PBEE of California High Speed Rail System

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California High Speed Rail

Original Project Vision: Great Candidate for PBEE

- Specific (and stringent) Performance Expectations
- Large Variation of Seismic Hazard
- Large Budget (> $77B cost)
- Numerous Bridges → Standardization
- Enthusiastic Partner (CA_HSR)
Collaboration with ABC UTC

- Accelerated Bridge Construction US DOT University Transportation Center (FIU)
  - Work closely with CA-HSR and Consultants
  - Extend ABC Concepts to CA-HSR
    - Prefabrication
    - Seismic Isolation (multiple-level resistance)
    - Contracting Methods
  - CA-HSR Workshop
Superstructure LL Deformation Limits

- Vertical Deformations
- Relative Deformations
- End Rotations
- Frequency Ranges

Note: Higher $L/\Delta$ implies a more stringent requirement

Example: $150 \text{ ft} \times 12 \text{ in./ft} / 3200 = 0.56 \text{ in.}$
Span-To-Depth Ratios \((L/h)\)

Example: Simply Supported: \(150\) ft / 12 = 12.5 ft
Superstructure: Controlling Design Criteria.

- Superstructure dimensions are controlled by service load criteria (L/h ratio).
- Deep members are too deep and heavy for prefabrication and road transportation.
- *Cast-in-place* or *Full-Span Precasting* are the only real options.
- *Full-Span Precasting* requires large capital investment, large contracts, lots of repetition.
ABC Project Challenges

> Huge Superstructures → Heavy
  → Focus on Substructures

> Separate Design-Build Contracts
  → Each uses a different system
  → Little Repetition

California to scale back $77 billion high-speed rail project: governor

David Shepardson

(Reuters) - California Governor Gavin Newsom said on Tuesday the state will dramatically scale back a planned $77.3 billion high-speed rail project that has faced cost hikes, delays and management concerns, but will finish a smaller section of the line.
Revised Vision for PEER Project

Focus on PBEE of Connection between Column and Enlarged (Type 2) Drilled Shafts

- System important for HSR and Caltrans (Type 2 shafts).
- How should PBEE design requirements change with differences in performance expectations?
- Builds on work at UCSD and UW.
- Has potential for collaboration with other PEER TSRP projects
  > Joel Conte (Uncertainty in PBED)
  > Sashi Kunnath (Bridge Column Capacity Limit States)
  > Dawn Lehman (Concrete-filled Steel Tubes for HSR)
  > Michael Scott (Bridge Functionality as PBEE Metric)
Type 2 shafts – background

> Shafts have a smaller footprint than spread footings. May be used even in competent soil.
> Type 2 shafts: shaft diameter > column diameter.
> Beneficial because:
  – Shaft is stronger than the column, so
  – Critical plastic hinge forms at base of column, where it is accessible for inspection and/or repair after an earthquake. *(Performance benefit.)*
  – Provides the opportunity to place column accurately after the main part of the shaft has been poured. *(Construction benefit)*
Type 2 shafts - construction
Type 2 shafts – features

> Shaft reinforcement controlled by moments about 2 column diameters below grade.
> Thus, shaft reinforcement in transition region is stronger than needed there.
> Bond of column bars more critical than shaft bars.
Type 2 shafts - questions

> Connection between shaft and column is a non-contact splice.
> That causes the need for transverse reinforcement.
Type 2 shafts – questions

> Traditional approach is to assume uniform bond stress along (non-contact) spliced bars. *Strength approach.*
> Test evidence (Tran, UW; Murcia-Delso, UCSD) suggests that the bond stress is distributed very non-linearly.
> Peak bond stress, and lateral force, at “live” end of the column bar.
> High lateral forces at top of shaft, not uniform along splice.
> Mechanics of load transfer in connection region unclear.
Type 2 shafts - questions

> Potential for damage at top of shaft.
> Consider design for damage, not just life safety. (PBEE).
Research concept

> Investigate load transfer mechanism in non-contact splice region.
> Consider both cast-in-place (traditional) and precast column (ABC) configurations.
> Could concentration of load transfer at top be avoided by use of headed bars, combined with local debonding?
Planning activities

> Plan to conduct tests to investigate behavior.
> Preliminary analyses to design test configurations:
> Model the splice using bond models (ongoing).
  – Eligehausen model, with modifications by Murcia-Delso and Shing.
  – Reduction in bond strength caused by bar yielding appears to be important, but not well understood.
  – (Reduction in radius associated with plastic tensile strain causes lugs to partially disengage from surrounding concrete.)
Bond stress modeling

Test 2 Results: Peak Stress = 66 ksi

- Slip
- Axial Stress
- Bond Stress
Test Planning

Winter quarter (Jan-Mar):  test planning and design.
Spring quarter (Apr-Jun):  Build first specimens
Summer:  conduct tests
Thank You