Effects of Superstructure Time-Dependent Deformations on Bridge Column Design

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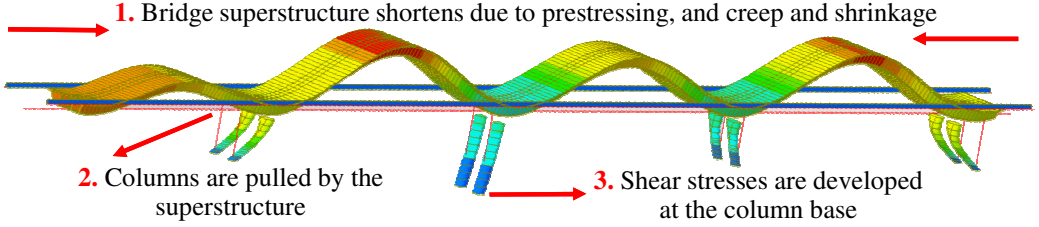
Problem Statement

How to efficiently design bridge columns to accommodate stresses induced by superstructure time-dependent deformations in ***posttensioned concrete box-girder bridges***



Methodology/Objective

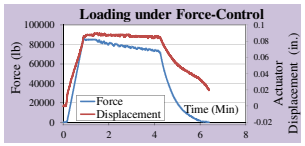
- Establish a realistic strain rate for the superstructure shortening
- Identify and quantify concrete relaxation phenomenon
- Analyze different bridge frame configurations using the Finite Element Analysis

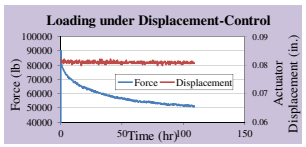
→ Propose a simplified design approach to calculate column moment/shear demands

Concrete Relaxation Test

Testing Procedure

- Force control mode
- Displacement control mode





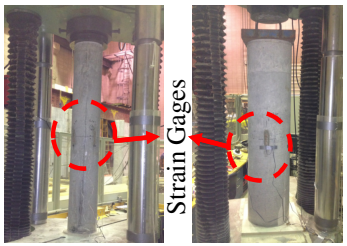
Column Test

Two specimen sizes to investigate any plausible size effect

Two various loading scenarios:

i. Instantaneous compressive axial displacement

ii. Step Loading

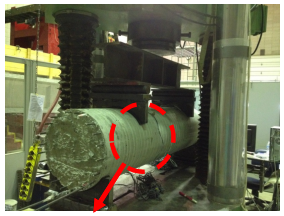


Beam Test

Precracking loading

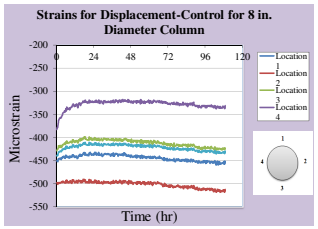
Post-cracking loading:

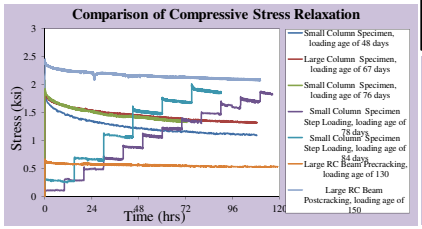
Failed the specimen to examine the possibility of any residual strains in the rebars



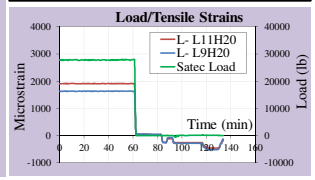
Concrete Relaxation Test-Results

For the seven conduced test, strain remained constant, while force reduced over time



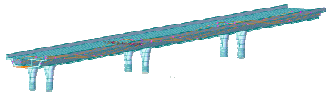


No residual strains in longitudinal rebars after the completion of the relaxation test

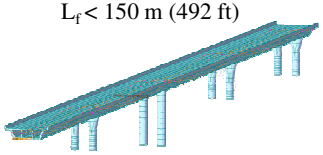


Analytical Investigation Results

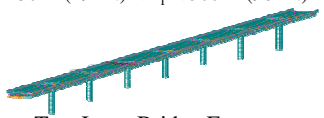
Analyzed six bridges with different lengths



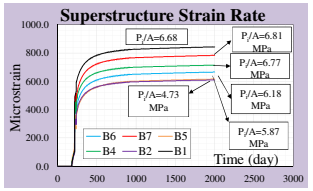
Two Short Bridge Frames;
L_f < 150 m (492 ft)



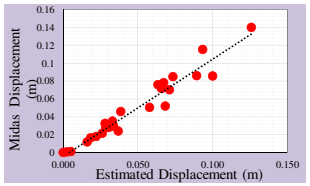
Two Medium Bridge Frames
150 m (492 ft) < L_f < 300 m (984 ft)



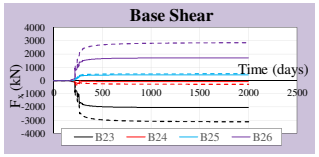
Two Long Bridge Frames
L_f > 300 m (984 ft)

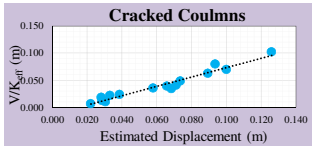


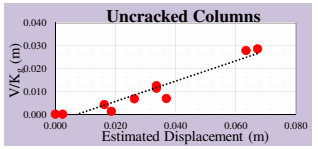
Using the calculated strain rate, estimated the top of column displacement with respect to point of no movement (PNM)



Column relaxation led to appreciable reduction in column base shear







Conclusions/Observations

- Concrete relaxation resulted in significant reduction in column base shear force
- Generally, the superstructure strain rate increased as the initial axial stress increased
- Top of column displacement was estimated fairly accurately using superstructure strain rate when it was compared to the analytical model results
- The maximum displacement and base shear force occurred for the most exterior columns, which cracked as well.
- The nearest columns to PNM experienced the minimum displacement and base shear force, thus remained uncraked.