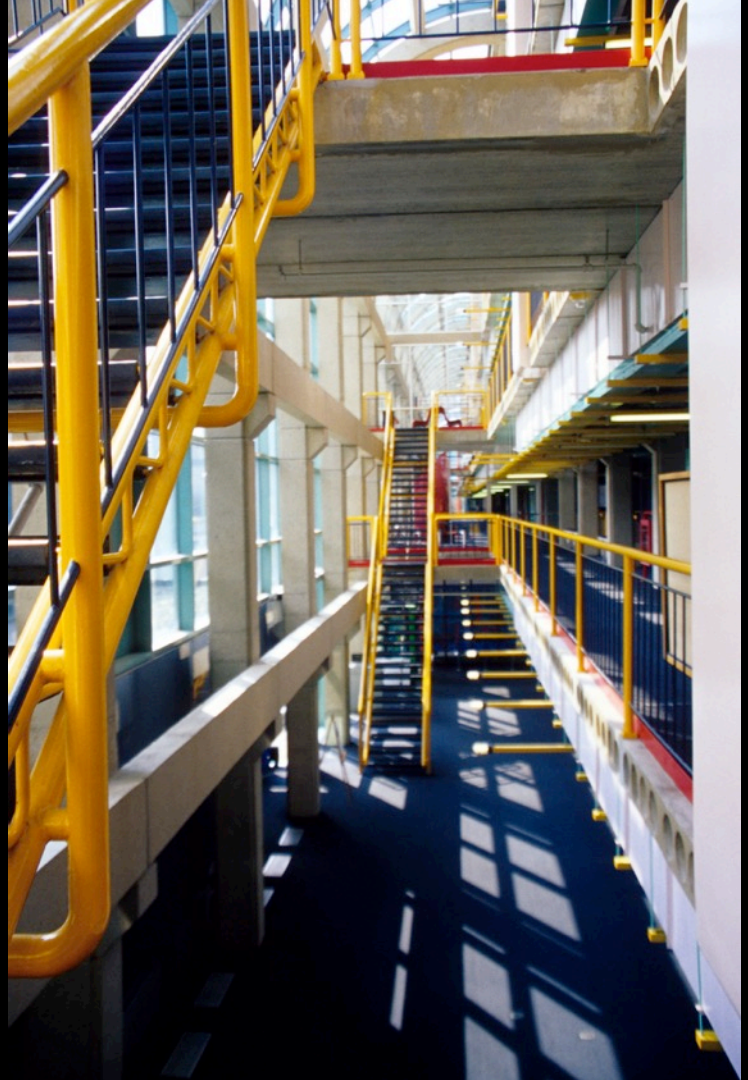

GROVE

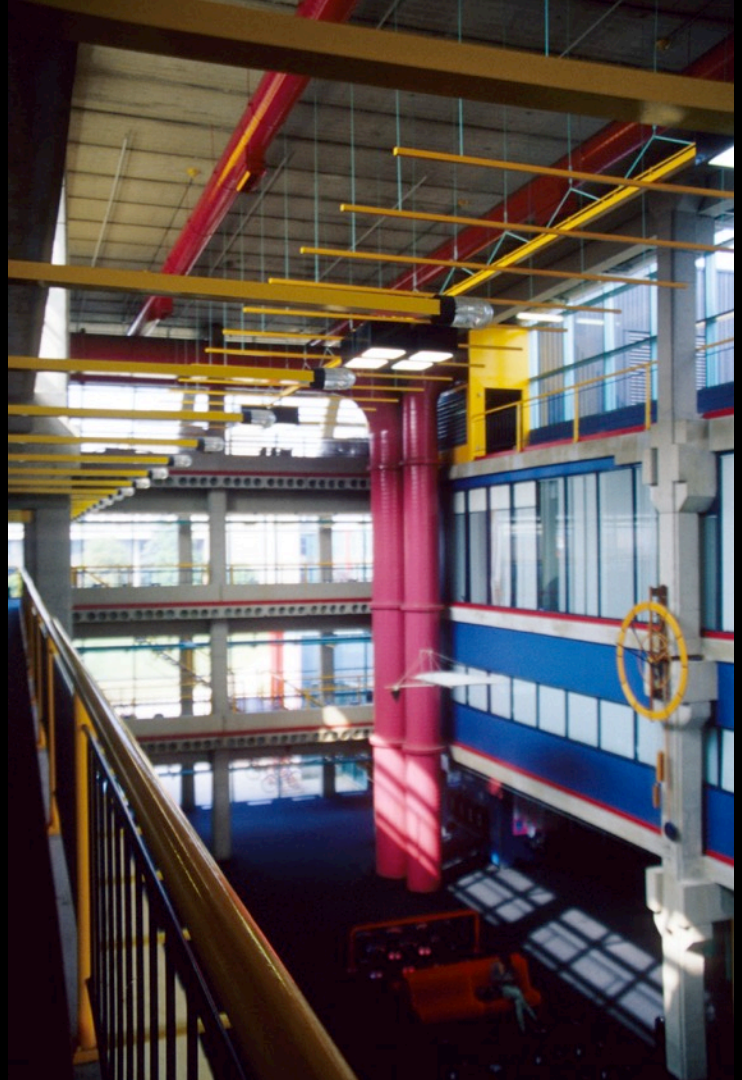


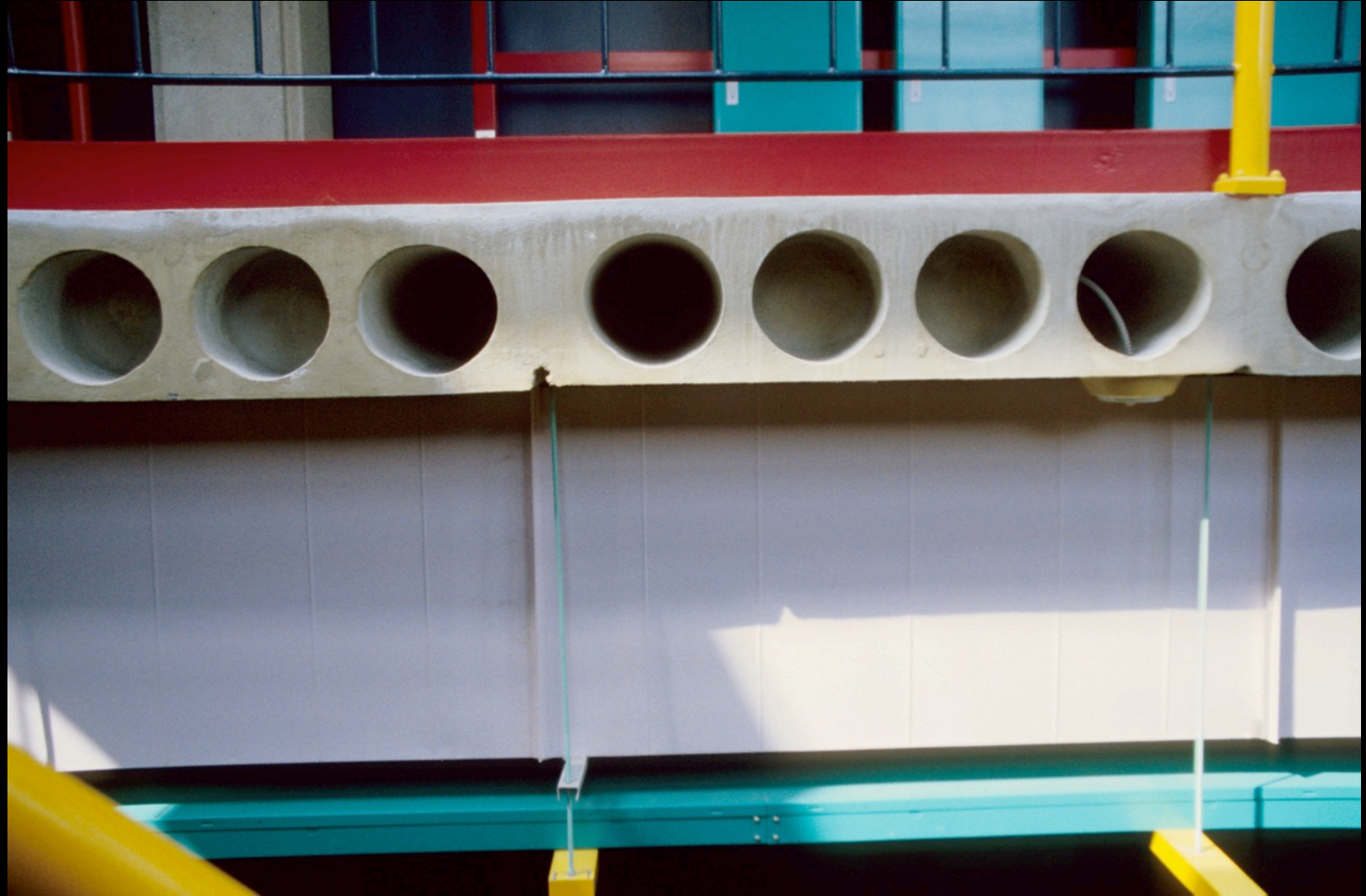
IKOY Architects



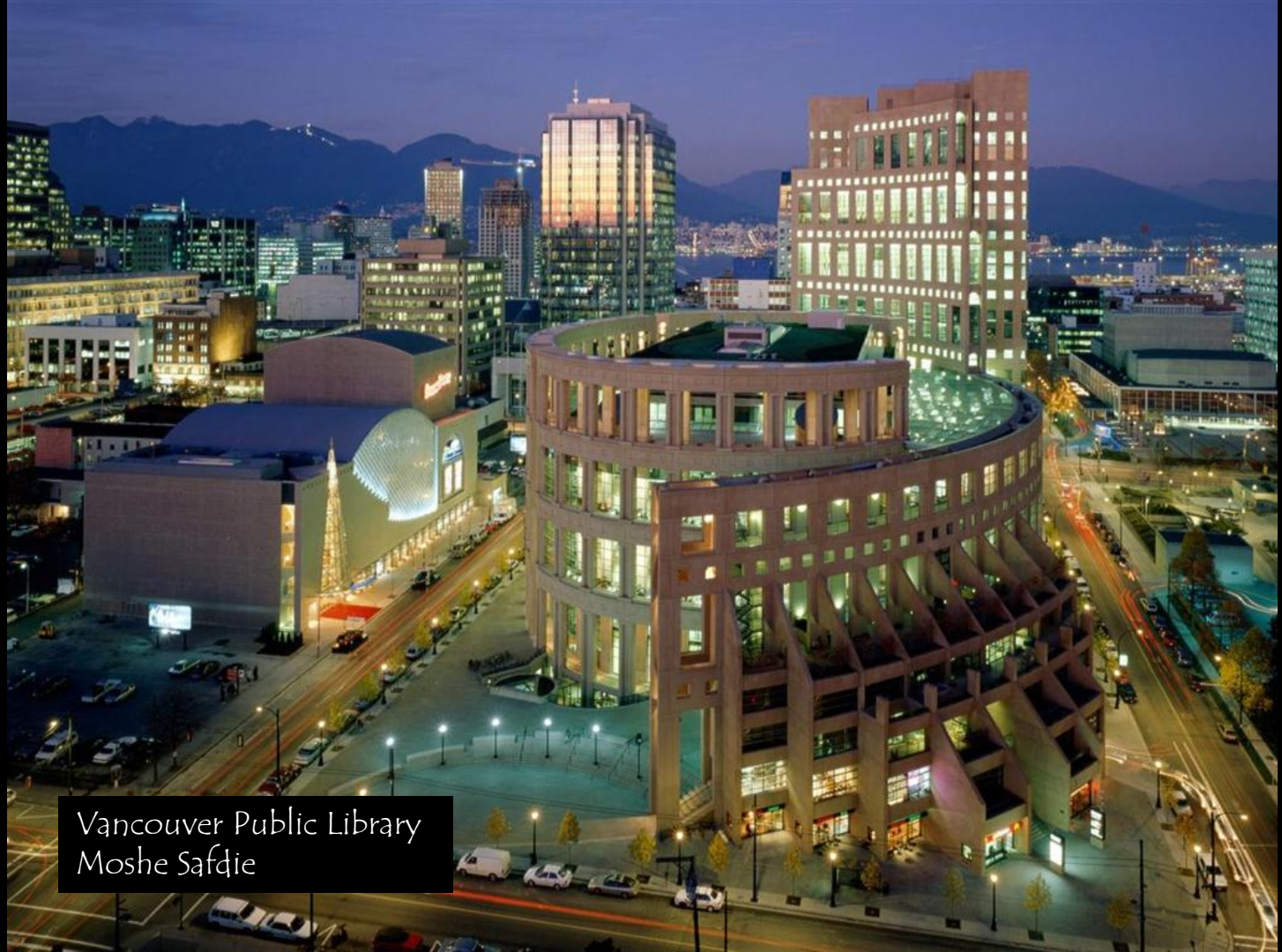









CHECKMATE
LOUNGE


Vancouver Public Library
Moshe Safdie


HANDWASH


Robson St
Homer St


Salt Lake City Public Library
Moshe Safdie


The City Library

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

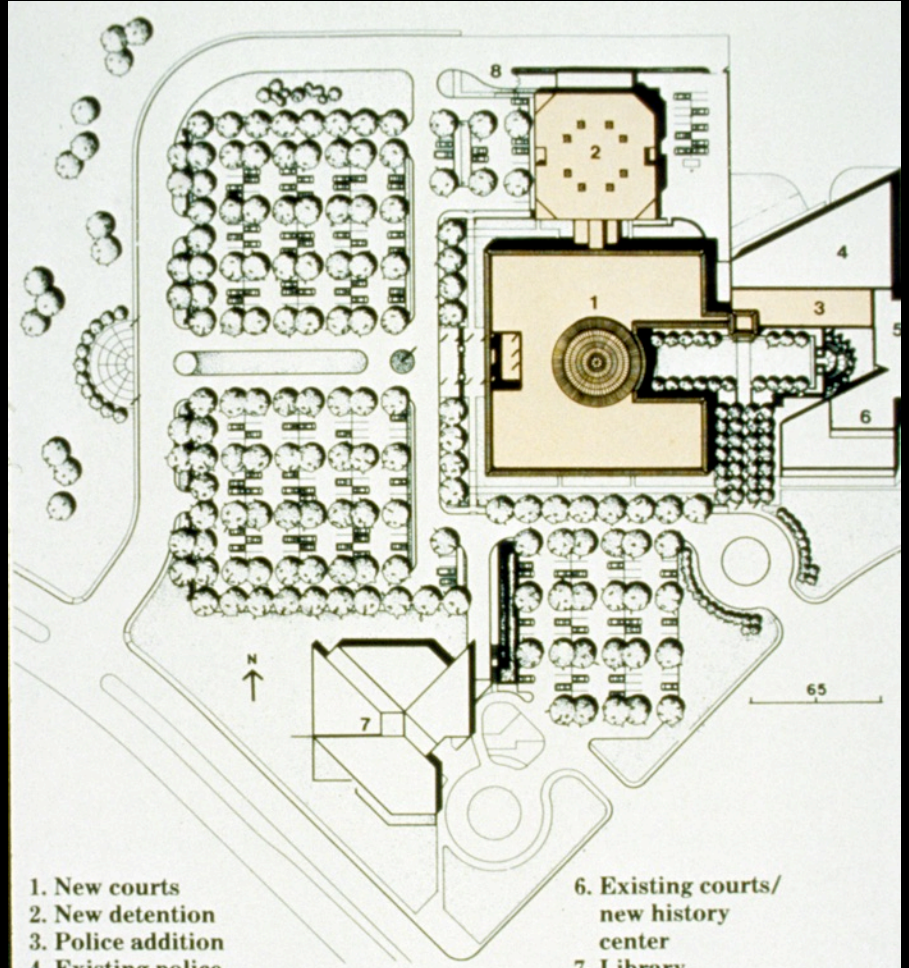
Ken Leibowitz, Structural Engineer

General Contractor: Weitz-Cohen Construction Co.

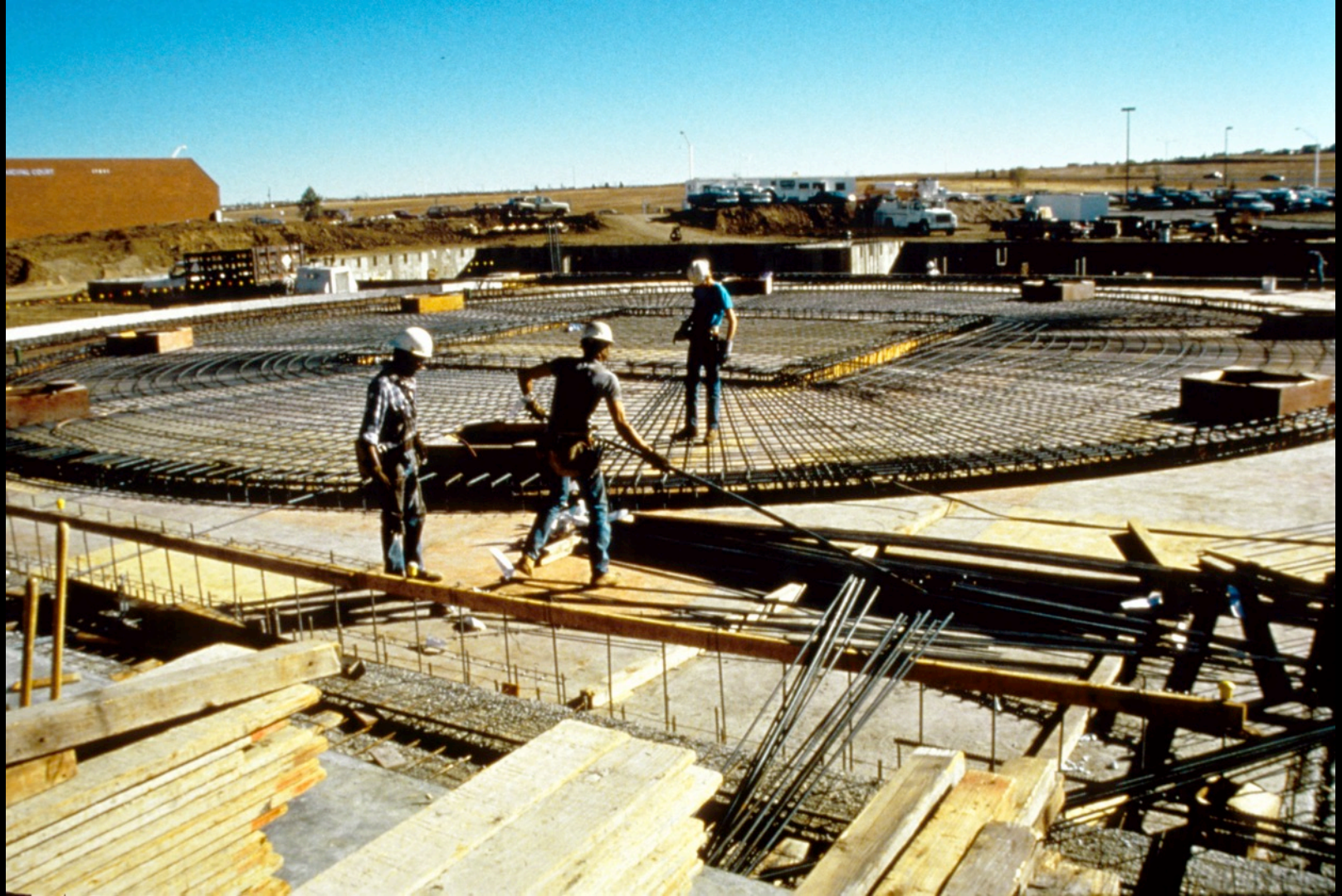
Precast / Prestressed Concrete Manufacturer:

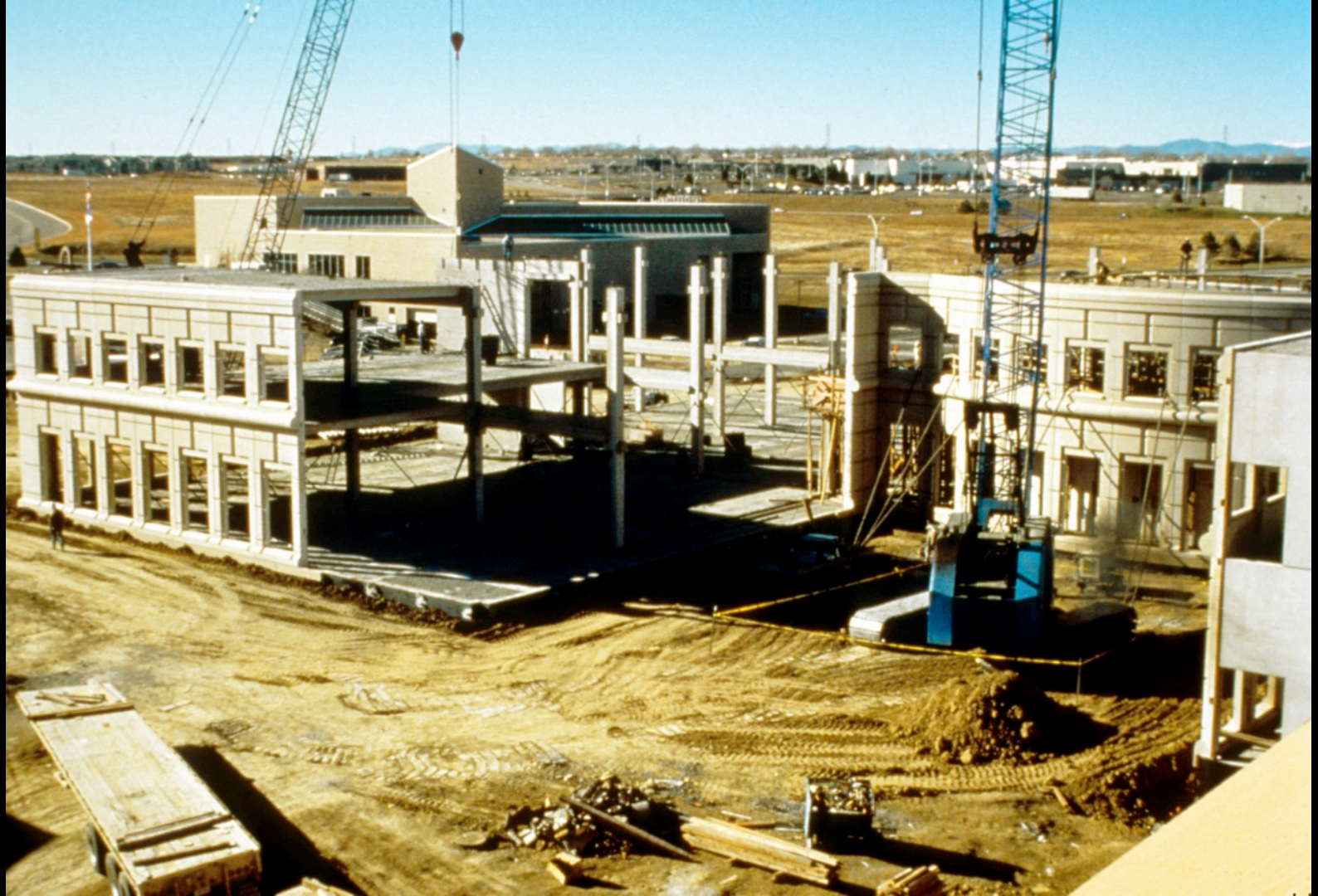
Rocky Mountain Prestress, Inc. Denver, Colorado

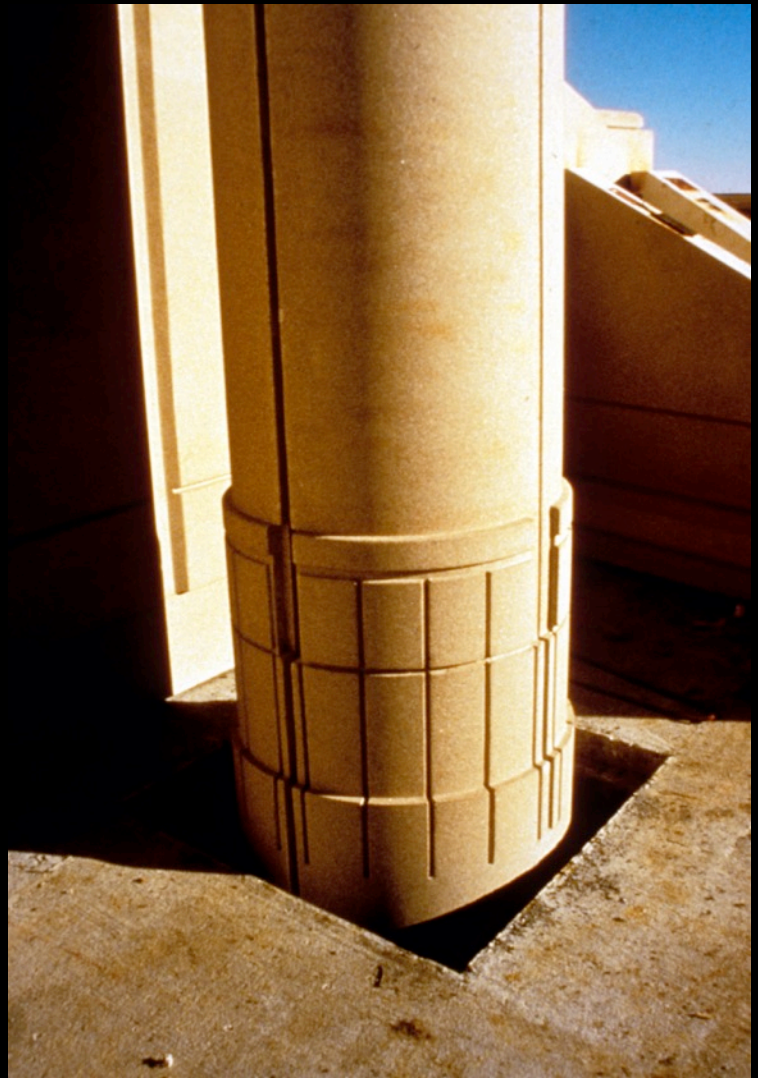

COURTHOUSE



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








MUNICIPAL COURT
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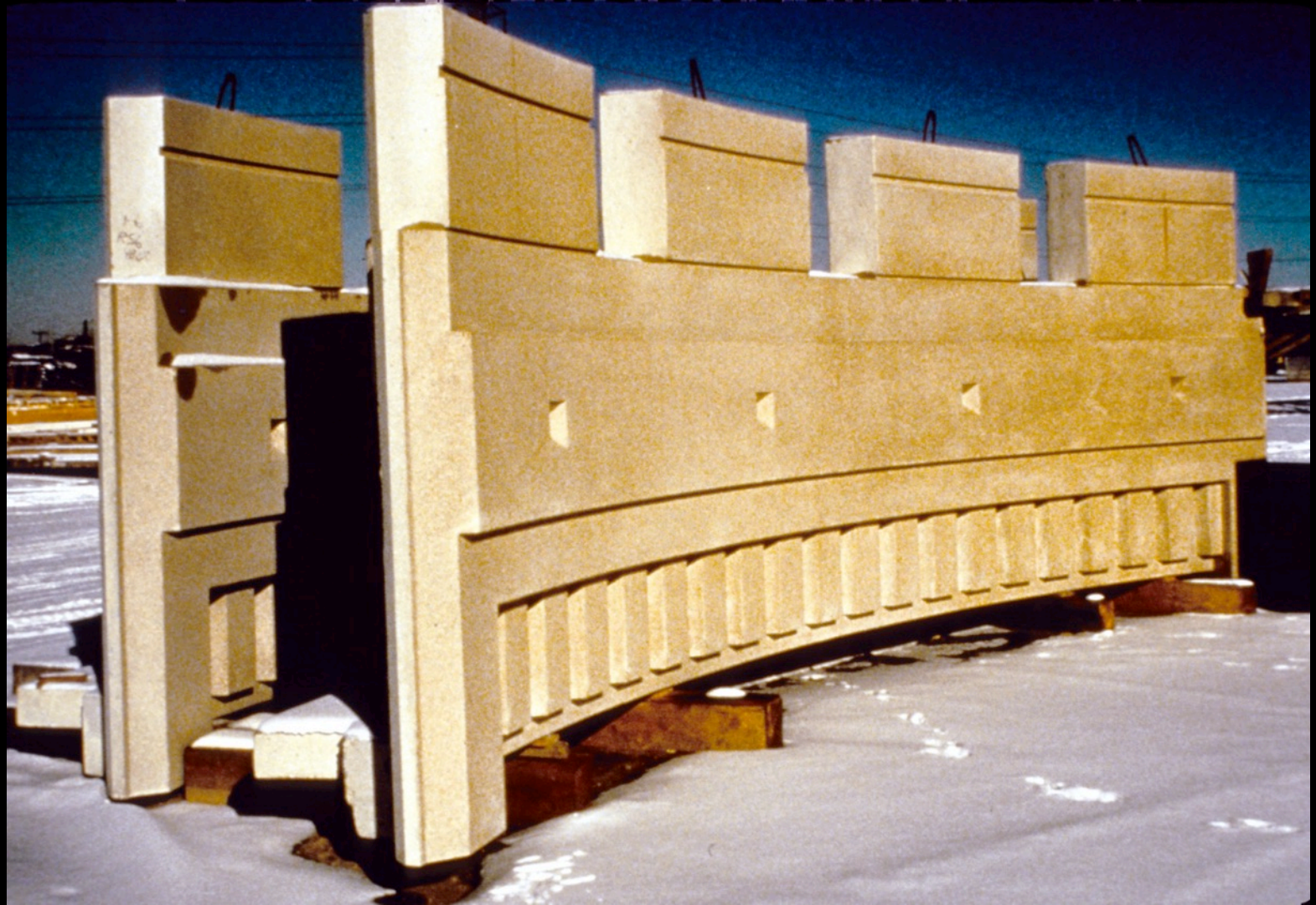
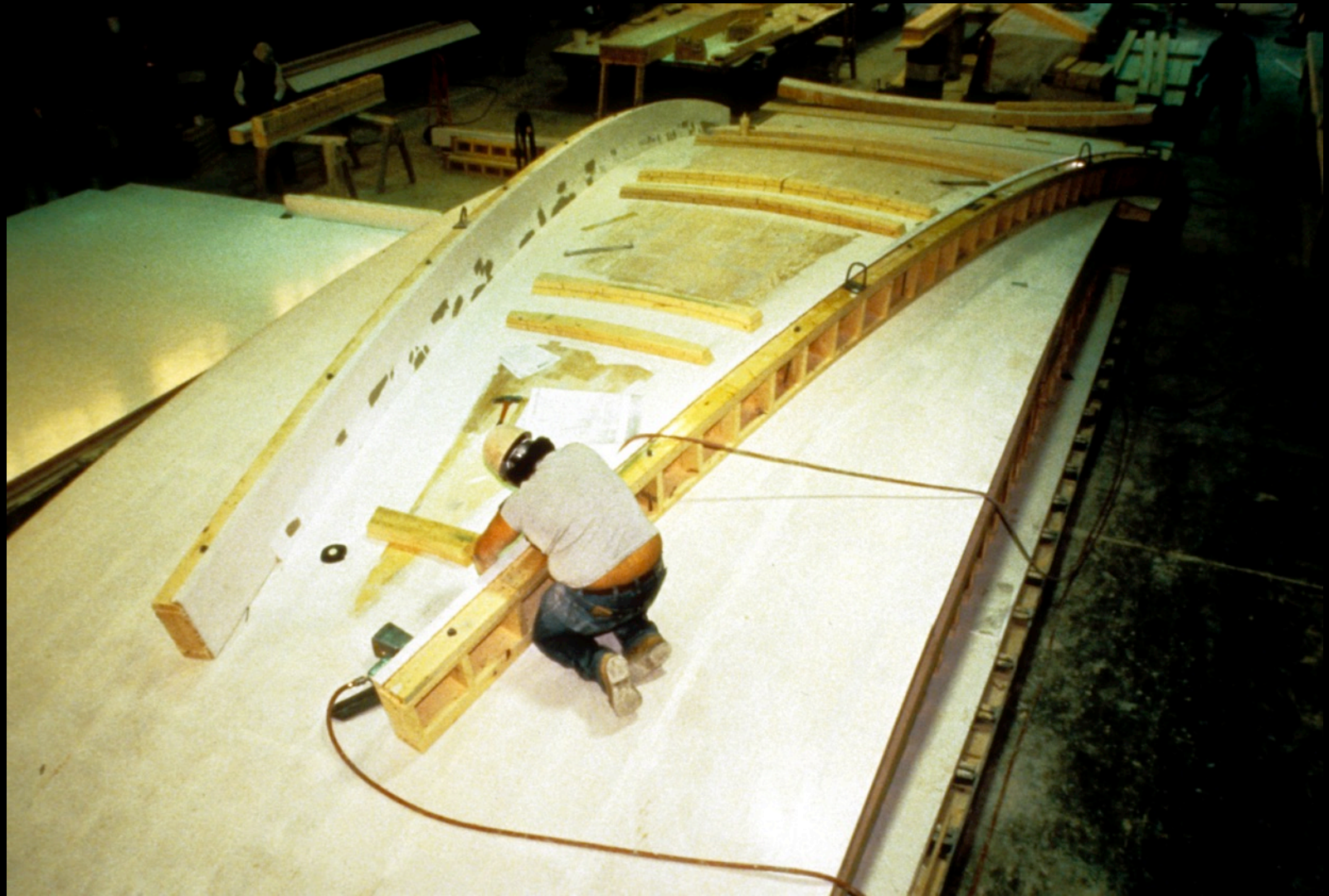
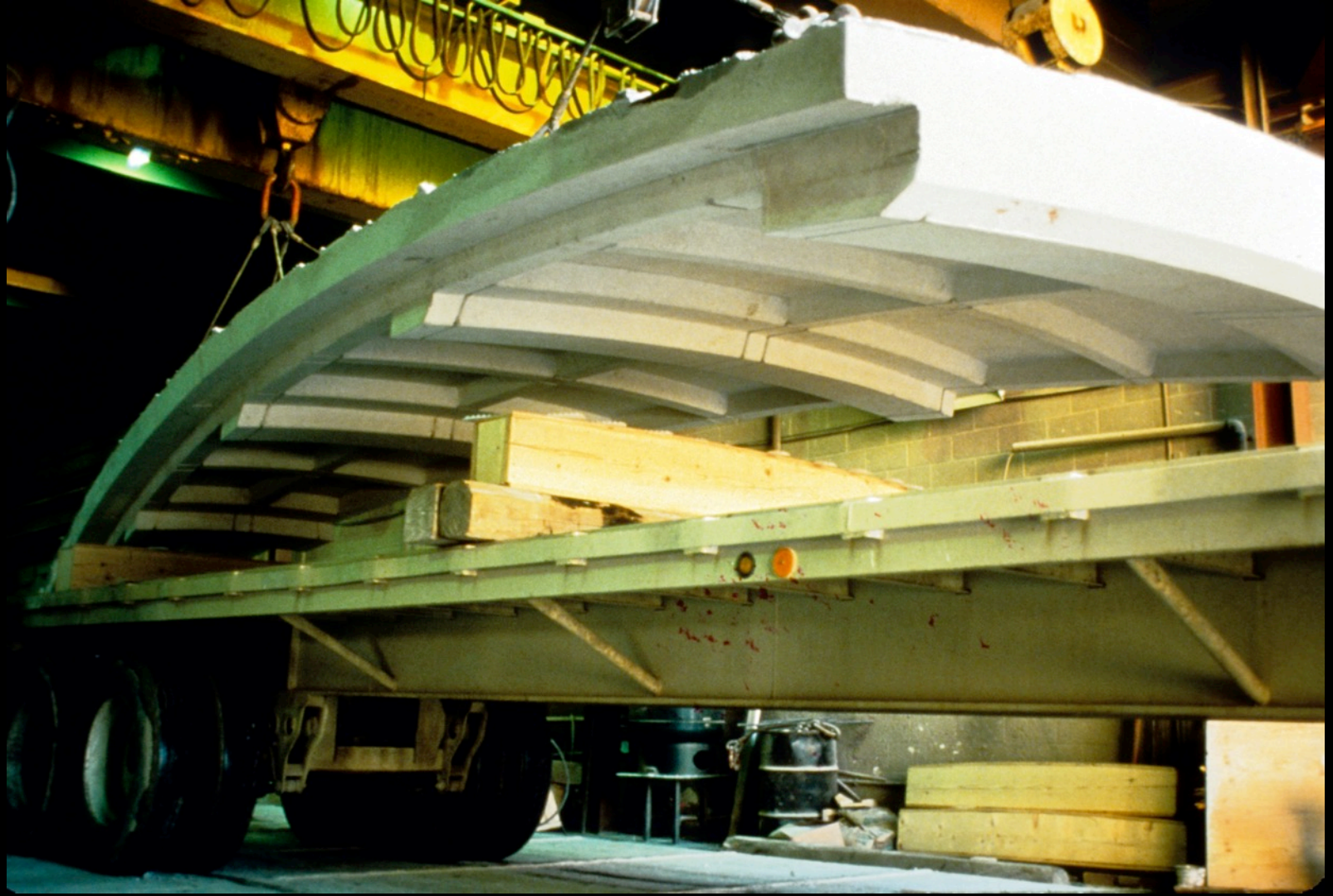
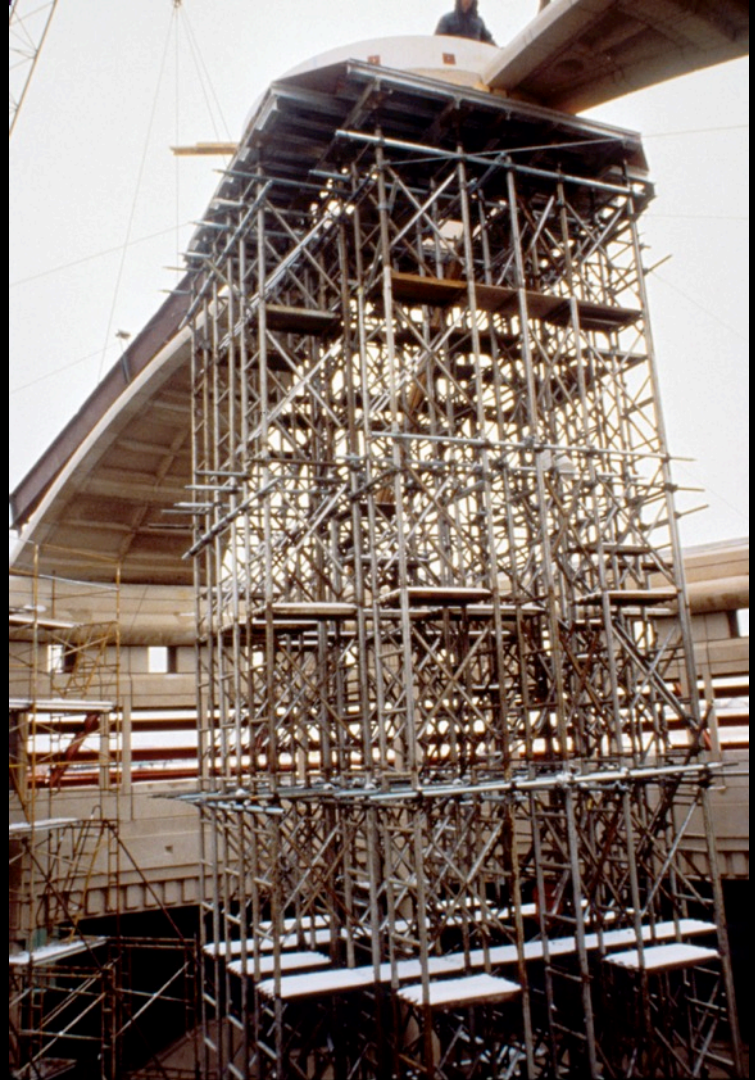
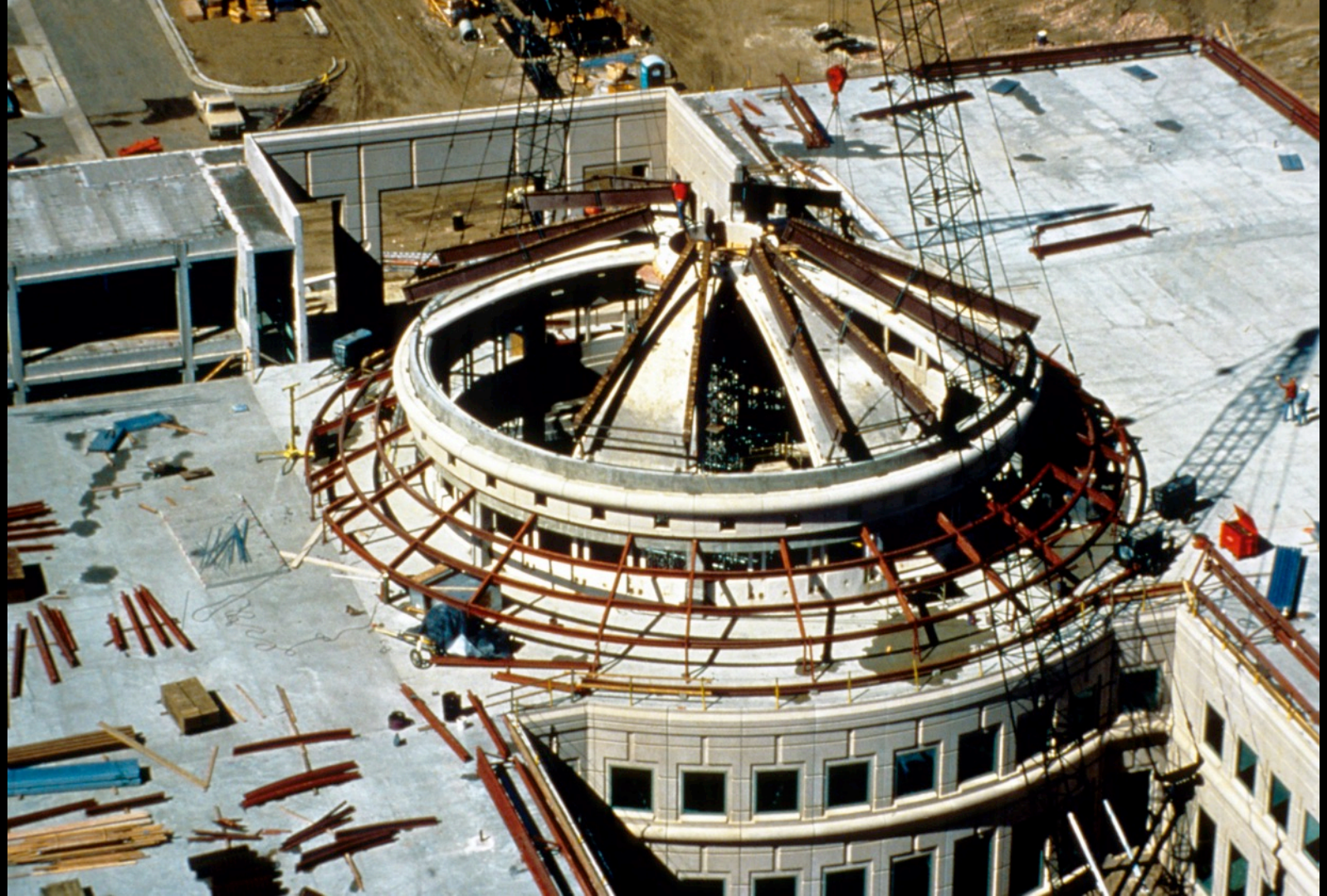


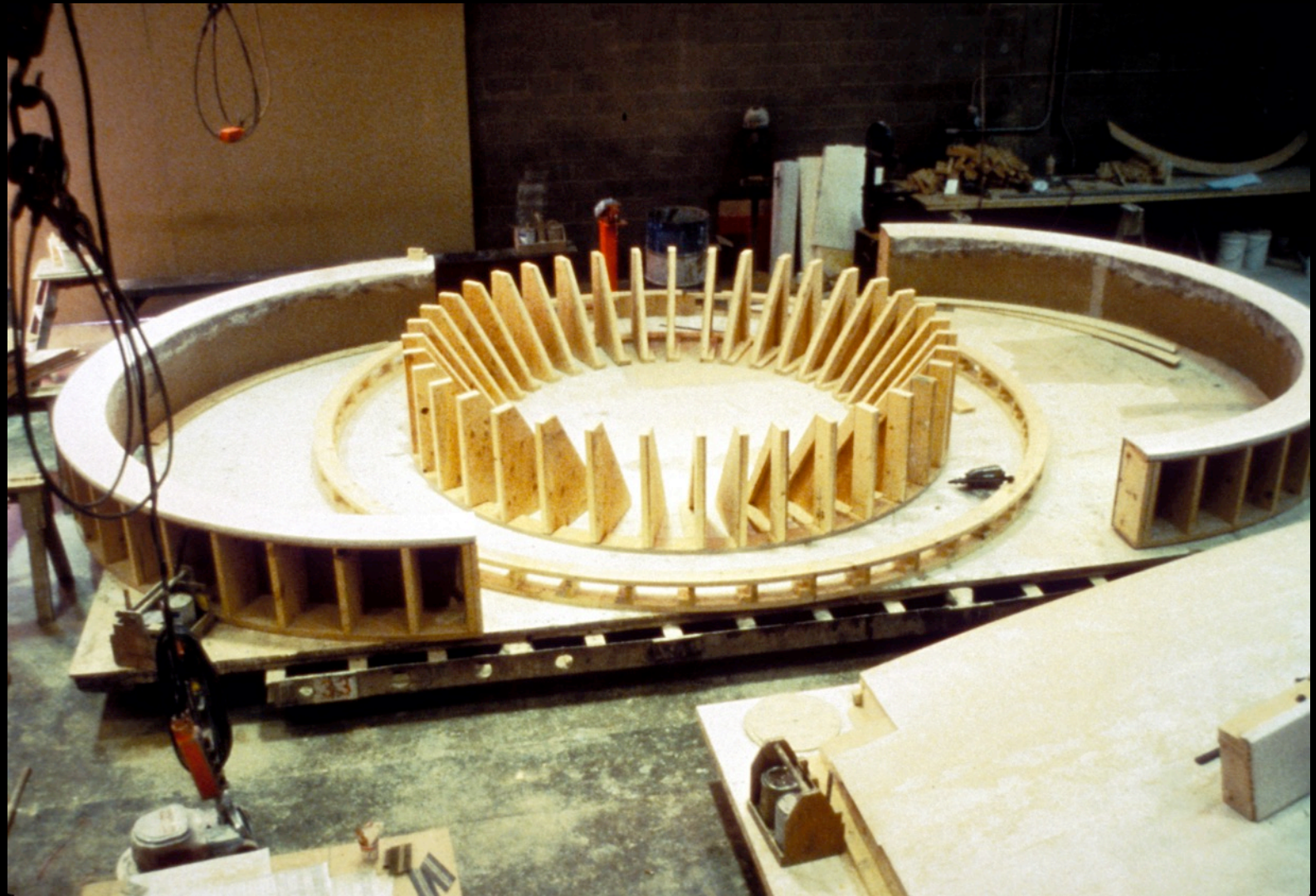





165'








POLICE

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.

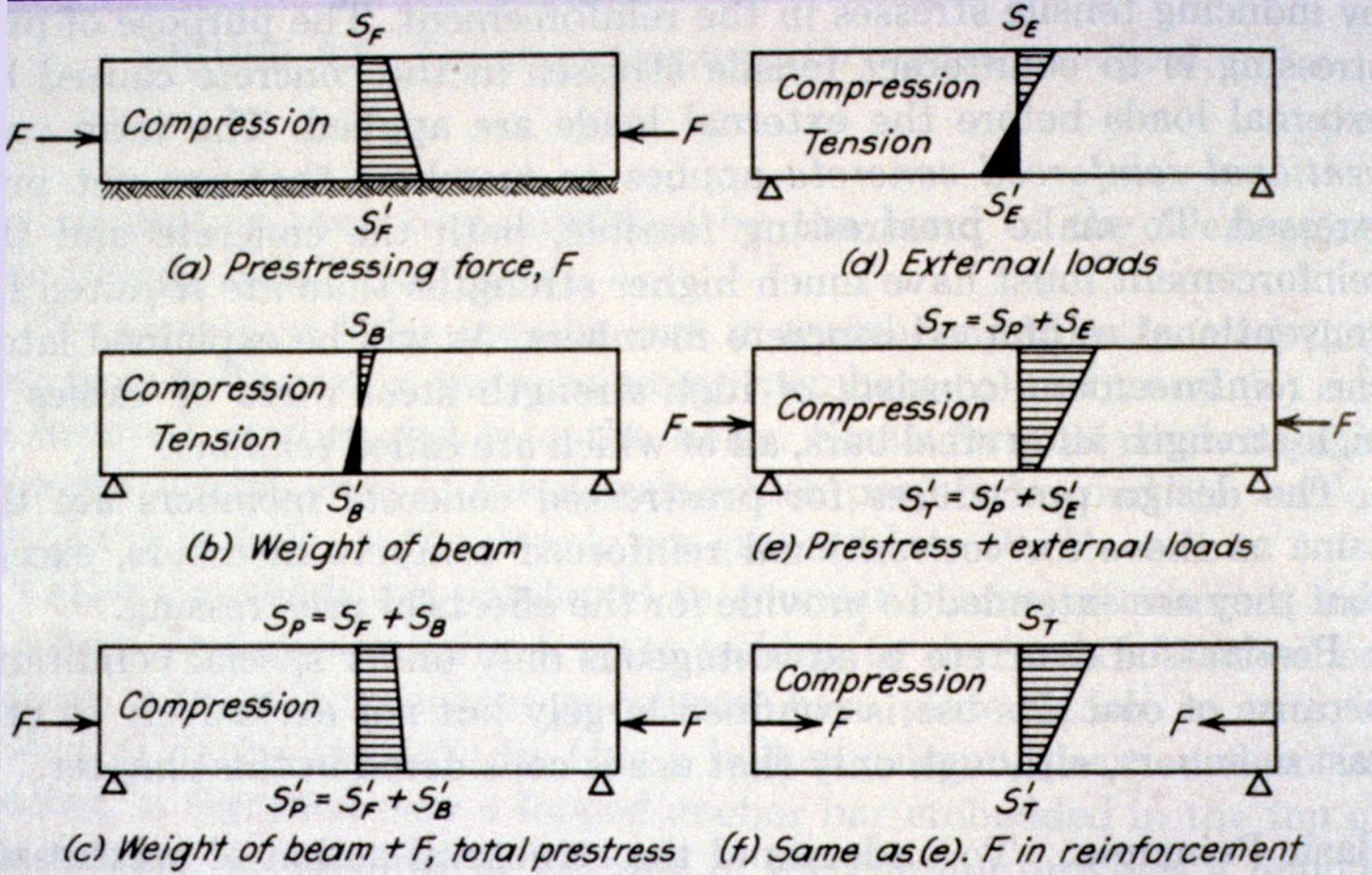
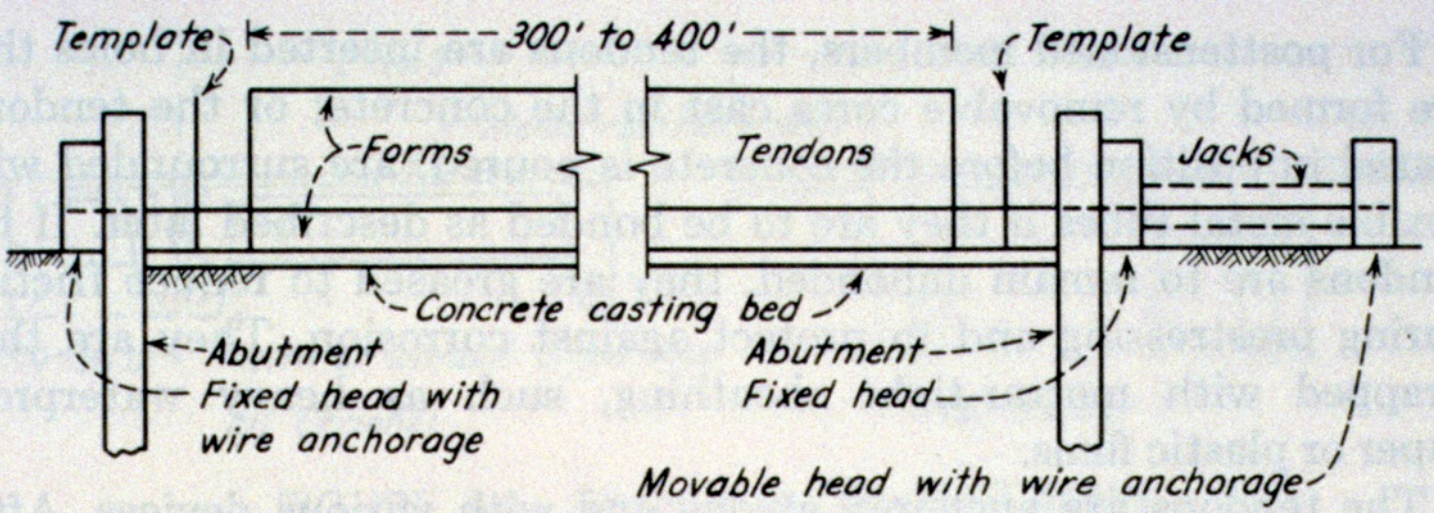
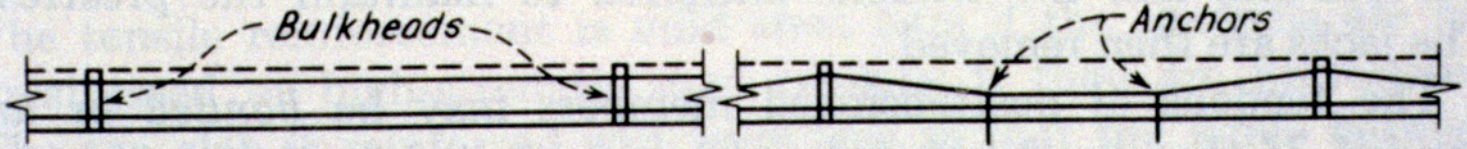


FIGURE 8.2 Fiber stresses caused by various loading conditions.



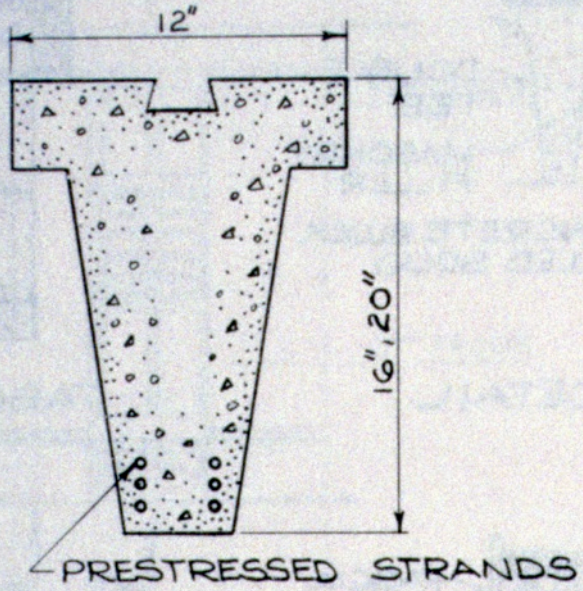
(a) Pretensioning bed for long-line process
Arranged from Portland Cement Assn publication

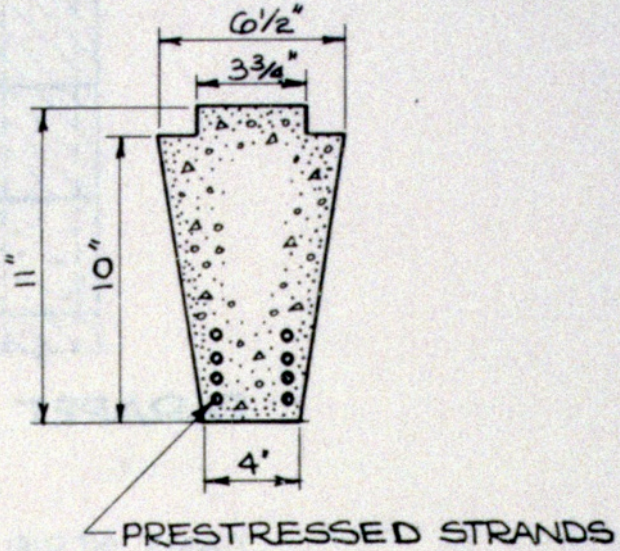


(b) Original position

(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

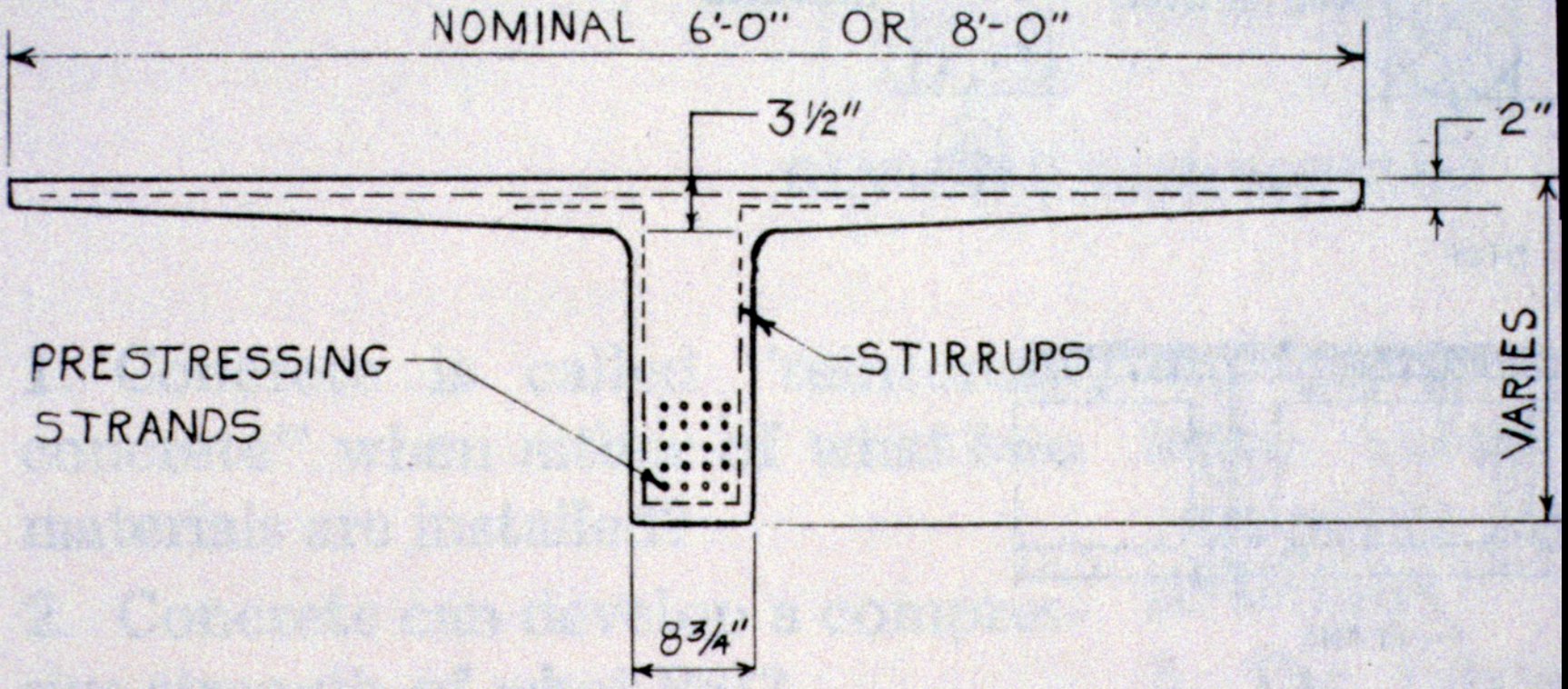
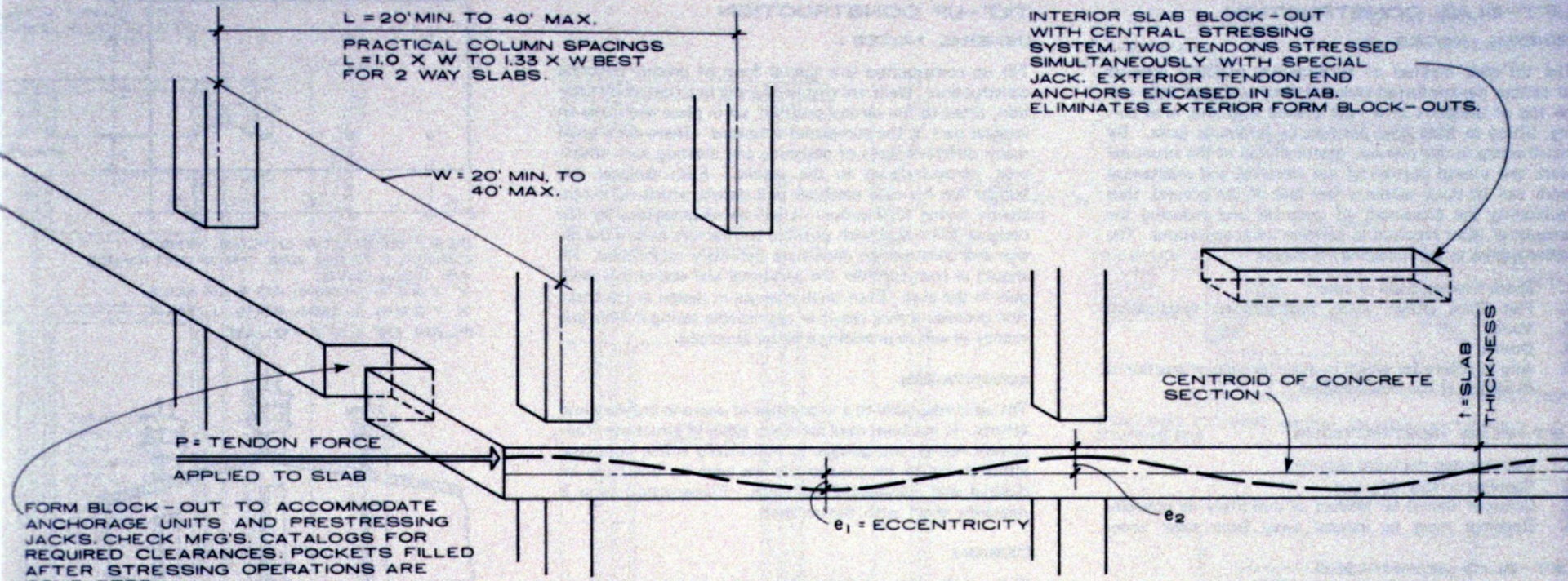


Figure 11-10. Typical Prestressed Tee Section



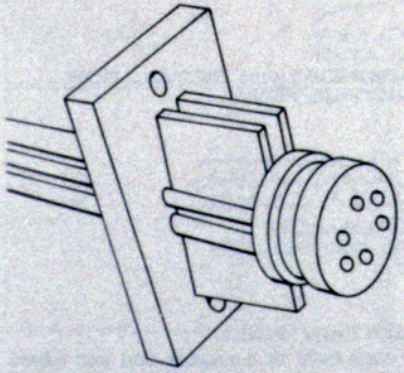
Draped post-tension tendons pre-compress concrete to provide resistance to tensile stresses produced by flexual bending due to dead + live loads on floor. Maximum tendon spacing should not exceed 8 times slab thickness (t).

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.

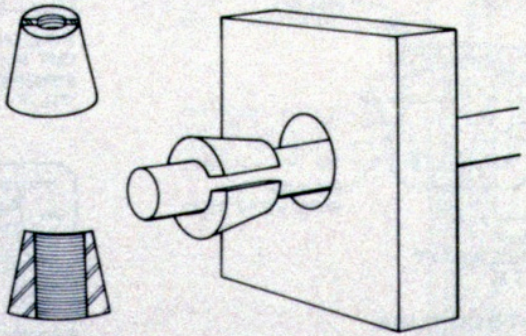
RECOMMENDED SPAN/DEPTH RATIO

FLOORS	42
ROOF	48

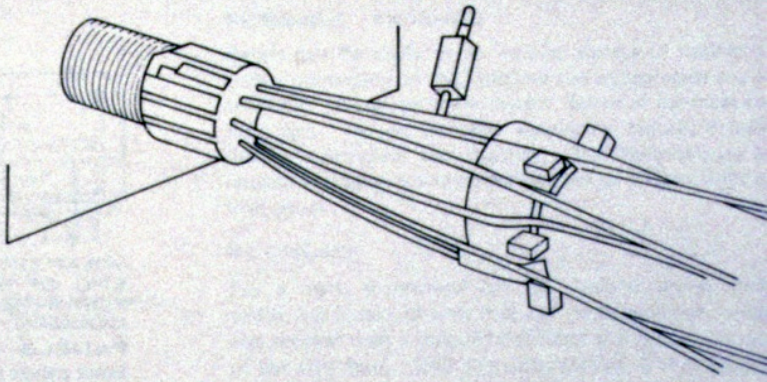
Check deflections, camber, and vibration.



PRESCON ANCHORAGE



STRESSTEEL BAR ANCHORAGE

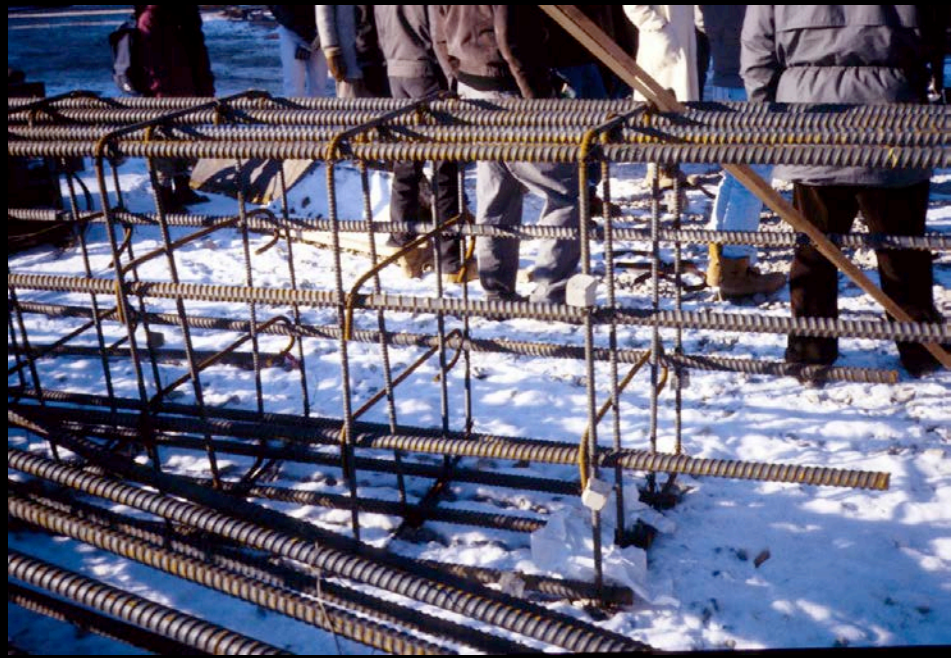


FREYSSINET WIRE ANCHOR AND JACK

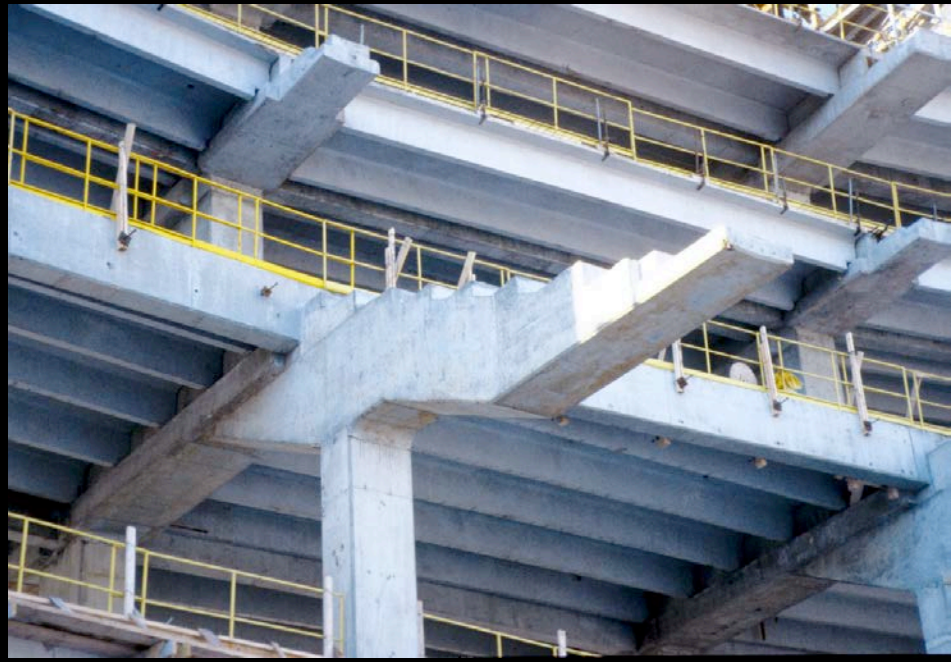
NOTE:

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 foo

Construction of SkyDome (Rogers Centre) - 1987




KEEP



ARATA ISOZAKI

"FOUR DECADES OF ARCHITECTURE"

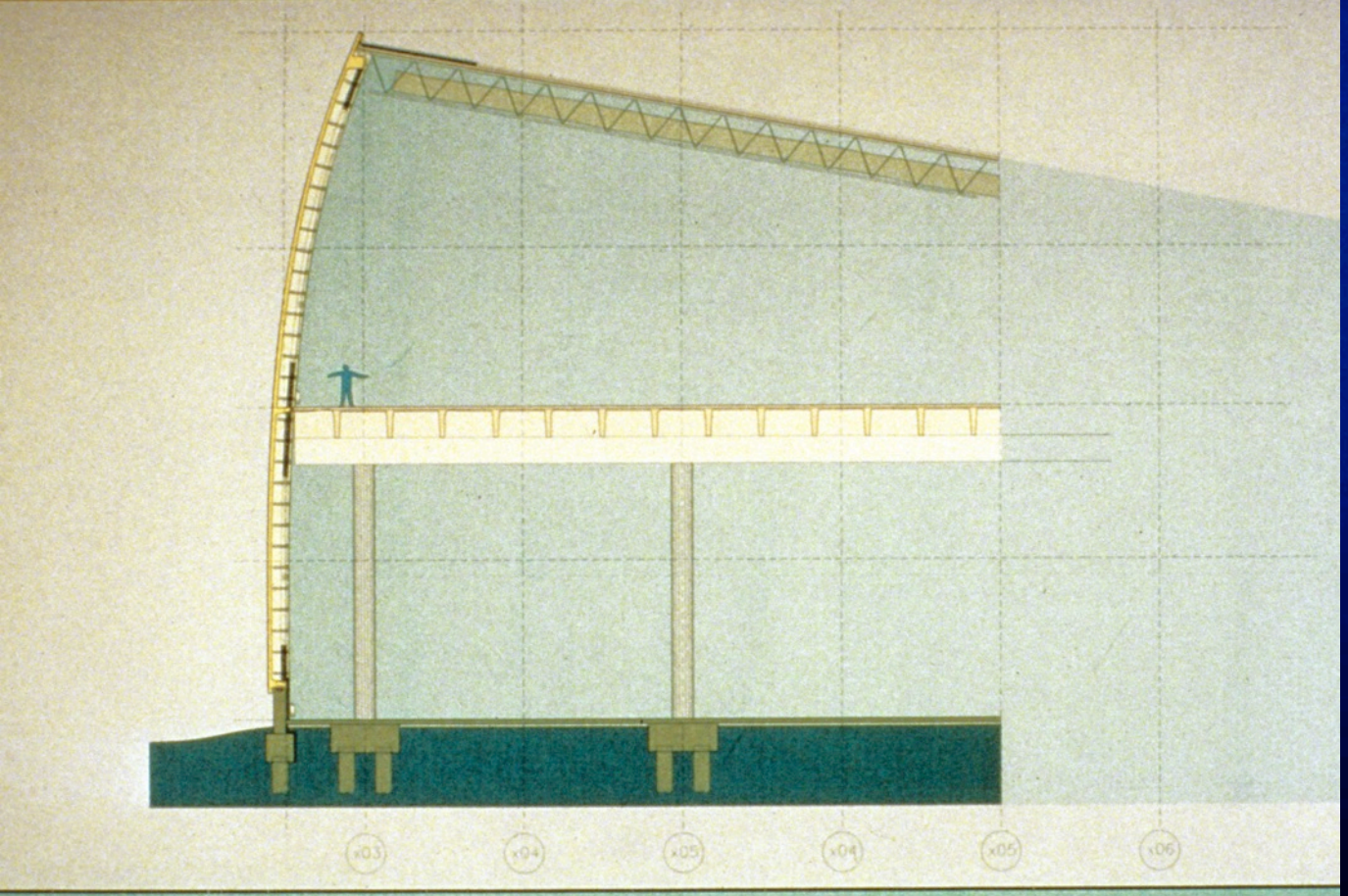
MEMBER, ARCHITECTURAL INSTITUTE OF JAPAN

PRINCIPAL; ARATA ISOZAKI & ASSOCIATES

TOKYO, JAPAN

PRINCIPAL ARCHITECT: COSI--- COLUMBUS, OH


Ruskin

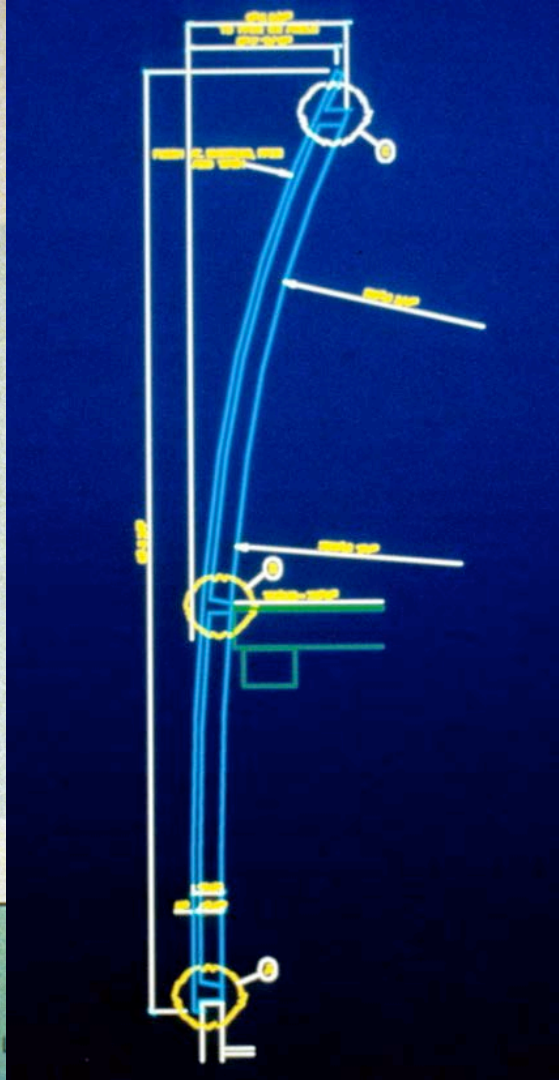


GREAT WALL SECTION

ARATA ISOZAKI & ASSOCIATES

NBBJ

MOODY/NOLAN

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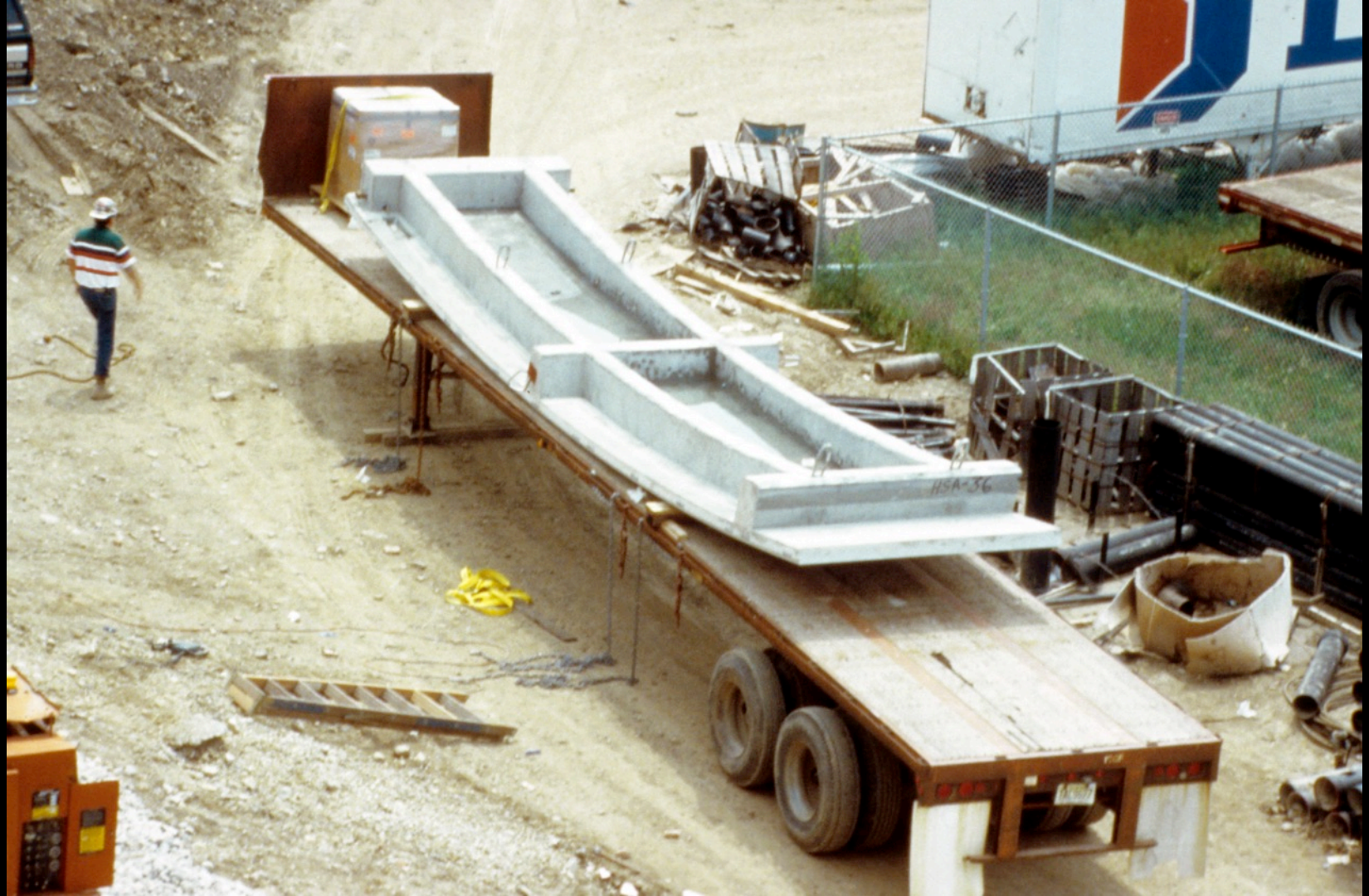
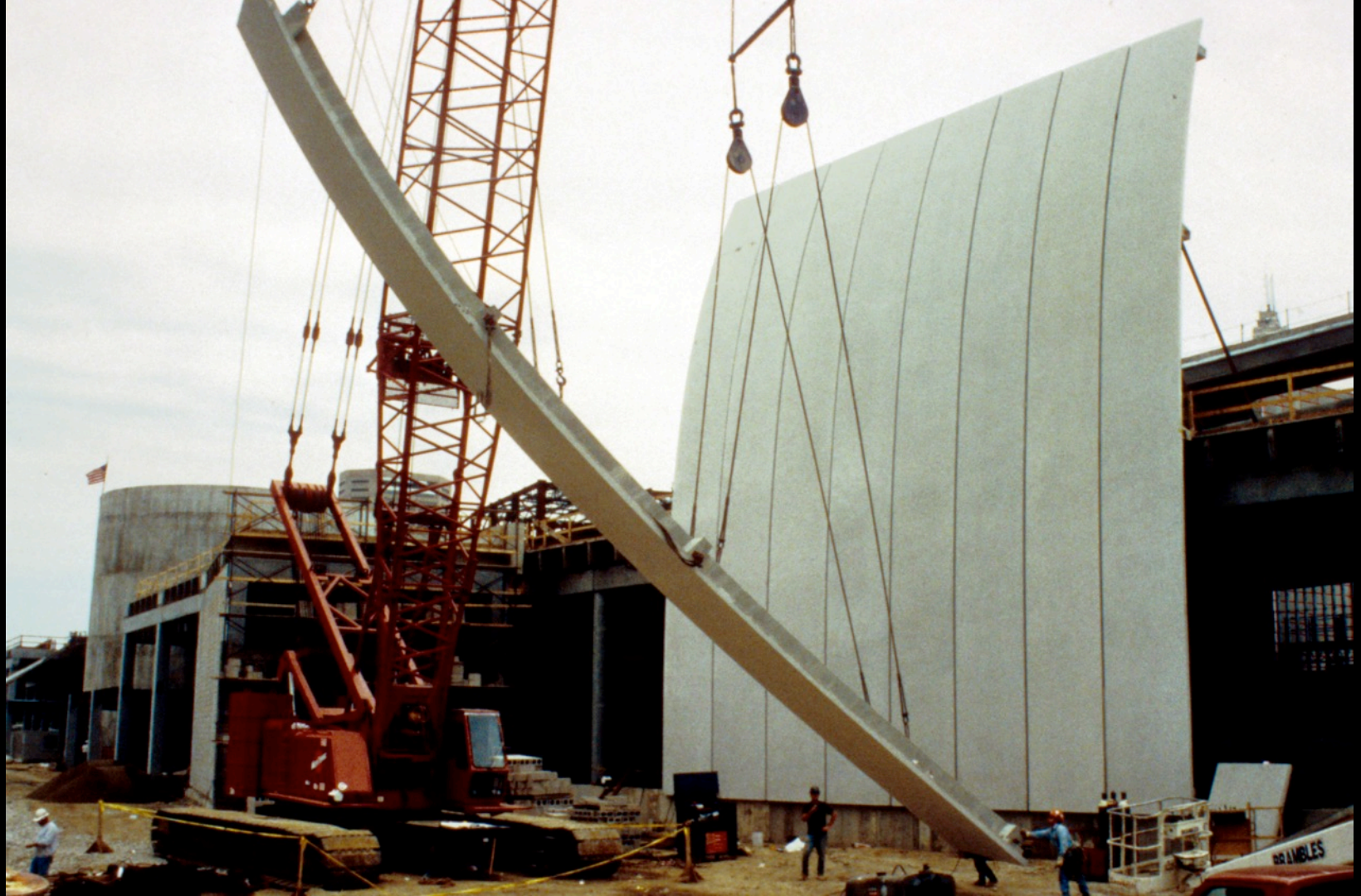

HSA-36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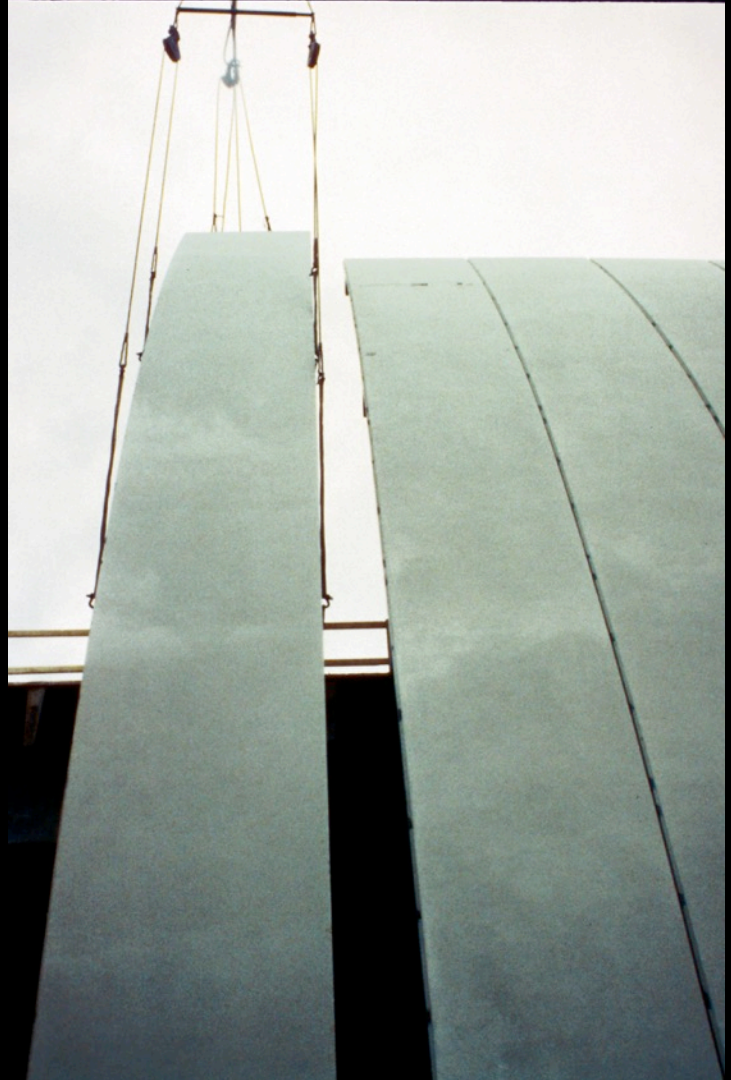

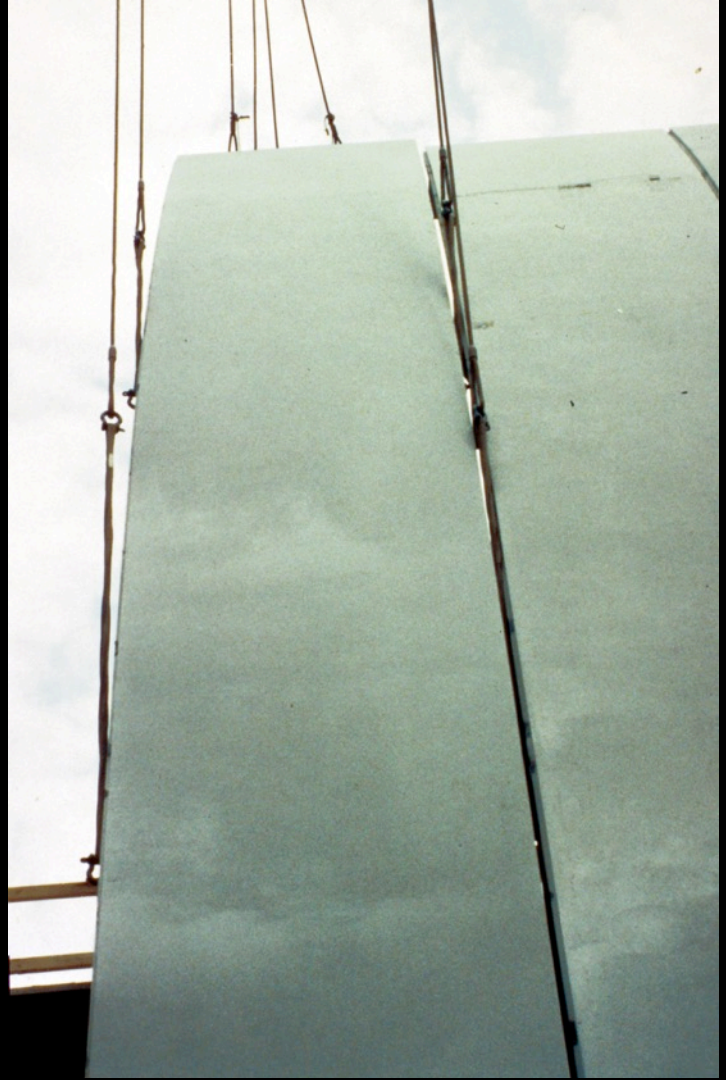

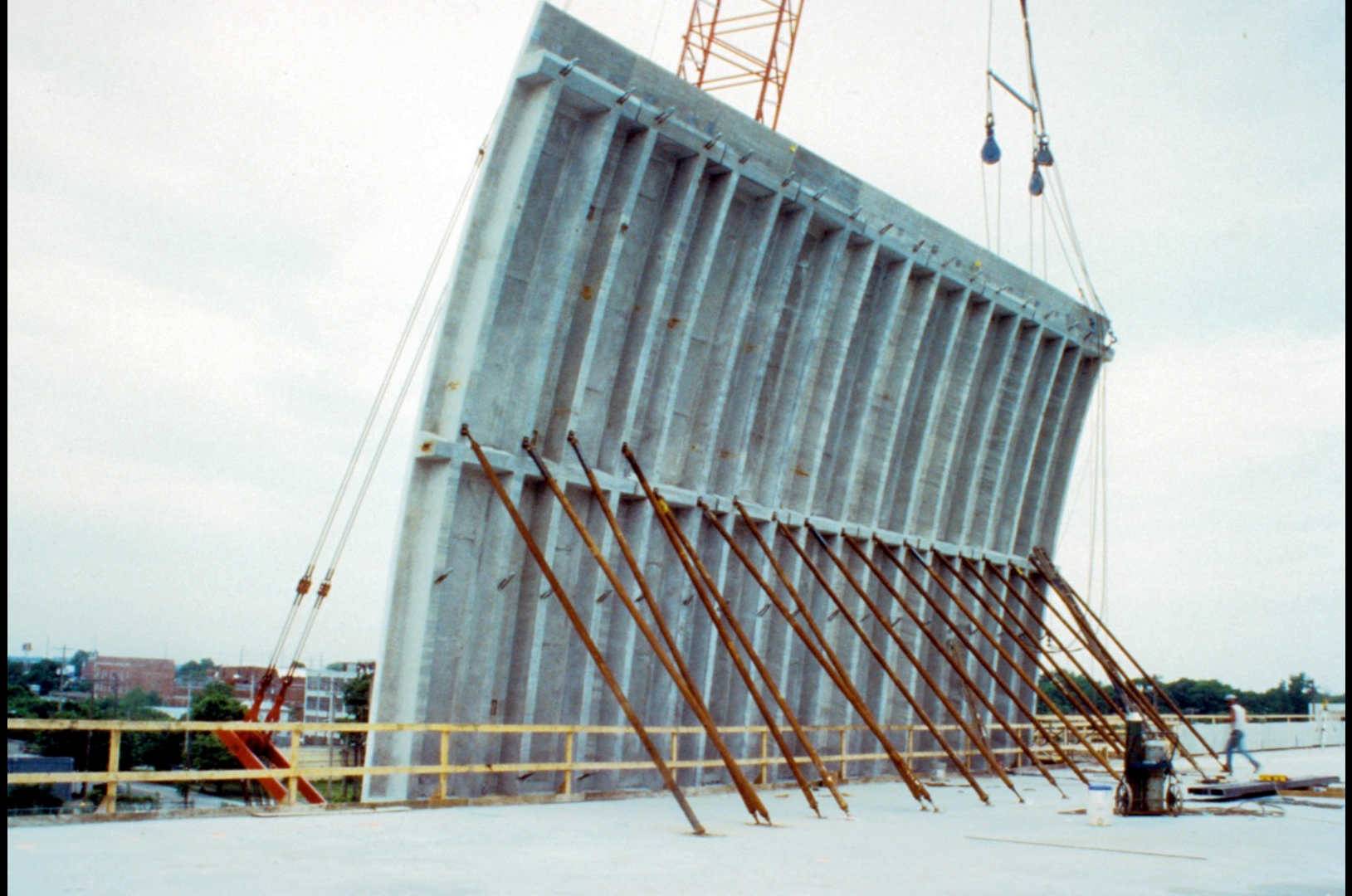

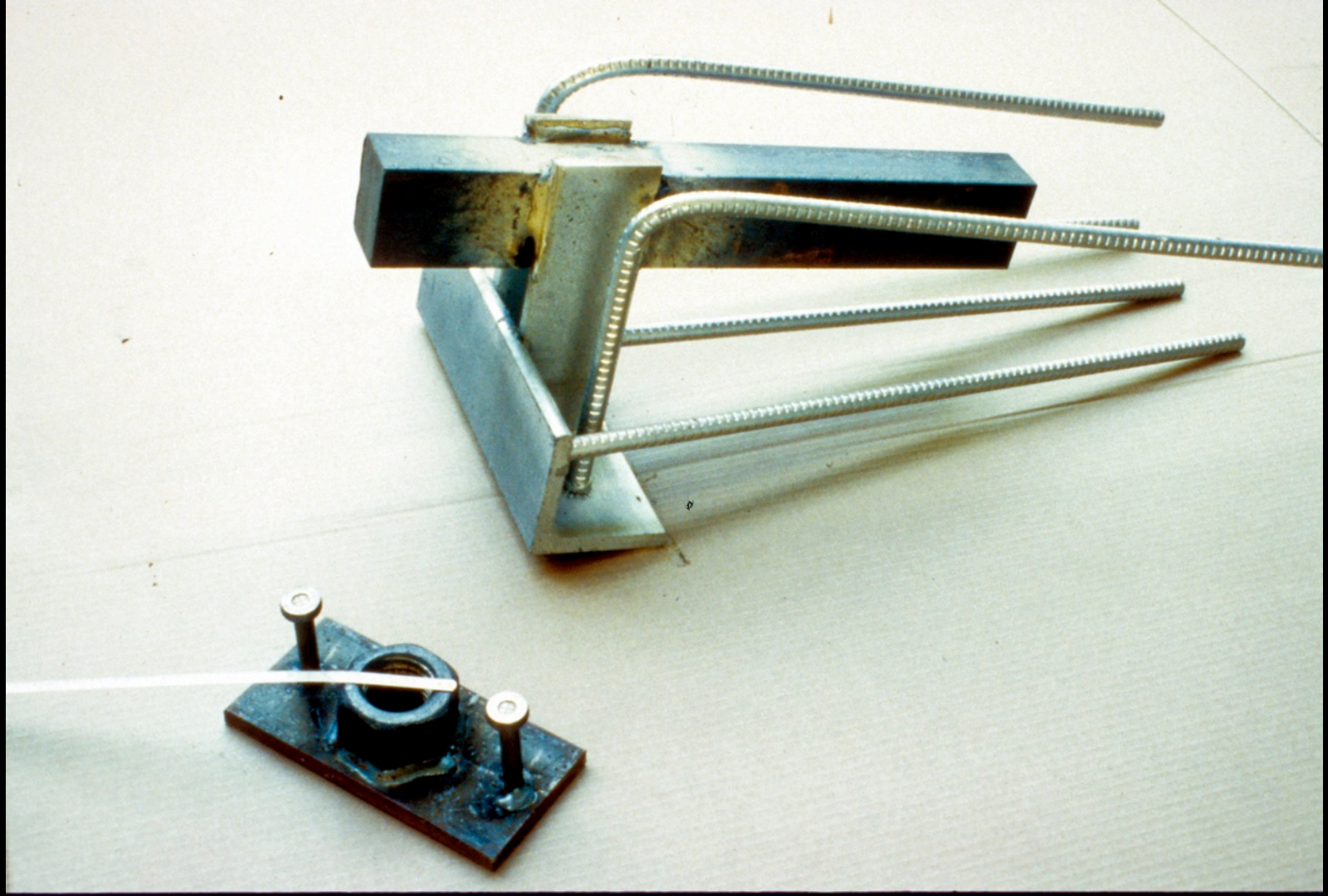

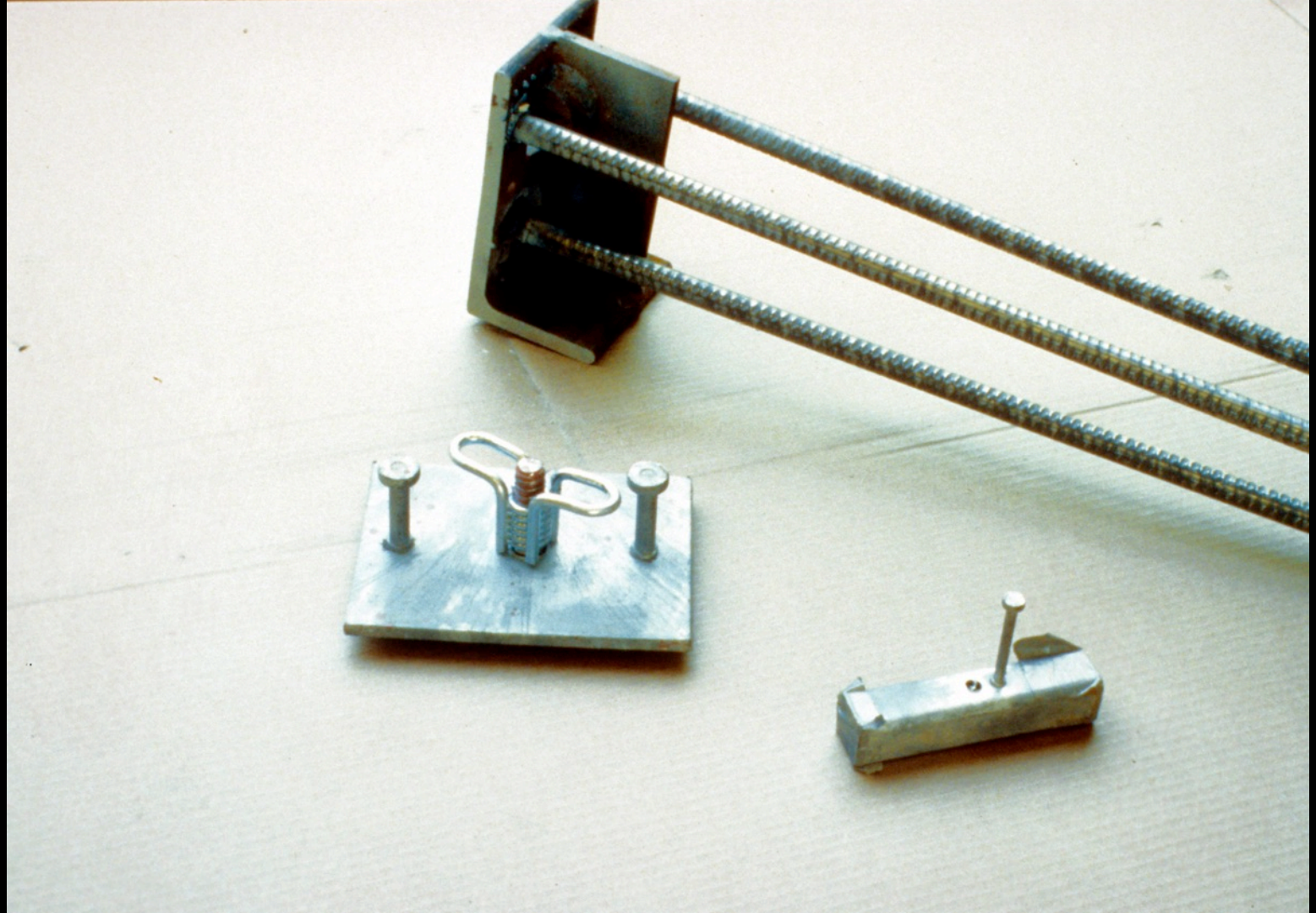


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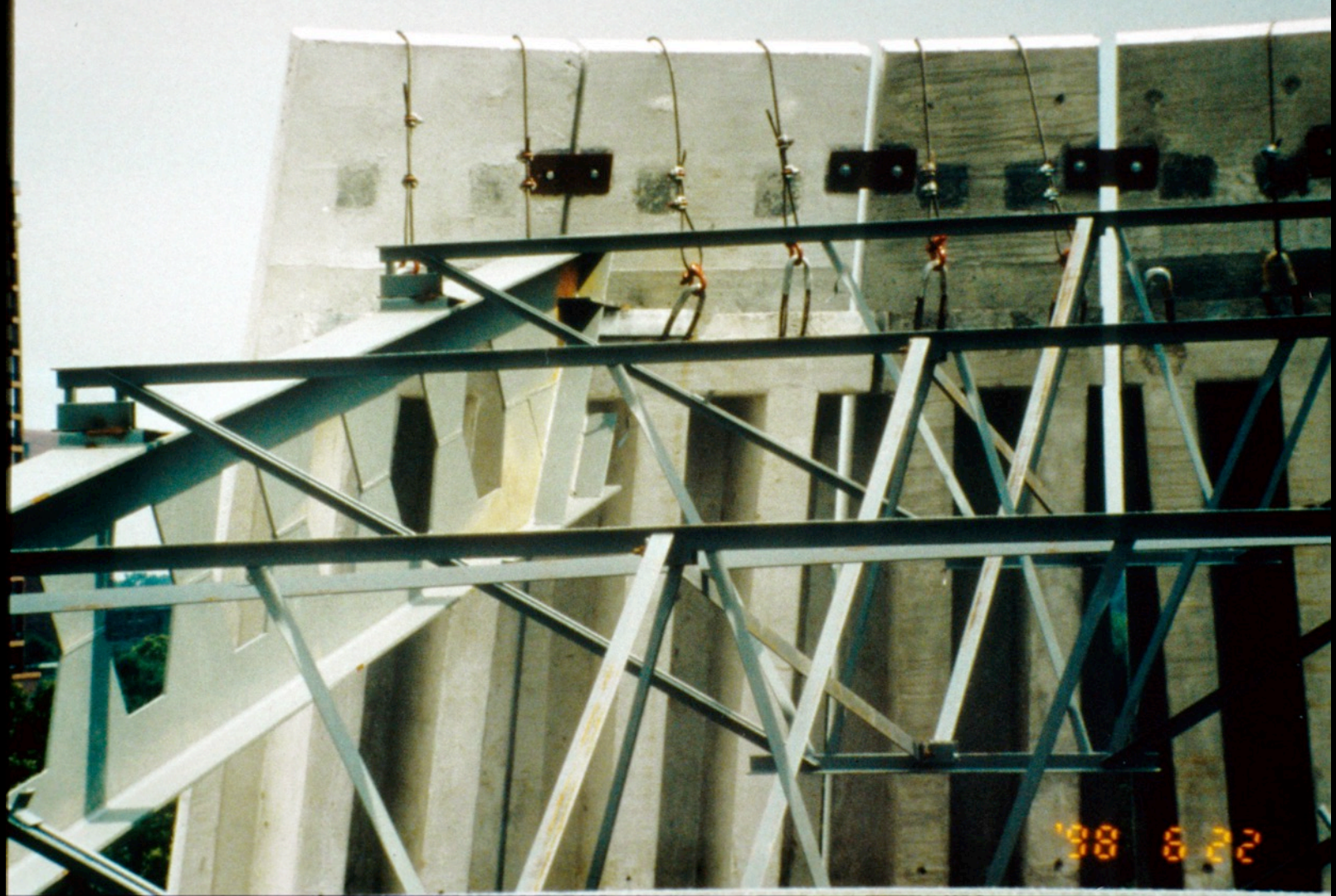
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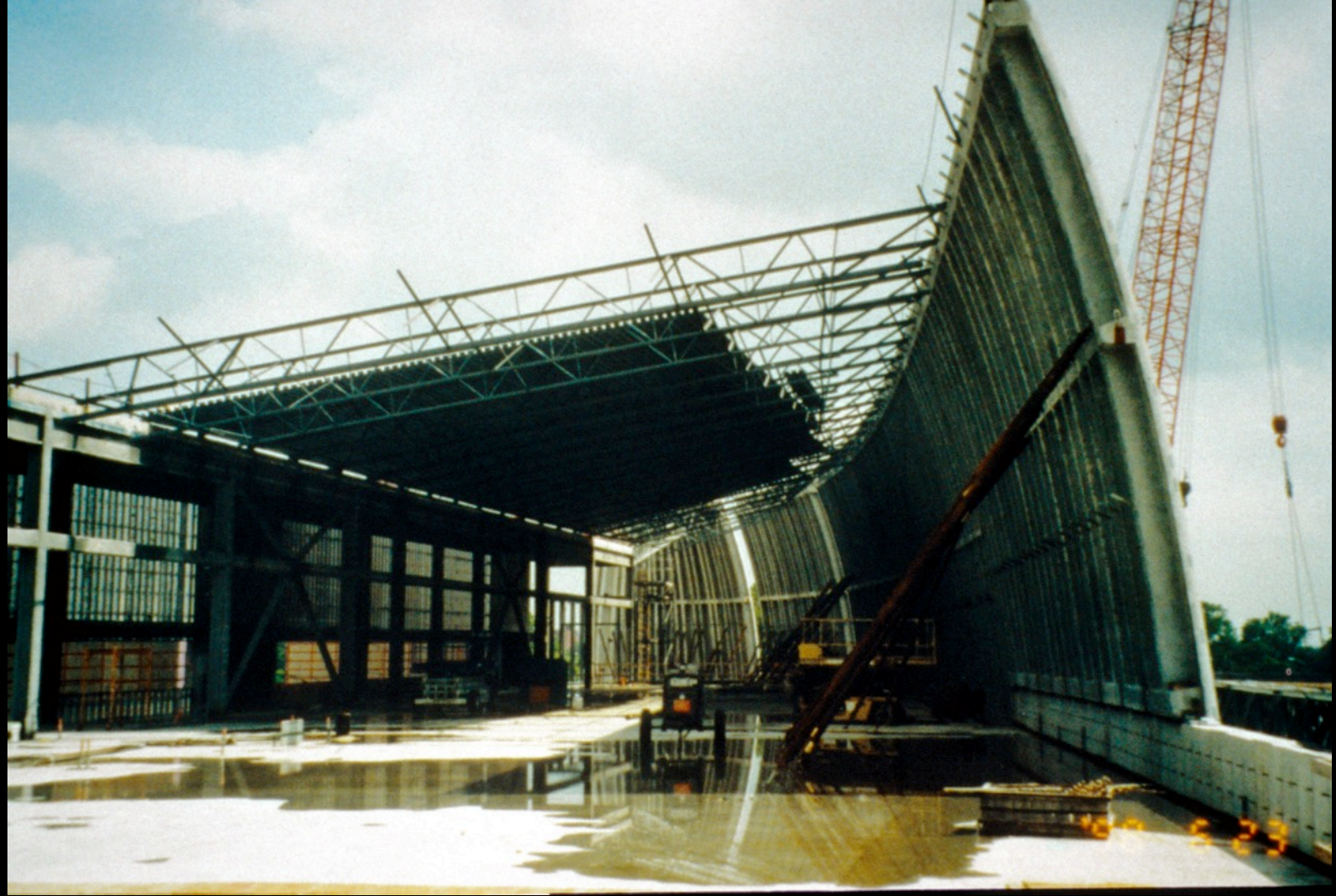


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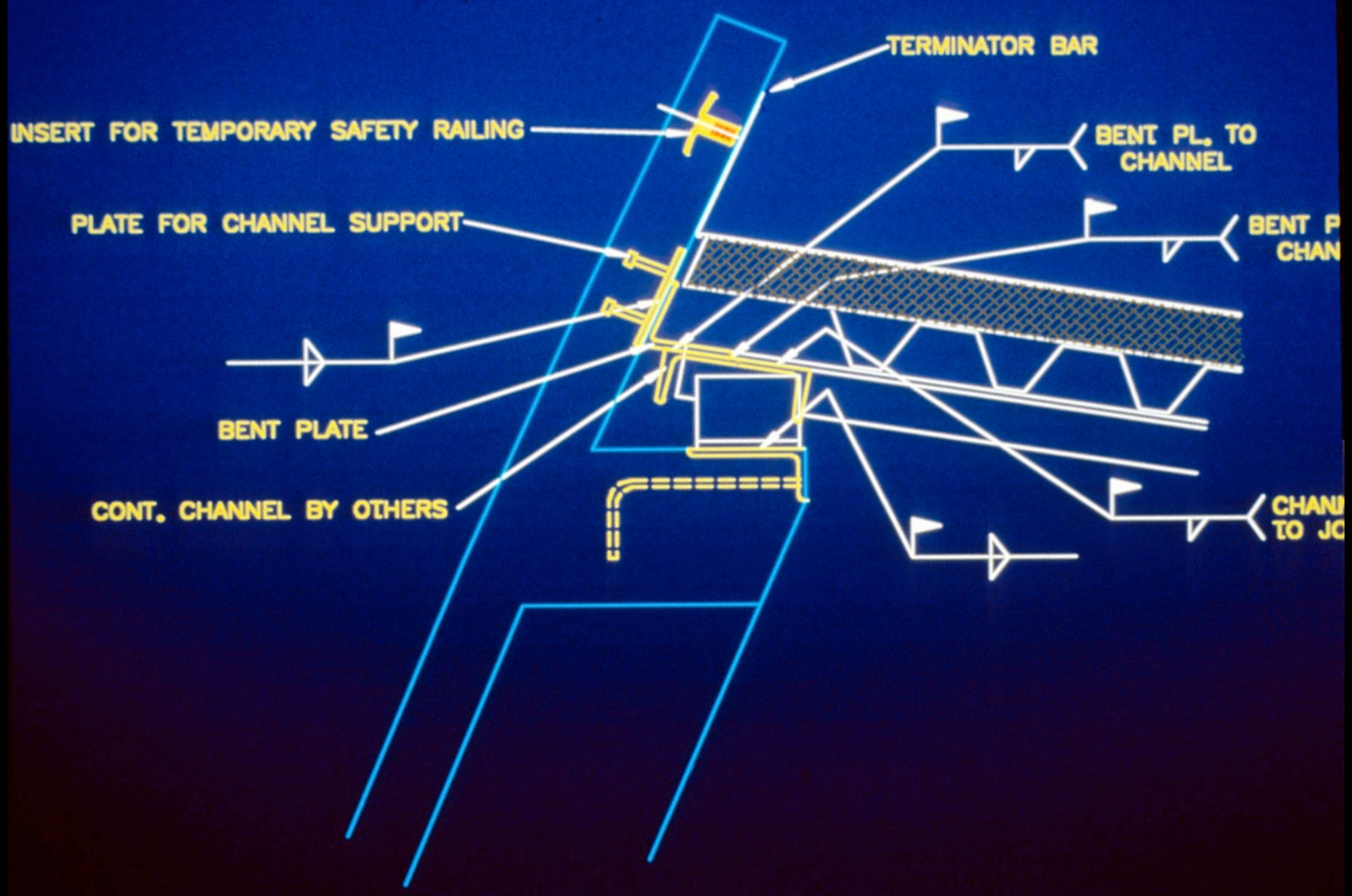
TERMINATOR BAR
INSERT FOR TEMPORARY SAFETY RAILING
BENT PL. TO CHANNEL
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BENT PLATE
CONT. CHANNEL BY OTHERS
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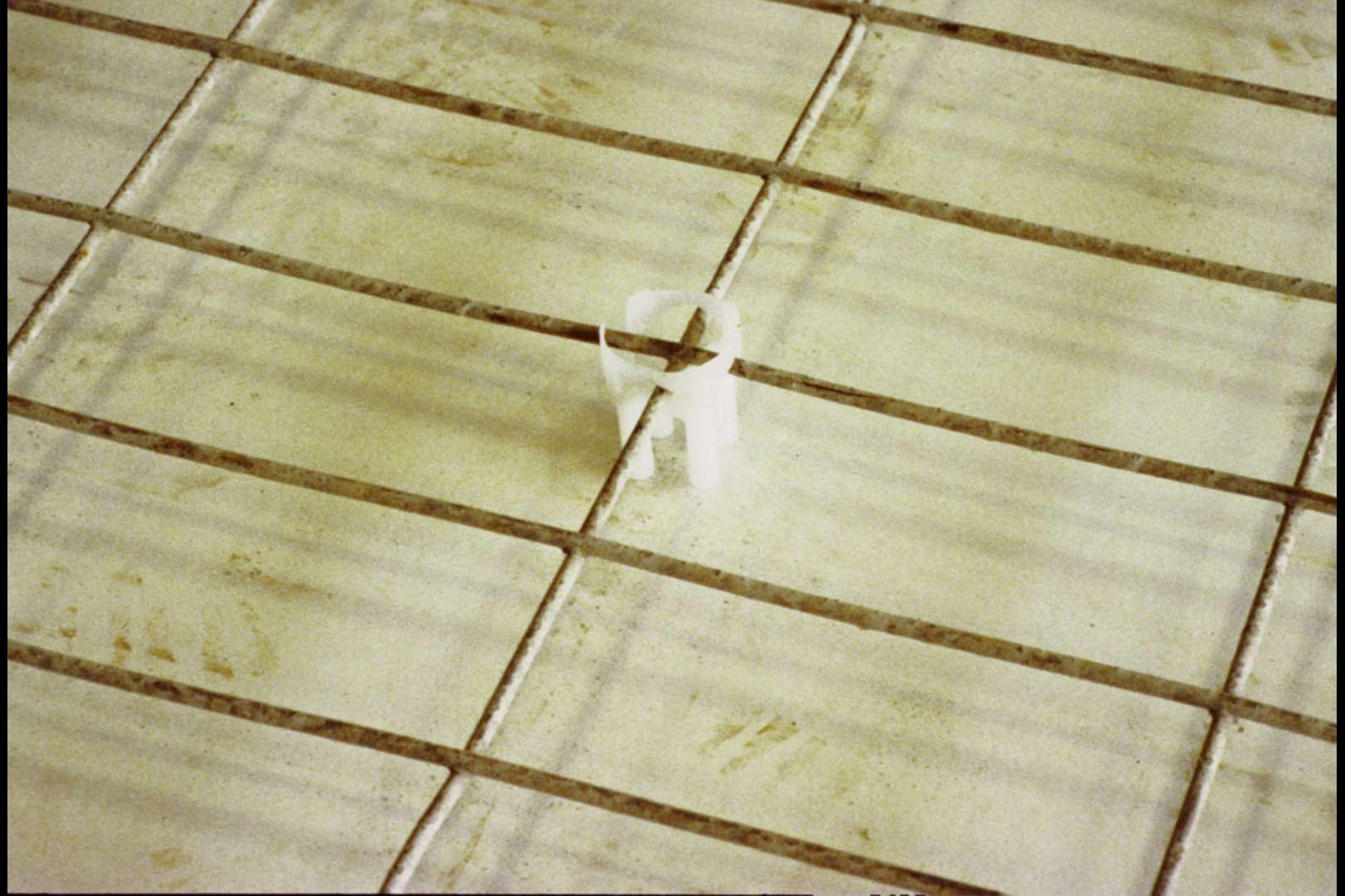

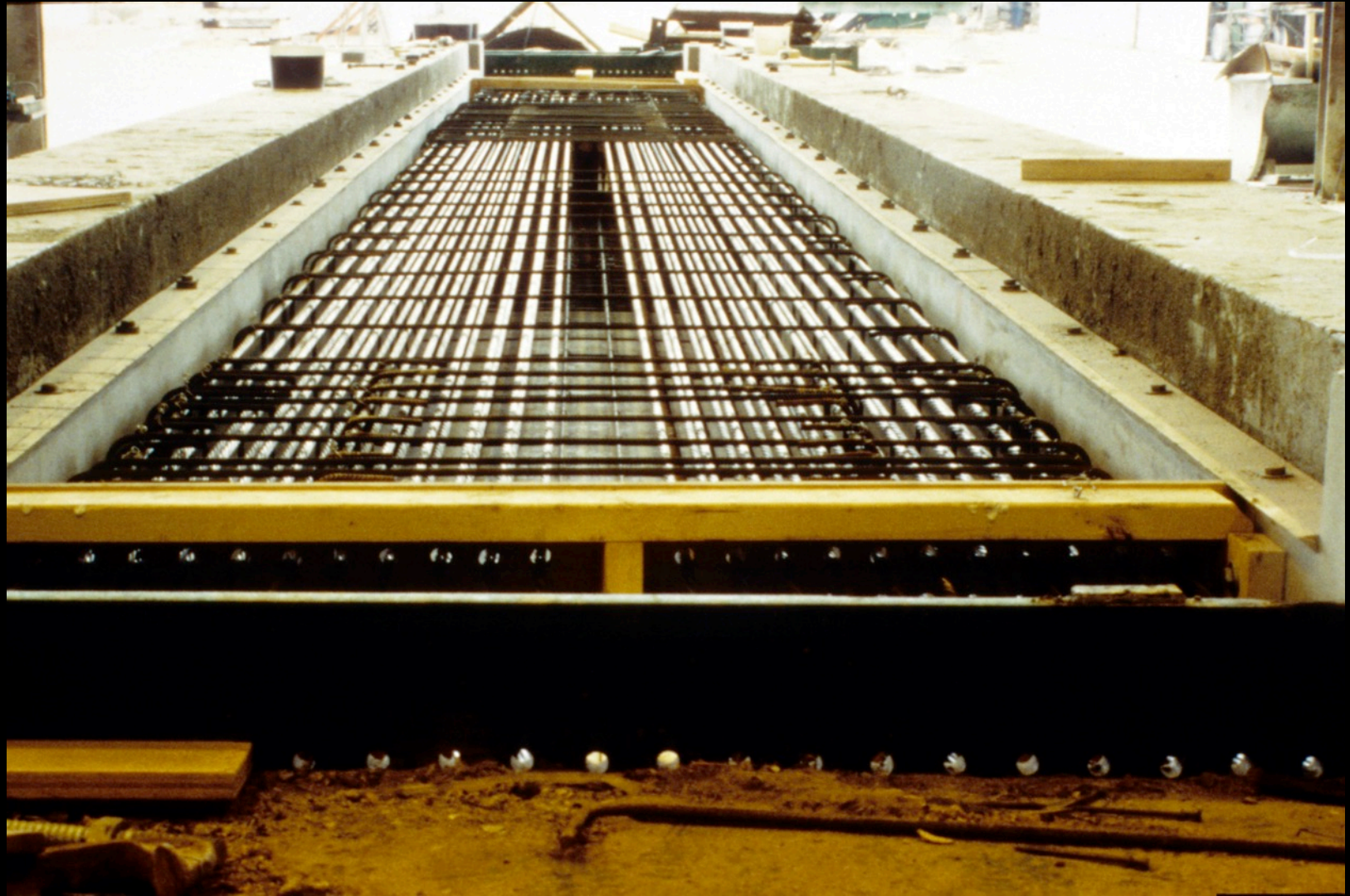

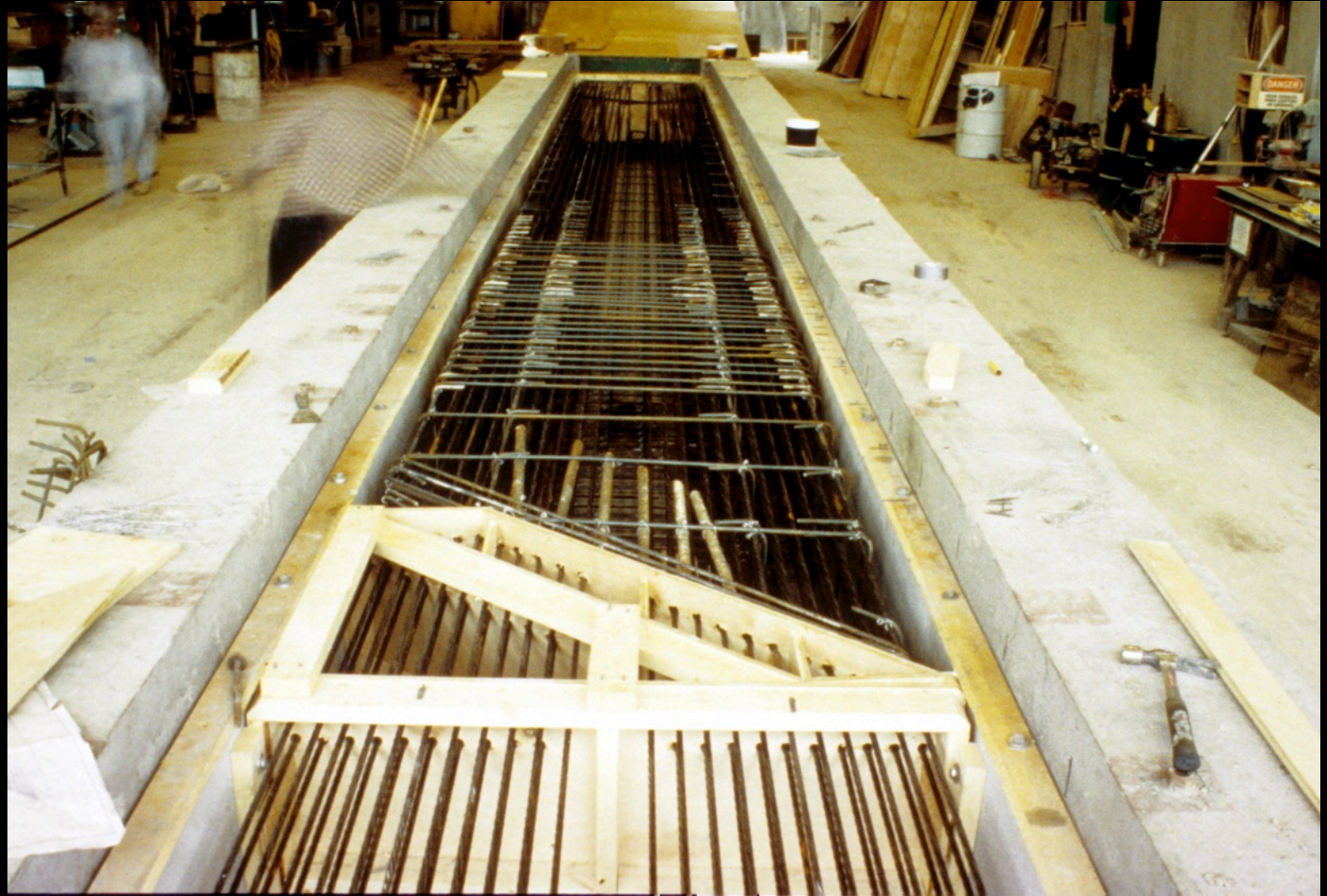
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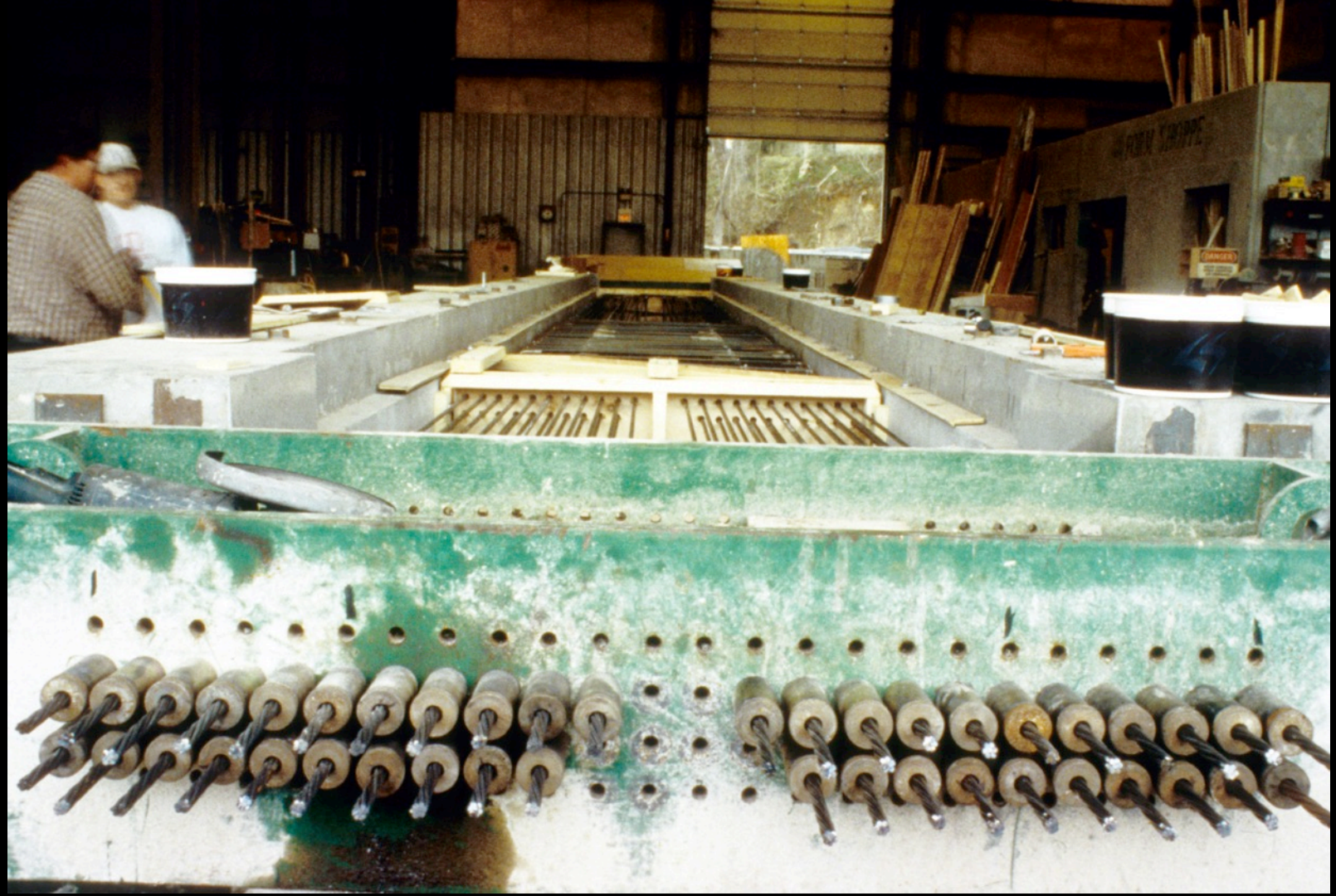

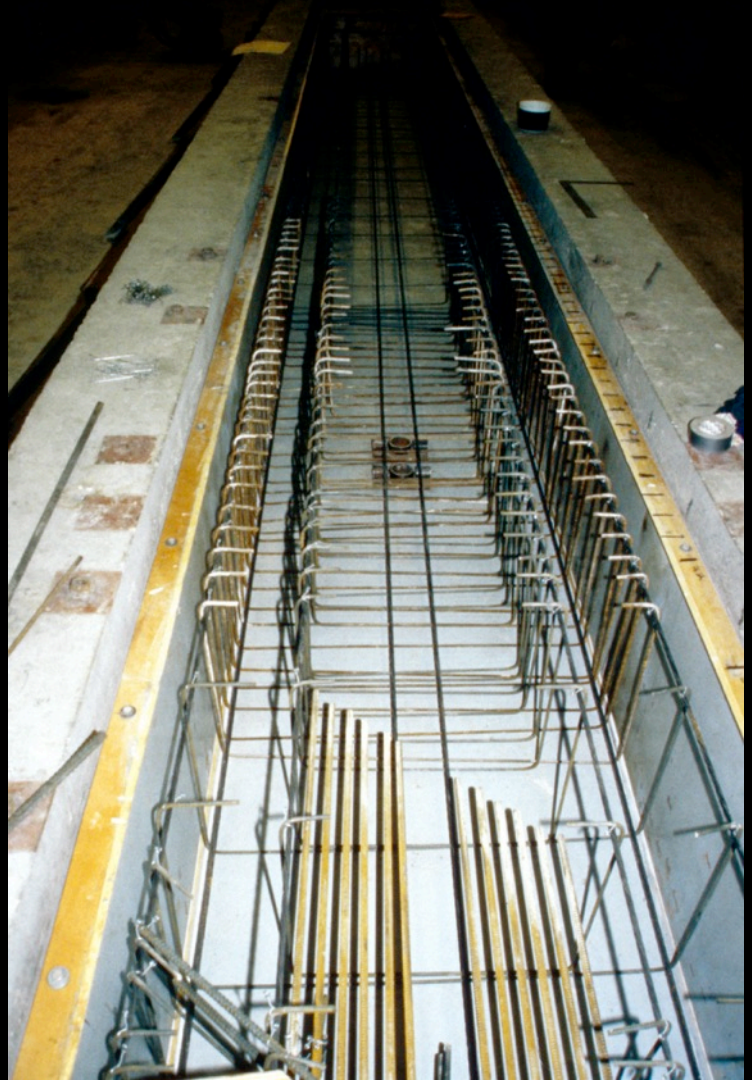

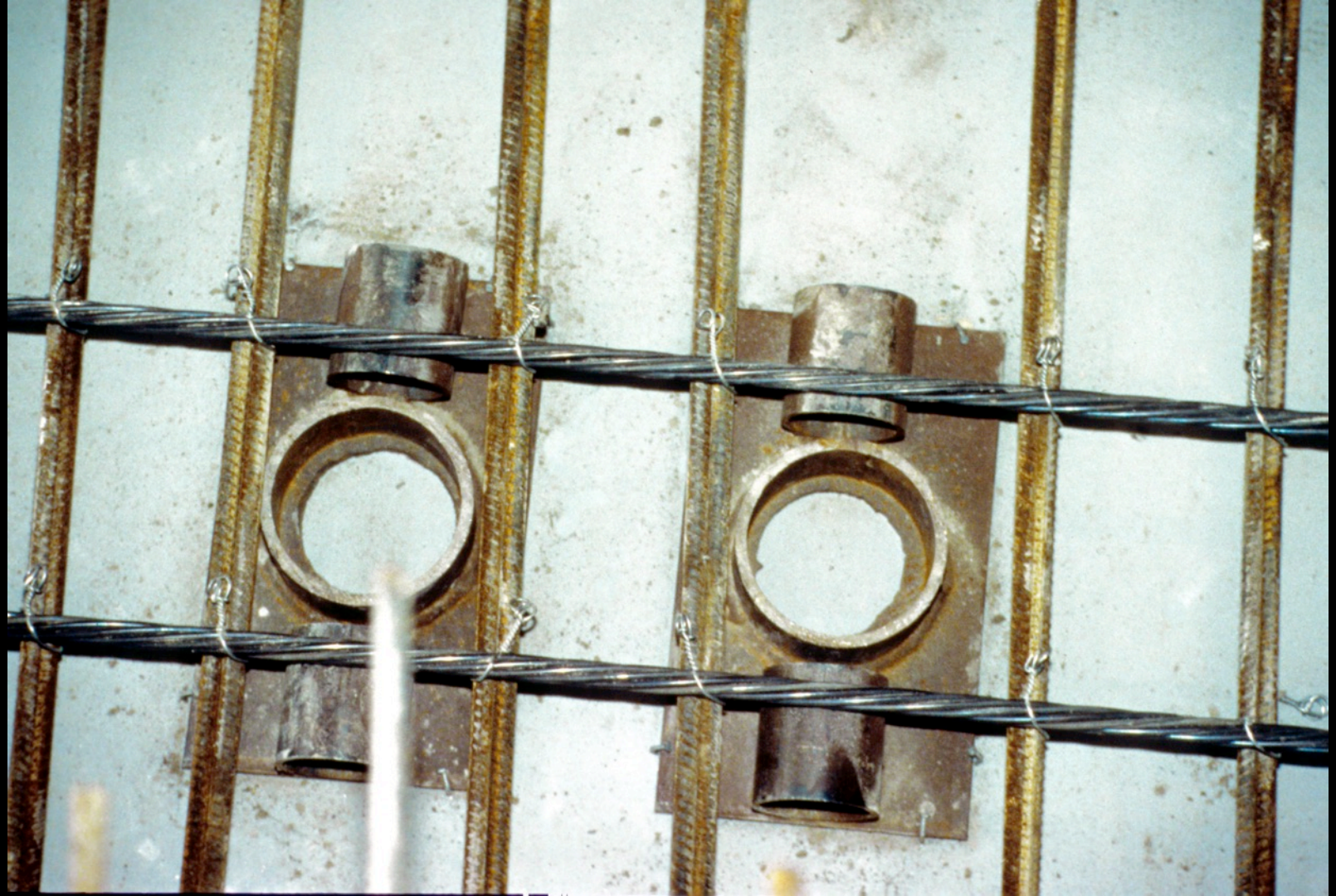


EXIT