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Visit of Chinese Academics to the Civil Engineering Department, 20 Sep. 2016

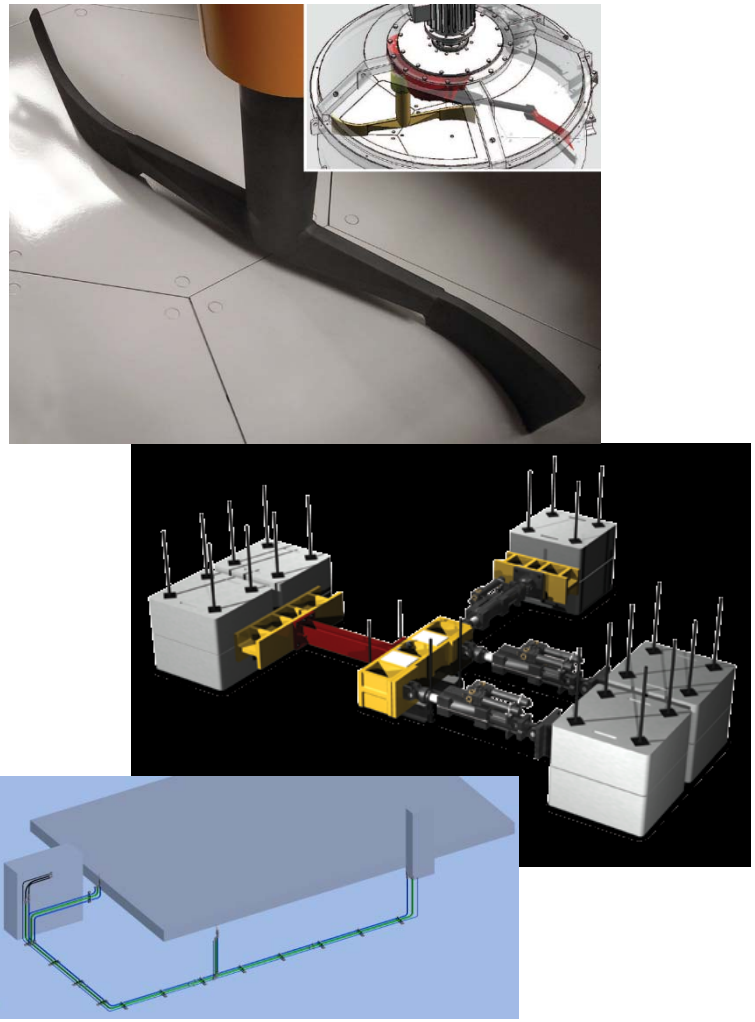
Research overview – Structures

Professor A J Kappos

The Structures group

Professor Ashraf Ayoub	
Professor Cedric D'Mello	
Professor Andreas Kappos	
Dr Agathoklis Giaralis Senior Lecturer	
Dr Brett McKinley Senior Lecturer	
Dr Tatyana Micic Senior Lecturer	
Dr Feng Fu Lecturer	
Dr Panagiotis Mergos Lecturer	
Dr Alfredo Camara Lecturer	

The Heavy Structures Laboratory



- £800K investment in equipment for teaching and research
- Servo-controlled concrete testing including FRC post-peak
- HPC, VHPC & UHPC concrete mixing in large volumes for research with moisture monitoring for repeatable mixing
- High flow computer-controlled hydraulic loading for static, cyclic and dynamic & hybrid testing with ring-main
- Loading frames including *strong-wall* for lateral loading of tall structures

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Key research areas

- Types of structures studied:
  - Buildings
  - Bridges

  } including complex/special ones
  - Nuclear structures
  - Offshore structures
- Types of 'special' loadings studied:
  - Earthquake
  - Blast/explosion
  - Fire
- Types of approaches used:
  - Analytical (finite element modelling)
  - Experimental (laboratory and in situ testing)
  - Empirical (statistical)

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Dr Agathoklis Giaralis

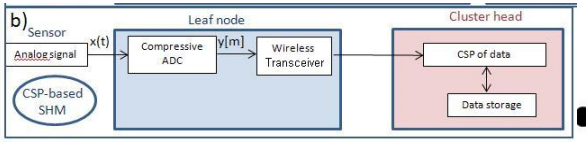
- **Structural health monitoring** via wireless sensor networks using compressive sensing data acquisition techniques (EPSRC funded project)

- **Vibration control and energy harvesting** from wind/wave/earthquake excited structures using the novel lightweight tuned mass-damper-inerter (TMDI) device (EPSRC funded project)

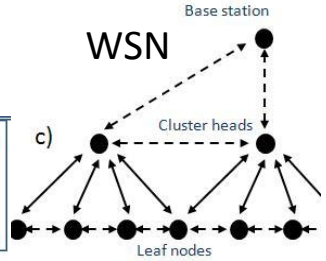
- **Seismic analysis and assessment** of ordinary and special structures using beyond-codes-of-practice Monte Carlo-based and Stochastic Dynamics-based techniques (Internally funded project)

- **Wavelet-based stochastic modelling, representation, and simulation** of extreme dynamic loads in earthquake, wind, and wave engineering applications (Internally funded project)

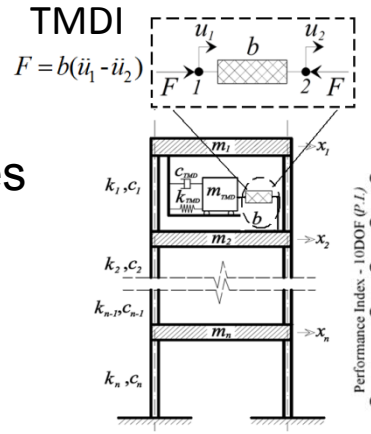
CSP node



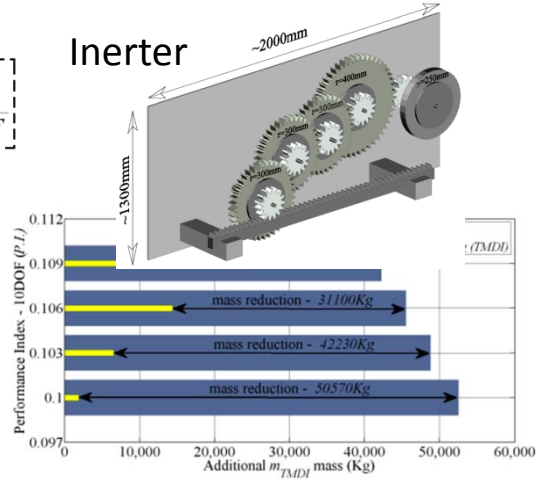
WSN



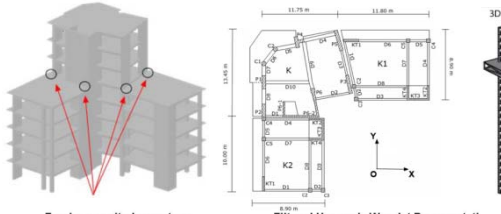
TMDI



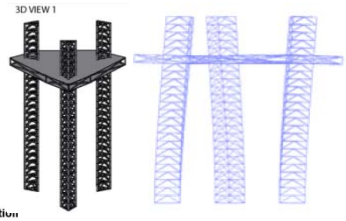
Inerter

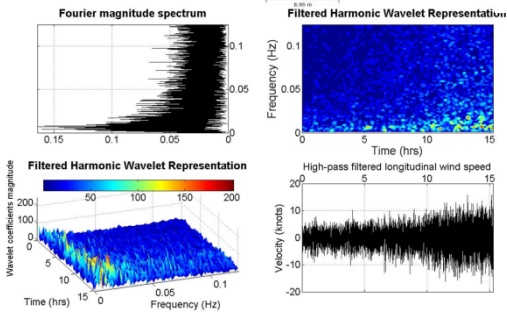


Seismic pounding

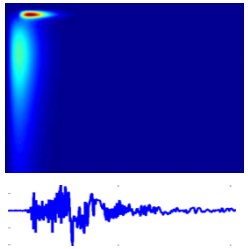


Jack-up platforms





Hurricane wind field

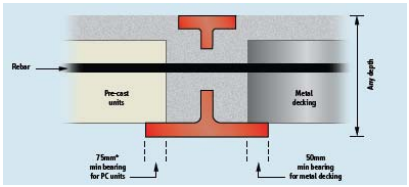


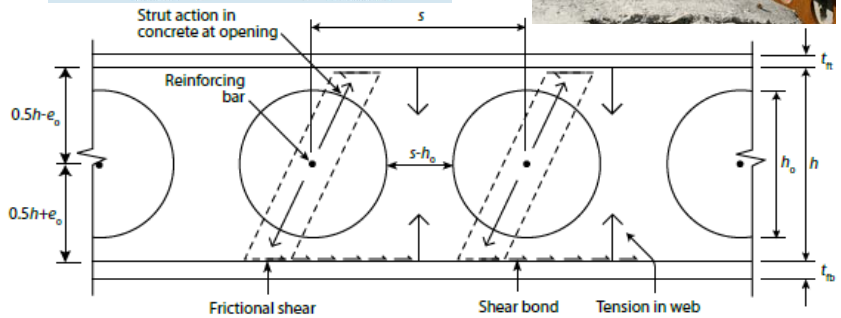
Pulse-like accelerograms

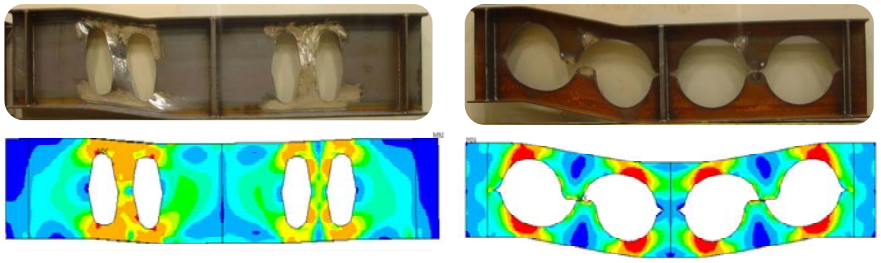
Professor D'Mello &
Dr Brett McKinley

Improving the financial and environmental cost of steel framed buildings

- Product development in composite construction
  - Floor dynamics, strength, stiffness, interface strength
- Industry supported
- Impact
  - Six design guides
  - Two software suites
  - Products account for c.7% of commercial market
    Cellular beams, Ultra shallow floor beams (USFB), Bi-Steel/Corefast, Slimflor, Slimdek, Asymmetric beams (ASB)

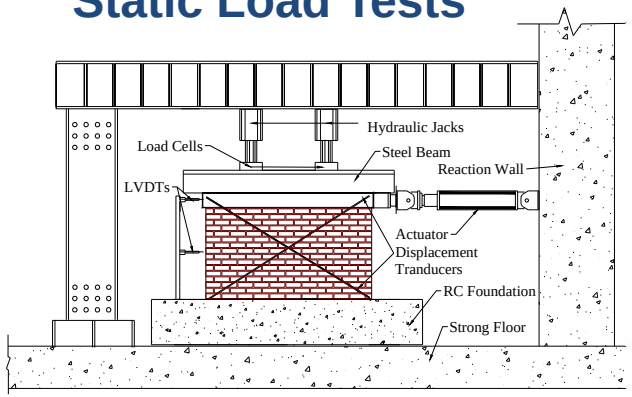


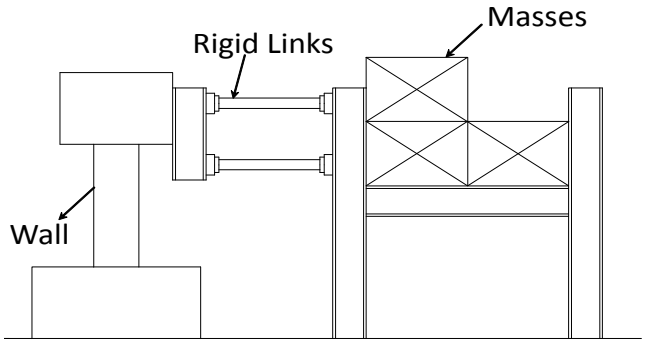




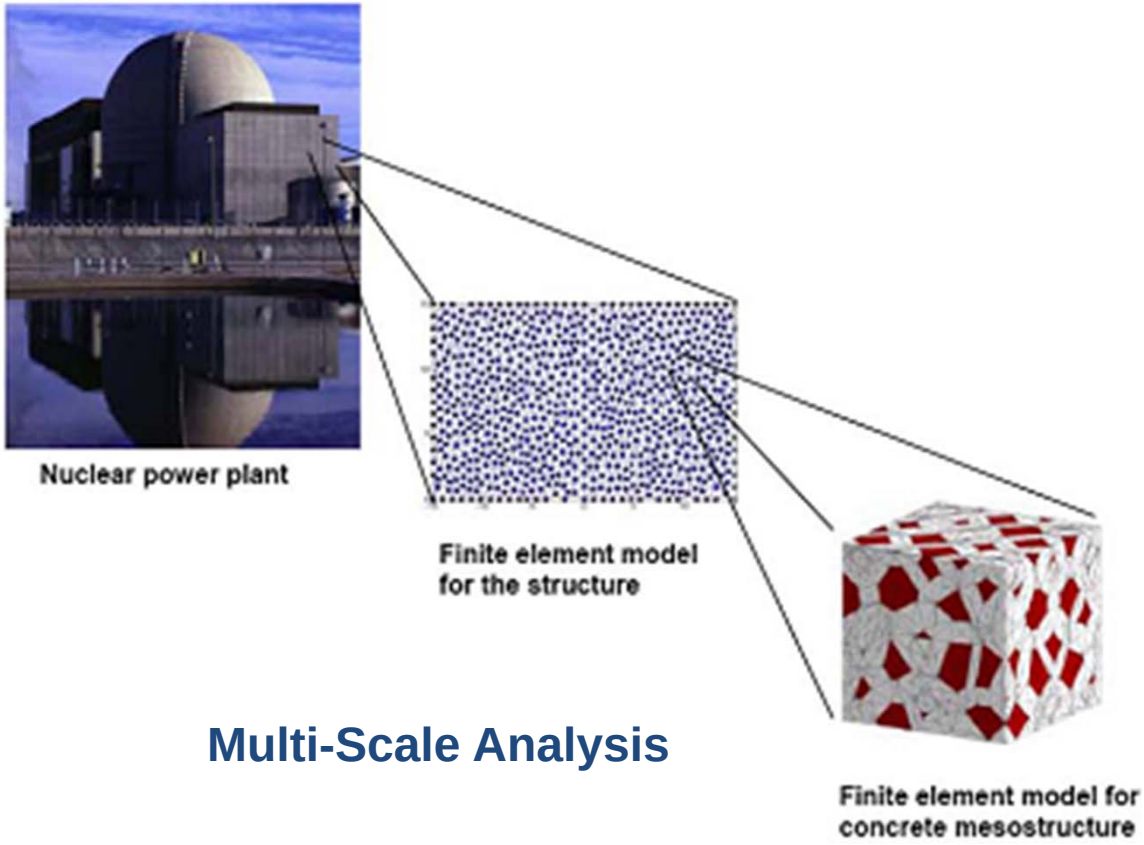
Prof. A. Ayoub
Royal Academy of Engineering/Pell Frischmann Chair

Static Load Tests





Shake Table Tests



Multi-Scale Analysis

Analysis of Nuclear Structures

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Dr Panagiotis Mergos

- Seismic assessment and retrofit of reinforced concrete structures with sub-standard detailing

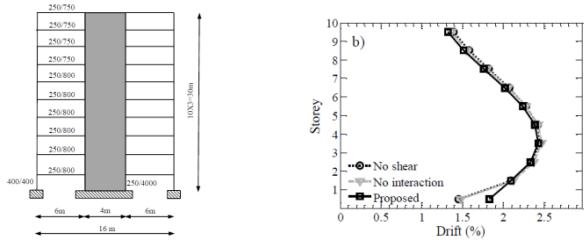
  (Mergos and Kappos 2008, 2010, 2012, 2013)

Shear failure

FRP retrofit

- Inelastic lateral response of slender concrete walls in tall buildings

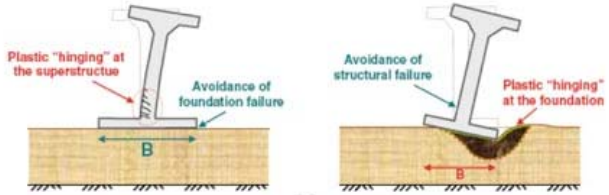
  (Mergos and Beyer 2013)



Inter-storey drifts of tall buildings with concrete walls

- Rocking isolation of structures resting on spread foundations

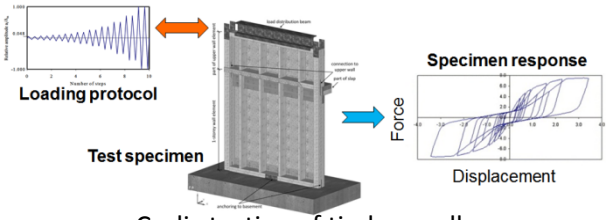
  (Mergos and Kawashima 2005)



Bridge piers with and without uplift

- Cumulative damage effects and cyclic testing of structures

  (Mergos and Beyer 2014)



Cyclic testing of timber walls

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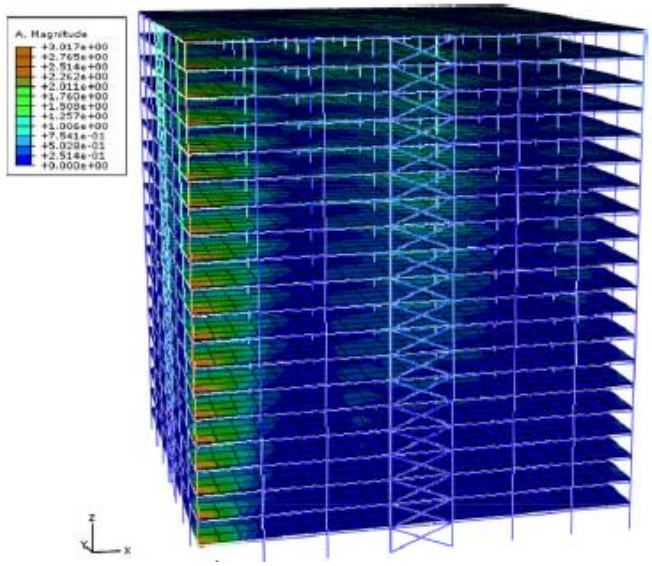
Dr Feng Fu

- Progressive collapse analysis of long span structures and tall buildings under earthquake, explosion and fire



- Full scale testing on structures under extreme loading condition

Prof. A. J. Kappos

- Analysis of the elastic and inelastic response of R/C structures (buildings, bridges, etc.) using member-by-member models (lumped or distributed plasticity), and members under monotonic and cyclic bending and shear, using member-type, fibre, or finite element models.
- Experimental study of reinforced concrete members (beams, walls, slabs) under monotonic and reversed cyclic loading.
- Elastic and inelastic analysis of (load-bearing) masonry buildings using equivalent frame or finite element models.
- Repair and strengthening of R/C members using conventional methods or FRP's – Experimental and analytical studies.
- Constitutive laws for normal and high-strength confined concrete
- Analysis of pounding between adjacent structures (buildings, bridge segments) – Methods based on impact laws and/or dimensional analysis.
- Vulnerability to earthquakes of R/C and masonry structures – Analytical, empirical, and hybrid methods.
- Cost-benefit and life-cycle cost methods for pre-earthquake strengthening of structures.
- Improved seismic design methods include performance-based and deformation-control methods – Design methods involving use of advanced analysis tools.

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International impact of our research

Google label:bridges

Scholar

1 - 10

Profiles

Andreas Kappos
City University London, Aristotle University of Thessaloniki
Verified email at city.ac.uk
Cited by 3436
Civil Engineering Earthquake Structural Engineering Concrete Structures Bridges Seismic Design

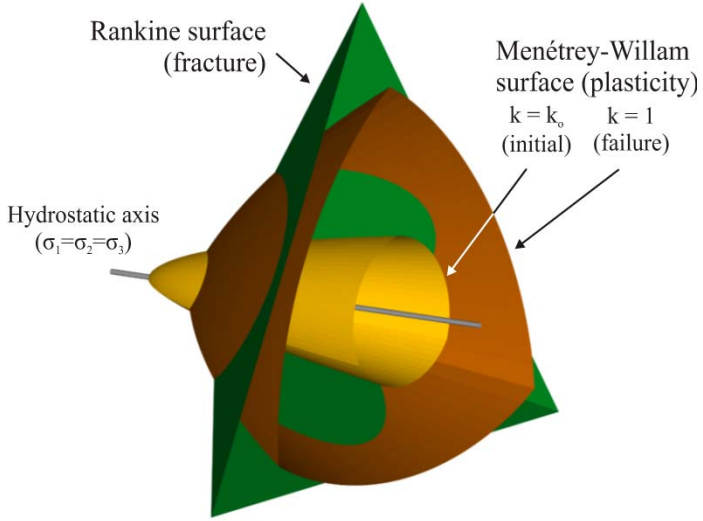
"Steve" CS Cai
louisiana state univ
Verified email at lsu.edu
Cited by 3236
bridges structures wind engineering

Mehdi Saiidi
Professor of Civil Engineering, University of Nevada, Reno
Verified email at unr.edu
Cited by 2697
Structures Bridges Earthquake Engineering Bridge Innovation Advanced Materials

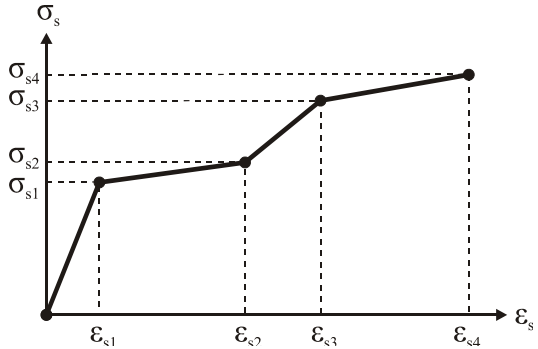
Eugene J. OBrien
Professor of Civil Engineering, University College Dublin
Verified email at rod.ie
Cited by 2350
Bridges Dynamics Loading

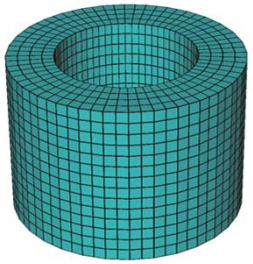
Necati Catbas
Professor of Civil Engineering, University of Central Florida & Bogazici University
Verified email at ucf.edu
Cited by 2308
Civil Infrastructure Systems Bridges Structural Identification Structural Monitoring Modal Analysis

Constitutive modelling of confined concrete



incorporated in ATENA



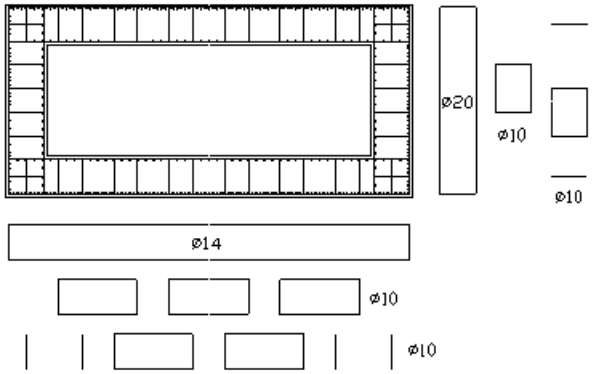


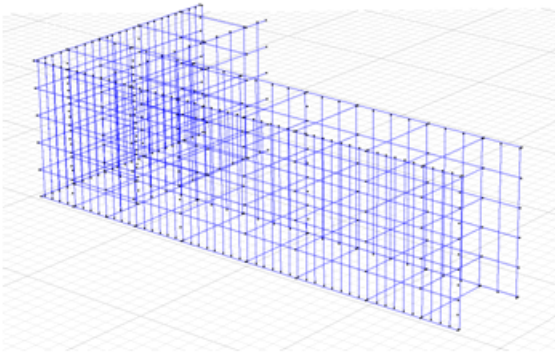
Circular hollow sections (CHS) :

Outer diameter 1.50 m

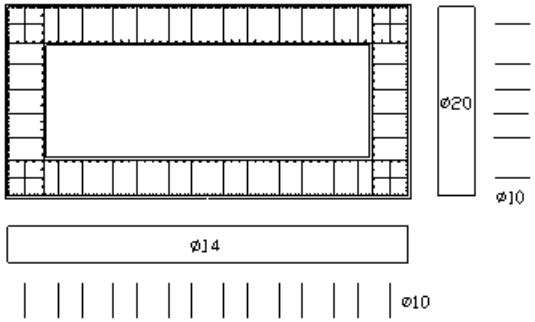
Type 1 (CHS1) : Thickness 30 cm
Type 2 (CHS2) : Thickness 45 cm

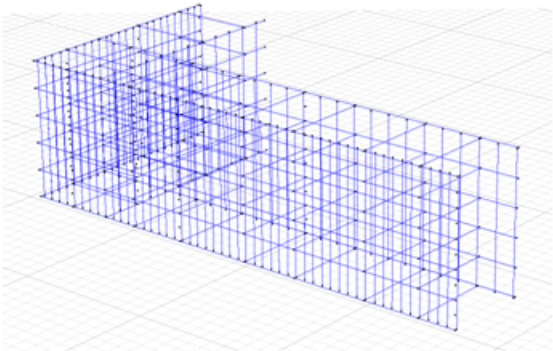
Concrete cover 5 cm





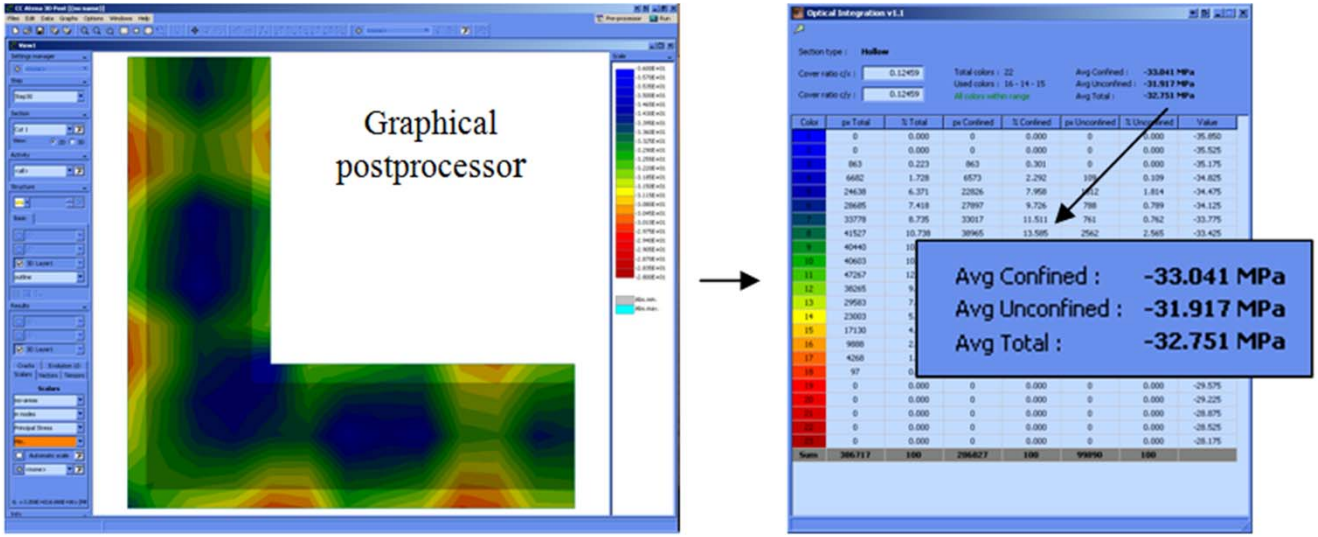
Transverse links

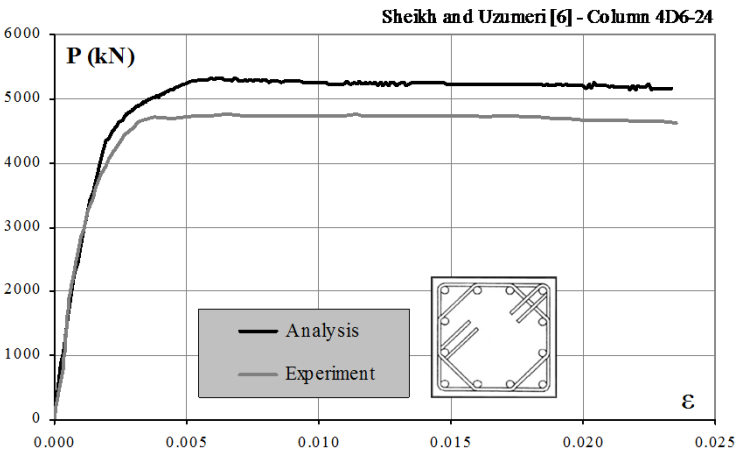




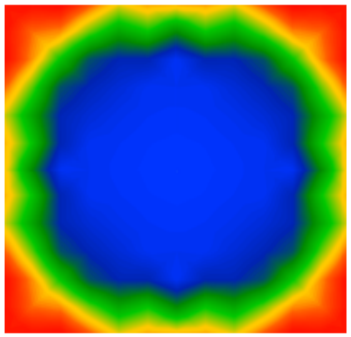
Papanikolaou, V.K. and Kappos, A.J. "Numerical study of confinement effectiveness in solid and hollow reinforced concrete bridge piers: Methodology", Computers and Structures, V. 87, no. 21-22, 2009.

Application of the optical integration method

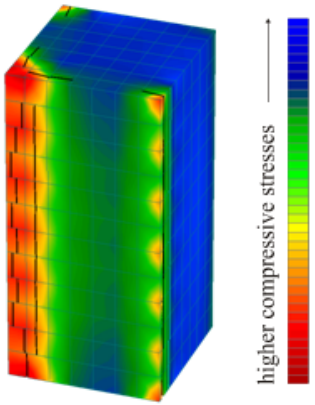




Axial stress iso-areas for column 4B3-19 at the load step of maximum response.



Cracking pattern of column 2A1-1at ultimate strain.



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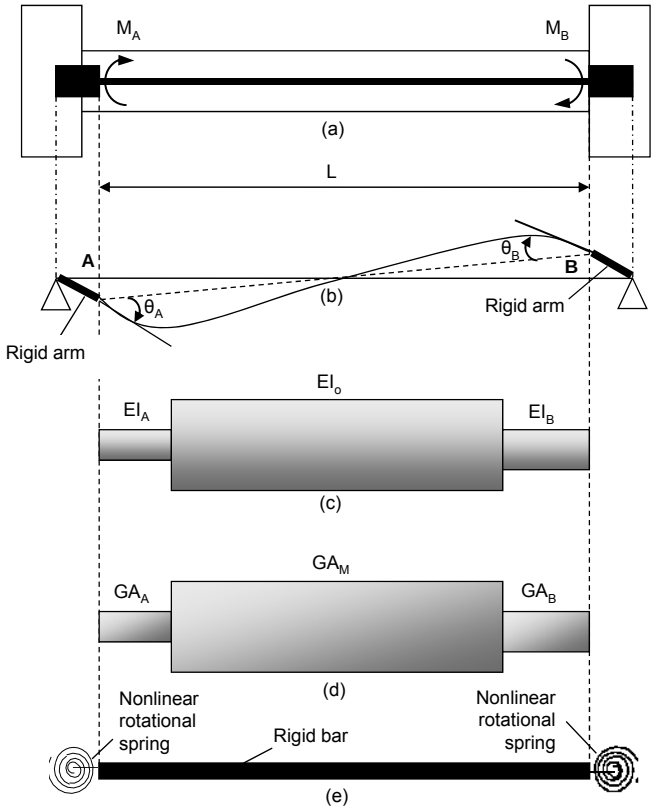
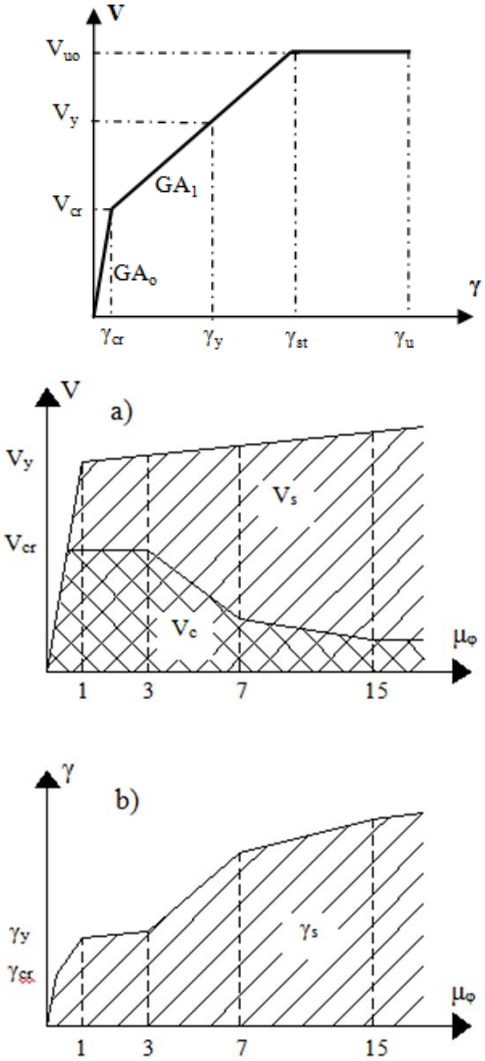
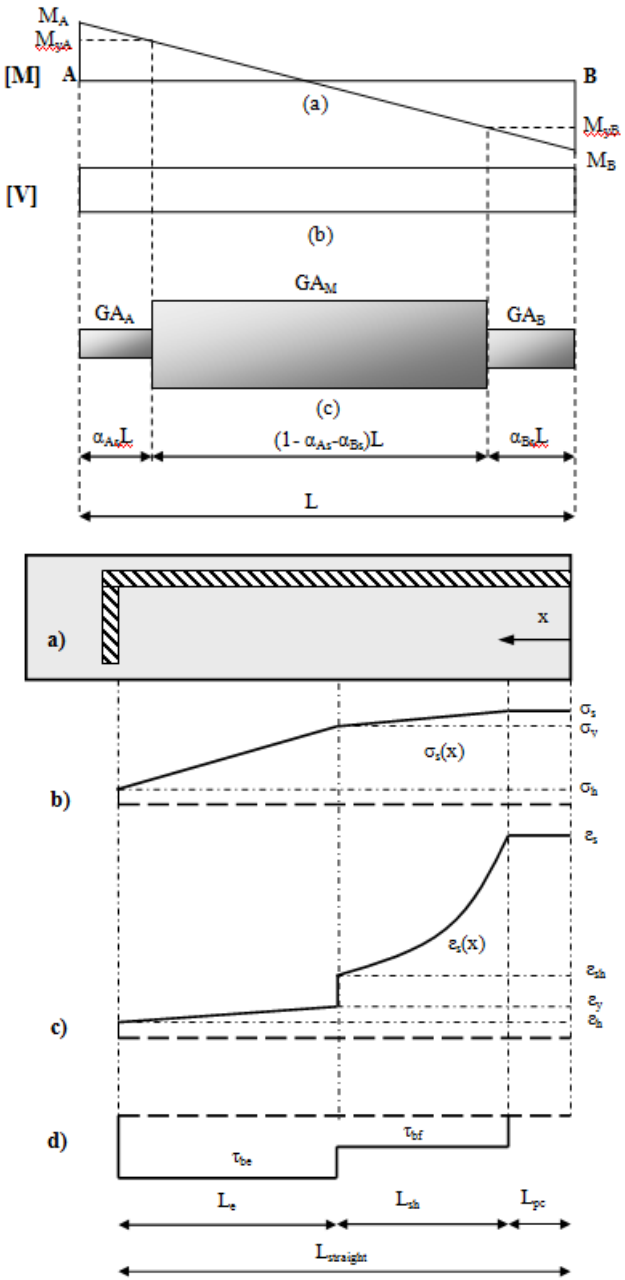
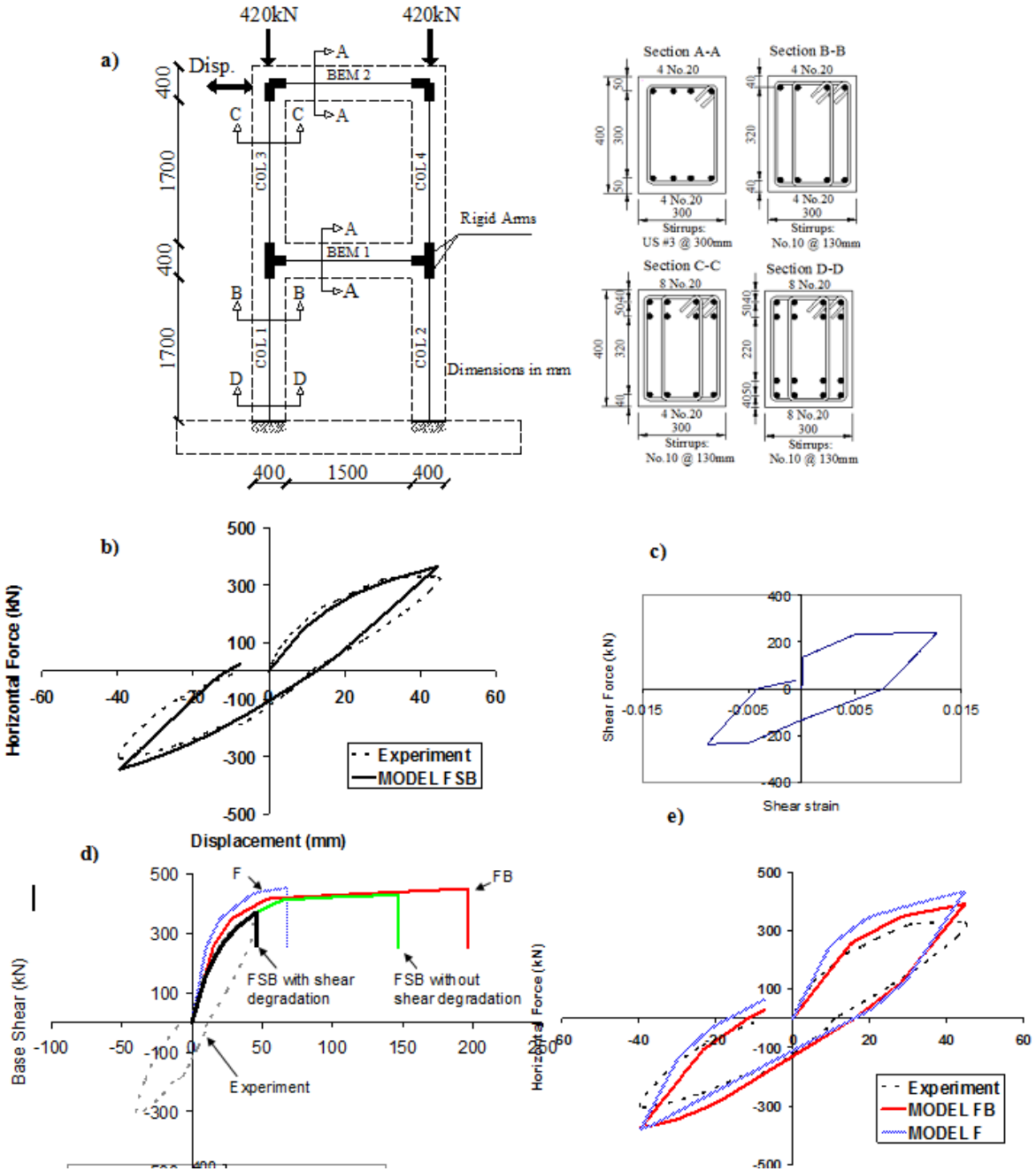
Modelling of inelastic shear effects



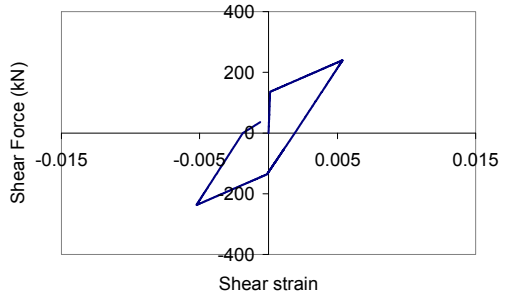




Mergos, P.E. and Kappos, A.J. "A gradual spread inelasticity model for R/C beam-columns, accounting for flexure, shear and anchorage slip", Engineering Structures, V. 44, Nov. 2012.



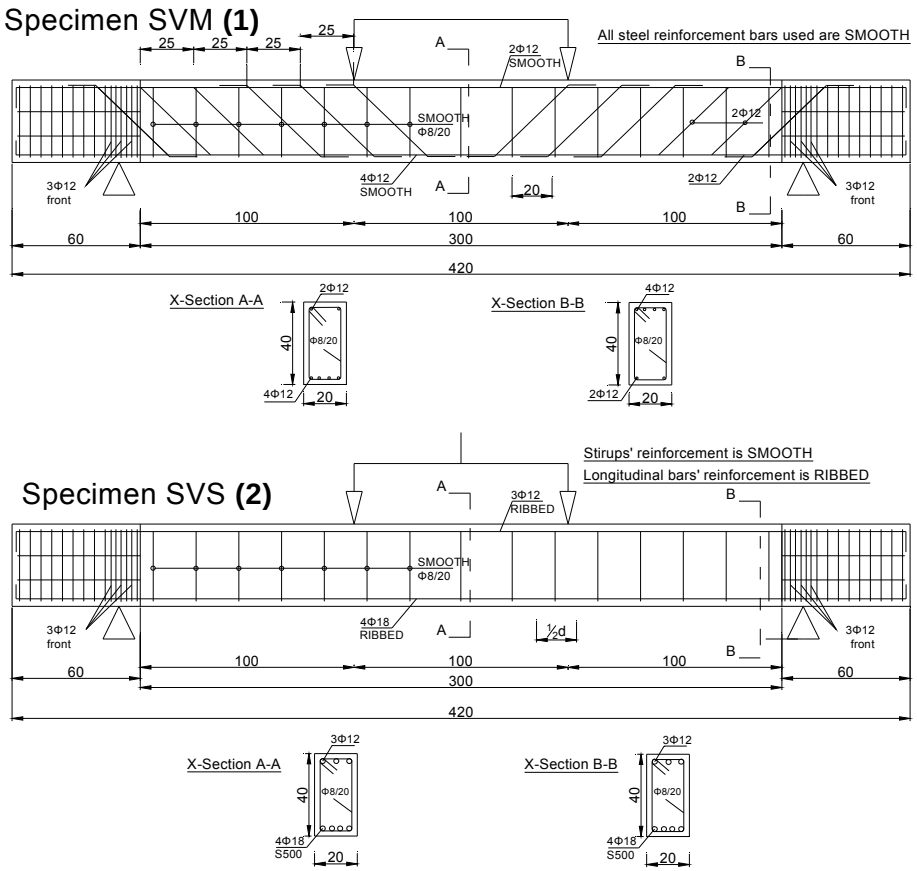
Analysis of Duong et al. (Un. Toronto) frame specimen, using IDARC-AUTh
(b) base shear vs. top displacement prediction by FSB model;
c) base shear vs. top displacement predictions by F and FB models;
d) pushover curves from different finite element models;
e) first storey beam shear force vs. shear strain response inside plastic hinges;
f) first storey beam shear force vs. shear strain response outside plastic hinges.

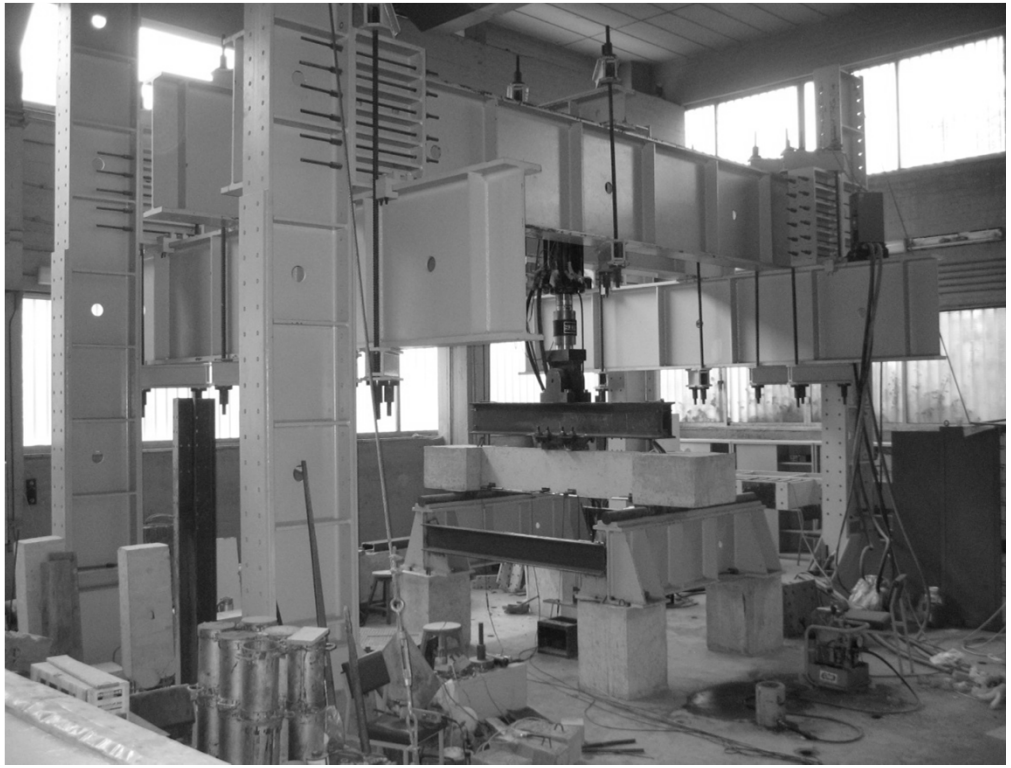


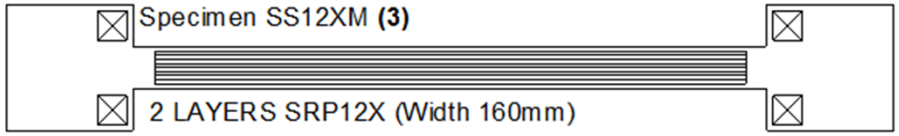
f)

Mergos, P.E. and Kappos, A.J. "A gradual spread inelasticity model for R/C beam-columns, accounting for flexure, shear and anchorage slip", Engineering Structures, V. 44, Nov. 2012.

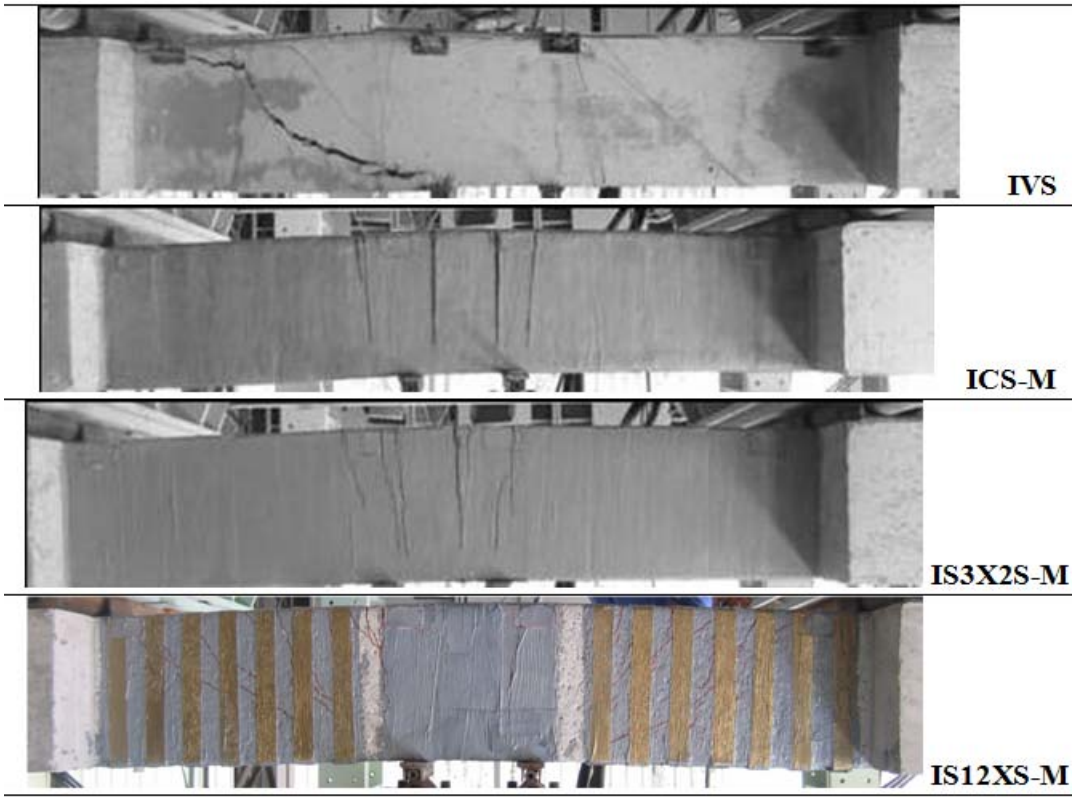
Testing of FRP/SRP-strengthened members

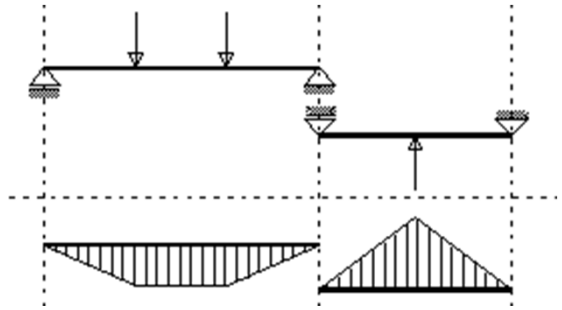


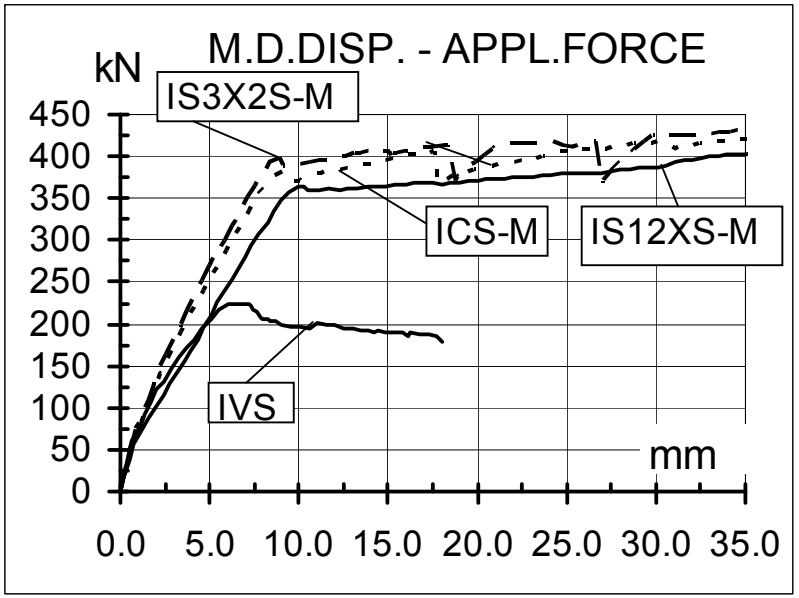




Mitolidis, G.J., Salonikios, T.N. and Kappos, A.J. "Test Results and Strength Estimation of R/C Beams Strengthened Against Flexural or Shear Failure by the Use of SRP and CFRP", Composites – Part B: Engineering, V. 43, no. 3, 2012.







$$V_{deb} = V_{crit} + 1.40 \cdot V_{R,f}$$

$$V_{Rd,f} = 0.9 \cdot d \cdot f_{fdd,e,W} \cdot 2 \cdot t_f \cdot \left(\frac{w_f}{s_f}\right)^2 \cdot (\cot\theta + \cot\beta) \cdot \sin\beta$$

Mitolidis, G.J. Salonikios, T.N. and Kappos, A.J. "Test Results and Strength Estimation of R/C Beams Strengthened Against Flexural or Shear Failure by the Use of SRP and CFRP", Composites – Part B: Engineering, V. 43, no. 3, 2012.

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The Research Centre for Civil Engineering Structures was established in 2014

http://www.city.ac.uk/department-civil-engineering/research-centre-civil-engineering-structures

- Three key research areas
  - Tall buildings
  - Long-span bridges
  - Nuclear structures
- Research questions
  - How can we design or assess complex engineering structures, like long-span or irregular bridges, for extreme loadings to ensure high performance?
  - Can we achieve “S-cubed” tall buildings using energy harvesting-enabled vibration suppression configurations and autonomous structural health monitoring wireless sensor networks?
  - How can we design nuclear power plants under multi-hazard risks?”

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Thank you for your kind attention!

Monet Le Pont du chemin de fer a Argenteuil

Websites:

www.city.ac.uk/engineering-maths/staff/professor-andreas-kappos

ajkap.weebly.com/english.html

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Andreas.Kappos.1@city.ac.uk