

Historic Overview

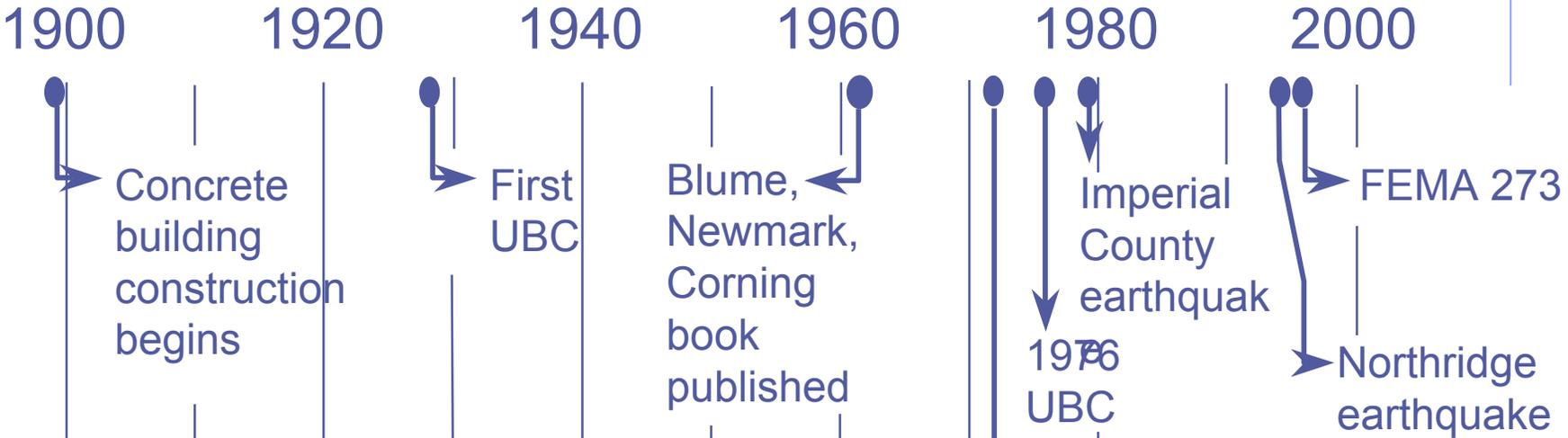


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Concrete Design, Codes, Events



Ductile detailing today



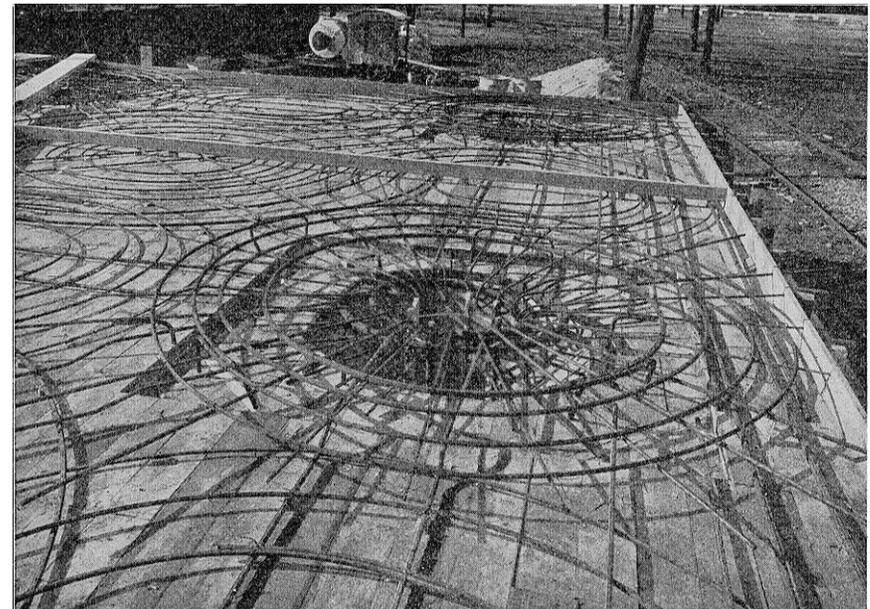
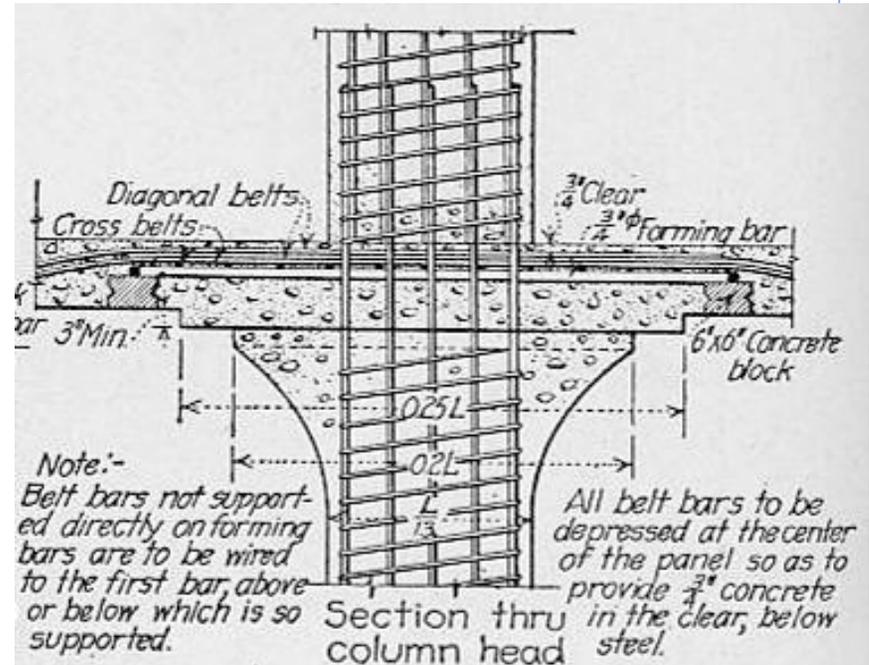
General Trends in Construction Practices

◆ 1900-1910

- earliest construction
- structural systems
 - ◆ frames
 - ◆ bearing walls
- concrete quality
- interior and exterior infills

◆ 1910-1920

- development of specialized systems
- flat slabs
 - ◆ drop panels and capitals
 - ◆ reinforcement arrangements
- joist and waffle slabs
 - ◆ steel pan or hollow clay tile void formers
- bearing walls



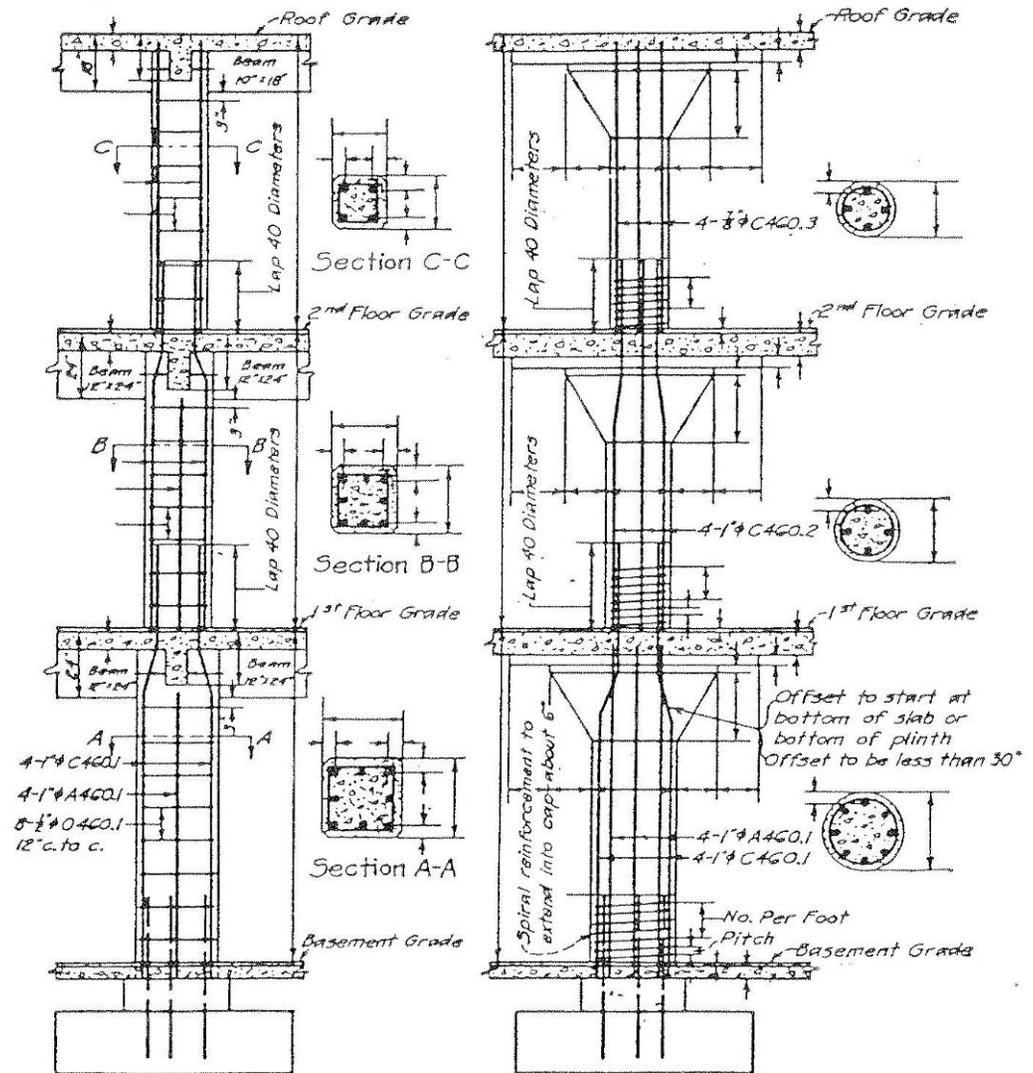
General Trends in Construction Practices

◆ 1920-1930

- era of improved construction quality
- improvements in gravity load design
- seismic design still in its infancy

◆ 1930-1950

- slight progress in concrete construction



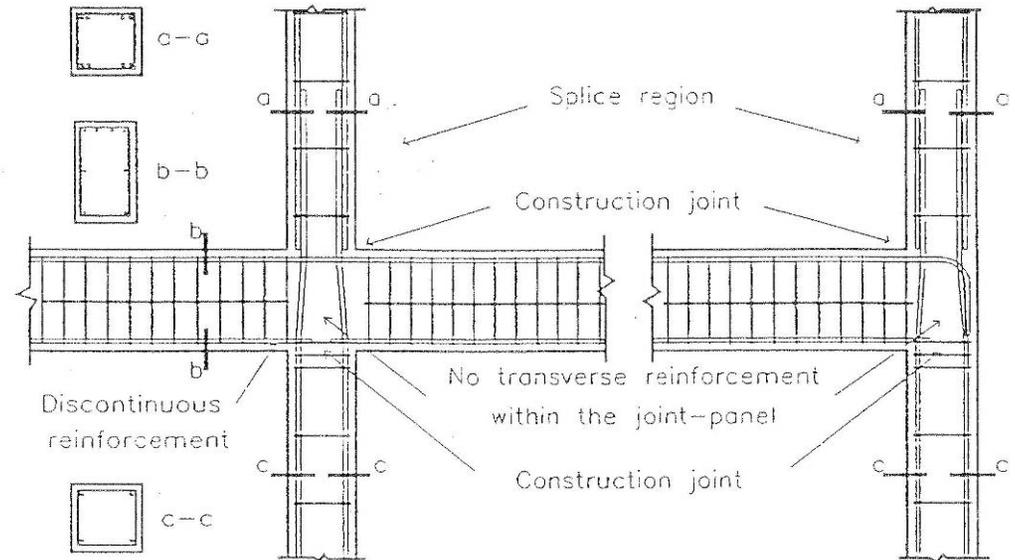
General Trends in Construction Practices

◆ 1950-1960

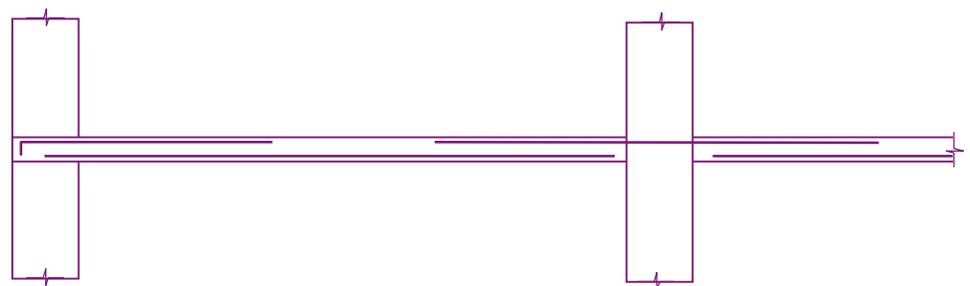
- rapid change in systems, design methods, and construction practices
- more open interiors and lighter cladding
- some seismic development
- prestressed and precast concrete
- formal use of shear walls

◆ 1960-1970

- improvement seismic design, but lack of attention to concrete detailing requirements
- designated lateral load systems
- lightweight aggregate concrete



Beam-column frame



Slab-column frame

General Trends in Construction Practices

◆ 1970-1980

- 1971 San Fernando earthquake
- 1976 UBC ductile concrete provisions
- 1979 Imperial Valley earthquake

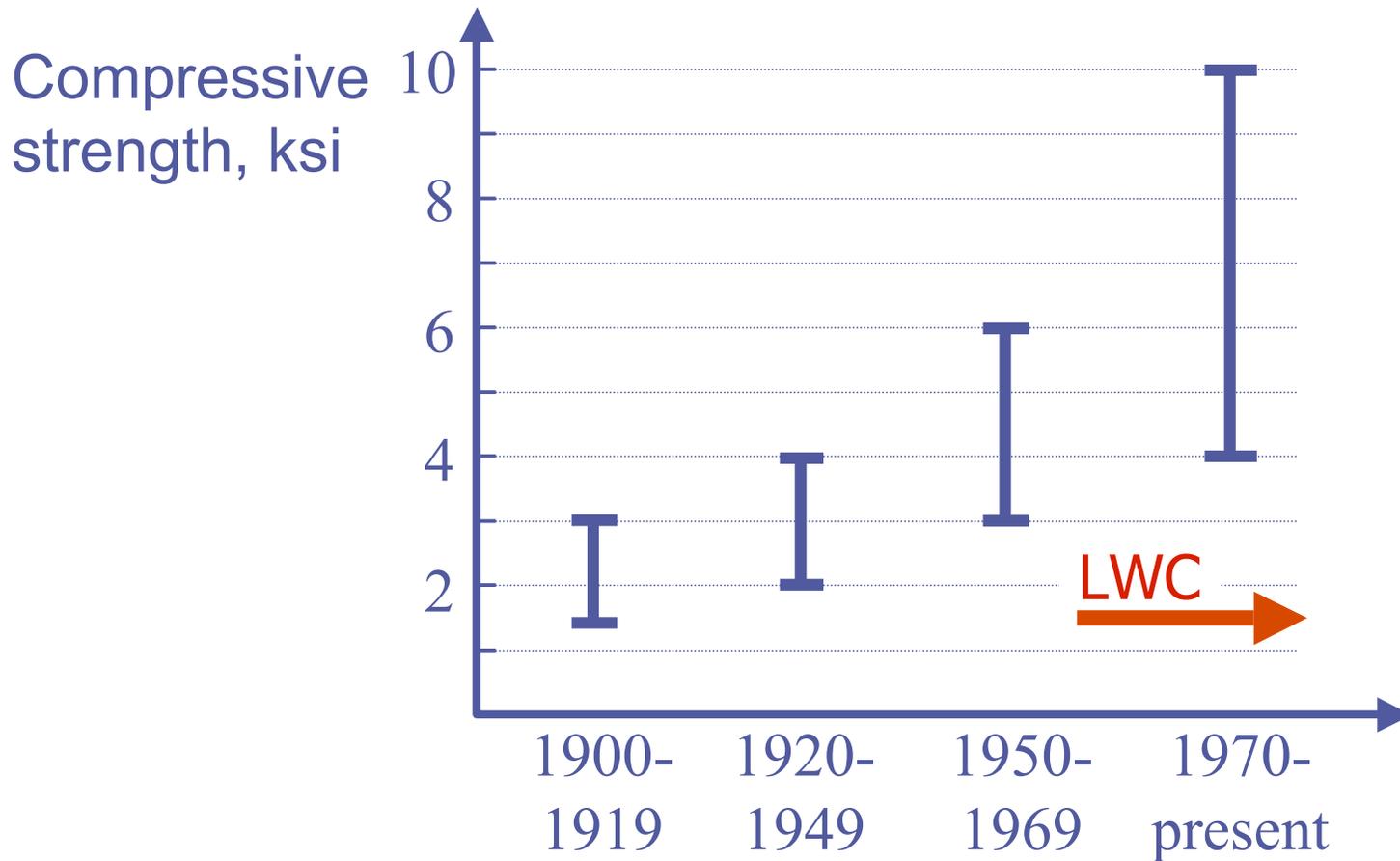
◆ 1980-present

- continued improvement and consolidation in design, code provisions, and construction
- gravity framing
- 1994 Northridge earthquake
- FEMA 273/356



Materials

◆ Typical range of column concrete strengths



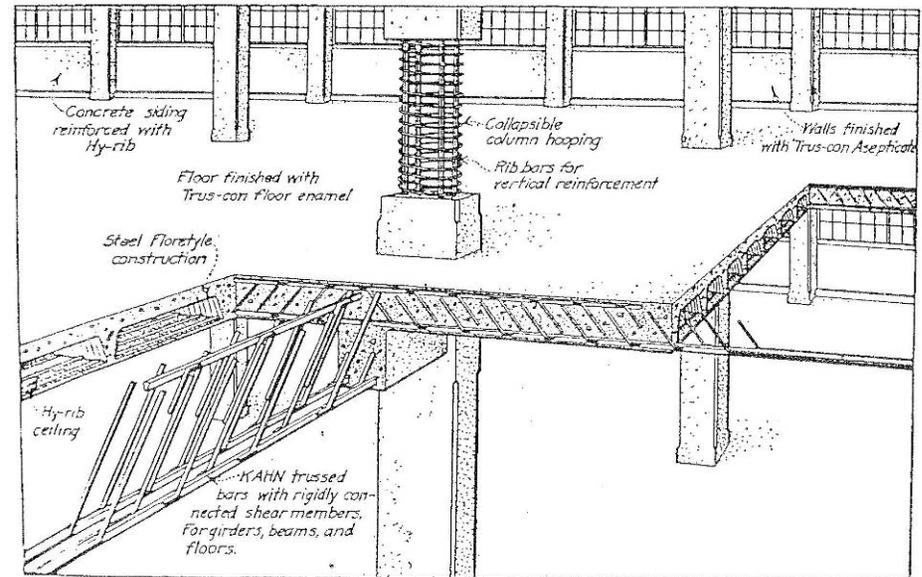
Materials

◆ Non-prestressed Reinforcement

- Early proprietary systems
- Plain bars, twisted bars
- Deformed reinforcement
 - ◆ prominent use starting in 1950's

◆ Prestressed Reinforcement

- prominent use starting in 1950's
- corrosion
- lack of non-prestressed reinforcement

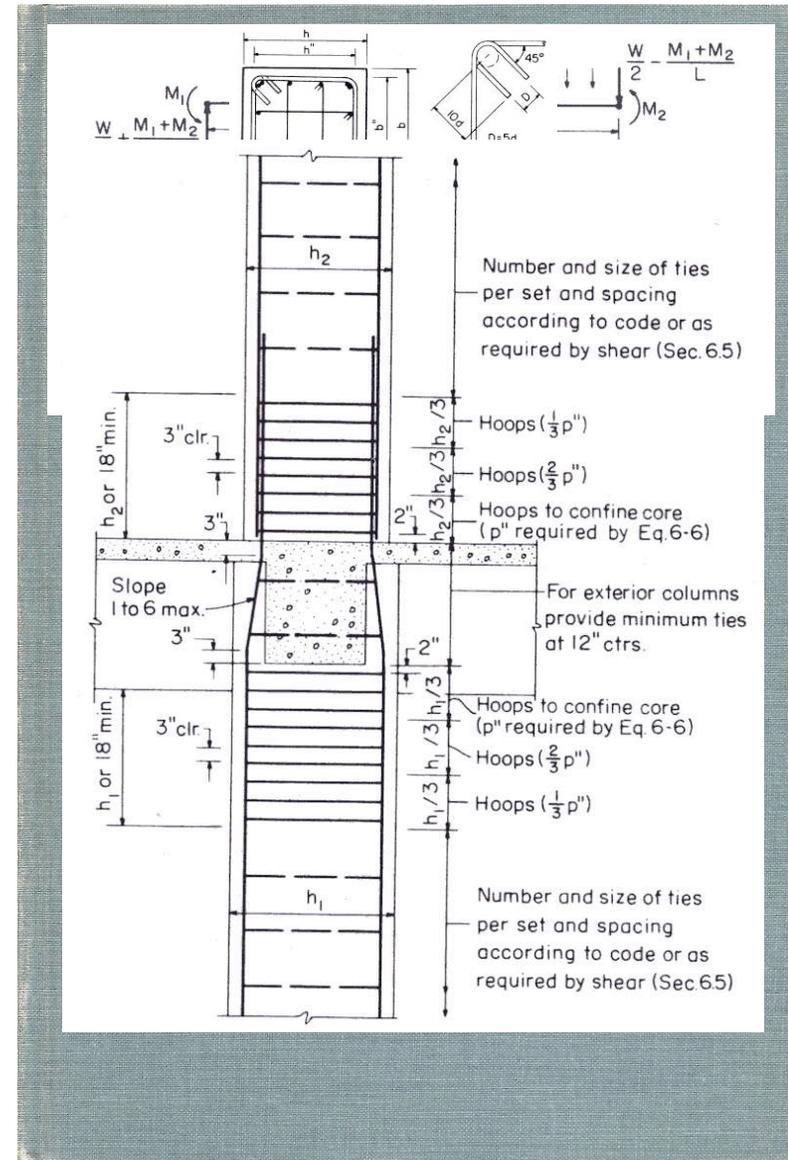


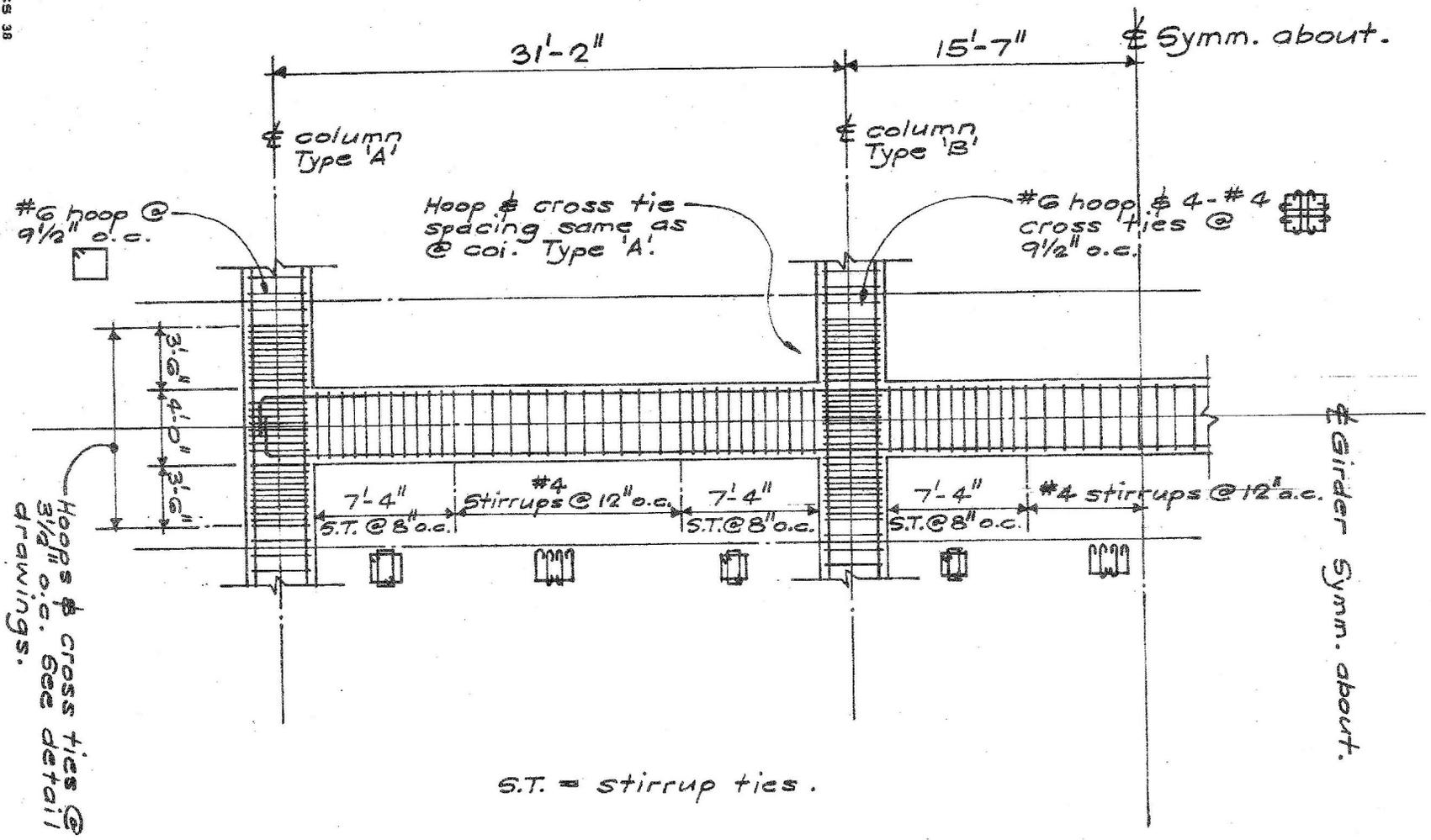
Materials - Reinforcement

| | | | | Structural | Intermediate | Hard | | | |
|------|------------|------------|-----------------------|------------|--------------|--------|--------|--------|---------|
| | | | Grade | 33 | 40 | 50 | 60 | 70 | 75 |
| | | | Minimum Yield (psi) | 33,000 | 40,000 | 50,000 | 50,000 | 60,000 | 75,000 |
| ASTM | Steel Type | Year Range | Minimum Tensile (psi) | 55,000 | 70,000 | 80,000 | 90,000 | 80,000 | 100,000 |
| A15 | Billet | 1911-1966 | | x | x | x | | | |
| A16 | Rail | 1913-1966 | | | | x | | | |
| A61 | Rail | 1963-1966 | | | | | x | | |
| A160 | Axle | 1936-1964 | | x | x | x | | | |
| A160 | Axle | 1965-1966 | | x | x | x | x | | |
| A408 | Billet | 1957-1966 | | x | x | x | | | |
| A431 | Billet | 1959-1966 | | | | | | | x |
| A432 | Billet | 1959-1966 | | | | | x | | |
| A615 | Billet | 1968- | | | x | | x | | x |

Transition to ductile detailing – 1960s onward

- ◆ 1961 - Blume, Newmark, Corning published
 - Many fresh concepts
 - ◆ confined concrete
 - ◆ flexural ductility concepts
 - ◆ plastic hinge length
 - ◆ capacity design for shear
 - Many aspects not considered
 - ◆ column/beam strength ratios
 - ◆ lap splices
 - ◆ joint design





ELEVATION OF TYPICAL COLUMN & GIRDER

Transition to ductile detailing

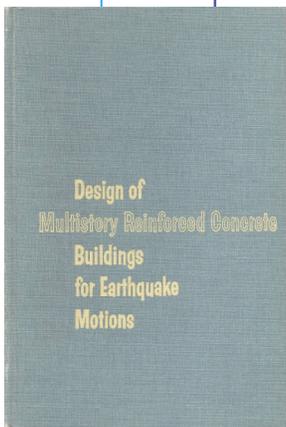


1900 1920 1940 1960 1980 2000

Concrete buildings

First UBC

1976 UBC



1965 Blue Book

- highrise
- ✓ ductile moment frame
- ✓ wall confined boundaries

1967 Blue Book

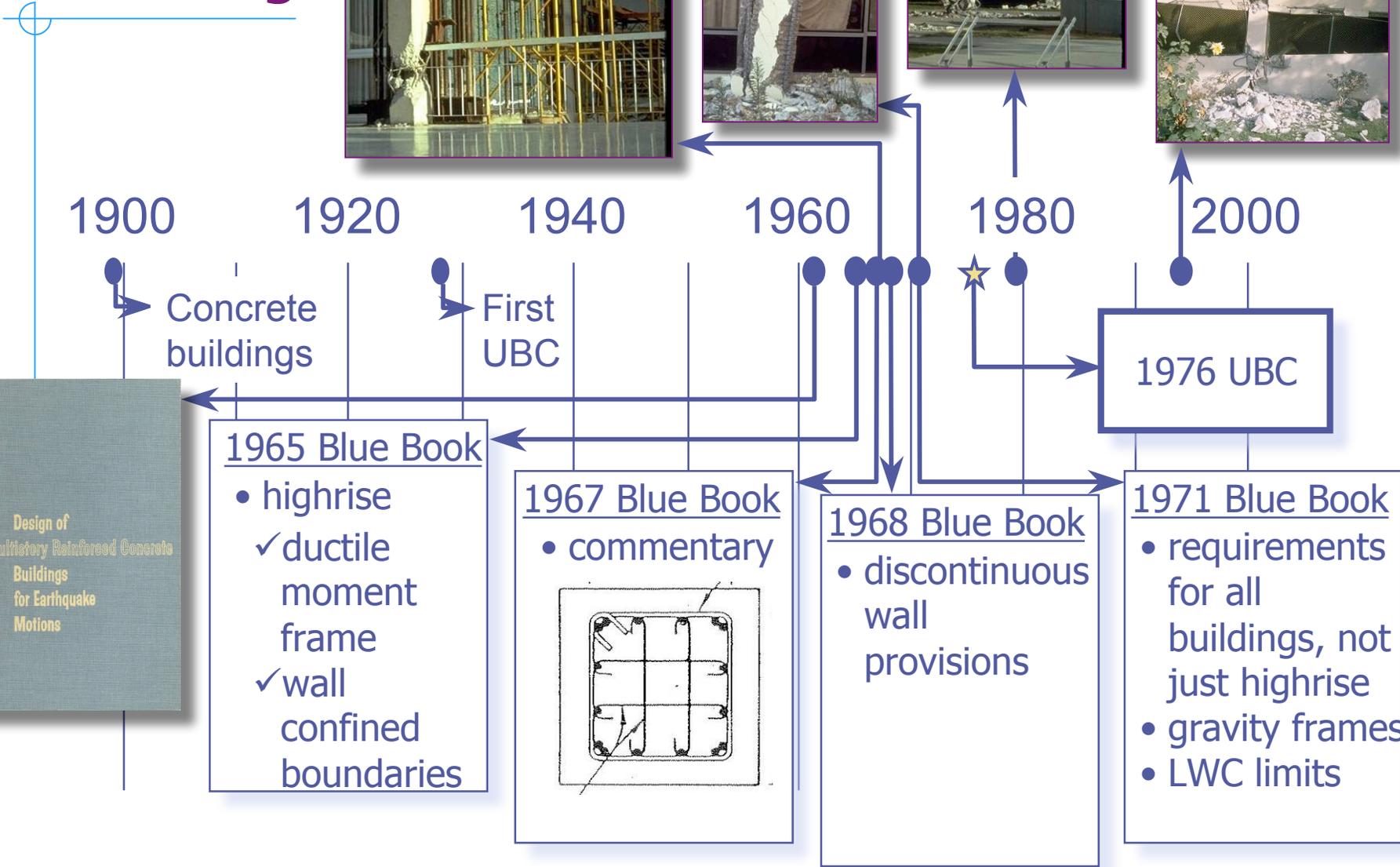
- commentary

1968 Blue Book

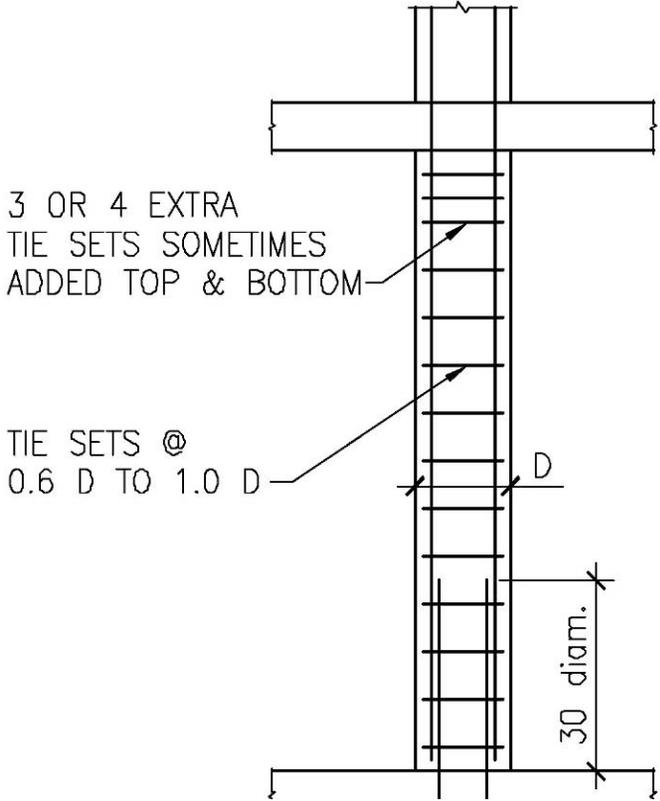
- discontinuous wall provisions

1971 Blue Book

- requirements for all buildings, not just highrise
- gravity frames
- LWC limits

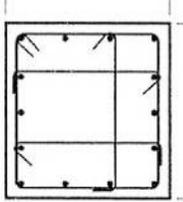
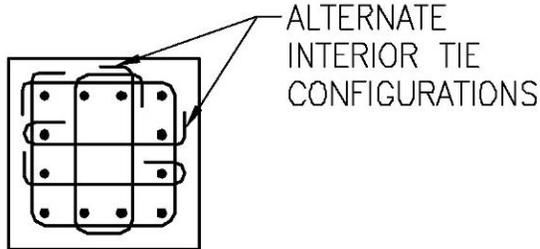
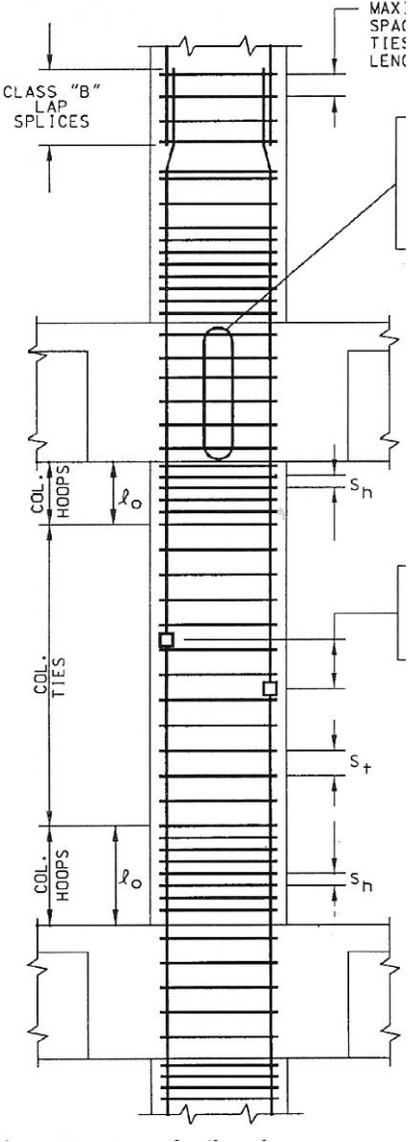


Columns

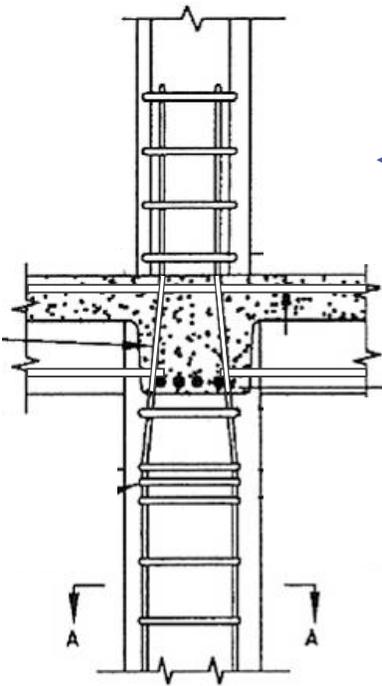


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Today →

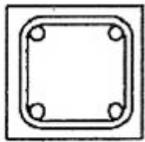
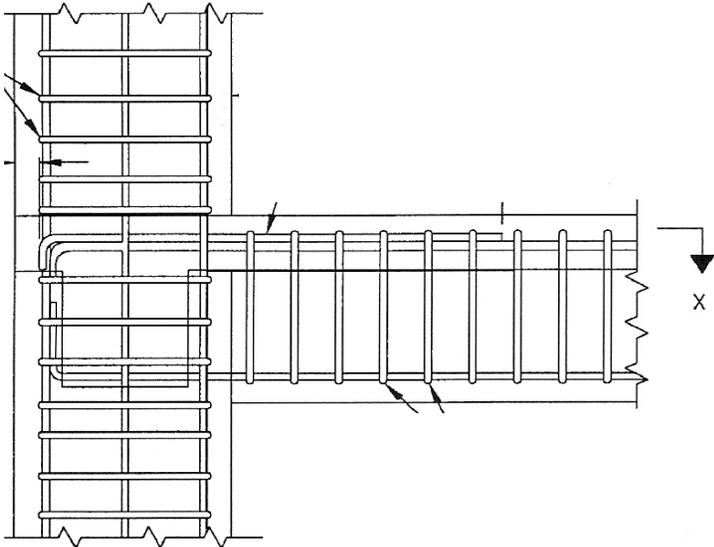


Beam-column connections

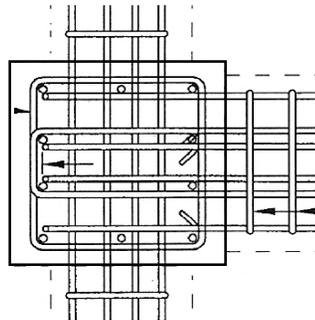


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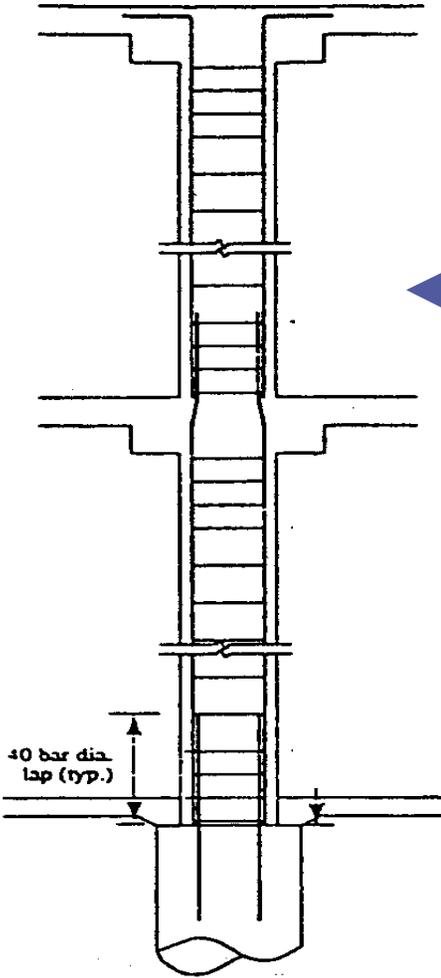
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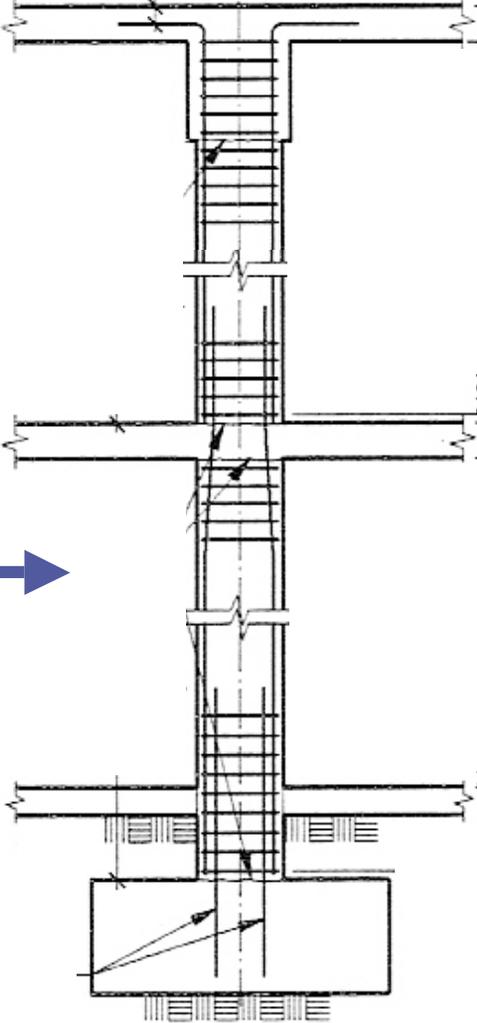
SECTION A-A



Gravity columns



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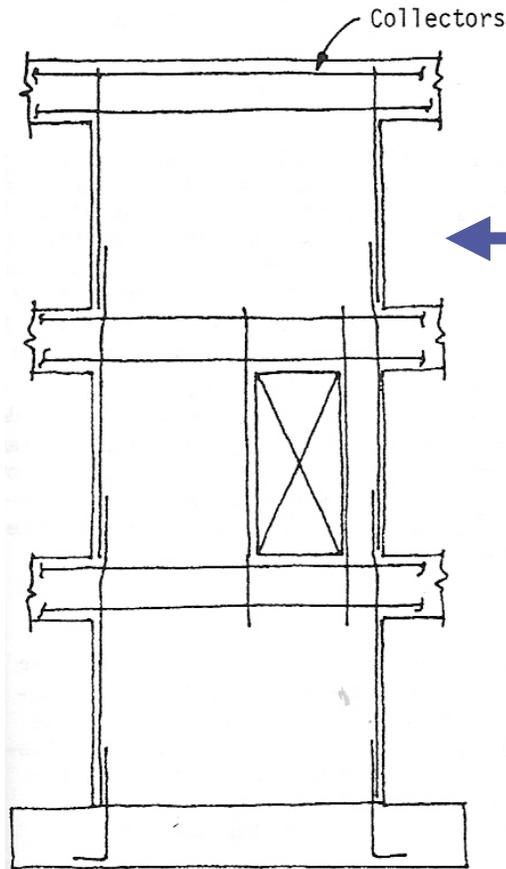


Today →



INTERIOR COLUMN

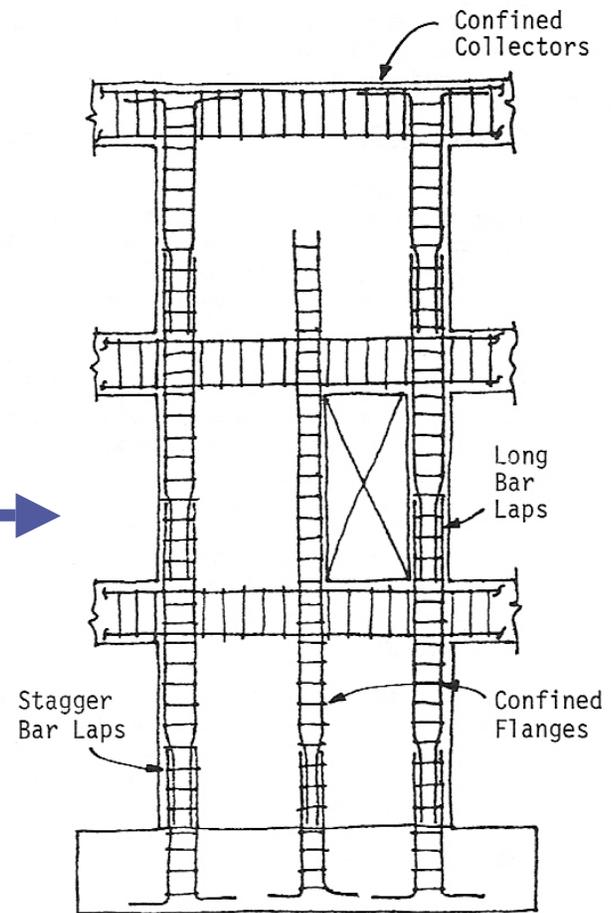
Walls



CONVENTIONAL

← Older

Post-1976 →



SPECIAL

Modern framing systems



Research today



NIED 独立行政法人防災科学技術研究所

Historic Overview



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