Educating engineers about design differences in European countries

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Abstract

The Eurocode Standards EN 1993 [2] for the design of steel structures are close to become mandatory in all of the countries of the European Union. As a country adopts the Standards they have prepared their National Annexes. Since the Eurocode Standards should be a common European Standard it is a natural requirement that all parts of the Standard, including National Annexes should be understandable by all the European engineers. The fulfillment of this requirement would open up markets, for example a Spanish engineer can design a structure for the German market. The EURING "Leonardo Da Vinci" project, which has been finished in 2008 december, had the aim that through a case-study design the differences in the National Annexes can be explored and shown to engineers. This paper will discuss the results of the EURING project.

Introduction

Although Eurocode standards [1-3] will become mandatory in the very near future in all European countries, however designs will not be standardised. Furthermore each country has a set of national annexes which provide specific mandatory factors which must be used when designing in that particular country. This may result in a problem when engineers are required to design a structure in European countries of not their own, since they have to familiarise themselves quickly with the country-specific national annexes. The design and construction in a particular country is also affected and influenced by several other factors including developed practices and other legislations such as Health and Safety. In order for the vision inspired by the Eurocodes, of real mobility across Europe, to be realised, designers must have access to thorough information about the design processes in the county they are working in.

The EURING project

To achieve this vision the EURING project has been initiated. The EURING project was a 2 year pilot project funded by the European Commission under the second phase of the Leonardo da Vinci programme that has been running from October 2006 to October 2008 [6]. Its full title is 'Development of ICT supported, flexible training to enable designers to apply Eurocodes in accordance with the national regulations of different member states'. The main aim of the project was to provide information for designers from any European country to produce easily a steel building design in other European countries.

The first stage of the EURING Project was to define a case study allowing each partner to identify the specific requirements existing in its country, and to compare their consequences regarding the final design of the chosen structure. The chosen case study was an office building (the Sheffield Bioincubator) which has been designed and completed at Sheffield (England), one of the partner countries.
The second stage was to redesign the building according to the new Eurocodes but taking into account the National Annexes (NA) and the National Practices (NP) relevant for each partner country. It allowed some of the important differences between the NA and NP to be clearly identified and emphasised.

The Sheffield Bioincubator

The case study was the so-called "Bioincubator", a scientific research centre erected some years ago in Sheffield, in the North of England. It has fully furnished laboratories, offices and a café over 5 floors. The building enables bioscientists to build their business in a community of other like-minded professionals. Figure 1 shows the real building.

Figure 1 – The Sheffield Bioincubator.

The building has 5 storeys measuring approximately 20 m x 29 m, with a total floor area of 2800 m^2. The ground floor has a height of 3.975 m and the remaining floors have a height of 3.875 m.
The Bioincubator is an example of a typical British steel frame building designed according to the BS5950 Standard.
It is a braced frame with simple joints and bolted end plate connections. The frame is braced and no concrete core exists to support the building against lateral loading. The building is braced using 200 x 20 mild steel flats, which are located in the opposite corners of the building in the first bay of both faces of the corner. This cross bracing is found at every floor. The beams are of steel grade S275 and the columns are steel grade S355.
The Bioincubator uses composite flooring, utilising the properties of the beams and floor slabs. The floor slabs are composite using steel decking with insitu concrete cast over the deck. The deck acts as permanent shuttering. It is connected to the beams with shear studs using through deck welding technique. The concrete used to create the floor is grade C35.

The results of the project

The project has produced the following results:

- A complete building design for each country involved in the project incorporating national annexes.
- A Technical Description explaining the design approach in each country. This has been translated into all the partner country languages.
- An explanation of the non-technical issues which need to be taken into account when procuring and designing a building in a particular country.
- A comparative list of the major differences between the national annex clauses for EC3 and EC4 in each country.

The main results of the project are shown in Table 1-3 [5] which compare the designs of the European partners of the project. These results of the EURING project can give an insight into the design processes in the different European countries and it makes possible to understand the consequences of the Eurocode choices in those countries.

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Table 1: Comparison of beam and connection types in the structure

Country	Edge main beams *Steel grade*	Inner main beams *Steel grade*	Secondary beams *Steel grade*	Connection type
Original design	406x140x46 UB *S275*	457x152x60 UB *S275*	457x191x67 UB *S275*	Pinned
Belgium	*S235*	*S235*	*S235*	Pinned
Germany	*S355*	*S355*	*S355*	Pinned
Greece	IPE 400 *S275*	IPE 400 *S275*	IPE 400 *S275*	Braced frame with pinned beams
Hungary	HEA 340 *S275*	HEA 340 *S275*	HEA 280 A *S275*	1st design: pinned 2nd design: rigid 3rd design: semi rigid
Slovakia	S355	S355	S355	Pinned
Spain	IPE 450 *S275*	IPE 450 *S275*	IPE 270 *S275*	1st design: rigid 2nd design: pinned 3rd design: semi rigid
UK	356x171x51 UB *S275*	356x171x51 UB *S275*	356x171x51 UB *S275*	Pinned

Table 2: Comparison of columns and bracings in the structure

Country	Edge columns Ground floor *Steel grade*	Inner columns Ground floor *Steel grade*	Edge columns 4th floor *Steel grade*	Inner columns 4th floor *Steel grade*	Bracing system
Original design	254x254x89 UC *S355*	254x254x89 UC *S355*	203x203x60 UC *S355*	203x203x46 UC *S355*	200x20 mild steel *S355*
Belgium	*S235*	*S235*	*S235*	*S235*	L 120x120x15 *S235*
Germany	*S235*	*S235*	*S235*	*S235*	Rigid frames
Greece	*HEB 300* *S355*	*HEB 300* *S355*	HEB 260 *S355*	HEB 260 *S355*	HEB 260 *S355*
Hungary	HEB 260 *S 275*	HEB 320 *S 275*	HEB 260 *S 275*	HEB 300 *S 275*	Bracing with circular hollow sections
Slovakia	*S355*	*S355*	*S355*	*S355*	
Spain	HEB 240 *S355*	HEB 280 *S355*	HEB 240 *S355*	HEB 280 *S355*	200x20 mild steel flats *S355*
UK	203x203x71 UC *S355*	254x254x73 UC *S355*	203x203x60 UC *S355*	152x152x37 UC *S355*	200x20 mild steel flats *S275*

Table 3: Comparison of the loading of the structure

Country	Live load *(kN/m²)*	Wind load *(kN/m²)*	Snow load *(kN/m²)*	Seismic loading	Temperature *(°C)*	Fire resistance *(mn)*
Original design	5.0	*1.261*	*No*	*No*	*±20°C*	
Belgium	3.0	0.55 (base) to 1.0 (top)	No	No	Not considered	60
Germany	2.0	0.5 (base) to 0.75 (top)	0.52	No		90
Greece	3.0 (office floors) 5.0 (plant room)	1.404	0.6	**Yes**	±20°C	?
Hungary	3.0 (office floors) 5.0 (plant room)		?	No		60
Slovakia	4.0 (office floors) 5.0 (plant room)		0.84	No		?
Spain	3.0 (office floors) 5.0 (plant room)		0.5	No	Not necessary	90
UK	5.0	1.261	No	No		90

Furthermore the Hungarian partners have done calculations about the differences of the structure using pinned, pinned and fixed, and thirdly fixed connections. These results have been published in a book [4]. The Greek partners provided guidelines how to consider seismic effects in the design and the Slovak partners proposed solutions where the slabs are not composite. In Spain the slabs are also non-composite, they are normal concrete slabs as it is usual in Spain.

According to Reference 5: "When an engineer is required to prepare a design in another country, it is precisely these sorts of issues which would be difficult to find in text books and advisory documents. Many of these are related to national practises rather than pure technical design considerations."

As a further result of the project national design practices, procurement processes and interpretations of the Eurocodes were identified at partner meetings and via a questionnaire to steering committees. The questionnaire covered five main areas that are very important in relation to a design process:

- Initiation of a new project
- Finalising a design
- Direct issues relating to the design of a building
- How the process of design takes place
- Further issues that can affect engineers designing steel buildings

To ensure maximum use, these key documents were translated into all partner languages and published on the web [7]. The extensive material on the web site includes the data produced in previous projects and links to relevant material on other websites. The original intention of using a variety of presentational formats for the material was abandoned in favour of a web-based system for everything, enabling to take full advantage of the enhanced learning environment developed on the new website.

Summary

The main innovative process in the EURING project was the production of a multi-national approach to the design of one real building. Worked examples in this field do exist, but are country-specific and did not describe how national annexes and local applications and regulations affect the design process in different countries, resulting usually in different solutions. By working in a trans-national way it has been discovered that, not only differences in codes and annexes but also variations in design and construction practice, planning procedures, procurement routes and other factors contribute to very diverse national design approaches. It is expected that the availability of such innovative reference and learning material in seven European languages will facilitate the mobility of designers and the ability of organisations to operate under the regulations and traditions of other countries by increasing confidence.

Acknowledgements

The authors gratefully acknowledge the financial support provided by the European Commission for this project under the Leonardo da Vinci programme. They would also like to thank all the partners participating in the Eur-Ing project for their work and their contribution to the project's success.

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