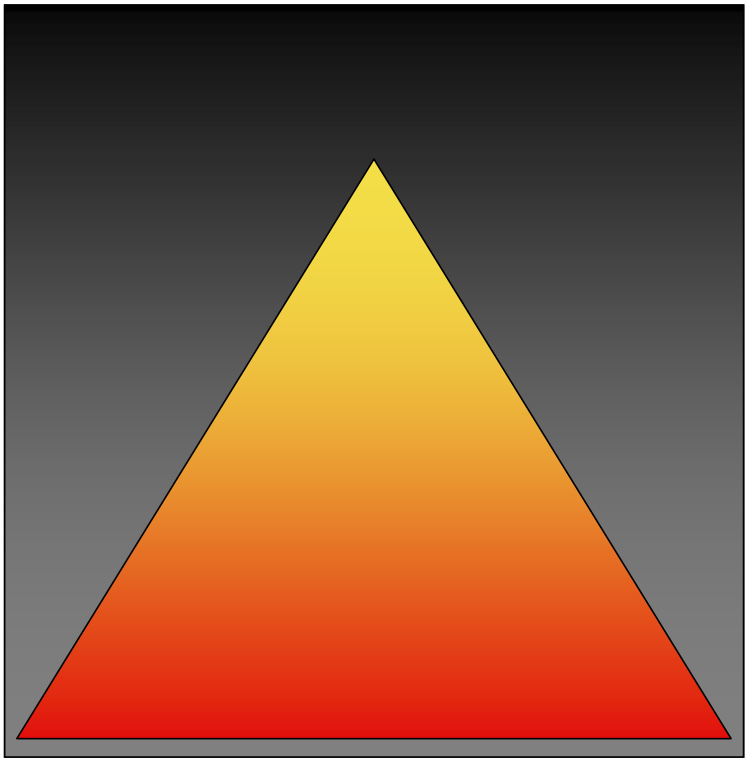
JRC Scientific and Technical Reports

IDENTIFICATION OF NEEDS FOR IMPROVED FIRE PROTECTION BY USE OF THE EUROCODES

Support to the implementation, harmonization and further development of the Eurocodes

S. Dimova, A. Pinto, A. Oztas, M. Geradin, A. Altinyollar



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Summary

This document provides description of the progress of the work on identification of key needs for improved fire protection in the context of implementation, harmonization and further development of the Eurocodes. The EU policy background of the fire design of construction works and construction products is identified on the basis of the Construction Products Directive (CPD, 89/106/EC), the Decisions of the European Commission related to the fire safety under the CPD, the Interpretative Document 2 "Safety in Case of Fire" to the CPD, Guidance Paper G concerning the CPD and the Commission Recommendation to the Member States on the implementation and use of Eurocodes.

The International Standardization Committees and CEN Technical Committees relevant to fire safety of construction works and construction products are presented. The EN Eurocode Parts 1-2 (fire design) are examined and compared with each other for consistency. An overview of the fire design procedures and methods in the Eurocodes is presented.

The Nationally Determined Parameters (NDPs) in the Eurocodes fire design parts are presented and analyzed viewing at the needs for further harmonization. It is concluded that despite the relatively small number of the NDPs in the fire design parts, most of them (more than two thirds) originate from different design cultures and procedures for structural analysis, and this fact naturally calls for further harmonization. The use of the uploaded NDPs will allow comparing the safety levels in the different Member States and justifying the further steps needed to enhance the fire safety of civil engineering works.

Regarding the National implementation and use of the fire design parts of the Eurocodes, it is outlined that for many Member States there is a gap between the approaches in the National regulations and the Eurocodes, and this fact results in difficulty to ‘calibrate’ the NDPs to achieve similar fire performance. The National implementation of the Eurocodes and their correct use in the design practice require preparation and provision of background information on the recommended values of the NDPs, training courses, designer guides, worked examples, handbooks, manuals, design aids and software.

Research needs to achieve improved fire design guidelines have been discussed in a working meeting with Prof. Joel Kruppa, Chairman of the Horizontal Group on Fire Design of CEN/TC250. These research needs should be further discussed with a wider circle of stakeholders. To progress with the research needed for improvement of the design guidelines for fire protection, it would be rational to explore the possibilities to create Focus Areas on fire safety in the European Construction Technology Platform and in the European Steel Technology Platform.

The need of more close co-ordination between CEN Technical Committees is pointed out with regard to the need for co-ordination of the work of CEN/TC127 and CEN/TC250 for proper distribution of the subjects of standardization concerned (*e.g.* the strength attenuation with the temperature should be given in the product standards and not in the Eurocodes).

It is concluded, that the identified needs for improved fire protection necessitate organizing a workshop on fire design using the Eurocodes with key representatives of the European Commission, different CEN/TCs relevant to fire design, EOTA, European Construction Technology Platform, European Steel Technology Platform and National Authorities of the Member States.

Table of Contents:

1 Introduction

The report presents material included in a deliverable to the Administrative Arrangement (AA) between the Enterprise and Industry Directorate General (DG ENTR) and the Joint Research Centre (JRC) regarding the support to the implementation, harmonization and further development of the Eurocodes. The work presented is part of the activity that sets as objective (*safety objective*) to establish further needs to achieve improved fire protection. The needs for improved design guidelines for fire protection are addressed exclusively from the point of view of Eurocodes implementation and further development. In the formulation of section 4 “Fire design according to the Eurocodes” the documents referenced under numbers 1 to 4 were used.

2 EU Policy Background

2.1 Construction Products Directive (CPD, 89/106/EC)

The Construction Products Directive (CPD) specifies six essential requirements to the construction works in which the construction products are to be incorporated, second of which relates safety in the case of fire. This requirement implies that:

"The construction works must be designed and built in such a way that in the event of an outbreak of fire:

- the load-bearing capacity of the construction can be assumed for a specific period of time;
- the generation and spread of fire and smoke within the works are limited;
- the spread of fire to neighboring construction works is limited;
- occupants can leave the works or be rescued by other means;
- the safety of rescue teams is taken into consideration."

The vast majority (mere than 80%) of construction products covered by the CPD have a requirement related to their reaction to fire (the extent to which they burn and contribute to the development of a fire), their resistance to fire (the ability to prevent the spread of flame and/or smoke, and, where relevant, to maintain mechanical stability etc.), or both. Harmonization in these areas is thus crucial to the successful implementation of the CPD, as the plethora of existing national regulations and classification systems present manufacturers with significant barriers to trade.

The CPD also covers products and systems installed in buildings either to control fire, to assist in fighting fires, or to provide warning of fire. Many barriers to trade have been reported by industry in these areas, due to differing requirements in Member States.

2.2 Commission Decisions

The following Decisions of the European Commission are related to the Fire safety under the CPD:

- Reaction to fire 2000/147/EC - February 2000: Commonly referred to as the Euroclasses. This document outlines classes of performance in relation to reaction to fire for construction products. This decision supersedes Commission Decision 94/611/EC.
- Resistance to fire 2000/367/EC - May 2000**:** This document outlines classes of performance in relation to resistance to fire for construction products.
- List of products/materials - external fire performance of roof coverings - 2000/553/EC - September 2000: This document gives a list of products which can be considered to fulfill all of the requirements for the performance characteristic "external fire performance" without the need for testing.

- External Fire Performance of Roofs/roof coverings 2001/671/EC - August 2001: This document outlines classes of performance in relation to EFP for roofs and roof coverings for construction products.

2.3 Interpretative Document 2 "Safety in Case of Fire" to Council Directive 89/106/EEC

This Interpretative Document deals with the aspects of the works where "Safety in case of fire" may be concerned. It identifies products or product families and characteristics relating to their satisfactory performance. For each intended use of the product, the mandates will indicate in further detail which of those characteristics shall be dealt with in the harmonized specifications, using a step by step procedure with CEN/CENELEC/EOTA, which will allow the product characteristics to be modified or complemented, if necessary.

2.4 Guidance Paper G concerning the Construction Products Directive - 89/106/EEC – amended, May 2000

This Guidance Paper addresses issues relating to the functioning of the European system for the classification of the reaction to fire performance of construction products (Euroclasses), within the context of the implementation of Council Directive 89/106/EEC. Guidance Paper G is intended for technical specification writers (CEN/CENELEC and EOTA members), regulators and enforcement authorities within the European Economic Area (EEA) and industry. References to Member States in the document also apply to the EEA EFTA States.

2.5 Commission Recommendation to the Member States on the implementation and use of Eurocodes (2003/887/EC)

A shared effort between the Commission, the Member States and Industry is put forward by the Commission Recommendation of 11 December 2003 on the implementation and use of the Eurocodes for construction works and construction products. In particular, Recommendation 6 defines the EU policy with regard to ensuring an ongoing increased level of the resistance of structures to fire.

“6. Member States should undertake research to facilitate the integration into the Eurocodes of the latest developments in scientific and technological knowledge. Member States should pool the national funding available for such research so that it can be used at Community level to contribute to the existing technical and scientific resources for research within the Commission, in cooperation with the Joint Research Centre, thus ensuring an ongoing increased level of protection of buildings and civil works, specifically as regards the resistance of structures to earthquakes and fire.”

3 Standardization Committees Related to Fire Safety

3.1 International

The most important International Standardization Committees related to fire safety are as follows:

- ISO/TC 92 “Fire Safety”
- ISO/TC 21 “Equipment for Fire Protection and Fire Fighting”
- ISO/TC 61 “Plastics”, TC 136 “Furniture”, TC 38 “Textiles”, TC 8 “Ships and Marine Technology”
- IEC/TC 20 "Electrical Cables", IEC/TC 89 "Fire Hazard Testing"
- International Maritime Organization - Sub-Committee "Fire Protection"

3.2 CEN Technical committees

The CEN Technical Committees related to fire safety are as follows:

- CEN TC 72 "Fire detection and alarm systems“
- CEN TC 127 "Fire safety in buildings"
- CEN TC 191 "Fixed firefighting systems"
- CEN TC 250 "Structural Eurocodes"

4 Fire Design According to the Eurocodes

4.1 Fire design parts

The following seven parts of the Eurocodes are connected to the fire design:

- EN 1991-1-2 - Actions on structures: Exposure to fire
- EN 1992-1-2 - Design of concrete structures: General rules - Structural fire design
- EN 1993-1-2 - Design of steel structures: General rules - Structural fire design
- EN 1994-1-2 - Design of composite steel and concrete structures: General rules - Structural fire design
- EN 1995-1-2 - Design of timber structures: General - Structural fire design
- EN 1996-1-2 - Design of masonry structures: General rules - Structural fire design
- EN 1999-1-2 - Design of aluminum structures: Structural fire design.

The fire design parts of the “material” Eurocodes (EN 1992 to EN 1996 and EN 1999) have similar structure, namely:

- Section 1: General. This section includes general information like scope, assumptions, definitions and symbols.
- Section 2: Basis of Design. This section includes requirements, actions, design values of material properties and verification methods.
- Section 3: Material Properties. This section differs in the different Eurocodes. It relates to the material. Every Eurocode has explanations about related material like, steel, wood or R/C.
- Section 4: Design Procedures. This section is the same in all Eurocodes. It explains design methods namely tabulated data, simple calculation method and advanced calculation methods.
- Section 5: Detailing. This section deals with detailing of members.

The main difference in the contents of fire design parts of the “material” Eurocodes (EN 1992 to EN 1996 and EN 1999) are as follows:

- EN 1992-1-2: Section 4 and 5: Section 4-design procedures: introduces simplified and advanced calculation methods, shear torsion and anchorage, spalling, joints and protective layers calculation methods; tabulated data method is given in a separate section (section 5). This code also introduces High Strength Concrete in a separate section.
- EN1993-1-2: Section 4: structural fire design. It introduces simplified and advanced calculation methods. No tabulated data method. No detailing section.
- EN1994-1-2: Section 4: Design procedures (tabulated data, simplified and advanced methods). Section 5: Detailing.
- EN1995-1-2: Section 4 and 5: Design procedures (simplified and advanced methods). No tabulated data method. A separate section (Section 6) is devoted to the connections. Section 7: Detailing.

- EN 1996-1-2: Section 4: Design procedures based on different assessment techniques (by testing, by tabulated data and by calculation). Section 5: Detailing.
- EN1999-1-2: Section 4: Structural Fire Design (simplified calculation and advanced methods). No detailing.

4.2 Background

According to the Interpretative Document N°2 "Safety in Case of Fire", the CPD Essential Requirement for safety in the case of fire may be observed by following various possibilities for fire safety strategies prevailing in the Member States like conventional fire scenarios (nominal fires) or "natural" (parametric) fire scenarios, including passive and/or active fire protection measures.

The fire parts of Structural Eurocodes deal with specific aspects of passive fire protection in terms of designing structures and parts thereof for adequate load bearing resistance and for limiting fire spread as relevant. Required functions and levels of performance can be specified either in terms of nominal (standard) fire resistance rating, generally given in National Fire Regulations or, where allowed by National Fire Regulations, by referring to fire safety engineering for assessing passive and active measures.

Supplementary requirements concerning, for example:

- the possible installation and maintenance of sprinkler systems;
- conditions on occupancy of building or fire compartment;
- the use of approved insulation and coating materials, including their maintenance;

are not given in the Eurocodes, because they are subject to specification by the competent Authority.

The general objectives of fire protection are to limit risks with respect to the individual and society, neighboring property, and where required, environment or directly exposed property, in the case of fire.

4.3 Design procedures

A full analytical procedure for structural fire design would take into account the behaviour of the structural system at elevated temperatures, the potential heat exposure and the beneficial effects of active and passive fire protection systems, together with the uncertainties associated with these three features and the importance of the structure (consequences of failure).

Two alternative design approaches (procedures) are used in the Eurocodes:

- *prescriptive design approach:* fire safety is usually achieved by designing various components in isolation. The building layout must meet certain requirements, such as maximum compartment size and minimum/maximum dimensions of the exit routes. The building fabric, structural elements and other building components only have to meet prescriptive requirements. Any possible interactions between different fire

protection measures are not considered, unless explicitly allowed as acceptable trade-offs (alternative prescriptive solutions).

- *performance based fire safety design approach*: appropriate fire resistance requirements are established by considering the actions and acceptable consequences of various fire scenarios. The structural fire design parts of material Eurocodes (EN 1992 to EN 1996 and EN 1999) follow mainly this fire safety engineering approach. This approach consists of the application of engineering principles, rules and expert judgments based on a scientific assessment of the fire phenomena and their effects.

The implementation of these two approaches is illustrated in Figure 1.1.

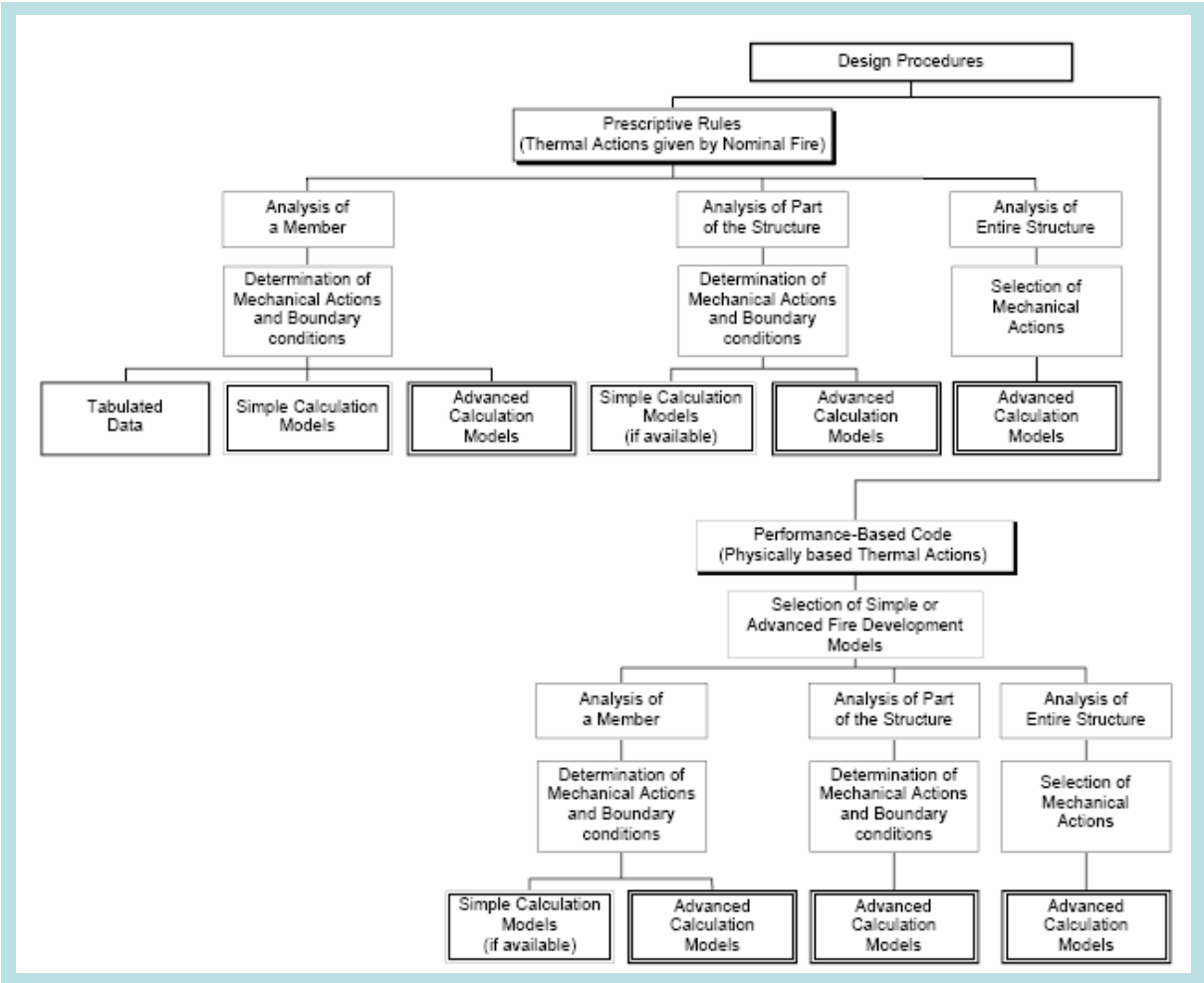

Figure 1.1. Alternative design approaches

Structural fire design analysis should take into account the following steps as relevant:

- selection of the relevant design fire scenarios;
- determination of the corresponding design fires;

- calculation of temperature evolution within the structural members;
- calculation of the mechanical behaviour of the structure exposed to fire.

4.4 Actions Considered in Fire Design

Structural fire design involves applying actions for temperature analysis and actions for mechanical analysis. Actions on structures from fire exposure are classified as accidental actions. Mechanical behaviour of the structure is depending on thermal actions and their thermal effect on material properties and indirect mechanical actions, as well as on the direct effect of mechanical actions.

4.4.1 Thermal Actions

The specification of appropriate fire scenarios is a crucial aspect of fire safety design. The selected fire scenarios have a major influence on all aspects of the design as they represent the input for most of the quantification processes.

A design fire scenario is a qualitative description of the course of a particular fire with respect to time and space. It includes the impact of the fire on all parts of the building, including the occupants and the fire safety systems. The design fire scenario considers the ignition source and mechanism, the growth of fire on the first item ignited, the spread of fire, the interaction of the fire with its environment and its decay and extinction. It could also include the interaction of the fire with the building occupants and the interaction with the fire safety systems within the building.

In the Eurocodes, fire actions are considered by use of the following classes:

- Nominal Temperature–time curves:
  - Standard temperature-time curves;
  - External fire curve;
  - Hydro-carbon curve;
- Natural Fire models:
  - Simplified Fire Models (parametric fires):

    Compartment fires;

    Localized fires.

  - Advanced fire models:

    one zone model;

    two zones model;

    computational fluid dynamics models.

4.4.2 Mechanical actions

Mechanical actions on a structure in the case of fire design are defined as follows:

$$\sum \gamma_{GA} \cdot G_k + \psi_{1,1} \cdot Q_{k,1} + \sum \psi_{2,i} \cdot Q_{k,i} + \sum A_d(t)$$

where:

G_k is the characteristic value of permanent action ("dead load");

$Q_{k,1}$ is the characteristic value of one (the main) variable action;

$Q_{k,i}$ is the characteristic value of other variable actions;

Ad(t) are the design values of actions from fire exposure (mainly indirect actions due to thermal elongation);

γ_{GA} is the partial safety factor for permanent actions in the accidental situation (1.0 is suggested);

$\psi_{1,1} \cdot \psi_{2,I}$ are the combination coefficients for buildings according to EN 1991-1-1.

Simultaneous occurrence with other independent accidental actions needs not be considered according to EN 1991-1-2.

Imposed and constrained expansions and deformations caused by temperature changes due to fire exposure shall be also considered.

4.5 Verification for fire resistance

According to the fire design parts of the “material” Eurocodes (EN 1992 to EN 1996 and EN 1999), it shall be verified that for the relevant duration of fire exposure *t*:

$E_{d,fi} \leq R_{d,t,fi}$

where:

$E_{d,fi}$ is the design effect of actions for the fire situation, determined in accordance with EN 1991-1-2, including effects of thermal expansions and deformations;

$R_{d,t,fi}$ is the corresponding design resistance in the fire situation.

The analysis of a structure can be performed as:

- Member analysis (mainly when verifying standard fire resistance requirements),
- Analysis of parts of the structure,
- Global structural analysis.

There are three assessment methods in Eurocodes:

- tabulated data;
- simple calculation models;
- advanced calculation methods.

Where simple calculation models are not available, the Eurocodes fire parts give design solutions in terms of tabulated data (based on tests or advanced calculation models), which may be used within the specified limits of validity. Tabulated data is generally conservative because it is often used by designers with limited knowledge of the subject.

Simple calculation models are design methods for individual members, which are based on conservative assumptions. They are rather easy to use. However, due to this simplicity, their field of application is restricted, since they are generally not valid outside the range for which they were developed.

Advanced calculation models are based on fundamental physical behavior to give a reliable approximation of the expected behavior of the structure in case of fire. Advanced calculation models are used only by a small number of expert designers, using specialized computer software.

In Table 1.1 the application of the different methods of verification for fire resistance according to EN 1992-1-2 is presented.

Table 1.1. Application of the different methods of verification for fire resistance

	Tabulated data	Simplified calculation methods	Advanced calculation models
Member analysis The member is considered as isolated. Indirect fire actions are not considered, except those resulting from thermal gradients	**YES** - Data given for standard fire only, 5..1(1) - In principle data could be developed for other fire curves	**YES** - standard fire and parametric fire, 4.2.1(1) - temperature profiles given for standard fire only, 4.2.2(1) - material models apply only to heating rates similar to standard fire, 4.2.4.1(2)	**YES**, 4.3.1(1)P Only the principles are given
Analysis of parts of the structure Analysis of parts of the structure Indirect fire actions within the sub-assembly are considered, but no time-dependent interaction with other parts of the structure.	**NO**	**YES** - standard fire and parametric fire, 4.2.1(1) - temperature profiles given for standard fire only, 4.2.2(1) - material models apply only to heating rates similar to standard fire, 4.2.4.1(2)	**YES** 4.3.1(1)P Only the principles are given
Global structural analysis Analysis of the entire structure. Indirect fire actions are considered throughout the structure	**NO**	**NO**	**YES** 4.3.1(1)P Only the principles are given

5 National Implementation and Further Harmonization

5.1 Nationally Determined Parameters

The Eurocodes are the result of a long procedure of bringing together and harmonizing the different design traditions in the Member States. In the same time, the Member States keep exclusive competence and responsibility for the levels of safety of works. The differences in the environmental conditions and in the ways of life in the Member States also require flexibility in the National Application of the EN Eurocodes.

Therefore the Eurocodes include Nationally Determined Parameters (NDPs) which:

- take into account differences in geographical, geological or climatic conditions;
- result from different design cultures and procedures for structural analysis;
- arise from the requirement for safety levels in the relevant Member States.

A NDPs database has been created by the JRC in the framework of the Administrative Arrangement with DG ENTR in view of implementing the concerned parts of the Commission Recommendation of 11 of December, 2003, namely in notifying the Commission on the NDPs and in use of the recommended values. The database is an on-line tool where users can access:

- the NDPs: “recommended values”, country choice and the reasons for non-acceptance of the recommendation;
- the National Annexes of the participating countries.

By the end of February 2007 all fire design parts except EN 1999-1-2 (still not published by CMC) have been open for upload of NDPs and of National Annexes. Although, no uploads from the Member States have been processed.

5.2 Needs for the National implementation and use

As already commented in the Report on the progress of the work for the second six months of the Administrative Arrangement (reference 6), the pace on laying down the NDPs and production of National Annexes seems slow. In fact, in spite of the availability of the standards, the first National Annexes have just been produced or were scheduled for 2006. Furthermore, Member States point out two factors contributing to the delay in the production of the National Annexes, namely:

- the gap between the approaches in the National regulations and the Eurocodes and consequently,
- the difficulty in ‘calibrating’ the NDPs to achieve comparable fire performance.

The proper National implementation of the Eurocodes and their correct use in the design practice require more attention to the preparation and provision of:

- background information on the recommended values of the NDPs;
- training courses;
- designer guides, worked examples, handbooks, manuals, design aids and software.

As an example, the handbook “Design of Buildings for the Fire Situation” (reference 5) is available in Internet as a result of the Leonardo da Vinci pilot project on implementation of Eurocodes.

5.3 NDPs in the fire design parts

The work on the design of the NDPs database has shown that in a number of cases an NDP cannot be represented by a single value. There are many NDPs which take the form of tables, graphs, acceptance of recommended procedure, choice of calculation approach, when alternatives are given, or introduction of a new procedure, provision of further, more detailed information, etc. For this reason a general classification of the NDPs types was developed aiming at simultaneous mirroring the functionality of the NDPs in the code and the data type needed for the definition of the fields in the NDPs database. In Table 1.2 the number of the NDPs of all Eurocode Parts corresponding to the different types is presented. The statistic is based on data for 44 Eurocode Parts in stage 64 and the rest of the parts in stage 51 (formal vote launched) or higher.

Table 1.2. Number of the NDPs in all the Eurocode Parts

#	Type	Nb NDPs	% from the total
1	Value(s) of (a) parameter(s)	337	23.9
2	Reference to some set of values – table(s)	163	11.5
3	Acceptance of the recommended procedure, choice of calculation approach, when alternatives are given, or introduction of a new procedure	463	32.8
4	Country specific data	18	1.3
5	Optional National chart(s) or table(s) of a parameter	1	0.1
6	Diagrams	15	1.1
7	References to non-contradictory complementary information	22	1.6
8	Decisions on the application of informative Annexes	245	17.4
9	Provision of further, more detailed information	115	8.1
10	Reference to information	31	2.2
	Total	1410	100

As seen from Table 2 only in 35 % of the cases (relevant to types 1 and 2) the divergence of the NDPs from the “recommended values” can be estimated by statistical analysis. In the rest of the cases expert analysis is needed for assessment of the degree of divergence from the recommendation. The analysis of the content of the NDPs shows that most of them relate to:

- Selection of thermal actions:
- Nominal fires;
- Parametric fire (simplified fire models);
- Advanced fire models;
- Some coefficients for load combination;
- Default values for reduction factor for the design load level in fire situation;
- Use of advanced calculation models.

5.4 Needs for further harmonization of the Eurocodes approaches and safety levels

In Table 1.3, the number of the NDPs in the separate Eurocodes fire design parts is presented versus the different NDPs types.

Table 1.3. Number of the NDPs in the Eurocodes fire design parts

EN parts	1991-1-2	1992-1-2	1993-1-2	1994-1-2	1995-1-2	1996-1-2	1999-1-2	Total	% from the total
Number of NDPs (all types)	20	22	8	17	11	13	5	96	100
Type 1	-	4	3	2	3	2	3	17	17.7
Type 2	-	3	-	-	-	1	-	4	4.2
Type 3	8	10	2	3	2	5	-	30	31.2
Type 4	-	-	-	-	-	-	-	-	-
Type 5	-	-	-	-	-	-	-	-	-
Type 6	-	-	-	-	-	-	-	-	-
Type 7	-	-	-	-	-	-	-	-	-
Type 8	7	5	3	9	6	4	2	36	37.5
Type 9	-	-	-	-	-	-	-	-	-
Type 10	5	-	-	3	-	1	-	9	9.4

The analysis of the data in Table 1.2 and Table 1.3 shows, that:

- the fire design parts contain 6.8 % of all the NDPs in the Eurocodes;
- the average number of NDPs in the fire design parts is 14 (96 NDPs in 7 parts). It is less than the average for all the Eurocode Parts, which is 24 (1410 NDPs in 58 parts).

Despite this relatively low number of the NDPs:

- only 22% of the NDPs in the fire design parts (relevant to types 1 and 2) are numerical values and the divergence of the NDPs from the “recommended values” could be estimated by statistical analysis;
- this percentage is much lower than the respective percentage for all the Eurocode Parts.

The relatively low percentage of the NDPs with numerical values in the fire design parts could be explained by the prevailing number of NDPs of type 3 (31%) and type 8 (37.5%). These NDPs:

- are related to choice of calculation approaches or to decisions on application of Informative Annexes (normally also related to choice of calculation approaches);
- do not arise from the necessity to take account of different geographic, geological and climatic conditions, which is reasonable in the case of fire design;
- originate from different design cultures and procedures for structural analysis, and hence, naturally call for further harmonization.

Consequently, the analysis of the NDPs in the fire design parts of the Eurocodes puts forward the necessity of:

- expert assessment of the degree of divergence of the NDPs from the recommendation and identification of the reasons for the divergences;
- exploration of harmonization possibilities to reduce the number of the NDPs in the Eurocodes resulting from different design cultures and procedures in structural analysis.

At the same time, the use of the uploaded NDPs will allow to compare the safety levels in the different Member States and to justify the further steps needed to enhance the fire safety of civil engineering works.

6 Research Needs

On the basis of available relevant documents and discussion with experts, it has been seen that the current prescriptive code environment in most Member States will evolve to a performance-based code environment when adopting the Eurocodes. That will foster and reward innovation in fire resistant technology, but basic research is needed to pave the way for improvement of the European fire design standards. The advances in fire safety require research in a number of topics.

A seminar and working meeting with Prof. Joel Kruppa, Chairman of the Horizontal Group on Fire design of CEN/TC250, were organized at the JRC on 12.07.2006 (see reference 7). Prof. Kruppa focused on Eurocodes approach to fire design and recent advances. Following the presentation a discussion has taken place on the subject. As a follow-up of the discussion, the subsequent important research needs were outlined:

Regarding the “Nominal” fire approach:

- Harmonized procedure to determine safety factors
- Calibration of calculation methods to tests
- Thermal conductivity for various types of concrete
- Connections
- Aluminum alloys
- Effects of creep (steel, concrete) at elevated temperature
- Unbraced steel or composite frames

Regarding the “Fire Safety Engineering” approach:

- Under real fire scenarios:
  - Scope and limitation of models for design fires
  - Define the way to take into account, in fire development, active fire measures like detection, smoke evacuation, sprinklers, etc.
  - Spalling conditions for concrete (HSC) for various fire scenarios
  - Behavior of structural elements (concrete, steel, composite, timber)
- Under real fires including cooling phase:
  - Determination of “real” thermal characteristics of fire protection materials

It should be noted, that there is no specific European Technology Platform devoted to fire safety issues. The need of performing research for new developments in fire safety is pointed out only in the Strategic Research Agenda of the European Steel Technology Platform, but there is no specific Focus Area on fire safety issues. To meet the important research needs for improvement of the design guidelines for fire protection it would be rational to explore the possibilities to create Focus Areas on fire safety in the:

- European Construction Technology Platform;
- European Steel Technology Platform.

7 Co-ordination between CEN Technical Committees

There is a need for co-ordination of the work of CEN/TC127 and CEN/TC250 with regard to the proper distribution of the subjects of standardization concerned, *e.g.* the strength attenuation with the temperature should be given in the product standards, and not in the Eurocodes.

8 Conclusion

The work on identification of the needs for improved fire protection outlines the following groups of issues:

- ***Needs for the National implementation and use:*** the fire design parts of the Eurocodes will need some time to be implemented appropriately, since for many Member States the gap between the approaches in the National regulations and the Eurocodes results in difficulty to 'calibrate' the NDPs to achieve similar fire performance. The appropriate National implementation of the Eurocodes and their correct use in the design practice require preparation and provision of background information on the recommended values of the NDPs, training courses, designer guides, worked examples, handbooks, manuals, design aids and software.
- ***Needs for further harmonization of the Eurocodes approaches and safety levels:*** more than two-thirds of the NDPs in the fire design Eurocode Parts originate from different design cultures and procedures for structural analysis, and hence, naturally call for further harmonization. The use of the uploaded NDPs will allow comparing the safety levels in the different Member States and to justify the further steps needed to enhance the fire safety of civil engineering works.
- ***Research needs:*** Important research needs have been discussed in a working meeting with Prof. Joel Kruppa, Chairman of the Horizontal Group on Fire design of CEN/TC250. These research needs should be further discussed and defined with a wider circle of stakeholders. To progress with the research needed for improvement of the design guidelines for fire protection, it would be rational to explore the possibilities to create Focus Areas on fire safety in the European Construction Technology Platform and in the European Steel Technology Platform. The European Technology Platforms are becoming the main drive for identifying research priorities at European level.
- ***Co-ordination between CEN Technical Committees:*** there is need for co-ordination of the work of CEN/TC127 and CEN/TC250 with regard to the proper distribution of the subjects of standardization concerned (*e.g.* the strength attenuation with the temperature should be given in the product standards and not in the Eurocodes).

The above discussed needs for improved fire protection necessitate organizing a workshop on fire design using the Eurocodes with key representatives of the European Commission, different CEN/TCs relevant to fire design, EOTA, European Construction Technology Platform, European Steel Technology Platform and National Authorities of the Member States with the following objectives:

- Overview of the preparedness of the Member States and identification of the specific problems, research and legislation needs for adoption of National Standards implementing Eurocodes fire design parts.
- Exchange of experience and views on the strategy of training and on the elaboration of guidelines and training materials on fire design.
- Strengthening of the international co-operation on the methods and approaches for adoption of the Nationally Determined Parameters aiming at their future harmonization.
- Definition of the important research needs to achieve improved fire design guidelines. Contribution to the setting-up of a network of European key research institutions

engaged in fire safety engineering. Discussion of the possibilities for active involvement of the European Construction Technology Platform and the European Steel Technology Platform in the fire safety issues.

- Direct feedback by the representatives of the Commission and CEN/TC250 to the potential legislation and technical problems in the adoption of the Eurocodes fire design parts.

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Abstract

This document describes the progress of the work on identification of key needs for improved fire protection in the context of implementation, harmonization and further development of the Eurocodes. The EU policy and the key actors in standardization relevant to the fire design of construction works and construction products are presented. Fire design procedures and methods in the Eurocodes are overviewed. The Nationally Determined Parameters (NDPs) in the Eurocodes fire design parts are analyzed viewing at the needs for National implementation of the Eurocodes and the potential for further harmonization. Key research directions for further development of the Eurocode fire design parts are presented following a discussion with the Chairman of the Horizontal Group on Fire Design of CEN/TC250.

Finally, the document provides a proposal for the further actions needed to formulate and justify the key needs for improved fire design using the Eurocodes.

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