Retrofit Measures for Abutments, Footings, and Foundations

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Purpose

- To describe typical retrofit measures for:
  - Abutments
  - Footings
  - Piles

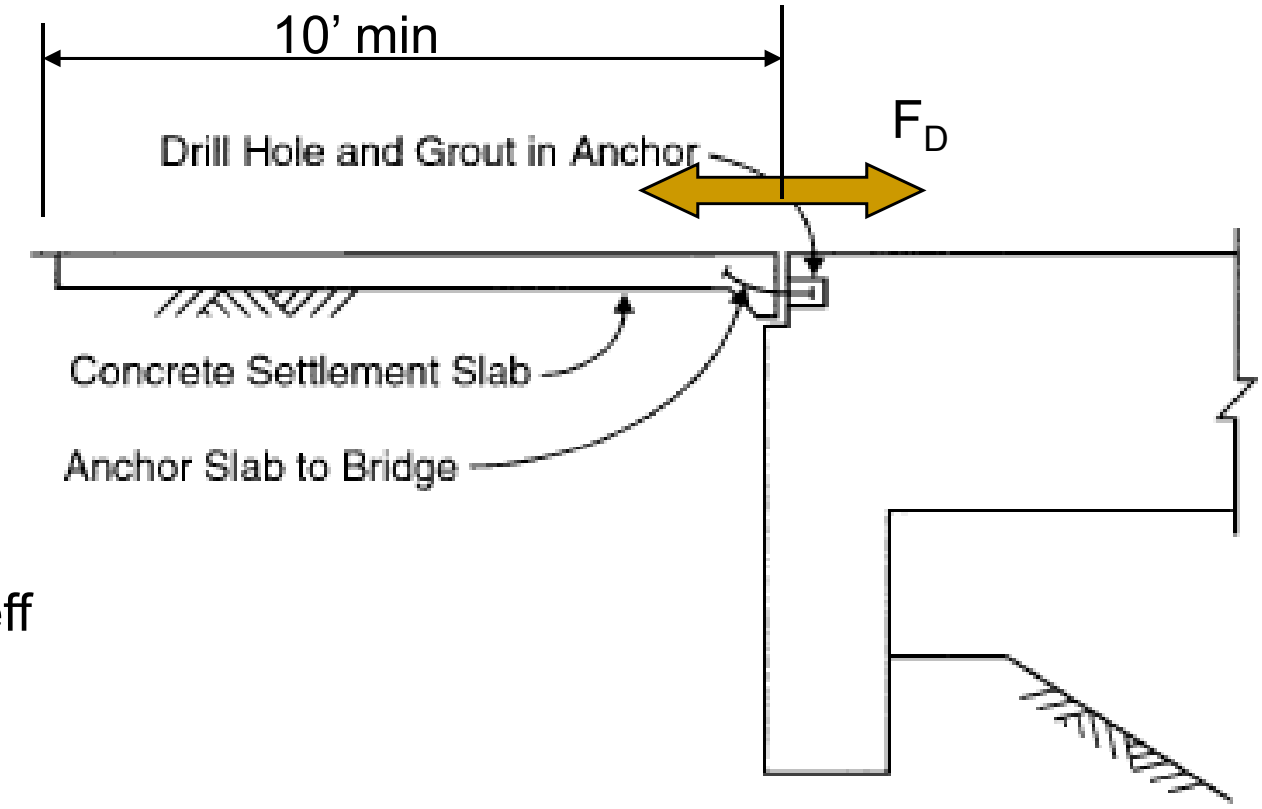
Abutment retrofit measures

- Approach slabs
- Anchor slabs
- Diaphragm walls
- Transverse shear keys
- Transverse soil anchors
- Soil and gravity anchors

Abutment retrofit measures

- California settlement (approach) slab
  - Design as SS
  - Spans soil to deck
  - Connection F_D is

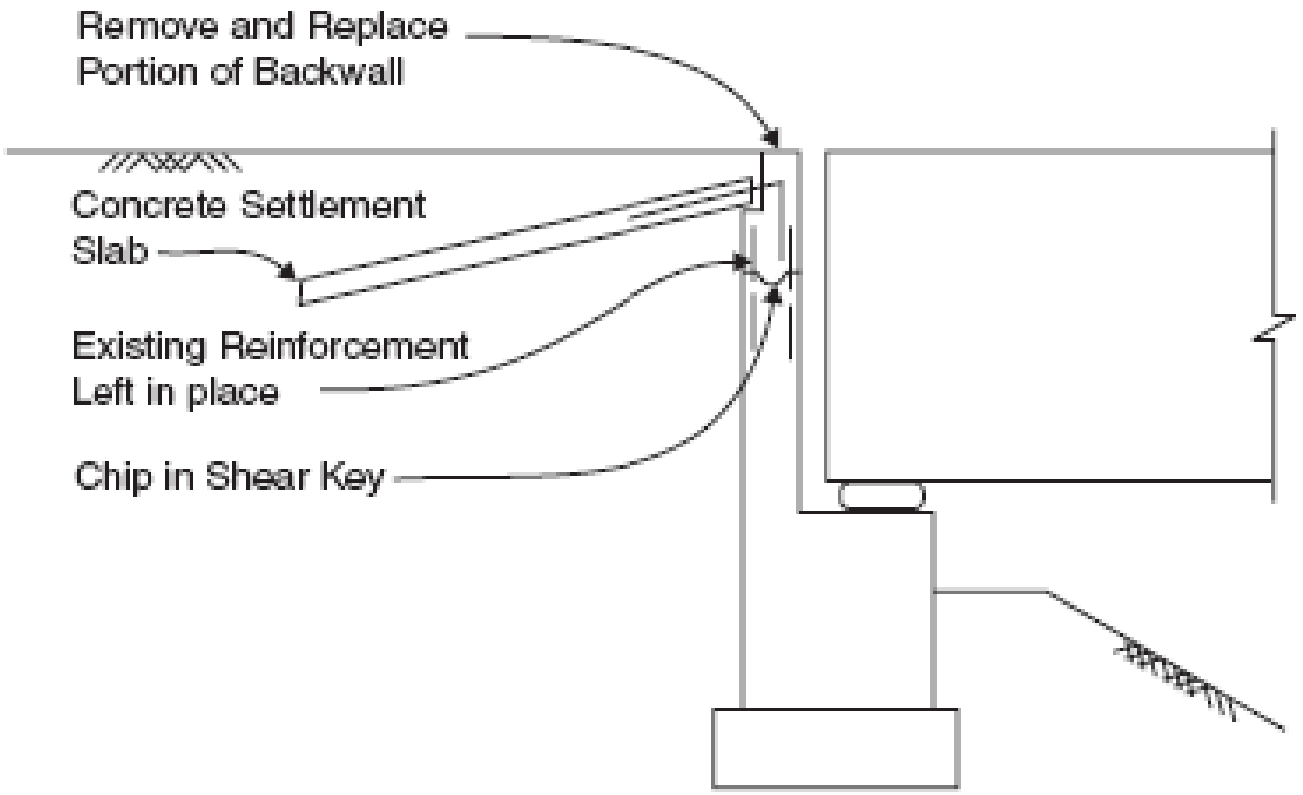
$$F_D := (\mu + S_a) \cdot DL$$



μ≈0.6 Friction Coeff
S_a=Spectrum Acc
DL=Dead Load

Abutment retrofit measures

- New Zealand settlement slab
  - Angle offers longitudinal resistance
  - Still have smooth approach



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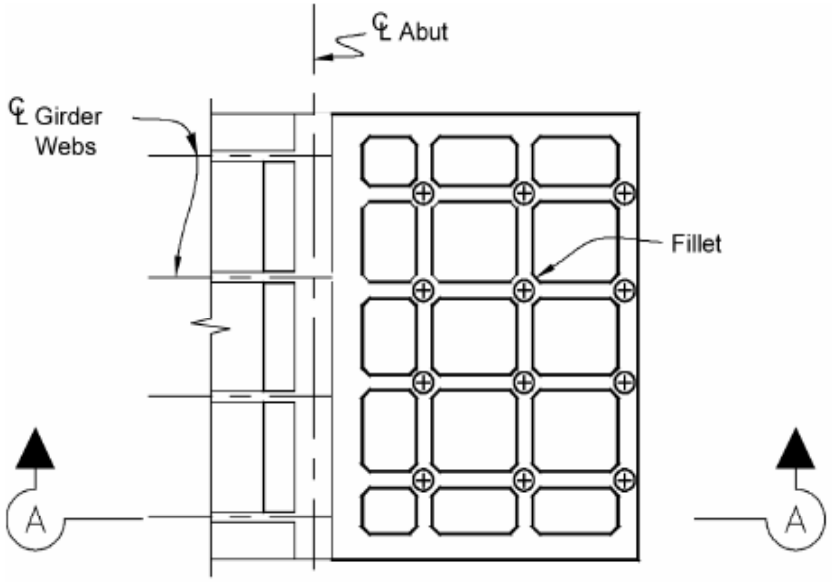
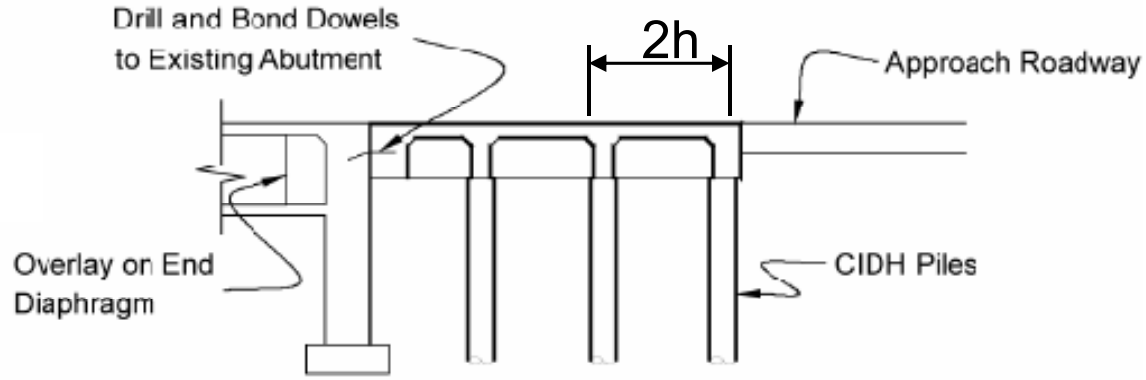
Abutment retrofit measures

- Waffle slab retrofit

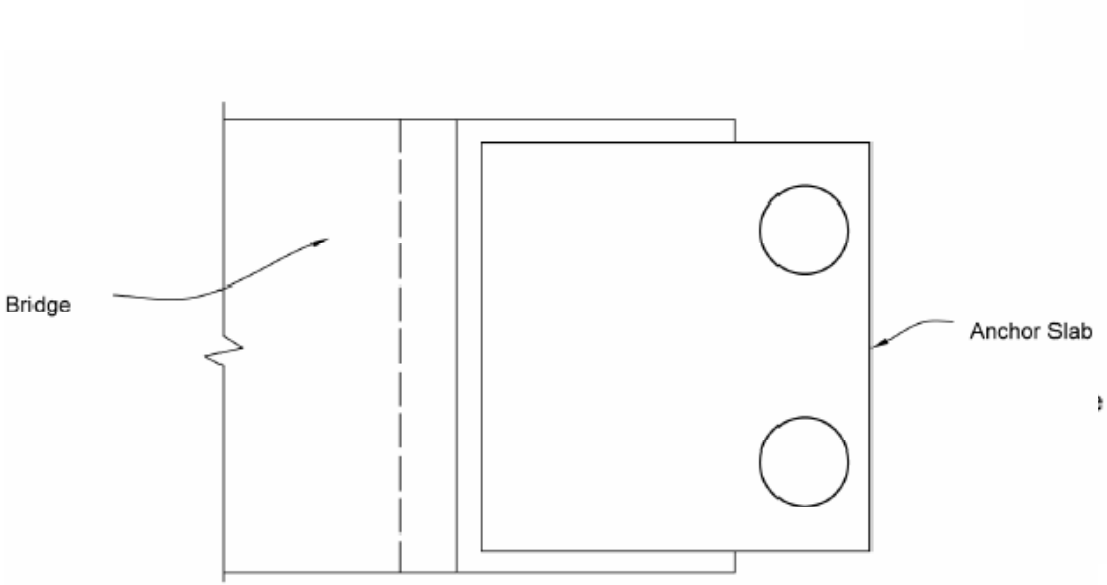


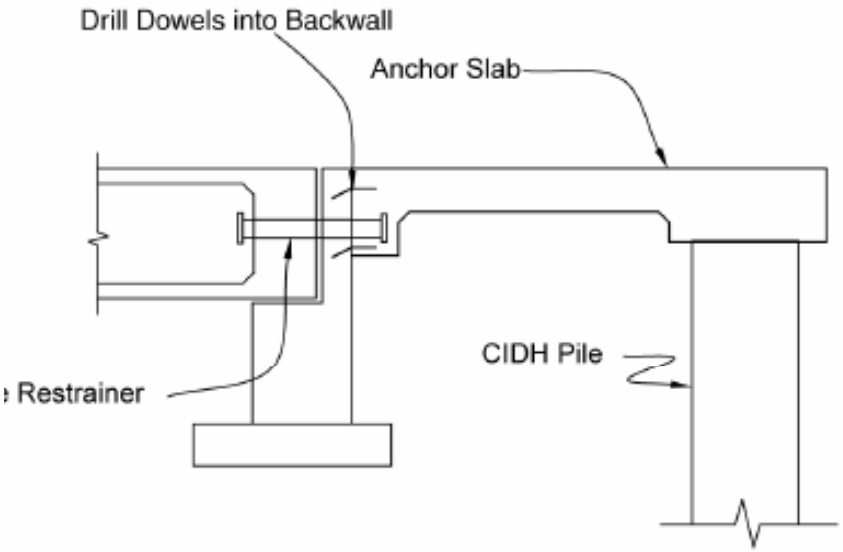


  - Resistance=.96h ksf
  - Resistance 16” pile=40 kips ultimate

Abutment retrofit measures

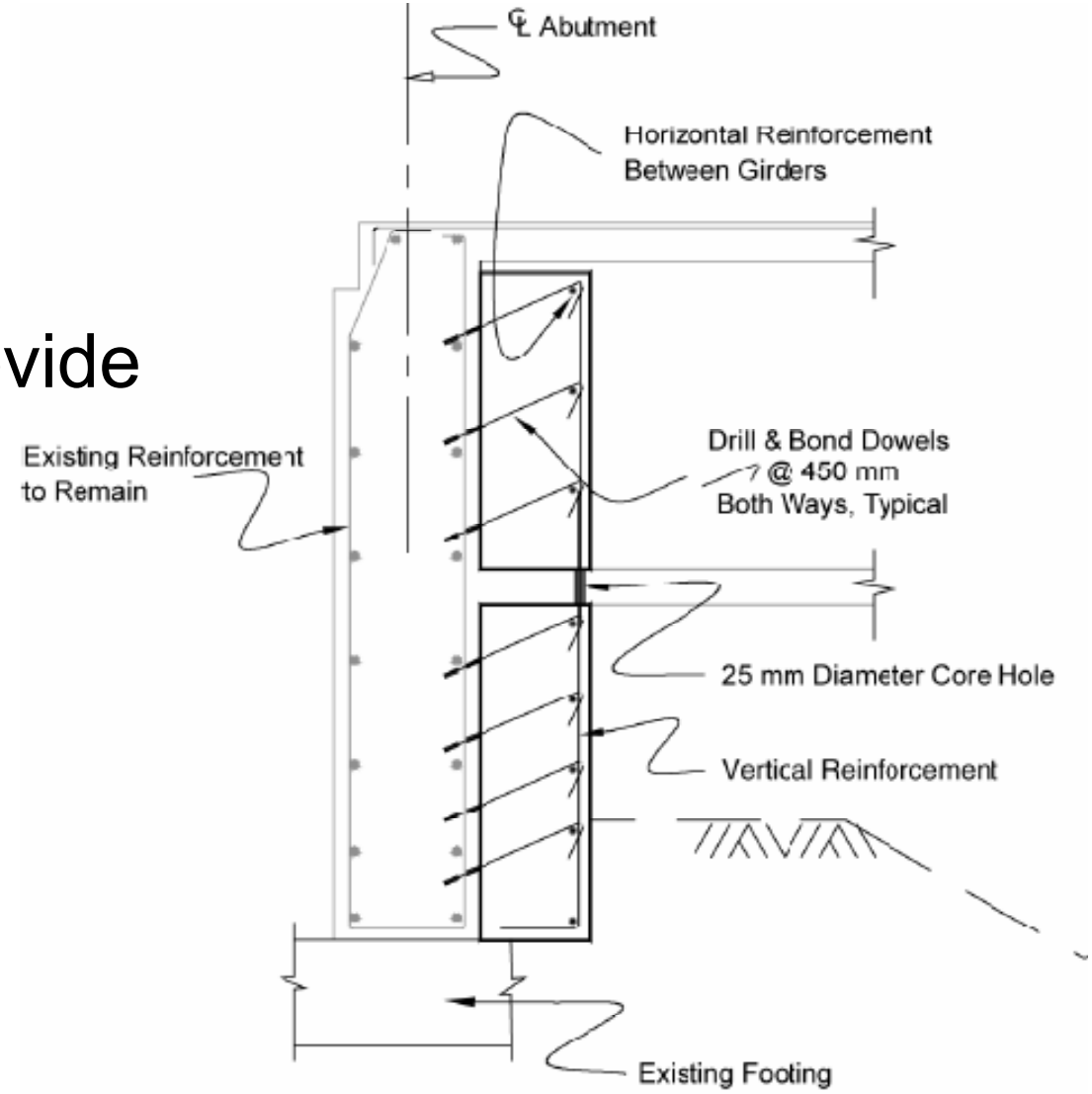
- Anchor slab retrofit
  - Vertical capacity is of no concern
  - Must be securely connected to superstructure
    - Use damping ratio of 10%
      - Longitudinal forces will reduce 20%





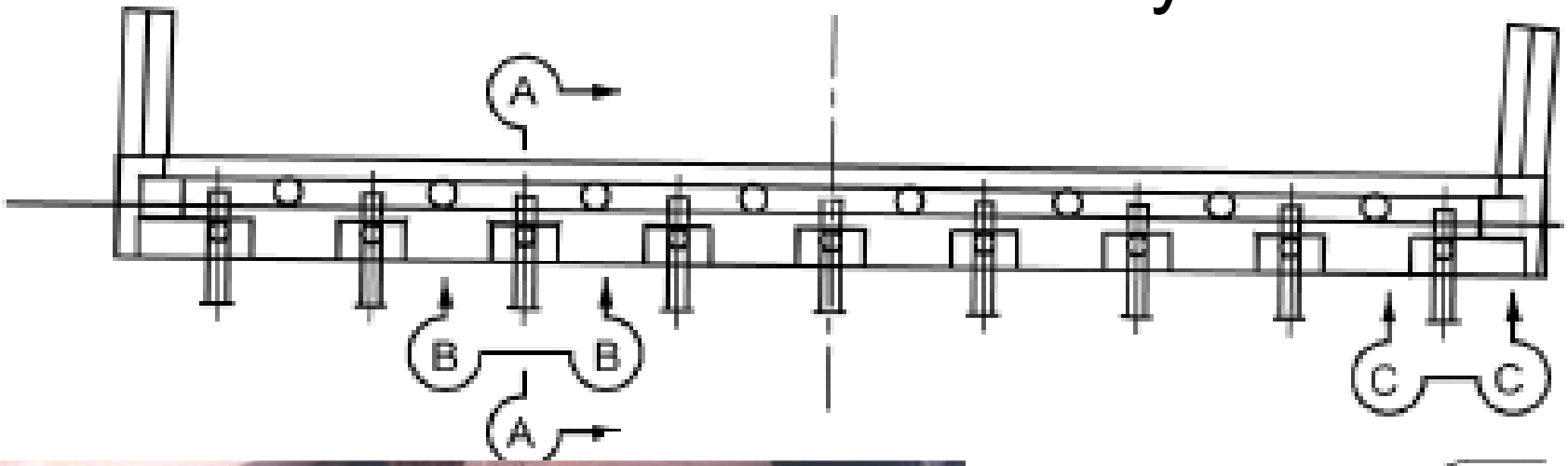
Abutment retrofit measures

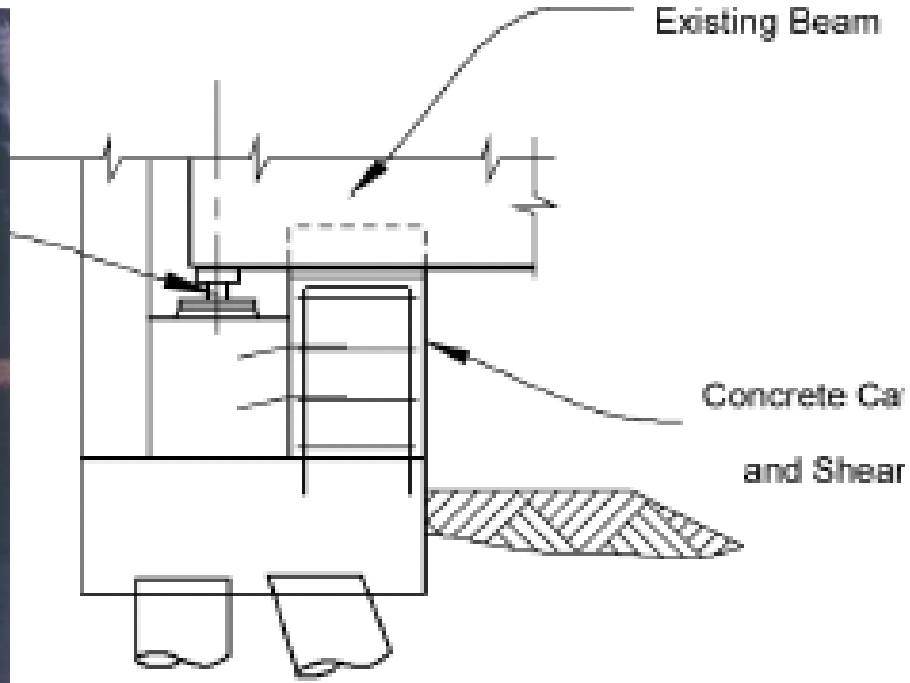
- Diaphragm overlay
  - Must act composite
  - Utilize dowels to provide shear transfer



Abutment retrofit measures

- Concrete transverse shear keys

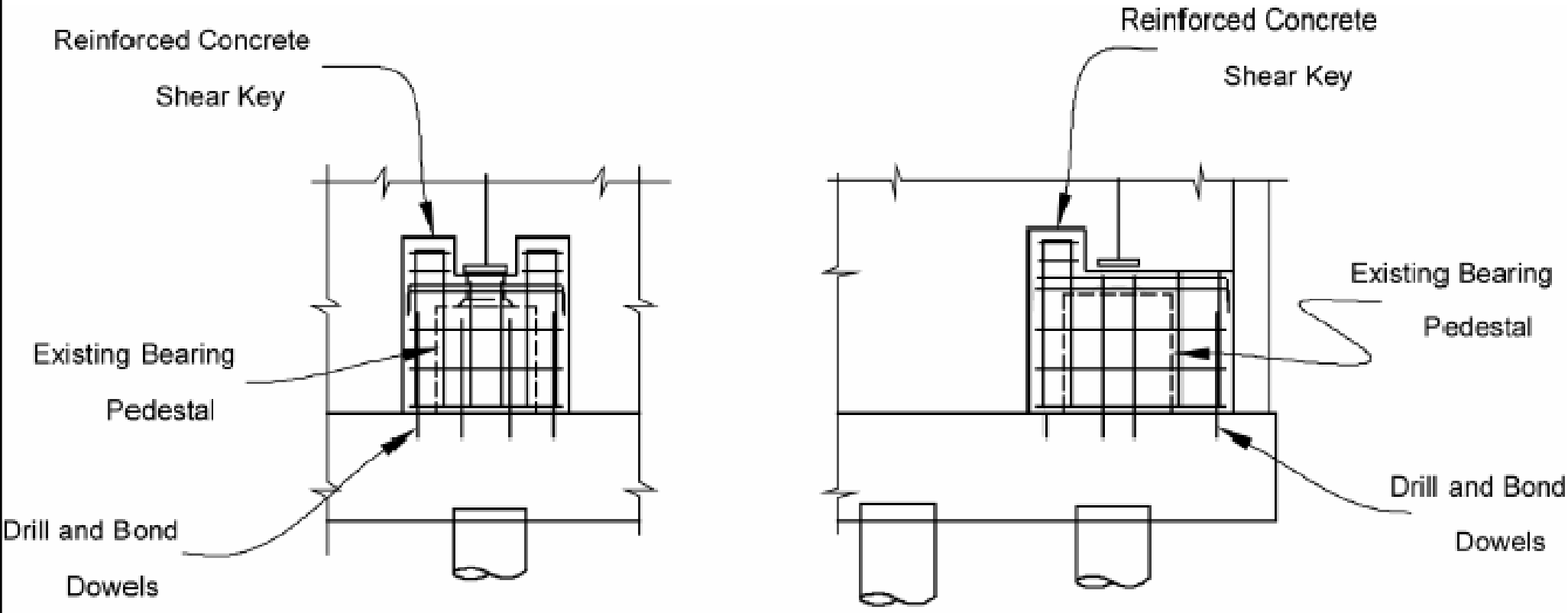




Section A - A

Abutment retrofit measures

- Concrete transverse shear keys



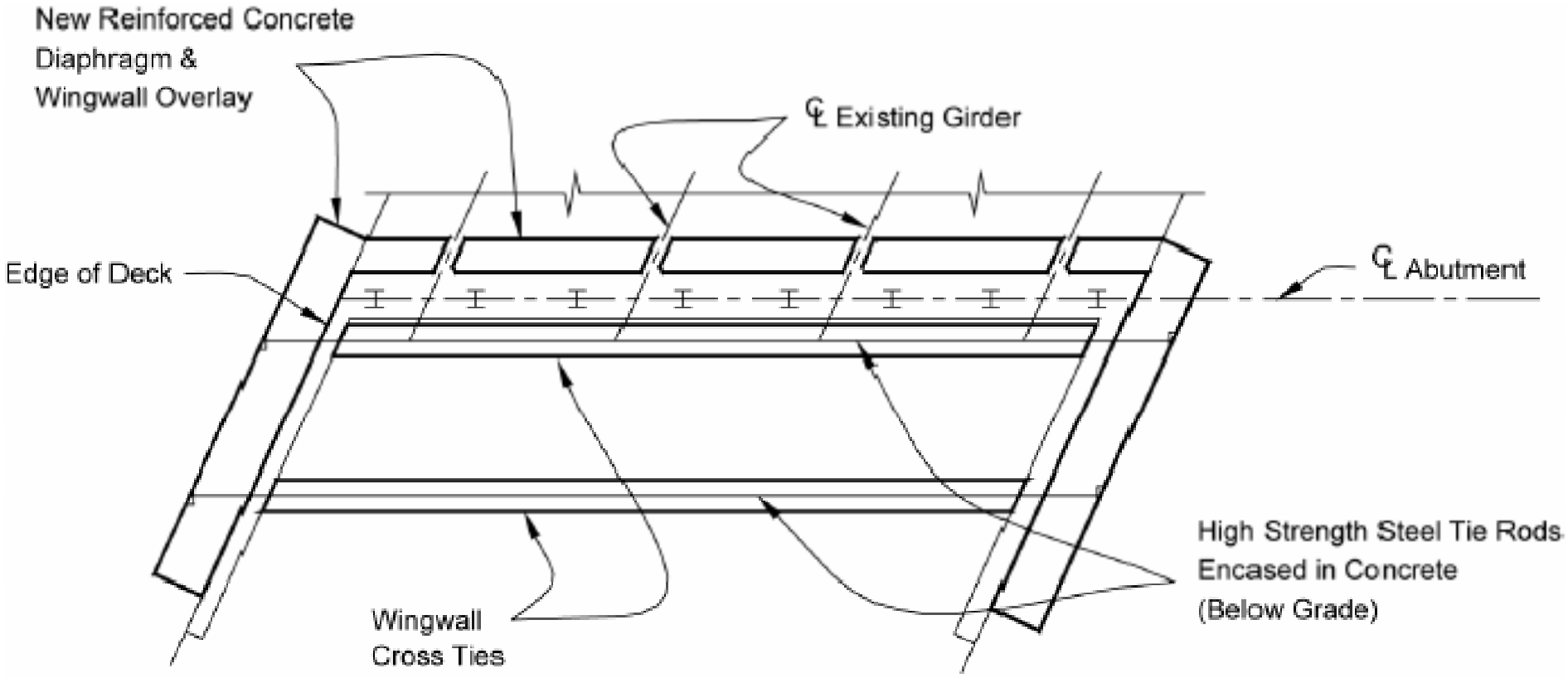
Abutment retrofit measures

- Transverse soil anchors
  - Lateral resistance methods:
    - Lateral capacity of piles
    - Passive pressure on wingwalls
    - Friction on bottom of footing
    - Anchor slabs (previously discussed)

    - When these are not sufficient, consider soil anchors

Abutment retrofit measures

- Wingwall cross-tie



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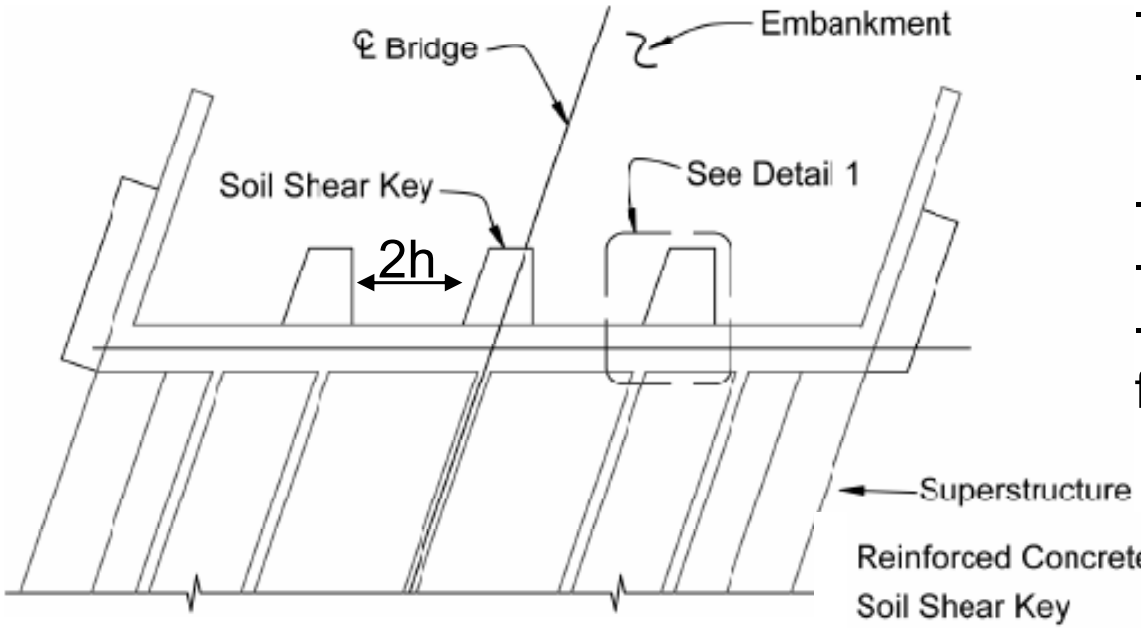
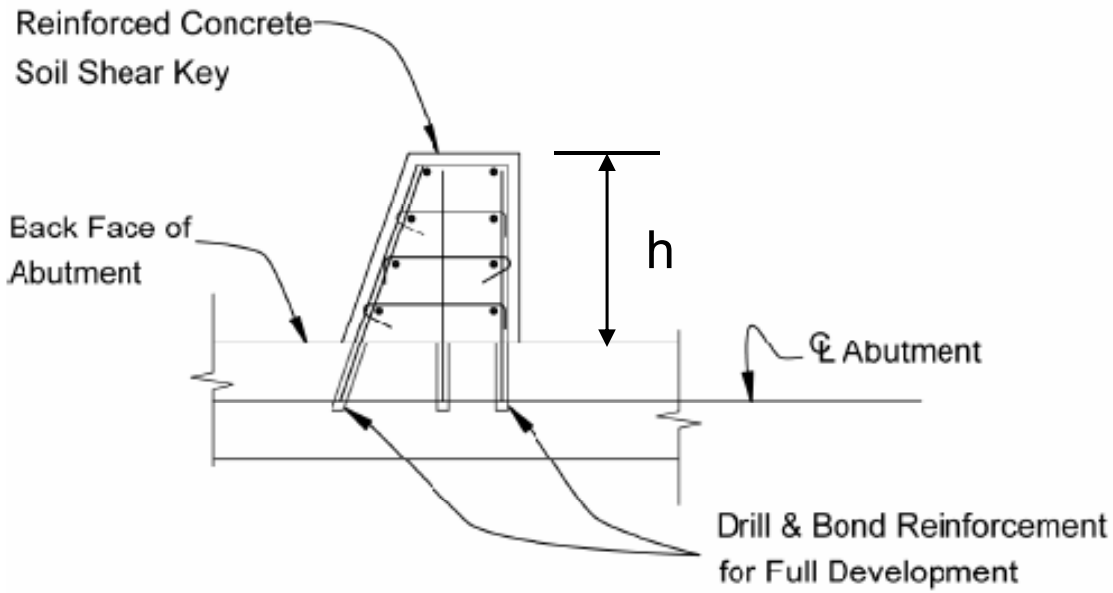
Abutment retrofit measures

- Abutment soil shear keys



Design tips

-Pp=.96h ksf
-To be fully effective:
clear space=2h
-Design shear for full passive pressure
-Use R=2 for flexure
-Abutment connection designed for overstrength moment



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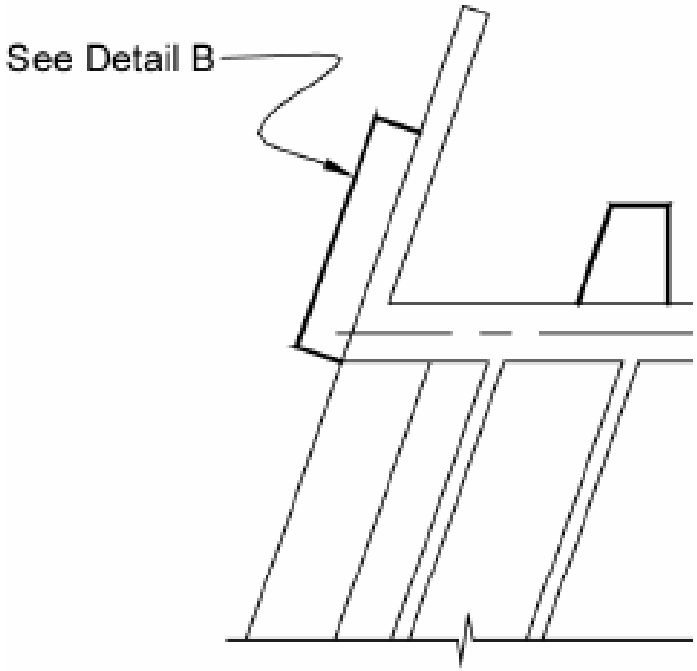
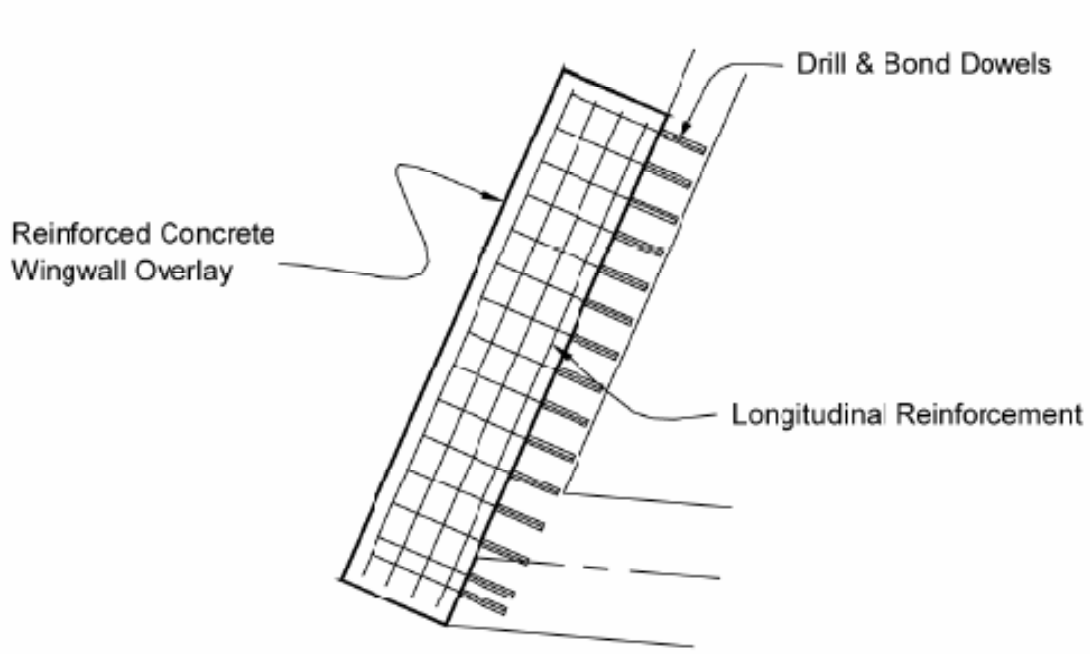
Abutment retrofit measures

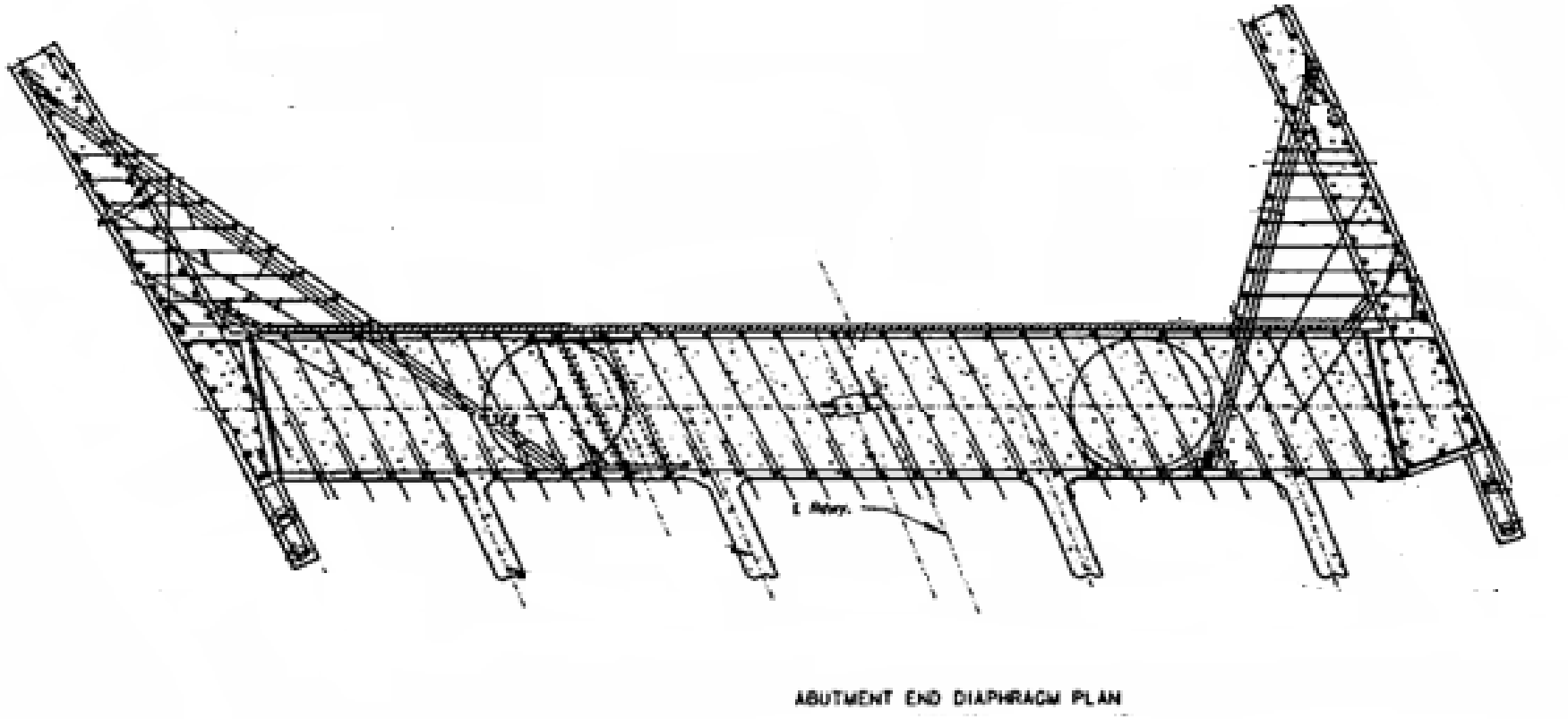
- Wing overlay





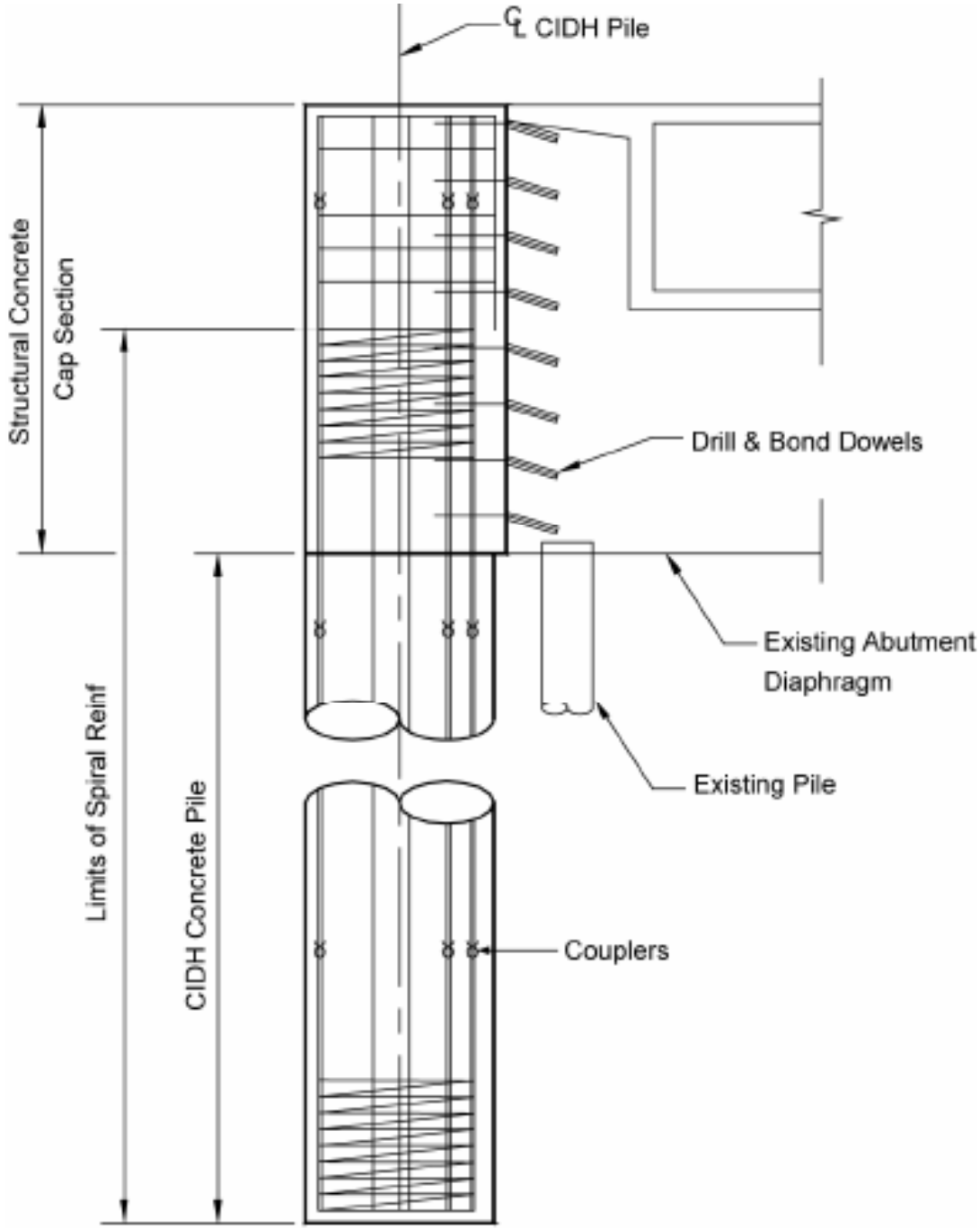
Abutment retrofit measures

- Wing overlay



Abutment retrofit measures

- CIDH pile shear key
  - Designed for lateral capacity only
  - More effective when fixed at top



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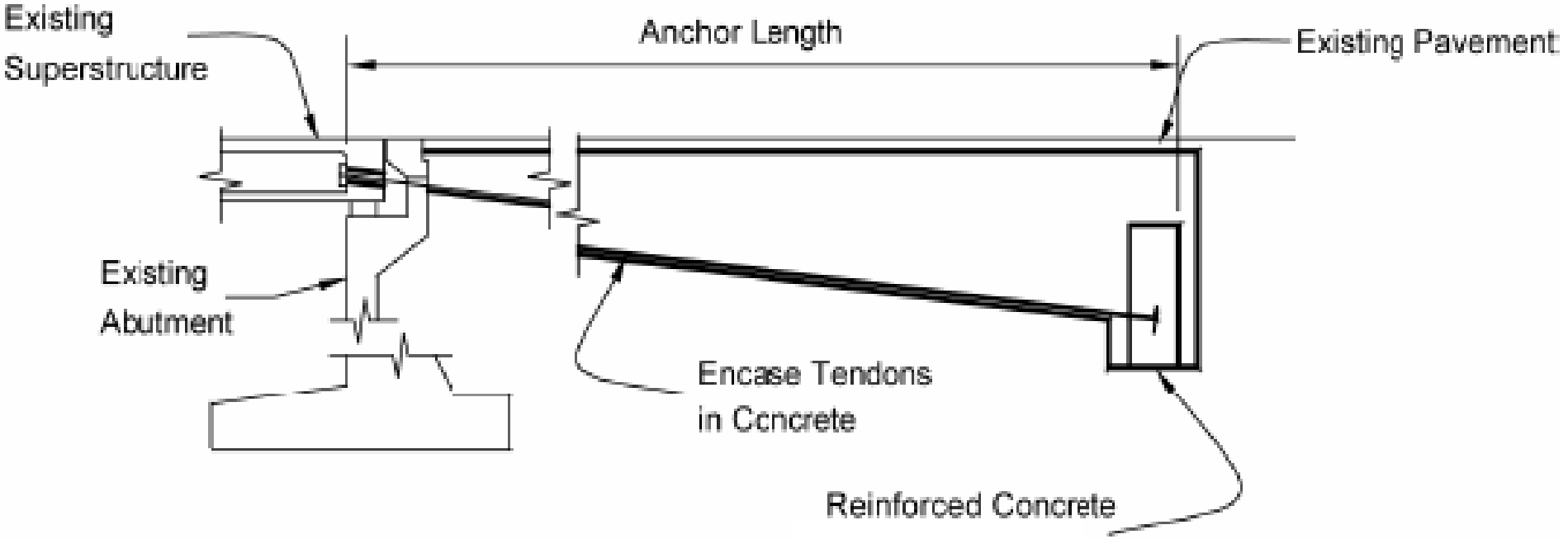
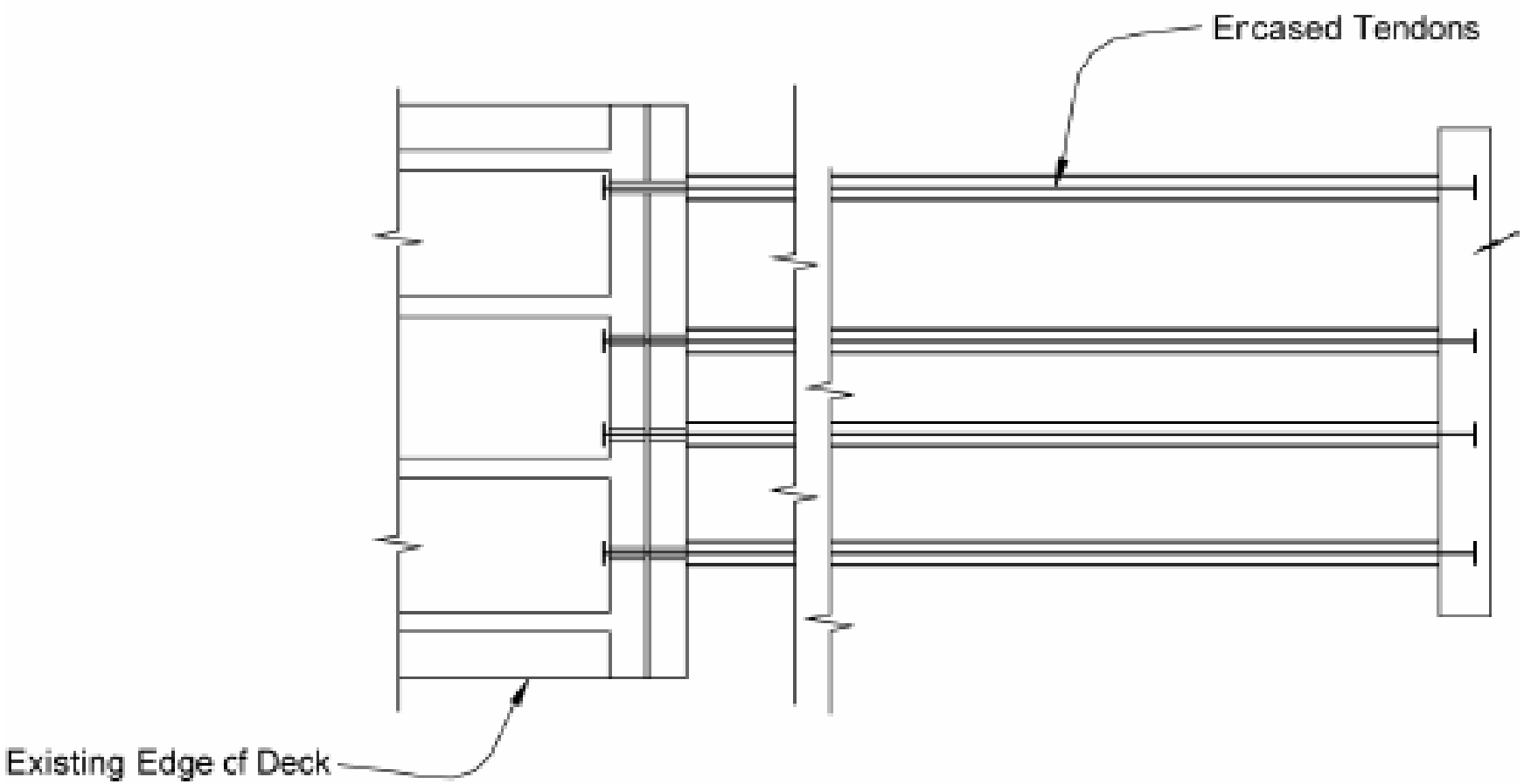
Abutment retrofit measures

- Deadman anchor
  - Extend anchors to avoid backfill movement
  - Embed tie rods in concrete trench for protection



Abutment retrofit measures

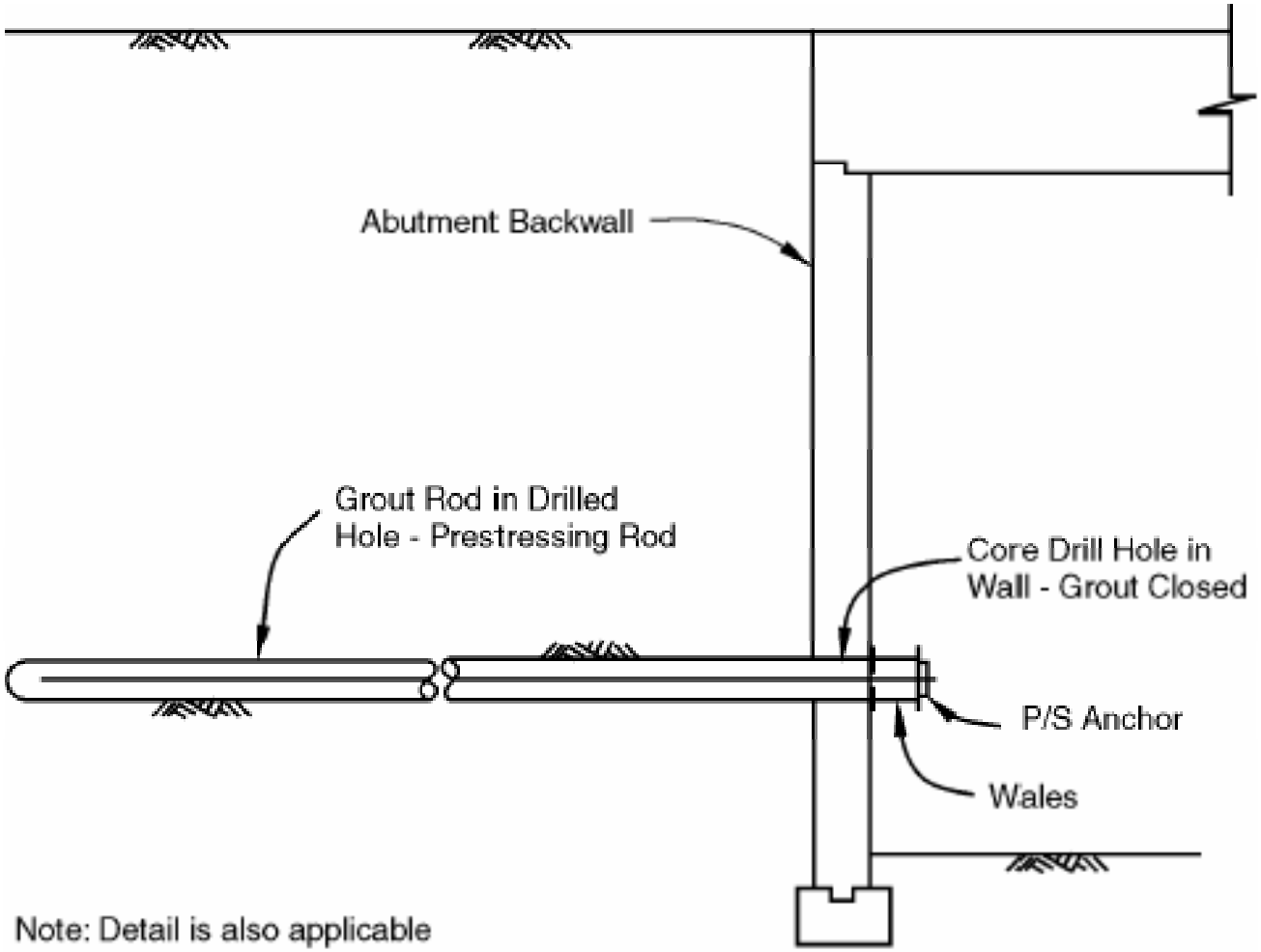
- Deadman anchor



Abutment retrofit measures

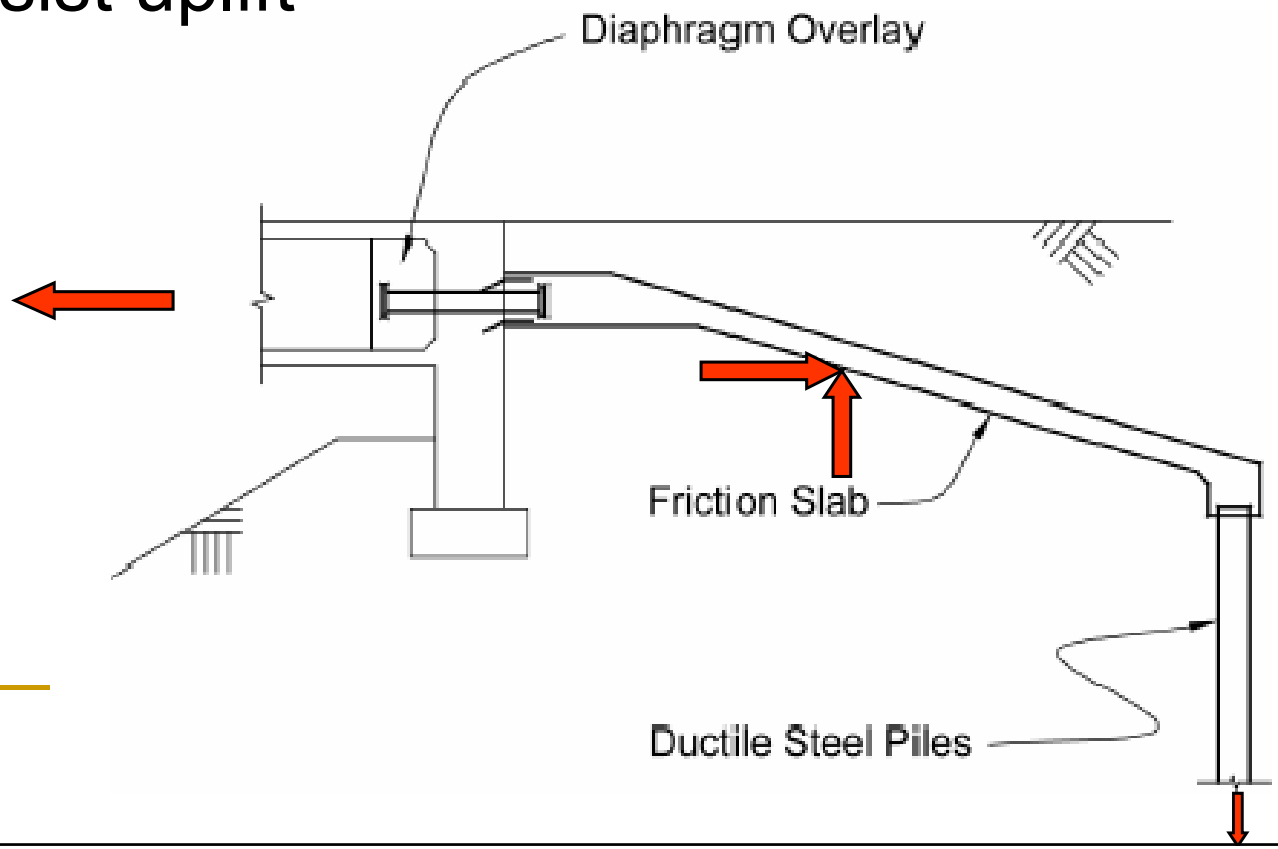
Abutment retrofit measures

- Soil anchors
  - Portion of rod is not grouted for prestressing
  - Prestress ensures anchor is solid



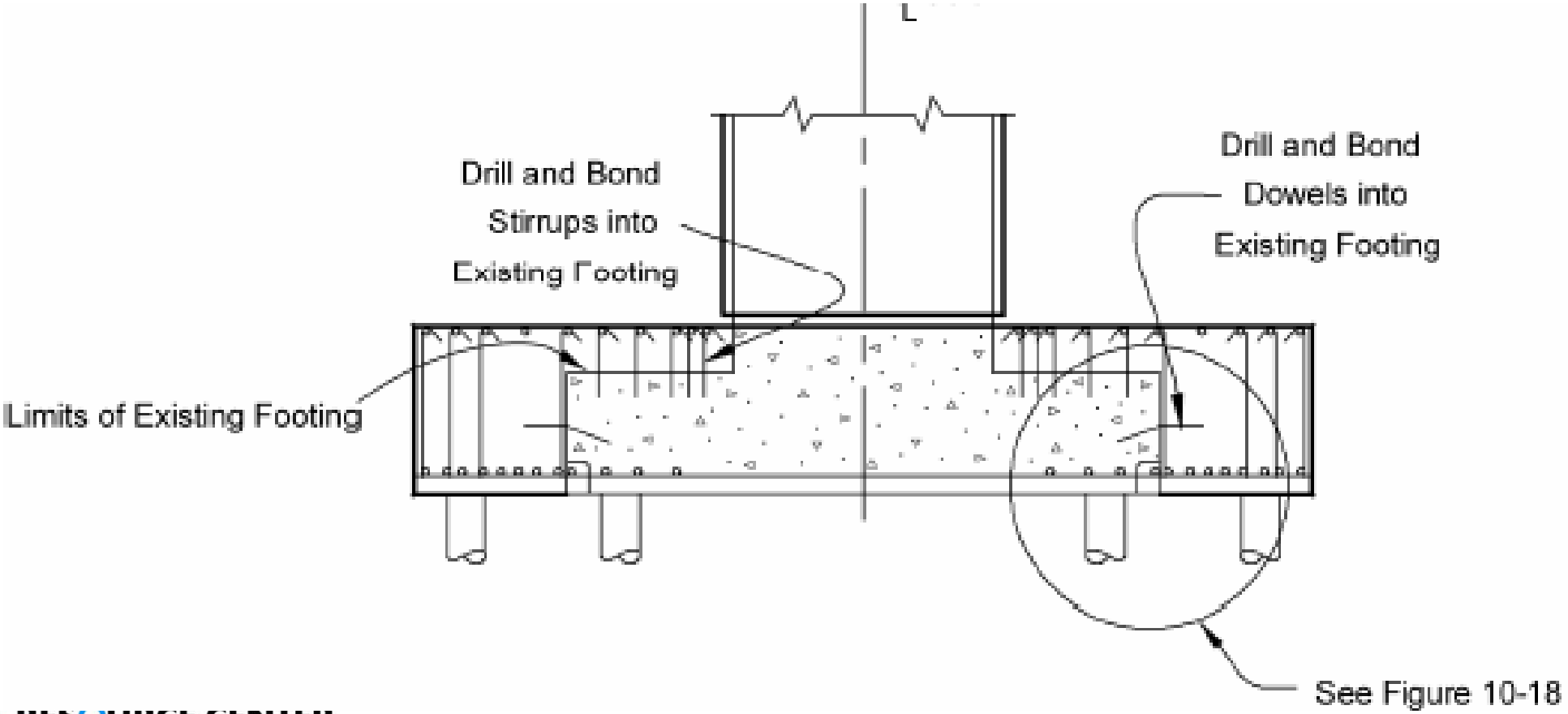
Abutment retrofit measures

- Abutment friction anchor
  - Use with granular soils with little settlement
  - 15 degree slope compresses slab as longitudinal movement occurs
  - Steel piles resist uplift



Footing retrofit measures

- Footing strengthening
  - For stability
  - Check moment at top



Footing retrofit measures

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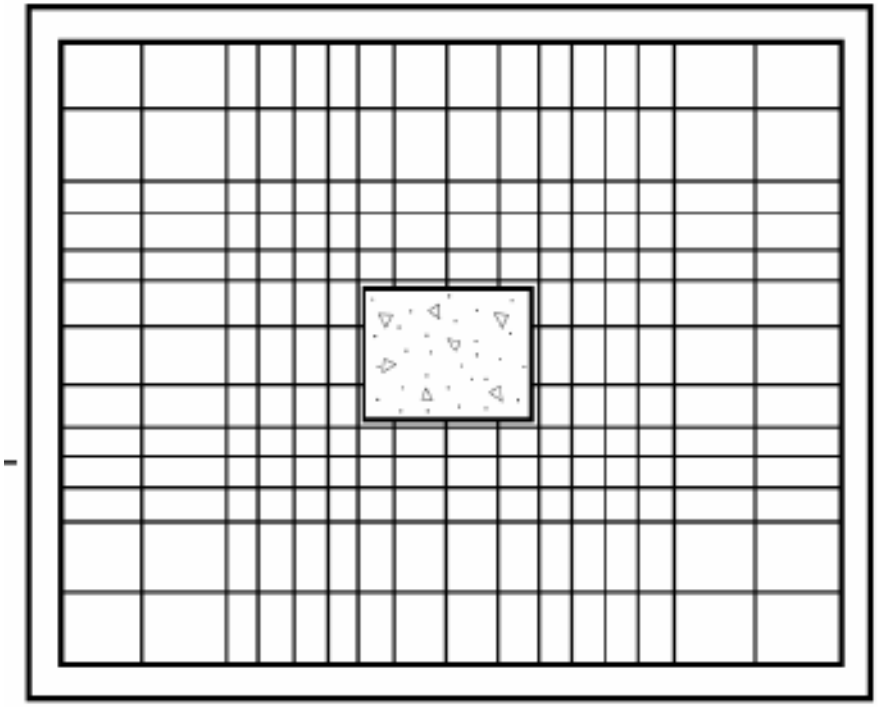
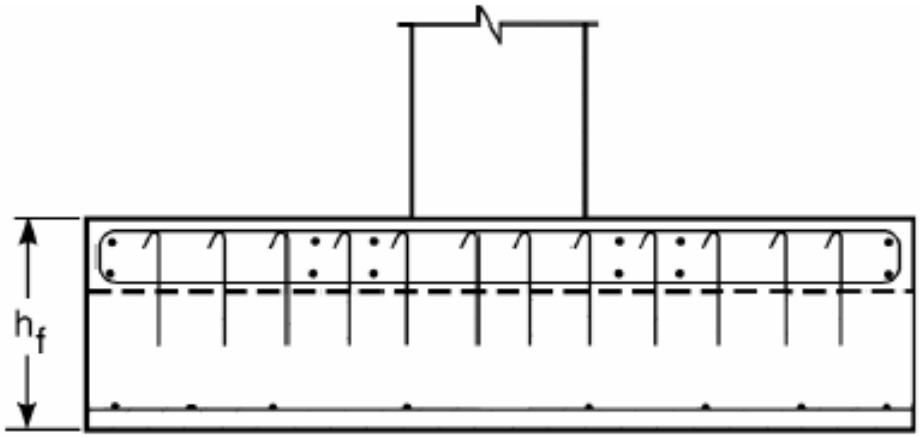
Footing retrofit measures

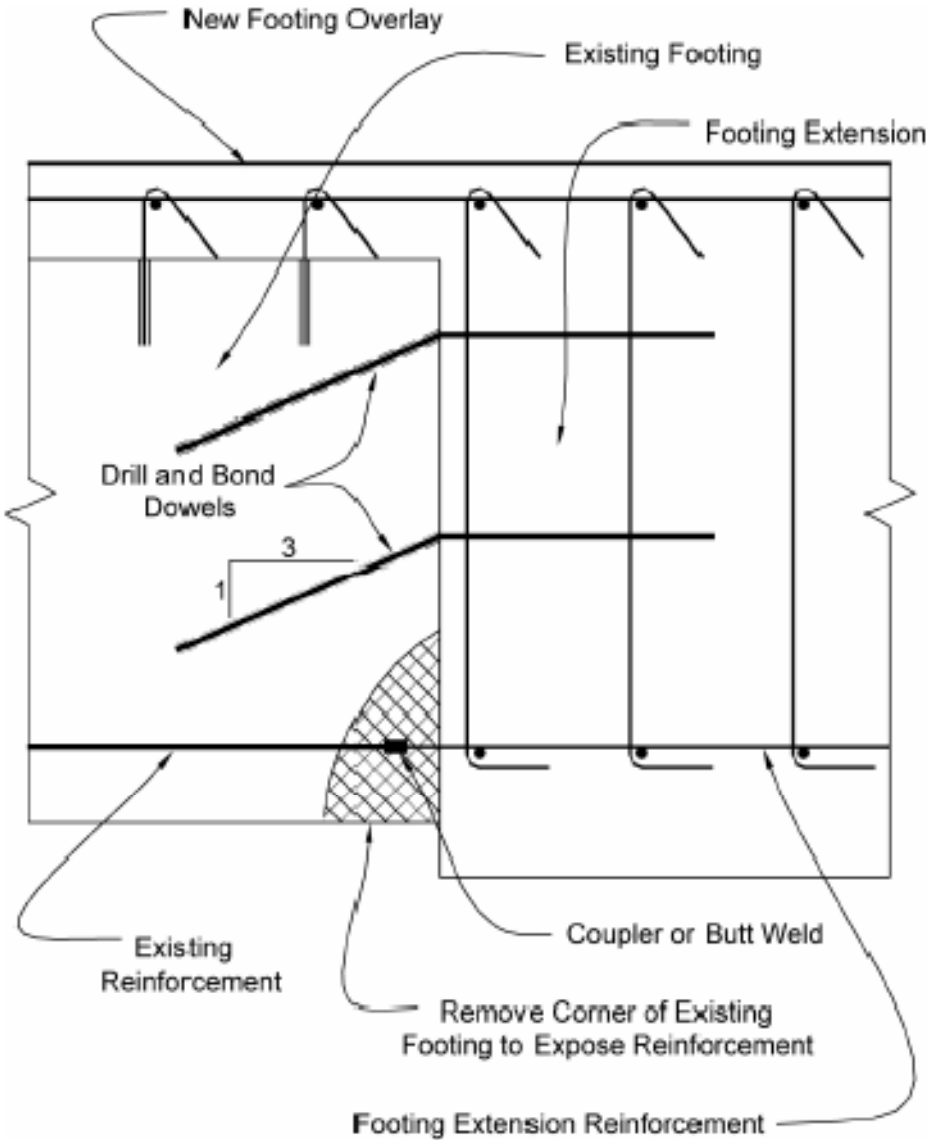
- Footing concrete overlay
  - Use overlay to increase negative moment capacity
  - Use added depth to check positive moment





Footing retrofit measures

- Reinforcing splice detail



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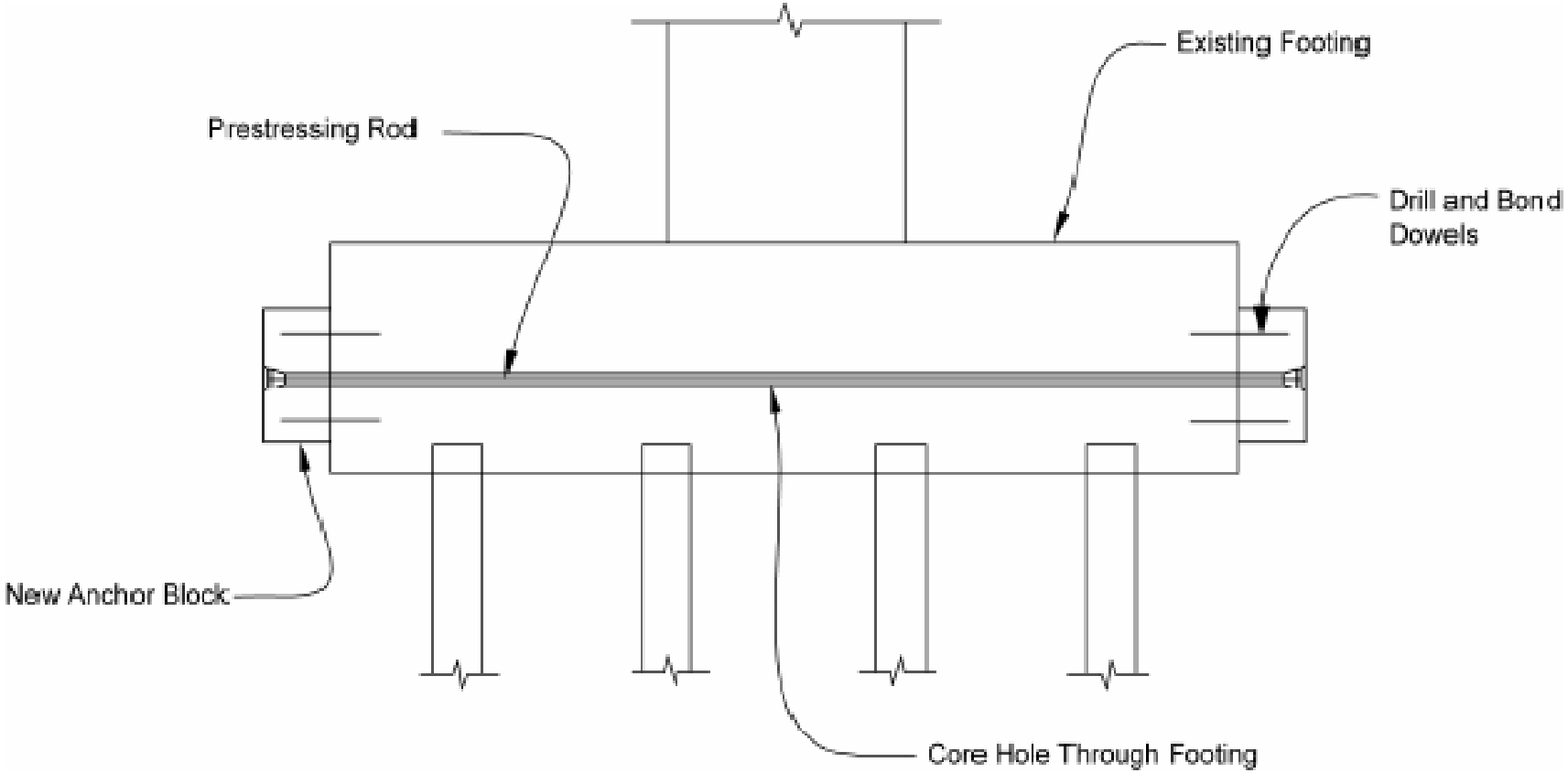
Footing retrofit measures

- Prestressing
  - Use to help positive moment



Footing retrofit measures (step 1)

- Determine design forces
  - Limit to flexural capacity of pier
    - Use overstrength moment
      - Material stronger than expected
      - Confinement of concrete
      - Strain hardening of steel
    - Increase axial load from EQ

Footing retrofit measures (step 2)

- Check OT capacity
  - If exceeded-check stability with a rocking analysis
    - This may eliminate retrofit requirements

Footing retrofit measures (step 3)

- Design for shear
  - Difficult to retrofit
    - Increase footing depth with overlay
    - Add prestressing bars
    - Add vertical bars through drilled holes (must pass bottom layer with hooks (anchors) to be effective or reduce effectiveness 50%

Footing retrofit measures (step 4)

- Design for flexure
  - Top reinforcing lacking very often
    - Add overlay with steel and dowels
      - ½ should be within thickness of footing from column
    - Extra depth helps positive moment
    - Place prestress as close to column as possible

Footing retrofit measures (step 5)

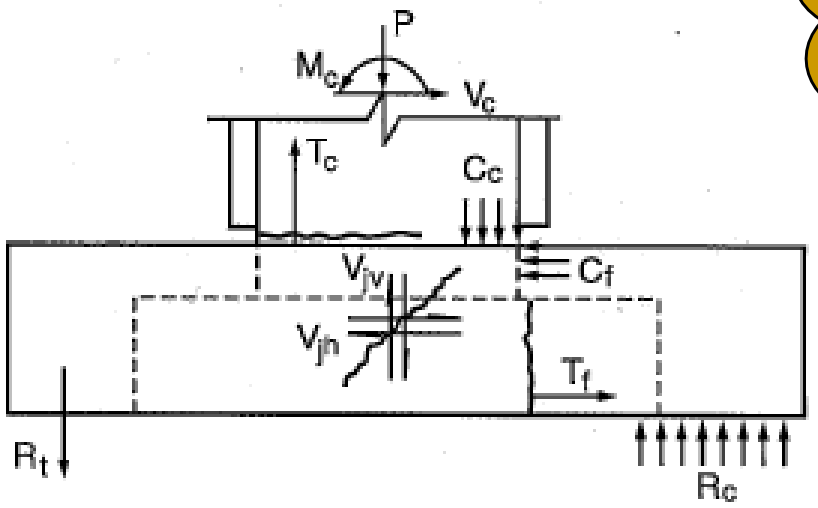
- Design dowels to connect to existing concrete
  - Should transfer shear stress at interface
  - Use shear friction approach-friction=1.0
  - If used for shear strength, proper anchorage at bottom is required-(difficult to do this)

Footing retrofit measures (step 6)

- Check column-to-footing joint shear
  - Research shows principal failure is from joint shear

Footing retrofit measures (step 7)

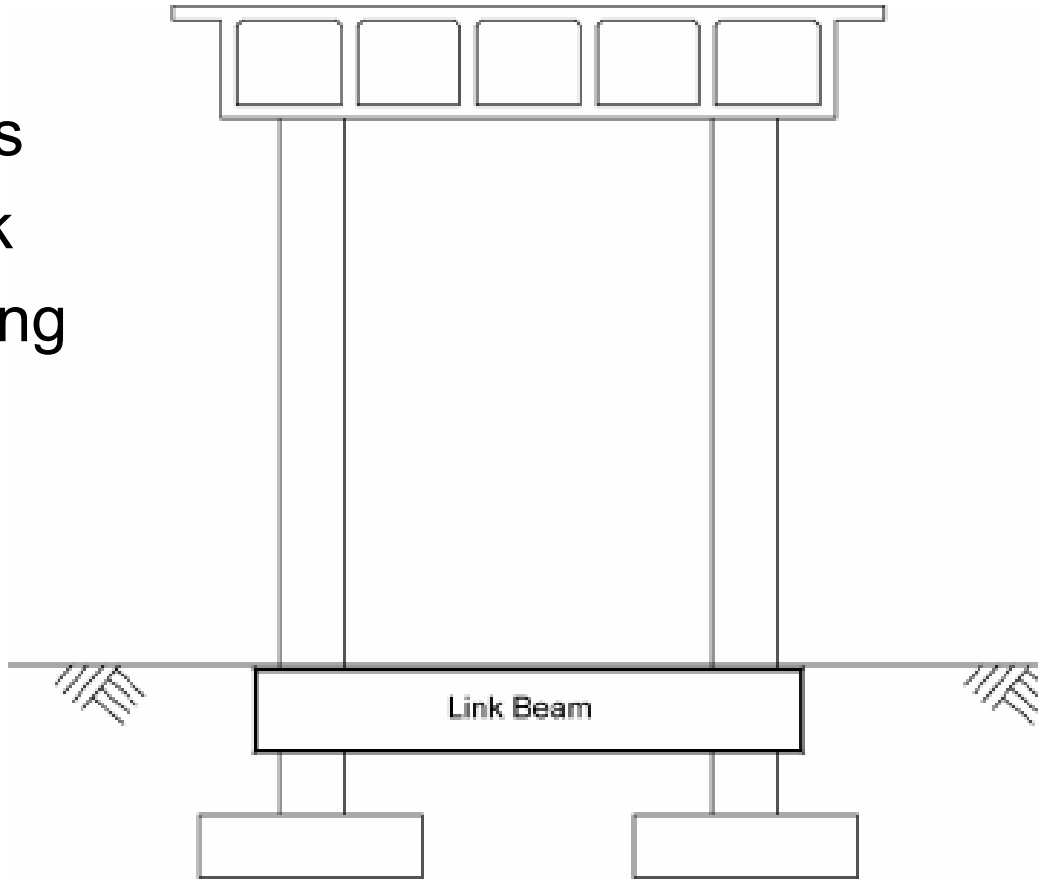
- Overlay capacity
  - Strut and tie model
  - Yield line theory
  - Easier to just make overlay thicker



Example 10.1 provides retrofit of footing

Limiting forces transmitted to footings

- Footing link beam
  - Objective is to force hinge in the column above the link
    - Redistribution of forces
    - Limits shear below link
    - Limits moment at footing

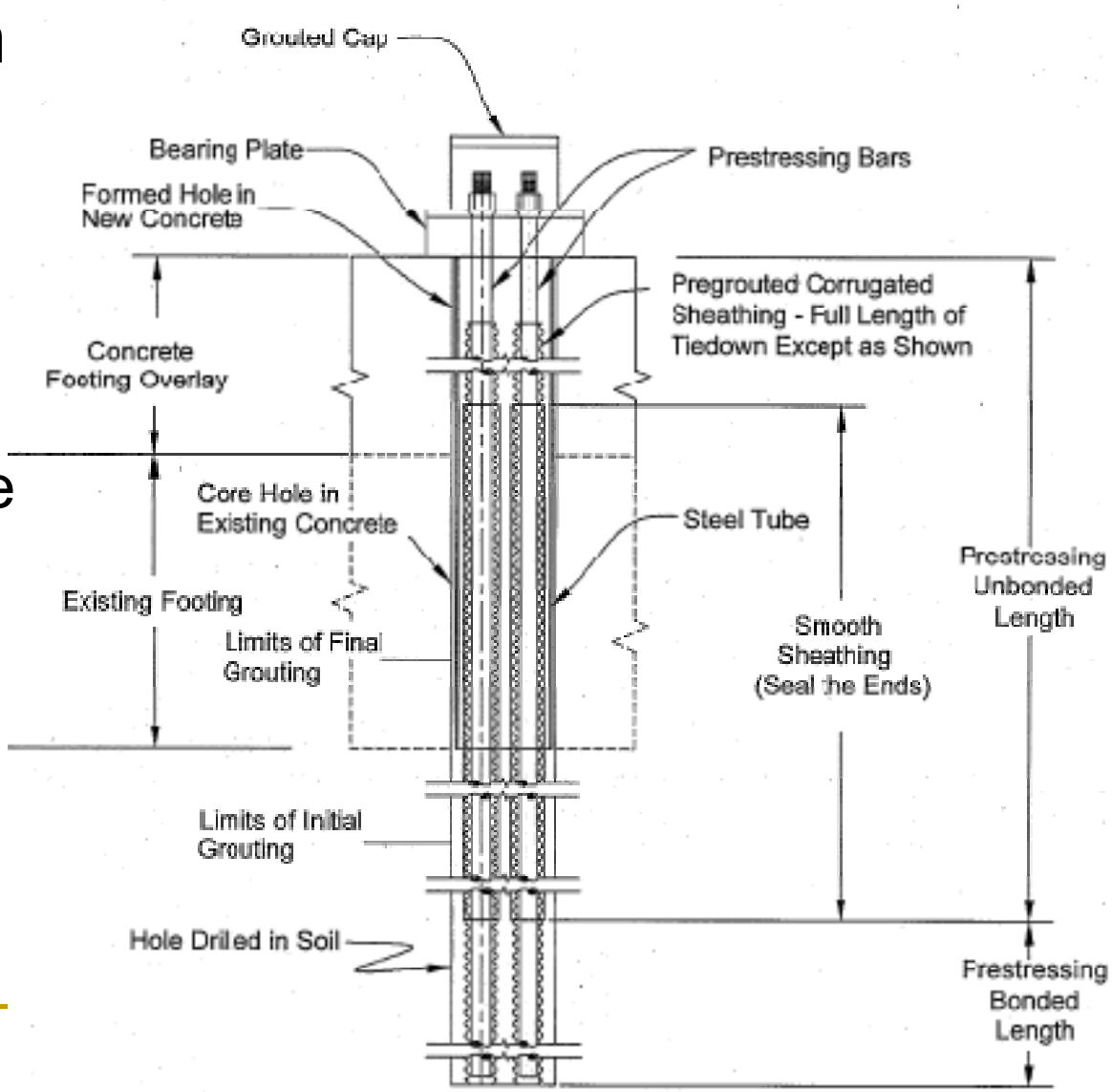


Pile to footing connection

- Adding new piles
  - Steel pipe piles filled with conc and rebar
    - Stiffer than H piles to resist lateral loads
    - Good connection to new footing
- CIDH
  - Can be drilled in low head room
  - Very stiff for lateral loads
  - Good connection to new footing

Pile to footing connection

- Prestress tie down
  - Proof load tiedown
  - Pile capacity limits amount of prestress
    - Due to footing rotation, limited use to short columns (before fully effective-rotation may be large)



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Summary

- To describe typical retrofit measures for:
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Abutment retrofit measures

- Approach slabs
- Anchor slabs
- Diaphragm walls
- Transverse shear keys
- Transverse soil anchors
- Soil and gravity anchors

Footing retrofit measures

- Footing replacement
- Strengthening of footings
- Limiting forces transmitted to footings

- What questions do you have?