3-Day Course in Practical Design to MS EC0, MS EC1 and MS EC2 from a Consulting Engineer's Perspective

by Ir. Prof. Dr Mohd. Zamin bin Jumaat and
Ir. Assoc. Prof. Dr Chiang Choong Luin, Jeffrey

CIVIL AND STRUCTURAL ENGINEERING TECHNICAL DIVISION

THE IEM Civil and Structural Engineering Technical Division organised the above course from 10 to 12 March 2010 at the Armada Hotel, Petaling Jaya. The course leader was Ir. M.C. Hee, a very experienced and prominent consulting structural engineer and also one of the past current Vice Presidents of The Institution of Engineers, Malaysia.

About 100 engineers, including company directors and academicians, attended the course. The course was chaired by Ir. Assoc. Prof. Dr Chiang Luin, Jeffrey and started with an opening remark from the IEM President Ir. Vincent Chen Kim Kieong.

The course started with Ir. Hee highlighting the impact of structural Eurocodes on designers. Among others, he emphasised that engineers need to familiarise themselves with new terminologies, notations and the fact that the code is a performance based code and not a descriptive type as in the BS 8110. Ir. Hee announced to the participants the availability of the newly drafted Malaysian Standards based on Eurocodes for the basis of structural design, actions on structures and design of concrete structures.

He then went on to elaborate the scope of the MS EN1990 EC 0 and touched on the principles of Limit States design philosophy. The new loads and materials safety factors, and how they are used in the Ultimate Limit State and Serviceability Limit State load combinations were illustrated with practical examples.

MS EN1991-1-1 EC 1: Actions on Structures was deliberated after the tea break. The code provides guidance on design actions (or design loads) for the design of buildings and civil engineering works. These include the densities of construction materials, self-weight of construction workers, and equipment and imposed loads for buildings.

The afternoon session was devoted to practical ways of designing reinforced concrete structures in accordance with the MS EN1992-1-1 EC 2: Design of Concrete Structures, using fundamental and innovative methods. These include the use of the two-cycle moment distributions and the designing of reinforced concrete beams using the unified method, which was first introduced by Prof. Antoine Naaman. The MS EN1992-1-1 effectively supersedes MS1195, which was the Malaysian Standard version of BS8110. Readers may refer to the insert article on the application of the unified method in Eurocode 2.

The second day of the course started with a discussion on the Serviceability Limit States, which include design considerations for durability, fire actions and deflection. Ir. Hee elaborated at length the causes of the loss of durability in practice and related these to the requirements stipulated in the Eurocode. Definitions of concrete cover in the Eurocode and how they are supposed to be used in relation to durability and fire requirements were also elaborated during the course.

Design of shear and torsion for reinforced concrete columns and walls in accordance with the MS EN1992 were the main focus on the second day of the course. Ir. Hee explained the design concept in the new codes, compared them with the BS 8110 and gave practical design examples. The concept of braced column was emphasised during the course. In the example, Ir. Hee suggested, for simplicity sake, the recommendations by the Institution of Structural Engineers may be adopted instead.

Day 3 was devoted to the design of a 10-storey office building in accordance with the Eurocode. The participants were given the opportunity to design a 10-storey office building in Kuala Lumpur, based on Malaysian conditions. The design process was then discussed at length and the participants were given the complete design example of the building at the end of the session.

The course was concluded by the course leader with a discussion on why sometimes we (as the designers) get it wrong. In this session, the participants were warned about the common practical mistakes that could happen during the design process.

In conclusion, the course was very well received by the participants as confirmed by the survey conducted. It also imparted a lot of new knowledge in terms of the use of the Eurocode and, more importantly, the practical aspects in the design of concrete structures.

(To be continued at page 48)

DESIGN PROCEDURES TO MS EC0, MS EC1 AND MS EC2 USING THE UNIFIED METHOD APPROACH

In general, for designing concrete structures, Equation 6.10 of the code for the Ultimate Limit State Fundamental Combination and Equation 6.14 of the code for the Serviceability Limit State Characteristic Combination can be used. These are reproduced as Equations (1) and (2).

$$E_d = \sum \gamma_{G,j} G_{k,j} + \gamma_p P + \gamma_{Q,1} Q_{k,1} + \sum \gamma_{Q,i} (\psi_{o,i} Q_{k,i}) \qquad (1)$$

$$E_d = \sum_{J\geq 1} G_{k,j} + \mathrm{P} + Q_{k,1} + \sum_{i\geq 1} \psi_{o,i} Q_{k,i} \qquad (2)$$

where,

$\gamma_{G,j}$ = Partial factor for parmanent action,
$G_{k,j}$ = Characteristics value of permanent action
γ_p = Partial factor of prestressing action,
P = Representative value of a prestressing action,
$\gamma_{Q,i}$ = Partial factor for variable action.
$Q_{k,1}$ = Characteristics value of the leading variable action,
$\psi_{o,i}$ = Factor for combination value of variable cation,
$Q_{k,i}$ = Characteristics value of variable action

The Unified Method deliberated by Ir. M.C. Hee was shown to be suitable for use for designing reinforced, partially pre-stressed and pre-stressed concrete flexural members. In this report, usage of the method for the simplest case, *i.e.* for a singularly reinforced rectangular concrete section, is used to illustrate the method. It is based on the EC2 simplified stress block approach as shown in Figure 1.

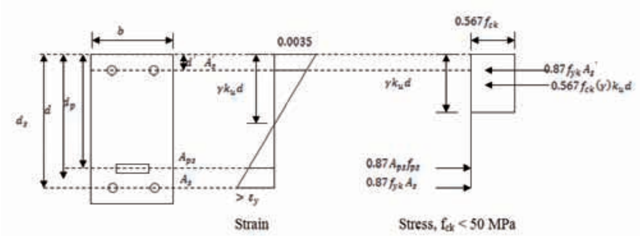

Figure 1: Simplified stress block for reinforced, partially pre-stressed and pre-stressed concrete

From the simplified stress block diagram (Figure 1),

$$d = \frac{(0.87\, A_{ps} f_{ps}) d_p + (0.87\, A_s f_{yk}) d_s}{(0.87\, A_{ps} f_{ps}) + (0.87\, A_s f_{yk})} \qquad (3)$$

$\gamma = 0.8$

For horizontal force equilibrium,

$$q = 0.87\, q_p + 0.87\, q_s - 0.87\, q_s = 0.567\, \gamma k_u \qquad (4)$$

Where,

$$q_p = \frac{A_{ps} f_{ps}}{bdf_{ck}}, \quad \mathrm{qs} = \frac{A_s f_{yk}}{bdf_{ck}}, \quad \mathrm{qs} = \frac{A_s f_{yk}}{bdf_{ck}} \qquad (5)$$

Hence, q is a combined reinforcing index, *i.e.* a unifying parameter between reinforced, pre-stressed and partially pre-stressed sections.

For moment equation about the hybrid centroid, d,

$$\sum M_{Ed} = 0.567 f_{ck} b(\gamma) k_u d\,(d - \gamma k_u d/2) + 0.87 f_{yk} A_s\,(d-d')$$
$$= bdf_{ck} q d(1-0.5(\gamma)k_u) + 0.87 f_{yk} A_s\,(d-d')$$
$$= bd^2 f_{ck} q \left(1 - 0.5q/0.567\right) + 0.87 f_{yk} A_s\,(d-d') \qquad (6)$$

For the case of the singularly reinforced rectangular section,

$$M_{Ed} = bd^2 f_{ck} q \left(1 - 0.5q/0.567\right) \qquad (7)$$

$$q = 0.567 \left\{ 1 - \sqrt{1 - \left(\frac{2K}{0.567}\right)} \right\} \qquad (8)$$

where

$$K = \frac{M_{Ed}}{bd^2 f_{ck}} \qquad (9)$$

$$= q\left(1 - \frac{0.5q}{0.567}\right) \qquad (10)$$

Equations (8) and (10) are the equations normally used to design and check singularly reinforced rectangular concrete sections.

For setting practical limit, the maximum and minimum values for 'q' must be established. These are set as follows,

From Equation (4),

$$q = \frac{0.87 A_s f_{yk}}{bdf_{ck}}$$
$$= 0.567\,(0.8)\,K_u \qquad (11)$$

For $f_{ck} \leq 50/60$, the maximum value for K_u for ductile failure is given by $K_u = 0.45$. Hence, $q_{max} = 0.567\,(0.8)\,(0.45) = 0.204$

From Figure 1, the lever arm,

$$z = d - 0.8K_u \frac{d}{2} \qquad (12)$$

The maximum lever arm allowed by the code for practical reasons is

$z = 0.95d$.

From Equation (12), we have,

$K_{u_{min}} = 0.125$.

Substituting this in Equation (11),

$q_{min} = 0.057$.

Hence the limitation values for 'q' allowed by the code is $0.057 < q < 0.204$. ■