



## Photogrammetric Assessment of Flexure Induced Cracking of Reinforced Concrete Beams under Service Loads

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# Photogrammetric Assessment of Flexural Induced Cracking in Reinforced Concrete Beams under Service Loads

Brad Pease, Mette Geiker,  
Henrik Stang, and Jason Weiss

2<sup>ND</sup> International RILEM Symposium,  
September 11-13, 2006

# Outline of Today's Talk

- Motivation & Goal
- Experimental Investigation
  - Sample Geometry
  - Three-Dimensional Photogrammetry Technique
- Test Results
  - Crack Geometry
  - Crack Measurements
- Conclusions



# Outline of Today's Talk

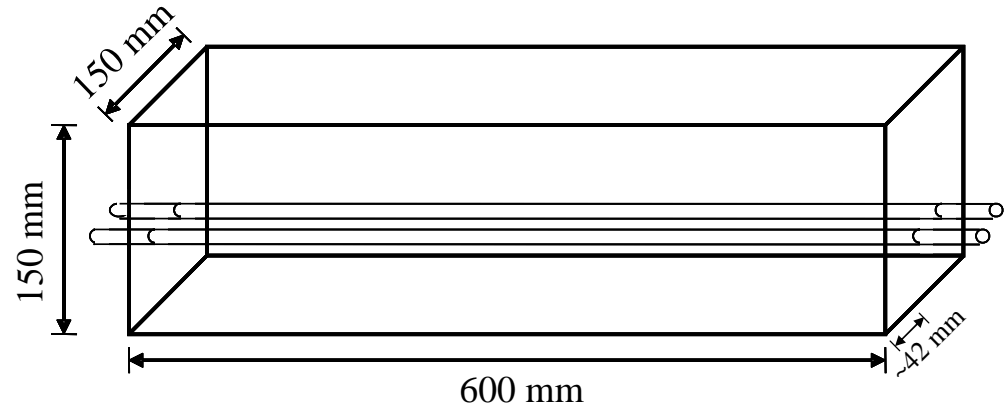
- Motivation & Goal
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# Motivation and Goal

- Motivation
  - Cracking in concrete affects ingress and corrosion (i.e. service life)
  - Cracking in reinforced concrete is complicated by slip and separation at reinforcing bar
- Goal
  - Quantify crack geometry in reinforced concrete beam during loading

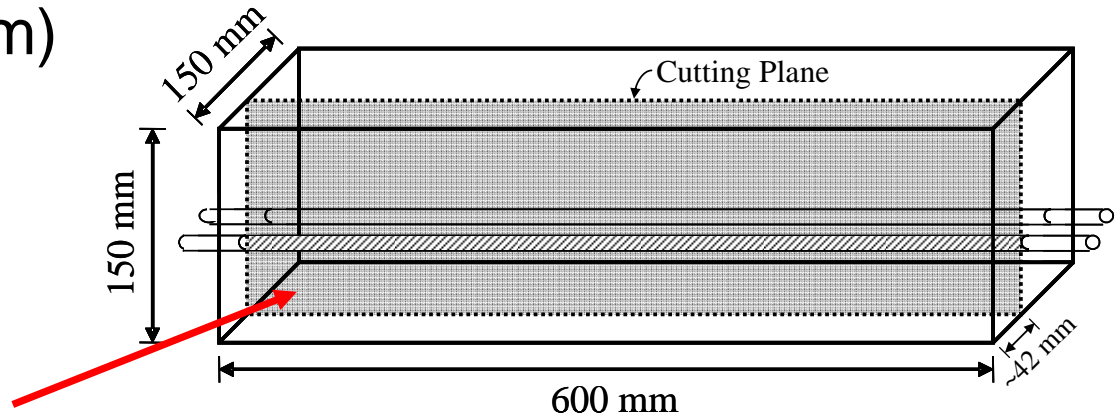
# Experimental Observation of Cracks: Sample Geometry and Loading

- Reinforced beams  
(150 x 150 x 600 mm)



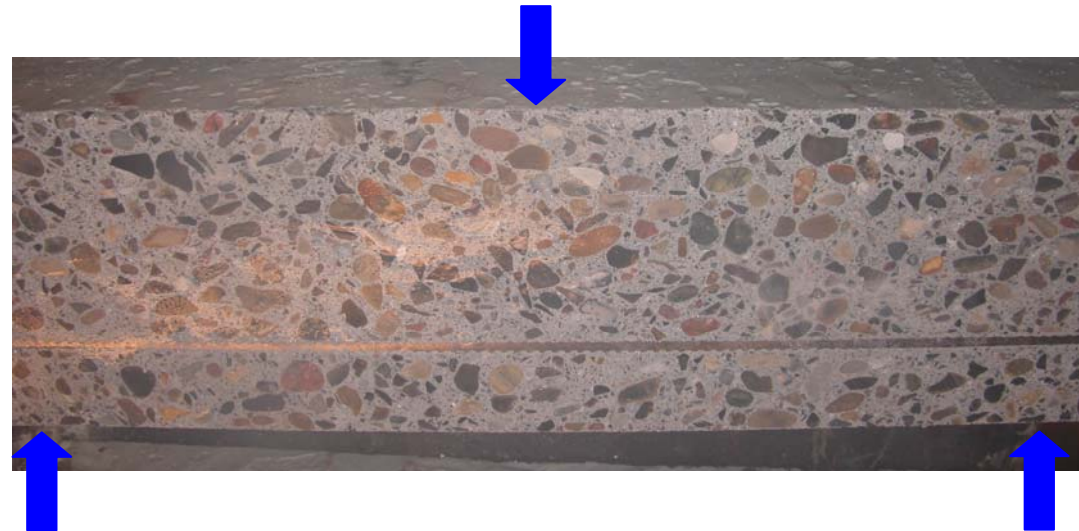
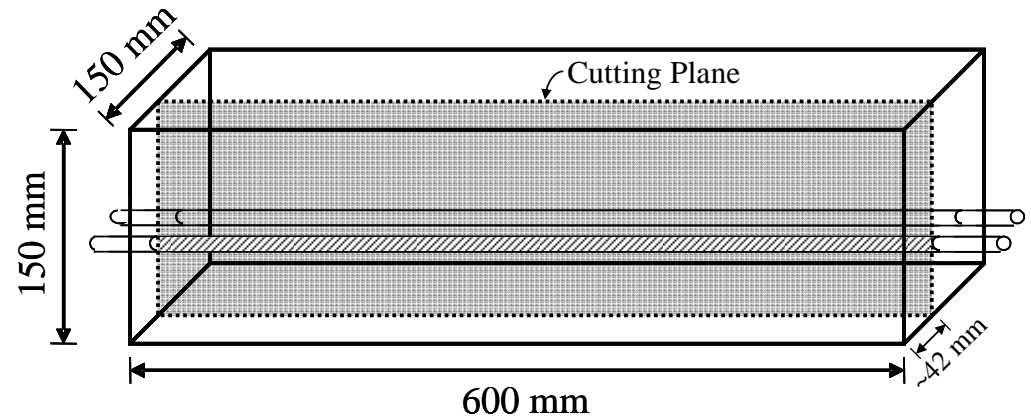
# Experimental Observation of Cracks: Sample Geometry and Loading

- Reinforced beams (150 x 150 x 600 mm)
- Face of concrete removed
- Exposed reinforcement and aggregate



# Experimental Observation of Cracks: Sample Geometry and Loading

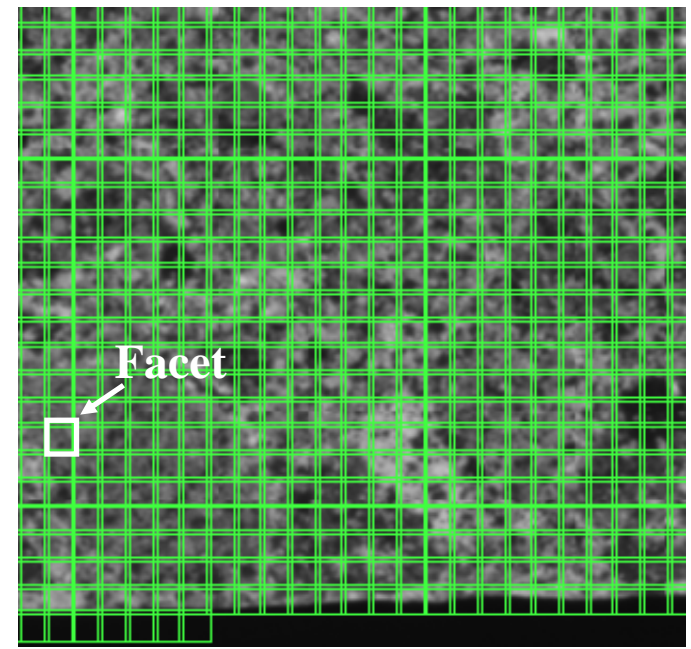
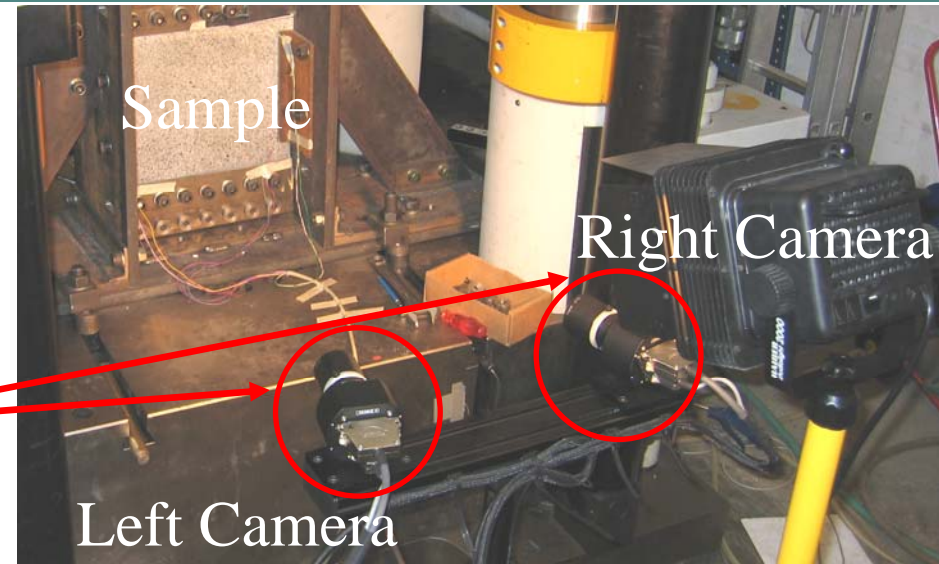
- Reinforced beams (150 x 150 x 600 mm)
- Face of concrete removed
- Exposed reinforcement and aggregate
- 3-Point bending
  - 1.0 and 1.8 times estimated cracking load (13 and 25.2 kN)
  - 35 kN





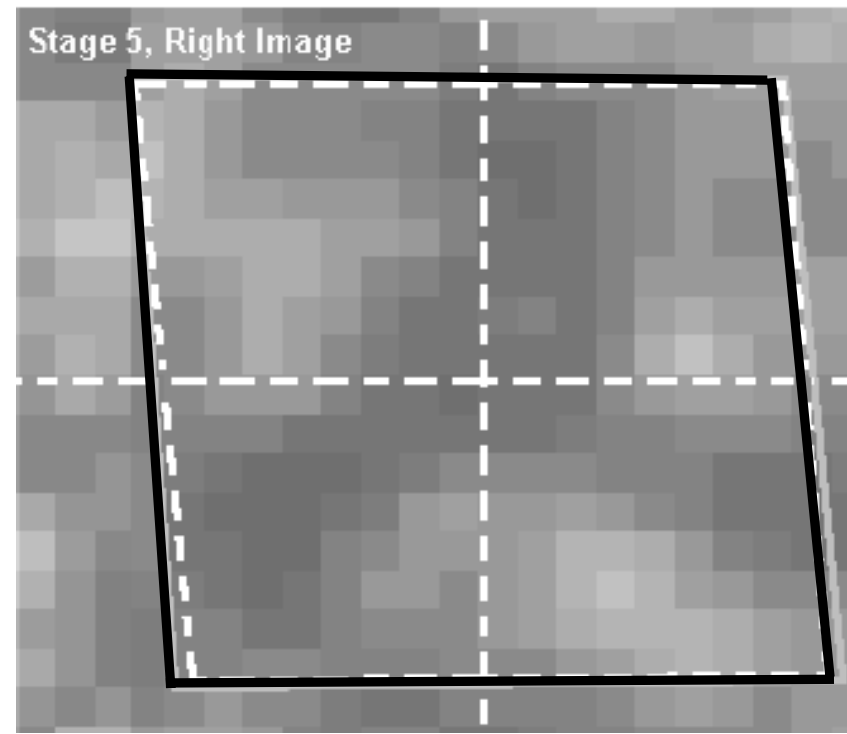
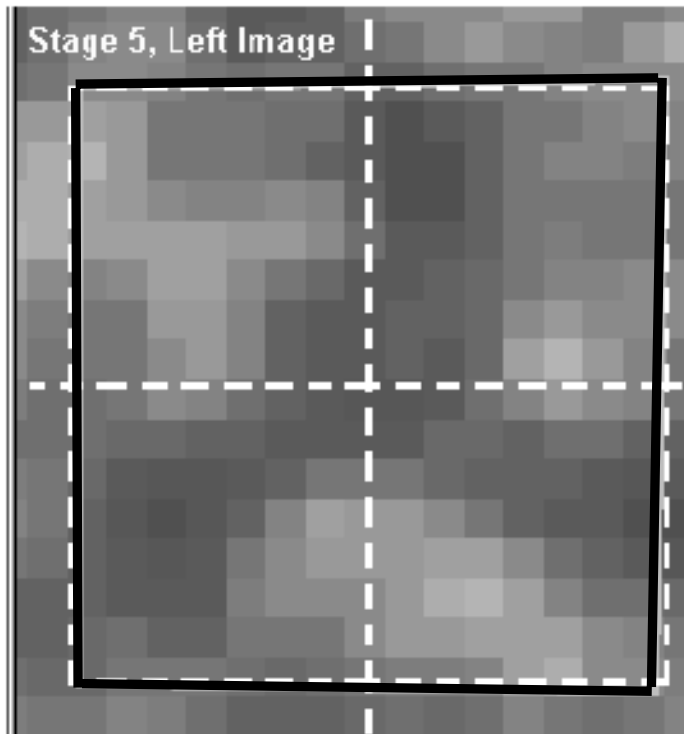
# 3-D Photogrammetry

- Photogrammetry quantifies cracking during loading
- Two digital cameras placed equidistant from sample, focused on same point collect images
- Images separated into a mesh by software
  - Individual mesh box = facet



# 3-D Photogrammetry: General Measurement Process

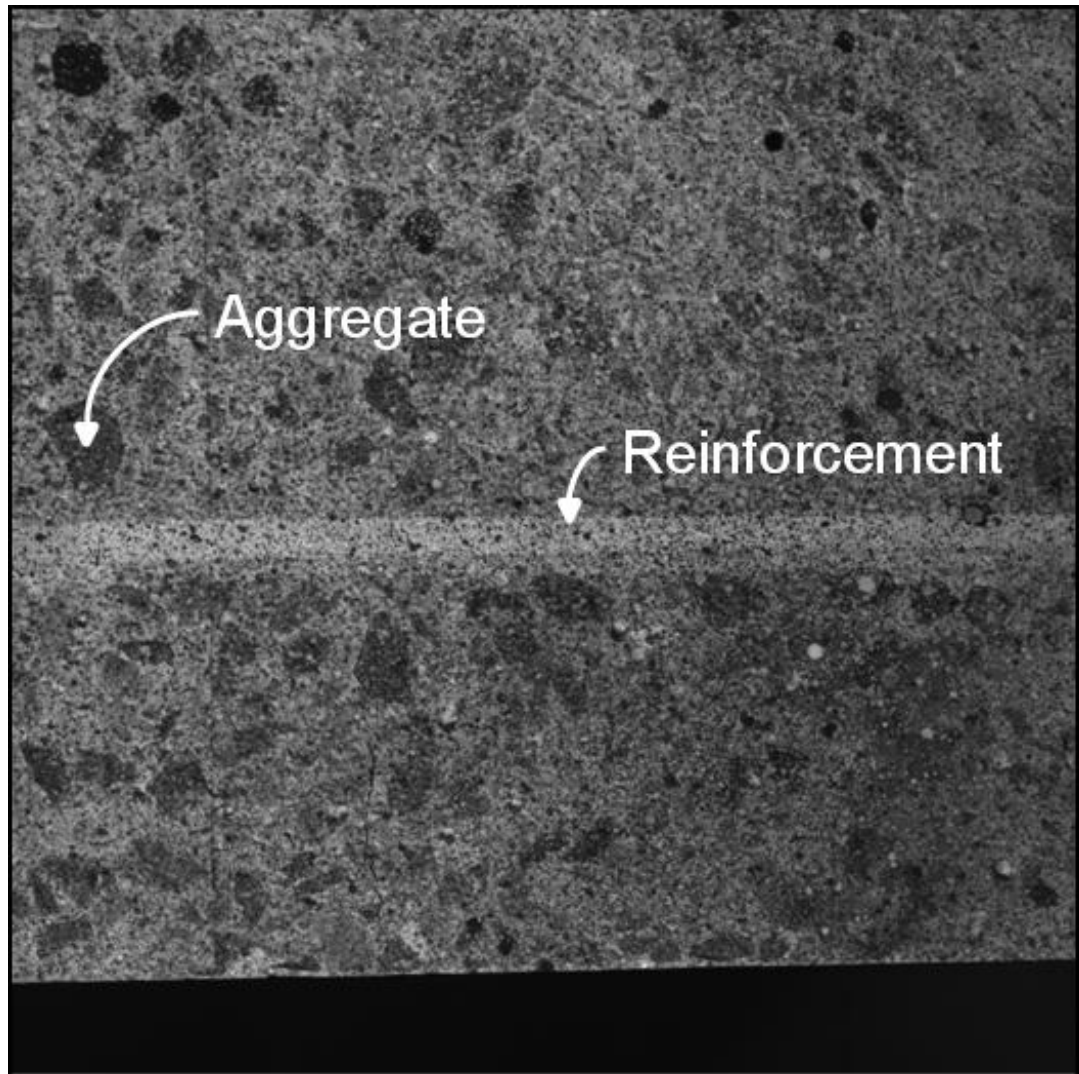
- Coordinates assigned to facet corner and center by grayscale variation
- System tracks movement of facet center and corners



White line – original location  
Black line – deformed shape

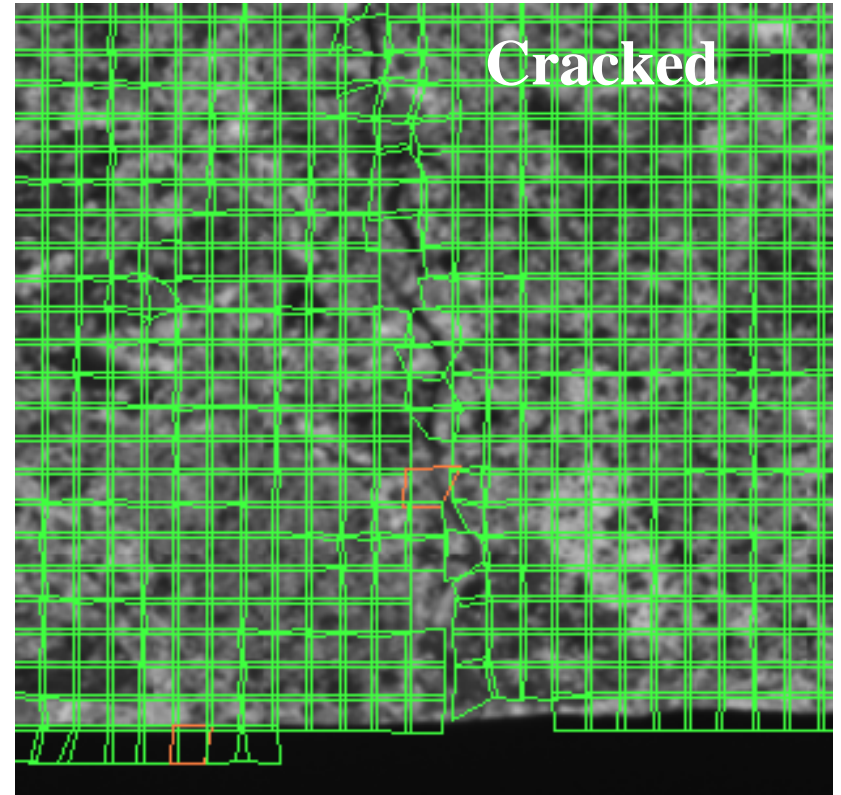
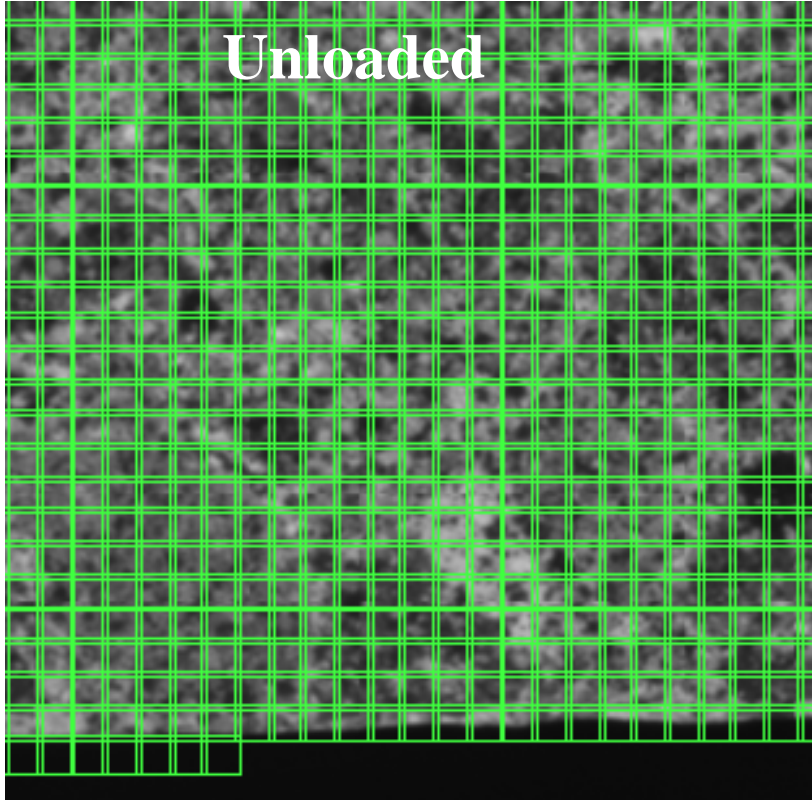
# 3-D Photogrammetry: Surface Preparation

- Grayscale contrast obtained by speckle pattern



# 3-D Photogrammetry: Deformation Measurement

- Sample deformation measured as mesh movements

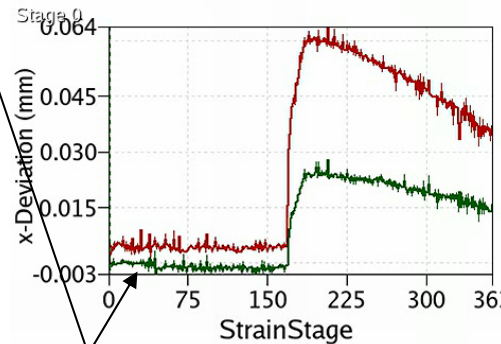


# Outline of Today's Talk

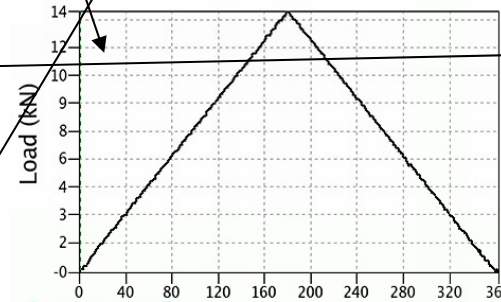
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# 3-D Photogrammetry: Crack Geometry

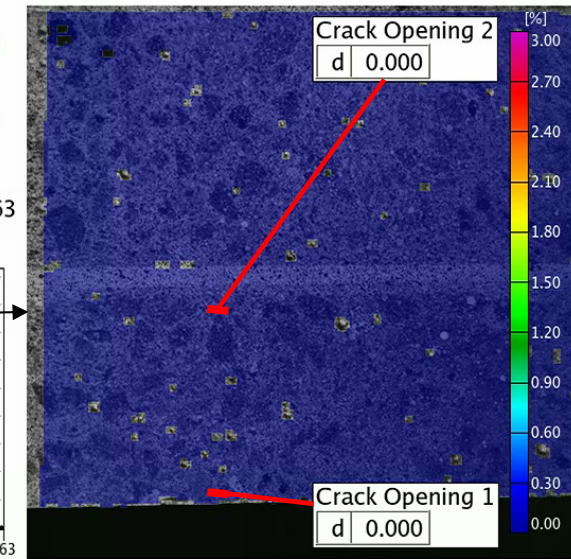
- All beams loaded at constant rate, maximum – 3 min. unloaded – 3 min.
- Video of measured deformation projected on beam surface
- Crack opening measurements from tension face and near reinforcement



— Crack Opening 1: X-Deviation  
— Crack Opening 2: X-Deviation



Actual stage 0

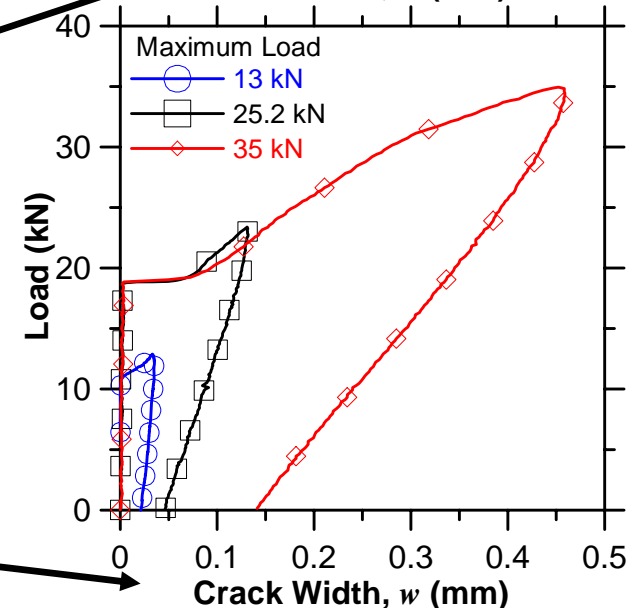
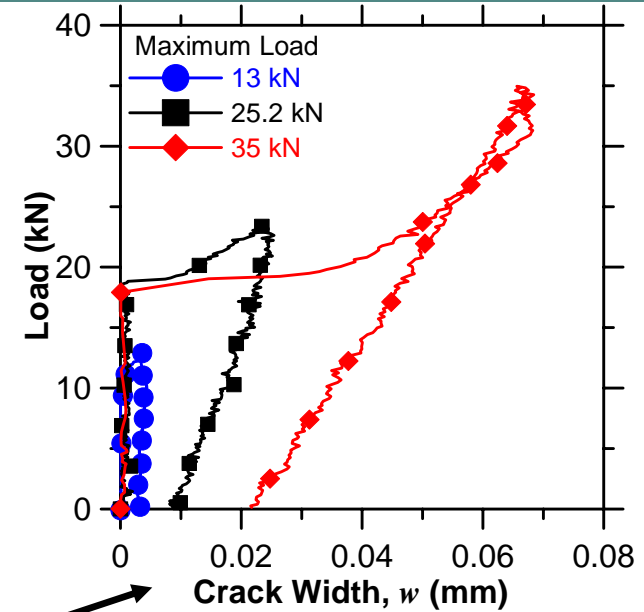
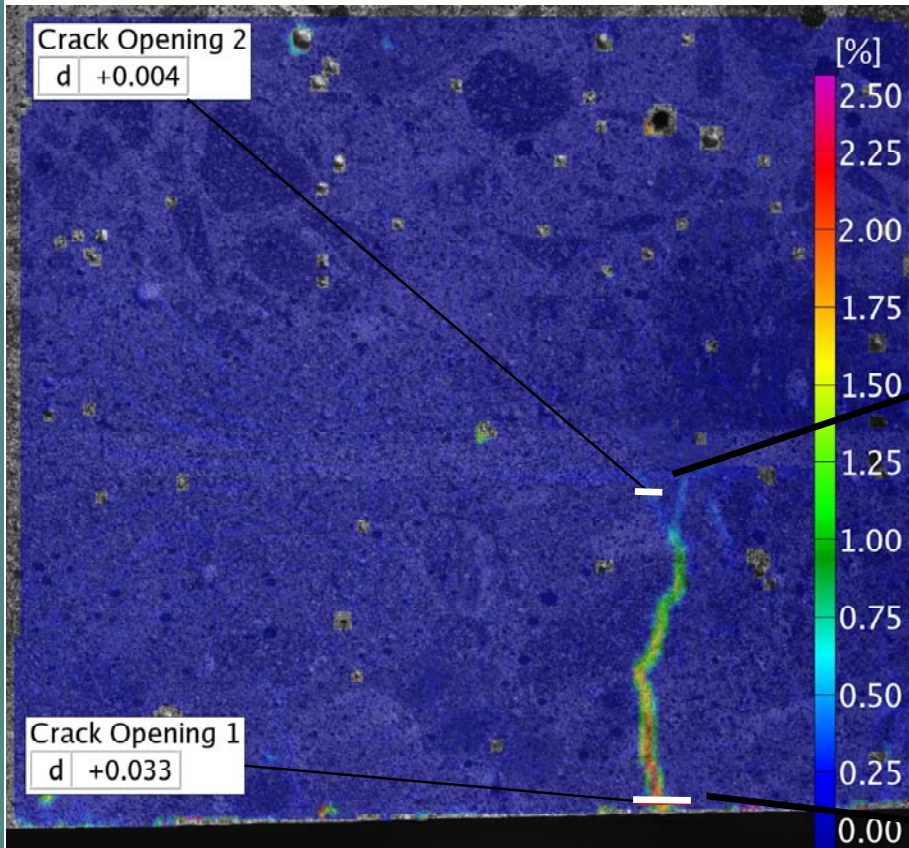


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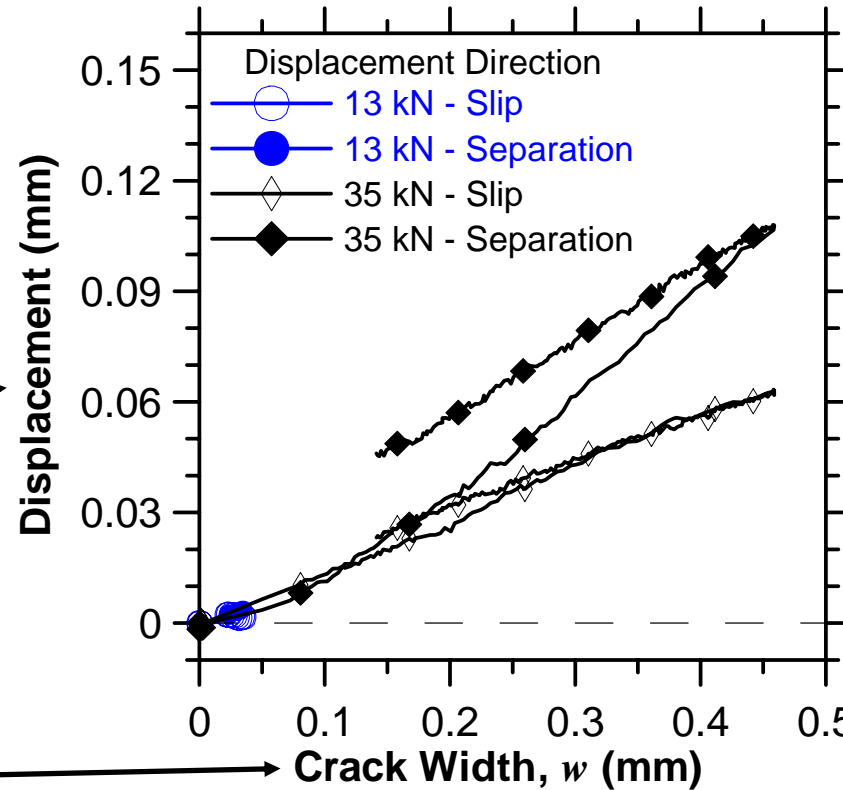
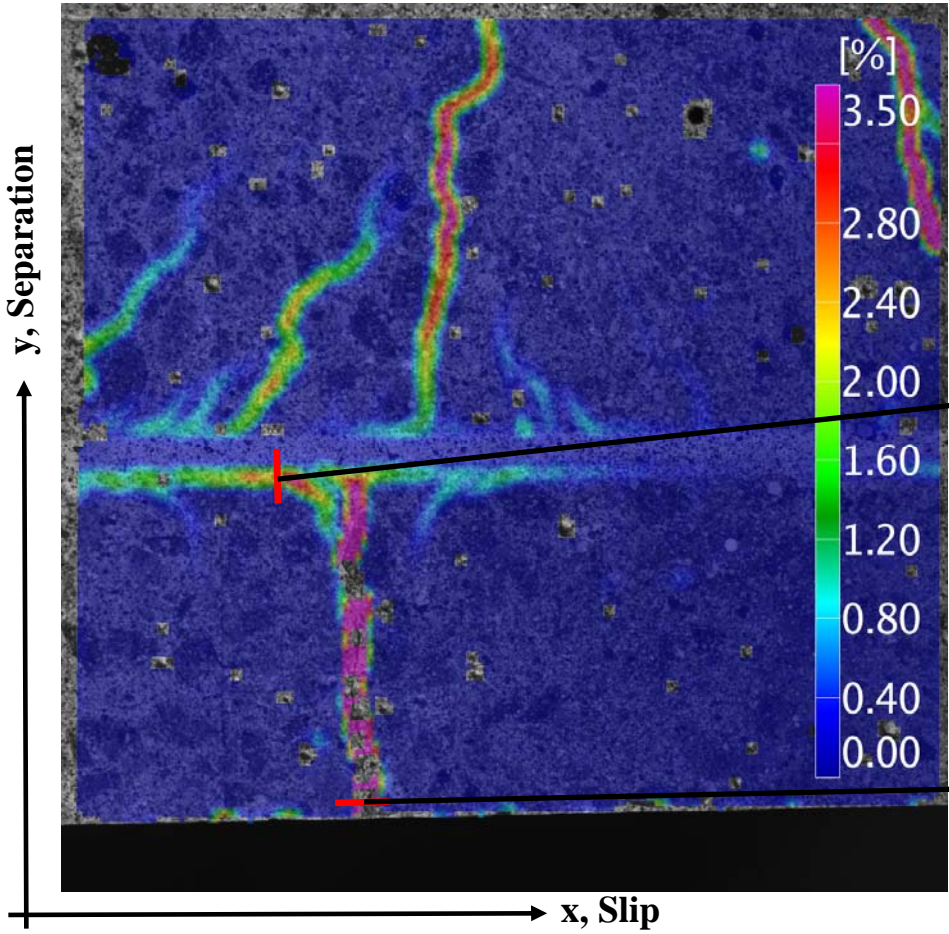
# Crack Measurements: Crack Shape

- Load vs. crack width at various loadings from two locations
- V-Shaped crack



# Crack Measurements: Slip and Separation

- Slip and separation vs. crack width near tensile face

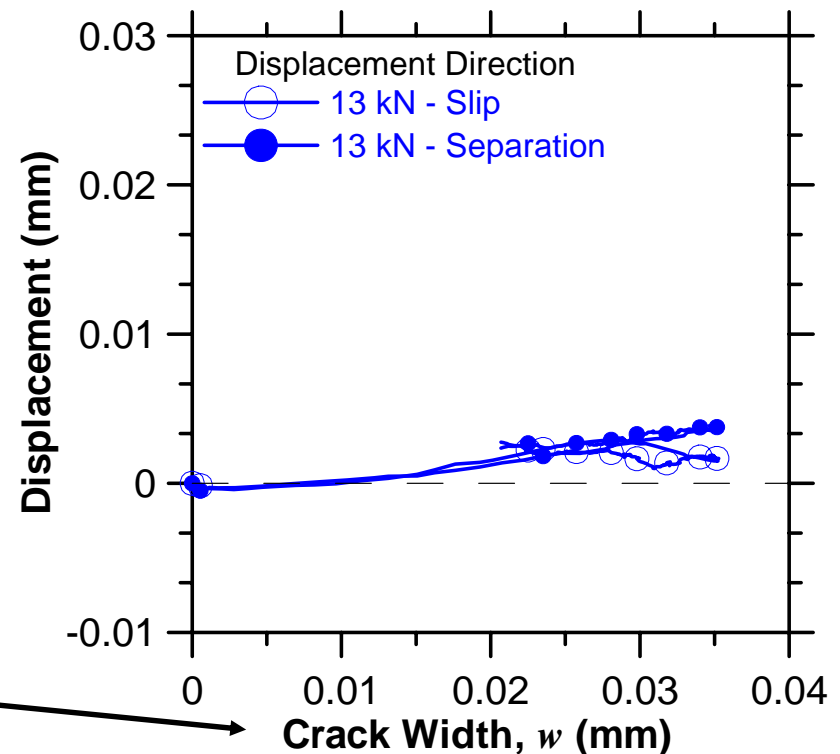
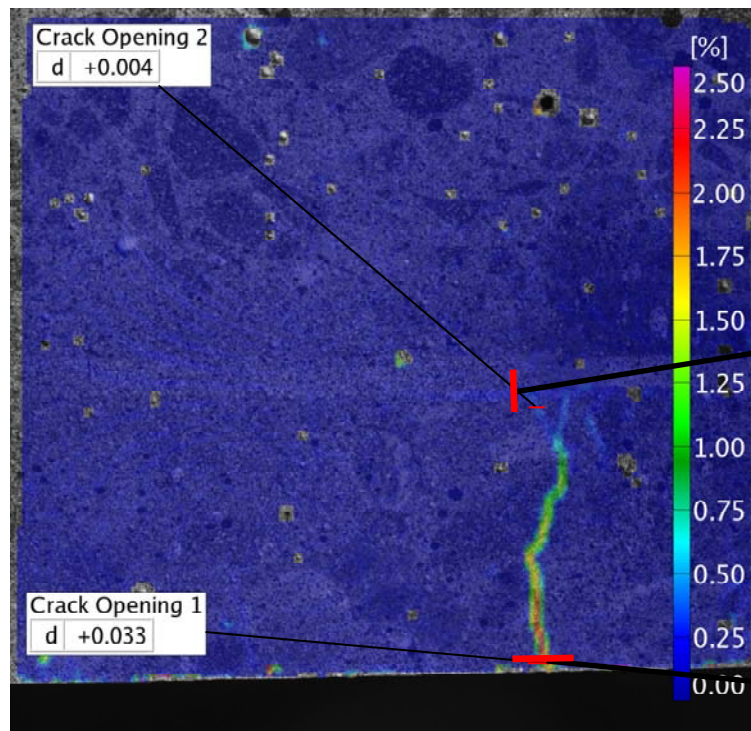


- Elastic slip response, inelastic separation



# Crack Measurements: Slip and Separation

- Initiation of slip and separation
  - At estimated cracking load
  - ~4  $\mu\text{m}$  measured slip and separation
  - Measured deformations close to resolution, results inconclusive



# Conclusions

- 3-D Photogrammetry used to quantify cracking under flexural loading
- Slip behavior between reinforcement and concrete is elastic while separation behavior is inelastic
- Slip and separation between reinforcement and concrete initiates after opening of crack at tensile face

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