Learning Objectives

- Discuss seismic design methodology using precast concrete.
- Explain how precast concrete can be used to meet performance needs in seismic regions.
- Describe the PRESSS system.
- Describe the benefits of using precast concrete in seismic region.

Emulation Design

- ACI 550.1R-01 Emulating Cast-in-Place Detailing in Precast Concrete Structures
- ACI 318-11, Chapter 21 Earthquake-Resistant Structures
  - 21.4 Intermediate precast structural walls
  - 21.8 Special moment frames constructed using precast concrete
  - 21.10 Special structural walls constructed using precast concrete
**Intermediate moment frames**

- “A cast-in-place frame complying with the requirements of 21.3 in addition to the requirements for ordinary moment frames”
- An intermediate moment frame can be constructed with precast concrete with emulative detailing

**Intermediate precast concrete walls**

- In ACI 318-02, the scope in Chapter 21 was changed to require intermediate precast concrete walls “in regions of moderate risk.” The commentary states that the intention was “to result in an intermediate precast structural wall having minimum strength and toughness equal to that for an ordinary reinforced concrete wall of cast-in-place concrete.”
- In ASCE 7-05, Table 12.2-1 added lines for intermediate precast concrete shear walls to recognize the distinctive precast wall created by ACI 318.

**Intermediate precast concrete walls**

- ASCE 7-05, however, went further than was intended by ACI 318H when the table also permitted the intermediate precast concrete wall to be used to a height of 40 ft (or to 45 ft for single story warehouses) in SDC D, E and F.
- The simple improvement made by ACI 318H to precast walls in SDC C was complicated by this additional application, where ordinary cast-in-place concrete walls are not permitted.
Intermediate precast concrete walls

- The additional requirements imposed by ACI 318 required that connections between wall panels or between wall panel and foundation be restricted to yielding of steel elements or reinforcement. Any connection not intended to yield must be designed for 1.5Sy.
- ASCE 7, in chapter 14, modifies ACI 318 to add deformation requirements for connections and shear detailing for wall piers.
- Type 2 spliced bars meet the ductility requirements.

Reinforced Concrete Brace Frames

- UBC 97 had system parameters for reinforced concrete braced frames.
- With IBC 2000, there was a transition from the 3 separate model codes, and ASCE 7 became the referenced load standard.
- ASCE 7 – 99 did not include reinforced concrete braced frame in the systems table.
- ASCE 7 – 05 expanded Table 12.2-1 to include many added structural system, but did not include reinforced concrete braced frames.
Reinforced Concrete Brace Frames

Special moment frames

• Special moment frames of precast concrete must satisfy all the requirements for cast-in-place special moment frames in addition to the requirements of 21.8

• Special moment frames with ductile connections
• Special moment frames with strong connections
Ductile Connections

- \( V_n \) for connections designed by shear-friction \( \geq 2V_n \)
- Mechanical splices of beam reinforcement shall not be located closer than \( h/2 \) from the joint face

Special moment frames
Monolithic Joint

Special Moment Frames

Special precast structural walls

- Special precast structural walls must meet the requirements for intermediate precast concrete walls and for special cast-in-place concrete
Special precast structural walls

- Type 2 Splices

Special precast structural walls

- Strong and Ductile connections are implied by reference to 21.4, but not prescribed

Special precast structural walls

- Strong connection with cast-in-place closure
**Special precast structural walls**

- Strong connection using high-strength bolts (after AISC composite requirements)

**Emulation Design**

- Emulation is the application of the requirements for cast-in-place construction with adaptation to the manufacture, transportation and erection of discrete components

**PRESSS Research**

- Precast Seismic Structural Systems
- Five systems tested
  - Hybrid Frame
  - Pretensioned Frame
  - TCY Gap Frame
  - TCY Frame
  - Unbonded Post-tensioned Wall
PRESSS Codification

- Hybrid Frame
  - ACI 374.1
  - ACI ITG-1.2
- Unbonded Post-Tensioned Wall
  - ACI ITG-5.1
  - ACI ITG-5.2

PRESSS Hybrid Frame

- Hybrid frame design in practice
Project Description

- Single Story Fruit Sorting/Packaging
- Approximately 600,000+ SF
- Seismic Design Category (SDC)=D
- Facility Design Criteria:
  - Elevated Food Safety
  - Large Open Span for large equipment and Specialty Rooms
All Precast Building Components

- Precast Gravity Components
  - Roof Double Tees
  - Beams
  - Columns
  - Bearing Wall panels
- PRESSS
  - Intermediate Precast Shear Walls
  - Topped concrete Diaphragm
  - Hybrid Precast Moment Frames

Each Area as a ‘Separate Building’
Building Gap Locations

Lateral Force Resisting System

Shear Transfer at Building Gap
A2 Diaphragm/Chords

A2 Diaph Reinforcement Patterns

[Diagram of reinforcement patterns]

[Diagram of diaphragm and chords]
Intermediate precast concrete walls

- The additional requirements imposed by ACI 318 required that connections between wall panels or between wall panel and foundation be restricted to yielding of steel elements or reinforcement. Any connection not intended to yield must be designed for 1.5Sy.
- ASCE 7, in chapter 14, modifies ACI 318 to add deformation requirements for connections and shear detailing for wall piers.
- Type 2 spliced bars meet the ductility requirements
Shear Panel Stitch Connections

Special/Hybrid Moment frames

- Special moment frames of precast concrete must satisfy all the requirements for cast-in-place special moment frames in addition to the requirements of 21.8

Hybrid MF/ Line 1
Hybrid MF/ Line 1

Joint Shear Affects Col Size
Ductile Connections

- \( V_n \) for connections designed by shear-friction \( \geq V_e \)
- Mechanical splices of beam reinforcement shall not be located closer than \( h/2 \) from the joint face

Hybrid MF Joint

Hybrid/ Beam Reinforcement
Resist Torsion Beam Reaction
Hybrid/ Column Section

Hybrid MF Column Reinforcement

Hybrid MF/ Baugrid
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Thank you!