11 WCEE

Published by Elsevier Science Ltd 1996
Paper No. 2157. (quote when citing this article)
Eleventh World Conference on Earthquake Engineering
ISBN: 0 08 042822 3

NEW TRENDS OF EUROCODE 8 / GENERAL RULES

Victor E. Davidovici
Earthquake Engineering Consultant

SOCOTEC, 3 av. du Centre
78182 St-Quentin Yvelines, France

ABSTRACT

Eurocode 8, the European standard for structures in seismic regions, offers the opportunity to obtain agreement between European countries involved by earthquake risk. EC8 is an important code because it may well become the basis of many national seismic codes outside Europe as well as being used within the European Community. The present paper describes briefly the typical trends in EC8.

KEYWORDS

Peak ground acceleration ; equivalent static analysis ; multi-modal analysis ; behaviour factor ; ductility ; strengthening ; repair.

1 - INTRODUCTION

In Eurocode 8 - Design Provisions for Earthquake Resistance of Structures -, composed of commun rules is established as a basis for the design and construction of structures in seismic regions of the members countries of European Community. The general seismic provisions of EC8 are based on the seismic codes and experience of Europe. An important aspect of the Eurocodes is the opportunity to insert specific numerical values of key factors ("boxed values"), such as peak ground acceleration and load parameters by the individual countries, to suit to local conditions of economy, social conditions, degree of industrialisation and seismic risk. EC8, as the other Eurocodes, is firstly being published as an European pre-Standard (ENV) with an initial life of three years for experimental application and for the submission of comments. This paper pointed out some brief comments particularly on the strides along the unification of national seismic codes.

2 - SEISMIC ACTIONS AND GENERAL REQUIREMENTS FOR STRUCTURES (PART 1.1)

Together with other relevant ECs, the EC8 purpose is to ensure that in the event of earthquakes : (1) human lives are protected, (2) damage is limited, (3) structures important for civil protection remain operational.

These design objectives are translated into two basic requirements to be met by structures, one dealing with no-collapse of the structure under design earthquake and the other with the damage limitation under a seismic action having a larger probability of occurence.
The limitation of damage is a criteria which gives the option of considering a high initial cost than possible extensive costly damage later as a result of a major earthquake. Hence national authorities can set target reliabilities fot the "no collapse requirement" and the "damage limitation requirement" on the basis of economic and risk considerations for different types of buildings.
To do this it is obvious that both the ultimate limit state (ULS) and the serviceability limit state (SLS) need to be considered.
The ULS requirements are intended to protect life and to ensure that the structures will not collapse in a major earthquake, defined as an event with a specified return pperiod.
As concerns the SLS, its verification is limited to the interstorey displacement only, in order to protect non-structural elements from damage.

According to EC8 the seismic zonation of each country is made in such way, that within each zone peak ground acceleration in rock or firm soil, to be considered for design purpose, is constant. In addition to the seismic activity in the past and to general tectonic features of the region, also seismic hazard map may be used for the establishment of a seismic zonation which is completely left to the National Authorities except the fact that the seismic hazard has necessarily to be described in termes of the effective peak ground acceleration in rock or firm soil. In EC8 the peak ground acceleration a_g, corresponding to a seismic zone, is a parameter of the normalized elastic response spectra. The shape of response spectrum is defined by the amplification factor β_0, for a damping ratio of 5 %.
The influence of the geological site conditions is introduced by the soil parameter s, multiplying the spectrum as whole. The influence of the layer thickness in the case of unconsolidated sediments is introduced by shifting of the maximum spectral values towards higher periods and the enlargement of the plateau with increasing thickness.

3 - GENERAL RULES FOR BUILDINGS (PART 1.2)

The rules for regularity of structures determine whether the designer can use either plane or spatial models for the structure, and either an equivalent static method along with the approximate analysis of torsional effects or multi-modal analysis. On the other hand, the variety and sophistication of the methods of analysis, depending on the degree of irregularity of the structure.
The proper use of capacity design and appropriate detailing procedures should permit equivalent static (simplified modal response spectrum) method for many structures. Three-dimensional dynamic method (multi-modal response spectrum analysis) requires good modelling of the structure and proper interpretation of the results of the analysis to be dependable. *It may give a fals sense of security and take design time away from important task of detailling reinforcement (R. Park 1994).*
The concept of behaviour factor (also referred to as reduction factor) have been introduced in order to link the elastic response spectrum and the reduced design spectrum (design of seismic actions). The parameter so-called q-factor introduce the ability of a structural system to resist seismic actions in post-elastic range by taking into account the energy dissipation capacity of a ductile response.

The code suggested values of q-factors are essentially of an empirical origin. So, in addition to ductility, they generally automatically imply overstrength, althoug this is usually not explicitly realised. Typically, EC8 as the majority of codes use constant behaviour factors throughout the entire spectrum in spite of the fact that, in the short-period range, the reduction based on ductility is low or even impossible. The discrepancy is partly eliminated by using the constant plateau in the short-period range of the design spectrum. Having in mind the fact that the ductility dependent factor decreases in the short-period region, while the overstrength factor typically increases in this region, it appears that a constant, period independent, overall behaviour factor q, as used, migth be a very rough but reasonable approximation.
The implementation of the formulae based on physical concepts combined with behaviour factors which explicitly consider ductility and overstrength may contribute to safer and more rational structures.
The values of q-factor given in table of the code represent the design values which are valid under some requirements dealing with : (1) the structural regularity, (2) the procedures which consider the structure as a system and the design of the individual elements may not be carried out separately, (3) the resistance of adjacents members, (4) the cross-section rotation capacity.
The design values of q-factor given by EC8 are valid for regular buildings ; for non-regular buildings the listed values are reduced. It should be emphasized that structures are classified in regular or irregular with respect both plan and vertical configurations..

4 - SPECIFIC RULES FOR VARIOUS MATERIALS AND ELEMENTS (PART 1.3)

Today, with EC8, we have probably reached a high degree of sophistication but at the expense of simplicity, both on contents of the code itself and on its application.
The global ductility demand of the structure, concept adopted throughout the code, corresponds to the design an earthquake resisting structures in order to have an equilibrium between resistance and ductility. It should be noted, however, that the EC8 allows the designer to choose among different Ductility Classes, enabling an ajusted solution to the particular features of each design situation.
For reinforced concrete structures three ductility classes are established with three separate sets of detailing rules : (a) **Low** ductility class corresponding to structures designed according to EC2 (general code for concrete structure) with few detailing rules for enhancement of detailing, (b) **Medium** ductility class corresponding to structures designed to be able to enter within the inelastic range without britlle failures, (c) **High** ductility class corresponding to structures for which the design ensure large hysteretic energy disipation.
The severity of the detailing of reinforcement for local ductility, diminishes when going from ductility class H to M to L. That is, it is assumed that reduction in the q-behaviour factor is accompanied by a reduction in the local ductility demand at the critical regions of the structure.
This reduction in the detailing of reinforcement for local ductility it must also ensure by capacity design that appropriate mechanisms of post-elastic deformation will form.
According the hierarchy strength of capacity design concept, in a frame the design values for bending moments in the columns shall not be less than the sum of the resisting moments in the beams connected to the column.
This statement should guarantee that the plastic hinges form at the end of the beams rather than in the columns, with the only exception of the column bases, in order to avoid the formation of undersired local collapse mechanisms.

Again it is emphasised that the detailing of reinforcement associated with the structural behaviour factor used to determine the design seismic actions should be closely aligned with the expected behaviour of the structure in the post-elastic range.

5 - STRENGTHENING AND REPAIR OF BUILDINGS (PART 1.4)

The redesign, repair and strengthening of buildings in seismic regions is a subject of growing interest; This part of EC8 is intended to cover all commonly used types of structural materials (concrete, steel, masonry and timber), and all kind of buidings . Its scope is the following : (1) to set forth criteria for the evalution of the seismic performance of existing structures, (2) to describe the approache to selecting the corrective measures to be taken in case of inadequate seismic capacity of existing structures, (3) to set forth criteria for the design of the repair and/or strengthening of existing structures.

EC8 gives only a general philosophy of evaluation and verification of an existing building damaged or unadmaged, taking into account the non-seismic and seismic actions, during its intended life time period.

Strengthening refers, in the main, to measures designed to render a structure capable of withstanding intensity loads in exces of those initially provided for. However, it may be that strengthening is called for merely because the impact of certain structural modifications that could not be accurately quantified at the inception of the project was underestimated.

Repair applies to all the work that must be performed on a structure that has already incurred earthquake damage in order to restore its initial characteristics, or, wherever possible, to improve on these, in which case the objectives become similar to those of strengthening. In post-earthquake situation, the repair of buidings damaged assumes the status of an emergency measure, and the economic factor becomes a minor concern.

The approach to the problem will accordingly not be the same, according to whether the former or latter situation is involved. Notably, a thoroughgoing diagnosis of the structure will almost always be given greater emphasis in the pre-repair studies than in those performed in support of a decision to strengthen, because in the former case the extent of damage must first be determined.

In strengthening, and accordingly in a pre-earthquake (preventive) situation, it can generally be taken for granted that the building is structurally sound, but that its eartquake-resistant properties require enhancement for one or more of the following reasons :

(1) At the time of its construction, the building had been exempted from compliance with earthquake design codes,

(2) Design standards for new buildings are continually being modified to incorporate the latest results of seismological advaces into material and subassembly testing programs, as well as observations of building performances during earthquakes; Owing to this ever-changing data base, buildings become seismically deficient, to a ceratin extent, with each succesive code change, with each succesive code change. Accordingly, exclusive of any political objectives, the strengthening problem stems from retroactive application of technicalm prigress in the realm if earthquake engineering.

(3) Modifications have been made on the original structure - quite common in the case of industrial facilities. These may be needed for various reasons : more demanding exploitation conditions, change in industrial procedure, shift in usage of all or part of the building. Monitoring modifications to the structure effected in the course of its foreseeable lifetime does away with improvisation, makes it possible to catch deterioration at its onset, enables insightful reflection to be conducted over a wide-enough time frame so that the facility may be brought on-

line again without endagering the structure. Therefore, from the design stage on, all conditions must be taken into consideration that would be conductive to restricting modification anf avoiding certain fatal economies.
(4) The structure must withstand higher intensity loads and/or overloads deriving from changes in exploitation conditions.
(5) New structure projects incorparate existing buildings, the integrity of which must first of all be ensured.
Naturally, the spirit behind strengthening is not the same where the object is old structures of established historical significance, such as particular quarters in old towns of cities, protected buildings, and historical monuments.
Strengthening existing structures is quite a recent face of earthquake engineering. The methods called upon combine classical earthquake design techniques with proven consolidation practices ; although designed for structures that are still intact, they are also of considerable interest for the repair of damaged ones.
Despite these remarks, the chapter "Repair and Strengthening" of the last edition (july 1994) pratically keeps the same features as in the first edition of 1988. The motivation of present text is to emphasize the main points which require more developments.

REFERENCES

Eurocode 8 (1995). Design provisions for earthquake resistance of structures. Part 1.1 : General rules - Seismic actions and general requirements for structures (ENV 1998-1.1). Part 1.2 : General rules - General rules for buildings (ENV 1998-1.2). Part 1.3 : General rules - Specific rules for various materials and elements (ENV 1998-1.3). Part 1.4 : General rules - Strengthening and repair of buildings (prENV 1998-1.4). Part 2 : Bridges (ENV 1998-2). Part 3 : Towers, masts and chimneys (prENV 1998-3). Part 4 : Silos, tanks and pipelines (TC 250/SC8/N 128). Part 5 : Foundations, retaining structures and geotechnical aspects (ENV 1998-5). CEN (European Committee for Standardization).

Bisch, P. (1994). General rules for buildings. Contents and comments. Proceedings of the 10th ECEE. Vienna, 1994.

Carvalho, E. C.(1994). Eurocode 8 - Basic concepts, distinctive features and futur developments. Proceedings of the 10th ECEE. Vienna, 1994.

Eibl, J., Keintzel, E. (1992). Proposal for harmonized rules for thez determination of seismic input data according to Eurocode 8. Proceedings of the 10th WEE. Madrid (1992).

Fajfar, P. (1994). Design spectra for the new generation of codes : Eurocode 8 achieves the half-way mark. Proceedings of the 10th ECEE. Vienna, 1994.

Mazzolani, F.M. (1994). Steel : Background and remarks. Proceedings of the 10th ECEE. Vienna, 1994.

Park, R. (1994). A perspective on Eurocode 8 : Earthquake resistant design of structures. Proceedings of the 10th ECEE. Vienna, 1994.

Tomazevic, M. (1994). Safety verification of masonry buildings. Proceedings of the 10th ECEE. Vienna, 1994

Vintzileou, E. (1994). Eurocode 8 - Specific rules for masonry buildings : presentation / comments. Proceedings of the 10th ECEE. Vienna, 1994.