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

Research overview – Structures
Professor A J Kappos
# The Structures group

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<th>Professor Ashraf Ayoub</th>
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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
Key research areas

- Types of structures studied:
  - Buildings
  - Bridges
  - Nuclear structures
  - Offshore structures
  - Including complex/special ones

- 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)
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)
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)*
Static Load Tests

Shake Table Tests

Analysis of Nuclear Structures

Multi-Scale Analysis

Finite element model for the structure

Finite element model for concrete mesostructure
Dr Panagiotis Mergos

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

- Inelastic lateral response of slender concrete walls in tall buildings
  
  (Mergos and Beyer 2013)

- Rocking isolation of structures resting on spread foundations
  
  (Mergos and Kawashima 2005)

- Cumulative damage effects and cyclic testing of structures
  
  (Mergos and Beyer 2014)
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
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.
International impact of our research

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Civil Engineering, Earthquake Structural Engineering, Concrete Structures, Bridges, Seismic Design

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Civil Infrastructure Systems, Bridges, Structural Identification, Structural Monitoring, Modal Analysis
Constitutive modelling of confined concrete


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

incorporated in ATENA
Application of the **optical integration** method

Modelling of inelastic shear effects

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.

Testing of FRP/SRP-strengthened members


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

\[ V_{rd,f} = 0.9 \cdot d \cdot f_{ld, e,W} \cdot 2 \cdot t_f \cdot \left( \frac{w_f}{s_f} \right)^2 \cdot (\cot \theta + \cot \beta) \cdot \sin \beta \]
The Research Centre for Civil Engineering Structures was established in 2014

- 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?

http://www.city.ac.uk/department-civil-engineering/research-centre-civil-engineering-structures
Thank you for your kind attention!

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