



## Updates on Eurocode 2 and Preparing for the Implementation in Malaysia

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### INTRODUCTION

This article is written to update some of the development of Eurocode 2 (EC 2) and hopefully it will generate more interest among engineers in the construction practice to explore for more information regarding the EC 2. The strategies to ensure smooth transition from BS 8110 to EC 2 in Malaysia are also proposed and discussed. This article contains no specific guidance or calculation on the design using EC 2 as this kind of information will be more appropriate to be produced in the form of proper design guidelines. Most of the materials appear in this article are obtained from various documents produced by the Concrete Centre of the United Kingdom, the leading organisation promoting EC 2 in the UK, and the limited website version of some of the documents are available.

### THE DEVELOPMENT IN THE UNITED KINGDOM AND MALAYSIA

Since the publication of an article entitled 'BS 8110 Replaced by EC 2: Are We Ready for It?' [1] in Jurutera's October 2001 issue, a significant development with regard to EC 2 has taken place not only in the United Kingdom (UK) and Europe, but quite an interesting development has also taken place in Malaysia. In the UK, the British Standard Institution (BSI) has published the final design document of EC 2 in the form of EN to supersede the earlier draft version (ENV) in December 2004. The publication signifies that EC 2 will be implemented in the UK. The official identification of the document is BS EN 1992-1-1:2004 and the full title is Eurocode 2: Design of Concrete Structures, Part 1-1: General rules and rules for buildings. The original date set for the full implementation of EC 2 in the UK has been shifted from 2006 to 2008 and to be shifted again to 2010. In the

ISO-TC 71 – Concrete, Reinforced Concrete and Prestressed Concrete meeting in Istanbul in September 2004 (attended by the author representing Malaysia), EC 2 has been accepted as to comply with the ISO standards.

In Malaysia the Institution of Engineers Malaysia (IEM), in 2003, has issued a Position Paper on Concrete Codes of Practice In Local Construction Industry After 2008 (2). The statement was issued after a long deliberation among the committee members on the various options available to Malaysian engineering practice with regard to the shifting from BS 8110 to EC 2 in the UK. The recommendation in the Position Paper was that for Malaysia to consider adopting EC 2 as our new concrete design code, in-line with the move in the UK and 28 European Union (EU) countries.

Following the recommendations made by IEM, the Department of Standard (DSM) has appointed IEM as the Standard Writing Organisation (SWO) for a concrete design code. A technical committee was then formed and known as 'IEM Technical Committee for Malaysian Standard in the Design of Concrete Structures' and members came from the industry and academics. The tasks of the committee are due to be completed quite soon and Civil and Structural engineers may now be

prepared to a new concrete building design code which is most likely a total adoption of EC 2.

### EUROCODES

There are 10 design standards of Eurocode to be used in the construction. There are listed in Table 1.

Besides those listed in Table 1, there are many other parts of Eurocodes connected to EC 2 and may require cross-referencing during the process of design and construction. One example is BS EN 206 a standard for concrete materials. The existence of many parts make the process of shifting to EC 2 looks rather complicated at least during the early stage of familiarisation.

Only BS EN 1990: Basis of structural design has been produced in a single part. This basic document (occasionally known as EC 0) contains principles and requirements for safety, serviceability and durability of structures. EC 1 consists of 4 parts, and part 1 is further subdivided into 7 sections. Details are listed in Table 2. Some parts are still to be published by BSI.

### EUROCODE 2 BENEFITS OF EC 2

In the UK, designers are encouraged to use EC 2 before the year

Table 1: Eurocodes in Construction

Eurocodes	Contents/Description
BS EN 1990: Eurocode: Basis of structural design	Structural safety, serviceability and durability
BS EN 1991, Eurocode 1: Actions on structures	Actions (loads) on structures
BS EN 1992, Eurocode 2: Concrete BS EN 1993, Eurocode 3: Steel BS EN 1994, Eurocode 4: Composite BS EN 1995, Eurocode 5: Timber BS EN 1996, Eurocode 6: Masonry BS EN 1999, Eurocode 9: Aluminium	Design and detailing
BS EN 1997, Eurocode 7: Geotechnical design	BS EN 1998, Eurocode 8: Seismic design
Seismic design BS EN 1998, Eurocode 8:	

Table 2: Eurocode 1

Eurocode 1	Title	Standards superseded
BS EN 1991-1-1	Densities, self-weight and imposed loads	BS 6399: Part 1 and BS 648
BS EN 1991-1-2	Actions on structures exposed to fire	
BS EN 1991-1-3	Snow loads	BS 6399: Part 2
BS EN 1991-1-4	Wind actions	BS 6399: Part 3
BS EN 1991-1-5	Thermal actions	
BS EN 1991-1-6	Actions during execution	
BS EN 1991-1-7	Accidental actions	
BS EN 1991-2	Traffic loads on bridges	BD 37/01
BS EN 1991-3	Actions induced by cranes and machinery	
BS EN 1991-4	Silos and tanks	

2010 in order for them to familiarise with the new codes and among the benefits outlined by the UK Concrete Centre are (3):

- The new Eurocodes are claimed to be the most technically advanced codes in the world
- Eurocode 2 should result in more economic structures than BS 8110
- The Eurocodes are logical and organised to avoid repetition
- Eurocode 2 is less restrictive than BS 8110
- Eurocode 2 is more extensive than BS 8110
- Use of the Eurocodes will provide more opportunity for designers to work throughout Europe
- In Europe all public works must allow the Eurocodes to be used for structural design

For engineers in Malaysia the additional benefits of using EC 2 can be listed below:

- Able to compete globally in providing building design services since the code has been accepted by ISO
- Enjoy the benefit of continuous improvement and advancement in concrete design as EC 2 will be updated according to the progress in the new knowledge discovered through extensive research in Europe
- Utilising local values in our own National Annex

### EC 2 VS BS 8110

EC 2 consists of four Parts. Part 1-1 (General rules for buildings) is the principal part, Part 1-2 (Fire resistance of concrete structures), Part 2 (Bridges) and Part 3 (Liquid-retaining and containment structures). There are a number of

differences between BS 8110 and EC 2 and are listed below (3):

- Eurocode 2 is generally laid out to give advice on the basis of phenomena (e.g. bending, shear etc) rather than by member types as in BS 8110 (e.g. beams, slabs, columns etc)
- Design is based on characteristic cylinder strengths not cube strengths
- The Code does not provide derived formulae (e.g. for bending, only the details of the stress block are expressed). This is the traditional European approach, where the application of a code is expected to be provided in a textbook or similar publication.
- Units for stress are mega pascal, MPa (1 MPa = 1 N/mm<sup>2</sup>)
- Eurocode 2 uses a comma for a decimal point. It is expected that UK designers will continue to use a decimal point. Therefore to avoid confusion, the comma should not be used for separating multiples of a thousand
- The partial factor for steel reinforcement is 1.15. However, the characteristic yield strength of steel that meets the requirements of BS 4449 will be 500 MPa; so overall the effect is negligible
- Eurocode 2 is applicable for ribbed reinforcement with characteristic yield strengths of 400 to 600 MPa. There is no guidance on plain bar or mild steel reinforcement in the Code, but guidance is given in the background paper to the UK National Annex.
- The effects of geometric imperfection ('notional horizontal loads') are considered in addition to lateral loads
- Minimum concrete cover is related to bond strength, durability and fire

resistance. In addition to the minimum cover an allowance for deviations due to variations in execution (construction) should be included. Eurocode 2 recommends that, for concrete cast against formwork, this is taken as 10 mm, unless the construction is subject to a quality assurance system in which case it could be reduced to 5 mm or even 0 mm where non-conforming members are rejected (e.g. in a precast yard). It is recommended that the nominal cover and permitted deviation are clearly stated on the drawings

- Higher strengths of concrete are covered by Eurocode 2, up to class C90/105. However, because the characteristics of higher strength concrete are different, some expressions in the Code are adjusted for classes above C50/60
- The 'variable strut inclination' method is used in Eurocode 2 for the assessment of the shear capacity of a section. The assumed angle of the concrete compression strut can be altered to give the most economic design
- The punching shear checks are carried at 2d from the face of the column and for a rectangular column, the perimeter is rounded at the corners
- Serviceability checks can still be carried out using 'deemed to satisfy' span to effective depth rules similar to BS 8110. However, if a more detailed check is required, Eurocode 2 guidance varies from the rules in BS 8110 Part 2.
- The rules for determining the anchorage and lap lengths are more complex than the simple tables in BS 8110. Eurocode 2 considers the effects of, amongst other things, the position of bars during concreting, the shape of the bar and cover.

### NATIONAL ANNEX

EC 2 has a supplementary document known as National Annex which allows the use of alternative values that suit the individual country. Malaysia should take the full advantage of this facility as there are many design parameters taken directly from the foreign codes that are

usually not very suitable to our environment. Concrete cover, which is related to durability and fire requirement; and time-dependent deformation of concrete, such as creep and shrinkage for examples may require local design values. It is an opportunity for local researchers to carry out study on these topics and perhaps in other areas. For information a study on creep and shrinkage of local concrete is currently being carried out in UTM and funded by the Construction Industry Development Board (CIDB). The output of this study is intended to form part of the Malaysian National Annex.

### DESIGN TO EC 2

Reading through the list of the differences between EC 2 and BS 8110, it seems that designing to EC 2 should not cause much difficulties to designers. Difficulties may arise more due to confusion of the terms used, the approach in design and some differences in the recommended values to be used in design. Once the designer become familiar with the EC 2, the design process in many aspects will be very much similar to BS 8110.

In most cases the fundamentals behind the design recommendations and calculations provided by EC 2 are very similar to BS 8110. For example in the design of flexural element, EC 2 allows the use of simplified rectangular stress block. However since EC 2 caters the design for higher concrete strength (up to 105 N/mm<sup>2</sup>), the limit of maximum neutral axis to ensure ductile failure has two different values, to cover both for lower and higher strength concrete.

EC 2 measures concrete strength based on cylinder, not very common for Malaysian engineers and industry. Malaysian has been very familiar with cube strength. Although EC 2 provides the conversion between cube and cylinder strengths, concern has been raised on the accuracy of the figures to Malaysian concrete as limited studies carried out by author have shown that the conversion factors can be quite different.

In the case of shear design of beams, the major difference is that EC 2 does not fix the angle of diagonal shear crack at 45° as suggested by BS 8110. The method

used in EC 2 is known as the variable strut inclination method (4). The method allows the engineers to choose the optimum angle in order to achieve the most economic design.

In EC 2, more emphasis is given to the design of durability. Rather than simply the environment exposure and fire requirement that determines the cover as recommended by BS 8110, EC 2 requires the designer to identify the most severe conditions for potential deteriorations to occur and the concept of explicitly defined design life is to be taken into account.

It is admitted that many more aspects should be discussed to assist Malaysian engineers to understand the EC 2, but this will done in other publications. In short EC 2 is simply a design guide and engineers have more options to exercise their own engineering judgement based on their level of competencies in engineering knowledge. The new challenge is that engineers are expected to be more competent and have deep understanding of the subject and should be fully prepared to acquire new knowledge in order to gain the maximum benefit of EC 2.

### ADOPTING EC 2

It seems that Malaysia has no better options. Looking at the development in recent years and the position we are in, it seems that adopting EC 2 is the best alternative for Malaysian construction practice. Other alternatives available are to continue using BS 8110 or to develop our own code or adopting other country's codes. Continue to use BS 8110 means we would not achieve the best design as BS 8110 will eventually become obsolete once UK shifting to EC 2. BSI has stated that there will be no further updates of BS 8110. Developing our own codes requires huge effort and resources including financial and expertise and it will be very time consuming. The research that has been carried out in Malaysia is insufficient to support the development of a comprehensive code of practice.

In term of familiarity, most of the Malaysian designers are very familiar with British codes compared with codes from other countries, thus following

UK's step is quite a natural process and would cause minimum inconveniences during the transition stage.

It is expected that Malaysia will be very soon to announce its decision officially on the adopting of EC 2 to replace BS 8110. The sooner the final decision of adopting EC 2 can be made, the better for Malaysia. The next important decision is to set the date for the designers in Malaysia to fully use EC 2. It is important that ample time should be given for familiarisation before the use of EC 2 is made mandatory to local designers.

### SHIFTING FROM BS 8110 TO EC 2: THE IMPLEMENTATION STRATEGIES

Malaysia can learn from the UK in its effort to implement the use of EC 2 among local engineers. In the UK the date for mandatory use of EC 2 has twice been shifted. It was initially set in 2006 and later shifted to 2008, and eventually shifted again to 2010. The reason for the shifting is that the final version of the code is only published in 2004, and also there are many other companion parts of Eurocode which yet to be published in the final form. The situation in the UK can be easily understood. The implementation of the Eurocodes is made while the codes are still in the development stage. It causes many confusion and difficulties. At the same time the guides on how to use EC 2 are developed parallel with the development of the codes.

Until recently the work to ensure smooth transition to EC 2 continues with many parties in the UK combines their effort in producing various documents to assist engineers in using EC 2. The professional institutions, research associations, trade associations and other bodies including regulatory are participating in the promotion of EC 2. Perhaps the most notable is the effort by the Concrete Centre of UK and the establishment of the Concrete Industry Eurocode 2 Group (5). The participating parties are the British Cement Association, the Building Research Establishment, The Concrete Centre, Construct, The Concrete Society, Arup, Clark Smith Partnership, Alan Baxter and Associates, Office of the Deputy Prime Minister, Quarry Products

Association, British Precast, Department of Trade and Industry and Concrete Innovation and Design.

Their efforts in promoting EC 2 include producing various design guides, design softwares, carrying out design comparisons between EC 2 and BS 8110, and conducting courses. The Concrete Centre has established a dedicated website on EC 2 and some documents are available for downloading by the interested parties.

It is good to have similar arrangement in Malaysia. The Institution of Engineers (IEM) perhaps can play a leading role and initiate a special task-force to get participation from the government bodies, industry and other parties. It is important that the implementation of EC 2 to be carried out efficiently and cost effective. Many parties within the construction industry have their stake in the transition such as clients, engineers/consultants, regulators, contractors, academics and suppliers. Guidance on the use of EC 2 and other related Eurocodes and the actions that need to be taken will be required not only by the designers or engineers but other parties related to building constructions. The implementation must be coordinated across the industry. The shifting from BS 8110 to EC 2 has no similarities from the previous experience of code shifting such as the shifting from CP 110 to BS 8110. The shifting this time will involve almost a total change in the design practice and other aspects that are related to it. Some recommendations which may be considered for the effective shifting from BS 8110 to EC 2 are discussed below.

No doubt in order to ensure the success of the shifting to EC 2, it must be strongly supported by the government. It is the duty of professional bodies such as IEM together with others to take initiative to advice the government on the appropriate action to be taken. The discussions can be held with SIRIM and the Department of Standards in order to identify the required course of actions. A task-force at national level is to be formed with memberships

representing professional bodies, relevant government departments such as the Public Works Department, officials from the Ministry of Housing and Local Government, and academics.

The task-force should look into various aspects of the transition from BS 8110 to EC 2. Perhaps the first issue is to decide the period to be given to the Malaysian engineers and also the approval authorities to familiarise with EC 2 before its mandatory use is fully imposed. In view of that many references such as design guides and design textbooks are already available (published in the UK), a period between 4 to 5 years may be sufficient. Looking at the development of the Eurocodes in the UK and other EU countries and also the progress of the IEM-SWO committee, 2008 may be reasonable to start the adoption of EC 2. Based on 5 years period Malaysia will be fully shifted to EC 2 by 2013. Universities and institutions that offer Civil Engineering courses should be advised to commence their concrete design course based on EC 2. Other bodies should also be notified for them to make preparations accordingly.

The task-force should also identify, besides the design process that involved EC 2, other aspects that need changes such as the process of approval by authorities, legal documents such the Uniform Building By-Law (UBBL) etc.

During the period of parallel use of BS 8110 and EC 2, extensive effort of re-training the engineers should be carried out. A kind of incentive should be introduced to persuade engineers to learn this new code. Board of Engineers (BEM) may consider giving a higher CPD values for engineers attending courses on EC 2. Consultants that submit their design works using both BS 8110 and EC 2 should be given appropriate incentive.

A formal contact with relevant bodies and authorities in the UK should be established to ensure we are updated of every development in the UK on EC 2. The contact may also benefit us as we may request for an exclusive copyright or

special price of numerous materials on EC 2 that have been published in the UK. Through this contact special advice may also be sought from relevant UK experts on certain aspects of EC 2 if the needs arise.

The local academics should take the lead in conducting courses locally as they may have a better access to latest publications and develop relevant course materials. A joint work with practicing engineers will ensure a good balance of the course materials. The author already established a group called 'EC 2 Core Group' with colleagues in the faculty of Civil Engineering, UTM to develop course materials on EC 2. It is not only for our students but will be extended for practicing engineers. It is hoped the group can develop their knowledge on EC 2 and become the reference points for local engineers. The present IEM-SWO committee members who have the privilege of earlier exposure to EC 2 should also play their role in disseminating the knowledge on EC 2 to local engineers.

The task-force may consider conducting awareness seminar on EC 2 throughout the country. A mechanism of funding the activities should be established. The government should take some of this burden and the industry should also contribute. The concrete industry should take this opportunity to campaign for more use of concrete in the building construction by providing fund to promote the use of EC 2. They can contribute to fund the project to produce educational materials and also to subsidise seminars and short courses.

## CONCLUSIONS

Malaysia should be prepared for the shifting from BS 8110 to EC 2. There are various challenges ahead and all parties should work together to ensure the process of transition will be smooth and cost effective. Strategies need to be properly planned and some proposals are outlined. Both government bodies and industries should look at the shifting to EC 2 as an opportunity to be fully exploited. ■

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