PRECAST CONCRETE in the UNITED STATES

- The precast, prestressed concrete industry is coming out of the Covid 19 pandemic strong
- The forced separation has caused a major change in work processes
  - Working Remote
  - On-line meetings
    - Zoom
    - TEAMS
    - RingCentral
- The most significant challenge for the industry is production capacity

PRECAST CONCRETE CAPACITY

- Limits of workforce
- Limits of manufacturing plants
- Facilities to meet new types of structural demands
- Trucking
- Technical Support

PRECAST CONCRETE CAPACITY

- Workforce development is a strong new initiative within PCI
- Manufacturing jobs
- Engineering and Technical Training
- Supply chain issues

PRECAST CONCRETE BUILDINGS

- For almost 50 years, precast concrete parking garages have been half of the precast market in the US
- Warehouses
- Architectural cladding
- Manufacturing in special industries
- Housing using hollow core

PRECAST CONCRETE BUILDINGS

- Parking Structures are still a strong market
- More emphasis on buildings with thermally-efficient enclosures
  - Insulated wall panels
  - Continuous insulation
  - Composite wall
- Data Centers
- Logistics Centers

PRECAST CONCRETE BUILDINGS – DATA CENTERS

- Muti-story Buildings with exceptionally high loading
- Data hall floors have sustained live loads of 1900 kg./m^2 with hanging collateral loads of 275 kg./m^2
- Data hall floors have spans around 15 meters
- UPS floors have 1250 kg/m^2 sustained live loads with 550 kg/m^2 collateral hanging loads
- UPS floors have spans of 20 to 21 meters
- Double tee depths are a meter to 1.2 meters with minimum 8 cm concrete topping
- Above the roof are added platforms of steel or precast to support chillers

PRECAST CONCRETE BUILDINGS – LOGISTICS CENTERS

- Muti-story Buildings with parking for delivery vans or even tractor trailers
- Van parking floors have live loads of 400 kg./m^2
- Truck loading is like bridge loading applied over large areas
- Parking floors have spans of 18 to 20 meters
- Double tee depths are a meter to 1.2 meters with minimum 8 cm concrete topping
- These building can include conventional parking for employees, office space and warehouse space (at 1200 kg/m^2)

PRECAST CONCRETE BUILDINGS – MISSION CRITICAL

- The buildings have large plans
  - 170 x 200 meters for logistics center
  - 85 x 215 meters for data center
- The number of precast pieces on these projects can vary from 1500 to 4000
- Beam spans are around 14 meters with depths of 162 cm and weight to 29,500 – 30,000 kg.
- Design risk categories for wind and seismic are usually higher than conventional structures.

PRECAST CONCRETE BUILDINGS – MISSION CRITICAL

- Precast is also used for storm shelters or critical content protection, such as electric power equipment.
- Schools are including gymnasiums with 30-meter roof spans bearing on insulated walls.
- Designs for hurricane or tornado with wind speeds from 320 kph to 400 kph

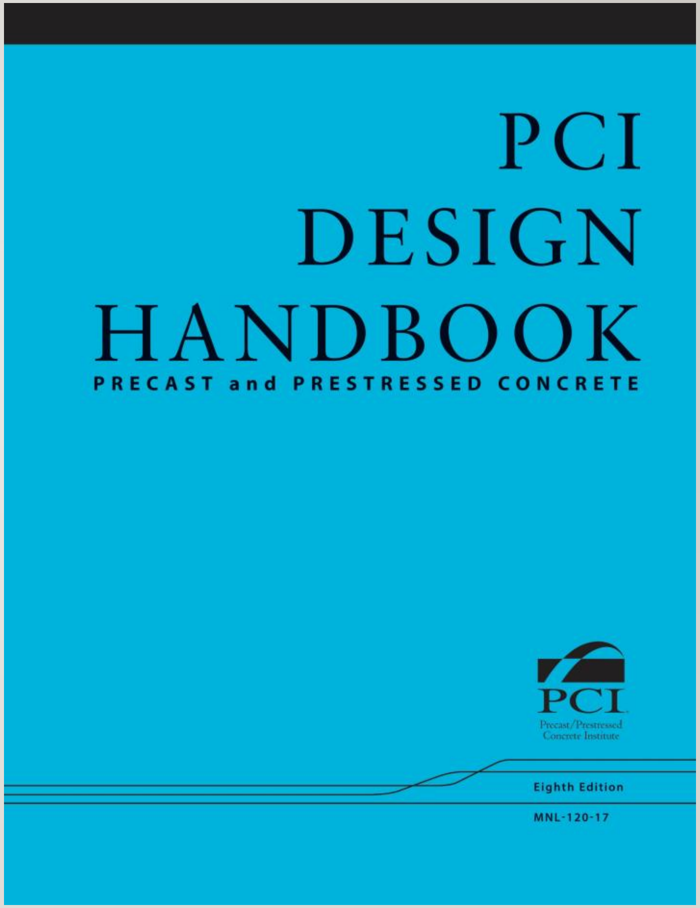
PRECAST CONCRETE REGULATION – BUILDING CODES

- Changes in the US Model Code (International Building Code, IBC)
- Changes in Building Code Enforcement
- Changes in the types of precast structures being built
- Changes in the load standard (ASCE 7-16) that imposes a more rigorous load calculation for seismic diaphragms constructed with precast concrete

PCI Code Development

PCI History

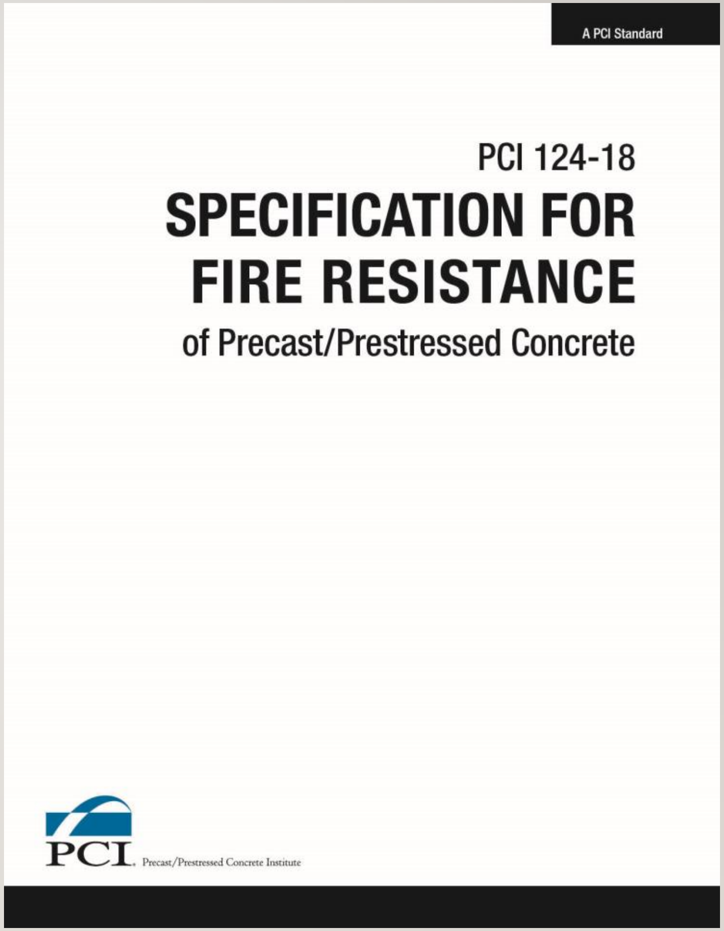
- Since its founding in 1954, PCI has developed, maintained, and disseminated the body of knowledge for the Precast/Prestress industry.
- In March 2014, PCI was accredited by the American National Standards Institute (ANSI) as an accredited Standards Developer.



PCI Body of Knowledge

- PCI's Body of Knowledge includes:
  - Journal Articles
  - White Papers
  - Quality Assurance Manuals
  - Guides for Recommended Practice
  - The PCI Design Handbook

- In 2018, PCI completed its first Specification for Fire Resistance PCI 124, which will be adopted into IBC 2021



PCI - Why develop standards?

- There is a need:
  - Public safety
  - Hold designers responsible
  - Recommended practice not enough
    - Not enforceable
  - PCI holds the most knowledge concerning precast/prestressed concrete
    - Expertise from design practices, quality control, to safe erection procedures

PCI: ANSI Accredited Standards Developer (ASD)

- PCI Standards Committee
  - Independent of any PCI Council
  - Maintain balance
    - Producer - Manufacturers, distributors, professional consultants to these groups
    - User – Representatives of owners, testing laboratories,
    - General Interest – neither producers or users; educators, representatives of technical societies

PCI: ANSI Accredited Standards Developer (ASD)

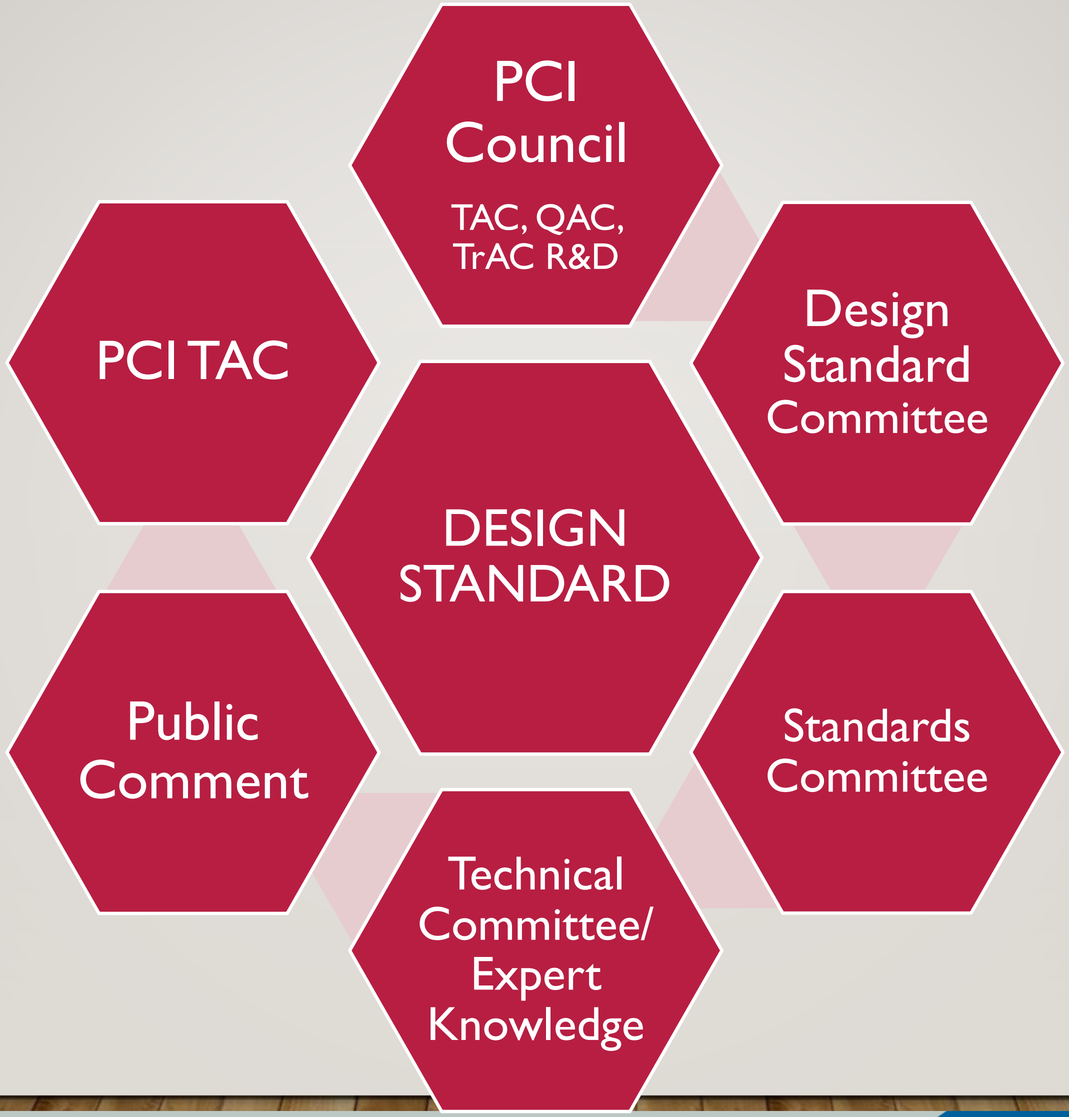
- PCI Standards Committee
  - Review the standard for non-technical items
    - Document format
    - Language used
    - PCI & ANSI Policies
    - Balloting & resolution

- More information about PCI Procedures as they relate to ANSI
- https://www.pci.org/PCI/About/Standards_Development.aspx

ACI and PCI: The Conflict

- PCI found that the regulatory environment was questioning the authority of the PCI Design Handbook
- ACI 318, Building Code Requirements for Structural Concrete
  - The reference standard for concrete construction in the model code.
  - ACI 318 was reorganized in 2014 and removed the three specific chapters managed by precast concrete engineering interests
  - The 318 committee has only about 10% of its membership with precast concrete expertise
- PCI began an initiative to develop its own code from the precast body of knowledge

PCI: The Design Standard Challenge



ACI and PCI: The Conflict

- ACI was threatened by PCI's intent to develop its own design standard.
- The initial reaction was to remove all precast concrete representatives from is code committee
- Compromise was negotiated
- Both ACI and PCI will participate in developing a code emphasizing precast content as a companion to ACI 318.
- In addition, ACI will use this model to develop to develop a companion code of cast-in-place post-tensioned concrete, and another companion for sustainability practices
- ACI/PCI 319; ACI/PTI 320; ACI 321

PCI: The Design Standard Committee

- A PCI committee to develop code language on the issues within the PCI body of knowledge
- The initial roadmap identified 60 precast issues
- Not all of these can be developed in the first cycle
- The content developed in PCI is passed to the ACI/PCI Committee 319 to be placed within a code that derives precast concrete content from 318

PCI: The Design Standard Committee

- The PCI Design Standard committee is organized into four task groups:
  - Connections and Joints
  - Design Handbook Content (members)
  - Insulated precast walls
  - Seismic
- There is a separate ACI/PCI task group trying to update shear friction provisions
- There is also a separate effort with the PCI professional members committee to develop standards on the delegation pf precast concrete design by the Structural Engineer of Record

The Design Standard Committee – Connections and Joints

- Beam Bearings
- Dapped Ends
- Notched Ends
- Bearing Pad Design
- Cazaly Hangers

The Design Standard Committee – Handbook Member Content

- Ledges
- Slender Spandrel Beams
- Alternative torsion design for prestressed beams
- Opening in webs
- Minimum ties in prestressed columns
- Corbels
- Temporary loading during construction
- Testing precast structures
    - Exemplar testing

The Design Standard Committee – Seismic Design

- Diaphragm Design with untopped floors and pour strips
- Intermediate precast concrete walls
  - Wall connections
  - Assembled walls as a system

The Design Standard Committee – Insulated Wall Panel Design

- Nothing in current ACI code addresses insulated walls with both outside concrete wythes acting together through shear connectors through the insulation layer a composite or partially composite
- Research advances have been made through beam-spring models to better characterize the partial composite behavior of these walls
- This Standard is being developed as an independent document to be referenced by ACI/PCI 319 but also submitted for direct reference by the model code.

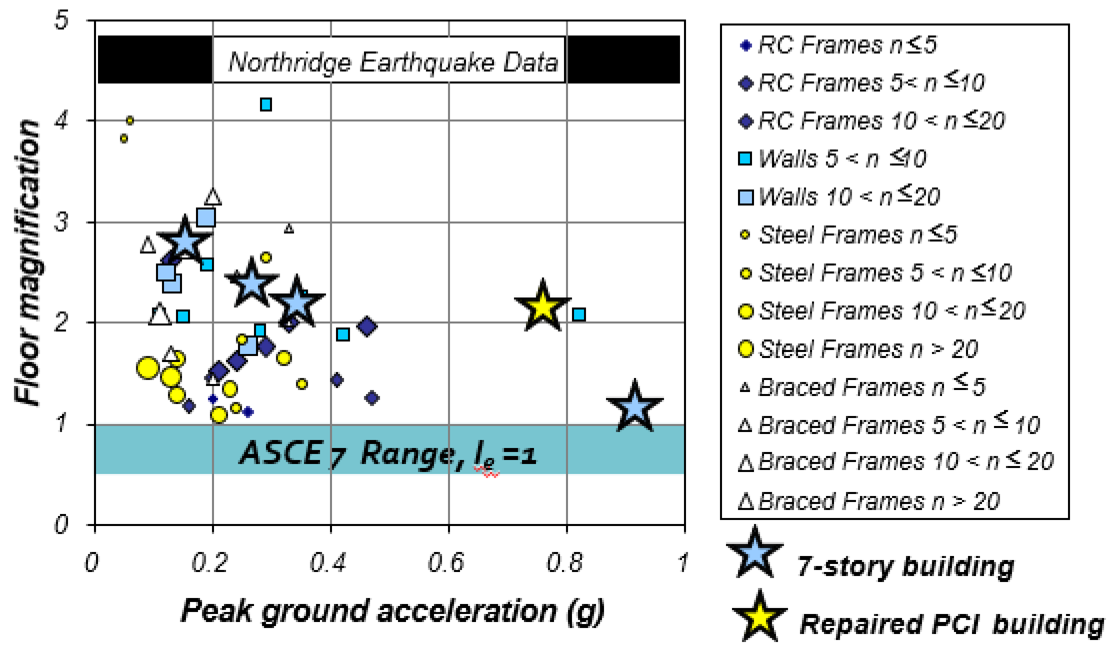
ASCE 7 -16 Minimum Design Loads for Buildings and Other Structures

- PCI sponsored 10 years of research on the behavior of precast concrete diaphragms: Diaphragm Seismic Design Methodology (DSDM)
- The Building Seismic Safety Council (BSSC) develops seismic design provisions for the National Earthquake Hazard Reduction Program (NEHRP)
- BSSC established a task group, chaired by S. K. Ghosh, to turn research into code language, not just for precast, but for all diaphragm systems
- Provisions were published for consideration by ASCE 7
- ASCE 7 adopted the provisions as an alternate method fro all systems, but made them mandatory for precast concrete

ASCE 7 -16 Section 12.10.3

- The alternate method addresses actual diaphragm demands more closely than the older provisions.

$0.5\,I_e \leq$ Acceleration "Magnification" $\leq 1.0\,I_e$



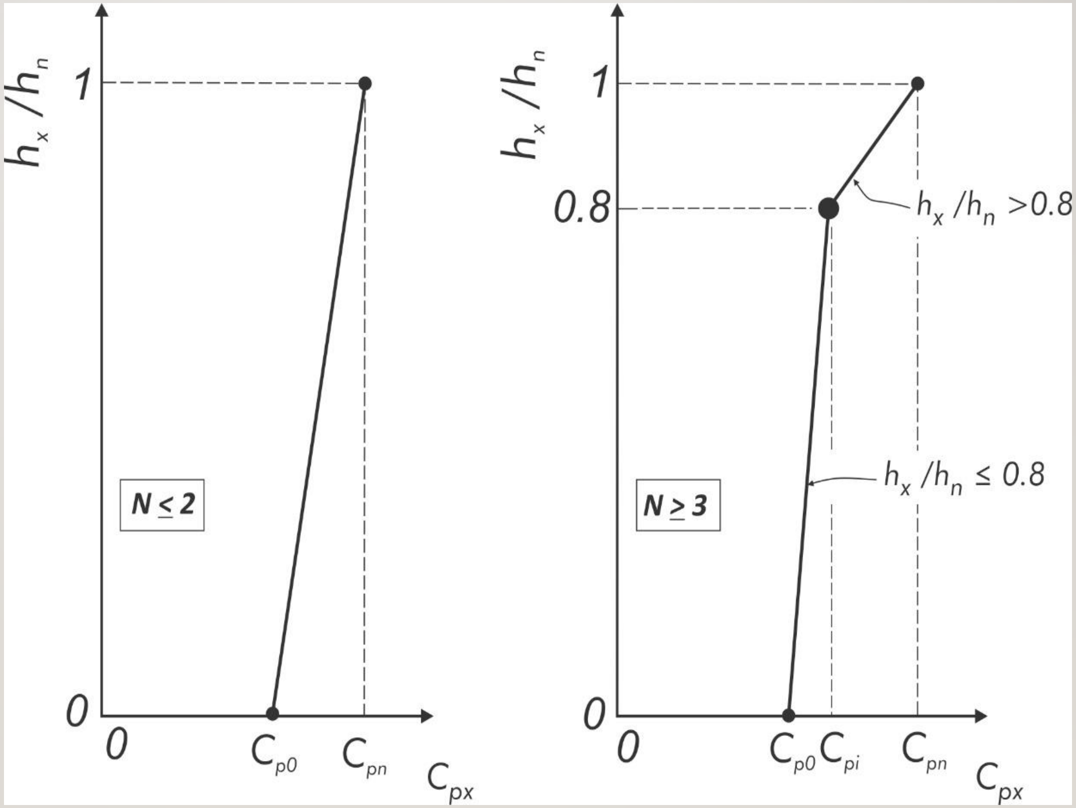
- The upper and lower limits in ASCE7 do not seem to be rational
- The computation of floor acclerations based on the assumption that all modes are equally reduced by plasticity does not seem rational either

ASCE 7-16

12.10-4	$F_{px} = \frac{C_{px}}{R_s} w_{px}$	where R_s is the diaphragm design force reduction factor
12.10-5	$F_{px} = 0.2 S_{DS} I_e w_{px}$	threshold minimum
12.10-6	$C_{p0} = 0.4 S_{DS} I_e$	base diaphragm design acceleration coefficient
12.10-7	$C_{pn} = \sqrt{(\Gamma_{m1} \Omega_0 C_s)^2 + (\Gamma_{m2} C_{s2})^2} \geq C_{pi}$	

DIAPHRAGM DESIGN

ASCE 7-16



ASCE 7 -16 12.10.3

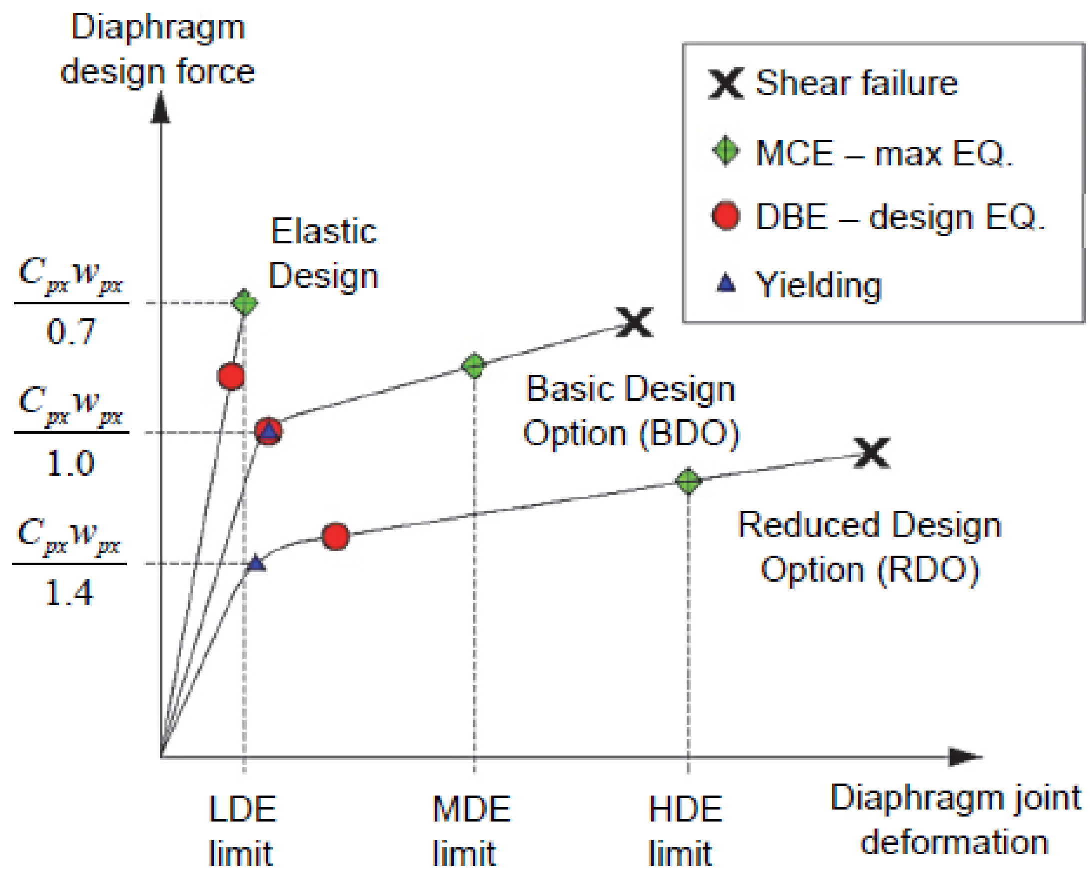
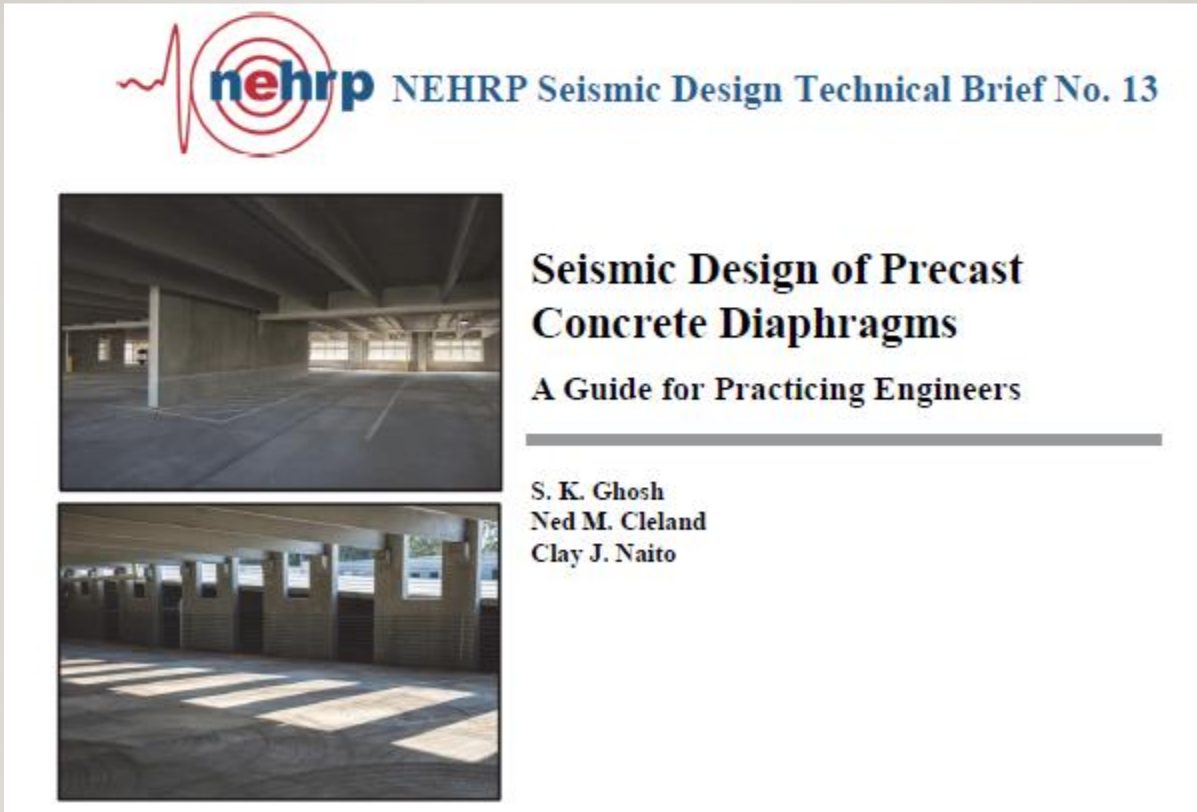


Figure 8-1. Diaphragm deformation relative to design option.

ASCE 7 -16 12.10.3



NEHRP Seismic Design Technical Brief No. 13

Seismic Design of Precast Concrete Diaphragms

A Guide for Practicing Engineers

S. K. Ghosh
Ned M. Cleland
Clay J. Naito

Precast Concrete in the United States

- The industry is currently strong and is having difficulty meeting demand
  - Backlogs currently are as much as a year or more.
- Increasing capacity is not as simple as building more facilities
- PCI is addressing regulatory challenges by developing standards and cooperating with ACI in code development specifically for precast
- More designers are looking at precast to solve new challenging building types
- Precast is gaining wider acceptance in seismic applications with innovative systems and research.

Any Questions?

THANK **YOU**