Retrofit Measures for Abutments, Footings, and Foundations
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

\[ F_D := (\mu + S_a) \cdot DL \]

- $\mu \approx 0.6$ Friction Coeff
- $S_a =$ Spectrum Acc
- $DL =$ Dead Load
Abutment retrofit measures

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

- Waffle slab retrofit

- Resistance = 0.96h 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
Abutment retrofit measures

- Concrete transverse shear keys

[Diagram showing reinforced concrete shear keys with existing bearing, pedestal, drill and bond dowels.]
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
Abutment retrofit measures

- Abutment soil shear keys

**Design tips**

- $P_p = 0.96h$ 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
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
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

Note: Detail is also applicable to seat-type abutments
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
Footings 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
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
      - \( \frac{1}{2} \) 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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Footing retrofit measures

- Footing replacement
- Strengthening of footings
- Limiting forces transmitted to footings
What questions do you have?