



Performance assessment of RC Structures using Fiber Optic Sensing

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Objectives for performance assessment

Part 1: Post-earthquake performance assessment of RC structures

- Moderate damage and functional recovery

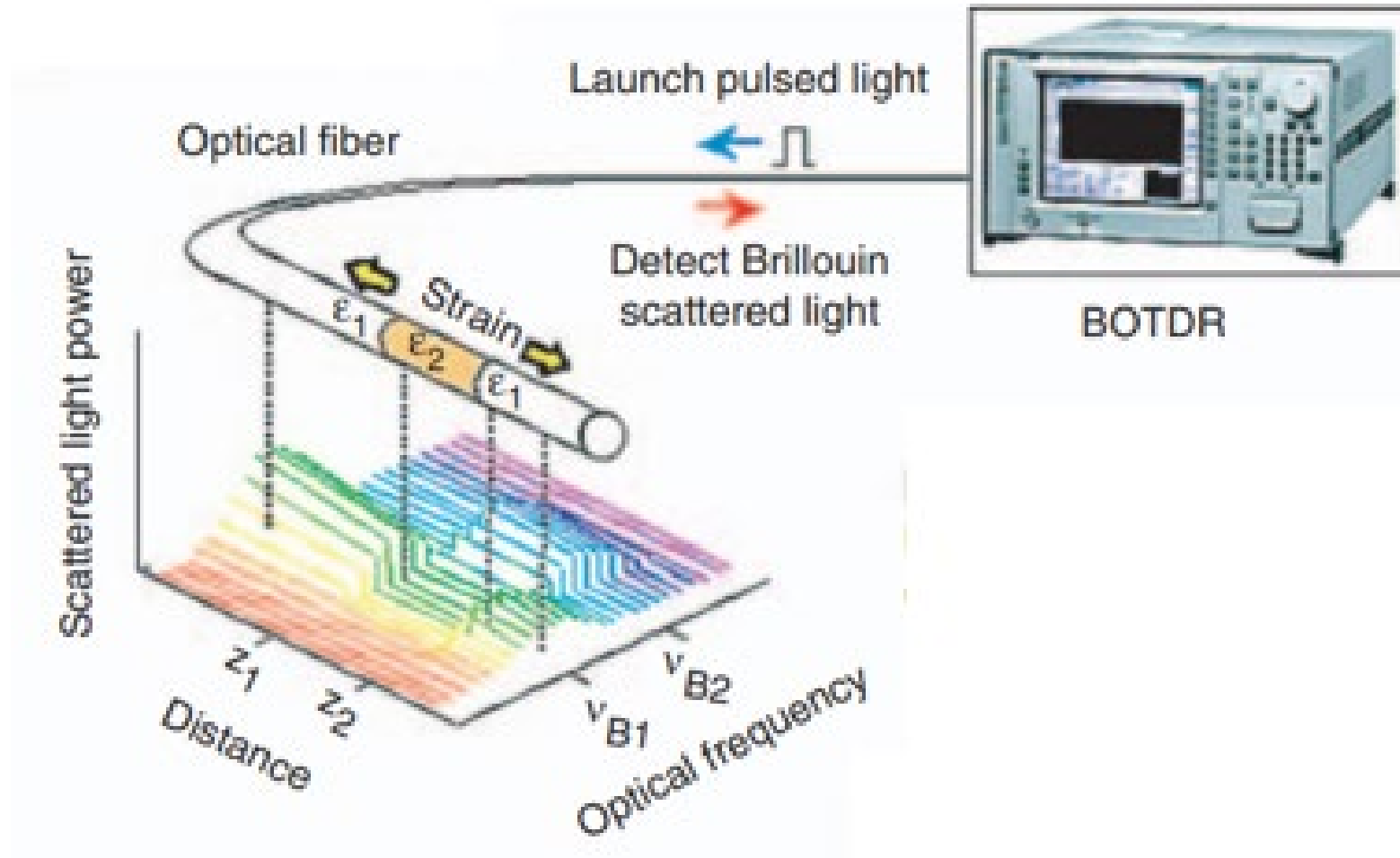
Part 2: Service load performance assessment of an RC bridge





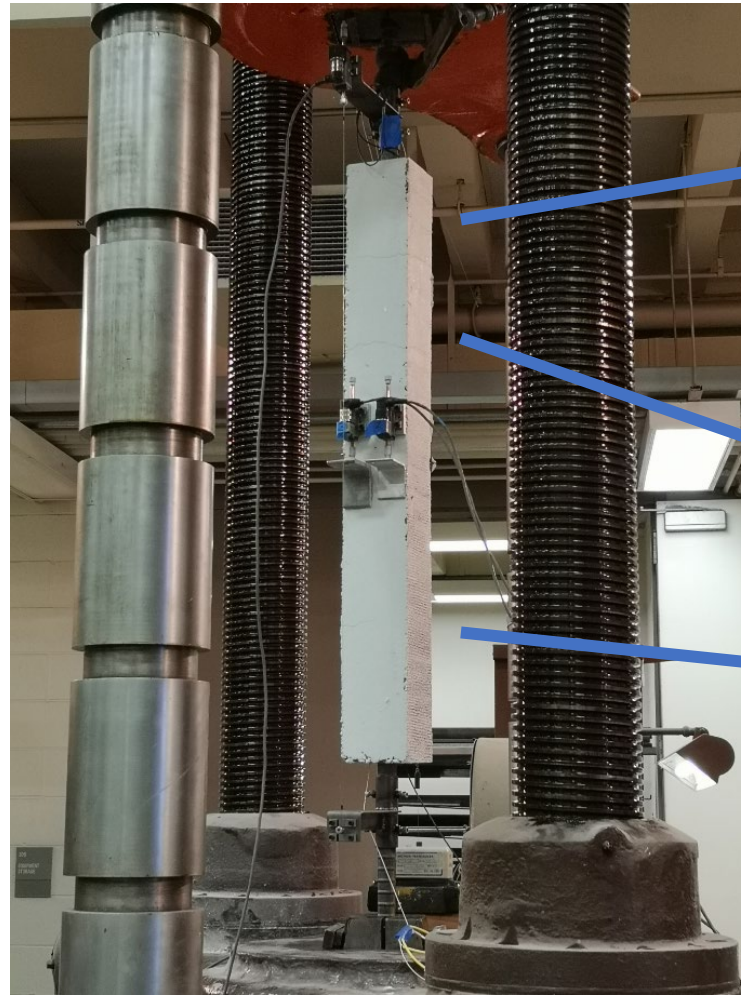
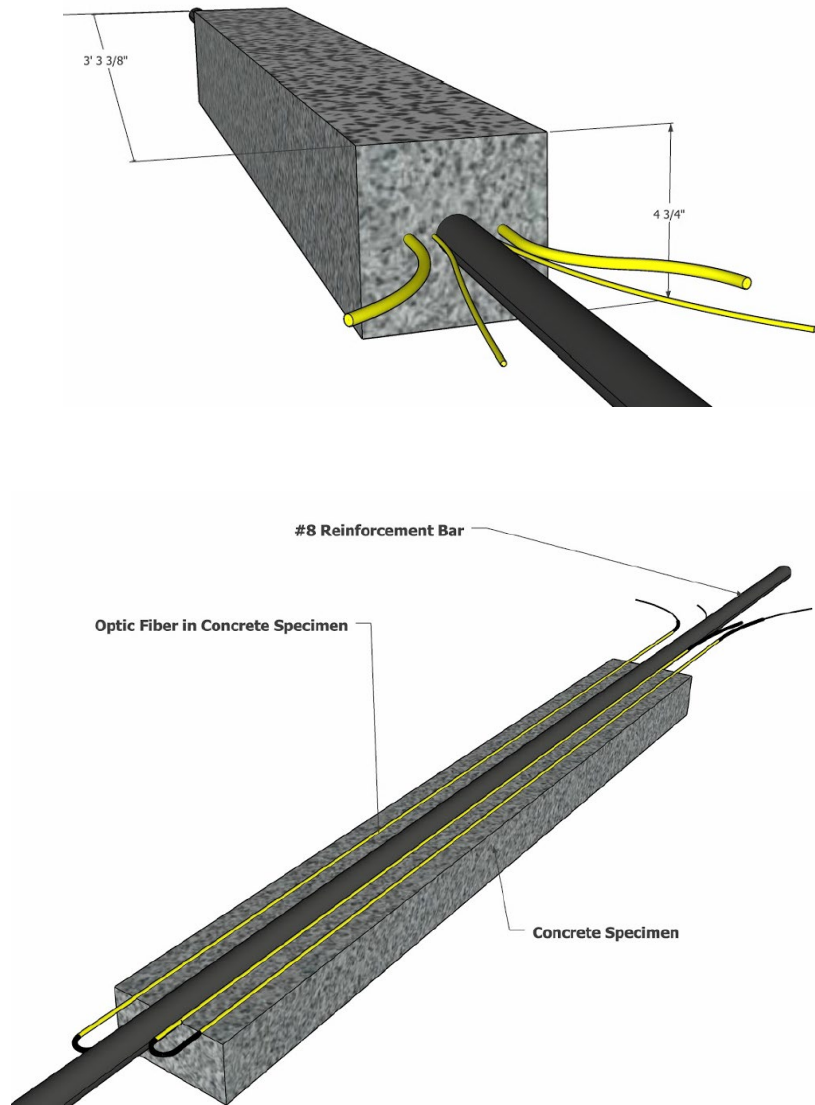
Background

Fiber optic strain sensing

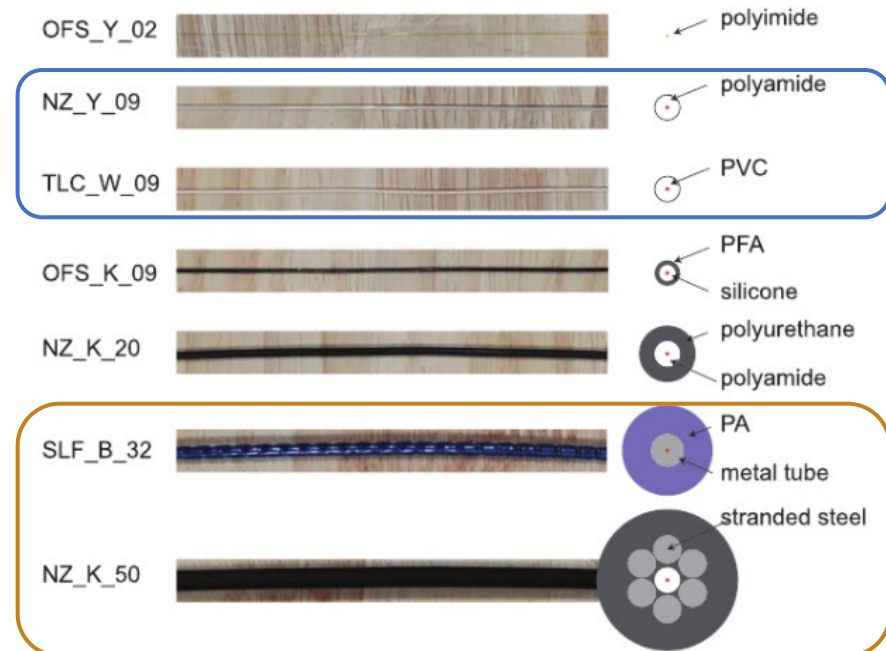
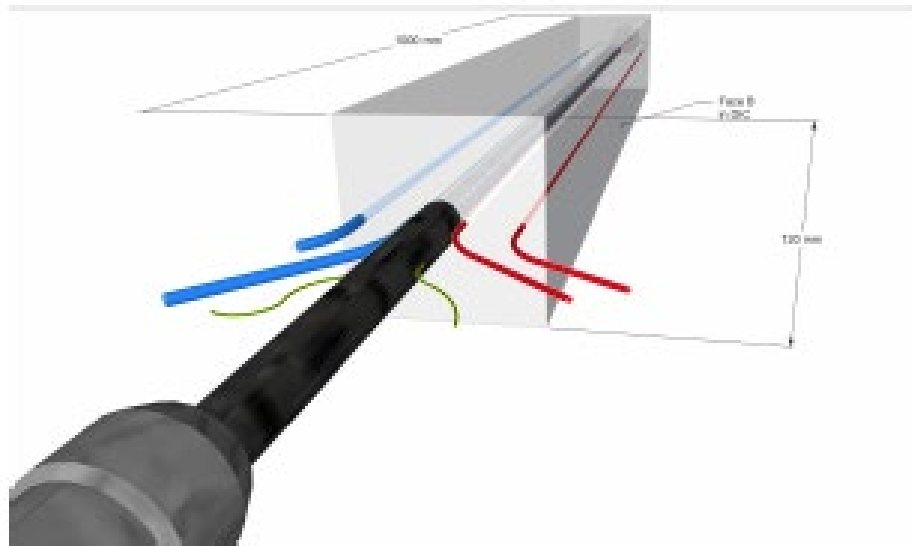


(reference: Nicky De Battista
<https://www.repository.cam.ac.uk/handle/1810/255405>)

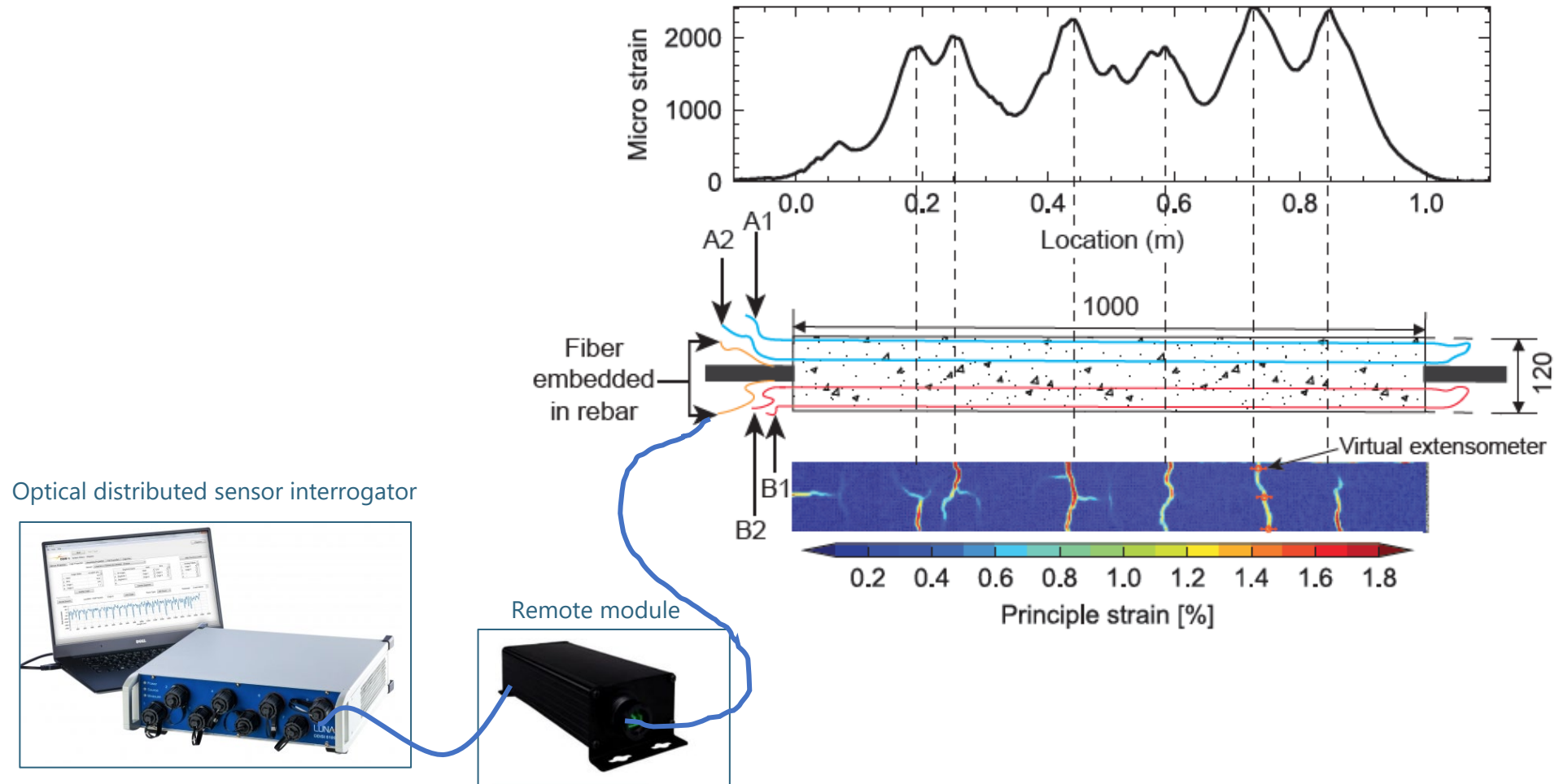
Crack measurement using fiber optic sensing



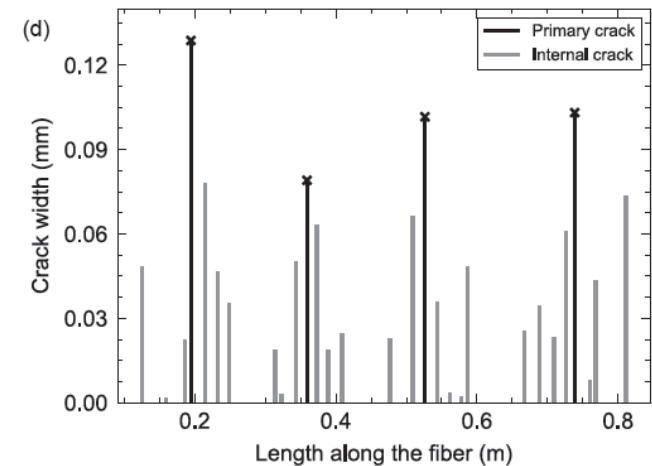
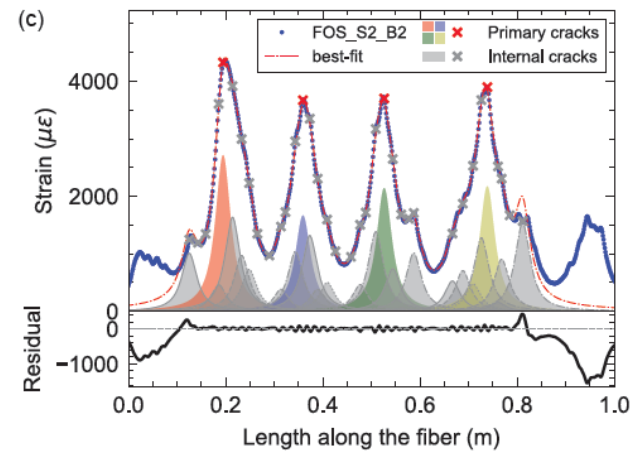
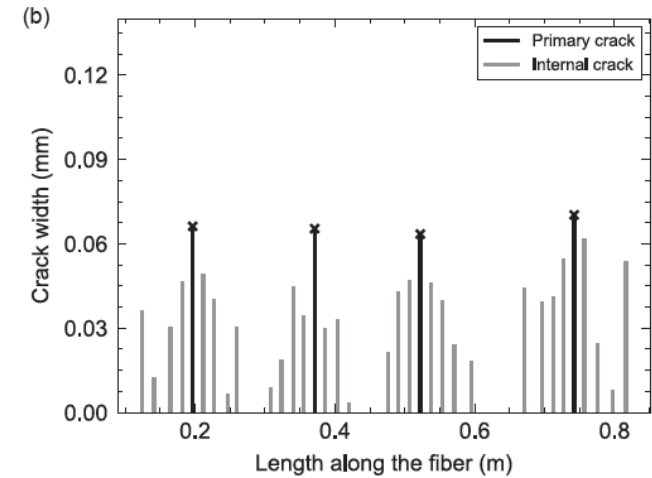
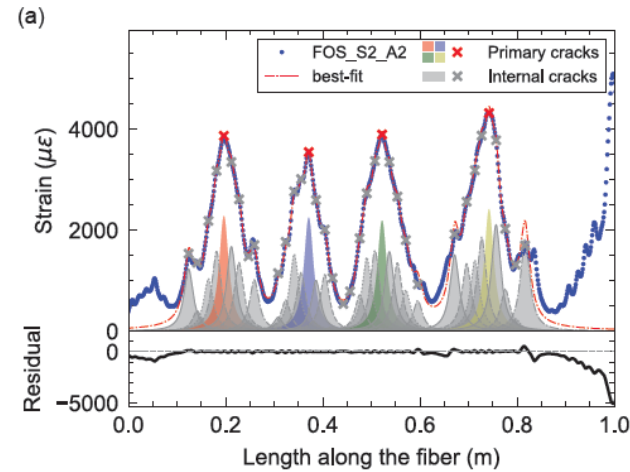
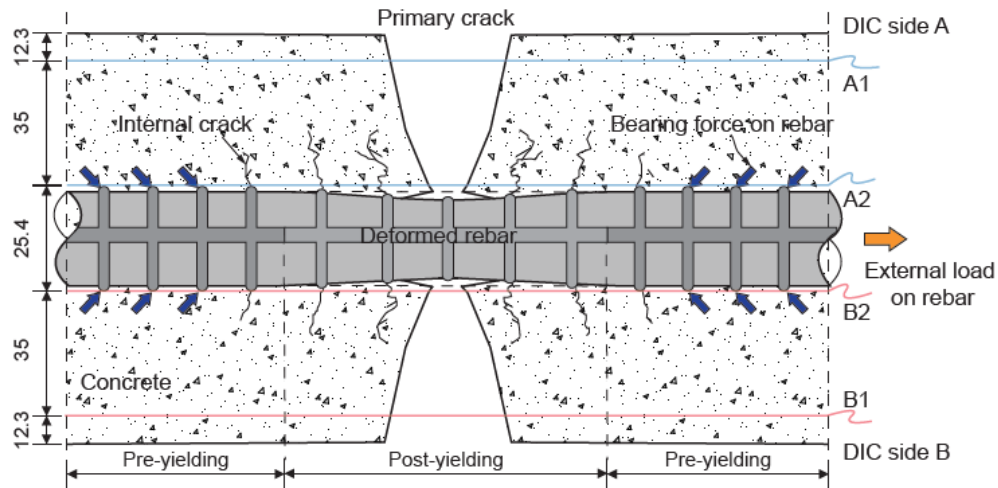
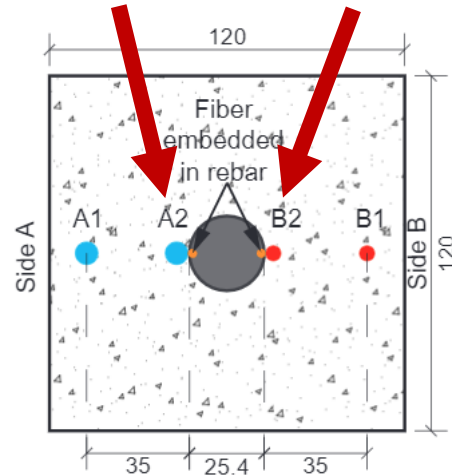
Crack measurement using fiber optic sensing



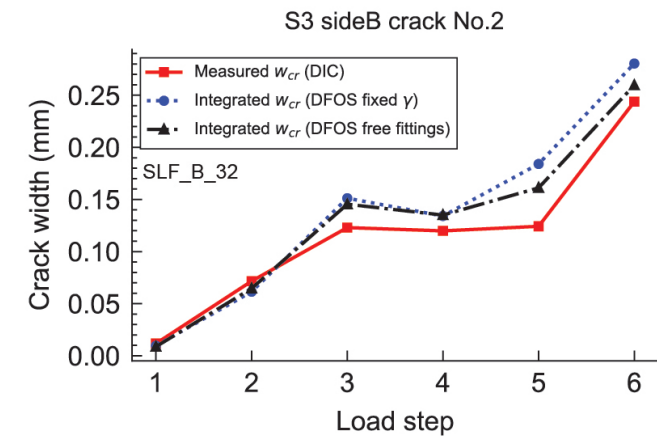
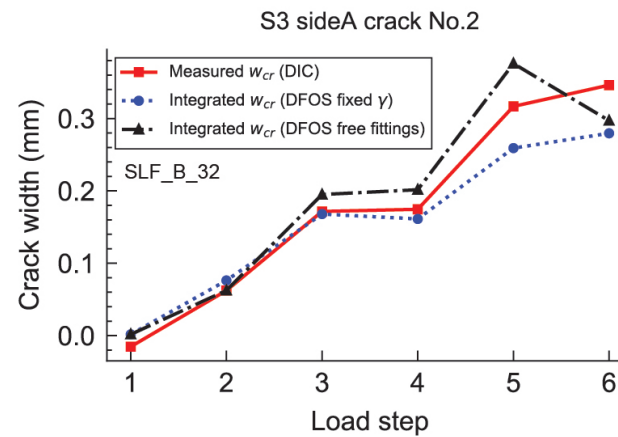
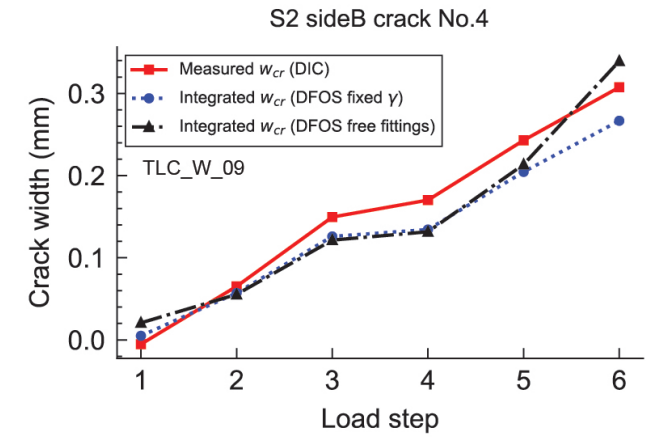
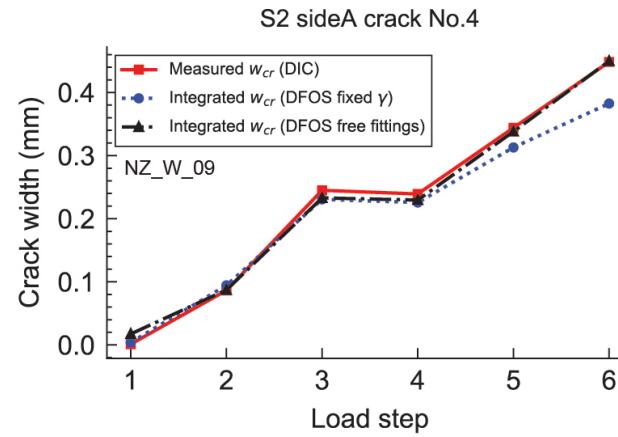
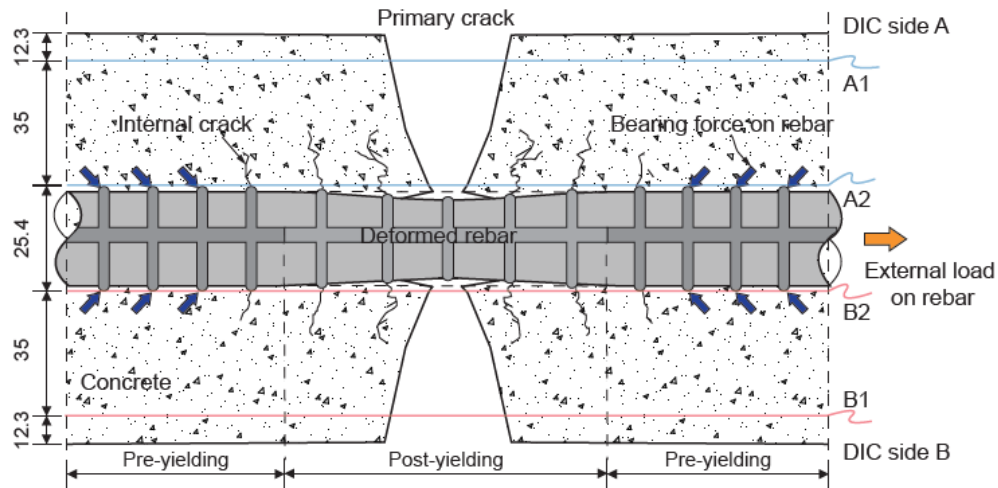
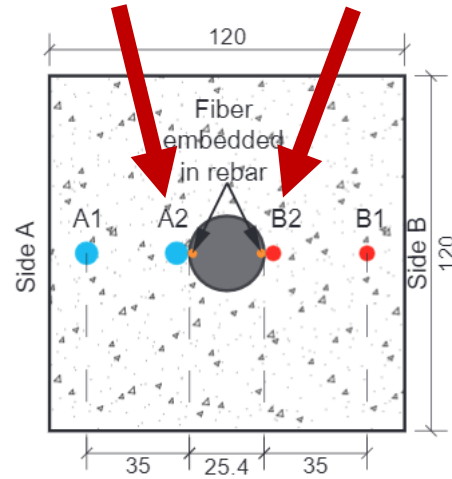
Crack measurement using fiber optic sensing



Crack measurement using fiber optic sensing



Crack measurement using fiber optic sensing



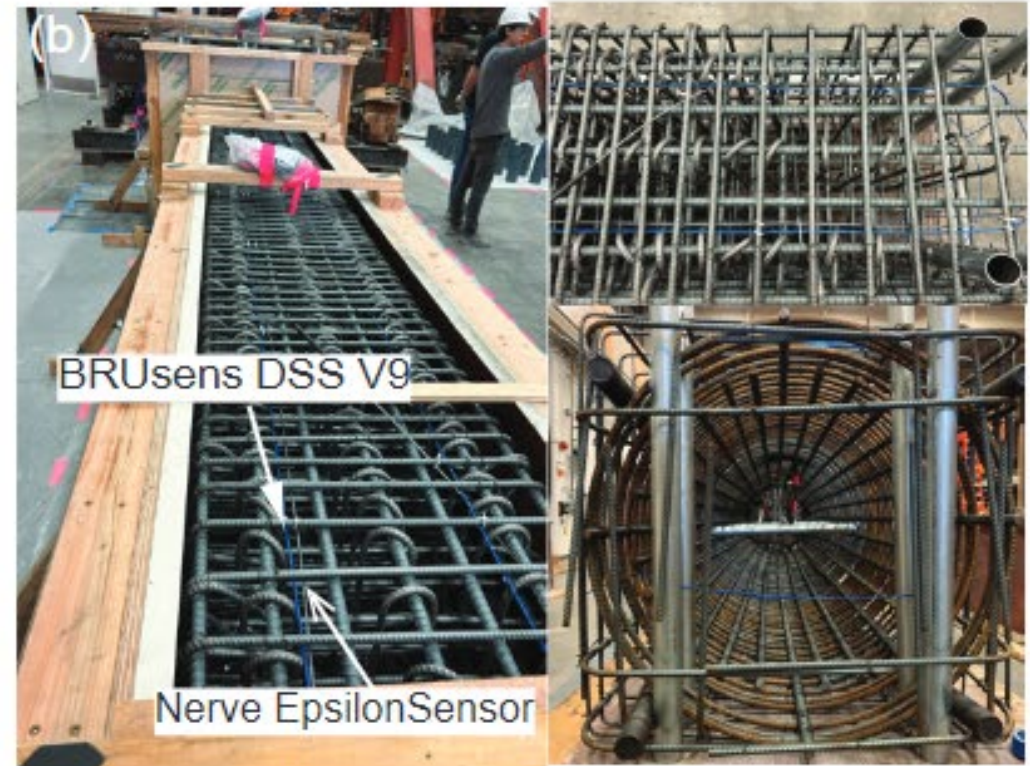
Part 1: Post-earthquake performance assessment

Motivation

Evaluate potential for post-earthquake damage (moderate) assessment using only post-event data

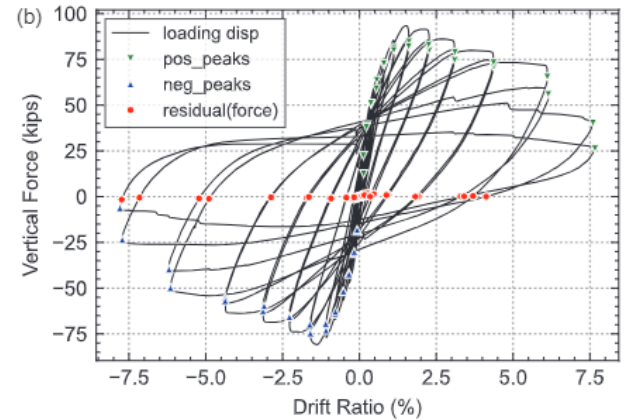
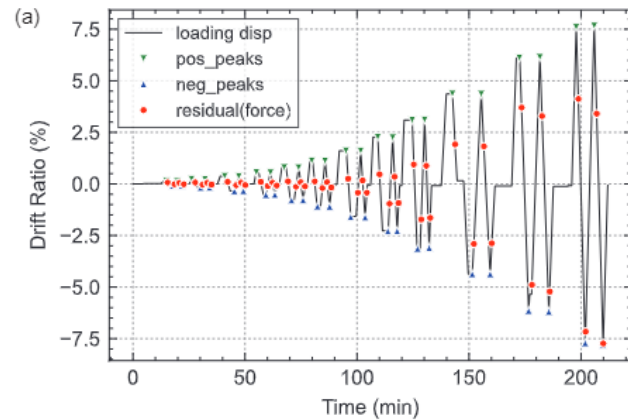
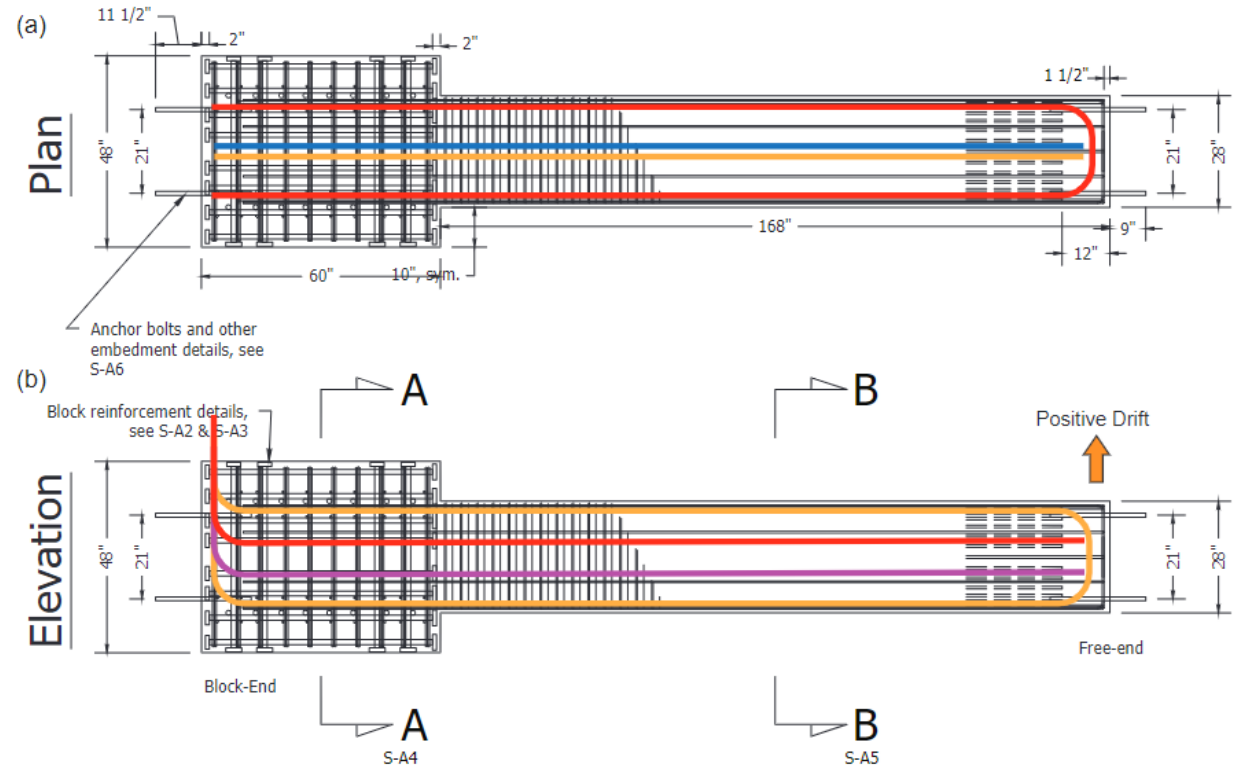
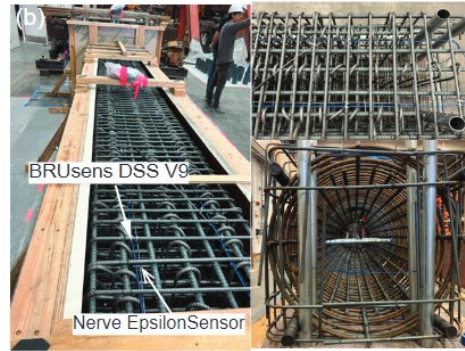
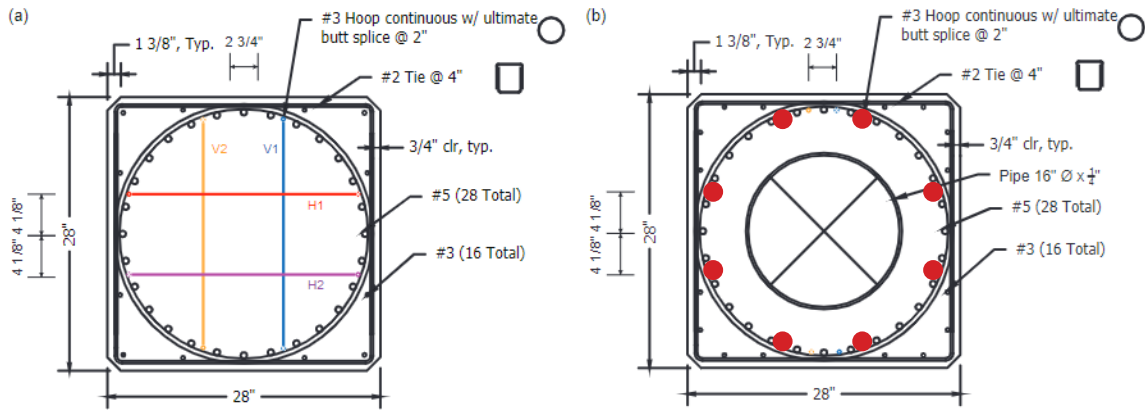
RC Arch Bridge Tests

- High axial load plus cyclic bending
- Monitor Plastic Hinge Formation & Curvature



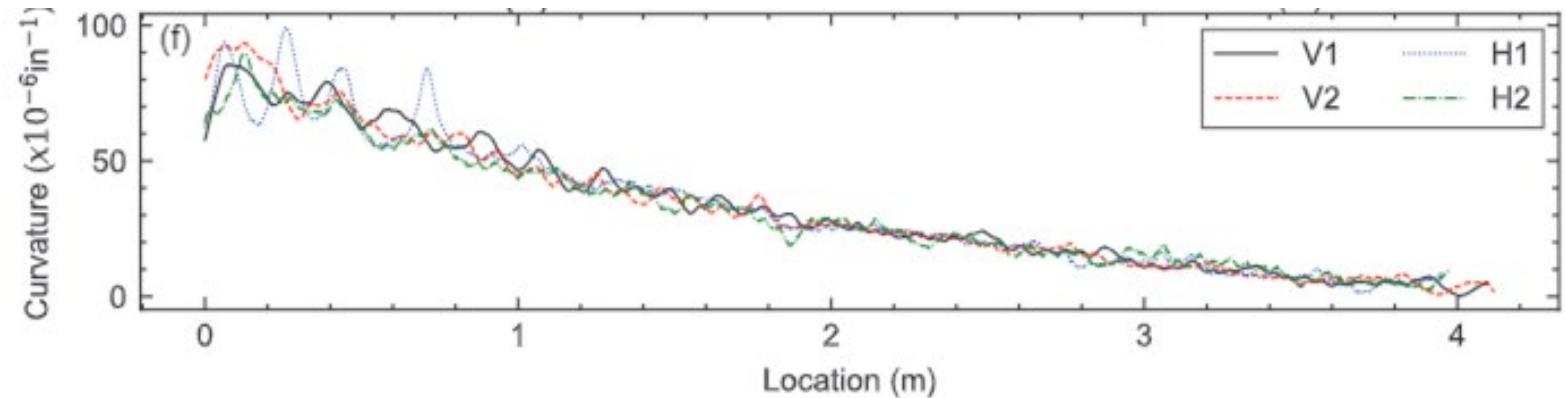
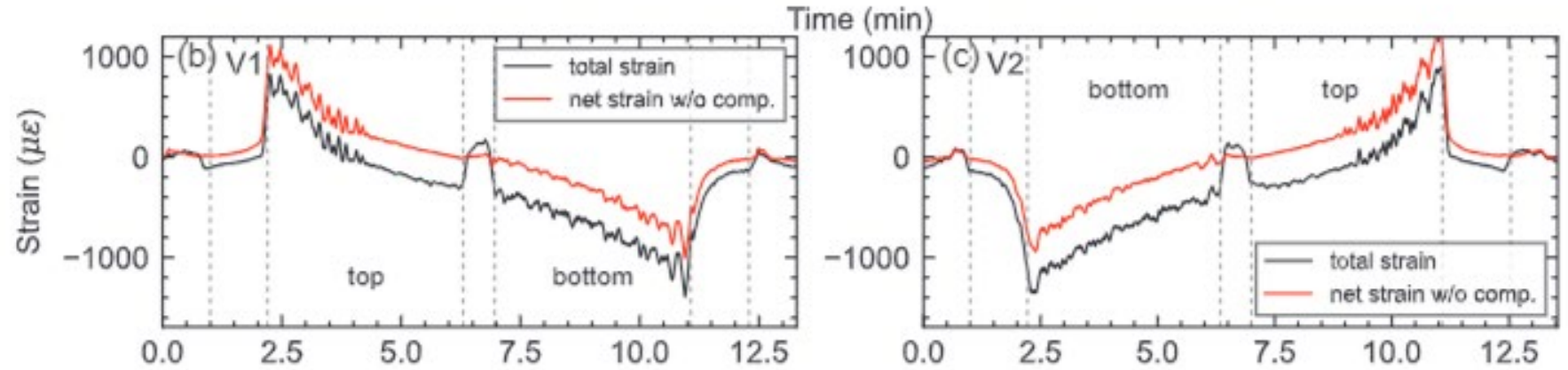
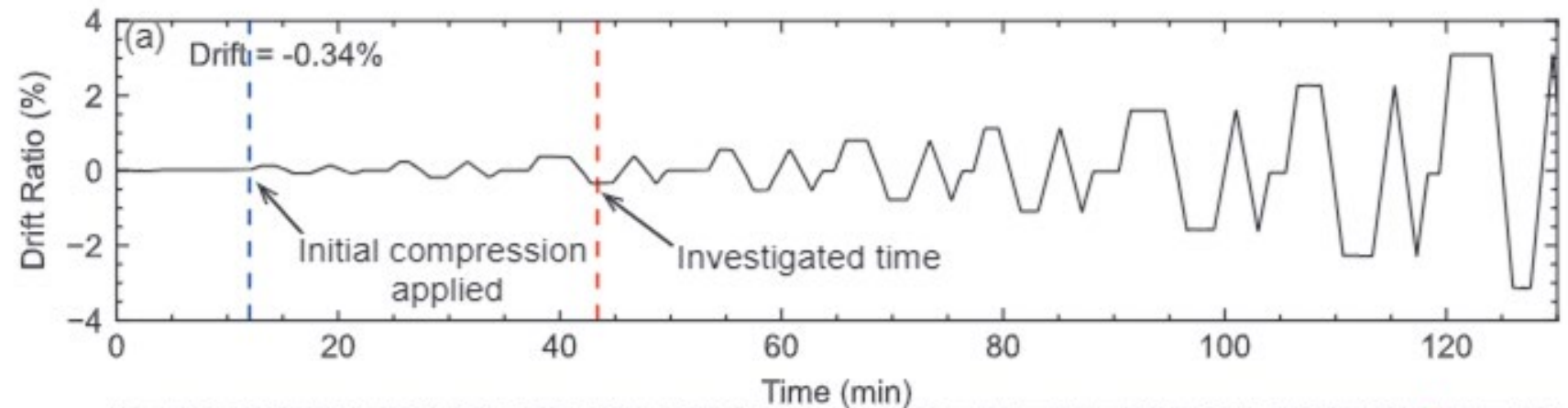
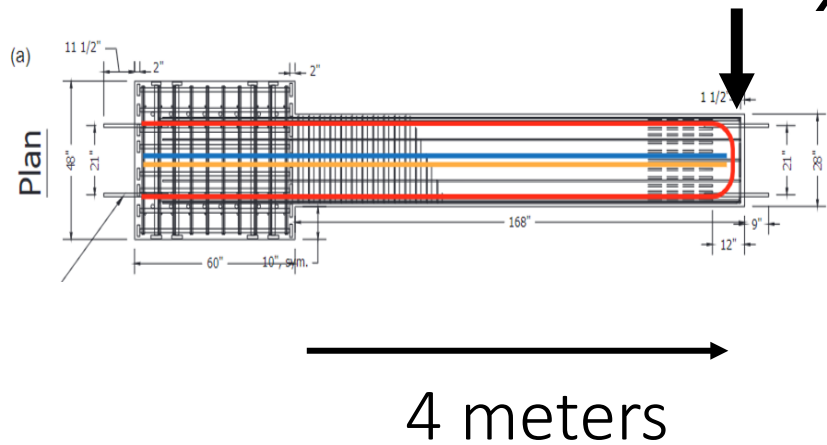
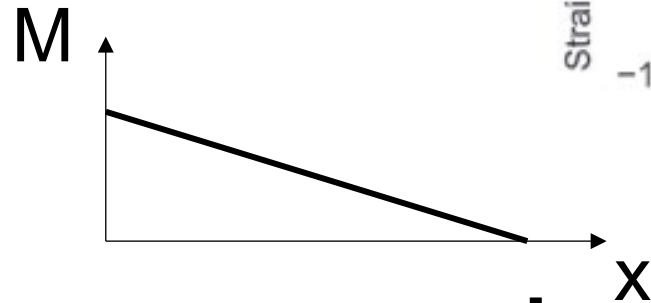
**In collaboration with: Prof Jack Moehle, Diego De La Mora Bayardo

RC Arch Bridge Tests



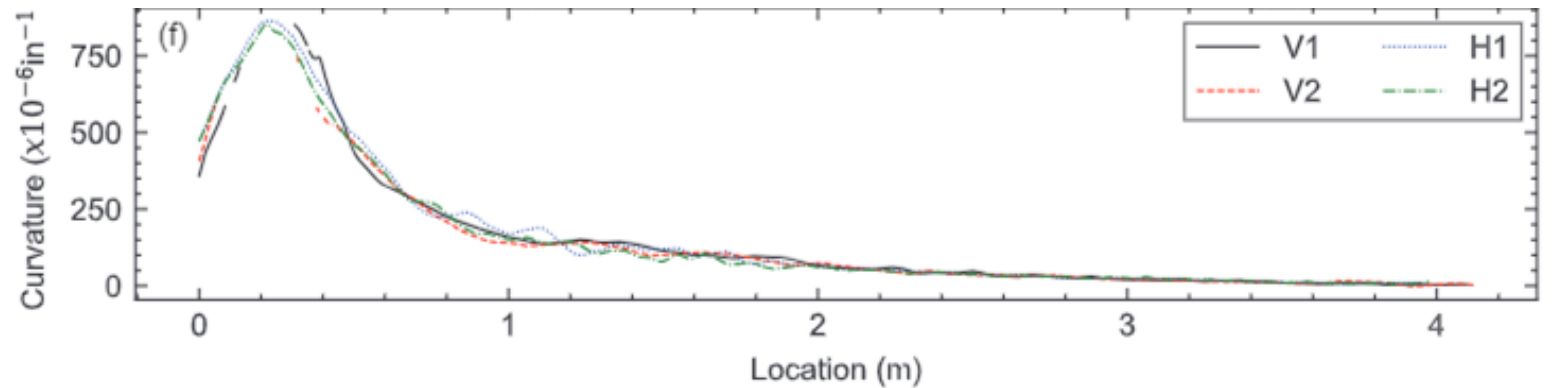
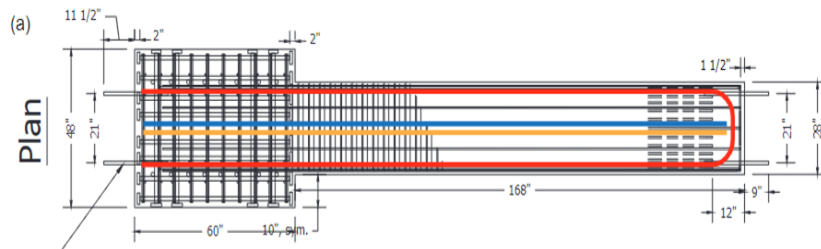
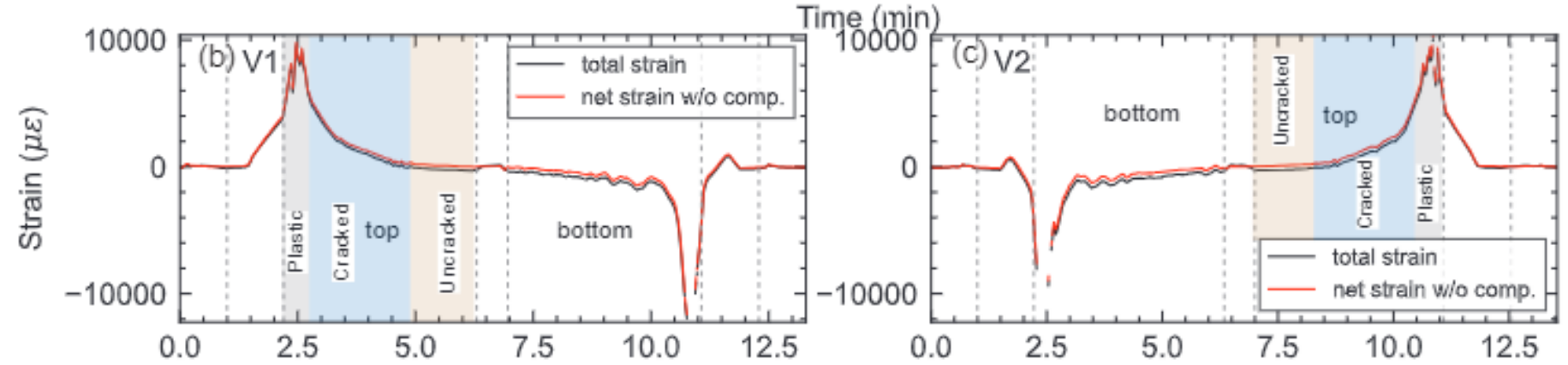
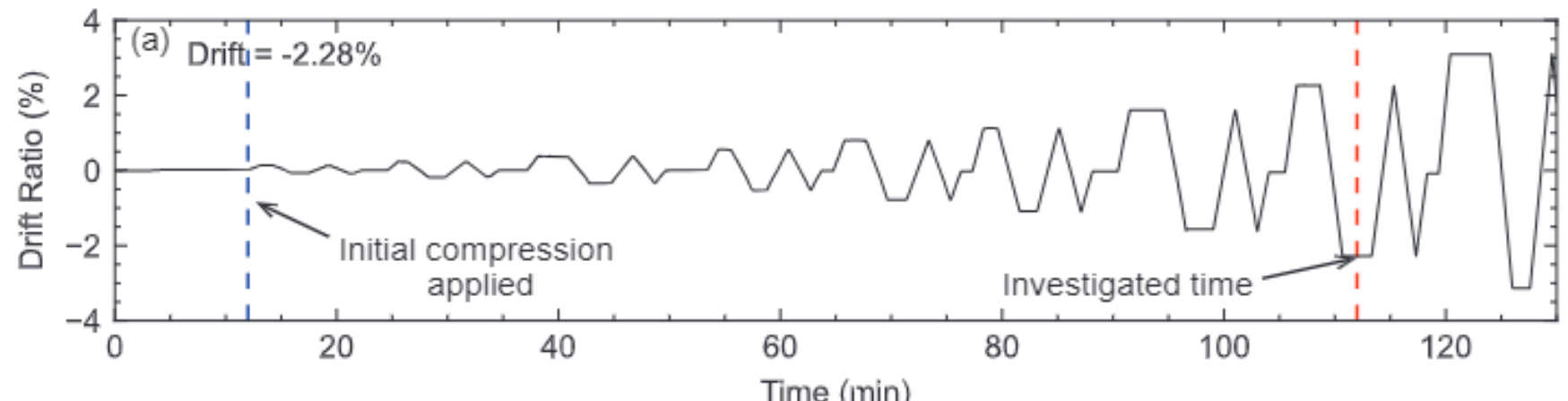
Results

Strain Distribution
at low drifts
(mostly elastic)



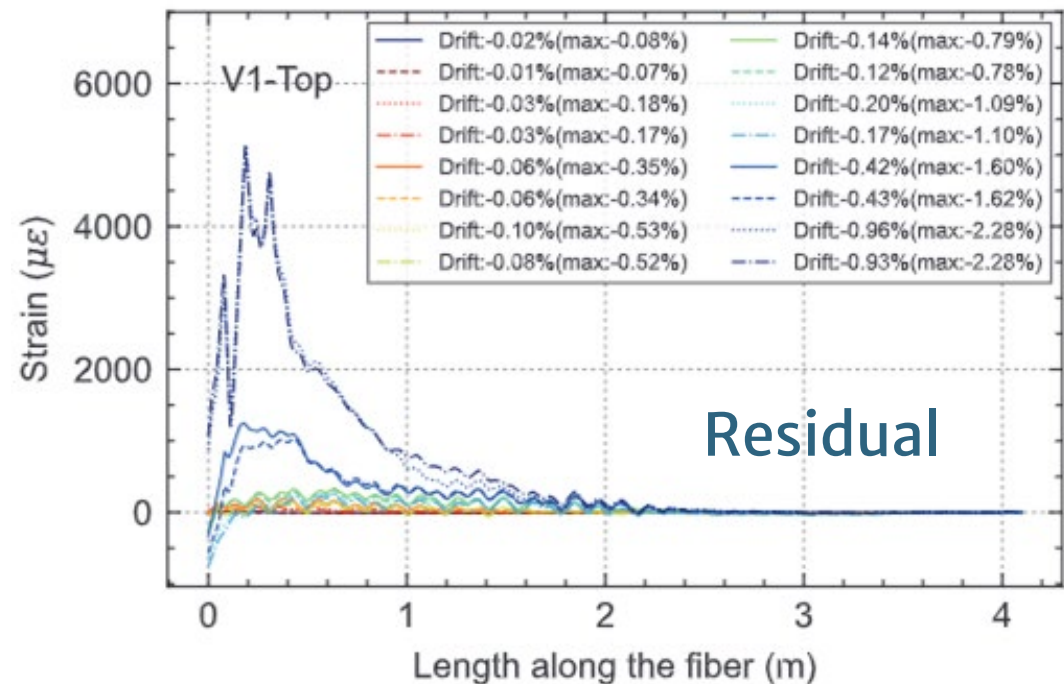
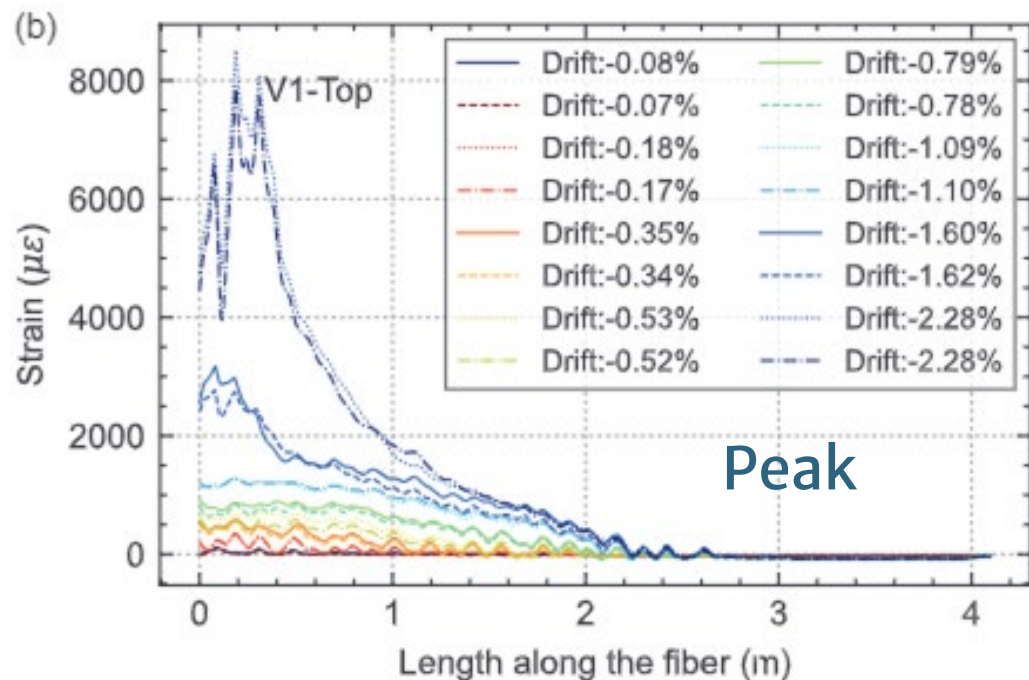
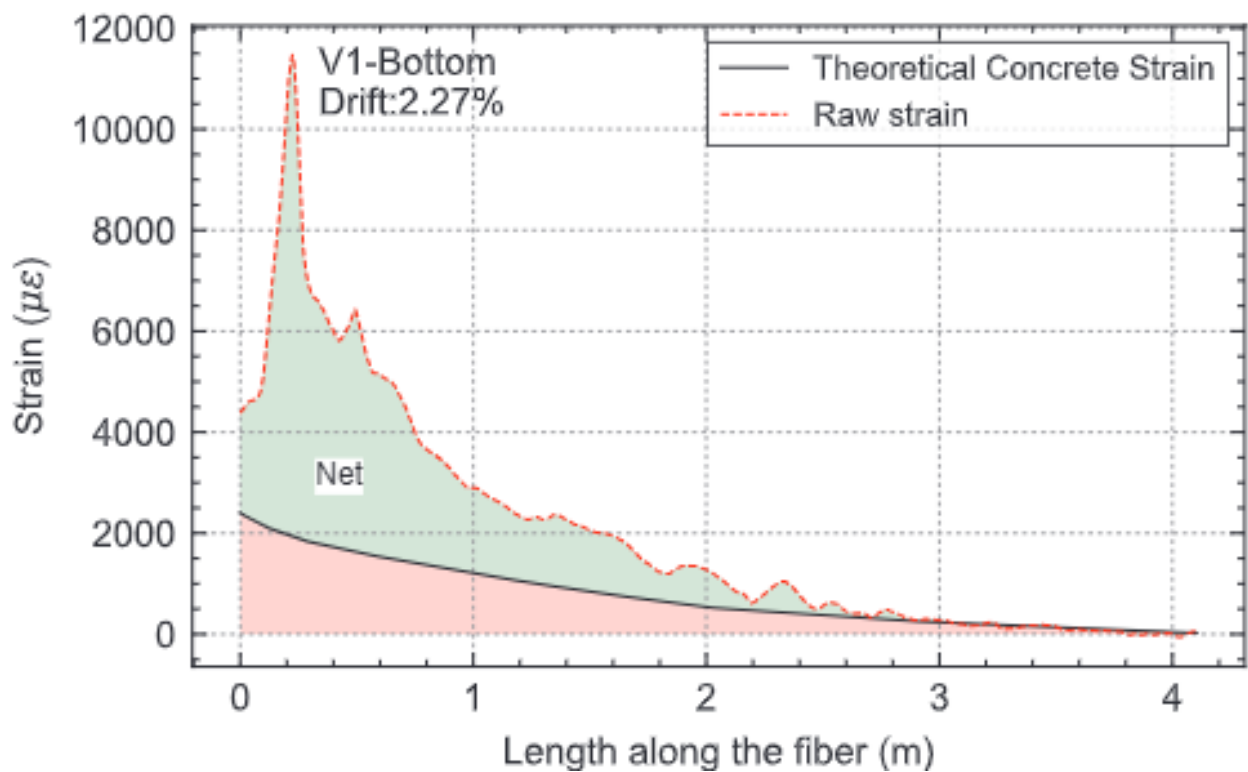
Results

Strain Distribution
at large drift
(plastic hinge
formed)



Results

- Net Strain (at each peak load): $\epsilon_{net} = \epsilon_{raw} - \epsilon_{c,theo}$
- Residual Strain (after each peak)



RC Moment Frame Test

Objectives:

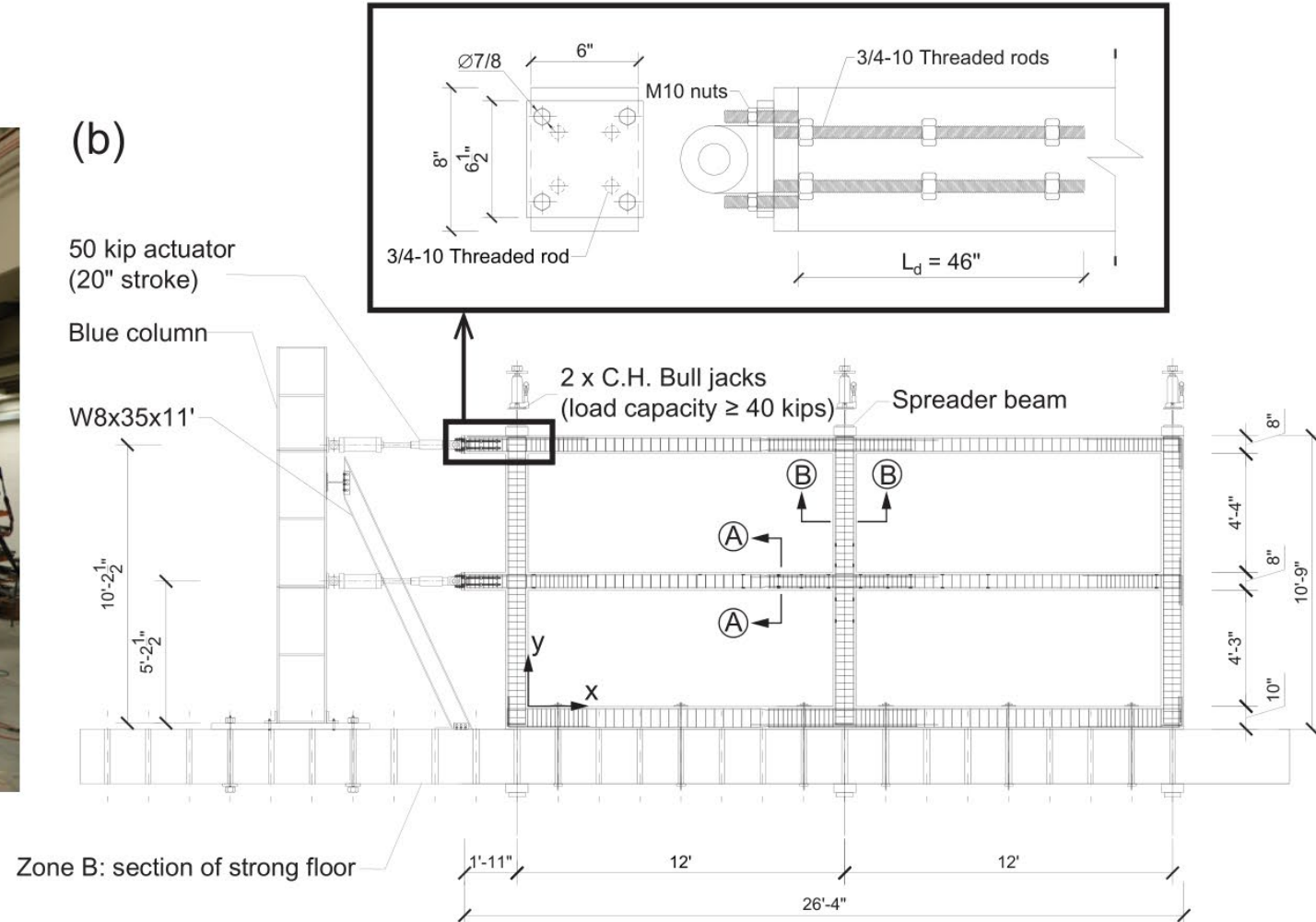
- Detect damage progression
- Evaluate post-earthquake damage evaluation capability
- Evaluate retrofit effectiveness
 - globally
 - locally



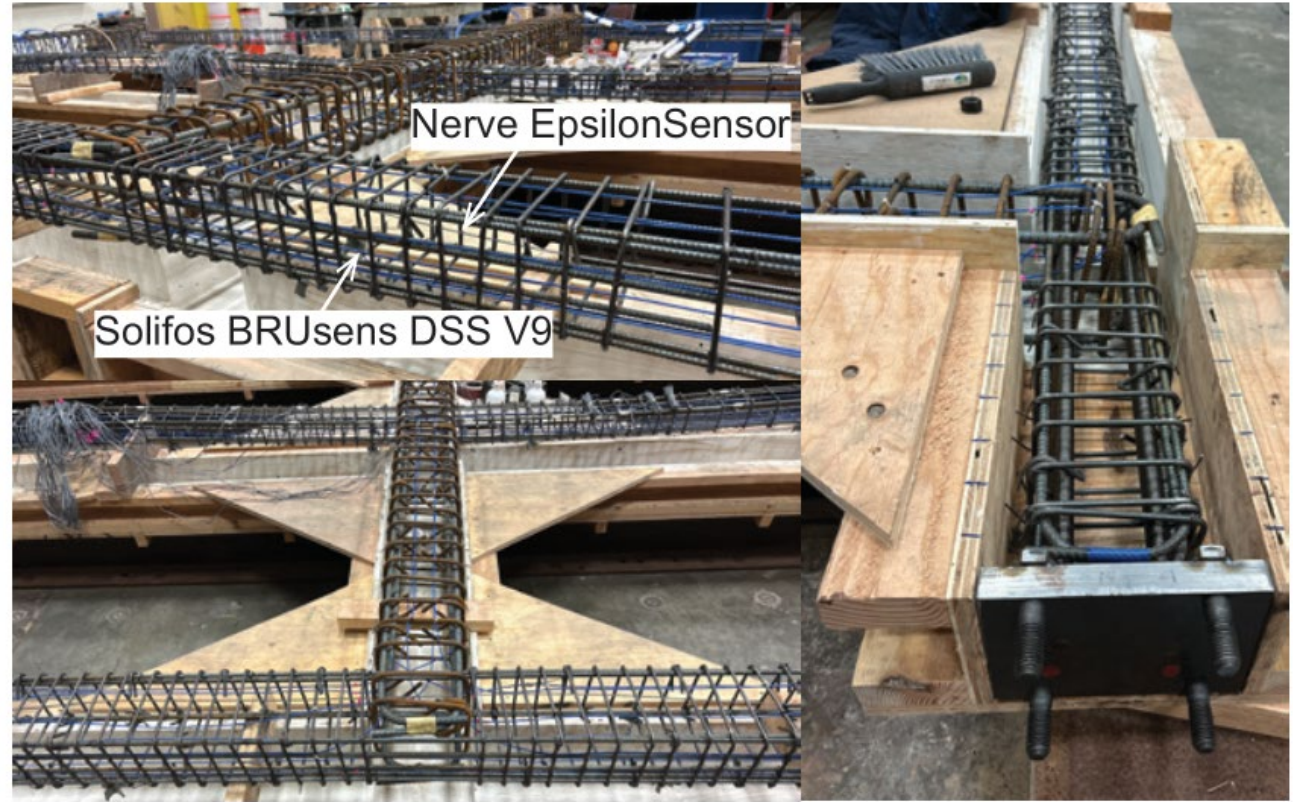
RC Moment Frame Test - Setup



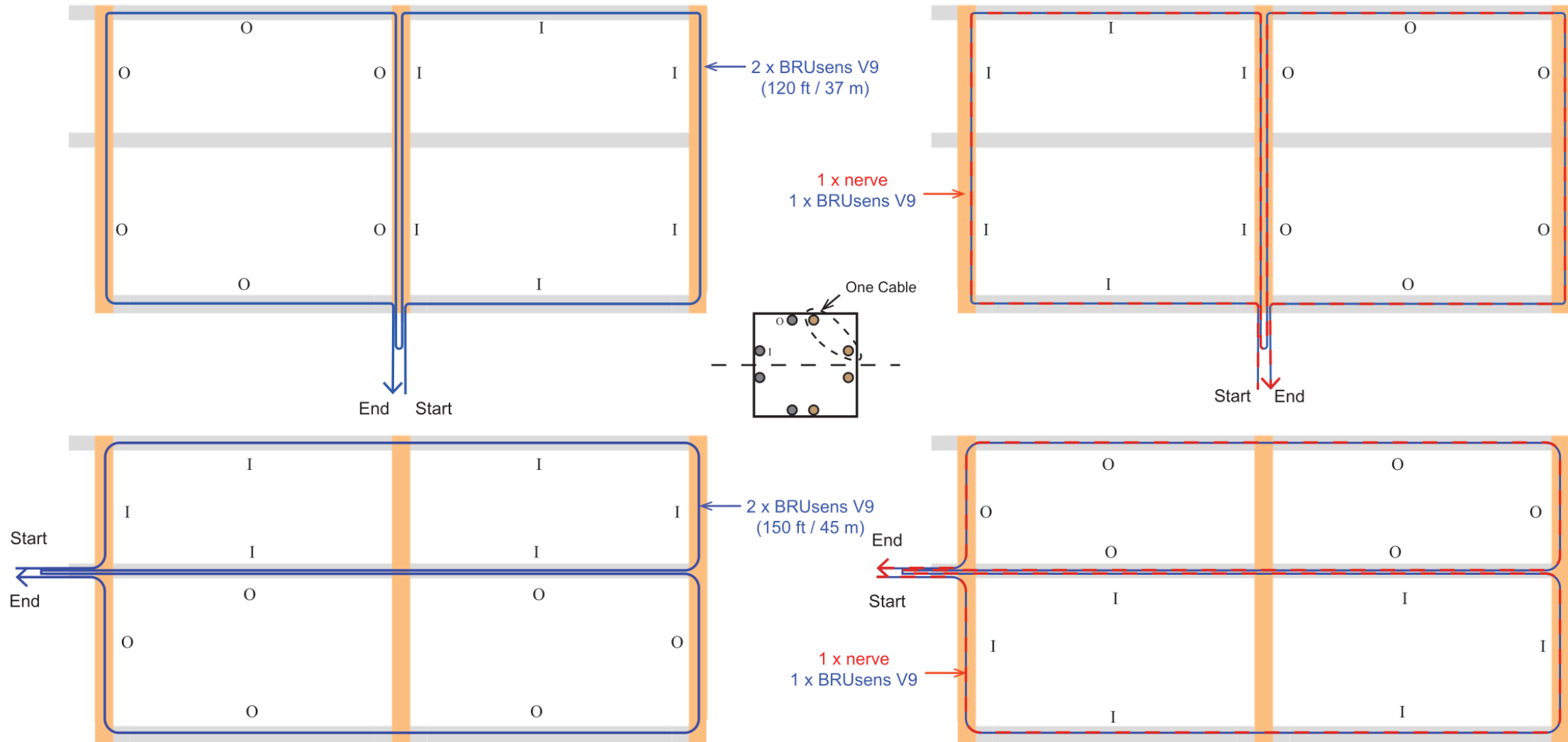
(b)

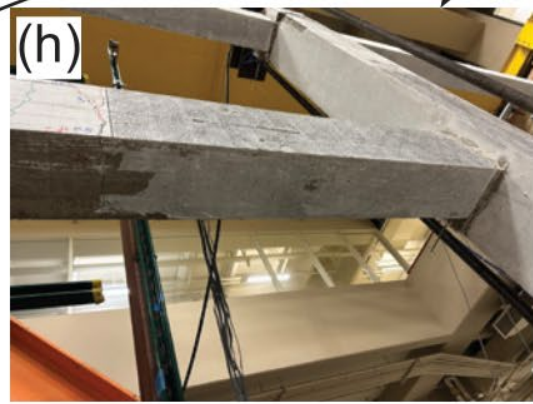
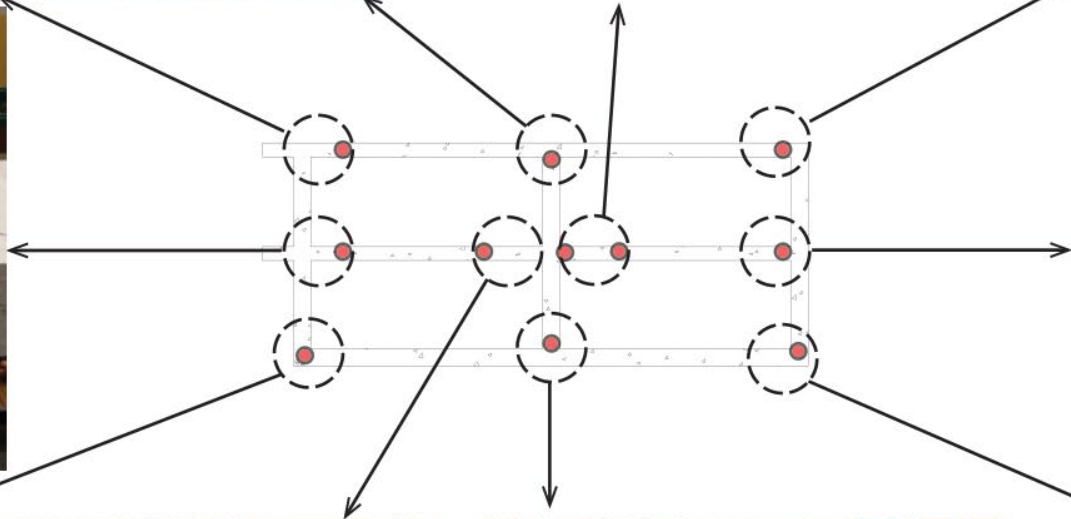
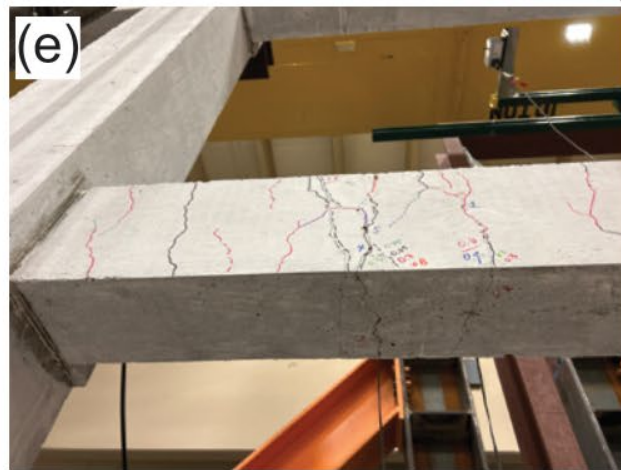
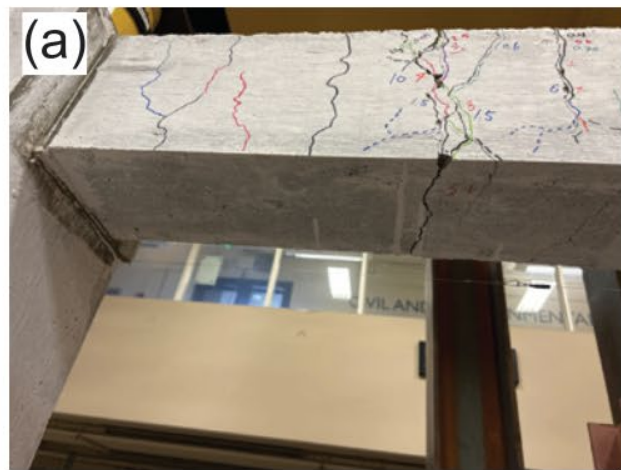


RC Moment Frame Test – Construction



RC Moment Frame Test – Fiber Layout

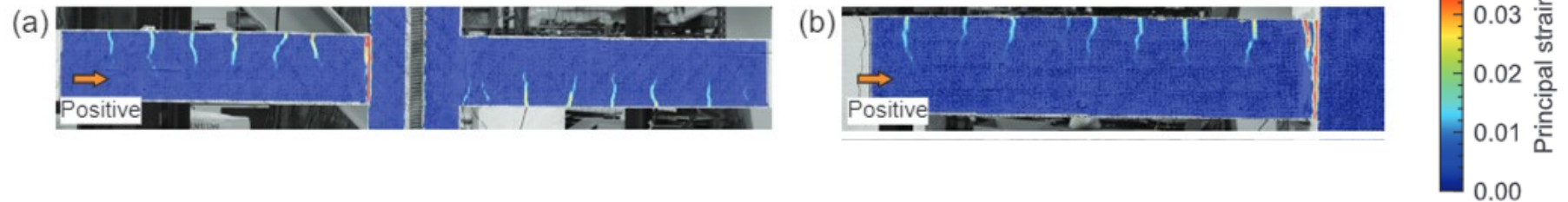
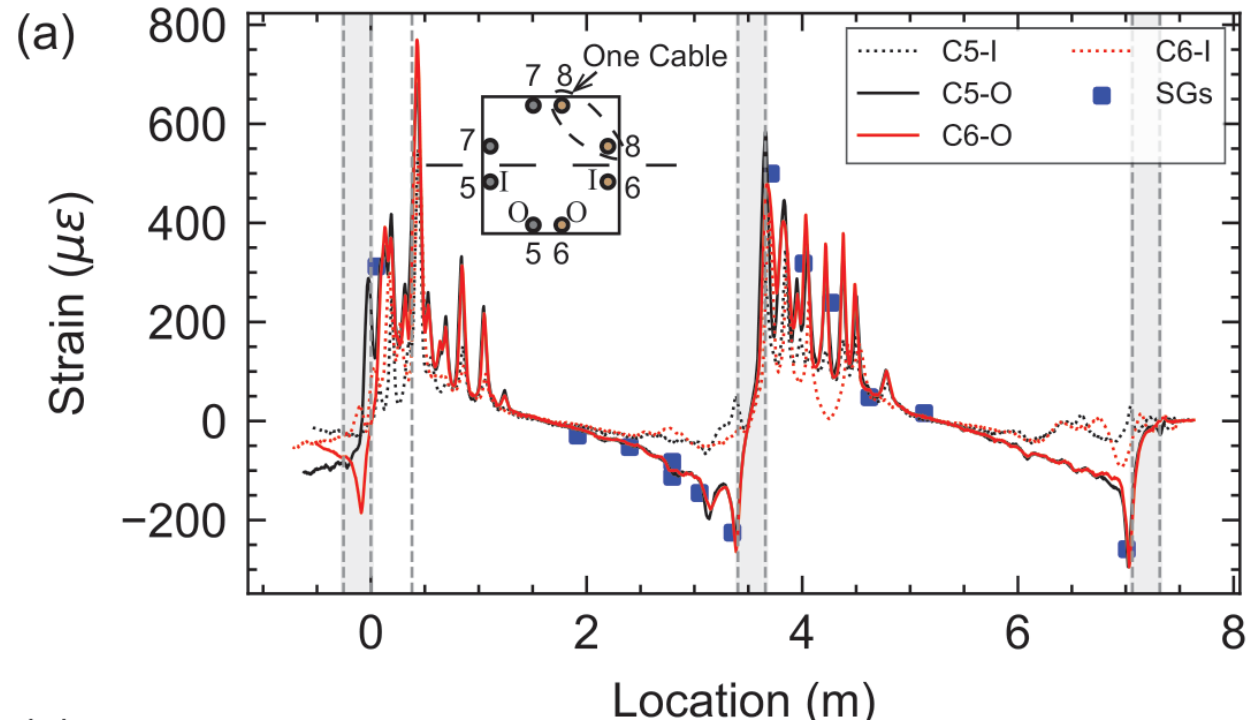
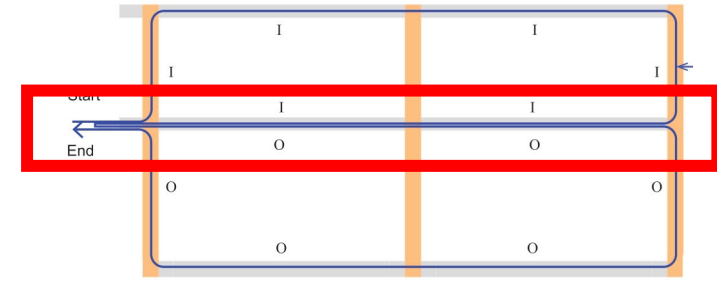




Results

Strain Distribution in Central Beam @ Peak Loads

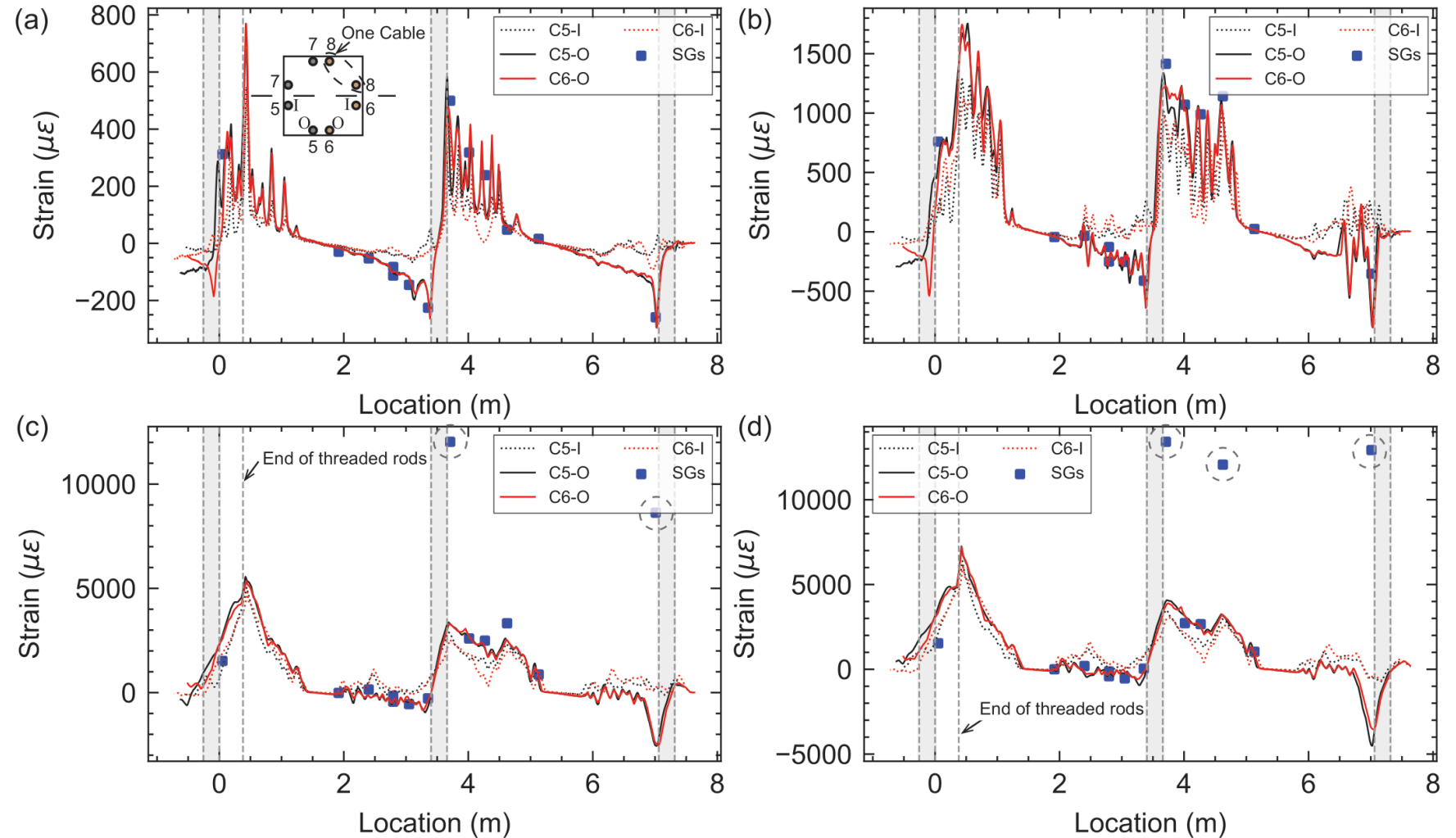
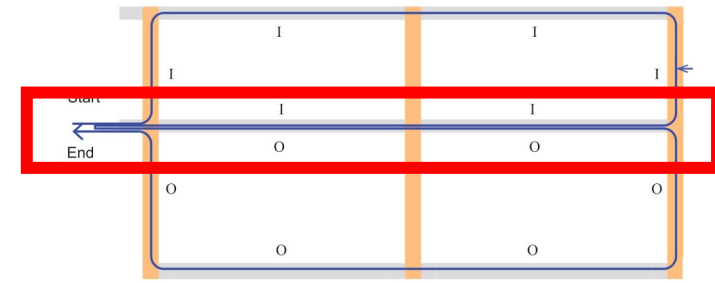
(a) 0.2%



Results

Strain Distribution in Central Beam @ Peak Loads

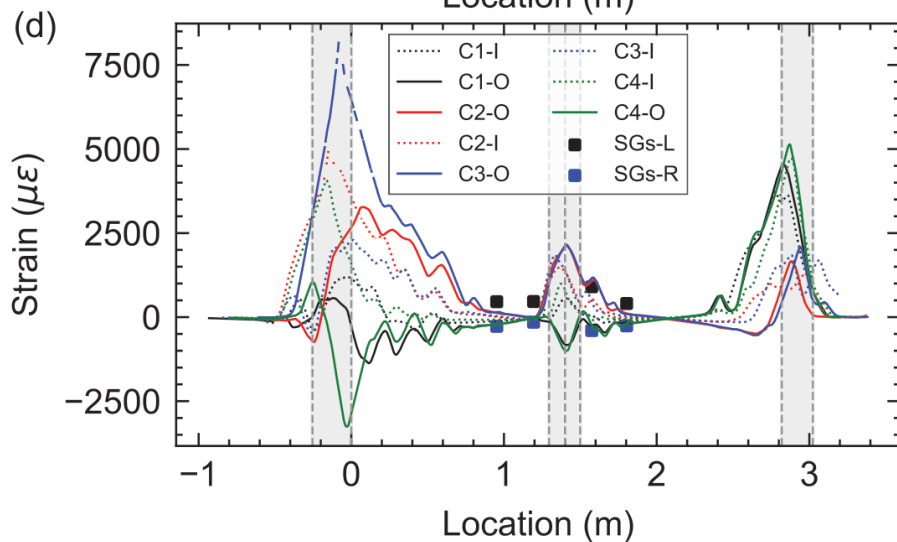
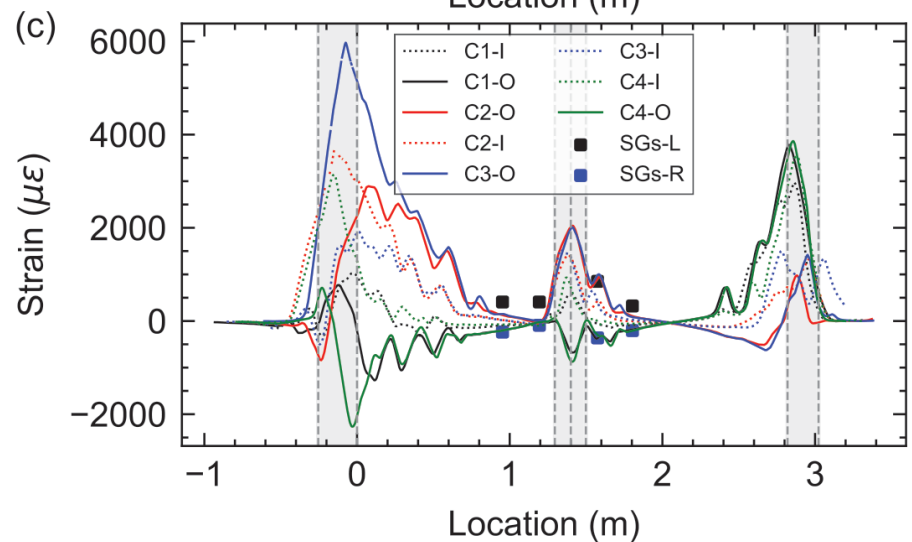
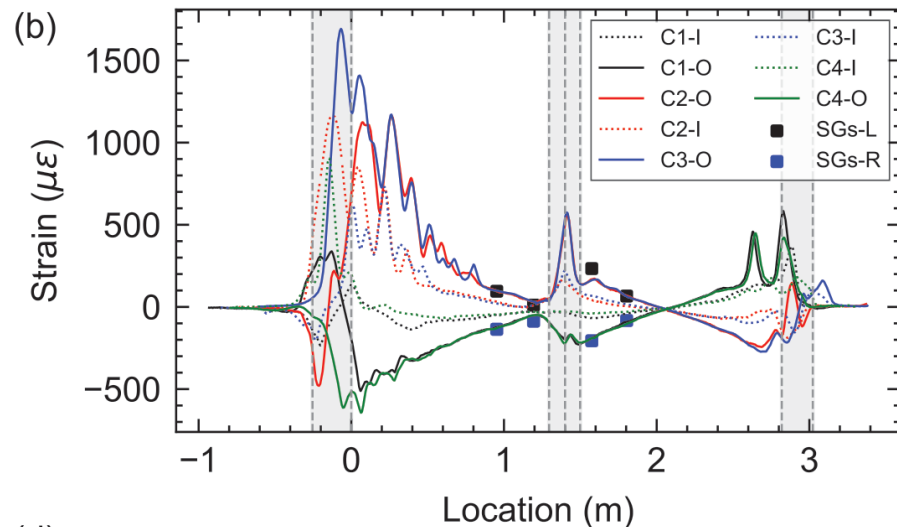
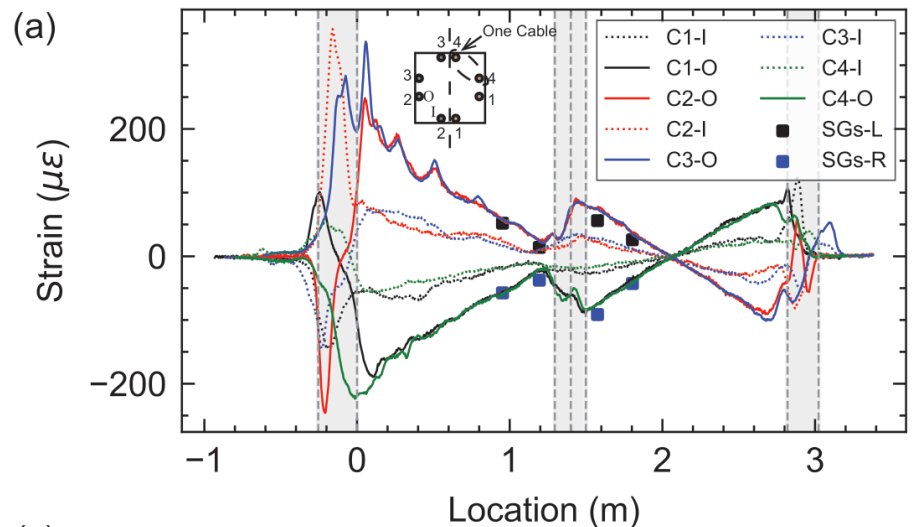
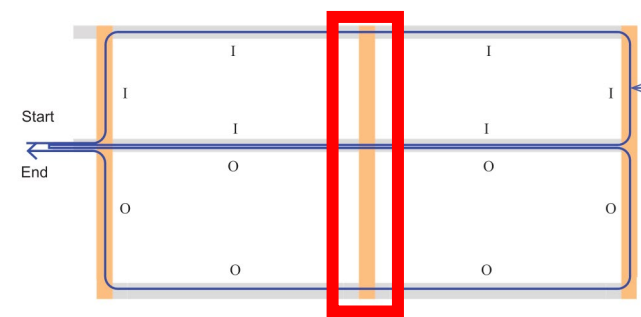
- (a) 0.2%
- (b) 0.7%
- (c) 2.1%
- (d) 2.6%



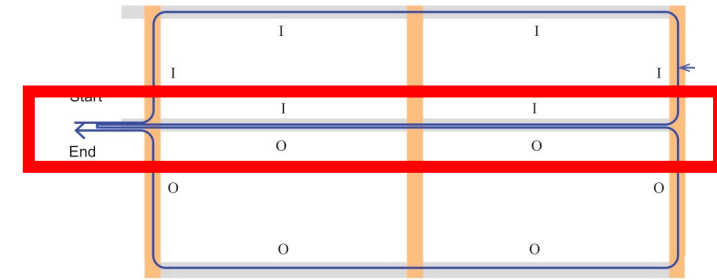
Results

Strain Distribution in Central Column @ Peak Loads

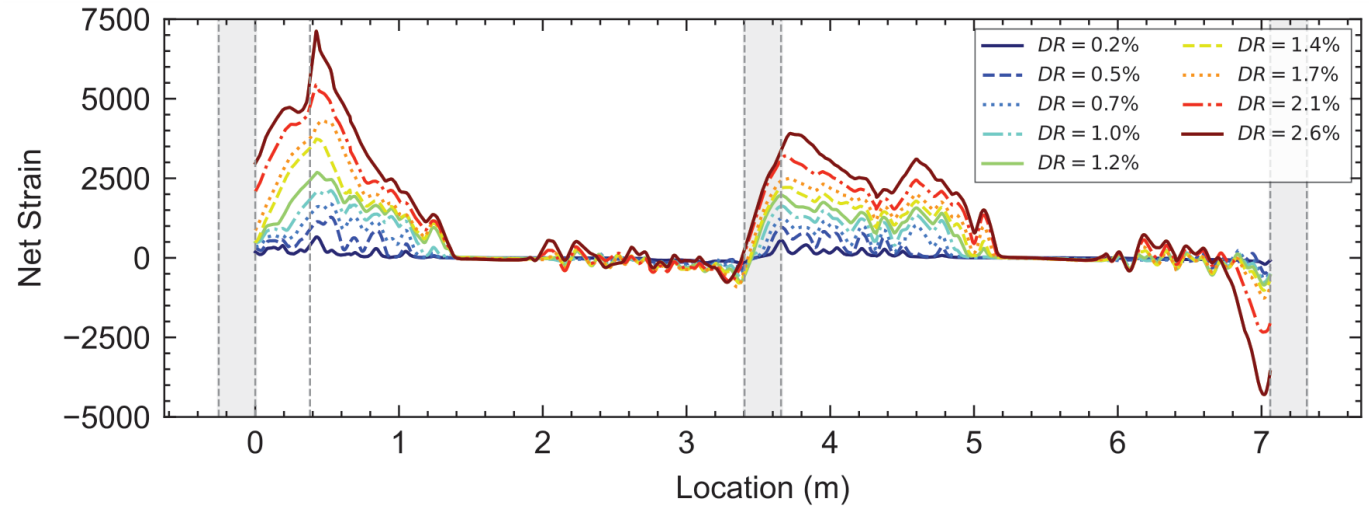
- (a) 0.2%
- (b) 0.7%
- (c) 2.1%
- (d) 2.6%



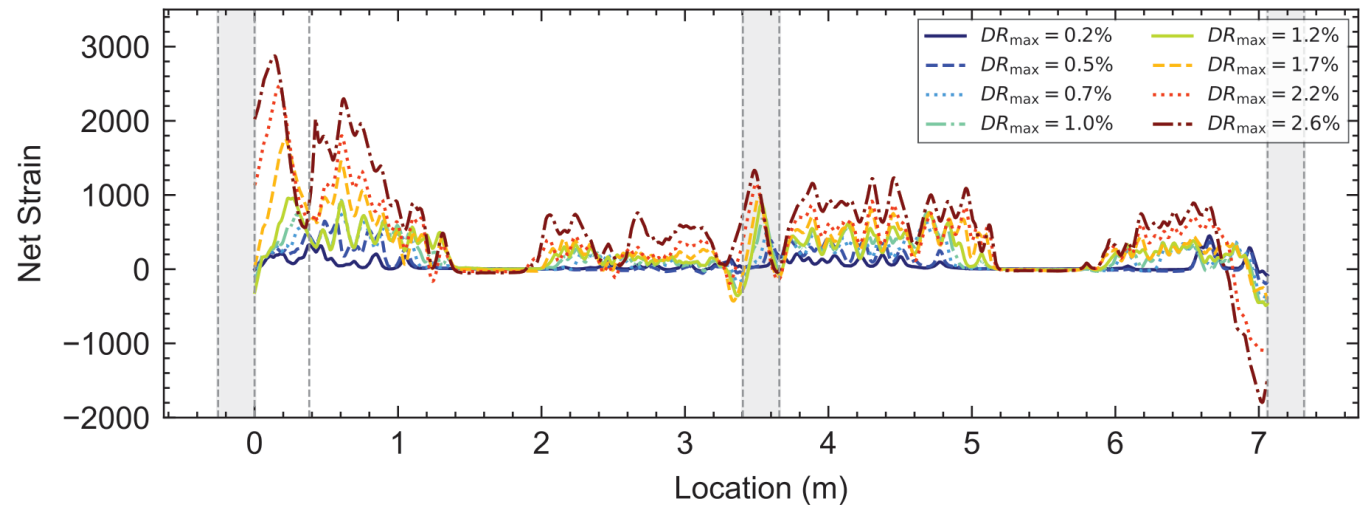
Results



Net Peak Strain Distribution
in Central Beam
(elastic strain subtracted)



Residual Strain Distribution
in Central Beam



Conclusions

- FOS effective for measuring
 - crack opening (through deaggragation)
 - Different FOS cables need calibration
 - detailed damage progression
 - post-earthquake damage level from residual distributed strain
 - Connect and measure post-earthquake
 - Detailed evaluation of epoxy retrofit effectiveness

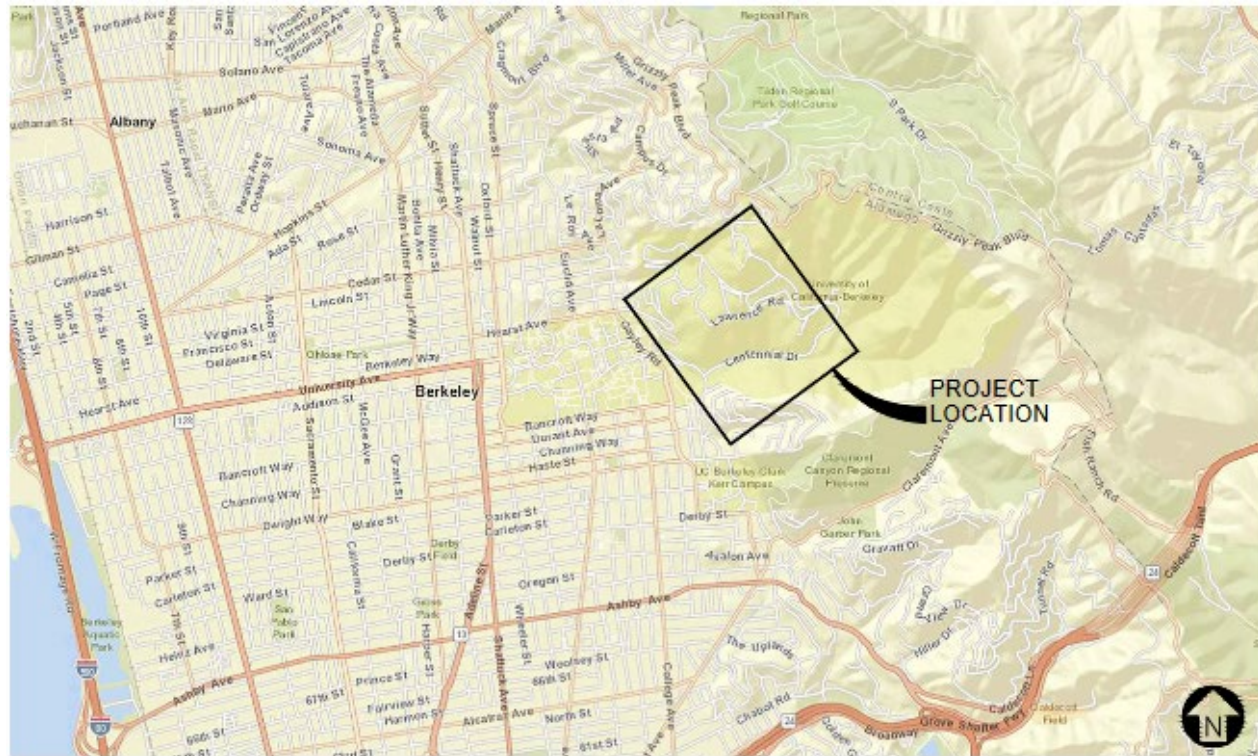
Part 2: Service Load performance assessment



Motivation

Evaluate use of fiber optics for quantifying real service loads and structural performance (+ future post-eq seismic performance)

Centennial Viaduct

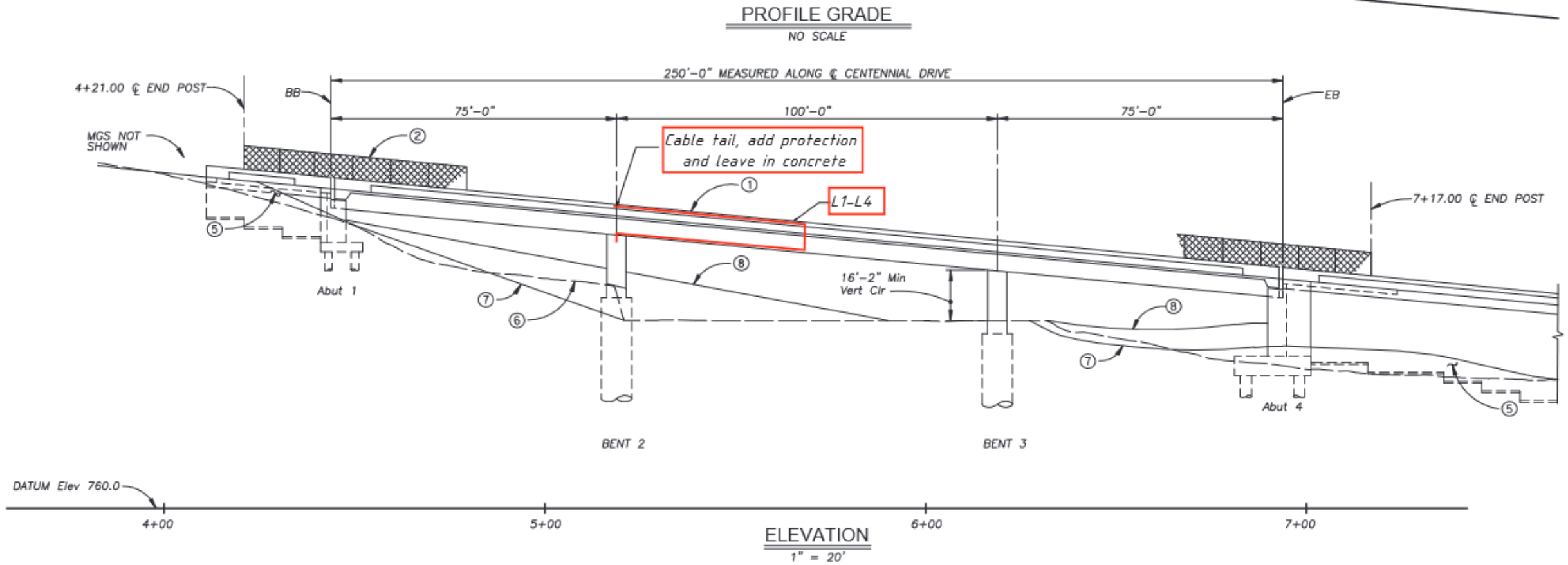


VICINITY MAP
SCALE: N.T.S.

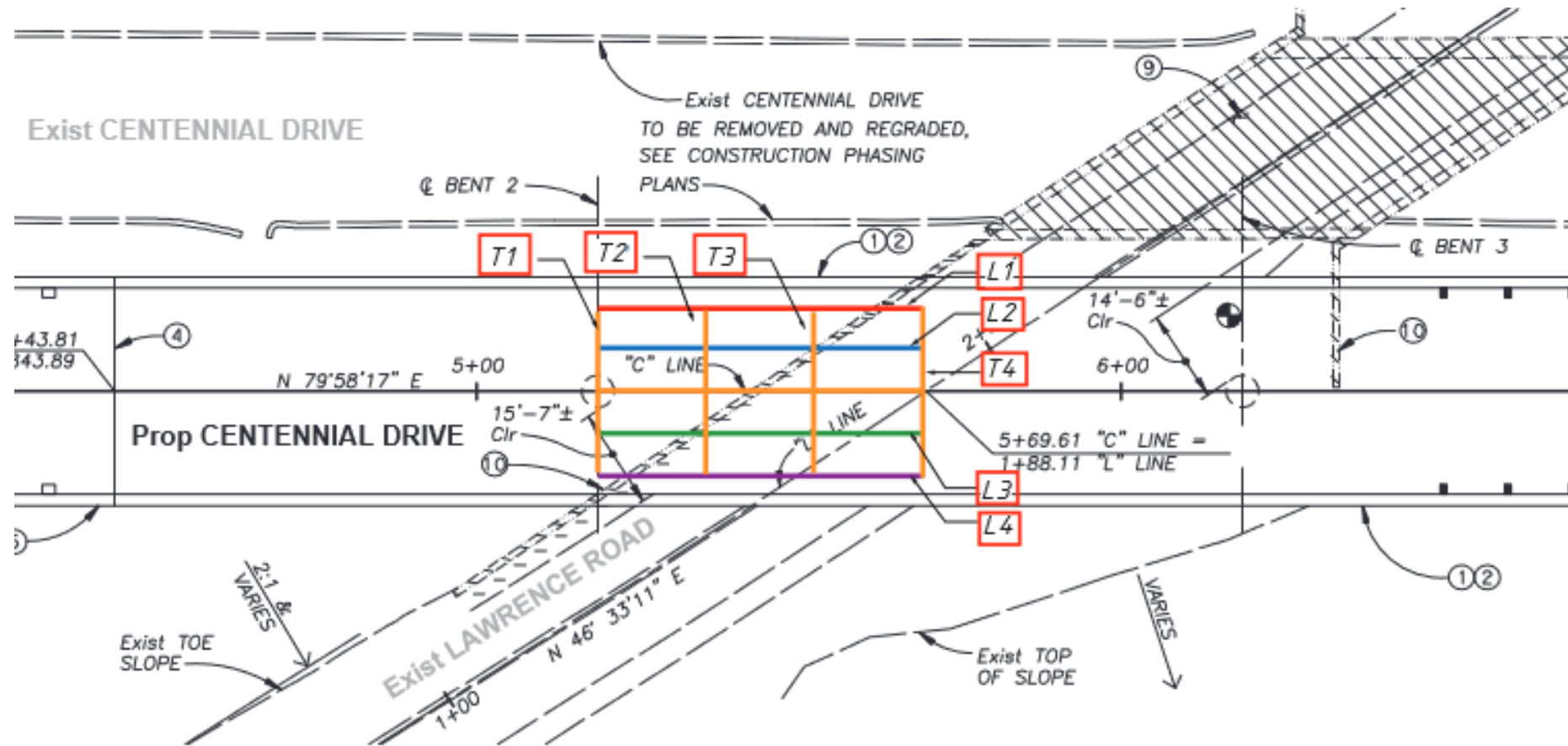


LOCATION MAP
SCALE: N.T.S.

FO sensing plan - deck



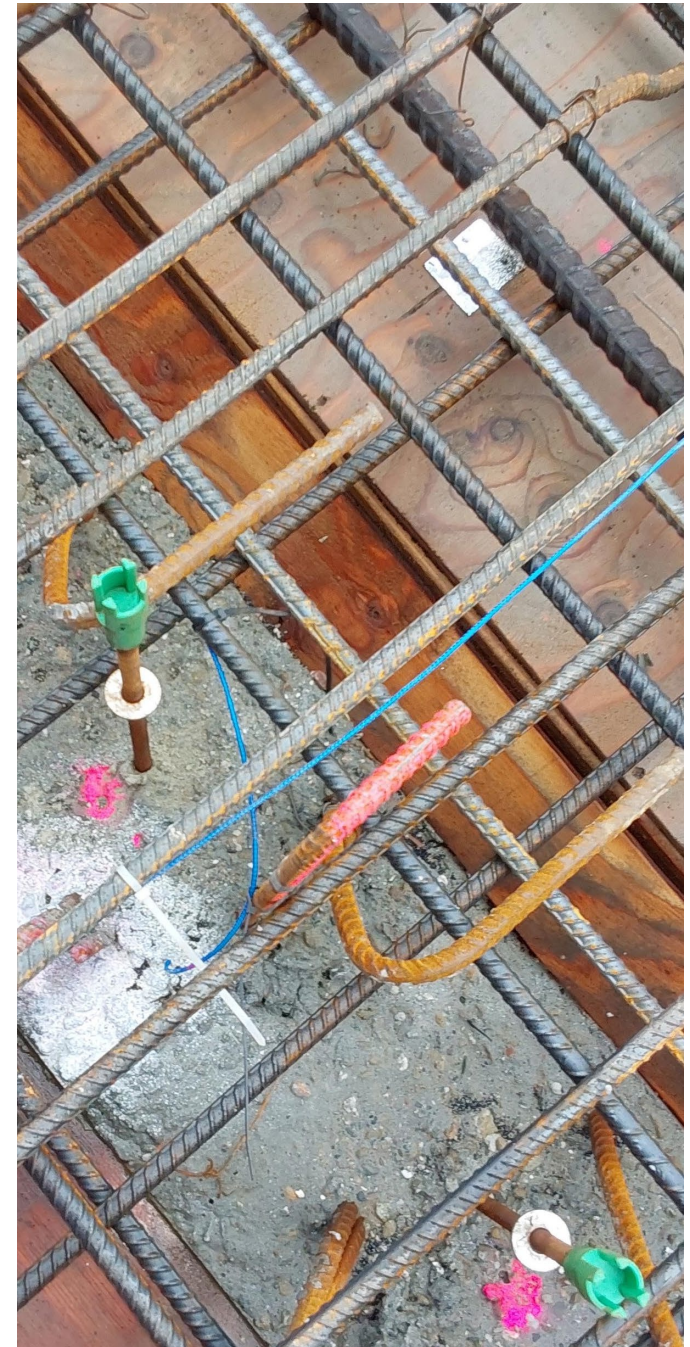
FO sensing plan - deck



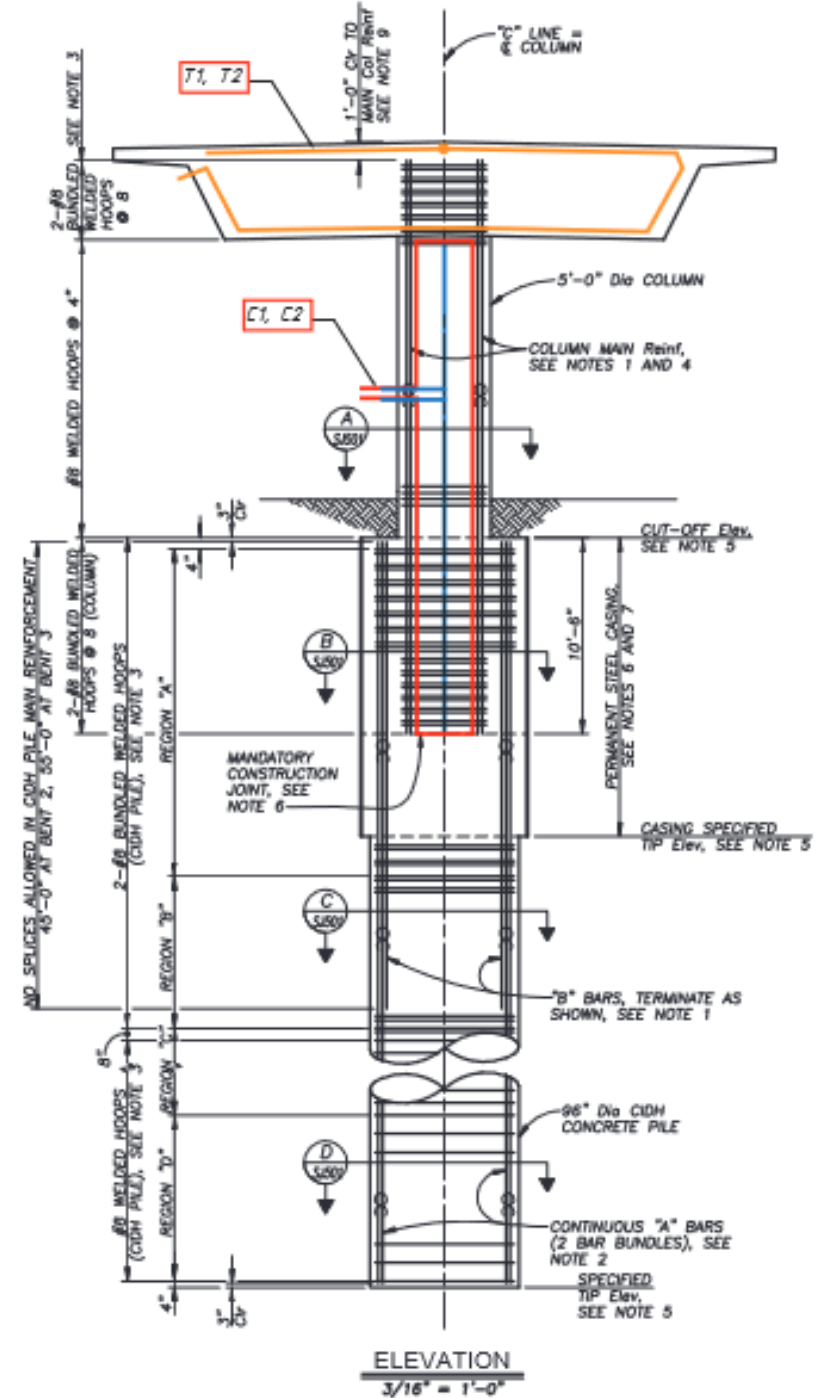
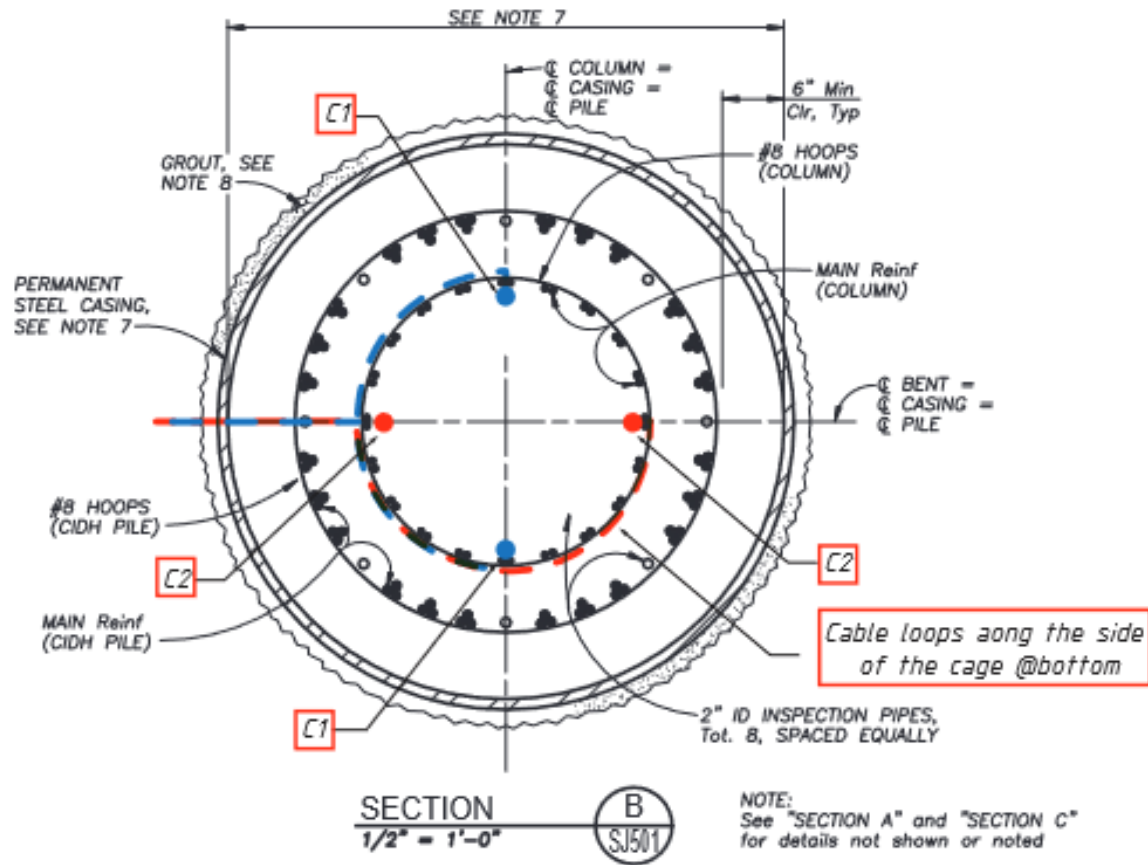
PLAN
1" = 20'



FO cables embedded in deck



FO sensing plan - columns

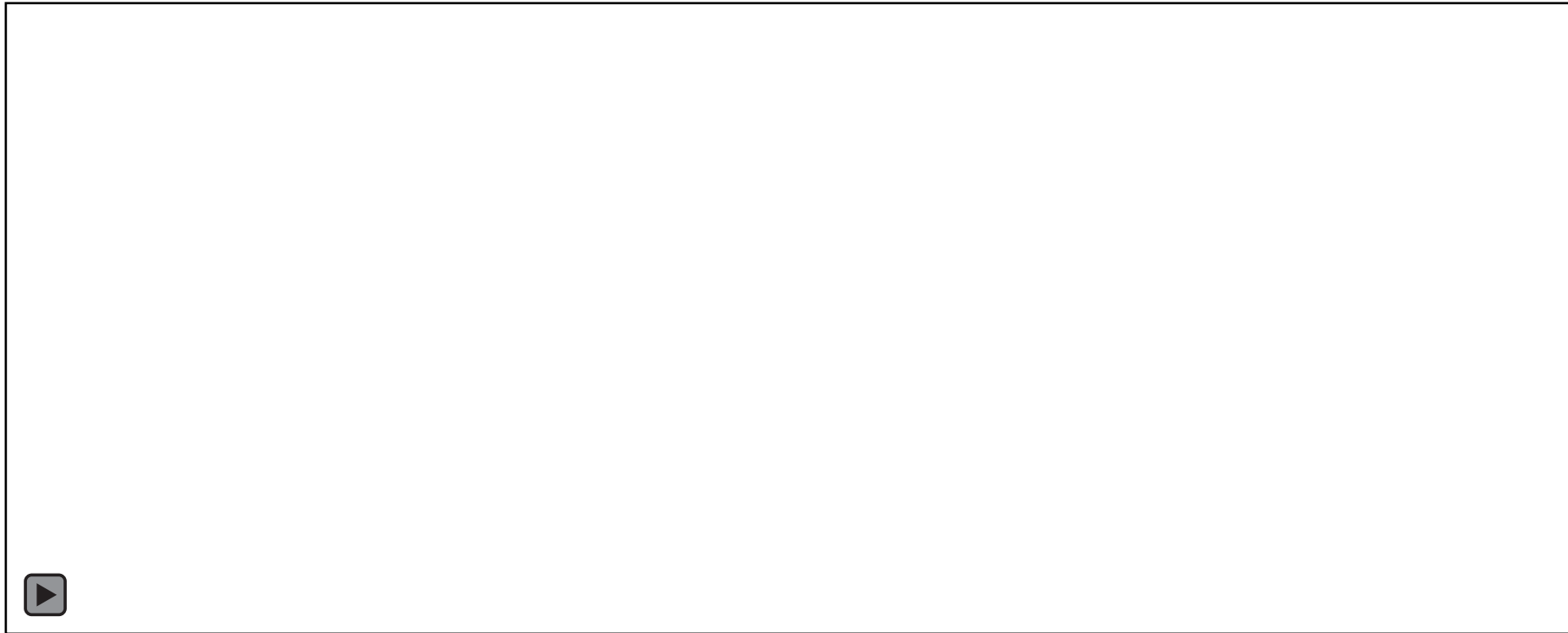
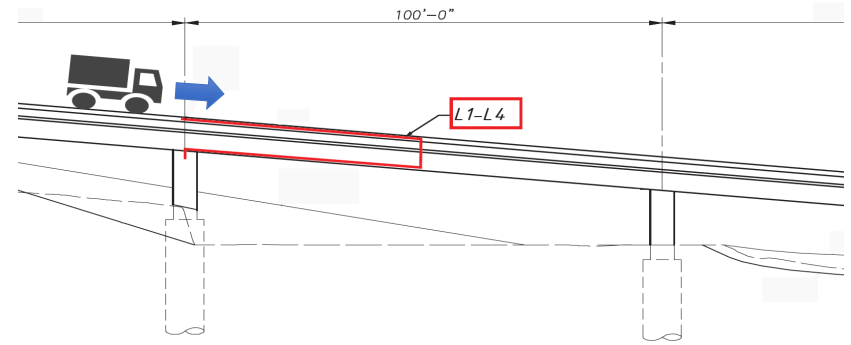




Data collection

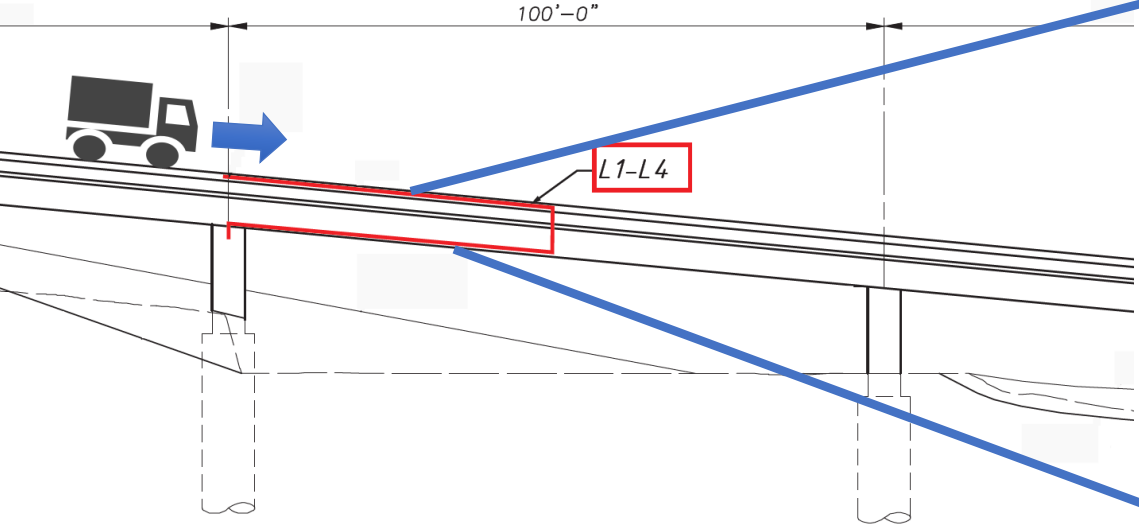


Example measurement

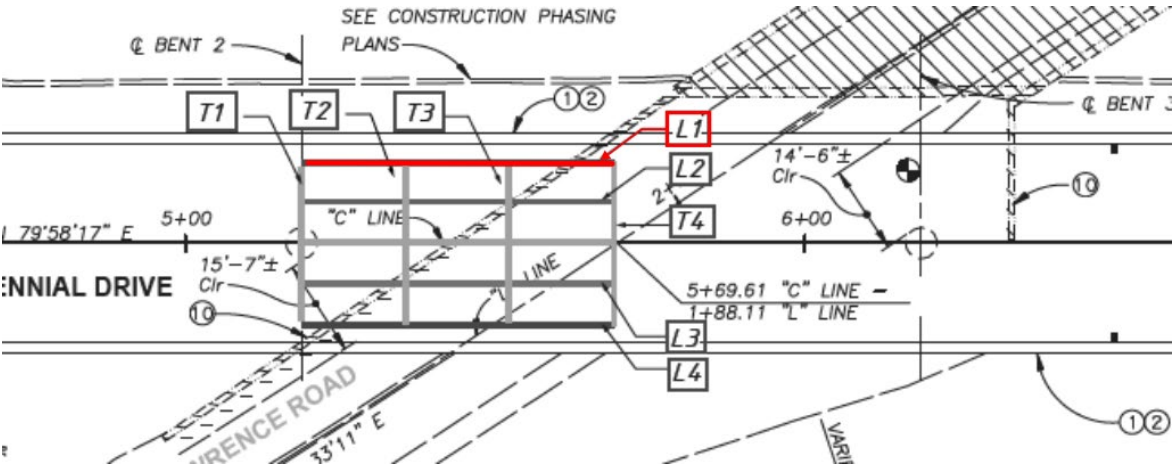


Measurement

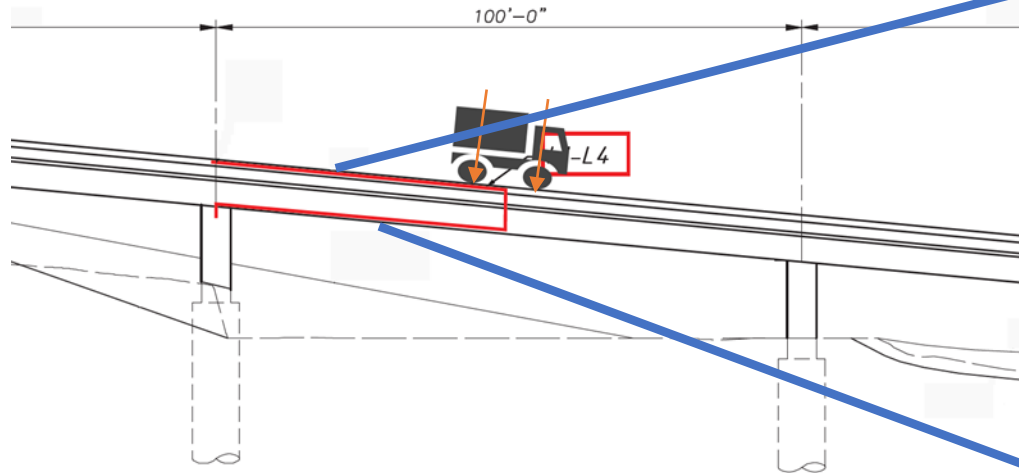
Top cable:



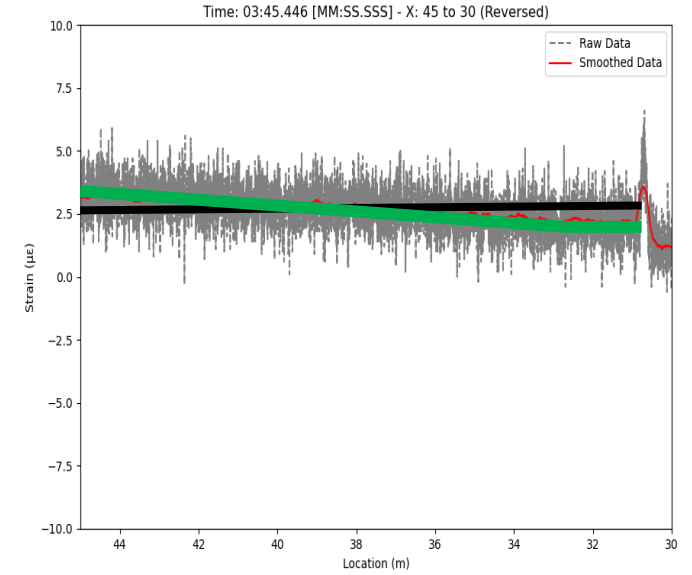
Bottom cable



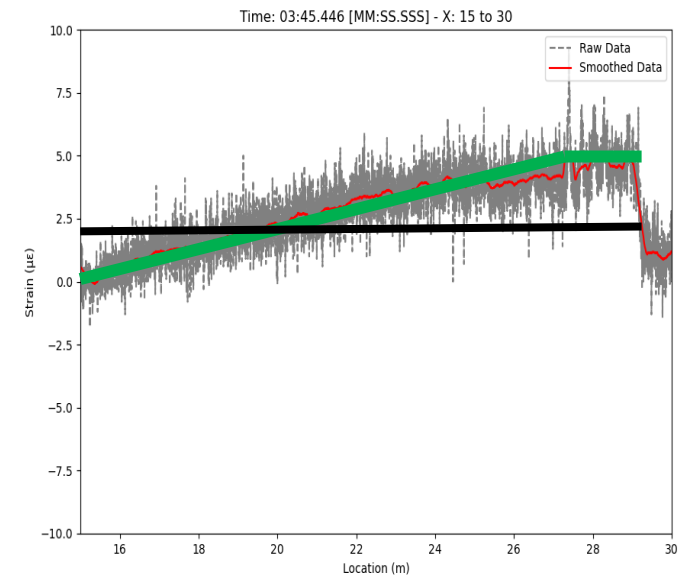
Measurement



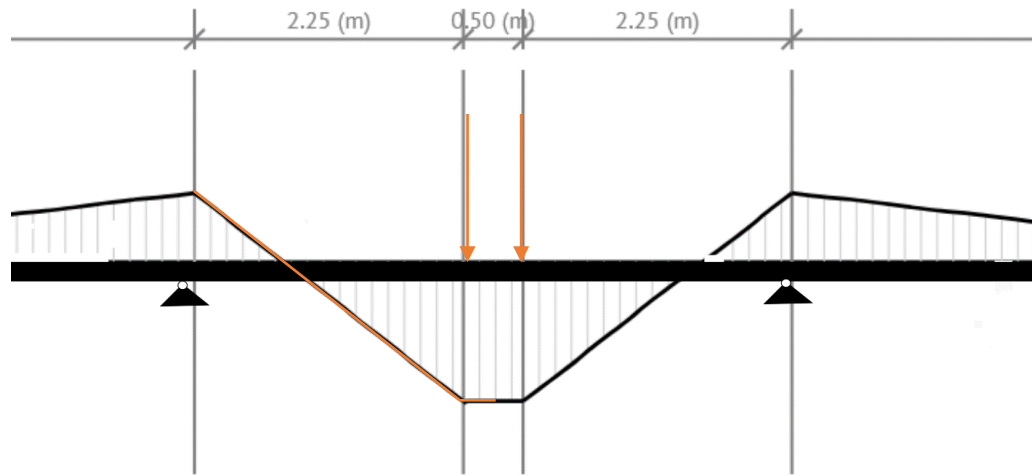
Top cable:



Bottom cable:



Moment diagram:



Future work

- Data collection
- Automated data interpretation
- Characterization of load distribution
- Computational modeling
- Weight in motion
- (Post-eq assessment)

