第５回定期研究会

平成16年度ＳＧＳＴ第５回研究会議事録

日時　：平成１６年１２月１４日（火）15：00～17：00
場所　：大同工業大学　滝春校舎Ａ棟１４階　会議室
講師　：福山大学　福本先生
出席者：安藤（瀧上），海老澤（名工大），尾関（瀧上），小畑（名工大），嘉津（川田テクノ），加藤（瀧上），久保（名城），後藤（名工大），事口（大同工大），清水（信州大），鷲見（八千代エンジ），高橋（日車　田中代理），田中（ＪＩＰ），田中（瀧上），土橋（横河ﾌﾞﾘｯｼﾞ），中川（瀧上），長谷部（名工大），原田（創建），福本（福山大），古市（第一技研），酒造（大同工大），水澤（大同工大），山田（名大），吉田（川田工業），長屋（ﾄﾋﾟｰ山田代理）　計25名　敬称略

1.定期研究会（海老澤担当幹事）

講演題目　SGST記念講演　「鋼構造研究とその基準化」

内容：

(1)　EUROCODE３の現状
(2)　Ｉ形はり，プレートガーダの曲げ強度に関する最近の基準改定の事例
(3)　アジアにおける構造設計基準化の動き
(4)　鋼構造設計基準に見る実験規定

EUROCODEやAASHTOなどの海外の基準は、日本の道路橋示方書などの基準と異なり、安全率を考慮するのではなく、限界状態での実験データを示し、設計に生かす形としている。

ヨーロッパでは、不明確なことは実験で検証して、設計へ生かす性能設計が定着している。日本では、性能設計が導入され始めた程度である。ヨーロッパの基準では、実験により設計を援助すると明確にうたっているが、日本の基準では、荷重や強度がわからない場合に実験で検証する必要があると述べるに留まっている。日本の鋼橋設計は、安全率に頼るのではなく、もっと実験を行い基準を改訂し経済的な設計にすることが望まれる。そして、PC橋やコンクリート橋に負けない鋼橋をつくっていく必要がある。福本先生の長い経験に基づく興味深いご講演であった。

SGST 研究会　2004.12.14

鋼構造研究とその基準化

福山大学　福本唀士

はじめに

1. EUROCODE 3 の現状

“EUROCODE 3 : DESIGN OF STEEL STRUCTURES - AN OVERVIEW” by Prof. F S K Bijlaard , Delft University of Technology, Chairman of CEN - TC 250 - SC3 Design of Steel Structures, Proc. of International Symposium on Innovation and Advances in Steel Structures, Singapore, August, 2004

2. I 形はり、プレートガーダーの曲げ強度に関する最近の基準改定の事例

1) **AASHTO LRFD 6.10 : I - SECTION IN FLEXURE**
   AISI/AASHTO T14 Task Group to update LRFD 6.10, 2002 by private communication of Prof. D. White, Georgia Institute of Technology
2) **Eurocode 3**
   “Recent European Advances in the Member Verification to Lateral-Torsional Buckling by Prof. R, Maquoi, Coordinator of the Three - year *ECSC* Research Project, Proc. of the SSRC 2004 Annual Stability Conference, Long Beach, March 2004

3. アジアにおける構造設計基準化の動き

1) **Code of Practice for the Structural Use of Steel, 2004, Hong Kong**
2) **Perspectives on Development of Asian Steel Code, by Prof. Hyo-Nam Cho, Proc. of the 7th Japan-China-Korea Symposium on Structural Steel Construction, Beijing, October 2004**

4. 鋼構造設計基準に見る実験規定

むすび

シンガポール鋼構造協会（SSSS）設立20周年記念シンポジウム

本協会副会長　福山大学教授　福本唀士

PCSSA（太平洋鋼構造協議会）の有力メンバーであるSSSSの設立20周年記念国際シンポジウムが2004年8月30,31日にラッフルズシティ会議場にて行われた。テーマは“Innovation and Advances in Steel Structures”（鋼構造の革新と進歩）である。シンポジウムの他に記念事業として、記念出版物“BEYOND STEEL”(過去20年の著名建築家によるシンガポール鋼構造物の紹介87p.)の刊行、鋼デザイン賞表彰式、祝賀大晩餐会、ゴルフ大会などが賑やかに行われた。

シンポジウムの構成は、公募による研究発表会ではなく、すべてが招待者による講演会の形式である。講演会の主題は“鋼技術の革新と進歩”に関するもので、①構造設計基準－Eurocodesが今後の設計・建設に与える影響、②新材料の革新的利用－新高強度鋼材、新高強度圧延断面、テーパー鋼板、高分子材・鋼材のサンドイッチ構造、③耐火設計法の進歩－耐火構造設計、耐火性能の向上、④鋼コンクリート合成構造、鋼管構造、薄板構造の進歩などを中心に、国外からの講演13件（香港3、英2、米2、日、中、加、豪、和蘭、Lux. 各1)、国内の大学、企業から5件となっている。シンガポールを中心に200名の若い構造技術者、研究者、院生が熱心に聴講した。プログラムは下記のようである。

EC3(公認の名称はEN1993) Design of Steel Structures に関連する発表が2件あり、D Nethercot 教授(Imperial College London主任教授、英構造工学会(ISE)会長)とF Bijlaard教授(TU Delft, CEN/TC250-SC3(EC3)委員長)が講演した。Nethercot ISE会長は35年にわたる構造研究、技術アドバイサー、英内外の構造基準作成、構造基準委員長を経て、英国のBS 449, BS 5950からEC3への移行に際して、伝統ある英国構造界の素早い対応と設計マニュアルの早期の刊行に努力している。Bijlaard 委員長はEC3の概要、安全性レベルと部分安全係数の決め方、これまでの基準に比べて日常使用が複雑とされるEC3のソフトウェアの開発を求め、“Simple rules sell steel”から“Simple TOOLS sell steel”へ言い換えようと話す。合成構造の進歩については、R Leon 教授(Georgia Tech)がAISC LRFD 2005の合成構造の柱、はり一柱の部材設計のための断面強度式の大幅な革新とスタッドのせん断抵抗値の見直し、合成床板の進歩などについて発表した。

後日、J Y R Liew教授(シンポジウム委員長、前SSSS会長、シンガポール国立大学)のもとに寄せられた大学・企業参加者の反応は、主題に深く興味をひかれ、講演会の成功を圧倒的にたたえるものであった。この種の会議にしては、めずらしく講演者も最後まで他の発表者の話を聞き、聴講者の数も最後まで減らないことであった。D Nethercot 教授は多くの著者がこの講演会のために先進的な論文を書き、今後、より広く読まれる価値があるとコメントを残している。

Monday, 30 August 2004

0845-0900	Welcome by Mr Leonard Soh, President, Singapore Structural Steel Society
0900-0945	S449 to EC3 via BS5950: The Process the Pitfalls and the Preparations *Professor David Nethercot, Imperial College London, UK*
0945-1030	Recent Developments in Composite Construction in the USA *Professor Roberto T. Leon, Georgia Institute of Technology, USA*
1100-1145	Innovative Use of Profiled Steel Plates for Structural Performance *Professor Yuhshi Fukumoto, Fukuyama University, Japan*
1145-1230	Direct Analysis and Design of Steel Frames Allowing for Column Flexural and Beam Lateral-Torsional Buckling, Professor S L Chan, The Hong Kong Polytechnic University
1400-1445	Innovative Use of Sandwich Plate Systems for Civil and Marine Applications *Dr. Stephen J. Kennedy, Intelligent Engineering, Canada*
1445-1515	Application of Steel-Concrete Hybrid Structures for Tall Building Construction in China *Professor Guo Qing Li, Tongji University, China*
1515-1545	Eurocode 3 : Design of Steel Structures - An Overview *Professor F S K Bijlaard, Delft University of Technology, The Netherlands*
1615-1645	Structural Performance of Cold-formed Steel Structures with Bolted Connections *Professor K F Chung, The Hong Kong Polytechnic University*
1645-1715	Design of Unconventional Steel Roof Structures *Mr Albert Loh, Albert Loh Consultants Pte Ltd, Singapore*

Tuesday, 31 August 2004

0900-0945	Realistic Performance Requirements for Steel in Structures *Dr Reidar Bjorhovde, The Bjorhovde Group, USA*
0945-1030	Design of Steel Arches to AS4100 *Professor Mark Bradford, University of New South Wales, Australia*
1100-1145	Recent Advances in the Fire Engineering Design of Steel Structures *Professor Colin Bailey, University of Manchester, UK*
1145-1230	Large-span Steel-concrete Composite Shell Roofs *Professor Jin-Guang Teng, The Hong Kong Polytechnic University*
1400-1430	A New Generation of High Strength Steel Rolled Sections *Mr Jean-Claude Gerardy, Arcelor, Luxemburg*
1430-1500	Recent Development and Innovation in Tubular Structures *Professor Y S Choo, National University of Singapore*
1500-1530	Large Span Cantilever Roof Truss for Grandstand at Singapore Racecourse *Mr Simon Wee, CPG Consultants Pte Ltd, Singapore*
1600-1630	Towards Good Welding Design and Fabrication, Dr N Krishnamurthy, Singapore
1630-1700	Hot-dip Galvanizing for Steel Corrosion Protection, Mike Ainsley, Zinifex Metals

「論文集（S＄50.送料共）はMs P. Zee, Singapore Structural Steel Society 232A River Valley Road, Singapore 238290 まで。」

International Symposium on Innovation and Advances in Steel Structures
30 - 31 August 2004, Singapore Structural Steel Society, 20th Anniversary Celebration

EUROCODE 3: DESIGN OF STEEL STRUCTURES - AN OVERVIEW

F S K Bijlaard

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PO Box 5048, 2600 GA Delft, The Netherlands

Prof Ir Frans Bijlaard is currently professor of steel structures with the Department of Civil Engineering & Geosciences at Delft University of Technology. His main specialties are on stability of steel structures, structural behaviour of joints in steel structures and design of greenhouses. He is chairman of the Dutch Society "Bouwen met Staal", is Chairman of the ECCS-Technical Committee TC10 "Structural Connections" and is chairman of CEN-TC250-SC3 "Design of Steel Structures". He is active professionally by providing advisory services and organizing advanced courses.

ABSTRACT

The European Standards Organisation (CEN) has taken over the initiative from the European Commission to develop a set of harmonized European standards for Structural Design, the Eurocodes. Together with standards for fabrication and erection and harmonized product standards these standards form the bases for the design of structures and structural products. After a period of experimental use of the ENV (European Pre Standard)-versions of the Eurocodes, these are now converted into official EN's (European Standards).
Eurocode 3 covers design of steel structures. This paper gives an overview of the context in which Eurocode 3 exists and of the accompanying codes. The various individual parts of Eurocode 3 are mentioned and discussed briefly. Attention will be paid on the statistical evaluation of test results that form the basis for the determination of the recommended values for the safety elements like the partial safety factors for strength and stability. Finally an opinion is presented on the possibilities and difficulties the practitioners will experience using the Eurocode 3 and on the future developments that are needed.

HISTORY AND CONTEXT OF EUROCODE 3

In the early eighties of previous century the European Commission took the initiative to ask several experts to develop a complete series of structural design codes, the Eurocodes. The first draft of Eurocode 3 was prepared in 1983/1984, and published by the CEC in 1985. Extensive and detailed comments on the 1985 draft were received from the twelve member states of the EEC in 1987. At that time the responsibility for further development of the first generation Eurocodes was mandated to CEN were than handed over to the European Standards Organisation CEN to further develop these documents towards formal CEN Standards. To achieve this goal CEN has set up a Technical Committee TC 250: "Structural Eurocodes", which within CEN is solely responsible for all structural design codes. This TC has nine Subcommittees (SC), each responsible for one volume, see figure 1.

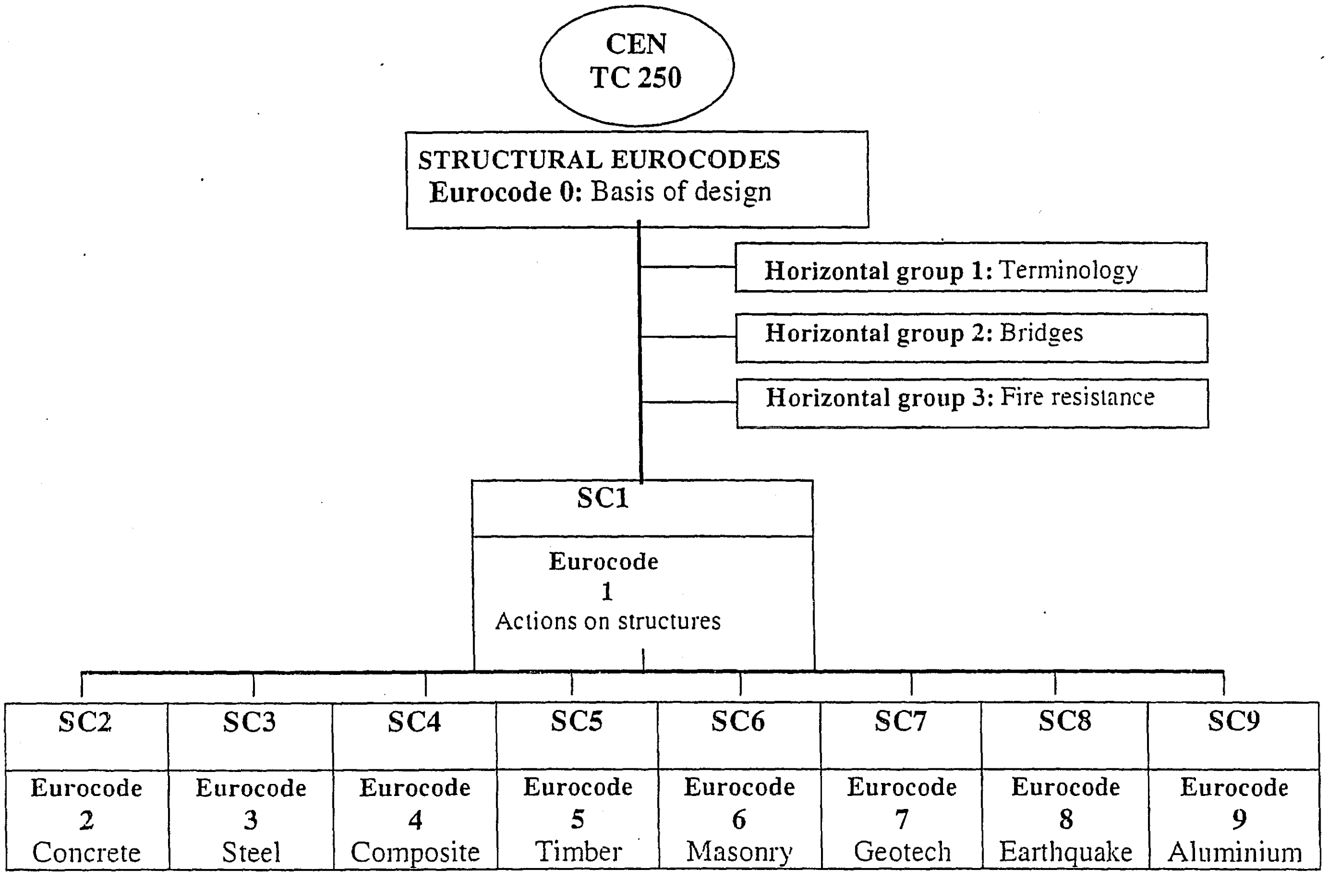

Figure 1 - Organization of CEN/TC250

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. This is covered in Eurocode 0 Basis of Design.

Basis of Design (EN1990) covers general design philosophy, basis of design, structural reliability, common non material-related aspects and common terminology and symbols.

Eurocode 1 covers general actions (effects of loadings) applicable to all structures in Part 1 and additional actions for specific structures in further parts. Eurocode 1 has the following Parts:

EN1991-1-1: Densities, self-weight, imposed loads
EN1991-1-2: Actions exposed to fire
EN1991-1-3: Snow loads
EN1991-1-4: Wind actions
EN1991-1-5: Thermal actions
EN1991-1-6: Actions during execution
EN1991-1-7: Accidental actions due to impact or explosion
EN1991-2 : Traffic loads on bridges
EN1991-3 : Actions on silos and tanks
EN1991-4 : Actions induced by cranes and machinery

The Eurocodes - being design standards - are to be used in combination with standards for fabrication and erection (in Euro-lingo called: execution) and product standards. The Eurocodes on Geotechnical Design and on Earthquake are also of importance the material related structural Eurocodes. For Eurocode 3 this relation is illustrated in figure 2. These related standards will be discussed briefly.

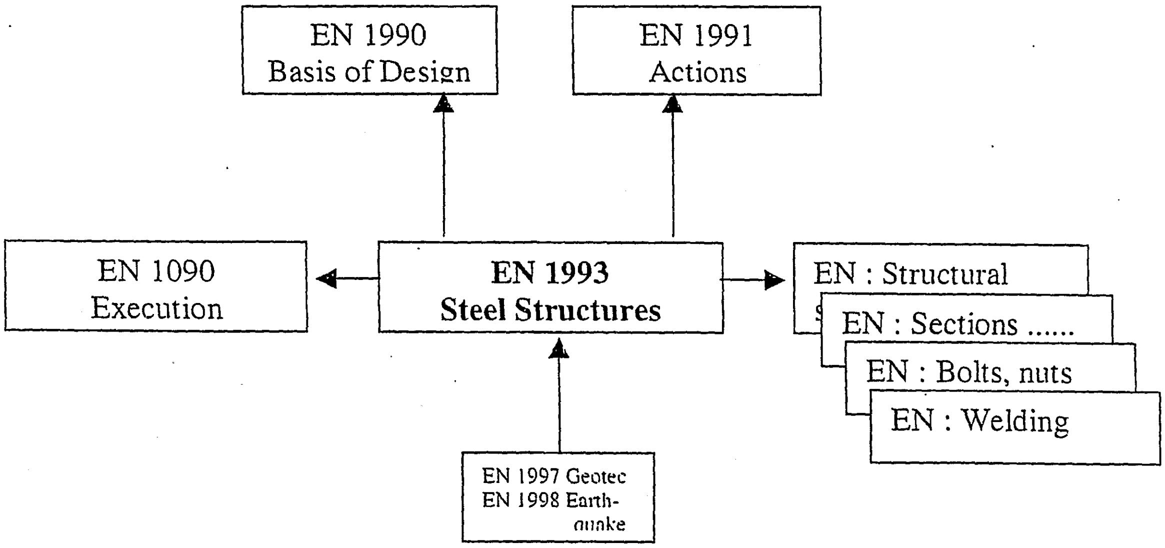

Figure 2 - Relation of EN1993: Eurocode 3 with other European standards

Execution:

The design procedures in the Eurocodes are only valid if adequate workmanship criteria during fabrication and erection are satisfied. For example, the levels of initial geometric imperfections assumed in many of the strength rules in Eurocode 3 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 ENV1090, to be converted in EN1090.

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.

Products:
Steel structures are normally fabricated from standardized industrial products. In the development of the design rules assumptions had to be made on the values and statistical variations of the geometrical and physical properties of materials and products. In the Eurocodes these assumptions are based on European product standards (EN's) and therefore Eurocodes refer to EN product standards. These standards are mainly equal with or derived from existing Euronorms or ISO-standards. The referenced product standards for example concern the following categories of products:

- Structural steel
- Sections and plates
- Bolts. nuts and washers
- Welding consumables
- Rivets
- Corrosion protection

They include classification, product range, dimensions, and tolerances, physical and chemical properties.

Basis of Design and Actions on structures:
These codes have already been discussed.

Geotechnical Design and Earthquake:
Eurocode 7 deals in Part 1 with geotechnical design for structures and in Parts 2 and 3 with geotechnical field tests and laboratory tests to assist design. This code is especially important for soil-structure interaction.
Eurocode 8 covers design of structures for earthquake resistance and is organised on a similar basis as the material-related Eurocodes.

STRUCTURE OF EUROCODE 3 STEEL STRUCTURES

The set-up of EN 1993 Steel Structures, in terms of Parts and Sections, resulted from policy decided by SC3 (with respect of the Parts) and TC250 (with respect of the Model Sections within each Part) and is as follows. The parts EN 1993-1-1 to EN 1993-1-12 are the so-called General Documents and contain rules that are applicable to more than one type of steel structure. The parts EN 1993-2 to EN 1993-6 are the so-called application parts. In an application part reference is made to those clauses of the general parts that are to be taken into account for that application. Part EN 1993-1-1 is an exception to this system because that part contains besides the general rules also the specific rules for buildings.

ENV 1993: Eurocode 3 - Design of Steel Structures consists of the following **general parts:**

prEN 1993- Part 1.1: General rules and rules for buildings

Part 1.1 gives rules for the design of Steel Structures in general together with specific provisions for Buildings. Provisions in Part 1.1 specific to buildings have been placed at the end of clauses and are indicated with a capital B behind the clause number. The intention being to make clear what is specific to buildings.
This part pays attention to the global analysis of the structure and the imperfections to be taken into account. Several Ultimate Limit States are considered like Resistances of Cross-Sections; Buckling Resistance of Members; Uniform Built-up Compression Members.

prEN 1993- Part 1.2: Structural fire design
This part is concerned with the determination of resistance of steel structures to fire. It provides information on how to determine the fire resistance based on the classical method with the standard fire curve but also on the much more advanced method "the Natural Fire Concept".

prEN 1993- Part 1.3: Supplementary rules for cold formed members and sheeting
This part is concerned with the strength and stability design of cold formed members and sheeting and is especially important for building products. Special attention is paid on the testing procedures of structural elements as well as op complete assemblies.

prEN 1993- Part 1.4: Supplementary rules for stainless steels
This part is concerned with stainless steel that has become popular for use in buildings, chimneys and tanks. A very important item is the selection of the material dependent on the circumstances of use.

prEN 1993- Part 1.5: Plated structural elements (in-plane loaded)
This part is in particular important for bridge structures and other structures where plate stability plays an important role.

prEN 1993- Part 1.6: Strength and stability of Shells
The design of structures like chimneys, tanks and pipelines is based on the theory of shells. In this part attention is paid effects of the boundary conditions, the influence of the geometrical imperfections and the design concepts for the limit state design.

prEN 1993- Part 1.7: Plated structural elements (transversely loaded)
This part is still in the ENV-stage and will be developed towards an EN.

prEN 1993- Part 1.8: Design of Joints
This part contains information on the strength capacity of individual fasteners and groups of fasteners. It also provides information about welded connections. Modelling of beam-to-column joints and the influence of joints on the global analysis is treated. Detailed information is provided on the design and verification of structural joints connecting H or I sections based on the component method. Detailed information is also given about hollow section joints.

prEN 1993- Part 1.9: Fatigue
This part is about the fatigue verification.

prEN 1993- Part 1.10: Material toughness and through-thickness properties
This part provides information about maximum permitted thickness value. Furthermore it provides an evaluation using fracture mechanics. It gives a selection procedure for the selection of materials for through-thickness properties.

prEN 1993- Part 1.11: Design of structures with tension elements
Aspects like design situations and partial factors, strength of steels and wires, length and fabrication tolerances, corrosion protection of each individual wire and corrosion protection of the rope / strand / cable interior are treated. Attention is paid to transient design situations during the construction phase, persistent design situation during service and non-linear effects from deformations. Also the various Ultimate and Serviceability Limit States are dealt with like strength vibrations and fatigue.

prEN 1993- Part 1.12: Additional rules for the extension of EN1993 up to steel grades S700
This part contains additions to EN 1993-1-1 to EN 1993-1-11, additions to application parts EN 1993-2 to EN 1993-6 and additions to EN 1090 from which it can be concluded if the rules can be used for steel grades up to S700.

ENV 1993: Eurocode 3 - Design of Steel Structures consists of the following **application parts:**

prEN 1993- Part 2:	**Steel Bridges**
prEN 1993- Part 3.1:	**Towers and Masts**
prEN 1993- Part 3.2:	**Chimneys**
prEN 1993- Part 4.1:	**Silos**
prEN 1993- Part 4.2:	**Tanks**
prEN 1993- Part 4.3:	**Pipelines**
prEN 1993- Part 5:	**Piling**
prEN 1993- Part 6:	**Crane supporting structures**

All these application parts contain Sections with clauses giving specific information to be taken into account for the design of that application. These clauses either refer to clauses in the various general parts and / or provides additional information specific for that application.

SAFETY LEVEL

In applying the rules in Eurocode 3 a structural safety is reached of not less than the reliability index β equal 3,8. Because the member states are entitled to choose their own safety level for structures, the rules are set up such that they contain safety elements of which the value can be chosen by the individual member state. These safety elements are for instance the partial (safety) factors for the resistance (limit states) of structural elements. For these safety elements in the Eurocodes so-called recommended values are given in notes accompanying the clauses containing these safety elements. To promote harmonization of design rules throughout Europe the Commission strongly advises to choose the recommended values for these safety elements.

The procedure to determine the partial safety factors for the resistance of structural elements can be explained in gross terms by the following steps:

1. The rules in the Euro-codes are based on limit state design format

- Effects of Actions $E_d \le R_d$ Design Resistance
- Effect of Actions
- $E_d = E_k \cdot \gamma_E$
- where E_k is the Characteristic Value for the Effects of Actions
- and γ_E is the Load Factor

- Design Resistance
- $R_d = R_k \cdot \gamma_M$
- where R_k is the Characteristic Value for the Resistance
- and γ_M is the partial safety factor or Model Factor

2. Splitting the Action side from the Resistance side leads to a simplified procedure to determine the Partial Safety Factors γ_E and γ_M by using the sensitivity factor $\alpha_E = 0.7$ for the effects of actions side and $\alpha_R = 0.8$ for the resistance side

3. Start with "ideal" assumptions:

- a) The strength function is a product function of independent variables (e.g. bolt in tension: $F_t = A_s \cdot f_u$ where: A_s is the stress area of the threaded part and f_u is the tensile strength of the bolt material);
- b) A large number of test results is available;

– c) All actual geometrical and material properties are measured;
– d) All variables have a log-normal distribution;
– e) The design function is expressed in the mean values of the variables;
– f) There is no correlation between the variables of the strength function.

4. The Standard Procedure to determine γ_M :

–Step 1 : Develop a "Strength Function" for the strength capacity of the structural member or detail considered,

$$r = g_R(X_i)$$

The strength function includes all relevant basic variables X_i which control the resistance in the limit state.
All variables should be measured for each test specimen i (assumption C).

–Step 2 : Compare experimental and theoretical values.
The experimental values r_{ei} are known from the tests.
Using the relevant strength function and putting the actual properties into the formula, leads to the theoretical values r_{ti} .

–Step 3 : Check whether the correlation between the experimental and theoretical values is sufficient.
If the strength function is exact and complete, all points (r_{ti}, r_{ei}) lie on the bisector of the angle between the axes of the diagram and the correlation coefficient $\rho = 1.0$

The correlation coefficient *r* needs to be determined. If the value $\rho \geq 0.9$, than the correlation is considered to be sufficient. In general the points (r_{ti}, r_{ei}) will scatter (See figure 3).

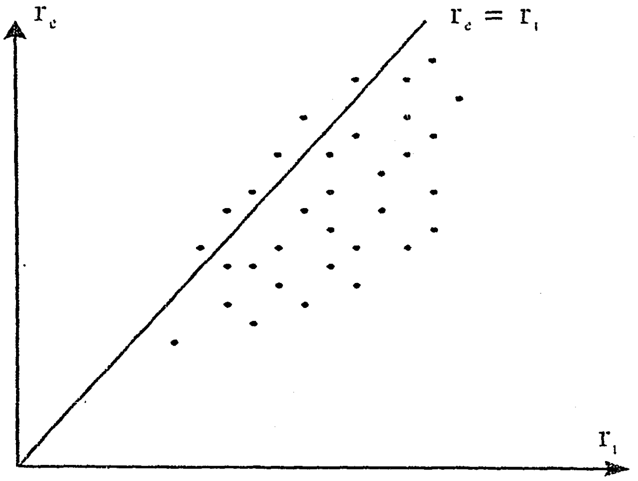

Figure 3 - Scatter of the points (r_{ti}, r_{ei}) in the theory - experiment diagram

–Step 4 : Determine the mean value correction via the correction terms $b_i = r_{ei} / r_{ti}$
The mean value correction

$$b_{mean} = \frac{1}{n}\sum_{i=1}^{n} b_i$$

The corrected strength function is:

$r_m(X_m) = b_{mean} \cdot r_t(X_m) = b_{mean} \cdot g_R(X_m)$ (See figure 4)

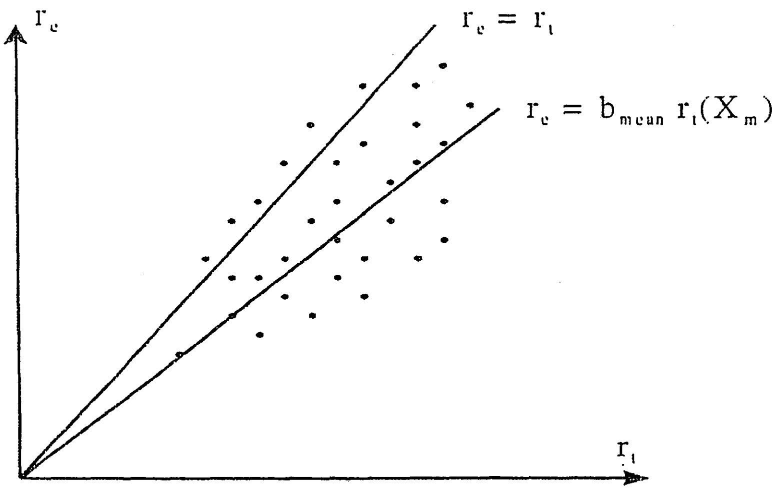

Figure 4 - Mean value correction in the theory - experiment diagram

–<u>Step 5</u> : Determine the coefficient of variation V_δ of the error terms δ_i

The error terms δ_i of each experimental value r_{ei} with respect to each theoretical, mean value corrected, resulting in $b_{mean} \cdot r_{ti}$, is determined as follows:

$$\delta_i = \frac{r_{ei}}{b_{mean} \cdot r_{ti}}$$

In most cases the coefficient of variation V_δ is relatively small

$$\delta_{mean} = \frac{1}{n}\sum_{i=1}^{n} \delta_i$$

The standard deviation of the error terms δ_i is σ_δ and the coefficient of variation is $V_\delta = \sigma_\delta / \delta_{mean}$

–<u>Step 6</u> : Determine the coefficient of variation V_{X_i} of the basic variables X_i in the strength function

The coefficient of variation of all basic variables may only be determined from the test-data assumed that the test population is fully representative for the variation in the actual situation. This is normally not the case, so the coefficients of variation have to be determined from pre-knowledge.

–<u>Step 7</u> : Determine the characteristic value, the 5%-fractile of the strength.

For the log-normal distribution (assumption D) the characteristic strength follows from:

$$r_k = r_m(X_m) \cdot e^{-k_s \cdot \sigma_{\ln r} - 0.5\sigma^2_{\ln r}}$$

where $\sigma_{\ln r} = \sqrt{\ln(V_r^2 + 1} \approx V_r$

k_S is the fractile coefficient for the 5% fractile

See figure 5.

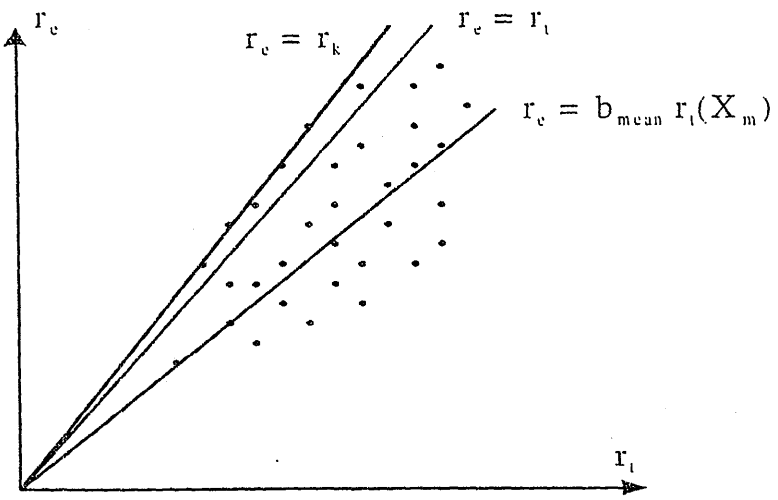

Figure 5 - Characteristic values r_k in the theory - experiment diagram

-<u>Step 8</u> : Determine the design value of the strength r_d and the partial safety factor (Model Factor) γ_M
The design value for the strength is related to the chosen reliability index $\beta = 3.8$

k_s is replaced by $k_d = \alpha_R \cdot \beta$ and $r_d = r_m(X_m) \cdot e^{-k_d \cdot \sigma_{\ln r} - 0.5\sigma^2_{\ln r}}$
with $k_d = \alpha_R \cdot \beta = 0.8 \cdot 3.8 = 3.04$

See figure 6.

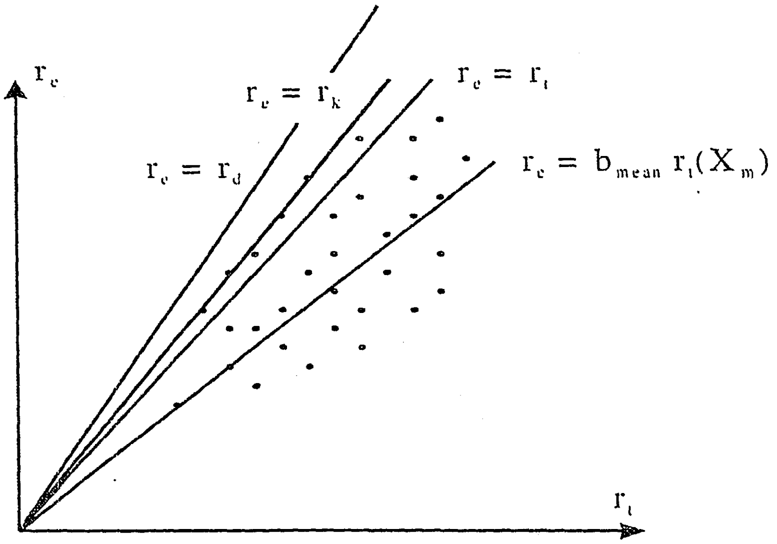

Figure 6 - Design values r_d in the theory - experiment diagram

The design value of the strength function is obtained by dividing the characteristic strength function by the partial safety factor or so-called model factor containing all uncertainties in the strength function.

$$r_d = \frac{r_k}{\gamma_M}$$

The characteristic strength and the design strength is known so that the partial safety or model factor can be calculated.

$$\gamma_M = \frac{r_k}{r_d} = \frac{r_m(X_m) \cdot e^{-k_s \cdot \sigma_{\ln r} - 0.5 \cdot \sigma_{\ln r}^2}}{r_m(X_m) \cdot e^{-k_d \cdot \sigma_{\ln r} - 0.5 \cdot \sigma_{\ln r}^2}}$$

This procedure, to determine the partial safety factors for the resistance of structural elements by a statistical evaluation of strength functions against experimental test results, is developed by Bijlaard in 1987 in close cooperation with Prof. Dr.-Ing. G. Sedlacek, RWTH-Aachen, Germany and Prof. Ir. J.W.B. Stark, Delft University of Technology, The Netherlands. The procedure contains adjustments for deviations from the "ideal" assumptions such as "a variable is defined as having another statistical distribution that a log-normal one, a limited number of test results is available, not all actual properties are measured and that the strength function is non linear with respect to the variables and may contain additions of the variables. The procedure is further developed to take account of the so-called "tail"-effect of the statistical distributions by the research team of Prof. Sedlacek and forms now Annex D of EN 1990 "Basis of Design".

INTRODUCTION OF EUROCODE 3 IN THE DESIGN PRACTICE

To introduce the Eurocodes in practice a lot is to be done to make the designers familiar with the Eurocode rules. Many initiatives are under way to organise courses to provide worked examples, to adjust education material for technical schools to the Eurocodes and to draft back ground reports to the rules in Eurocodes. The advantage of Eurocode 3 for the designer is that this code provides extensive information about how to calculate the structural behaviour of components like columns, beams and joints. However, many times it is said that the Eurocode is too complex for use in day-to-day practice. In the opinion of the author this is not the case but it is admitted that working with the Eurocode is a lot of work. And it is true that the designer has not much time to do his job in a commercial and competitive surrounding. Therefore it is necessary that user-friendly software is available to the designer to take the time consuming rules of the code to determine the joint behaviour out of his hands. In that situation the designer can spend his time to his profession being a designer looking for alternative structural solutions to reach a final design that reaches minimum integral costs (design + material + fabrication + erection + end-of-life + re-use) and leave the number crunching to the computer using adequate software. In that respect a warning should be made in using so-called expert-systems from the market. The designer should be very alert on the correctness of the software itself and on the correct use of that software. The term "expert-system" just means that only experts should use this software. In that case we can stop saying "Simple rules sell steel" and replace that by saying "Simple TOOLS sell Steel".

CONCLUSIONS

-The process of harmonization of design standards of the member countries of CEN will take a period of about three decades. Compared to the "life time" of an existing code in a country of about 15 years, for the Eurocodes this period is not so bad.

-Eurocode 3 "Design of Steel Structures" comprises a fairly complete set of design codes for uniquely designed structures and for a wide range of structural steel products.

-The introduction of the Eurocodes in the design practice needs great care. Design examples, guide lines, design tools (special software) should be developed in the various countries. Explanations of differences and the justification for these changes should be supplied to support the acceptation of the Eurocodes.

-To support these local activities in the various member states, background documents need to be drafted on which local design tools and examples need be based.

REFERENCES

EN 1993: 2004 "Eurocode 3 : Design of Steel Structures, Parts 1 to 6, CEN Central Secretariat, Rue de Stassart 36, B-1050 Brussels, BELGIUM

Bijlaard, F.S.K., Sedlacek, G. and Stark, J.W.B. (1987), "Procedure for the determination of design resistance from tests – Background report to Eurocode 3", TNO Building and Construction Research, Delft, The NETHERLANDS