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Eurocodes, Need or Nuisance ?

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Summary

In this paper a view is given on the role of standards in the building industry.
The question is discussed whether standards are really needed or form, as sometimes stated, a hindrance for the efficient flow of the building process.
Then an overview is given of the total system of harmonised European standards for steel structures, where Eurocodes form part of.
Finally activities are described undertaken to introduce this new system of harmonised standards and in this respect the possible role of modern computer based information transfer technology is discussed.

1. The role of structural standards

Standards currently play an important role in the building process. They contain written agreements on many aspects, so that partners automatically or simply by reference know the conditions. Standards may be considered as the 'rules of the game' for building.
Standardization may concern: administrative and legal conditions.
Standardization may also concern: uniform symbols, standard dimensions and physical properties and classification of products.
The third category concerns the standards relating to quality aspects such as design standards, standards for fabrication and erection and for testing and control. The Eurocodes belong to this last category.
Building regulations are not a modern invention. This may be illustrated by figure 1 showing the oldest known "Building regulation" in the world. If forms part of the code of laws of Hammourabi, King of Babylonia, and is dated 2200 BC.
It contains mainly legal requirements and these are rather simple and straightforward.
For example the first sentence reads: "If a builder builds a home for a man and does not make its construction firm and the house which he has build collapses and causes the death of the owner of the house - that builder shall be put to death".
Although this type of regulations possibly could help to reduce the overcapacity in the building industry, fortunately the modern building regulations are not so extreme. But on the other hand they are also not so simple and compact.

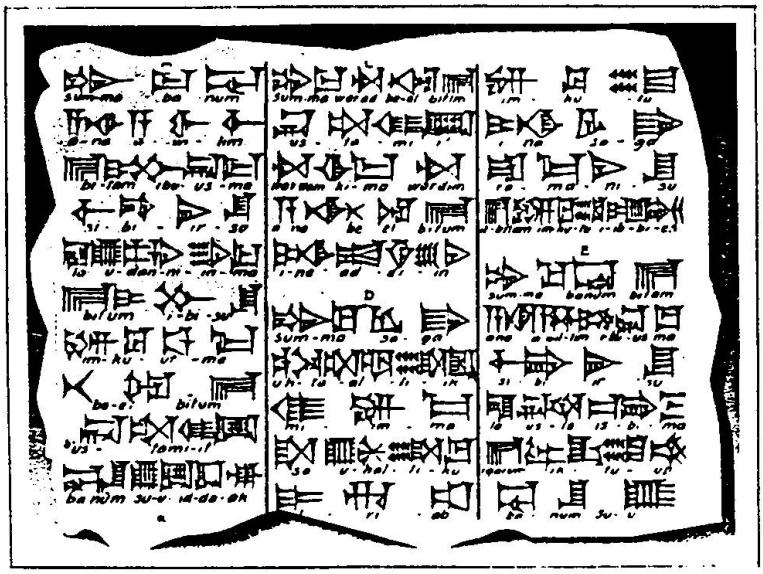

Figure 1. The oldest "building regulations" in the world

Just to give an idea I have checked how many standards are involved for the design and fabrication of a relatively simple steel structure for a building. This amounts between 30 and 35. For a more complicated structure such as a high-rise building and when also non structural aspects are taken into account the number is possibly close to 100.
Due to new developments the number of standards tends to increase.
Examples of such developments in the field of steel and composite structures are:

Product innovation

* Cold-formed steel products
* Open web sections
* Hybrid beams
* Slim floor construction
* Partly encased beams and columns
* Semi-automated connections
* Injection bolts

New materials

* High strength steel
* Super high strength steel
* High strength concrete
* Weather resistant steel
* Stainless steel
* Aluminium
* Coated sheeting

New design methods

* Plastic design
* Semi-rigid design
* Numerical methods
* CAD

New fabrication methods

* Special fasteners
* Welding methods
* Automation
* CAM

Allmost all of these topics were developed for use in structural steel design in the last decades and so were not covered by the standards of the past.

The structural standards formally describe the technical requirements for a building structure. Also they give methods to prove that the requirements are satisfied. Aspects to be covered are safety, serviceability and durability. The verification methods are based on analytical, experimental and empirical knowledge.
It is self-evident that the requirements and the required verification procedures have an important influence on the cost of the structure. As such an important role of standards is to avoid unfair competition between various manufacturers and various products and materials by defining uniform and harmonized requirements.
In many countries the standards have developed on one hand as source of knowledge for the designer but at the same time they serve as criterium for the evaluation of acceptance.
These two functions lead to different and contradictory requirements for the contents and presentation of standards.

The code-maker is confronted with the following requirements :

= The text shall be legal strict and not open for different interpretation but on the other hand the text must be easy to understand by designers;
= The rules must be simple but at the same time allow for economical and optimal designs;
= The rules must be suitable for hand calculations but also for computer-aided design;
= The scope should be well-defined but the standard should also be flexible so that new developments are not hindered by the standard;
= The size should be restricted but all new materials, products and systems should be included;
= Finally the code shall be modern but not changed frequently.

It will be clear that choices are necesary. And these choices have to be made by the engineering profession in a thorough discussion between all the interested parties. I am not convinced that this is now always the case !!

In conclusion my answer to the question posed in the title of this paper is :

= Yes, we need structural standards.
= Yes, they are a nuissance also. Especially so if not optimal attention is given to the structure, the scope and the presentation of the standards. Also instruments need to be developed for a better information transfer. For the future computer based knowledge transfer systems may help to overcome at least part of the problems.

It is obvious that an extra dimension to the nuissance is formed by the fact that different countries and regions all have their own rules and standards.
Fortunately in Europe the European Commission has initiated harmonisation of the structural standards for all European member states.
Hopefully this will be followed later by a world wide harmonisation.

2. Harmonized European standards

Stimulated and mandated by the Commission of the European Communities (CEC) the European Standards Organisation (CEN) has set up an action plan to develop a complete set of harmonized European building standards.
The complete set consists of design standards (Eurocodes), standards for fabrication and erection (in Euro-lingo called: execution) and product standards.
In figure 2 an overview is given of the set for steel structures for buildings. Similar sets are being developed for other materials as concrete, timber and masonry.

EUROPEAN STANDARDS

□ DESIGN CEN/TC250/SC3	→	ENV 1993 - Pt 1.1 Eurocode 3 Design of Steel Structures
□ EXECUTION CEN/TC/135	→	ENV 1090 - Pt 1 Execution of Steel Structures
□ PRODUCTS	→	EN - Standards ↑ ISO-Standards

Figure 2. European standards for steel structures in buildings

□ Design

The Commission of the European Communities (CEC) initiated the preparation of a set of European Codes - the Eurocodes - for the design of buildings and civil engineering structures. These codes are intended to establish a set of common rules as an alternative to the differing rules in force in the various Member States.
The advantages of having common rules are evident.

- The rules can be used in all European countries. This will make it possible to design a structure in one country for erection in another.
- Manufacturers will be able to design standard buildings for the whole European market with a single design.
- The use of common rules will make it easier for designers to work in other countries, without having to learn new Codes.
- The results of research carried out in all countries can be used for development of one set of design requirements.
- Handbooks, design aids and educational material can be produced for use all over Europe.

The Eurocode-programme is aiming at two dimensional harmonization:

(1) Harmonization across the borders of the European Countries;
(2) Harmonization between different construction materials, construction methods and types of building and civil engineering works to achieve full consistency and compatibility of the various codes with each other and to obtain comparable safety levels.

The EUROCODE-programme provides for a total set of nine volumes.

For the design of steel and composite structures the following volumes and parts are direct relevant:

ENV 1991: Eurocode 1 - Basis of design and actions on structures
Part 1 - Basis of design
Part 2 - Actions on structures
Part 3 - Traffic loads on bridges
Part 4 - Actions in silos and tanks
Part 5 - Actions induced by cranes and machinery

ENV 1993: Eurocode 3 - Design of Steel Structures
Part 1.1 - General rules and rules for buildings
Part 1.2 - Fire resistance
Part 1.3 - Cold formed thin gauge members and sheeting
Part 2 - Bridges and plated structures
Part 3 - Towers, masts and chimneys
Part 4 - Tanks, silos and pipelines
Part 5 - Piling
Part 6 - Crane structures

ENV 1994: Eurocode 4 - Design of composite steel and concrete structures
Part 1.1 - General rules and rules for buildings
Part 1.2 - Structural fire design
Part 2 - Bridges

ENV 1998: Eurocode 8 - Design provisions for earthquake resistance of structures
Part 1.1 - General rules
Part 1.2 - Building
Part 1.3 - Various materials and elements
Part 1.4 - Strengthening and repair
Part 2 - Bridges
Part 3 - Towers, masts and chimneys
Part 4 - Tanks, silos and pipelines
Part 5 - Foundation

□ Execution

The design procedures in EC3 and EC4 are only valid if the workmanship criteria during fabrication and erection given in Chapter 7 are satisfied. For example, the levels of initial geometric imperfections assumed in many of the strength rules are directly related to these criteria and are therefore invalid if they are exceeded.
A separate CEN committee, TC135 "Execution of Steel Structures" has drafted the fabrication and erection rules in close contact with CEN TC250/SC3.
These rules for fabrication and erection are given in ENV 1090.
The main reasons for developing a European Standard for execution of steel structures are:
- To transfer the requirements set during design from the designer to the constructor, i.e. to be a link between design and execution.
- To give instructions to the constructor on how to execute the physical work (fabrication, welding, bolting, erection, protective treatment) as well as to give requirements for

accuracy of the work.
The standard will thus serve as a document which gives standardized technical requirements when ordering a steel structure.
- To inform and serve as a checklist for the designer with respect to information which needs to be specified in the project specification for the particular project. It is foreseen and required that each project shall have a project specification which defines the technical requirements for that project. Such a project specification could be a single drawing for a minor project or a comprehensive package of documents for a complicated structure.

This standard for fabrication and erection will consist of the following parts:

ENV 1090: Execution of steel structures
Part 1 - General rules and rules for buildings
Part 2 - Rules for cold formed thin gauge members and sheeting
Part 3 - Supplementary rules for high strength steels
Part 4 - Supplementary rules for hollow section lattice structures
Part 5 - Supplementary rules for bridges and plated structures
Part 6 - Towers, masts and chimneys
Part 7 - Tanks, silos and pipelines
Part 8 - Piling
Part 9 - Crane structures

□ Products

The product standards are mainly equal with or derived from existing Euronorms or ISO-standards. The product standards may betwween more concern the following categories of products:
- Structural steel
- Sections and plates
- Bolts, nuts and washers
- Welding consumables
- Rivets
- Corrosion protection

An overview of the European standards for structural steel, sections and sheets is given in table 1.
European standardisation has led to new classifications for steel which have been published in EN 10020. Steels are classified in five types, contingent on their chemical composition, deoxidation method, and impact requirements.
As with classification, standardisation has led to new designations for steels. The system is given in EN 10027 and Information Circular ECISS/IC10.
The designation of structural steel is as follows:

S	275	J2	G2
structural application	minimum yield strength	impact symbol	deoxidation

In table 2 the standards for bolts, nuts, and washers are given. For washers the set of EN standards is not yet complete. The missing parts are for the time being replaced by the relevant ISO- standards. The classification system and general information on mechanical properties are given in EN 20898.

Products	Delivery conditions	Dimensions	Tolerances
I and H sections	EN 10025 EN 10113 EN 10155	missing	EN 10034
I sections-tapered flanges		missing	EN 10024
U sections		missing	missing
Angles		prEN 10056-1	EN 10056-2
T sections		missing	prEN 10055
Plates		not relvant	EN 10029 EN 10051
Strip		not relevant	EU 91
Hot formed hollow sections	EN 10210-1	prEN 10210-2	prEN 10210-2
Cold formed hollow sections	prEN 10219-1	prEN 10219-2	prEN 10219-2
Sheet	EN 10025 EN 10113 EN 10147	not relevant	EN 10131
Steel improv. deformation prop.	EN 10164	not relevant	not relevant

Table 1: Productstandards for steel and steel products

Class	Bolts	Nuts	Washers	Note
4.6	EN 24016 EN 24018	EN 24034	ISO 7091	Fully threaded
5.6	EN 24014 EN 24017	EN 24034		Fully threaded
8.8	EN 24014 EN 24017	EN 24032	ISO 7089 ISO 7090	Fully threaded
	PrEN 781	PrEN 780	PrEN 784 prEN 785	Suitable for preloading
10.9	EN 24014	EN 24032	ISO 7089	
	EN 24017	EN 24033	ISO 7090	
	prEN 781	prEN 780	prEN 784 prEN 785	Suitable for preloading
	prEN 782	prEN 783	prEN 785	Suitable for preloading

Table 2: European standards for bolts, nuts, and washers

3. Introduction of the European standards

The complete system of harmonised European standards is the result of a huge effort to harmonise and improve engineering practice across Europe. Now the task is to put these standards in practice. This is not at all easy. As illustrated before the designer is confronted with a great number of new standards.
Especially the design standards (Eurocodes) are voluminous and complex. Also the content, presentation and format is different from the existing national standards.
Therefore the steel construction industry has set up a number of activities for the dissemination of the European standards.
These activities are targeted at two groups: the students - the designers of the future - and the engineering profession of today.

☐ **Students**

Within the framework of the European action programme COMETT (European Committee Action Programme for Education and Training for Technology) the ESDEP project was launched. The aim of ESDEP (European Steel Design Education Programme) was the development and introduction of teaching material on steel structures for use in EEC-states and fully based on the new European standards. The material has been collected from over 400 contributors in 20 countries and over 10 European languages. This material is an important tool for the introduction of the European standards in education.
The complete ESDEP comprises 196 lectures and 36 worked examples in 15 volumes. These are illustrated by over 2000 figures and supported by 1000 slides, 20 videos and computer aided learning software. The material is presented in a modular format that enables it to be used in a flexible way to suit the needs of both the teacher and the learners.

☐ **Engineering profession**

For the introduction of the European standards on steel structures in the engineering profession the ECCS (European Convention for Constructional Steelwork) plays an important role. By various committees, with membership from fabricators, designers and academics, a number of publications and design aids have been prepared as a help for the use of the new standards. Examples of this material are:

- *Essentials of Eurocode 3*
  This is an "abridged" version of Eurocode 3 - Pt.1.1. It is intended to be used for daily practical design work. The contents covers about 90% of the normal applications of steel structures for buildings. For comparison EC3-Pt.1-1 has about 350 pages and the Essentials only 60 pages. Much attention is given to a users-friendly presentation with many explanatory figures and tables.
- *Design examples to Eurocode 3*
  This publication presents a series of design examples which conform with the requirements of Eurocode 3.
- *Composite beams and columns to Eurocode 4*
  In this publication instructions are given for the design and verification of composite steel and concrete beams and columns according Eurocode 4. The document provides background information for the rules in EC 4 and contains design tables and worked examples.
- *Design manual for composite slabs*
  This is a similar publication as above related to composite slabs

Many other dissemenation activities on national as well as international level are going on. Most of the projects however result in printed material.

4. Use of IT technology to support the introduction.

In section 2 an overview is given off the set of standards required for the design and execution of steel structures. Together with the introduction material as presented in section 3 this represents thousands of pages of text, figures and tables.
The standards contain many cross-references and are related to the general building regulations.
It is not at all easy to manage all this information in daily practice. It can be expected that the traditional methods of disseminating standards are not fast enough en not sufficient to allow the design profession to rapidly adapt themselves to the technical and economical changes imposed by the new standards.
Modern IT technology can provide important tools to overcome the obstacles.
This idea is supported by the experience with a project in the Netherlands. TNO developed a CD-ROM containing the text of the building regulations, the supporting standards and product information. TNO also developed the retrieval module including hypertext links, keyword search etc. This system is fully operational and succesfully used in practice.

Recently a number of research institutes and industrial partners formulated a proposal for a project aiming at the development of a prototype of an integrated working environment for the users of Eurocodes.
The basic layout of the targeted system is shown in figure 3.

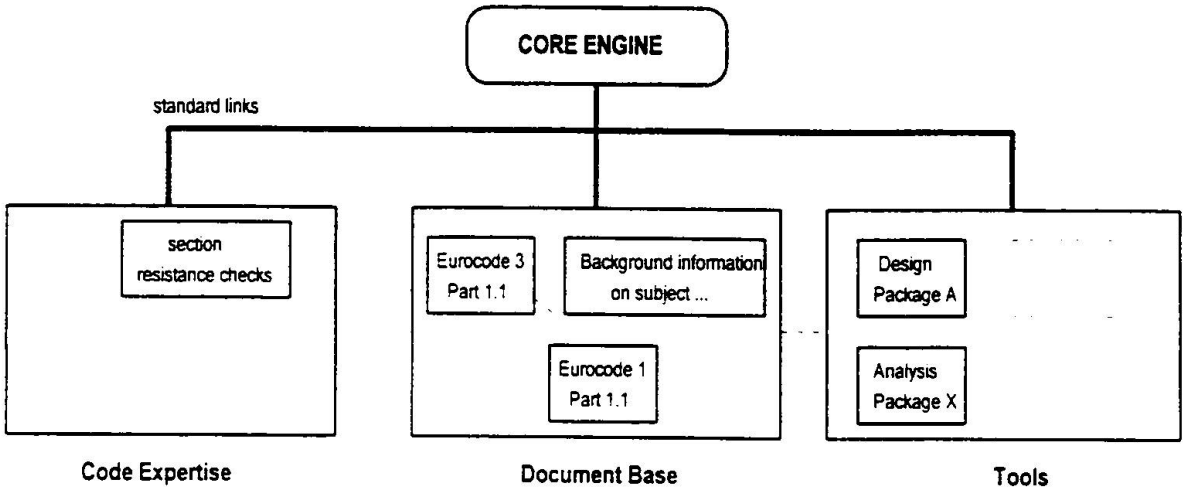

Figure 3. Integrated working environment for users of Eurocode 3

The author of this paper is convinced that this is a very promising development giving great changes to the engineering practice for an efficient use of the ever growing amount of technical information. Also it will provide an important tool for code makers to check the implications of changes and updates for cross references to or from other codes.
It is hoped that the industry and EEC will understand the importance of this development and provide the necesary means to start this project.

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