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Editorial

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The year 2010 is the 200th anniversary of the birth of several notable engineers who influenced the development and application of mechanics. John Frederick Bateman FRS (1810–1889) designed water supply systems in Manchester, Glasgow, Naples, Constantinople, Colombo, Majorca and elsewhere. Sir Charles Fox (1810–1874) was a railway engineer who drove a locomotive in the earliest railway trails at Rainhill in 1829, invented the railway switch (otherwise known as points) and supervised railway construction in many countries throughout the world. William Froude FRS (1810–1879) designed skewed railway bridges, applied disk actuator theory to propellers, analysed the roll characteristics of ships and developed a towing tank facility for scale model tests of naval vessels. Froude's invention of a dynamometer led indirectly to Froude Hofmann Ltd, a company which specialises in manufacturing high technology test equipment for the aerospace, automotive and marine industries. Stanislav Valerianovich Kerbedz (1810–1899) was a railway engineer who specialised in structural mechanics. He designed the first bridge over the river Neva, then the longest bridge in Europe. Kerbedz taught at the College of Railway Engineers, Mining Institute and University in St Petersburg, eventually becoming an honorary member of the St Petersburg Academy of Sciences. Robert Mallett FRS (1810–1881) supervised the construction of the Fastnet Rock lighthouse and authored *The Dynamics of Earthquakes and Volcanic Energy: An Attempt to Develop its True Origin and Cosmical Relations*. He was awarded the Telford medal by the ICE in 1859.

Volume 163, issue no. 1 of *Engineering and Computational Mechanics* contains five full papers and a book review, all of which have some connection to structural mechanics. The topics covered include vibrations due to ship collisions with offshore platforms, finite element software for undergraduate education and conceptual design, the analysis of prestressed concrete box girders, heat exchange processes in concrete dams and the behaviour of reinforced concrete structures in fire.

Offshore engineering involves the design and construction of platform structures that must survive hostile environmental conditions while remaining economically viable. Supply vessels interact with such platforms and, although great advances have taken place in ship positioning systems, collisions occasionally occur between ships and offshore structures. Grewal and Lee (2010) use finite-element analyses to investigate the responses to ship impacts of offshore platforms typically used for the

exploration and exploitation of marginal hydrocarbon fields. Three kinds of lightweight platform structure are considered (the braced caisson, three-pile monotower and Vierendeel platform), as well as a standard four-pile jacket structure. Maximum forces, eigenmodes, displacements and maximum acceleration response spectra are computed for head-on impacts by a ship weighting 3500 t, travelling at 2 m/s. The authors find that the local stiffness of the platform is an important factor; as the local stiffness increases, the response motions reduce, but at the cost of greater damage. They recommend that designers aim for more structural redundancy in zones vulnerable to ship impact. This paper makes a strong case for the production of guidelines on ship impacts and should be essential reading for offshore engineers involved with the design and construction of so-called minimum structures.

The paper by Lindemann *et al.* (2010) outlines 2D finite-element, open-source software designed for use by students learning about structural analysis and by architects and engineers undertaking conceptual design. The focus is on ease of use and computational speed (as a supplement to ideas sketched using pencil and paper), rather than accuracy (which would be dealt with by more sophisticated 2D and 3D finite-element codes later in the design process). The software has a similar user interface to many commercial image editors and substitutes the image for the more complicated geometry required by standard finite-element packages. A greyscale code relates the structural stiffness to pixels within the object that has been sketched. Boundary (load) conditions are added directly to the image sketch by the user. 2D plane-stress analysis is undertaken using 4-node iso-parametric elements. The software includes an efficient topology optimisation algorithm for refining the structural shape according to the stress distribution. Output is visualised as principal stresses, von Mises stresses and deflections. Case studies include bicycle design by industrial design undergraduate students at Lund University and building design by undergraduate students at the Royal Institute of Technology.

Madhavi *et al.* (2010) describe the use of multi-shell elements in Abacus for modelling prestressed concrete box girders typically used in long-span bridges. Girder webs and flanges are represented by composite layered shell elements. End diaphragms are modelled using solid brick elements. A nonlinear analysis is performed allowing for the proper

constitutive relations for concrete and steel, the prestressing load history, cracking of concrete, the interaction between concrete and steel reinforcement, and the effect of tension stiffening. The paper describes vertical load tests on three laboratory-scale 4.5 m long concrete box girders, each prestressed up to 700 N/mm². Experimental measurements of surface strains and deflections were made, load-deflection curves obtained, the effect of prestressing cable stiffness assessed, shear lag factors determined and failure loads estimated. Agreement is obtained between the experimental and numerical load-deflection curves and failure loads, indicating that Mahdavi's model is potentially very useful for analysing prestressed concrete box girder structures. The paper ends by tabulating a list of modification factors for estimating peak top flange stresses; these factors should be useful to practising bridge designers.

Bayagoob *et al.* (2010) examine the thermodynamic behaviour of roller compacted concrete (RCC) dams throughout their construction and early operational phases. The paper details a finite-element model that takes account of heat generated by cement hydration and the convective heat transfer processes at the boundary between the dam and reservoir water (noting the ambient temperature of the external climate). The thermal stress distribution within the dam is computed by solving the Fourier equation for conduction with heat generation. The model also accounts for the stresses induced in the concrete dam from its self-weight and the hydrostatic loading from the external reservoir water. Displacements and possible cracking (denoted by a crack index) are then evaluated. A case study is presented for the 78 m high Kinta RCC gravity dam in Malaysia, whose cement content comprises 100 kg/m³ of ordinary Portland cement and 100 kg/m³ of fly ash. Results include temperature contour plots, water interaction isothermal plots and the time history of the crack index. The finite-element model is an advance on present simplified approaches, and so this paper should be relevant to dam designers and constructors, particularly those concerned with applications in hot countries.

Huang (2010) describes a 3D finite-element model of the behaviour of reinforced concrete structures subject to fire. At present, design of reinforced concrete against fire is undertaken using empirical rules determined from fire tests. Spalling greatly reduces the fire resistance of reinforced concrete. Using a layering or segmenting methodology with certain layers or segments permitted to have no structural strength or thermal

resistance, Huang has developed a 3D finite-element model that accounts for the effect of concrete spalling on major structural elements during a fire. The model results demonstrate that a performance-based design approach is required, the bond between the concrete and steel reinforcement has a crucial affect on fire resistance, the global fire resistance of a building is particularly sensitive to the spalling of floor slabs and columns unlike beams, and concrete spalling has much less influence on slabs deep inside a building than at corner bays due to the way in which compressive membrane forces act in a fire. This paper is aimed at building design engineers and Health and Safety Executive experts.

Again, the editorial panel would like to encourage practitioners to submit short articles on their experience of new or unusual applications of mechanics in civil engineering practice. Such articles would be most welcome, as they would help balance the content of the journal while improving its attractiveness to young engineers working on civil-engineering projects.

REFERENCES

- Bayagoob KH, Noorzaei J, Jaafar MS, Thanoon WA and Abdulrazeg AA (2010) Modelling of heat exchange between roller-compacted concrete dam and reservoir. *Proceedings of the Institution of Civil Engineers, Engineering and Computational Mechanics*, 163(1): 33–42, doi: 10.1680/eacm.2010.163.1.33.
- Grewal GS and Lee MMK (2010) Ship impact on offshore minimum-structure platforms. *Proceedings of the Institution of Civil Engineers, Engineering and Computational Mechanics*, 163(1): 3–13, doi: 10.1680/eacm.2010.163.1.3.
- Huang Z (2010) Modelling of reinforced concrete structures in fire. *Proceedings of the Institution of Civil Engineers, Engineering and Computational Mechanics*, 163(1): 43–53, doi: 10.1680/eacm.2010.163.1.43.
- Lindemann J, Sandberg G and Damkilde L (2010) ForcePAD: a finite-element software for teaching and conceptual design. *Proceedings of the Institution of Civil Engineers, Engineering and Computational Mechanics*, 163(1): 15–22, doi: 10.1680/eacm.2010.163.1.15.
- Madhavi TC, Sekar M and Paramsivam V (2010) Performance estimation of prestressed concrete box girders. *Proceedings of the Institution of Civil Engineers, Engineering and Computational Mechanics*, 163(1): 23–31, doi: 10.1680/eacm.2010.163.1.23.