Structural Design to Eurocodes: *EC4 (Composite Construction) and Fire Engineering Course*

by Ir. Chan Zhi Han and Engr. Yap Ooi Kheng

CIVIL AND STRUCTURAL ENGINEERING TECHNICAL DIVISION

A two-day course on "Structural Design to Eurocodes – EC4 (Composite Construction) and Fire Engineering" was jointly organised by the Civil and Structural Engineering Technical Division of IEM and the Institution of Structural Engineers, Malaysia Division, on 22-23 November 2010. Held at Armada Hotel PJ, the course was supported by the Board of Engineers, Malaysia and the Malaysian Structural Steel Association.

The speakers invited for the course were Professor Roger Plank, currently the Head at the School of Architecture of the University of Sheffield, and Dr Buick Davidson, also from the University of Sheffield. Both the speakers have 30 years of experience in steel construction and were heavily involved in the development of Eurocodes.

The course, chaired by Ir. Assoc. Prof. Dr Sooi Took Kwong, was attended by 119 participants. Prof. Plank started the course by introducing the Eurocodes and gave a brief overview of the codes, particularly EC1: Actions of Structures and EC4: Composite Construction. While in principle there are similarities between EC4 and BS5950: Parts 3.1, 3.2 and 4, there are also some notable differences, especially on the extensive usage of suffices in terms of conventions. Prof. Plank then moved on to elaborate on the Eurocode system, basis of design, structural loading, material properties, design at the ultimate and serviceability limit state.

Next, Dr Davidson touched on the benefits of composite construction in terms of architectural, economy and functionality. Concrete being efficient in compression, and steel being efficient in tension, complement each other by enhancing ductility and providing protection against fire and corrosion. He showed various examples to illustrate the application of composite structures with direct reference to the Eurocodes.

One of the principal design checks under Ultimate Limit State for composite beam is to ensure that shear connectors must have sufficient deformation capacity to allow shear redistribution before any connector failure. He stressed that continuous beams are beneficial because higher span/depth ratios can be utilised for a given deflection and the floor structure typically has a higher natural frequency to avoid resonating with human-induced vibration, which will compromise the comfort level of the building.

In the next session, Dr Buick talked about the behaviour of composite slab acting as formwork for wet concrete. One has to be careful of the ponding effect where the depth of concrete increases due to the deflection of sheeting. Profiled steel sheeting must be capable of transmitting horizontal shear at the interface with concrete, and it is insufficient to rely on bond only. Steel sheeting must have indentations (known as embossments) or 'frictional interlock' where the lateral pressure is contributed from the shrinkage of concrete in re-entrants profiles.

Once the concrete has hardened, steel sheeting and concrete combine to form a composite slab, which is similar to a conventional RC slab. However, a longitudinal slip may occur before a steel deck yields. As such, the interaction between steel sheeting and concrete may not be fully effective and may lead to flexural or shear-bond failure.

Prof. Plank presented the different types of composite columns that provide good structural performance during the final session of the first day. Although the fabrication for a composite column is complex, it is compensated by an increased axial compression resistance and bending capacity, contributed by steel section, concrete and reinforcements.

Structural fire engineering design in accordance to Eurocodes was presented on the second day of the course. To ensure stability in the event of a building fire, traditional ways are often inflexible and can be expensive. Prof. Plank stated that the new codes have radically changed this and include extensive details of alternative approaches which designers can adopt to achieve structural fire resistance.

The effects of fire should be considered as an accidental limit state. The two most important points mentioned were the introduction of load reduction factors at accidental limit state, and the alteration of material properties as temperature increases not only to steel but to concrete as well. Therefore, it is necessary to apply passive protection.

A variety of systems are available, one of the most commonly used in the United Kingdom is intumescent coatings. There are two basic methods in the Eurocode and BS5950 to determine fire resistance in beams and columns, *i.e.* a structural performance-based approach and a temperature-based approach. The latter is only applicable when no stability or deflection problems are found.

(To be continued at page 44)

Following that, Dr Buick explained that light timber structures generally rely on protection such as gypsum boards for fire resistance. On the contrary, heavy timber construction has better fire resistance as a result of charring, which protects the undamaged timber within. As for concrete, it has good fire resistance due to poor conductivity and good insulation, even if its structural properties deteriorate at high temperature.

However, he cautioned that spalling (the separation of concrete from structure's surface) may occur and expose the reinforcements beneath. One method to minimise risk is to introduce polypropylene fibres to help dissipate water vapour on heating. Prof. Plank ended the course by sharing the results from full-scale fire tests and whole-structure modelling to simulate a realistic analysis of structures exposed to fire. ■

Mobile Adhoc Network (MANET): *An Overview*

ENGINEERING EDUCATION TECHNICAL DIVISION

by Engr. Balamuralithara Balakrishnan

A talk on "Mobile Adhoc Network (MANET): An Overview" by Dr Morris Ezra was conducted on 27 January 2011. Attended by 16 participants, the talk was organised by the Engineering Education Technical Division.

MANET is an autonomous system of mobile routers (and associated hosts) connected by wireless links, the union of which forms an arbitrary graph. The routers are free to move randomly and organise themselves randomly, whereby the network may change rapidly and unpredictably. Sensor nodes comprise sensing, data processing and communication components that build up the adhoc networks. Due to the lack of infrastructure support, each node acts as a router to forward data packets for other nodes.

The system can be classified into two main entities: i) Server and ii) Client, where adhoc networking is like a big community in which the time taken to traverse the network can be up to seconds. This mobile adhoc network has many advantages compared to typical wireless networks in the aspects of on-demand setup, fault tolerance and unconstrained connectivity. Research level efforts are still ongoing to design algorithms for mobile adhoc networks.

Dr Ezra highlighted a few issues such as topology pattern and power control, which remain major hindrances for this network to be applied for domestic use. On the other hand, the performance of the system is mainly defined by the effectiveness, efficiency and router properties. These attributes are critical in the construction of the system.

Currently, MANET is used in defence systems for battlefields, but a modified version of MANET called VANET (Vehicular Adhoc Network) is being introduced to pass traffic information between vehicles, which in turn provides more information to the driver or GPS system to plan a new route in case of traffic obstacles. At the same time, this network system can be used in areas hit by a disaster where the cellular and fixed line infrastructure has taken a massive hit. The applications using this system are very wide and are slowly developing. More research and development activities are being carried out in order to adapt MANET for daily use. ■

CONDOLENCES

With deep regret, we wish to inform that **Ir. Lee Sing Pen (M 02327)** had passed away on 1 May 2011. On behalf of the IEM Council and management, we wish to convey our condolence to his family and acknowledge his past support and contribution to the Institution.

Ir. Lee had been actively involved with the IEM Technical Committees in the drafting of the Malaysian National Annexes in adopting structural Eurocode standards for the design of concrete structures, design for earthquake resistance and also design for wind actions.

With deep regret, we wish to inform that **Ir. Chuah Chin Kah (M 09213)** had passed away on 22 August 2010. On behalf of the IEM Council and management, we wish to convey our condolence to his family.