ACI 440 - Review of Design Guide Becoming Code in 2022

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Design Guide to Design Code

- Design Guide: PRC ACI 440.1-15
  - Written similar to an educational textbook
  - Original Release Date: Committee Report in 1995
- Design Code: CODE ACI 440
  - Written similar to ACI 318
  - Release Date: Estimated End of 2022

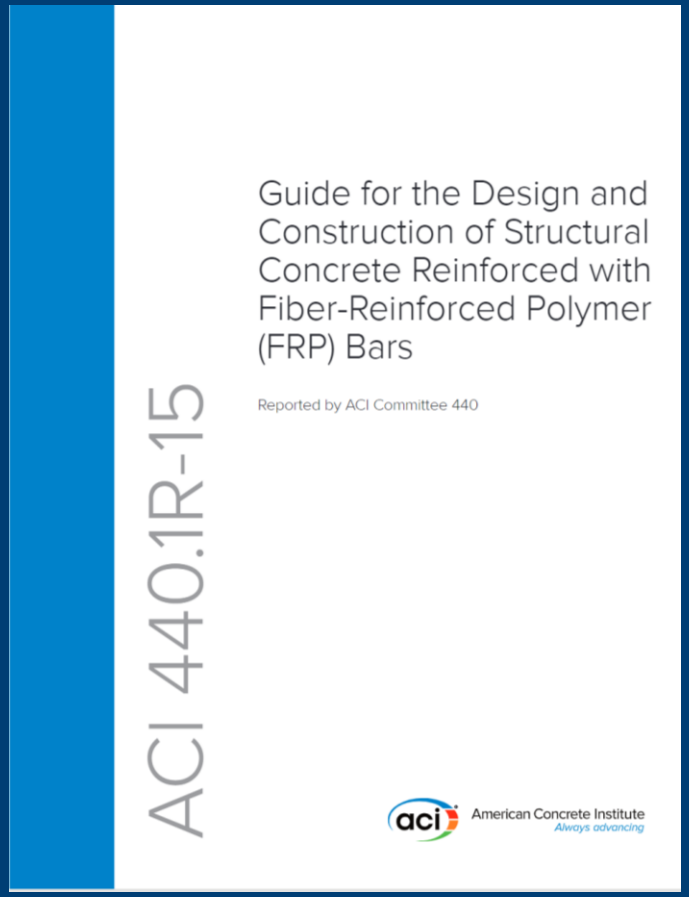
PRC 440.1-15

12 Chapters

1 Chapter covers design examples

1 Chapter of documents references

Appendix A: Slab on Grade Temperature and Shrinkage Reinforcement



CODE 440

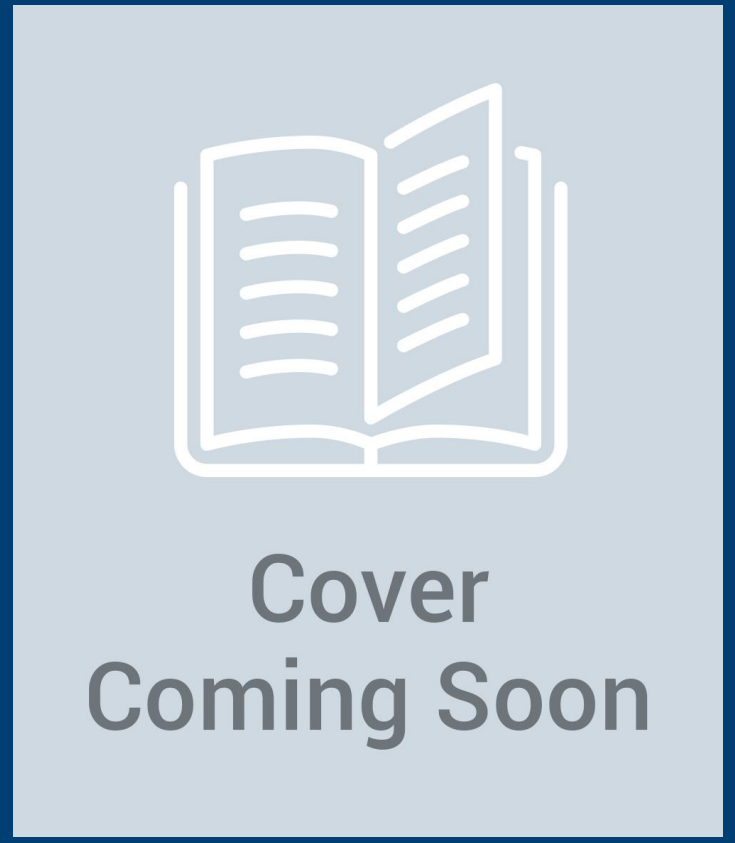
Same 27 Chapter layout as ACI CODE 318

6 Chapters (Do not Apply)

i.e. Chapter 14: Plain Concrete

ONLY ADDRESS GFRP REINFORCEMENT

Does not include design examples






WHAT'S NEW IN CODE 440?

IT WILL ADDRESS:

- COLUMN
- WALLS

COLUMN DESIGN

- CHAPTER 10

  Does not address Composite Columns

  No Shape Limit

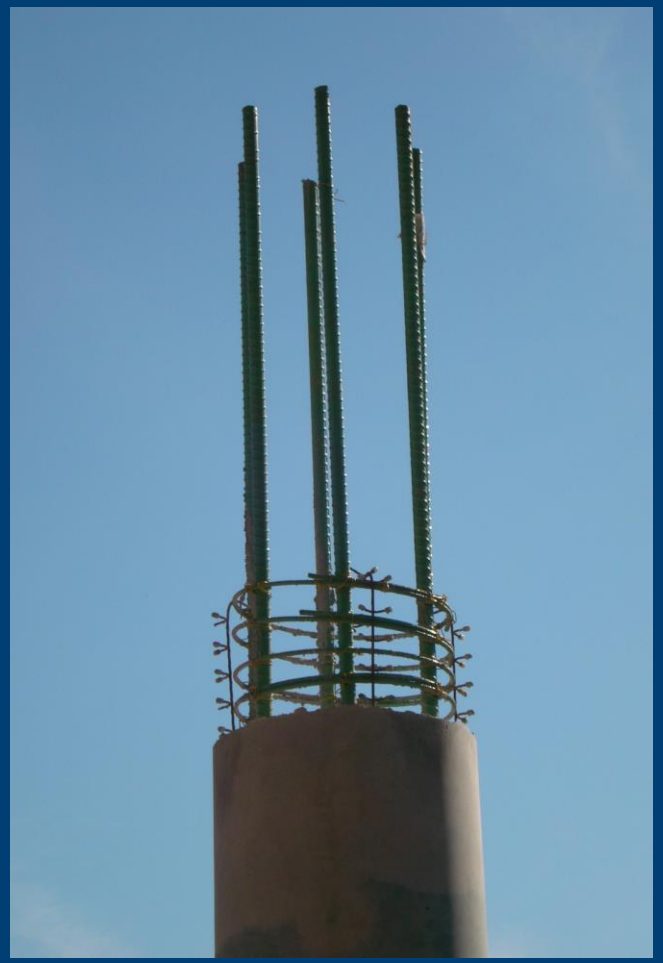
  Limits Strain to $0.01E_f$

  Addresses:

    Fire Rating Detail Requirements

    Reinforcement Limits

    Reinforcement Detail Requirement



WALL DESIGN

- CHAPTER 11
  - Applies to CIP and PreCast
  - Limits to Shear for Ordinary Structural Walls Only
  - Addresses:
    - Minimum Wall Thicknesses
    - Reinforcement Limits
    - Reinforcement Detail Requirement

DESIGN EXAMPLES

CURRENT PRC 440.1

Current Chapter 11

- Examples in SI and Metric
- 11 Examples covering:
  - Flexural Beams
  - One Way Slab
  - Crack Control Reinforcement
  - Deflection
  - Creep
  - Shear
  - Bar Development

DESIGN EXAMPLES

CODE 440.1 Column

- STEP 1

  Determine Column Sizing and loading

  GFRP Modification:

  No modifications

See ACI Reinforced Concrete Design Handbook for example on a step by step process if not using a modeling software.

DESIGN EXAMPLES

CODE 440.1 Column

- STEP 2

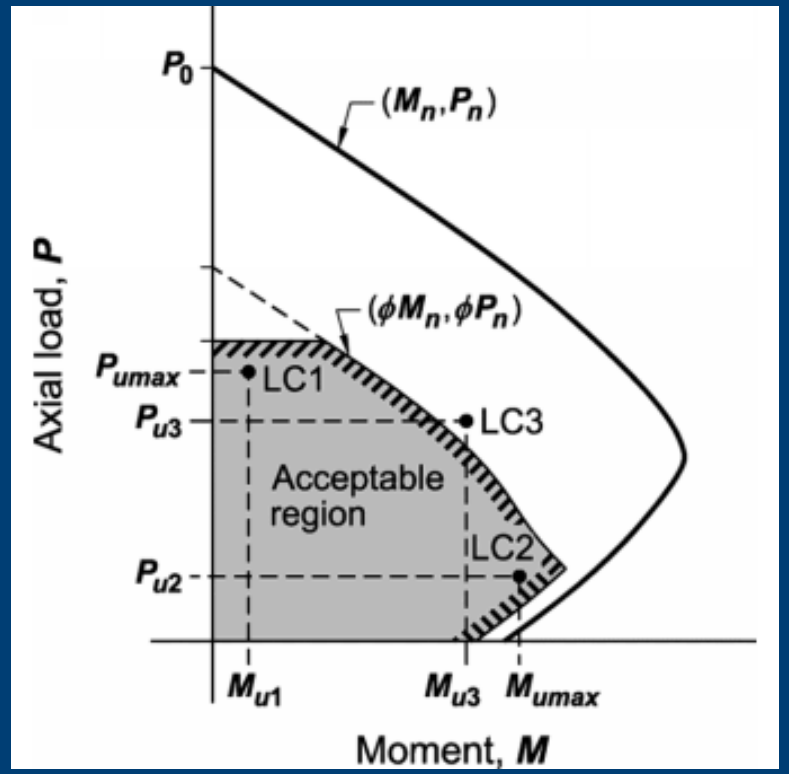
  Find Required Area of Longitudinal Reinforcement

  <u>GFRP Modification</u>:

  Factored axial compression

  Pu > 0.10 f'c Ag

  Tensile design strain of the GFRP longitudinal bars shall be limited to 0.01



DESIGN EXAMPLES

CODE 440.1 Column

- STEP 3

  Detailing

  <u>GFRP Modification</u>:

  - *No offset bent longitudinal laps*
  - *No current mechanical couplers available*

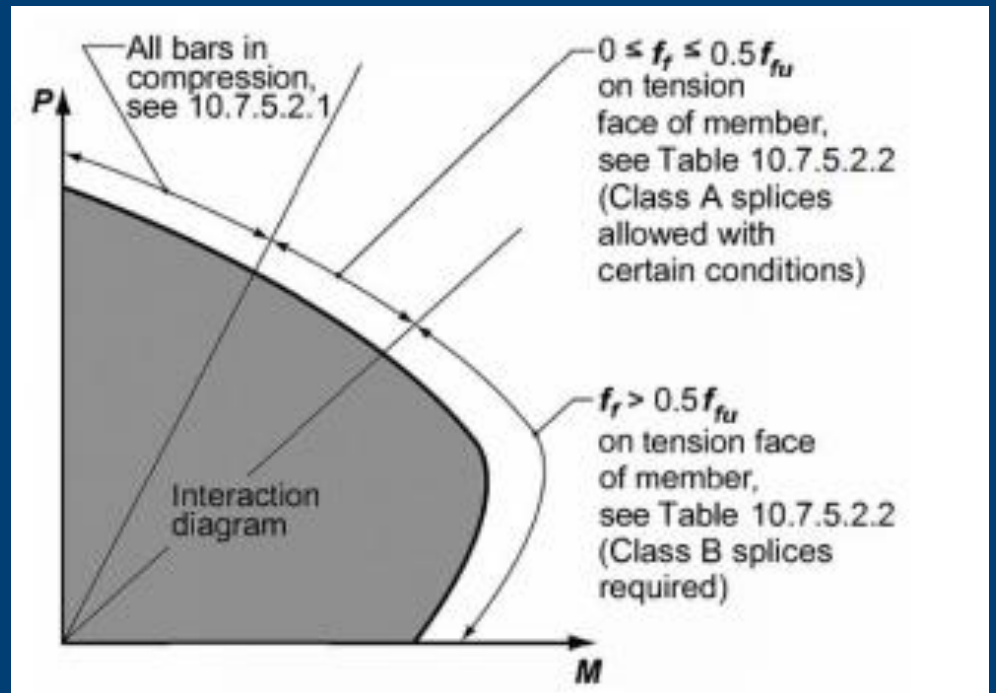


Fig. R10.7.5.2—Lap splice requirements for columns.

DESIGN EXAMPLES

CODE 440.1 Walls

- STEP 1

  Determine Wall Thickness and loading

  GFRP Modification:

  New Table thickness for Bearing walls (4” to 5.5”)

Table 11.3.1.1—Minimum wall thickness *h*

Wall type	Minimum thickness *h*		
Bearing*	Greater of:	5.5 in.	(a)
		1/24 the lesser of unsupported length and unsupported height	(b)
Nonbearing	Greater of:	4 in.	(c)
		1/30 the lesser of unsupported length and unsupported height	(d)
Exterior basement and foundation*	7.5 in.		(e)

DESIGN EXAMPLES

CODE 440.1 Walls

- STEP 2

  Design Strength

  <u>GFRP Modification</u>:

  Pn Equation

  0.55 reduced to 0.45

$$P_n = 0.45 f'_c A_g \left[1 - \left(\frac{k \ell_c}{32h} \right)^2 \right] \quad (11.5.3.1)$$

DESIGN EXAMPLES

CODE 440.1 Wall

- STEP 3

  In Plane Shear

  <u>GFRP Modification</u>:

  ACI 318: $V_n = 8 \sqrt{f'_c} A_{cv}$

For in-plane shear design, **h** is thickness of wall and **d** shall be taken equal to 0.8 ℓ_w.

V_n at any horizontal section shall not exceed

$0.2 f'_c$ **h d**

DESIGN EXAMPLES

CODE 440.1 Wall

- STEP 3

  In Plane Shear

  GFRP Modification:

  ACI 318: Vn = 8 √f'c Acv

For in-plane shear design, **h** is thickness of wall and **d** shall be taken equal to 0.8 ℓ_w.

$$Vc = Vn + Vf$$

$$V_f = \frac{A_{fv} f_{fs} d}{s} \quad (11.5.4.8)$$

Horizontal bars of walls subject to in-plane shear be limited to 0.005 under factored loads to control the shear crack width in GFRP reinforced concrete squat walls

DESIGN EXAMPLES

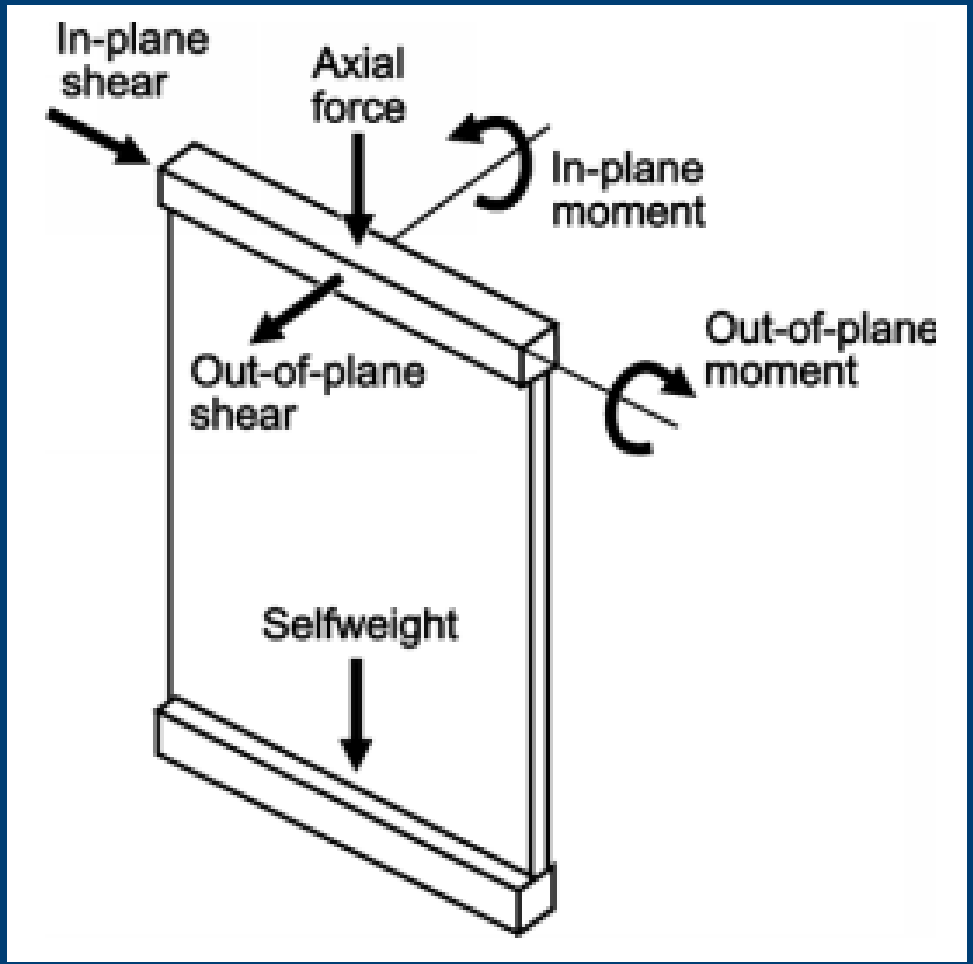
CODE 440.1 Wall

- STEP 4

  Out of Plane Shear

  <u>GFRP Modification</u>:

  No modification



DESIGN EXAMPLES

CODE 440.1 Wall

- STEP 5

  Reinforcement Limits

  GFRP Modification:

  ACI 318:

  $Vn = 0.5\ \varphi\ \alpha_c\ \lambda\ \sqrt{f'c}\ A_{cv}$

  - *Refer to Table 11.6.1 for reinforcement limits for less than*
  - *0.0025 greater than*

If in-plane Vu ≤ 0.5 φ Vc, minimum ρ_{fl} and minimum ρ_{ft} shall be 0.0036

If in-plane Vu > 0.5 φ Vc,
(a) and (b) shall be satisfied:
(a) ρ_{fl} shall be at least 0.0055 but need not exceed ρ_{ft} required for strength
(b) ρ_{ft} shall be at least 0.0055

DESIGN EXAMPLES

CODE 440.1 Wall

- STEP 5

  Reinforcement Limits

  <u>GFRP Modification</u>:

  ACI 318:

  ***s** spacing shall not exceed 5h or 18” (exterior) or 30” (interior)*

Spacing s of longitudinal bars in walls shall not exceed the lesser of 3h and 12 in. If shear reinforcement is required for in-plane strength, spacing of GFRP longitudinal reinforcement shall not exceed $l_w / 3$


ALTAIR

Thank you

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www.concrete.org