Fire Safety Codes and Construction Products within the EU
– An Evaluation of Harmonisation

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Preliminary Matter

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Abstract

The objective presented in this thesis is to evaluate Fire Safety on Construction Products within the EU from the aspect of harmonisation. The variations in regulations between countries in the EU regarding Fire Safety may be an obstacle to the free trade of goods and services for Construction Products. The aim is to show to what degree the Building Codes are harmonised in respect to the use of Construction Products. Ten countries within the EU were studied; Denmark, the Czech Republic, France, Germany, Italy, the Netherlands, Poland, Spain, Sweden and the UK. Five research questions are addressed;

1. How can the level of harmonisation of the Building Code be evaluated?
2. How harmonised are the Building Codes?
3. How are the Building Codes for Fire Safety Design structured for the studied countries?
4. Will a higher level of harmonisation result in a higher level of Fire Safety?
5. Can the harmonisation process result in a higher level of Fire Safety?

The criterion for a high degree of harmonisation was defined in the work by the authors. The definition was: “if it would be possible for a company in the building industry to complete a Fire Safety Design for a specific building.” This was evaluated from the viewpoint of a Code Consultant, who without previous knowledge about a specific country was trying to access and design the Fire Safety Solutions for a four storey building. For this study the approach was a prescriptive based design. This viewpoint was summarised into three aspects to use for the evaluation of harmonisation, *attainability of the regulations*, *structure in the regulations* and *level of Fire Safety*.

The level of Fire Safety, the last of the tree aspects defined here as important for harmonisation, was based on the framework for Fire Safety as described in the Construction Product Regulation (CPR). The CPR is a regulation of building products within the EU, with the aim to reduce trade barriers associated with test-methods and standards. Reducing trade barriers for product is part of the EU aim to create a single market. CPR is not intended to be the sole method for the EU to reach this aim but in this thesis it is used as a bench-mark because it references Fire Safety Regulations as a part of harmonisation. The five requirements on regulations concerning Fire Safety mentioned in the CPR are listed below:

1. The Load-bearing capacity of the construction can be assumed for a specific period of time;

2. The generation and spread of fire and smoke within the Construction Works are limited;
3. The spread of fire to neighbouring Construction Works is limited;
4. Occupants can leave the Construction Works or be rescued by other means;
5. The safety of rescue teams is taken into consideration

The following work was carried out to answer the research questions; a Case Study on the attainability of regulations, a review of the structure within the regulations, and a Case Study to evaluate the level of Fire Safety.

The results from the analysis show that the Case Studies were useful for evaluating harmonisation per the definition in the report. On the other hand the review of the structure using the CPR- requirements gave very little information and was not a useful method to evaluate harmonisation.

Case Study 1 on attainability shows a low level of attainability for parties outside of the studied country. Of the ten countries studied the relevant regulations were attained for only five countries. For a majority of the countries it was a difficult process to find and understand the documents. There is great room for improvement to make sure that all relevant documents are available online. If websites were presented in English it would open to a larger audience, also other large languages could be considered. The building codes have a low level of harmonisation regarding attainability.

The CPR Analysis showed that the headlines from the five CPR Requirements were mentioned in the regulations, but provided no information on how well they were implemented in the detailed regulations. The building codes have a high level of harmonisation regarding structure.

Case Study 2 on Fire Safety in a residential building showed three major themes; the level of Fire Safety is very varying although the requirements are described in a similar approach, the level of Fire Safety is lower than expected and different Design Requirements may result in the same level of safety. The study indicated that the level of Fire Safety is very complex, and in order to provide similar levels of Fire Safety a joint scientific approach must be taken when developing prescriptive based code. Requirements on Load-bearing construction stand out as the exception. For Load-bearing construction there is an adopted Eurocode (EN 1990:2003 Eurocode 2004). This could be the explanation for the high degree of harmonisation in this area, or it could be that the Eurocode was possible to develop based on the preexisting high level of similarity. The building codes have a low level of harmonisation regarding the level of Fire Safety. The requirements mentioned in the CPR does not describe what the specific level of Fire Safety should be, each country decides themselves through political decisions on a reasonable level of Safety, appropriate to their specific circumstances. A Case Study, as used in this thesis, will only show variations between the countries and cannot be used to evaluate a reasonable level of Fire Safety.

This work has several practical applications. Firstly, it points to the need for guidance to the correct documents. The countries could improve the access to websites and understanding of the hierarchy with search optimisation and introductions to the hierarchy of regulations in different languages. The findings also suggest a role for the EU to function as a gathering source. All the regulations can be found once the name of the relevant regulation is defined, but this first step can present a large obstacle without network or previous knowledge. Lastly the differences in the content of the regulations implicate that to achieve the aim in the CPR regarding the level of safety; a work similar to the Eurocodes for construction could be the solution if developed for all of the five requirements. This work does not evaluate if this is a practically viable solution.

Sammanfattning

Målet redovisat i denna uppsats är att utvärdera graden av harmonisering inom EU avseende brandskydd som påverkar byggprodukter. Brandskyddsregler kan utgöra ett handelshinder för den fria rörligheten av varor och tjänster inom byggproduktsektorn. Syftet är att redovisa hur harmoniserade reglerna inom brandskydd är för användandet av byggprodukter. Tio länder inom EU har studerats; Danmark, Tjeckoslovakien, Frankrike, Tyskland, Italien, Nederländerna, Polen, Spanien, Sverige och Storbritannien.

I uppsatsen avhandlas följande frågeställningar:

1. Hur kan graden av harmonisering i byggreglerna utvärderas?
2. Hur harmoniserade är byggreglerna?
3. Hur är brandskyddsreglerna strukturerade för de olika länderna i studien?
4. Leder en högre grad av harmonisering till ett högre brandskydd?
5. Leder harmoniseringsprocessen till en högre nivå av brandskyddet?

Kriteriet för en hög grad av harmonisering fastställdes i arbetet till möjligheten för ett företag inom byggsektorn att utföra en brandskyddprojektering för en specifik byggnad. Detta omformulerades till en situation där en projektör, utan landspecifika förkunskaper, söker efter byggregler för att fastställa vilka brandkrav som gäller för ett fyravånings-bostadshus. I det här arbetet var utgångspunkten en förenklad dimensionering. Kriterier för harmonisering bestämdes i arbetet till tillgänglighet av reglerna, brandskyddsreglernas struktur och brandskyddsnivån

Brandskyddsnivån baserades på brandskyddsmål enligt Byggproduktförordningen (CPR). Byggproduktförordningen reglerar byggprodukter inom EU, med målet att reducera handelshinder som uppstår från olika testmetoder och produktstandarder. Byggproduktförordningen är dock inte den enda metoden för att nå detta mål en används i denna uppsats eftersom den beskriver ett antal mål för brandskydd som en del av harmoniseringsarbetet. De fem brandskyddsmålen i CPR är listade nedan;

1. Bärförmåga vid brand kan antas vara given för en specifik tid.
2. Skydd mot brandspridning inom brandcell.
3. Skydd mot brand- och brandgasspridning mellan brandceller.
4. Utrymning.
5. Räddningstjänstens insats.

Metoderna för att besvara frågeställningarna var en fallstudie av tillgängligheten av brandskyddsregler, en jämförande litteraturstudie för utvärdering av brandskyddsreglernas struktur och en fallstudie för att utvärdera brandskyddsnivån.

Resultaten visar att fallstudier var användbara för att utvärdera graden av harmonisering, enligt den definition av harmonisering som beskrivits i detta arbete. Den jämförande litteraturstudien bedömdes som en mindre användbar metod eftersom den gav begränsad information.

Den första fallstudien på tillgänglighet visar på en låg nivå av tillgänglighet för byggreglerna om man befinner sig utanför det studerade landet. Av de tio studerade länderna erhölls endast relevanta byggregler för fem länder. För en majoritet av länderna var sökprocessen omständlig och förenad med svårigheter att tolka innehållet. Skillnaderna mellan länderna visar att det finns stort utrymme för att förbättra tillgängligheten så att de relevanta dokumenten finns på myndigheternas hemsidor och så att regler och hemsidor är tillgängliga på Engelska. Nivån av harmonisering för brandskyddsreglerna är låg avseende tillgänglighet.

Den jämförande litteraturstudien visar att de övergripande rubrikerna från de fem brandskyddsmålen i CPR används. Inga slutsatser kunde dock dras om implementation av dessa mål i föreskrifterna eftersom analysen begränsade sig till struktur. Nivån av harmonisering för brandskyddsreglerna är hög avseende struktur.

Fallstudien på brandskydd i ett bostadshus visade på tre slutsatser, nivån på brandskydd kan variera trots att kraven är utformade på liknande sätt, nivån av brandskydd var lägre än förväntat och att olika krav kan resultera i samma nivå av brandskydd. Resultaten från fallstudien indikerade att nivå på brandskydd är en mycket komplex fråga, och att för att uppnå likvärdiga brandskyddsnivåer i föreskrifter krävs en vetenskaplig ansats. Krav på bärförmåga på brand visar på ett undantag där nivån är likvärdig, och det är också det område där det är framtaget dimensioneringsregler med en Eurocode. (EN 1990:2003 Eurocode 2004). Det kan vara så att anledningen till att nivån är likvärdig är att det finns en Eurocode, men det kan också vara så att anledningen till att en Eurocode är framtagen är för att nivån sedan tidigare var likvärdig. Nivån av harmonisering för brandskyddsreglerna är låg avseende nivå av brandskydd. Kraven i byggproduktförordningen anger inte vad so är en acceptabel nivå på brandskyddet, varje land bestämmer genom politiska beslut vad som anses vara en acceptabel nivå. Den acceptabla nivån är en komplex fråga eftersom förutsättningar varierar mellan länder. Fallstudien kan därför inte ge svar på vad som är en acceptabel nivå men utan kan användas för att studera variationer.

Detta arbete har ett antal praktiska tillämpningar. Först så pekar det på ett behov av vägledning för att hitta de relevanta brandskyddsreglerna. Länderna har möjlighet att förbättra tillgängligheten till hemsidor och förståelse av hur reglerna är utformade genom sökoptimering och introduktionssidor. Arbetet påvisar också en roll för EU som sammanhållande funktion för byggregler. Byggregler kan hittas om det framgår vad den relevanta regeln heter men detta steg kan innebära en stor svårighet utan nätverk eller förkunskaper. Slutligen påvisar skillnaderna i brandskyddsnivå att för att uppnå samtliga fem brandskyddsmål i CPR skulle liknande regler som Eurocode för bärförmåga även kunna utformas för övriga mål. Arbetet har inte värderat om heltäckande regler är ett uppnåeligt mål.

Abbreviations

Table i List of Abbreviations used

BauGB	BauGesetzBuch (Germany)
BauO Bln	BauOrdnung Berlin (Germany)
BBR	Boverkets Byggregler(Sweden)
BMUB	Bundesministerium für Umvelt, Naturschutz, Bau und Reaktorsicherheit (Germany)
BR	Bygningsreglement (Denmark)
BR	Building Regulations (UK)
BRL	Bauregelliste(Germany)
CE	Conformité Européenne
CPR	Construction Product Regulation
CTE	El Código Técnico de la Edificación (The Technical Building Code, Spain)
DIN	Deutsches Institut für Normung eV(Germany)
DoP	Declaration of Performance
DTU	Techniques Unifiés(France)
EC	European Comission
EN	Européen de Normalisation
EPS	Expanded Polystyrene
EU	European Union
GN	Gyproc Plasterboard
GTAI	German Trade and Invest(Germany)
ISO	International Orginization for Standardization
MBO	MusterBauOrdnung(Germany)
NF	Norme Francaise(France)
PBL	Plan- och Byggförordningen(Sweden)
PVC	Polyvinyl Chloride
PRC	Performance Review Commission
SI	Seguridad en caso de incendio(Spain)
UK	(the) United Kingdom
VPN	Virtual Private Network
VROM	Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer(The Netherlands)
WWII	World War 2

Glossary

Table ii Glossary of technical terms regarding Fire Safety

R xx	Load-bearing Capacity of structure. (xx states number of minutes element is tested for)
E xx	Integrity of structure. (xx states number of minutes element is tested for)
I xx	Insulation of structure. (xx states number of minutes element is tested for)
M	Mechanical effect. States that the element is tested for a shock load.
A,B,C,D,E,F	Classification of Surface Materials in accordance with EN 13501 where A is the highest and F is the lowest.
s1,s2,s3	Production of smoke from a Surface Material in accordance with EN 13501 where 3 is the highest and 1 is the lowest.
d0,d1,d2	Production of droplets from a Surface Material in accordance with EN 13501 where 2 is the highest and 0 is the lowest.
K1 10/K2 10	Fire Cladding in accordance with EN 13501 where K1 is the highest and K2 is the lowest.

Disclaimer

The authors are responsible for the content of this thesis.

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1 Introduction

Europe is an important market area for manufacturers of Construction Products. A large market is preferable to achieve a profit performing volume for a product; for European countries this will most often entail exporting the product outside the country of origin.

The European Union started as a post WWII project to increase trade between countries in Europe, for the benefit of peace and prosperity. The early agreements concerned reduction of trade barriers such as tariffs and quotas between the EU countries. One of the aims for the EU is to provide one open market for EU-countries, the concept is called ´the Single Market` but there are still various trade barriers. (European Comission 2012) (European Union 2007) (Leif Andersson 2014). The single market is based on the four freedoms. In the European Commission (EC) treaty this is defined as the free movement of people, goods, services and capital (European Commission 2002),

In order to achieve these goals there are extensive efforts to use legislation to eliminate technical obstacles to achieve a free movement of goods and services. This process is called harmonisation and includes legislation and monitoring. (EU parliament and council 1998) The legislation regarding Building Products is primarily the Regulation (EU) No 305/2011, *Laying down harmonised conditions for the marketing of Construction Products and repealing Council Directive 89/106/EEC, replacing the previous Construction Product Directive*, commonly called the Construction Product Regulation (CPR). (EU Parliament 2011) The focus in the CPR are harmonising standards and test methods for different products and the so called Declaration of Performance (DoP). There is also an adopted Eurocode for structural design. (EN 1990:2003 Eurocode 2004). For products that have not yet been included in the CPR there is also a voluntary system with standards for manufacturers seeking CE-marking of their products, this is called the European Organisation for Technical Assessment (EOTA). For the other areas of building and construction concerning Fire Safety such as fire spread within and between buildings, egress and the safety of rescue teams there are no adopted standards. (EU Parliament 2011) .

The CPR states that products declared, tested and approved with a CE–marking according to the CPR shall be approved for use in all EU countries. The CPR manages how to declare products, how to specify requirements and how to choose the products for structural use. Not all products have yet a standard and test method. When new standards come into place there is a transition period where both the new test protocol and the old certificates are valid but after the transition period all products that are included in the standard must be CE-marked. (EU Parliament 2011)

Whereas the intent for the harmonisation process is certainly the single market, there is also an element of concern for safety and health issues.

The CPR also describes how the Building Code should be structured and requires Construction Work to satisfy five basic requirements for Fire Safety. (EU Parliament 2011) The following is a quote from the CPR:

> "*Safety in case of fire*
>
> *The Construction Works must be designed and built in such a way that in the event of an outbreak of fire:*
>
> 1. *The load-bearing capacity of the construction can be assumed for a specific period of time;*
> 2. *The generation and spread of fire and smoke within the Construction Works are limited;*
> 3. *The spread of fire to neighbouring Construction Works is limited;*
> 4. *Occupants can leave the Construction Works or be rescued by other means;*
> 5. *The safety of Rescue Teams is taken into consideration*"

In this work the five requirements in the CPR will be described as:

1. Load-bearing capacity
2. Limiting Fire and Smoke Spread
3. Limiting Fire Spread to an adjoining building
4. Egress
5. Safety of Rescue Teams

The focus in the CPR is the major undertaking to describe and adopt the standards and test protocol. The structure of the Building Codes is not subject to active commission work but depends on the discretion of each country. (Wessel 2014)

All member states are required to implement the CPR via the Lisbon treaty, and several reports are written on the need for reduced trade barriers and show the concern of the commission. According to the European Commission (EC) newsroom statistics on trade within the EU show that in the category ´Manufacturing added value´ the Construction Products sector stands for 15% of the total value, but only for 5% of the intra-EU trade in this category. This means that the Construction Products are exported less than other sectors of manufactured goods, in the EU article this is interpreted as higher trade barriers in this sector. (EU 2014)

The process of harmonisation is ongoing and there are still differences in opinion regarding where the line between test standards and regulations are drawn. (Wessel 2014) Recently the EU ruled that German legislation is in conflict with the CPR since they required additional test methods. Germany has argued that these were not additional *tests*, but additional *regulations* for Construction Products that the CPR did not provide standards for. (EU 2014)

One of the perceived trade barriers by manufacturers of Building Products (Leif Andersson 2014) are the Building Codes and the national use and interpretation thereof.

As described above the work for the harmonisation mainly concerns standards related to test methods, by which each product has an adopted standard and can be tested and CE marked. This process will define *how* a product behaves in a Fire Test, but it will not define *when* it can be used. In one country a product with a specific CE marking may be used for all types of occupancies, but in another country it might only be allowed in office buildings, or not at all. This difference between standards and Building Codes is not governed by the commission but may still be a potential trade barrier. The differences may also affect the overall Fire Safety Level in a building. Since the CPR focuses on Product Standards rather than Building Regulation it is up to each Construction Company to find out what requirements affect their product and what criteria it needs to be tested for in order to be accepted by the authorities in each country.

The Building Codes will determine what products can be used, but these codes will vary and the companies are required to comply with several different regulations. An understanding and knowledge of the regulations appear to be of importance for a company wanting to develop and market products. A company trying to enter the European market will need to access and understand the Building Regulation of each country.

A work on how harmonisation of fire regulations could be achieved in the Nordic countries was presented in the SP report 2008:29 (Thuresson, et al. 2008). The SP-report methodically describes requirements for different materials, and notes if there are moderate changes that could be made to reduce trade barriers between the Nordic countries. The work is focused on what classifications are used in the different countries, and if these could be harmonised by limiting the use to the same classifications in all countries without specifying the application.

Studies also show that there are still differences on how the legislation is written and practiced. (Sheridan et al 2003)

From the viewpoint a manufacturer trying to comply with the Fire Safety requirements it is interesting to study the process of attaining the Building Regulations and evaluate what obstacles a company trying to fulfill the requirements would have to overcome. The harmonisation process in the EU does not have a definition or set parameters for when free trade is accomplished so there is a need for methods to evaluate how attainable the requirements are. The work presented in the thesis will explore the possibilities to evaluate if it would be possible for a company to complete a Fire Safety Design and understand what requirements are placed on their materials without using local expertise. It is also interesting to evaluate how the variation in detailed requirements interplay with the harmonisation goals as described in the CPR.

1.1 Aim and Objective

This work will analyse Building Codes within the European Union with the objective to evaluate the level of harmonisation, specifically the parts of the Building Codes that concern Fire Safety Regulations on Construction Products. From here on Building Code and Building Regulation refer to the parts that concern Fire Safety unless otherwise stated.

The objective is to investigate how harmonisation affects Fire Safety in buildings. The aim is to show to what degree the Building Codes are harmonised for the use of Construction Products within the EU.

1.2 Research Questions

The thesis will address the following research questions (RQ):

1. How can the level of harmonisation of the Building Code be evaluated?
2. How harmonised are the Building Codes?
3. How are the Building Codes for Fire Safety Design structured for the studied countries?
4. Will a higher level of harmonisation result in a higher level of Fire Safety?
5. Can the harmonisation process result in a higher level of Fire Safety?

1.3 Target Group

The target group for this work is the arena concerned with legislation of Fire Safety Regulations and reducing trade barriers. The report was written from the viewpoint in the Case Study, which is anyone without previous knowledge about a country who is trying to access and understand a country´s Building Code.

1.4 Limitations

The work is concerned with national variations in Fire Requirements on Construction Products. The thesis will therefore not address other aspects of the Building Codes. It will not evaluate or rate the efficiency of the code or the absolute level of Fire Safety in each country. It will not be a complete summary of the Building Codes regarding Fire Safety but will focus on harmonisation aspects.

The work is limited to prescriptive based codes and regulations that can be accessed via Internet or official CPR-channels. That a code or regulation is not included in this thesis is not equivalent to a lack of national standards. Ten countries from different parts of Europe are chosen to represent the EU in this work.

Internet search in Chapter 3.3.1 is limited to the first 10 pages of links displayed by Google. This applies for both primary and extended searches.

Since the method used is a case study using Internet searches there is a limitation in the result in attained documents. The main reason for this is that the purpose of the search is to determine the accessibility of the documents for everyone. No academic databases or public libraries are used for collecting regulations. Also for the same reason no money is spent in this work for additional information. Using other search methods and buying standards could have resulted in more attained regulations and standards, e.g. standards in the Netherlands and the Czech republic, and better translations so that e.g. the Polish regulations could have been researched properly. The thesis uses English for the internet search. The EU does not require that information should be provided in English, and many countries only allow use of the official languages in their country. This will affect the results in the thesis but it considered to exemplify one of the barriers to harmonisation.

Caution should be taken in interpreting the details in the collected regulations and Case Studies. The collection of the regulations has been undertaken with a limited amount of time and expenses, also the regulations have been interpreted to English via Google translate. The collected information may therefore not be comprehensive and in some cases even contradictory to the actual requirements.

1.5 Terminology - Acts and Regulations

This section explains the basic hierarchy of laws and regulations. The structure varies but the general hierarchy is that the legislative body adopts a framework for the Building Regulations, this can be for example be a law, act or an ordinance. The responsibility to interpret what this means on a practical level is delegated to a ministry, department, or other government agency. These interpretations are most often called regulations, and describe how the requirements should or can be met. It is also common, depending on the level of detail in the regulations, with complementing guidelines written by private enterprises and interest organisations. The ministries do not adopt these and therefore not legally binding, but can function as an established practice.

The names for these levels can vary between different countries but also the level of detail varies (see figure 1). (www.pub.iaea.org u.d.)

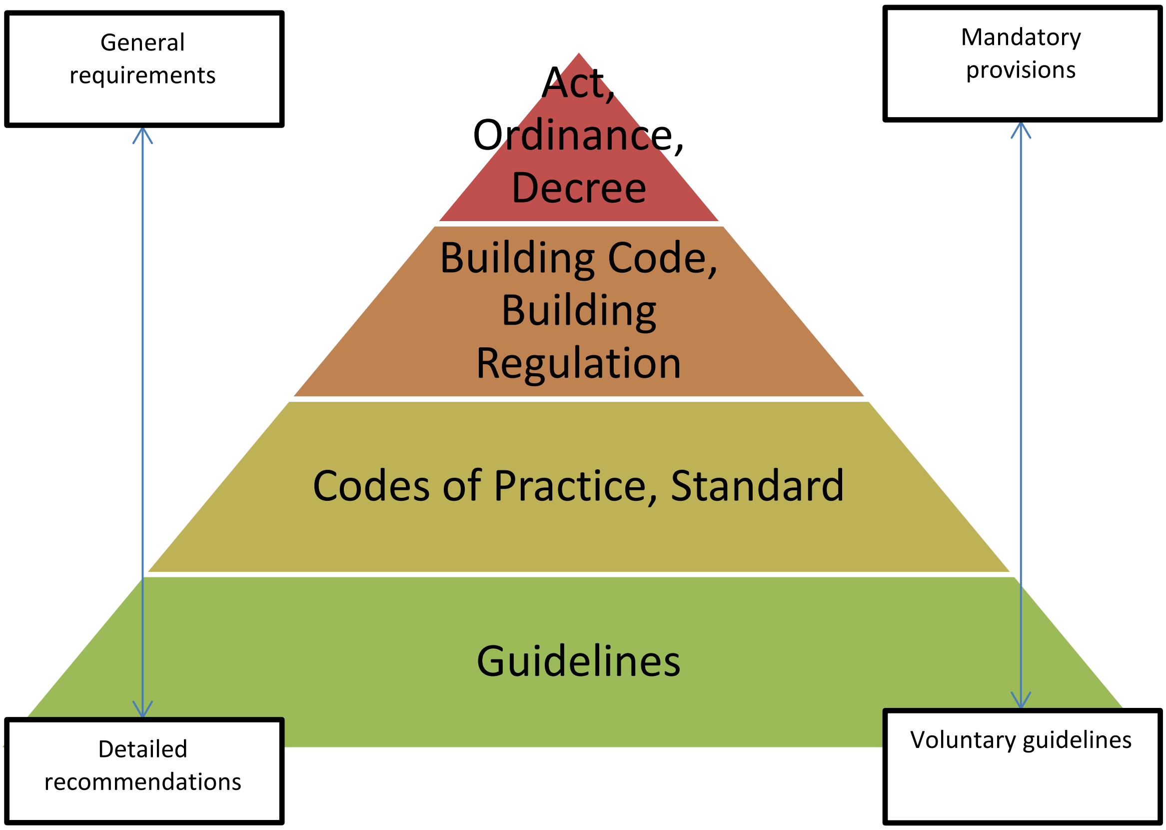

Figure 1 Hierarchy of Regulations.

The detailed requirements and guidelines on how to achieve the requirements are found at the lower levels. Where the law or an act will state that there must be an acceptable level of safety in case of fire, the actual rating of a Fire Barrier will be found on the three lower levels. The level where a detailed guidance is written depends on what hierarchy each country has decided upon. Some countries use a general language in the regulations and have different adopted standards for each section of Fire Safety, and others have all guidance written directly in the regulations. For this thesis the term Building Regulation will be used to describe a document with the level of detail to fulfill the intention written in an Act or Ordinance.

A building consists of walls, floors, stairs, openings and different installations such as water, electricity and ventilation. All aspects of a building can be considered from a safety viewpoint when it comes to regulations on Fire Safety. For people to be able to evacuate safely there must be egress routes and stairs that are protected from smoke, the construction must stand long enough for the evacuation to complete and the Rescue Teams to contain the fire. Fire Barriers and Fire Walls are needed to contain the fire to a reasonable size and the materials in a building can affect the intensity of the fire and Fire Spread. Installations and shafts can cause Smoke and Fire Spread via openings and if they are constructed by flammable materials. All of these are can be described in a Building Regulation.

Harmonisation in this context of the Lisbon Treaty does not state that reducing variations in Act and Regulations is a goal in itself. Variations between countries only become a problem in this context if they create trade barriers or that the overall requirements for health and safety are not met. (European Union 2007)

1.6 Defining the concept of Harmonisation

There are no official documents describing what the EU would define as a harmonised market for Construction Products. The word harmonisation does occur in several documents as a method to achieve the single market, and can be understood as a process rather than an end goal. (EU Parliament 2011) The work in the EU seems to focus on an agenda of what is politically possible to achieve, rather than a strictly scientific approach as to what would be the most important changes to achieve a single market.

For the purpose of this report the authors must make an interpretation of the concept harmonisation since there is no established definition. In order to compare the level of harmonisation in the Building Code the parameters will be defined based on the concept of reducing trade barriers. As mentioned in the introduction potential trade barriers can be investigated in the process for a company to attain the Building Regulations and to evaluate what obstacles a company trying to fulfill the requirements would have to overcome.

From the viewpoint of a manufacturer of Building Products a harmonised process could be described as the following; If there is a high level of harmonisation a manufacturer should be able to determine what regulations concern the specific product and be able to have the product tested in accordance to the relevant standard and use the CE marking to sell the product. The manufacturer should also be able to market the product in all EU countries. This requires the regulations to be attainable and structured in such a way that it is possible to understand them.

As described in the introduction, chapter 1, the CPR is the primary method used in the EU to achieve harmonisation. The CPR lists that the Building Code should address five basic requirements to achieve a reasonable level of safety. The reasonable level of safety is not quantified in the CPR. For the purpose of this work the terminology a reasonable level of safety is used when there is a quantifiable regulation in the code. When there are no such regulations, the level of Fire Safety is compared and not evaluated in terms of acceptable or too low. If it is equal between the countries it is evaluated with the terminology similar level of safety.

Analysing the concept of harmonisation and Fire Safety from the viewpoint stated above, some basic statements are defined by the authors. In order to be deemed harmonised in this thesis the building code must:

- be Attainable (e.g. possible to retrieve it through the relevant ministry webpages or through CPR contacts),
- be Structured in a transparent manner and
- Achieve a reasonable level of safety.

These statements in this work are derived from the necessities of exporting construction products and the description of Fire Requirements in the CPR, Appendix A. (EU Parliament 2011)

This process can be analysed with a Fire Safety Design, and if the level of harmonisation is high then the end product, the building, will meet the intention of the specific country's building code.

2 Content of work

The content of work in this thesis starts with an introduction in chapter 1 explaining the background and different problem statements. This is followed by research questions, limitations and an explanation of terminology regarding the Building Regulations. The final part of chapter 1 is the definition of harmonisation.

The purpose of the thesis is to evaluate the level of harmonisation of Building Codes for different countries in Europe. A definition of harmonisation is presented and is the basis for evaluating levels of harmonisation for different areas of the Building Codes. The thesis attempts to answer research questions stated beforehand by the authors related to harmonisation and Fire Safety. The methods for achieving this are two Case Studies and a CPR-Analysis, the methods are presented in chapter 3. The process is linked together through the work meaning that the methods follow each other and the result of a previous methods make up the input for the next one as seen in figure 2.

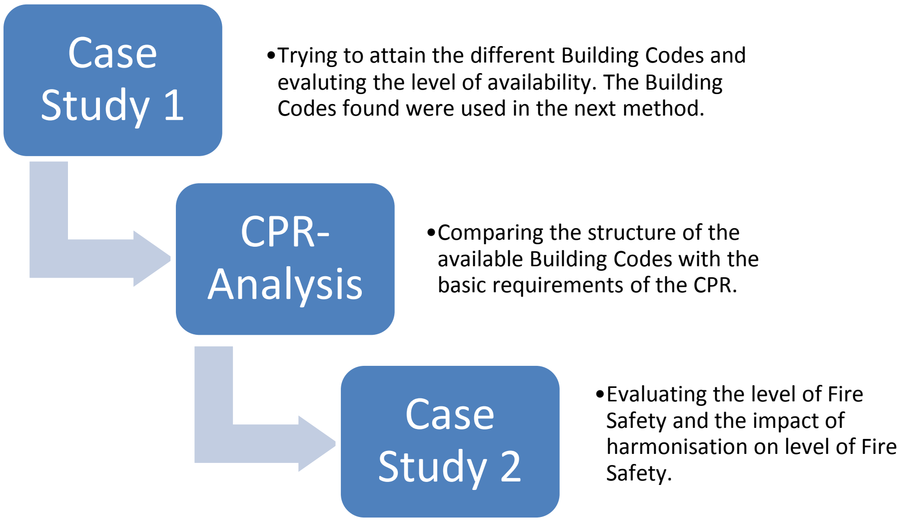

Figure 2 Structure of the analysis

The process related to each method is presented in the body of the work, chapters 4, 5 and 6, were the results are presented together with a brief summary and conclusion. The thesis is ended with a conclusion, chapter 7, where the results are discussed.

3 Method

3.1 Choice of Method

The method used in the thesis was derived from the research questions; to evaluate the different relations between harmonisation and Fire Safety. Firstly; a framework to evaluate the results was set by the authors by analyzing the concept of harmonisation and thereby constructing a definition. Harmonisation as decided upon in this work in Chapter 1.6 is that the Building Code must be attainable, structured in a transparent manner and achieves a reasonable level of safety.

This definition showed a need for an exploratory Case Study approach, to simulate how easy or difficult the process of engineering a Fire Safety Design would be in each country, and to evaluate what level of Fire Safety this particular design would reach.

A concern about a Case Study is that it focuses in detail on a specific situation and may lack in scientific generalization, but it has a value for this thesis since it can investigate a phenomena within its real-life context. (Yin 2003) What could be lost in providing general information in a single thesis can be won in deeper understanding of the interaction of complex variables. A study should also be seen in the context that multiple reports on the same topic can be written and give a wider base for scientific generalizations. (Yin 2003) A Case Study can therefore include the parts of harmonisation that depends more on the context where the code is adopted and how it is distributed than just the actual requirements in it. It also gives the opportunity to include the data collection process in the analysis as part of that context. It is important in a Case Study to construct validity in the design of collection of data. Bias may enter in the process, for this thesis this is preempted by setting up strict research questions and methods, and repeat the research process.

Two Case Studies and a CPR-Analysis constitute the body of the work (see figure 3). They are linked to the research question as described in the figure. They are chosen as methods because they each can potentially be used to assess, quantifiable or qualitative, the level of compliance with the different definitions of harmonisation. This refers to RQ 1, how to evaluate the level of harmonisation.

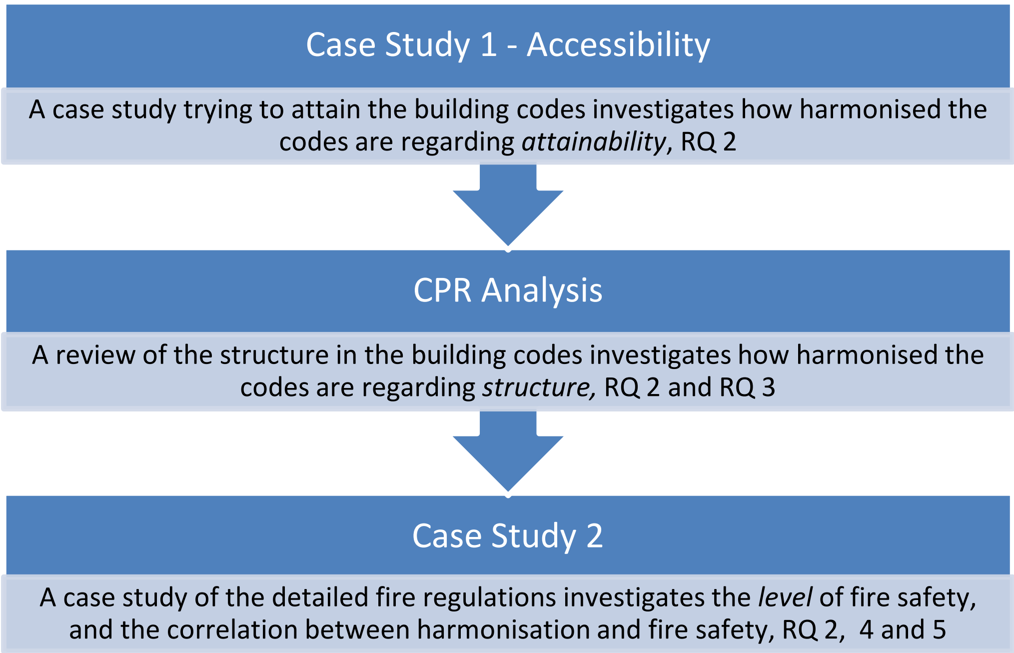

Figure 3 Description of methods

The evaluation of how harmonised the different parts of the Buildings Codes are validated and presented with quantitative and qualitative ratings.

If in case the Building Code was not accessible according to the search method described in the thesis it was disqualified from further research. This was also the case for Building Codes that could not be read and understood because of translation problems. This presents an unfair disadvantage to countries with non-roman languages but is due to the limitations in the translation engine, se Chapter 1.4.

If the Building Code was written by each autonomous state within a country then the country was represented by one of these states.

3.2 Choice of Studied Areas

Ten countries were chosen for the study, they were Denmark, the Czech Republic, France, Germany, Italy, the Netherlands, Poland, Spain, Sweden and the UK. The initial suggestion of countries came from manufacturers of construction products, Isover Saint Gobain, in their work to understand the building regulations. (Leif Andersson 2014) The company has not been involved in the work after the initial contact. The countries were chosen to represent different nations in the EU with a good geographical distribution and also to represent different financial status. There were no assumptions made beforehand on the level of harmonisation in each country.

The case chosen to represent a building for the Case Study was a four storey residential building, a common Building Type. It was interesting for the study because it would most likely be regulated, and likely to be in the prescriptive realm of the Building Code. Had a higher building been chosen there would likely have been more performance based design and it would have been more difficult to make scientific generalizations based on the findings. Since it represents a common Building Type it was also of interest since the sheer volume of residential buildings will make it relevant both in Life Safety and as a Product Market. A low level of Fire Safety in a standard residential building will affect many occupants.

3.3 Method of Case Study 1 - Accessibility of Building Codes

The accessibility of the Building Codes was evaluated with a Case Study. The process is systemised so that the level of availability can be rated and compared in a quantitative way by rating the accessibility of the Building Codes.

The Case Study on accessibility also answers the research question 1 and 2 (see figure 4). The method will show if this was an alternative to evaluate the level of harmonisation according to the definition in chapter 1.6. The Case Study will show to what degree the accessibility is harmonised and give insight into how the codes are structured.

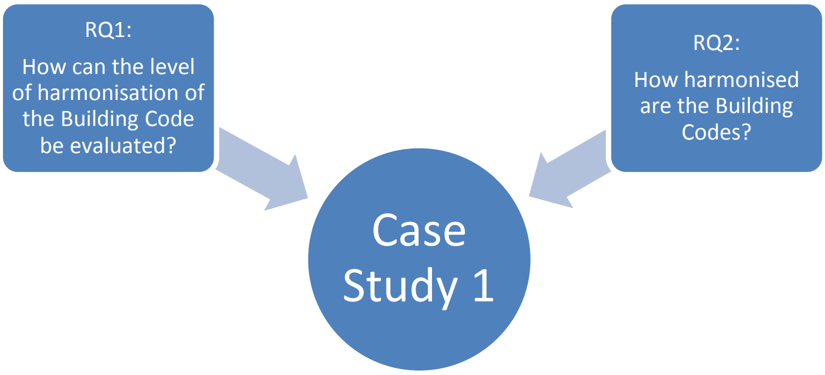

Figure 4 Case study 1 and RQ

As summarised in Chapter 3.1 the Case Study was introduced to simulate how easy or difficult the process of engineering a Fire Safety Design would be in each country. The viewpoint for the Case Study was that of a Code Consultant with knowledge of Fire Protection and fluent in English. The Case Study is designed to simulate how a company could attain and understand the requirements in countries they wished to export to. The company was assumed to have limited resources and previous knowledge about the potential markets, and also use Code Consultants in their own country that were familiar with Fire Safety Design.

The criterion for a high level of accessibility was to complete a Fire Safety Design with the use of limited resources, using English and with no previous knowledge of the countries Building Code. A prerequisite for this is to find documents and understand the requirements.

The simulated process was an Internet search for the relevant ministry or department, followed by email contacts via the CPR contact list. The results were evaluated with a summary of status of documents and a rating of the overall process.

Using the Case Study format excluded documents that could have been found via surveys, archives or extensive search for contacts in the personal network; but exemplified the obstacles in the process.

3.3.1 Internet Search

The format for the Internet search followed a strict procedure. To be sure that the document was the latest amended version it had to be found via an official channel. The hierarchy of legal documents (see Chapter 1.5) was also taken into account. These two aspects were the basis for choosing key words. The searches were performed 24-26th of April, 2015.

3.3.1.1 Key Words

The search process was divided into two parts; primary search and extended search. The primary search was very limited to provide a comparable result that could not be affected by previous knowledge by the authors, and to show the results from a very intuitive and basic search. The primary search was fixed with regards to key words and was the same for each country:

"Building Regulations + [country name]"
"Building Regulations + [country name] + English + pdf"
"Building department + [country name]"

The extended search was a recursive search where the key words depended on the outcome of the primary search. These key words can differ between the countries. The reason for the extended search is to avoid disqualification of a country's accessibility simply because it has a different name for its relevant ministry and/or legal documents. It is also reasonable to assume this to be standard Internet search behavior.

3.3.1.2 Internet Browser

The Internet browser used was Chrome. Internet browsers operate with cookies which allow for information about a user's Internet history to be available for the purpose of advertising, remembering visited sites etc. (Ulriksson 2015) this is often noticeable when ads and banners appear with products linked to sites the user visited earlier. Google uses this same method for remembering a user's earlier activity and in addition it also collects information about the user's location (Ulriksson 2015). This may lead to search results being sorted, in order of relevance, based on where in the world the search was made. To address this potential problem and to strive to keep each search independent of the previous searches the browser is reset before every new search. By clearing the Internet history any cookies will be deleted from the computer. Using the VPN-function of the Chrome browser gives the user a certain amount of anonymity on location being linked to search results.

3.3.2 Contact via CPR

The second step in the search process was using the CPR contact point. Contact points are assigned for each country on the europa.eu domain. (Industry 2015) An e-mail was sent using the contact list on the EU website for CPR contact points (see Appendix C). Each country was given 3 weeks to respond in order to receive points for accessibility. The time frame of 3 weeks was deemed to be the maximum time frame for a company trying to retrieve information before using a different source, and also adequate time for the contact points to reply. It did not influence the results since replies were given within 3 weeks or not at all.

3.3.3 Status of Document

Following the searches the attained documents were evaluated on their relevance and accuracy regarding a possible Fire Safety Design.

For the documents to be useful in a design setting the results need to be reliable, a bad translation endangers the interpretation of the Building Code and the design results may pose a Fire Safety Hazard; updated and on the correct level of hierarchy. To perform a design with the prescriptive method requires that the regulations has a high degree of detail and recommendations.

For the purpose of this report there is also the dimension of enough information to be used in the Case Study, but this is not rated since the primary objective is if a company can understand and follow the Building Code.

3.3.4 Evaluation of Results

The results were evaluated and rated with the criteria in table 1, 2 and 3. The rating system is designed after the definition of accessibility, with the end goal that the documents are easy to find and that the found documents can be used in Fire Safety Design. A full score of 10 represents a fully accessible Building Code.

Table 1 Rating of Internet Search

Q. nr	Internet Search	Points(0/1)
1	For finding the relevant website on the primary search. A relevant website should be the country's official website and either have the documents for download or refer to where they can be found	1
2	For finding the relevant documents on the primary search.	1
3	A well-structured website where information about hierarchy and process of building and Fire Safety Design is clearly described	1
4	Information on the website in English	1
	Total	**4**

Table 2 Rating for CPR Contact

Q. nr	CPR Contact	Points(0/1)
5	Email replied within 3 weeks.	1
6	For an answer that helps finding the Building Regulation.	1
7	Answer in English	1
	Total	3

Table 3 Rating of Documents

Q. nr	Documents	Points(0/1)
8	Documents translated into English	1
9	The latest amended version available	1
10	Sufficient information found in the documents to use in Fire Safety Design	1
	Total	3

3.4 Method of CPR Analysis

A transparent structure of the Building Code enables understanding and proper implementation of the regulations. As a measure of a transparent structure, the five basic requirements in the CPR was used in order to answer the research questions regarding the structure of the Building Codes (see figure 5).

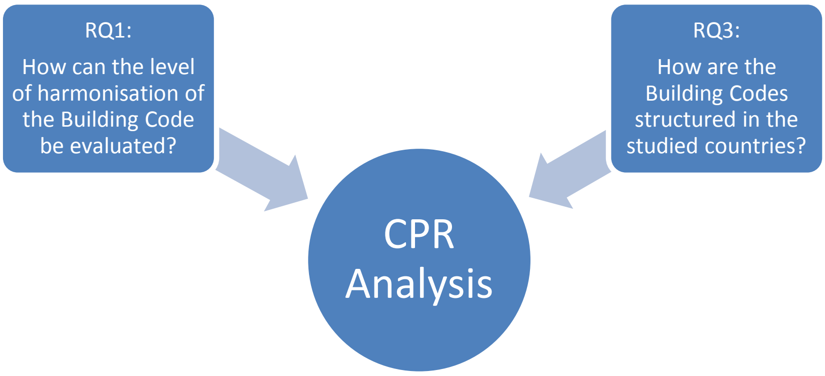

Figure 5 CPR Analysis and RQ

These requirements list a minimum of what should be addressed in the Building Code. To evaluate transparency a study of each Building Code was performed to see if these requirements were addressed. Results are presented in a qualitative matter with sections that address these requirements and with a yes or no statement to the question of structure.

The level of harmonisation in regards to structure is directly related to whether or not the Building Code of the country follows the CPR-Structure. The method does not evaluate the content and depth of information in the each chapter related to the structure.

3.5 Method of Case Study 2 – Residential Building

A Case Study was initiated to primarily answer the research questions regarding the correlation between level of harmonisation and overall Fire Safety (see figure 6). A four storey residential building was chosen as object for the Case Study. The properties of the building are described in chapter 6.5.1. The relevant Building Regulations associated with this object were gathered from each of the Building Codes. A Case Study offers a more illustrative view of variations in the Building Code. Since a specific case was chosen it was clearly limited to smaller parts of the Building Code, but it served as an example of how the Building Code and Product Requirements interact.

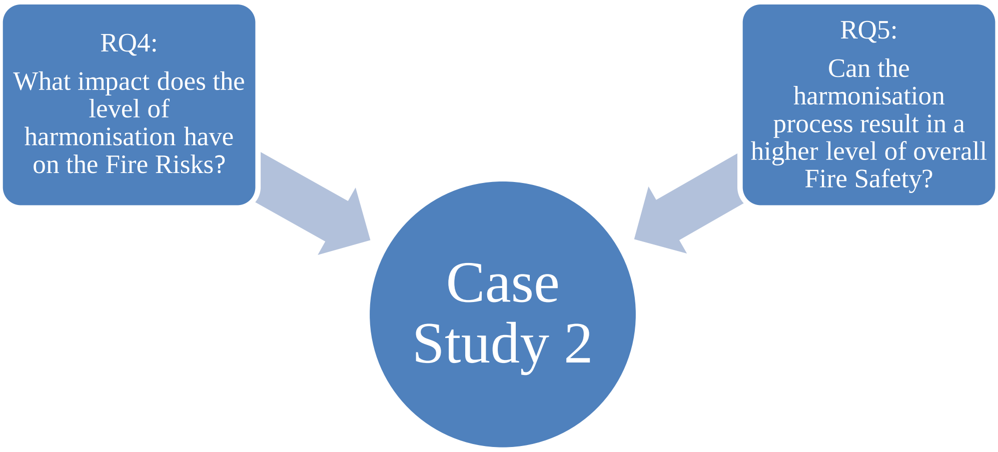

Figure 6 Case Study 2 and RQ4 and 5

The Case Study was initiated with a data collection; a gathering of detailed Building Code Requirements on the basis of what was relevant for the Case Study.

The Case Study focused on the same requirements as given in CPR, Load-bearing Construction, Fire Spread within the building, Fire Spread to adjoining buildings, egress and the safety of Rescue Teams. Results were presented for each section of safety, what the requirements were, what testing standard or norm they referred to and also in what code they could be found. The majority results were presented in qualitative summaries. For two of the requirements the results were presented as event-trees and evaluated in both a quantitative and a qualitative way.

The results were evaluated on a scale of more or less safe, and were also compared to what level they were harmonised, that is if they returned an equivalent level of safety in the different countries.

In this context harmonisation was related to the importance of the Building Code for the use of Building Products. If the Building Code affected the use of Building Products to a high degree they were an essential part of the work towards harmonisation and an inner market. The importance of an easily accessible and well-structured code was indicated if there were smaller country-variations that rendered large variations in what products could be used. On the other hand, if there were no effects on products, or that simply the variations did not exist, this may highlight that the differences in Building Codes were not a highly important factor for reducing trade barriers within the EU. Given the concept of Case Study the conclusions were limited to the studied parts of the Building Code.

4 Case Study 1 - Accessibility of Building Codes

Results of the Case Study are presented for each country with a summary and rated according to Chapter 3.3.4. The full summary of the research in Case Study is found in appendix B. The process of Case Study 1 is described in chapter 3.3. The searches were performed 24-26th of April, 2015.

4.1 Summary of Case Study 1

In this section a summary of the finding in Case Study 1 is presented.

4.1.1 Internet Search

The Czech Republic:

- The relevant website was found on the primary search.
- The relevant documents were not found on the primary search.
- The relevant website was poorly structured and the search function did not deliver result when searching for the name of the regulation.
- The website had information in English, but only for the start page.

Denmark:

- The relevant website was not found on the primary search.
- The relevant documents were found on the primary search.
- The relevant website was poorly structured and the search function did not deliver result when searching for the name of the regulation.
- The website did not have information in English.

France:

- The relevant website was not found on the primary search.
- The relevant documents were not found on the primary search.

Germany:

- The relevant website was not found on the primary search.
- The relevant documents were not found on the primary search.
- The relevant websites were poorly structured but the search function did deliver result when searching for the name of the regulation.
- The website did not have information in English.

Italy:

- The relevant website was not found on the primary search.
- The relevant documents were not found on the primary search.

Netherlands:

- The relevant website was found on the primary search.
- The relevant documents were found on the primary search.
- The relevant website was well structured.
- The website did not have information in English.

Poland:

- The relevant website was found on the primary search.
- The relevant documents were not found on the primary search.
- The relevant website was poorly structured.
- The website did have information in English.

Spain:

- The relevant website was found on the primary search.
- The relevant documents were found on the primary search.
- The relevant websites was well structured and had some information on the hierarchy of regulations.
- The website did have information in English.

Sweden:

- The relevant website was found on the primary search.
- The relevant documents were not found on the primary search.
- The relevant websites was well structured and had a comprehensive explanation of the hierarchy of regulations.
- The website did have information in English

The UK:

- The relevant website was found on the primary search.
- The relevant documents were not found on the primary search.
- The relevant websites was well structured and had a comprehensive explanation of the hierarchy of regulations.
- The website did have information in English

4.1.2 CPR Contacts

The following summary describes the results the from the CPR contacts:

The Czech Republic:

- The CPR e-mail was replied within 3 weeks, the answer helped find the Building Regulation and the answer was written in English.

Denmark:

- The CPR e-mail was not replied.

France:

- The CPR e-mail was not replied.

Germany:

- The CPR e-mail was not replied.

Italy:

- The CPR e-mail was replied within 3 weeks, the answer did not help find the Building Regulation and was not written in English.

Netherlands:

- The CPR e-mail was not replied

Poland:

- The CPR e-mail was replied within 3 weeks, the answer helped find the Building Regulation and the answer was written in English.

Spain:

- The CPR e-mail was replied within 3 weeks, the answer did not help find the Building Regulation and the answer was not written in English.

Sweden:

- The CPR e-mail was replied within 3 weeks, the answer helped find the Building Regulation and the answer was written in English.

The UK:

- The CPR e-mail was not replied.

4.1.3 Documents

The following summary describes the documents found from the search phase:

The Czech Republic:

- VYHLÁŠKA 23/2008 Decree No. 23/2008) Coll. on the Technical Requirements for the Fire Protection of buildings. (Republic u.d.)

The document is a decree on the highest level in the hierarchy and does not contain detailed regulations for Fire Safety Design, standards can be found on the department website for a fee.

- The decree and the standards can be found on: www.unmz.cz.
- The documents were translated to English, were the latest amended version but did not contain enough detailed requirements to use in a Fire Safety Design.

Denmark:

- Bygningsreglementet 2010 (BR10) (The Building Regulations 2010) (Building regulations 2010)

The document does not contain detailed regulations for Fire Safety Design.

- "Eksempelsamling om brandsikring af byggeri" (Collated examples of Fire Safety Measures in buildings) (Klima- 2012)

This document does contain detailed regulations for Fire Safety Design.

- The documents can be found on www.byggecentrum.dk (Danish version), www.bygningsreglementet.dk (English version)
- The document was not translated to English, it was the latest amended version and did contain enough detailed requirements to use in a Fire Safety Design.

France:

- Documents were not found but the relevant documents are most likely Techniques Unifiés (DTU) and Norme Francaise (NF). It is conclusive that national regulations are adopted.

Germany:

- BauGesetzBuch (BauGB) 2004 amended to 2014 (Building Code) (BauGesetzBuch augesetzbuch in der Fassung der Bekanntmachung vom 23. Septembe 2004 (BGBl. I S. 2414), das zuletzt durch Artikel 1 des Gesetzes vom 20. November 2014)

The document does not contain detailed regulations for Fire Safety Design

- MusterBauOrdnung (MBO) (template Building Standards) (Munsterbauordnung Fassung November 2002 Zuletzt geändert durch Beschluss der Bauministerkonferenz vom 21.09.2012)

The document does contain detailed regulations for Fire Safety Design, but not for all areas

- BauOrdnung Berlin (BauO Bln) 2005 amended to 2011 (adapted Building Standards for Berlin) (BauOrdnung Berlin Vom 29. September 2005 (GVBl. S. 495), zuletzt geändert durch Gesetz vom 29. Juni 2011)

The document does contain detailed regulations for Fire Safety Design, but not for all areas.

- Bauregelliste, BRL (BauRegelListe 2014)

The document does contain detailed regulations for rating of Construction Material and test methods

- The documents can be found on www.bmub.bund.de (BauGB), http://www.is-argebau.de (MBO), www.stadtentwicklung.berlin.de (BauO Bln). The BRL can be found on https://www.dibt.de
- The documents were not translated to English, were the latest amended version and did contain enough detailed requirements to use in a Fire Safety Design.

Italy:

- Documents were not found, it is inconclusive if there are national requirements or template regulations for Italy.

Netherlands:

- Bouwbesluit 2012 (Building Code) (BouwBesluit 2012 2012 amended to 01 april 2015)

The document does contain detailed regulations for Fire Safety Design, but not complete information. The requirements on how to decide Fire Load and how to achieve the required Fire Rating of construction and Fire Barriers are described in technical standards that can be found on the website for a fee.

- The documents can be found on http://www.bouwbesluitonline.nl
- The documents were not translated to English, were the latest amended version but did not contain enough detailed requirements to use in a Fire Safety Design.

Poland:

- Prawo Budowlane (Polish Building law act oh 7 July 1994- item 1409 u.d.) (Building Law)

The document does not contain detailed regulations for Fire Safety Design

- No 75 item 690, (Regulation of the Minister of Infrastructure of 12 April 2002 on technincal requirements, which shall fulfill buildings and their location (Dz. U No 75 Item 690, as amended) u.d.)

The document does contain detailed regulations for Fire Safety Design, but the language barrier and the translation with Google translate is not considered to be sufficient which makes it makes it unreliable for use in Fire Safety Design.

- The documents can be found on: http://isap.sejm.gov.pl
- The documents were not translated to English. They were the latest amended version and did contain enough detailed requirements to use in a Fire Safety Design.

Spain:

- Documento Básico SI Seguridad en Caso de Incendio, (Documento Básico Seguridad en caso de incendio February 2010 amended to 2014) (basic document for Fire Safety)

This document does contain detailed regulations for Fire Safety Design

- The documents can be found on www.codigotecnico.org, the homepage of the code administration.
- The documents were not translated to English, were the latest amended version and did contain enough detailed requirements to use in a Fire Safety Design

Sweden:

- Boverkets Byggregler (BBR 22) amended to 2015, (Boverket's Building Regulations) (Boverkets Byggregler 22, BFS 2011:6 amended to 2015:3 u.d.)

This document does contain detailed regulations for Fire Safety Design

- The documents can be found on www.boverket.se, the homepage of building department.
- The documents were translated to English, were the latest amended version and did contain enough detailed requirements to use in a Fire Safety Design.

The UK:

- Building Regulation 2014 and Annex: Approved document part B Fire Safety (The Building Regulations 2010 Fire Safety amended to 2013 April 2007)

This document does contain detailed regulations for Fire Safety Design

- The documents can be found on www.legislation.gov.uk, the homepage of the UK building department.
- The documents were written in English, were the latest amended version and did contain enough detailed requirements to use in a Fire Safety Design.

4.1.4 Rating

The rating in table 4 is based on the system in Chapter 3.3.4 and the findings in the Case Study in Appendix D. A higher score is equivalent with a higher accessibility.

Table 4 Rating of Accessibility

Countries	Internet Search					CPR Contact				Status of Documents				Total
Question nr	*1*	*2*	*3*	*4*	**Tot**	*5*	*6*	*7*	**Tot**	*8*	*9*	*10*	**Tot**	
Czech rep.	1	0	0	1	**2**	1	1	1	**3**	1	1	0	**2**	7
Denmark	0	1	0	0	**1**	0	0	0	**0**	0	1	1	**2**	3
France	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0
Germany	0	0	1	0	**1**	0	0	0	**0**	0	1	1	**2**	3
Italy	0	0	0	0	**0**	1	0	0	**1**	0	0	0	**0**	1
Netherlands	1	1	1	0	**3**	0	0	0	**0**	0	1	0	**1**	4
Poland	1	0	0	1	**2**	1	1	1	**3**	0	1	1	**2**	7
Spain	1	1	1	1	**4**	1	0	0	**1**	0	1	1	**2**	7
Sweden	1	0	1	1	**3**	1	1	1	**3**	1	1	1	**3**	9
UK	1	0	1	1	**3**	0	0	0	**0**	1	1	1	**3**	6

4.2 Conclusions and Discussion of Case Study 1

The results from Case Study 1 and table 4 in Chapter 4.1.4 show that there is a lot of variation regarding accessibility. In general the results are considered to be poor; a majority of the countries have a rating of 6 and less.

Sweden reaches the highest score and show that the requirements for accessibility are possible to fulfill. Since the authors are from Sweden the high score raises questions if the research was biased. The steps to limit any potential bias were to decide upon requirements before performing the search, and that all searches were conducted in the same way. Limiting the search criteria to fixed key words and using English meant that the search results were not affected by previous knowledge. The interpretation of the documents could have been problematic but the presentation in English on the official website was so informative that it was conclusive that the correct information was found. Although there is a risk for bias the results are included in the thesis as a reference and the searches and results are presented in a transparent manner.

The results show that if the countries wish to be accessible they need to apply search optimization and to write special sections in English on their webpages. They could also explain the hierarchy and structure on their webpage and guide the visitor to the right documents and contacts. This work should not be very time consuming. An alternative is to delegate this to an institute, in Germany there is a good example on a GTAI, Germany trade and Invest that is written in English to attract investors and thereby ranks high in the searches. The problem is that there is quality control of the information since the people working with trade is less involved in the current legislation. The CPR-contact lists could also be complemented with other sources to provide information on the regulations, which are not directly involved with the legislation of building codes, but have an interest in trade, such as a chamber of commerce or similar institutions.

Focus to increase accessibility should also be directed to how the Building Codes are structured and this would also increase accessibility for the local companies. A clear hierarchy makes it easier to follow the requirements down to where the most detailed versions can be found. In Germany the structure is complicated and design seems to rely on guidelines (e.g. the so-called Brandatlas) that are not adopted. This is also the case in Sweden. In Denmark and the UK the guidelines are written into the regulations and this enables a high level of quality control and also predictability in how the code will be used in an application.

As exemplified by the Netherlands and the Czech Republic taking out fees for standard that are a part of the regulation can be an obstacle. Since the standards are secret until bought it is impossible to decide if the information there is needed to perform a Fire Safety Design. Vital requirements should not be written only in standards if the code is to be accessible. There should be a distinction between requirements needed to perform a Fire Safety Design and test methods that can be placed in a separate standard.

France and Italy stand out as the country where no legal documents at all could be found. It is possible that they have a well-structured webpage and an exemplary hierarchy and structure in their regulations, but it is unattainable without previous knowledge or network in the country.

Germany and Denmark have a great potential to achieve a higher rating with simple means. What is needed is an explanatory page in English on the relevant webpage with links to pdf documents; this would yield a better rating in an Internet search and make sure that the latest amended version is attained. An explanation on how to use the different documents for a Building Design would also improve the understanding of their structure.

It is quite surprising that the UK does not get full score for the Internet search since they seem to have put a lot of energy into explanatory pages and description of the planning procedure. The documents are also well structured. It is also written in English and should get a high rating, but the BR 2014 was found via Wikipedia as shown in see Appendix D. A comparison can be made to Spain and Sweden that get full rating for the Internet search although their original languages are not English.

The issue of language is sensitive in the EU. EU regulations do not require information to be provided in English, and many countries only use the official languages in each country. This will be de facto become a trade barrier for anyone not familiar with each countries languages but is outside the aim of the work within EU. The importance of the trade barrier will vary depending on the resources of the company. If the focus of a study would be to accurately evaluate the regulations, the method of gathering regulations and interpretations through interviews would be the preferred option since the documents are so difficult to attain, and to interpret. Studies show that information can be gathered with quality controlled using this method. (Sheridan et al 2003)

5 CPR Analysis

In the CPR the section on Fire Safety presents five basic requirements that shall be described in each countries regulation. These are listed in the Introduction, chapter 1. The following chapter presents the results in table 5-12 from the review as described in chapter 3.4. The results are presented in a table for each country answering the question if the requirement was described in the structure and where it was found. For Italy and France no results are presented since there were no regulations found, see chapter 3.3.4.

Table 5 CPR req in The Czech Republic

Requirement	Described Y/N	Reference Building Act (Republic u.d.)
The load-bearing Capacity of the construction can be assumed for a specific period of time	Y	Building Act, Part Two, Division One, Fire Safety, Section 18, General Requirements/par.4
The generation and spread of fire and smoke within the Construction Works are limited;	Y	Building Act, Part Two, Division One, Construction, Section 31/32/33
The spread of fire to neighbouring Construction Works is limited	Y	Building Act, Part Two, Division One, Fire Safety, Section 20
Occupants can leave the Construction Works or be rescued by other means;	Y	Building Act, Part Two, Division One, Fire Safety, Section 19
The safety of Rescue Teams is taken into consideration	Y	Building Act, Part Two, Division One, Fire Safety, Section 21

Table 6 CPR req in Denmark

Requirement	Described Y/N	Reference BR 2010 (Building regulations 2010)
The load-bearing Capacity of the construction can be assumed for a specific period of time	Y	BR 2010 Chapter 5.3
The generation and spread of fire and smoke within the Construction Works are limited;	Y	BR 2010 Chapter 5.5 (1) +5.5 (2)
The spread of fire to neighbouring Construction Works is limited	Y	BR 2010 Chapter 5.5 (3)
Occupants can leave the Construction Works or be rescued by other means;	Y	BR 2010 Chapter 5.2
The safety of Rescue Teams is taken into consideration	Y	BR 2010 Chapter 5.6

Table 7 CPR req in Germany

Requirement	Described Y/N	Reference BaoO Bln and BauRL (BauOrdnung Berlin Vom 29. September 2005 (GVBl. S. 495), zuletzt geändert durch Gesetz vom 29. Juni 2011) (BauRegelListe 2014)
The load-bearing Capacity of the construction can be assumed for a specific period of time	Y	BauO 27§ + BauRL Annex 0.1.2
The generation and spread of fire and smoke within the Construction Works are limited;	Y	BauO 26§ + BauRL Annex 0.1.2
The spread of fire to neighbouring Construction Works is limited	Y	BauO 30§
Occupants can leave the Construction Works or be rescued by other means;	Y	BauO 33§
The safety of Rescue Teams is taken into consideration	Y	BauO 14§

Table 8 CPR req in Poland

Requirement	Described Y/N	Reference item 690 (Regulation of the Minister of Infrastructure of 12 April 2002 on technincal requirements, which shall fulfill buildings and their location (Dz. U No 75 Item 690, as amended) u.d.)
The load-bearing Capacity of the construction can be assumed for a specific period of time	Y	Item 690, paragraph 216
The generation and spread of fire and smoke within the Construction Works are limited;	Y	Item 690, paragraph 207.1
The spread of fire to neighbouring Construction Works is limited	Y	Item 690, paragraph 271
Occupants can leave the Construction Works or be rescued by other means;	Y	Item 690, paragraph 236
The safety of Rescue Teams is taken into consideration	Y	Item 690, paragraph 207.1 and 253.1

Table 9 CPR req in the Netherlands

Requirement	Described Y/N	Reference Bowbesluit (BouwBesluit 2012 2012 amended to 01 april 2015)
The load-bearing Capacity of the construction can be assumed for a specific period of time	Y	Bowbesluit 2.2
The generation and spread of fire and smoke within the Construction Works are limited;	Y	Bowbesluit 2.9 /2.10/2.11
The spread of fire to neighbouring Construction Works is limited	N	
Occupants can leave the Construction Works or be rescued by other means;	Y	Bowbesluit 2.12/6.6
The safety of Rescue Teams is taken into consideration	Y	Bowbesluit 6.7/6.8

Table 10 CPR req in Spain

Requirement	Described Y/N	Reference SI (Documento Básico Seguridad en caso de incendio February 2010 amended to 2014)
The load-bearing Capacity of the construction can be assumed for a specific period of time	Y	SI 6
The generation and spread of fire and smoke within the Construction Works are limited;	Y	SI 1
The spread of fire to neighbouring Construction Works is limited	Y	SI 2
Occupants can leave the Construction Works or be rescued by other means;	Y	SI 3
The safety of Rescue Teams is taken into consideration	Y	SI 5

Table 11 CPR req in Sweden

Requirement	Described Y/N	Reference BBR 22 (Boverkets Byggregler 22, BFS 2011:6 amended to 2015:3 u.d.)
The load-bearing Capacity of the construction can be assumed for a specific period of time	Y	BBR 22 Chapter 5:0 EKS section C, 1.1.2
The generation and spread of fire and smoke within the Construction Works are limited;	Y	BBR 22 Chapter 5:5
The spread of fire to neighbouring Construction Works is limited	Y	BBR 22 Chapter 5:6
Occupants can leave the Construction Works or be rescued by other means;	Y	BBR 22 Chapter 5:3
The safety of Rescue Teams is taken into consideration	Y	BBR 22 Chapter 5:7

Table 12 CPR requirements in the UK

Requirement	Described Y/N	Reference BR 2010 (The Building Regulations 2010 Fire Safety amended to 2013 April 2007)
The load-bearing Capacity of the construction can be assumed for a specific period of time	Y	BR 2010 App B Vol1 Section B3
The generation and spread of fire and smoke within the Construction Works are limited;	Y	BR 2010 App B Vol1 Section B2 Chapter 6
The spread of fire to neighbouring Construction Works is limited	Y	BR 2010 App B Vol1 Section B4
Occupants can leave the Construction works or be rescued by other means;	Y	BR 2010 App B Vol1 Section B1
The safety of Rescue Teams is taken into consideration	Y	BR 2010 App B Vol1 Section B5

5.1.1 Summary of CPR Analysis

The review in table 5-12 shows that the majority of the countries have complied with the CPR Requirements. The different chapters are most often even named in the same way as the requirements. Only one requirement in the studied countries is not structured the way the CPR requires, in the Netherlands there is no specific Chapter about reducing the spread of fire to neighbouring buildings. The limitation of using only prescripitive codes means that some requirements could be found in guidelines for performance-based design.

The method of review does not show how these requirements are met, or how high the level of Fire Safety is in each country. There are signs in the structure that there is intent to comply with the basic requirements.

The results show that the Harmonisation Requirements on structure are well implemented in the Building Code as described in the CPR. In this aspect the Building Codes can be said to be harmonised. The impact a standardised structure has on Fire Risks is that it makes it easier to identify the relevant Chapters and to find the requirements. The easier it is to read the easier it should be to design a building correct and in adherence with the regulations on Fire Safety.

The review shows that in some countries the requirements are implemented in the detailed regulations, and allowing the designer to understand the requirements needed in order to fulfill the overall ambition. In other countries the requirements are only found as general statements and it is not clear what this could. This can be exemplified with the Safety for Rescue Teams that is described in detail in the UK regulation but in Germany is a general statement with no direct practical implications. If the basic structure in the CPR is not implemented at a detailed level, or not mentioned in the overall structure, it is difficult to assess how the basic requirements can be fulfilled.

The review shows that the structure of Chapters alone is not enough to make the Building Code transparent. The level in the hierarchy of code where the requirements are is also important, if a requirement is only written in a decree then there will be no guidance on how it should be designed, making it less transparent to what requirements it implicates for a product. It is important that the structure according to the CPR is used also in the standards where the detailed requirements are found.

The lack of regulations in an area could mean that the safety level is lower but it is difficult to evaluate since there might be requirements to meet the specific areas without it being structured in accordance to the CPR.

6 Case Study 2 - Residential Building

A Case Study was performed to answer the research questions in Chapter 1.2 regarding the level of harmonisation, and more specifically research questions 1, 2, 3 and 4 in chapter 1.2, how can harmonisation be evaluated and what is the relation between harmonisation and the overall Fire Safety Level.

A specific case was chosen to illustrate whether the Building Code impacts the use of Building Products or not for the studied case, and to show how Building Code and Building Products interact. Building Codes sets general requirement and the practical implications can be unclear, a Case Study aims to give a practical interpretation of the Building Code.

In this chapter, Case Study 2 – Residential Building, following parts of the procedure are presented (see below):

- Presents the data collected of the detailed requirements in each studied country´s Building Code.
- Analyses what areas are interesting to study for each one of the five basic requirements listed in the CPR.
- Presents the studied areas for each requirements. The requirements are studied with simple comparisons for the straight-forward requirements and with event-trees for the more complex requirements.
- Presents conclusions and summary.

Since the Building Code for Fire Safety covers a large array of occupancies, structures and uses the results from a single Case Study are highly limited but is deemed relevant since a common building type is chosen. According to statistics a four storey building is the most common building type in Sweden for the past 50 years. (Utredning av alternativ för förbättrat brandskydd i trapphus i flerbostadshus 2011) The Case Study should be read as an exemplification rather than an attempt to evaluate all aspects.

The identified case is shown in figure 7 and 8. It is a 12.5 m high four storey residential building with a centrally placed exit stair. Four apartments are placed around the stair, and the apartment size is 70 m^2. The dimensions are 10x7x3(WxLxH). The attic is assumed to only be used for installations and to be separated with a Fire Barrier from the underlying apartments.

Figure 7 Facade with Fire Barriers

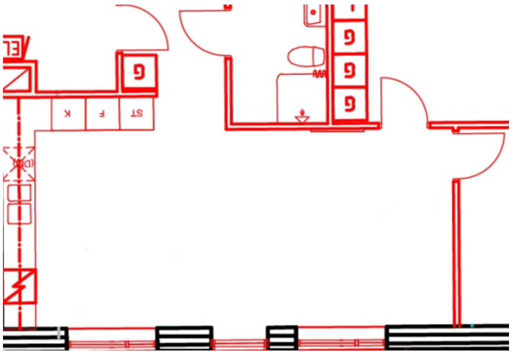

Figure 8 Floor plan

This example will give an opportunity to study the intricate nature of Fire Protection, where many parts of the construction affect each other.

Areas to be studied are the five basic requirements in the CPR as described in Chapter 1.

6.1 Data Collection

The countries where no relevant and detailed documentation was found are excluded from this analysis and the Case Study. This applies to Italy, France, Poland, the Czech Republic and the Netherlands as evaluated in chapter 4.2. The analysed countries are Denmark, Germany, Spain, Sweden and the UK for which enough information was found.

The results from the data collection are shown in detail in Appendix A.

The Building Regulations contain a large array of data for all kinds of building types and occupancies and for the use in the analysis the data was narrowed to a comprehensible number.

The major screening of requirements was only using the parts that apply to the four storey residential building chosen for the Case Study.

The second screening of detailed requirements was based on the five CPR Requirements. Requirements in the construction that affects these five areas are listed below. If a requirement is relevant to more than one area it is only listed once. This translates into the following requirements for each of the five areas:

1. Load-bearing capacity – All requirements regarding load-bearing Structure,
2. Limiting Fire Spread – Requirements on construction of walls and floors, Fire Barriers, construction of openings in Fire Barriers such as Ventilation Requirements and shafts, Fire Suppression Systems, Surface Materials, Requirements on Windows and Facade Materials,
3. Limiting Fire Spread to an adjoining building – The requirements in 2 and Fire Walls and Distance Requirements between buildings
4. Egress – The requirements in nr. 2 and 3 and for egress strategy, stairs and windows, Fire Alarm Systems
5. Safety of Rescue Teams – The requirements in nr. 2, 3 and 4 and and smoke evacuation.

6.2 Areas to Study

In the data collection process, see Chapter 6.1, all the detailed requirements regarding a four storey residential building were summarised into a comprehensive table for each country, see Appendix A. There was a need to limit the areas to study and four areas where chosen to represent each one of the five basic requirements. The tables in Appendix A were compared to find interesting areas that could be suitable to use in the Case Study and provide answers to the research questions. A summary of the areas is shown in table 13.

Some aspects of the Building Requirements are rather straightforward, for example will a higher rating of Surface Materials render a slower Fire Spread and less smoke and droplets and therefore limit the spread of fire and smoke in requirement 2. Although the overall fire safety level in a building is complex and cannot properly be evaluated without including all aspects, construction parts such as surface materials will burn more or less intense directly linked to their classification. If an intense surface spread becomes an issue for egress is of course dependent on other factors. Other areas are more complex to evaluate how they contribute to the fire spread since they interact with other parts of the construction. The effect on a fire from combustible insulation is related to requirements on cladding and fire stops, since it may not even be exposed to the fire.

Load-bearing Capacity

The first of the five requirements in CPR is that the load-bearing Capacity of the construction can be assumed for a specific period of time. Studying the Building Codes for information about the rating of the construction showed that there were very different requirements regarding rating and the number of levels of height. This is discussed in Chapter 6.3. For the comparison on Load-bearing capacity the four storey residential building is not used but instead all heights are listed for each studied country.

Limiting Fire Spread

The second requirement is that the spread of fire of smoke within the construction is limited. The Surface Requirements, as mentioned above, are rather straight forward in the way they affect Fire Spread and Smoke Generation. Studying the variations in the Surface Requirements was of interest since the fire spread on surface material has very little to do with other parts of the construction and should have the potential of a high degree of similarity. Surface Materials are studied in Chapter 6.4.

A more complex part of limiting fire spread is the Fire Behavior in exterior walls and openings. The studied countries had a high degree of variation in the requirements. Since there are so many requirements that interact it is very difficult to determine if the actual degree of Fire Spread varies just by reading the regulations. Since it is a complex question an event-tree was decided upon as the best method to evaluate the regulations. Exterior walls are studied in Chapter 6.5.

Other aspects of Fire and Smoke Spread, such as Ventilation Requirements, Fire Barriers and shafts were excluded from further study. These areas do not affect fire spread within a compartment and do not affect the fire spread in surface materials. They may affect fire spread within the building and fire spread to an adjacent building. Surface Materials and exterior walls were decided to be representative for the variations between the countries on Fire and Smoke Spread, both in complex and straight-forward aspects. The excluded topics also presented less variation.

Limiting Fire Spread to an Adjoining Building

The third requirement is to limit the Fire Spread to a neighbouring construction. This depends on the radiation from exterior walls and the distance between buildings. Since this concerns exterior walls it is also included in the event-tree analysis in Chapter 6.5.

Egress

The fourth requirement is the safe egress of occupants in the building, either on their own accord or by being rescued by other means. Since the Case Study was limited to a four storey residential building the exit strategies were very similar, this is discussed in Chapter 6.6.

Safety of Rescue Teams

The fifth requirement is the safety of Rescue Teams. This is a very wide requirement, and is affected of how well all above requirements are fulfilled. The safety of the Rescue Team is endangered if the fire has spread to a neighbouring construction, if occupants have not been able to evacuate, if a fire has spread beyond the Fire Barrier and affected more occupants or if the structure of the building in some way has been damaged. This is discussed in Chapter 6.7.

Table 13 Summary of Areas to Study

CPR Requirement	Exemplified by	Chapter
1 Load-bearing Capacity	Load Bearing Requirements for All Heights	6.3
2 Limiting Fire Spread	Requirements on Surface Materials	6.4
2 Limiting Fire Spread	Requirements on exterior walls	6.5
3 Limiting Fire Spread to Adjoining Building	Requirements on exterior walls and distances between buildings	6.5
4 Egress	Exit requirements on stairs, installations for early evacuation and fire spread	6.6
5 Safety of Rescue Teams	Load-bearing Requirements, fire spread and smoke evacuation systems	6.7

6.3 CPR Requirement 1 - Load-bearing Capacity

The load-bearing capacity is rated with “R” followed by a number which represents minutes. The minutes refer to the standardised test ISO 834. (ISO 834-10:2014 n.d.) The requirements for load-bearing Capacity for each country vary according to their specific requirements regarding height and use. [1] In this chapter a summary of load-bearing Capacity for several heights is presented in table 14-18.

The requirements that apply for the case study, the 12,5 metre high four storey residential building, are marked in grey.

[1] The tables do not list all special provisions but are schematic.

Table 14 Load-bearing Denmark

Height	Load-bearing Capacity
Max 1 storey	0
Max 5.6 m	R 60
5.6-9.4 m	R 60 and A2-s1,d0 or R 60 and D-s2,d2 and installation of sprinkler/K10 or R 60 and D-s2,d2 and wall rating EI 30 + EI 30
9.4-12 m	R 60 and A2-s1,d0
Over 12 m	R 120

Table 15 Load-bearing Germany

Height	Load-bearing Capacity
Max 7 m (with requirements of units and floor area)	0
Max 7 m	R 30
Max 13 m	R 60
Max 22 m	R 90
Above 22 m, special provisions	R 120

Table 16 Load-bearing Spain

Height	Load-bearing Capacity
Max 15 m	R 60
Max 28 m	R 90
Max 28 m	R 120

Table 17 Load-bearing Sweden

Height	Load-bearing Capacity
1 storey	0
2 stories	R 30
3-4 stories	R 60
5+	R 90

Table 18 Load-bearing UK

Height	**Load-bearing Capacity**
Max 1 storey	0
Max 5 m and no residential use	R 30
5-18 m	R 60
18-30 m	R 90
30 m+	R 120 with sprinkler

6.3.1 Summary and Conclusion Load-bearing Capacity

The rating of a building is not equivalent to the exact minutes a building will last in a fire. It is a quality tested under specific test conditions according to ISO 834, the actual fire can be more or less intense than the temperature curve used in a lab. (ISO 834-10:2014 n.d.) The rating describes a quality, and R 120 will last longer than R 30, and can be said to be a higher requirement since to achieve R 120 materials will need more protection and have higher Fire Resistance. For the unrated buildings materials can be used such as unprotected steel or optimised and slim dimensions of wood and concrete. To achieve a rating steel must be protected, and materials in general must be made of larger dimensions than is needed for the normal stability of the building.

The Load-bearing Requirements follow the same pattern in the different countries, the higher the building the higher the required rating. One storey buildings are in general allowed to be built without rating, unless there are some special occupancies such as large numbers of occupants or assisted evacuation facilities.[2] The buildings are rated in R 60 for the majority of the buildings with stairs, an R 60 rating is likely to keep the construction intact in a normal size fire and occupants have sufficient time to evacuate. Ratings as high as R 90 and R 120, used for very tall buildings, indicate that the building will stand after the fire, and full evacuation may not be necessary. This relates to the capacity of the Rescue Service. Very tall buildings make several floors inaccessible for a ladder engine, and it takes a longer time to reach a fire that is very high up.

The Fire Safety Level achieved seems to be similar in the countries, the differences are at what heights the rating changes, but in general the rating seems to reflect the risks with higher buildings. The requirements for Load-bearing Capacity are deemed to be implemented with a similar level of safety in case of fire.

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[2] The tables do not list all special provisions but are schematic.

The structure of the requirements varies. The majority of the countries use a combination of height of the building and occupancy type, whereas Sweden stand out for using number of floors instead of height for their Building Classification. Denmark also has a unique requirement that is not found in the other countries, they also list Material Requirements tied to the Height Requirement. Sweden and Germany also requires the reader to seek information about rating in a second document, the actual rating is not found in the Building Code.[3]

Although there are some differences in approach the structure is very similar between the countries and can easily be read and understood without previous knowledge. From the method and definition used in this work, as seen in Chapter 1.6, the section load-bearing Capacity is harmonised to a high degree. It is attainable, well-structured and achieve a similar level of safety.

6.4 CPR Requirement 2 - Surface Materials

Surface Classes regulate the rate of Fire Spread across a surface, and how much smoke and droplets that is produced according to test standard EN 13501-1. (SS-EN 13501-1:2007 2007) The terminology for surface in the Building Code is the lining, for example a board of gypsum with wallpaper. A is the highest requirement, and D is usually the lowest that is allowed inside buildings. s stands for Smoke Production, where s1 is a small Smoke Production. d stands for droplets, where d0 means that the material produces no droplets when ignited. K1 10/B-s1,d0 is a combination class. B-s1,d0 regulates the surface reaction to fire, K1 10 is an additional requirement for a Surface Cladding that protects the underlying material for 10 minutes, produces little smoke and is hard to ignite. The major purpose of this cladding is to prevent small fires from igniting the inner construction. (Winberg 2014)

[3] In Sweden it is the EKS; Germany the BRL, see chapter 3.3.3

Table 19 Surface Requirements

Country	Residential	Egress route	Exterior walls
Denmark	Ceiling K1 10/B-s1,d0 Walls K1 10/D-s2,d2	Ceiling and Wall K1 10/B-s1,d0 Floor Dfl-s1	B-s1,d0, max 20% D-s2,d2
Germany	Ceiling A2-s1,d0(A2) Walls E-d2	A2-s1,d0(A2)(All surfaces)	C-s1,d0(B1)
Spain	No regulations	Ceiling and Wall B-s1,d0 Floor Cfl-s1	No regulations
Sweden	Ceiling B-s1,d0 on A2-s1,d0 or K2 10/B-s1,d0 Walls C-s2,d0	Ceiling and Walls B1-s1,d0/A2-s1,d0 or K2 10/B-s1,d0 Floor Cfl-s1 Max 20% of wall D-s2,d0	A2-s1,d0
UK	C-s3,d2	C-s3,d2	B-s3,d2

By comparison in table 19 it is clear that there are variations between the countries. Denmark has a high level of protection from ignition of construction with the common use of Fire Retardant Cladding in K1 10, but they allow for the lower class D and larger Smoke Production in the longer Fire Scenario. Both Sweden and Denmark use cladding to protect the underlying construction. If Combustible Construction is used the K1 10/B-s1,d0 cladding will delay the ignition, but if only non-Combustible Construction is used it will make little difference as compared to regular a B-s1,d0 surface.

Spain has no requirements for surfaces within the apartment, this opens up for a use of more combustible materials and a higher Fire Load. The UK accepts C-s3, d2 which is equivalent to plasterboard covered with vinyl wallpaper. (Department for Communities and Local Government 2013). The BR 2010 states that they are not regulating the Smoke and Droplet Production, the reason for this is most likely that the old classes allowed for heavier vinyl and PVC wall coverings, whereas Sweden, Germany and Denmark all had high classifications before the EN classes were introduced. (Boverket 1998) The main focus for the UK requirements seems to be the room flashover and not the speed of Surface Spread. In the report '*The impact of European fire test and classification standards on wallpaper and similar decorative linings*' the results from test of vinyl covers and other materials and in the following discussion the effects of class C-s3,d2 on flashover is discussed. (Department for Communities and Local Government 2013)

Table 20 Comparison of Surface Requirements

Surface Requirements, highest to lowest.				
	Country	**Wall (apt)**	**Egress**	**Exterior**
1	Germany	Sweden	Germany	Sweden
2	Denmark	UK	Sweden	Denmark
3	Sweden	Denmark	Denmark	Germany
4	UK	Germany	Spain	UK
5	Spain	Spain	UK	Spain

Exterior Surface Requirements also interact with the Construction Requirements on the facade. Most countries also have requirements on the construction of the exterior wall, for example EI 60 rating from the inside out, non-combustible insulation or Fire Stops in the walls. This means that the evaluation of exterior surfaces becomes a bit more complex. Spain has no requirements on exterior Surface Material, but has an EI 60 requirement that will most often result in plasterboard and cement board used inside and out.

The difference in Surface Requirements or the lack thereof, is difficult to explain from a strict Fire Engineering viewpoint. If the definition of a limited fire spread were the same all the countries would have the same requirements to achieve an acceptable limitation. The variations, shown in table 11, also seem a bit erratic in comparison, with high requirements for some applications and lower in others. The UK have presented a practical reason for their requirements, as their building tradition is with heavier wall coverings, and evaluated the Fire Load instead of Flame Spread. (Department for Communities and Local Government 2013) It is plausible that similar adaptions to building tradition have been made in the other countries, setting the requirements to suit the products most used rather than analyzing the need for Smoke and Flame Control. Egress routes seem to be the area where most concern is given and where all countries prescribe Surface Classes. It is also possible that the need to limit fire spread varies due to other factors in the building or resources of the rescue team.

The limit of fire spread achieved seem to vary a great deal between the countries, from hardly any spread to materials that can result in a flash-over, and show very different view of the risks of Surface Materials contribution to a fire. Since requirements for

Surface Materials are non-existent for some areas, and low in others, this area is deemed to only give a moderate degree of similarity, see table 20.

The structure is almost identical and can easily be read and understood without previous knowledge. From the method and definition used in this thesis the section Load-bearing Capacity is harmonised to a high degree regarding attainability and structure, but only to a moderate degree achieves a similar level of safety in case of fire.

6.5 CPR Requirement 2 and 3 - Exterior walls

The chapter Exterior Walls will present a study of the spread of fire from an apartment via the exterior walls. The CPR requirements discussed are: Limit of Fire Spread within the building and limit of Fire Spread to an adjoining building. The chapter is divided into a description of a possible example of construction for each country. The analysis of the Fire Spread is then presented in two event-trees.

The Fire Behavior in exterior walls is dependent on many factors. The behavior can be divided into spread into exterior walls, spread inside and outside of the wall and spread through openings. The spread in the building affects the radiation to a neighbouring building because a larger fire will render a larger radiating surface and so does the distance between buildings. To compare the level of control of Fire and Smoke Spread between the countries, and to evaluate what impact the variations in regulations actually have on Fire Spread two event-trees are constructed. One will focus on Fire Spread within the construction and the other on Fire Spread to another building. Factors in the Building Regulation that affect the Fire Spread and level of radiation were identified and shown in table 21.

Table 21 Deciding Factors for Fire Spread in Exterior Walls

Factors	Chapter	
Size of fire in the apartment - Surface Requirements	Surface Requirements	6.5.1.1
Requirements or limitations on size of windows and openings	Openings	6.5.1.2
Requirements or limitations on distance between openings in different Fire Compartments	Openings	6.5.1.2
Requirements on Fire Rating of Roof Eaves to attics or Roof Construction	Roof Eaves	6.5.1.3
Minimum allowed distance to neighbouring buildings	Distance between buildings	6.5.1.4
Fire Rating of exterior walls	Construction of exterior walls	6.5.1.5
Combustible Construction or Insulation	Construction of exterior walls	6.5.1.5
Fire Stops inside construction	Construction of exterior walls	6.5.1.5

All the components that affect the Fire Spread via an external wall are discussed in the following chapters and used in the event-trees, all requirements in each chapter is from appendix A. Materials are chosen that could be used in each building and a possible fire scenario is described in chapter 6.5.2 and 6.5.3

Event-tree 1 is presented in chapter 6.5.2

Event-tree 2 is presented in chapter 6.5.3

6.5.1 Constructing the Residential Building

6.5.1.1 Surface Materials

The Surface Material can affect the Fire Scenario, that is the rate of Fire Spread on a surface in a Fire Compartment and the contributed Fire Load is both factors in how a fire behaves. For this Case Study it is assumed that the fire will be fully developed and variations in rate of spread is therefore less important than Fire Load.

Surface Requirements varies as described in in chapter 6.4 and there are small differences between Germany, Sweden, Denmark and the UK. Spain has no regulations and it is possible to use wood that could contribute to the Fire Load. Compared to variations in the Fire Load in a standard apartment due to different furnishings and interior decorations, the different uses of Surface Material is a small contributing factor to the Fire Load and will not decide if the fire will be fully developed or not. It is assumed it is not a deciding factor for the Fire Spread and Surface Material is not introduced in the event-tree. The starting event, fire in an apartment, is assumed to be of the same size independent of Surface Materials.

The Surface Materials of the exterior facades, constructed in order to comply with the requirements of each country, are all assumed to be non-combustible for the sake of this Case Study. Assumed Surface Materials are shown in chapter 6.5.1.5.

6.5.1.2 Openings

Windows in the exterior wall can spread fire to apartments above the Fire Exposed Compartment. Table 22 shows the requirements placed on Window Openings in each country:

Table 22 Requirements for Window Openings

Country	Minimum vertical distance
Denmark	No requirement
Germany	No requirement
Spain	1 m
Sweden	1.2 m
UK	No requirement

The assumed apartment for the Case Study as described in chapter 6 has windows that comply with all of the requirements so there are no differences between the countries on opening-sizes. The assumed openings for the Case Study is 4.8 m^2 divided on two windows and a terrace style door opening onto a French balcony.

6.5.1.3 Roof Eaves

Large flames from windows may spread to roof and attic construction via the open Roof Eaves. Roofs are often ventilated by openings where the wall meets the Roof Construction. If the attic is not separated into Fire Compartments a fire here can grow very large and be difficult for the Fire Department to extinguish.

The following requirements in table 23 are placed on Roof Eaves:

Table 23 Requirements for Roof Eaves

Country	Minimum protection
Denmark	300 mm of $K_1$10/ D-s2,d2
Germany	EI 60
Spain	No requirement
Sweden	EI 30
UK	No requirement

Only one of the countries has a rating of Roof Eaves in EI 60, the other have a rating of EI 30 or less. If the fire in the event-tree spreads to an adjoining apartment then the Roof Eave is assumed to have to be rated in EI 60 to withhold its integrity, due to the prolonged Fire Scenario. The possible difference in outcome in this design is described in the event-trees.

6.5.1.4 Distance to another building

The purpose of distance between buildings is to reduce the risk of fire spread to adjoining buildings. Fire can spread to an adjoining building via radiation; the longer the distance the more the radiation is reduced. Table 24 show the requirements for the Case Study.

Table 24 Requirements for distance between buildings

Country	Minimum distance to another building
Denmark	5 m
Germany	5 m
Spain	3 m
Sweden	8 m
UK	2 m

The distances vary and the outcome of these variations is described in event-tree 2.

6.5.1.5 Materials in exterior walls

Exterior walls in the Case Study of the four storey building are constructed based on the requirements for each country and on what could be a rational building technique. It is not always the lowest possible combination of materials since this would not be a realistic construction. The construction is based on approved solutions described by Gyproc, Cembrit and Isover but the combinations of materials may vary from the approved solutions[4]. The exterior walls in the case study are insulated with Expanded Polystyrene (EPS), this is used to investigate how the different countries approach the

[4] Information is found on www.gyproc.se, www.cembrit.se, www.isover.se

issue of fire spread inside the wall. EPS is flammable and all countries allow for the use of EPS, but with different requirements to prevent fire spread. EPS is an inexpensive way to insulate buildings and achieve a high thermal rating with small dimensions. This construction type is common in Sweden, this is not necessarily the case in the other studied countries but the interpretation of the studied regulations is that it is allowed.

Denmark

In Denmark exterior surface can be made of B-s1, d0 and a maximum area of 20% of D-s2, d2. Construction Materials can be rated lower than D-s2, d2 if the wall is rated in REI/EI 30 A2-s1, d0 on both sides of the wall. This means that EPS can be used if it is covered by a rated construction and covered with cementboard or similar.

A wall-construction that complies with the regulations can be constructed of (inside out):

Plasterboard, 13 mm GN
Particleboard, 15 mm
Wood studs, non-load-bearing
Insulation EPS 200 mm
Cementboard, 22 mm
Wood frame around windows, no additional Fire Stop

The interior and exterior cladding have to comply with REI 30. The EPS in the wall is protected with an EI 30 wall. The EPS will partake in the fire after the barrier is broken but the exterior cladding is also rated in EI 30. Spread via the exterior is not likely since the cladding is non-combustible; spread in the inside of the wall is possible.

Germany

In Germany exterior surface can be made of normally flammable materials if they are covered in non-flammable sheating. Insulation materials can be of normally flammable materials if Fire Stops in non-flammable material is provided in the Fire Barriers. In EN standard this means as low as E-d2 covered in at least A2-s1,d0 and Fire Stops in A2-s1,d0. This means wood and EPS can be used if it is covered by a cementboard or similar.

A wall-construction that complies with the regulations can be constructed of (inside out):

Plasterboard, 13 mm GN
Particleboard, 12 mm
Wood studs, non-load-bearing
Insulation EPS 200 mm

Cementboard, 10 mm
Rockwoll, 300 mm, in Fire Stops
Wood frame around windows

There are no requirements in the German regulations for the exterior wall to be rated in EI 30 or similar, which is shown in the use of thinner cladding. With this construction a fire in the compartment is likely to ignite the EPS. The EPS will partake in the fire and the exterior cladding is not rated. Spread via the exterior surface is not likely since the cladding is non-combustible and spread in the inside of the wall is limited by the rock-wool partitions in the Fire Barriers.

Spain

The main requirement for exterior walls is the function of EI 60. This allows for both combustible Surface Materials and Construction Material. This means wood and EPS can be used as long as the function of EI 60 for the entire wall is maintained.

A wall-construction that comply with the regulations can be constructed of (inside out)
Plasterboard, 13 mm GN
Particleboard, 15 mm
Wood studs, non-load-bearing
Insulation EPS 200 mm
Cementboard, 22 mm
Wood frame around windows
No additional Fire Stops

The wall has to comply with EI 60. The EPS in the wall is protected with an EI 30 wall from the inside. The EPS will partake in the fire after the barrier is broken but the exterior cladding is also rated in EI 30. Spread via the exterior surface is not likely since the cladding is non-combustible; spread in the inside of the wall is possible.

Sweden

In Sweden the requirements for exterior walls are rather complex, with material requirements and functional requirements such as no falling parts of the cladding allowed. Most parts of the requirements can be fulfilled with a special Swedish facade test, SP Fire 105. For buildings lower than 8 stories the requirements are lower.

The requirements are as follows: Exterior surface can be made of A2-s1, d0. No larger parts of the exterior will fall down and Fire Spread inside and on the exterior of the wall is limited to the lower edge of a window two stories above the fire and no flames are present that can ignite the Roof Eave. Ignition criteria is that the Roof Eave has to withstand temperatures up to 500 °C longer than 2 minutes and 450 °C longer than 10 minutes. Fire Stops need to be placed on every other Fire Barrier so no more than two compartments are affected and Window Openings need Fire Stopper.

This means EPS can be used if it is covered by a rated construction and covered with cementboard or similar. The Roof Eaves need to be covered in at least EI 30 to comply with the ignition criteria.

A wall-construction that comply with the regulations can be constructed of (inside out):
Plasterboard, 13 mm GN
Particleboard, 12 mm
Wood studs, non-load-bearing
Insulation EPS 200 mm
Cementboard, 10 mm
Rockwoll, 300 mm, in Fire Stops on every other barrier and around windows.

There are no requirements in the Swedish regulations for the exterior wall to be rated in EI 30 or similar, which is shown in the use of thinner cladding. A fire in the compartment is likely to ignite the EPS. The EPS will partake in the fire and the exterior cladding is not rated. Spread via the exterior surface is not likely since the cladding is non-combustible; spread in the inside of the wall is limited by the rock-wool partitions, but not on every floor.

UK

In the UK exterior surface can be made of B-s3, d2. The wall has the combination of requirements RE 60/REI 15 from inside out. Combustible materials are not restricted for the construction of walls. This means EPS can be used if it is covered by a rated construction and covered with cementboard or similar.

A wall-construction that comply with the regulations can be constructed of (inside out)
Plasterboard, 13 mm GN
Particleboard, 15 mm
Wood studs, non-load-bearing
Insulation EPS 200 mm
Cementboard, 22 mm
Fire Stops made of non-combustible insulation or timber, steel or calcium silicate with minimum Fire Resistance of 30 minutes.

The interior and exterior cladding have to comply with RE 60/EI 15 which is constructed as a wall complying with REI 60. The EPS in the wall is protected with an EI 30 wall. The EPS will partake in the fire after the barrier is broken but the exterior cladding is also rated in EI 30. Spread via the exterior is not likely since the cladding is non-combustible; spread in the inside of the wall is limited by the rock-wool partitions.

6.5.2 Fire Spread within the construction – Event Tree 1

Based on the requirements in Chapter 6.5.1 on a four storey residential building a scenario for fire spread is set up. This is done to evaluate how different parameters affect the spread of fire via the exterior wall. Since not one single factor decides whether a fire can spread within construction the study of these aspects listed in Chapter 6.5.1.1 through 6.5.1.5 have been carried out as event-trees. Since all countries rate the Fire Barrier between apartments in EI 60 this is considered to be the benchmark for limit of Fire Spread and all parts that are not protected to EI 60 are assumed to be involved in the fire.

The purpose of this event-tree is not to quantify the differences in Fire Spread within the construction but rather to discuss the consequences in a qualitative analysis.

The approach to the event-tree is to follow the Fire Spread through the construction and determine the areas affected by the fire. The area in square metres is a schematic assumption for affected compartments and facade.. For the purpose of the evaluation the event-tree will use a qualitative description of events rather than square metres, fire spread is defined not in absolute square metres but if the fire breaks any fire barriers in the building through the exterior walls.

- Event Compartment, (C), will represent a spread to the *neighbouring apartment*.
- Event Facade (F) will represent a Fire Spread *in the façade outside of the fire barrier*.
- Event Attic (A) will represent a Fire Spread *to the attic* via the Roof Eaves.

This procedure is acceptable since the overall purpose of this study is to compare and not to evaluate the exact level of Fire Safety. A fire spreading to the attic might affect a larger area of construction than a Facade Fire but the Facade Fire might be more dangerous because it is more difficult to extinguish; and a fire spread to a neighbouring compartment might threaten lives so therefore it is difficult to compare these events only on the basis of area in square metre of Fire Spread

Figure 9 Exterior wall, dotted lines represent Fire Barriers

For this event-tree there are three different parts of the construction that can contribute to the fire and these are linked to different requirements in the Building Regulations, as described in Chapter 6.5.1.1 through 6.5.1.5. The scenario for this event-tree is a fire starting at the 3rd floor.

Node 1- Compartment Breach, C

Flames from the Fire Room are considered the primary cause of Fire Spread to the compartment above the Fire Room. Even if Fire Spread within the facade might lead to spread to another compartment, the Window Flames are the major concern. Calculations in Appendix B according to Eurocode 1 (EU 1991) of the height of the flames show that they are well over the distance to the windows in the apartment above and to the Roof Eaves.

- All countries have a Fire Spread to the neighbouring apartment.

Node 2- Fire within Facade, F

All countries have combustible insulation (EPS). Fire Stoppers in the insulation prevent Fire Spread within the exterior wall outside of the original Fire Compartment. Since no countries have protection of the EPS from the inside over EI 30 the insulation is assumed to be involved in the fire. To stop the spread of fire within the exterior wall a Fire Stop is required in the Fire Barrier.

- The countries without Fire Stoppers are assumed to have spread of fire in the exterior façade outside of the Fire Compartment.

Node 3 - Fire Spread to Attic, A

The Fire Spread to the attic concerns both the Fire Spread within the construction and the Fire Spread to other buildings. Attics often cover a large area and create large radiating areas towards other buildings. For this event-tree the focus is only on the spread of fire to the attic and the fire is assumed to be contained to this part of the building.

- All countries that have a rating of the Roof Eave of less than EI 60 is considered to have Fire Spread to the attic in case they have Fire Spread to the above compartment.

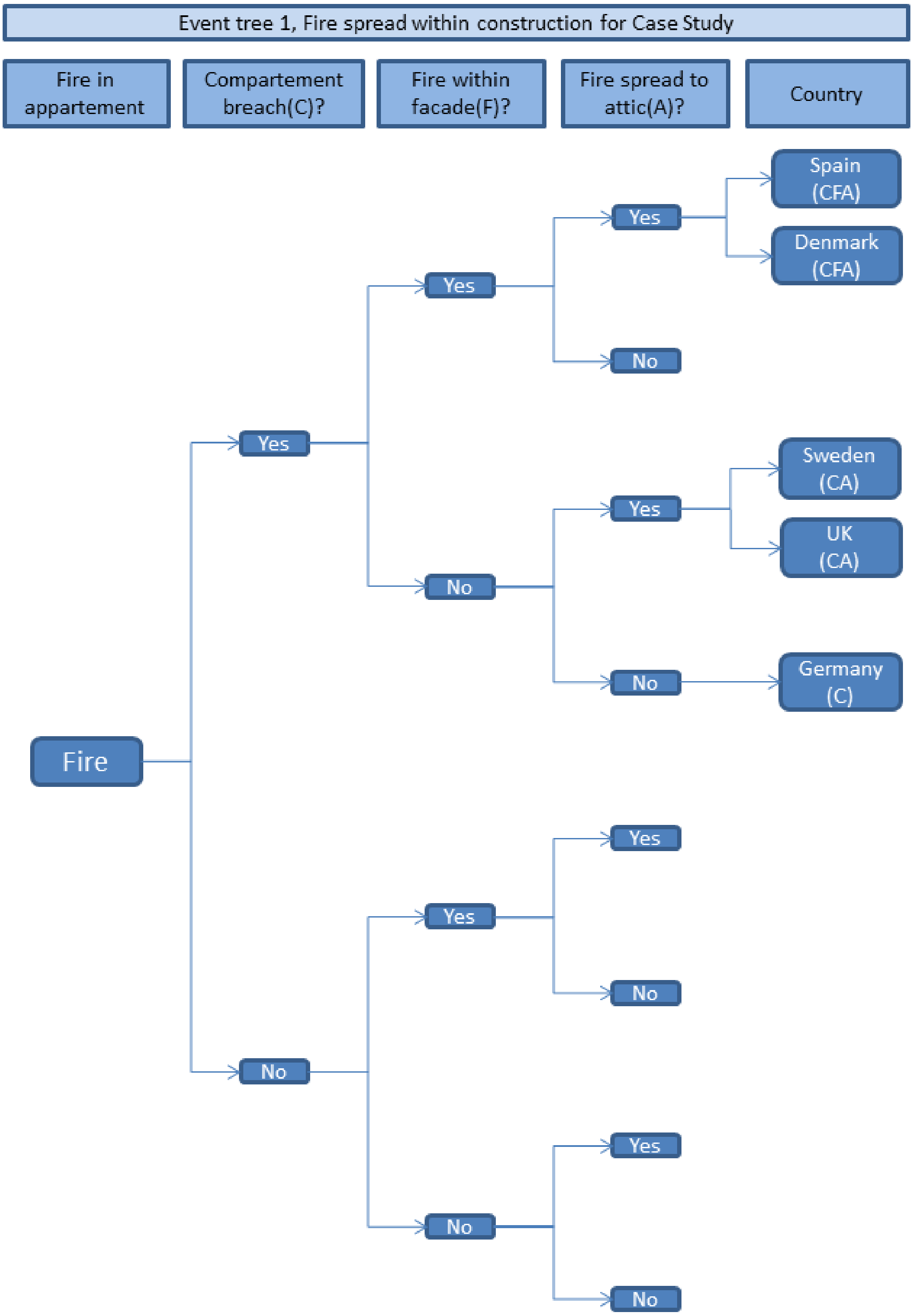

Figure 10 Event-tree 1

The event-tree in figure 10 shows that all countries have a risk of Fire Spread to the neighbouring apartment via the windows. Spread via windows is a real risk since flames can become very large as shown in Appendix B. UK and Sweden also have a possible spread to the attic via the Roof Eaves and Denmark and Spain have a possible spread to both the attic and inside the facade.

Countries that have a risk of Fire Spread to the neighbouring compartment, the attic and facade present a difficult problem for a Rescue Team. Not only must they extinguish fire in the initial Fire Compartment, the must also use resources at high levels, either interior via stair or exterior via a ladder. Depending on resources this may lead to hazards for occupants and neighbouring construction, and also for the Rescue Team. The degree of achievement of target, limiting Fire Spread in construction in EI 60, is significantly lower for Spain and Denmark than for Sweden and the UK. Germany has achieved the highest level of safety with the only spread occurring to neighbouring compartment.

From this event-tree the conclusion from the Case Study is that different requirements return a different outcome in the level of Fire Safety. The regulations can be viewed as harmonised in accordance to the criteria on structure in Chapter 1.6 and 3.4 but their level of Fire Safety is not similar. The Case Study also indicates that some countries have a lower level of safety than the intent in the CPR Requirement to reduce Fire Spread in a construction. A conclusion from the Case Study is that a high degree of harmonisation in structure in the code does not automatically lead to a similar or high level of Fire Safety. It also shows that if there would be an ambition to equalise the Building Codes great care should be taken to use a scientific approach to set the criteria for a reasonable level of safety and the methods used to determine this. If equalising would be based on what the most common solution is it could be possible that the overall criteria, for example to provide Fire Barriers in all dimensions rated equivalent to EI 60, would not be met.

6.5.3 Fire Spread to another building – Event-tree 2

Based on the requirements in Chapter 6.5.1 on a four storey residential building a scenario for fire spread to another building is set up. The event-tree is designed in accordance with Chapter 6.5 to evaluate how different parameters affect the spread of fire to a neighbouring building. The case study is shown in figure 14. Since not one single factor decides whether a fire can spread within construction or to another building the study of these aspects listed in Chapter 6.5.1.1 through 6.5.1.55 have been carried out with an event-tree. Since all countries rate the Fire Barrier between apartments in EI 60 this is considered to be the benchmark for limit of Fire Spread and all parts that are not protected to EI 60 are assumed to be involved in the fire.

The purpose of this event-tree is to quantify the differences in Fire Spread within the construction and to discuss the consequences in a qualitative analysis. The criterion for spread to another building is to limit the radiation to 15 kW/m^2 at the façade of the closest adjoining building. At this level of radiation wood and other combustible materials will start to burn.

The Case Study is a four story residential building, figure 11 and 12 show the floor plan and exterior of the building. The length of the façade of the compartment is assumed to be 10 metres and the height 3 metres. The window and glazed door is assumed to have a total area of 4.2 m^2.

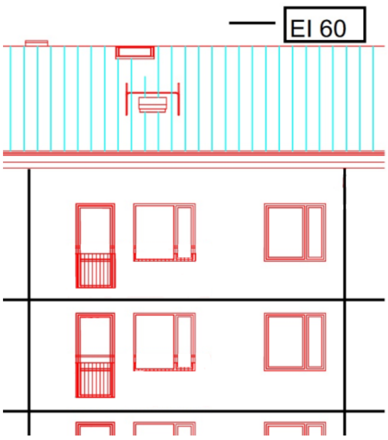

Figure 11 Exterior

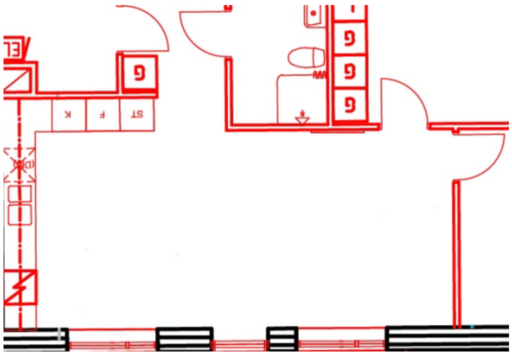

Figure 12 Floor plan apartment

The nodes of the event-tree are factors that all affect the level of radiation from the burning building to a neighbouring building. The question at each node is whether or not a certain part of the construction will be participating in the fire.

The scenario for this event-tree is a fire starting in an apartment on the 4th floor, see Figure 13. The arrows represent heat radiating from facade (yellow), Window Flame (red) and Roof Eave (orange). All three areas will contribute to the radiation.

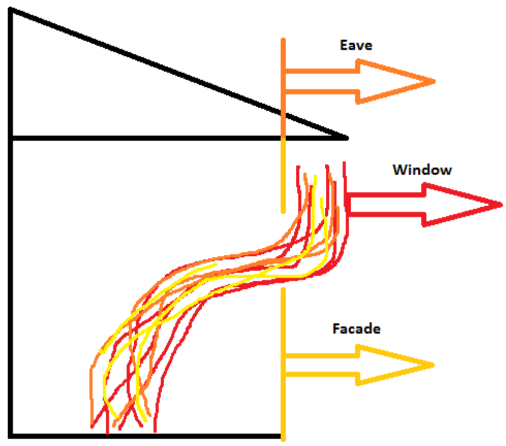

Figure 13 Flame Spread view from Section

Start Value, Flame from Windows

All apartments have the same amount of windows and the radiation from the compartment from Window Flames is therefore included in all events and will be the start value for the calculations. The fire will break the glazing in the windows and the door early on and flames will be coming out of the openings. Flame Size is calculated in Appendix B. The flames will be at a distance of 1.5 m from the facade and this affects the distance for which the radiation is being calculated. The area of the flames is set to 4.6 m^2, the flames are higher than the distance to the Roof Eave and the Flame Height is thereby restricted by the distance to the Roof Eave. This assumption will give less conservative results on radiation since not all of the possible Flame Height is in the calculation but the purpose of the event-tree is mainly for comparisons and this assumption affect the countries the exact same way since they all have the same Window Area.

- All countries have flames from glazed windows and doors.

Node 1 - Fire Spread to Eaves

All countries have flames that reach the Roof Eaves. Fire Spread to the eave will lead to the whole attic participating in the fire but only a part of the roof is considered to radiate. The radiating area of the flames, from the openings, towards the neighbouring building is set to 10 m^2 (1 m x 10 m). Distance to the adjoining building is calculated from the façade.

- If the Roof Eave is not protected in EI 60 the attic is assumed to be involved in the fire at some point in the scenario.

Node 2- Façade Part of the Fire

The exterior walls that are not rated in EI 60 are assumed to eventually start radiating, however no flames are expected to break through the construction so the radiating area is assumed to be only the facade. Since the fire starts in the upper floor the fire is limited from spreading upwards in the insulation and the existence of Fire Stops does not affect the area. The radiating area is the Facade Area minus the Flame Size, a total of 25.4 m^2. Distance to the adjoining building is calculated from the facade.

- The exterior walls that are not rated in EI 60 are assumed to eventually start radiating.

Node 3 - Distance

The distance to another building is generally calculated from facade to facade. For the Window Flame the distance 1.5 m is subtracted since the flames reach out through the windows.

- Distance to another building is set as the minimum requirement in each country´s regulation.

Node 4- Radiation

Radiation for different areas and distances are calculated in Appendix B.

Figure 14 Event-tree 2

6.5.4 Summary of Event-tree 2

The criterion for acceptable radiation towards a facade is set to be 15 kW/m^2. The assumptions of radiating temperature and radiating area in Appendix B have a large impact on the results. Since the calculations are made for comparison and not for design the assumptions are the opposite of conservative, with smaller flame sizes and radiating areas than the most conservative values. The calculations are schematic but show tendencies. The event-tree show that only Sweden achieves that level of protection, but Denmark is very close. By comparing the countries it can be summarised that risk of Fire Spread to an adjoining building is small for Sweden and Denmark, medium for Germany and high for Spain and the UK. Using 15 kW/m^2 as a required standard the majority of the countries do not achieve a reasonable level of Fire Safety.

The event-tree show that radiation varies a great deal depending on a multiple of features. The deciding event in the event-tree is the distance between buildings. For all combinations of protection a level under 15 kW/m^2 can be achieved with a greater Safety Distance. The UK can have exactly the same facade solution but increase the distance from 2 m to 5 m and reduce the radiation from 89 kW/m^2 to 16 kW/m^2. Based on the assumption in the event-tree the Facade Material is also important for radiation, improving the facade to EI 60 reduces the radiation by 50%, protecting the Roof Eave reduces the radiation with approximately 20%.

The degree of achievement of target, limiting Fire Spread to neighbouring construction, is significantly lower for Spain, Germany and the UK. Sweden and Denmark has achieved a reasonable level of safety, largely depending on the large distance between buildings.

The event-tree shows that requirements in construction are less important than distance between openings, and that flames from windows can be enough to create radiation well over the accepted level. The flames protrude away from the facade, in this case 1.5 m but if the Fire Compartment is well-ventilated the flames can reach even further.

The regulations can be viewed as harmonised in accordance to the criteria on structure in Chapter 1.6 but their level of Fire Safety are not similar. A conclusion from the Case Study is that a high degree of harmonisation in structure of the code does not automatically lead to a similar level of Fire Safety. It also shows that if there would be an ambition to equalise the Building Codes great care should be taken to use scientific approach to outcome in case of fire. If equalizing would focus on the rating of the exterior wall and Roof Eave rather than a combination of Window Size and distance between buildings the radiation levels could be well over the required level.

6.6 CPR Requirement 4 - Egress

The Egress Requirements for the studied countries are very similar for a four storey residential building. The egress strategy is designed with a central staircase in a Fire Rated Enclosure, and the second exit is via a window with the help of the emergency service. The one exception is the UK that requires a second access to a staircase or the installation of sprinkler. All other circumstances similar this could lead to a higher level of safety since there is less risk of both exits blocked, but it is possible that this is due to response time or resources in the Rescue Service and therefor it is not possible to evaluate if this would lead to a higher level of safety.

The most critical situation is in the apartment where the fire starts, and it is vital that sleeping occupants are given notice of the fire to evacuate. Denmark, Sweden and the UK have requirements for a Smoke Alarm to be installed. The occupants can install Smoke Alarms but a requirement on a Smoke Alarm will ensure that all apartments have the system in place.

The egress situation is also affected on how the fire spreads, a large fire will affect several apartments and depending on the resources of the emergency service it can prolong the time to rescue. As seen in the event-tree in Chapter 6.5.2 there is a risk for Fire Spread to neighbouring apartments.

The safety level for egress is a complex matter and depends on the design of the egress, installation of Smoke Alarm, Fire Spread in the building and the capacity of the local emergency service.

These factors, using data from the event-tree, show the major aspects that affect the level of safety in table 25.

Table 25 Egress Safety Components

Countries	Spread to	Stairs	Smoke Alarm
Denmark	Compartment above, Facade, Attic	1 stair	Yes
Germany	Compartment above	1 stair	No
Spain	Compartment above, Facade, Attic	1 stair	No
Sweden	Compartment above, Attic	1 stair	Yes
UK	Compartment above, Attic	2 stairs	Yes

Table 25 shows that all countries have spread to the compartment above, and this reduces the level of safety for all countries. A Fire Spread to the attic or in the facade is assumed to not have a high impact on Egress Safety since they do not directly affect the stairs. A Smoke Alarm is assumed to return a higher level of safety since it will awaken sleeping occupants. The impact of safety from the additional stair is as discussed above inconclusive. From the information in table 25 only the installation of a Smoke Alarm has a clear impact on the Egress Safety. The safety level for the occupants in the Fire Compartment is thereby lower for Germany and Spain since there are no requirements for Smoke Alarms. Since not all countries have a requirement for Smoke Alarm the level of Fire Safety is not similar.

6.7 CPR Requirement 5 - Safety of Rescue Teams

The requirements that are vital for the safety of the Rescue Team is the rating of the load-bearing Construction since they may need to enter the building during fire, Smoke Ventilation of the stair and the Fire Spread within the construction since this affect how many occupants are in acute danger and how difficult it will be to extinguish the fire. The requirements are listed in table 26.

Table 26 Factors for Safety of Rescue Teams

Countries	Load-Bearing Construction	Smoke Ventilation of Stair (Window or Hatchet)	Fire Spread inside construction (event-tree 1)	Risk of Fire Spread to adjoining building (event-tree 2)
Denmark	R 120	Yes	Compartment above, Facade, Attic	Small
Germany	R 60	No	Compartment above	Medium
Spain	R 60	No	Compartment above, Facade, Attic	Large
Sweden	R 60	Yes	Compartment above, Attic	Small
UK	R 60	No	Compartment above, Attic	Large

The rating of construction is R 60 and higher for all countries and this is deemed a reasonably high level since the rating of Fire Barriers and egress routes are rated in EI 60 and the fire is assumed to be extinguished or all occupants evacuated within this time frame. Germany, Spain and the UK lack requirements for Smoke Ventilation that can be important to gain access to a smoke-filled stair. The UK on the other hand has two stairs that may mitigate this lack since. All the countries have a risk of Fire Spread to the neighbouring apartment, and the UK and Sweden also have a possible spread to the attic via the Roof Eaves. Denmark and Spain have a possible spread to both the attic and inside the facade. This means that the Rescue Team may be exposed to greater risks trying to extinguishing an attic fire and evacuating multiple apartments.

There is also a high risk of Fire Spread to an adjoining building in Spain and the UK, this is largely due to a smaller distance between buildings. The short distance between the buildings can also have a negative impact on the possibility to safely protect the adjoining structure. Although there are requirements in the regulations to prevent falling pieces of the facade there is always a risk for glass shatter and it is inadvisable to stand close to the facade. The additional stair in the UK may mitigate this since the Rescue Team may have more resources available to limit Fire Spread to an adjoining building since the stair may reduce the need for them to assist in evacuation of the building.

In summary there are risks for the safety of the Rescue Team determined by several different requirements. The overall level is difficult to evaluate since the rating of the construction is reasonably high but the distance between buildings may lower the Fire Safety Level.

The regulations can be viewed as harmonised in accordance to the criteria on structure in Chapter 1.6 and 3.4 but the level of requirements on Safety for the Rescue Team are not similar since there are variations in Smoke Ventilation, distance between buildings, Fire Spread in the construction and risk of Fire Spread to an adjoining building. The impact of these regulations on the safety for the Rescue Team is also highly dependent on the resources and organisation of each countries rescue operation.

A conclusion from the comparison is that a high degree of harmonisation in structure of the code does not automatically lead to a similar or high level of safety for the Rescue Team. It also shows that if there would be an ambition to equalise the Building Codes great care should be taken to use a scientific approach to set the criteria for a reasonable level of safety and the methods used to determine this. It would also be important to weigh in factors such as resources, response time and organisation for the Rescue Team.

7 Conclusion and discussion

In this investigation, the aim was to assess the level of harmonisation in the Building Code concerning Fire Safety. Harmonisation, or the reduction of trade barriers, was evaluated by defining what a trade barrier can be in the design process. The found obstacles were lack of accessibility and poor structure. The third object to study was based on the Construction Products Regulation, an EU tool for achieving harmonisation that states that a reasonable Fire Safety Level shall be included in the nations Building Code. This applies to the five basic requirements in the CPR:

1. The load-bearing Capacity of the construction can be assumed for a specific period of time
2. The generation and spread of fire and smoke within the Construction Works are limited;
3. The spread of fire to neighbouring Construction Works is limited
4. Occupants can leave the Construction Works or be rescued by other means;
5. The safety of Rescue Teams is taken into consideration

It should be mentioned that all assumptions regarding the detailed requirement is based on what is found in the case study. Caution should be taken in interpreting the details. The collection of the regulations has been undertaken with a limited amount of time and expenses, also the regulations have been interpreted to English via Google Translate. The collected information may therefore not be comprehensive and in some cases even contradictory to the actual requirements.

In the following paragraphs will the five research questions presented in chapter 1.2 be discussed and addressed.

RQ1: How can the level of harmonisation of the Building Code be evaluated?
The three studied objects, attainability, structure and level of Fire Safety, were evaluated using the methods Case Study and review.

The method used for studying attainability was a Case Study. This was designed as a simulation on how to attain the documents from a layman perspective. This method was useful to understand and evaluate the first obstacle to harmonisation. It showed in detail how difficult accessing and understanding the regulations can be, and what level can be achieved and what is needed to accomplish a reasonable level of attainability.

The structure of the Building Code was evaluated both in the Case Study and with a review. The Case Study showed the different hierarchy's where detailed regulations can be found and the difficulties in understanding where requirements are listed. It was a relevant method to evaluate the obstacles concerning structure. The review was a comparison on how the Building Regulations were structured in accordance to the five basic requirements. This method was not sufficient for an evaluation since it only gave a restricted understanding on how the regulations were met.

The third object, a reasonable level of Fire Safety, was also evaluated using a Case Study. The Case Study was on a specific Building Type, and data was collected on the relevant regulations. The Case Study focused on attaining a reasonable level of Fire Safety and the relation between harmonisation and Fire Risks. The method was schematic, since Fire Spread and Fire Safety is a very complex science, but could be used for comparisons between the countries. Although the conclusions are limited due to the nature of a Case Study, the possible impact of the level of harmonisation on the level of Fire Risks could be discussed for the different regulations.

RQ 2 and 3: How harmonised are the Building Codes and How are the Building Codes for Fire Safety Design structured for the studied countries

Regarding attainability the Case Study show a low level of attainability. Of the ten countries studied the relevant regulations were attained for only five countries. For a majority of the countries it was a difficult process to find and understand the documents and the hierarchy of regulations. The countries with a high rating show that the means necessary to make the codes accessible is not very complicated. A search optimizing of the webpages, relevant information translated to English and the most common languages, and a brief description page where the hierarchy of regulations and procedures is explained, complimented links to updated Building Regulations would be sufficient for anyone trying to access the Building Codes. As the Case Study show it is now very dependent on the skills, network and previous knowledge of the subject to find information, and this could present an obstacle for the free movement of goods and information. This is not only an obstacle for harmonisation as defined in this work but also an obstacle for the main objectives in the Lisbon Treaty (European Union 2007). The EU does not require that information should be provided in English, and many countries only use the official languages in each country, so the language barrier can be considered as a trade barrier for anyone not familiar with each countries language.

The overall structure of subjects is almost identical for the ten countries studied. The CPR analysis shows that the five basic requirements are used in all ten countries with one minor exception. This shows the intent of the countries to comply with the CPR; it is also likely that this structure is a good summary of what should be required in a Building Code regarding Fire Safety Aspects. It is difficult to tell what came first,, the structure or the requirement to have such a structure, but it is decidedly a high level of harmonisation in this aspect. When it comes down to the detailed requirements there are variations in where the regulations can be found, as shown in Chapter 1.5. Some countries have divided their detailed regulations in several documents, and others reference to standards that can be accessed for a fee and it is unclear what the requirements are without these standards. For the five countries where the detailed regulations were attained the structure is very similar on the different topics, as shown in Chapter 5. In summary the obstacles are found in the hierarchy of regulations rather than in each document. The harmonisation of detailed requirements is good but the harmonisation of hierarchy is not.

The levels of Fire Safety are evaluated in Chapter 6. The different topics are analysed in a Case Study for a four storey residential building. The Case Study is schematic but offers a tool for comparison of Fire Safety Levels. Three major themes emerged from the analysis; the level of Fire Safety is very varying although the requirements are described in a similar approach, the level of Fire Safety is lower than expected and different Design Requirements may result in the same level of safety. Firstly the requirements on Load-bearing Structures, Surface Materials, exterior walls and distances between building vary in a way that does not seem related to the characteristics of a fire, since it is likely that a fire should behave similar the different countries. An implication of this is the possibility that requirements on Fire Safety are derived from national traditions in constructing buildings rather than from a scientific approach. The second major theme is that the level of Fire Safety is lower than described as requirements in the regulations. The ambition to limit Fire Spread to an adjoining building is not fulfilled with the distance required and similar results are found for the design of the Fire Barriers in the exterior wall. The third theme emerges in the Case Study on exterior walls that find that the same level of Fire Protection can be reached with varying requirements. A different set of Facade Protection and distances between buildings can result in the same radiation level. The findings of this research provide insights for how a process to harmonise requirements should be structured to achieve a reasonable level of Fire Safety. Harmonising the requirements based on a majority decision, to what the most common level already is, and would not be sufficient to reach a reasonable level of Fire Safety. The code should rather be derived with a scientific approach, deciding first on index values for a reasonable level of Fire Safety and secondly for analytical methods. This could enable each country to derive their own set of requirements but with a similar level of overall safety.

RQ 4 and 5: Will a higher level of harmonisation result in a higher level of Fire Safety and can the harmonisation process result in a higher level of overall Fire Safety

The correlation between harmonisation and the level of Fire Safety was evaluated using the Case Study and comparing the Fire Safety Level with the degree of harmonisation. The different topics suggested that there is no such correlation. For areas where structure and accessibility where harmonised the level of Fire Safety was still very varying and in some cases showed a low level of safety. The exception was requirements on Load-bearing Construction that showed similarities in the details. As mentioned in Chapter 1 the only code work on an EU level is the Eurocode (EN 1990:2003 Eurocode 2004) on construction, this can explain the similarities in this area. An alternate explanation for this is that the Eurocode could be developed because the countries already had similar regulations. Taken together, these results suggest that there is no association between a high level of harmonisation as defined in this work and level of Fire Safety, but that there might be if the process of harmonisation were to include guidelines on how to design the different topics, with Eurocodes for all the five basic requirements. A Case Study, as used in this thesis, will only show variations between the countries and cannot be used to evaluate a reasonable level of Fire Safety since it does not include all factors that could affect Fire Safety..

A low level of harmonisation in the area of accessibility means that the regulations are difficult to access. An implication of this is the possibility that the regulations may be misinterpreted by a designer and the Fire Safety in a building will not meet the goal. It may also implicate a more costly process to approve products for use, resulting in increased costs for Fire Protection. If the process was more harmonised the cost would be lower and this could open up for the legislation to suggest higher requirements without the added cost.

Overall, these results indicate that there is more work needed on the harmonisation of Fire Safety Codes and Construction Products. There are obstacles of attaining the Building Codes and understanding the requirements which is a prerequisite for developing and testing Construction Products. There is also a variation in the level of Fire Safety that may not meet the prescribed reasonable level of safety.

7.1 Possible improvements

This research has several practical applications. Firstly, it points to the need for search optimisation, better websites and introductions to access the documents. With a description of the structure all documents does not need to be designed the same way to be accessible. The CPR-contacts could be very useful to guide in the right direction, but their role is sometimes limited by the requirements to use the official languages in contacts. Translated regulations or guidelines are also necessary to be sure that the requirements are correctly interpreted. These findings suggest a role for the EU to function as a gathering source. An EU-governed database of adopted regulations and guidelines, and short descriptions of the relevant ministries together with functioning contact points in several languages would be a great improvement. All the regulations can be found once the name of the relevant regulation is defined, but this first step can present a large obstacle without network of previous knowledge. For the aim in the CPR to reach a reasonable level of safety; a work similar to the Eurocodes for construction could be developed for all the five requirements.

7.2 Further studies

To further enhance the understanding of obstacles to harmonisation connected to the Building Code and national regulations it would be interesting with further study with focus on the performance based design. This area has not been discussed in this work but the implications of performance-based design on harmonisation could be both that of an obstacle or a mitigating factor for the testing and marketing of Building Products. It could be possible to harmonise guidelines for performance-based design that can function as a replacement or complement to CE marking.

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Appendix A - Detailed regulations Case Study 2

Denmark

Area	Requirements	Referenced standard (EN 13501…)	Reference section
Rating of load-bearing Construction	R 120 A2-s1,d0 since over 12 m	Eurocode with Danish Annex DS EN 1991-1-2 DK NA	BR 2010 5.3 Eks 3.3
Rating of load-bearing Construction- top floor and roof	R 60 A2-s1,d0		
Rating of load-bearing Construction- stairs	R 30 A2-s1,d0		
Height or stories	Maximum 22 m with one stairwell + window		BR 2010 5.2 (8)
Combustible materials in construction allowed?	Yes, lower than D-s2,d2 allowed if placed in wall rated EI 30 from each side, or above a EI 30 rated floor OR verticals covered in K10 B-s1,d0 on each side. Fire Stop next to slab, openings, soffit		BR 2010 5.3 (1) Eks 3.2
Rating of Fire Barrier -compartment	EI 60		BR 2010 5.5.3 Eks 5.2.5
Rating of Fire Barrier -interior stair	Elevator shaft A2-s,d0 EI 30 C elevator - basement		BR 2010 5.5.3 Eks 5.2.7
Rating of Fire Barrier -exterior stair	-		BR 2010 5.5.3 Eks 3.2
Interior Doors in Fire Barrier	EI 60		BR 2010 5.5.3 Eks 5.2.7
Interior openings in Fire Barrier	EI 60		BR 2010 5.5.3 Eks 3.2
Exterior openings			BR 2010 5.5.2(1) Eks 3.2
Fire wall	REI 60		BR 2010 5.5.2(1) Eks 5.2.9
Distance to another building	5 m to border OR 2.5 m for exterior walls in		BR 2010 5.5.3

	K10 B-s1,d0 OR less than 2.5 m then REI 120 a2-s1,d0 OR if roof less than Broof then 10 m to border		Eks 5.3.1
Interior surface (ytskikt)	K 10-s2,d2 in general in stair K 10 B-s1,d0 on floor and ceiling and D-s1 on floor		BR 2010 5.5.2(1) Eks 5.1.1
Roofing Material	Broof		BR 2010 5.5.2(1) Eks 3.2
Exterior walls	No less than B-s1,d0 above 5.1 above ground		c.2(1) Eks 5.2.1
Fire Spread to attic	insulation lower than D-s2,d2 then cover of min 300mm with K10 <d-s2,d2		Eks fig 3.7
Distance between windows/openings	no		
Installation Fire Alarm	Smoke Alarm		BR 2010 5.4 (13)
Installation emergency lightlng	no		
Installation ventilation protection	of staircase for Fire Department, manual act, material min E-d2 min 0.4 m^2	DS EN 12101 B 300	BR 2010 5.6.2 EKS 4.1.5
Installation- Sprinkler	no		
usage cat	4		BR 2010 5.1.1
egress req	1 stair 1 window per unit 25 m to exit		

Germany

Area	requirements	Referenced standard (EN 13501…)	Reference section
Rating of load-bearing Construction	R 60		BauO 27§ BauRL Annex 0.1.2
Rating of load-bearing Construction and partition	REI 60		BauO 27§ BauRL Annex 0.1.2
Height or stories	7-13 m class 4 Highly Fire Resistant, ‘hochenfeuerhemmend’		BauO 2§2.4

Combustible materials in construction allowed?	Yes, if protected to F 30		BauO 26§ BauRL Annex 0.1 + 0.11
Rating of Fire Barrier -compartment	EI 60 for non-load-bearing interior walls		BauO 29§ BauRL Annex 0.1.2
Rating of Fire Barrier -interior stair	same		
Rating of Fire Barrier -exterios stair	same		
Interior Doors in Fire Barrier	EI_2-60-S_aC		BauO 29§
Interior openings in Fire Barrier	EI 60		BauO 29§
Exterior openings	EI 60 or 5 m		BauO 30§
Fire wall	REI 90-M		BauO 30§1 BauRL Annex 0.1.2
Distance to another building	5 m to building or 2.5 metre to property line		BauO 30§2.1
Interior surface (ytskikt)	Ceiling A2	DIN 4102	BauO 31§ BauRL Annex 0.1.2
	Stairwell non-combustible (A, A1, A2)	DIN 4102	BauO 34§4.1 BauRL Annex 0.2.1
Roofing Material	Broof		BauO 32§ BauRL Annex 0.1.3
Exterior walls	Non-combustible or separating elements Ventilated facade with separating elements		BauO 28§ BauO 28§4
Fire Spread to attic	EI 60		BauO 32§5
Distance between windows/openings	-		
Installation Fire Alarm	-		
Installation emergency lightlng	-		
Installation ventilation protection	EI 60		BauRL Annex 0.1.2
Installation- Sprinkler	-		

Spain

Area	requirements	Referenced standard (EN 13501…)	Reference section
Rating of load-bearing Construction	Main structural elements: R 60 for beams. Slabs and supports		SI 6
Rating of load-bearing Construction	Protected stairway, R 30		SI 6
Rating of load-bearing Construction			
Height or stories	Height, max 15 m for structural/max 14 m for unprotected evacuation stairs/max 15 m evacuation height for Facade Barrier		SI 6/SI 3/SI 2
Combustible materials in construction allowed?	Yes, wood is allowed under correct circumstances.		Schedule E SI
Rating of Fire Barrier -compartment	EI 60 (max 2500 m^2 for section)		SI 1
Rating of Fire Barrier -interior stair	Same as barrier, EI 60		SI 1
Rating of Fire Barrier -exterios stair	Same distance as for windows.		SI 6
Interior Doors in Fire Barrier	Same as barrier EI 60.		SI 1
Interior openings in Fire Barrier	Max 50 cm^2 and at least 3 m apart (no Fire Seals needed). All self-closing system must be C5.		SI 1
Exterior openings			
Fire Wall			
Distance to another building	Windows: Parallel – 3 m (otherwise EI 60 on both windows) Angle 45-2.75 m(otherwise EI 60 on both windows)		SI 2
Interior surface (ytskikt)	Corridors and protected stairs B-s1, d0 Cfl-s1		SI 1

Roofing Material	EI 60 according to table. Openings in Broof t1		SI 2 , Chapter 2
Exterior walls	EI 60 for max 15 m evacuation height.		SI 2
Fire Spread to attic	If roof separated from upper floor REI 60 then no barrier on attic as long as not activity or use for evacuation.		SI 1
Distance between windows/openings	60 degrees-2.5 m 90degrees-2 m 135degrees-1.25m 180 degrees-0.5 m Vertical separation of at least E 30 can be put between areas that doesn't meet demands.		SI 2
Installation Fire Alarm			
Installation emergency lightlng	N/A for residential. Others should read "OUT", distance not exceed 50 m. Doors from evacuation routes not used for evacuation should have a sign "no exit".		SI 3
Installation ventilation protection	Same as barrier.		SI 1
Installation- Sprinkler	Gives +25% evacuation distance.		SI 3
Evacuation routes	Max 50 people if only one escape route. If accending more than 2 m in route there must be two stairs.		SI 3

Sweden

Area	requirements	Referenced standard (EN 13501…)	Reference section
Rating of load-bearing Construction	Fire Safety Class 4 (max 4 stories) R 60		BBR 19 5:0 EKS, section C, Chapter1,1.2 boverkets mandatory provisions 2011:10, table C-3,

			C-7
Rating of load-bearing Construction-stairs balconies	Fire Safety Class 3 R 30		BBR 19 5:
Rating of load-bearing Construction-eaves	Fire Safety Class 1 R 0		BBR 19 5:
Height or stories	4 stories		BBR 19 5:
Combustible materials in construction allowed?	yes, material lower than D-s2,d0 protected by K 10-B-s1		BBR 19 5:521
Rating of Fire Barrier -compartment	EI 60		BBR 19 5:531, table 5:531
Rating of Fire Barrier -interior stair			BBR 19 5:
Rating of Fire Barrier -exterios stair			BBR 19 5:
Interior Doors in Fire Barrier	EI 30-S_m to stair, EI 60-C elsewhere		BBR 19 5:534
Interior openings in Fire Barrier	EI 60		BBR 19 5:
Exterior openings	-		BBR 19 5:
Fire Wall	REI 90-M		BBR 19 5:562
Distance to another building	4 m to boundaries, or 8 m to building		BBR 19 5:61
Interior surface (ytskikt)	ceiling b-s1,d0 on A2-s1,d0 wall C-s2,d0 escape route b-s1,d0 on A2-s1,d0, floor C-s1		BBR 19 5:521, 522, 524
Roofing Material	B roof on A2-s1,d0 or Broof on combustible material if more than 8 m to closest building		BBR 19 5:62
Exterior walls	A2-s1,d0 or as low as D-s2,d2 with Fire Stoppers passing a Fire Barrier or only used on ground floor	SP Fire 105 + SS-EN 13501-2	BBR 19 5:551
Fire Spread to attic	eaves rated in EI 60		BBR 19 5:535
Distance between windows/openings	1.2 m or E30		BBR 19 5:553
Installation Fire Alarm	Smoke Alarm		BBR 19 5:353
Installation emergency lighting	separate groups in stair		BBR 19 5:342
Installation ventilation protection	Fire Damper EI 60, Smoke Detector		BBR 19

			5:533
Smoke Vent	1 m^2 manually operated or windows on each floor		5:732
Installation- Sprinkler	no		BBR 19 5:
occupancy class	3 dwellings		BBR 19 5:213
building class	Br 1, more than 2 stories, less than 16 stories		5:216
Egress	egress stair and window 45 m		BBR 19 5:323, 32 5:331

United Kingdom

Area	requirements	Referenced standard (EN 13501…)	Reference section
Rating of load-bearing Construction Beam and column	R 60		Vol1 Section B3 Chapter 4.2 Annex A
Rating of load-bearing Construction Floor	REI 60		Vol1 Section B3 Chapter 4.2 Annex A
Rating of load-bearing Construction Roof	REI 30		Vol1 Section B3 Chapter 4.2 Annex A
Height or stories	Max 18 m		Vol1 Chapter 0.1
Combustible materials in construction allowed?	Yes, timber framing in accordance with report BRE 454		Vol1 Section B3 Chapter 4.2 Annex A
Rating of Fire Barrier -compartment	REI 60		Vol1 Section B2 Chapter 5.6 Annex A
Rating of Fire Barrier -interior stair	REI 30		Vol1 Section B2 Chapter 5.6 Annex A
Rating of Fire Barrier -exterior stair	RE 30		Vol1 Section B2 Chapter 6 Annex A
Interior Doors in Fire	FD 30 or E 30-Sa	BS 476-22 or	Vol1

Barrier		BS-EN 13501-2	Section B2 Chapter 6 Annex B
Interior openings in Fire Barrier	EI 60 or Limited area		Vol 1 Diagram 20
Exterior openings	EI 60 or Limited area		Vol 1 Diagram 20
Fire Wall	No special provisions, same as Fire Barrier		Vol1 Section B2 Chapter 6
Distance to another building	12.5 metres with no restrictions of openings 40% openings = 5 m 20% = 2.5 m		Vol2 Section B4
Interior surface (ytskikt)	C-s3,d2		Vol1 Section B2 Chapter 3.1
Roofing Material	AA or Broof		Vol1 Section B4 Chapter 10
Exterior walls	REI 15 or RE 60 from inside to outside		Vol1 Section B4 Chapter 8 table A1
Fire Spread to attic	-		
Distance between windows/openings	1500 mm		Diagram 20
Installation Fire Alarm	Grade A category LD2, partly covered Smoke Detectors	BS 5839-6:2004	Vol1 Section B1 Chapter 1.7
Installation emergency lightlng	-		
Installation ventilation protection	Fire Damper w fusible links ok in general, Smoke and Fire Damper to stairwells etc		Vol2 Section B3 Chapter 10.9
Installation- Sprinkler	Yes, unless two separate stairs		Vol1 Section B1 Chapter 2.5
Means of escape	Over 7.5 m high building requires two means of escape, windows are not permitted, or sprinkler installation		Vol1 Section B1 Chapter 2.5

Appendix B - Radiation calculations

Size of flames

The purpose is to find the radiating area of the flames. It's the surface area parallel to a neighbouring building. The method used is described in EN 1991-1-2(Eurocode 1).There are two types of flames relevant for these calculations; flame from window and flame from door. A flame is divided in to the vertical and horizontal lengths, L_L and L_H, see image 1. The width of the flame is same as the width of the window.

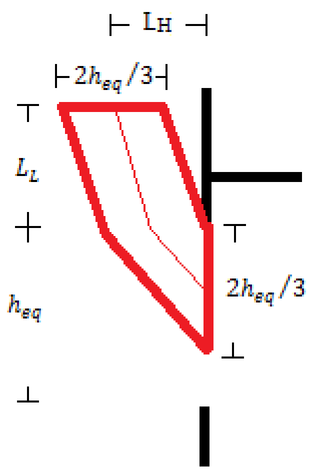

Figure 1 Flame through window

The vertical length of the Door Flame, L_L, is given by the following statement:

$$L_L = 1.9\left(\frac{\dot{Q}}{w}\right)^{2/3} - h\ [m]$$

$\dot{Q}$	Effect of fire [MW]	
w	Width of door [m]	1
h	Height of door [m]	2

The effect of the fire is given by the following statement:

$$\dot{Q} = \frac{A_f \cdot q_{f,d}}{\tau_f}\ [MW]$$

A_f	Floor area of Fire Room [m^2]	57
$q_{f,d}$	Fire Load $[MJ/m^2]$	800
τ_f	Time of fire [s]	3600

$$\dot{Q} = \frac{A_f \cdot q_{f,d}}{\tau_f} = \frac{57 \cdot 800}{3600} = 12.6\ MW \rightarrow$$

$$L_L = 1.9\left(\frac{12.6}{1}\right)^{2/3} - 2 \approx 8.2\ m$$

Window Flame

The vertical lenght of the Window Flame, L_L , is given by the following statement:

$$L_L = \frac{h_{eq}}{3}\ [m]$$

h_{eq}	Height of window [m]	1

$$L_L = \frac{1}{3} = 0.33\ m$$

Horizontal flame length

The total horizontal distance of the flame from the wall is given by the following statement (EN -1991-1-2, Figure B.2):

$$L_H + \frac{(2h_{eq}/3)}{2}\ [m]$$

Where L_H is the distance from the wall to the centre of the flame and $2h_{eq}/3$ is the total depth of the flame.

$$L_H = 0.454h_{eq}(h_{eq}/2w_t)^{0.54}\ [m]$$

Both Door Flame and Window Flame are assumed to have the same distance from the wall.

h_{eq}	Height of the opening [m]	2
w_t	Width of the opening [m]	1

$$L_H = 0.454 \cdot 2 \cdot (2/2 \cdot 1)^{0.54} = 0.808\ m$$

The end distance of the flame:

$$L_H + \frac{(2h_{eq}/3)}{2} = 0.808 + \frac{(2 \cdot 2/3)}{2} \approx 1.5\ m$$

	Flame Height above opening	Flame Height in the opening	Total Flame Area
Door	$0.9\ m$	$0.66 \cdot 2 = 1.32\ m$	$1.32 \cdot 1 + 0.9 = 2.1\ m^2$
Window	$0.33\ m$	$0.66 \cdot 1 = 0.66\ m$	$2(0.66 \cdot 1.4 + 0.33) = 2.5\ m^2$

Radiation

The radiation from a surface to a point is described as

$$E \cdot \Phi \ [W/m^2]$$

E	Emitted radiation $[W/m^2]$
Φ	Configuration factor $[-]$

$$E = \varepsilon \cdot \sigma \cdot T^4 [W/m^2]$$

E	Emitted radiation $[W/m^2]$	
ε	Emissivity of flames $[-]$	1
σ	Stephan Boltzmann constant $[W/m^2\,K^4]$	$5.67 \cdot 10^{-8}$
T	Temperature $[K]$	1115[5]

$$E = \varepsilon \cdot \sigma \cdot T^4 = 1 \cdot 5.67 \cdot 10^{-8} \cdot 1115^4 \approx 87\ kW/m^2$$

The configuration factor is a dimensionless factor which depends on the geometry of the radiating surface (see figure 2). The value is tabulated for different cases (Drysdale 1998) and will not be presented in this appendix. The radiating surfaces are windows, eaves and facade is based on the geometry of the compartment in the building used for the Case Study (see figure 3 and table x)

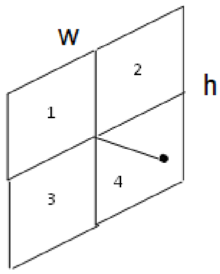

Figure 2 Radiating surface

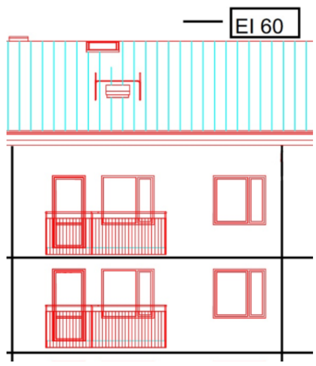

Figure 3 Compartment

[5] Temperature after 30 minutes of fire according ISO 834.

	Geometry
Windows	$w \cdot h = 3.8\ m\ \cdot 1.21\ m = 4.6\ m^2$ (equivalent area)
Eaves	$w \cdot h = 10\ m\ \cdot 1\ m = 10\ m^2$
Facade	$w \cdot h = 3\ m\ \cdot 10\ m = 30 - 4.6 = 25.4\ m^2$

Table 1 Geometry

The distances used in calculations are based on the requirements for each country. For the Window Flame 1.5 m is subtracted as the flame is closer to the neighbouring building. The results of the calculations for event-tree 2 is presented in table 1.

Case	$A_{Windows}$	A_{Eave}	A_{Facade}	Distance	A_{E+F}	$E_{Windows}$	E_{Eave}	E_{Facade}	E_{Total}
1	4.6	10	25.4	8	35.4	2.8	3.37	7.99	14.16
2	4.6	10	25.4	5	35.4	8.77	6.84	16.01	31.62
3	4.6	10	25.4	3	35.4	30.96	12.95	29.15	73.06
4	4.6	10	25.4	2	35.4	68.9	19.92	42.15	130.97
5	4.6	10	0	8	10	2.8	3.37	0	6.17
6	4.6	10	0	5	10	8.77	6.84	0	15.61
7	4.6	10	0	3	10	30.96	12.95	0	43.91
8	4.6	10	0	2	10	68.9	19.92	0	88.82
9	4.6	0	25.4	8	25.4	2.8	0	7.99	10.79
10	4.6	0	25.4	5	25.4	8.77	0	16.01	24.78
11	4.6	0	25.4	3	25.4	30.96	0	29.15	60.11
12	4.6	0	25.4	2	25.4	68.9	0	42.15	111.05
13	4.6	0	0	8	0	2.8	0	0	2.8
14	4.6	0	0	5	0	8.77	0	0	8.77
15	4.6	0	0	3	0	30.96	0	0	30.96
16	4.6	0	0	2	0	68.9	0	0	68.9

Table 2 Results for radiation calculation

Appendix C – CPR emails

The following request was sent to each of the countries listed CPR contact:

To concerned party,

I am inquiring for Building codes regarding Fire Safety. I am a fire protection engineer in Sweden and we are writing a thesis on the CPR relating to fire safety for the University of Lund. We are performing a comparative study with 10 different countries within the EU. We would like to include your building code in this. If there is a version available we would like a pdf of the code, or if we could be referred to a contact that may have it. We would also be interested in guidelines, an English version of the code would also be preferable.

If we could be assisted with this we would be very grateful.

Best regards,
Johan Bergström

CPR contacts:

Country	E-mail
Czech Republic	cpr@mpo.cy
Denmark	cpr@ds.dk
France	pcp.france@finances.gouv.fr
Germany	produktinfostelle@bam.de
Italy	pcp.italia@mise.gov.it
Netherlands	https://www.contactpuntbouwproducten.nl/Contactpuntbouwproducten_VraagStellen_noIE.rbm?FAQ=Zelf_een_vraag_stellen&noIE=true (not working)
Poland	Punkt-kontaktowy@gunb.gov.pl
Spain	pcontactpoint@comercio.minerco.se
Sweden	contactpoint-cpr@boverket.se
United Kingdom	enquiries.br@communities.gsi.gov.uk

The following replies were received:

Sweden, 28th of April, 2015

The English version of the Swedish Building Codes are found here: http://www.boverket.se/en/start-in-english/building-regulations/national-regulations/ (safety in case of fire is found in BBR section 5)

The connection to CPR: DoP and CE-marking applies to all construction products that are covered by a harmonised EN-standard, or for which an ETA has been given. Depending on the intended use of the product, its performance regarding reaction to fire may or may not have to be declared in the DoP. (The ENs for example often specify different conditions whether the product is intended for use in escape routes or not.)

Vänliga hälsningar

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www.boverket.se

Italy, 14th of April, 2014

Per quanto riguarda gli aspetti strutturali, al solito, si applicano le norme tecniche per le costruzioni (DM 14.01.08) e la relativa circolare esplicativa (Circ. Min. Infrastrutture e Trasporti 02.02.2009 n.617/C.S.LL.PP).

Tali documenti sono integralmente scaricabili dal sito internet del Consiglio Superiore dei Lavori Pubblici www.cslp.it, ai seguenti link:

http://www.cslp.it/cslp/index.php?option=com_content&task=view&id=66&Itemid=20

http://www.cslp.it/cslp/index.php?option=com_content&task=view&id=79&Itemid=20.

Traduzioni ufficiali in inglese non ce ne sono.

Forse potrebbe cercare nel database TRIS (il DM 14.01.08 è stato notificato), ma non si tratterebbe comunque di una traduzione ufficiale.

Dott. Ing. Emanuele Renzi, PhD
Ingegnere Civile
Dottore di Ricerca in Ingegneria delle Strutture

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Spain, 22nd of April, 2014

Gracias por contactar con nosotros. Si lo que desea es estar informado de las novedades relacionadas con esta web y de otras actividades de la Unidad de calidad en la construcción del Instituto de Ciencias de la Construcción Eduardo Torroja. CSIC, le rogamos se suscriba a nuestra lista de distribución pulsando el siguiente enlace y siguiendo las indicaciones:

https://listas.csic.es/ietcc/wws/subscribe/actividades_construccion

Se trata de una web oficial del Consejo Superior de Investigaciones Científicas del Ministerio de Ciencia e Innovación, y podrá darse de baja en cualquier momento.

En este buzón no se tramitan las consultas relacionadas con dudas sobre el CTE.
Si lo que desea es hacer alguna consulta genérica sobre el CTE, por favor hágalo a través del "Buzón del ciudadano" en www.vivienda.es

Czech Republic, 15th of April, 2015

1st Reply

Good morning,
In responds to your requirement we inform you that legislative provisions concerning construction works are the responsibility of Ministry for Regional Development in the Czech Republic.
The requirements for construction works are laid down by the Act No.183/2006 Coll. on Planning and Construction Code (Building Act) and implementing decrees, particularly by Decree No. 268/2009 Coll. on technical requirements for construction works and Decree No. 398/2009 Coll. on general technical requirements ensuring barrier-free use of construction works.
These legislative provisions can be found, unfortunately only in Czech, at http://www.mmr.cz/cs/Ministerstvo/Ministerstvo/Legislativa-v-priprave/Platne-pravni-predpisy/Oblast-uzemniho-planovani-a-stavebniho-radu.
Please note that it is necessary in connection with the fire protection to take into account the Law No. 133/1985 Sb. on fire protection, as amended and the implementing Decree No. 23/2008 Coll. on technical conditions for fire protection of construction works and Decree No. 268/2009 Coll. laying down conditions for fire safety and state fire supervision.
The fire protection is the responsibility of Ministry of the Interior of the Czech Republic. Legislative provisions can be found in Czech only at http://aplikace.mvcr.cz/sbirka-zakonu/start.aspx . You can search them when you fill the number /date of the prescription in the paragraph 1.
If you need further information don´t hesitate to contact us.

Best regards

Eva Stejfova
Product Contact Point for Construction

Ing. Eva Stejfova
Department of construction and construction materials
T +420 224 852 503
stejfova@mpo.cz
Na Frantisku 32, 110 15 Praha 1
www.mpo.cz

Follow up question

Thank you very much for your reply, I managed to find the laws concerning fire safety. Microsoft translation is a bit incoherent, but we will try to work out the structure at least. Language barriers are making this quite difficult! Are you aware if there are any design manuals that interpret the use of these laws, or handbooks etc? Or are there any persons to contact regarding fire safety in the Ministry of the Interior?

Here in Sweden we use a structure of law (overall aim, fex people shall be safe in case of fire)-regulations (more detailed aim, people shall be able to exit safely) –advice (technical descriptions of solutions to the regulations, fex maximum walking distance to exit 30 metre).

Where would I find the detailed requirements for exit distances, 60 minutes rated fire barrier etc? Are they in these laws you gave me or somewhere else?

I hope I am not taking up too much of your time, and I hope spring has come to Praha as it has here.

Best regards

Louise

2nd reply

Good morning,

The legislative system in the Czech Republic is similar as in Sweden. The Acts lay down the general requirements that are specified in the implementing decrees and governmental regulations. The specific requirements for the characteristics and properties are mostly specified through links to relevant mandatory Czech technical standards (CSN) or other types of documents. Individual authorities have the authority to issue requirements for different type of construction works according to their competences. The fire safety of buildings lies within the authority of the Ministry of the Interior.
In practice this means that the Act No.183/2006 Coll. on Planning and Construction Code (Building Act) in § 156 lays out basic requirements for construction works, including the requirement for the fire safety. Requirements are specified in the Decree No. 268/2009 Coll. on technical requirements for buildings which refers on the Decree No. 23/2008 Coll. on the technical requirements for the fire protection of buildings amended by the Decree No. 268/2011 Coll.
The Decree No. 23/2008 Coll. specifies the technical conditions for the design, implementation and use of buildings and contains an attached file of mandatory CSN.
We attach the English version of the Decree No. 23/2008 Coll. Please note however that the Decree No. 268 /2011 is not incorporated in this text. We believe nevertheless could be useful.

For more information about legislative acts we recommend to contact the Ministry of the Interior - ***General Directorate of Fire Rescue Service of the Czech Republic, Ing. Blanka*** *Mencelova-Spundova, E-mail: blanka.mencelova@grh.izscr.cz .*

For more information about Czech fire protection technical standards we recommend to contact The center of technical standardization for fire protection PAVUS, a.s., E-mail: ctn@pavus.cz.

For your information please note that the Czech technical standards CSN are available for reading on the basis of registration and registration fee of 1000, - CZK for 12 months. All information can be found on the website of the Czech Office for Standards, Metrology and Testing (ÚNMZ) – see the http://www.unmz.cz/urad/csn-on-line (only in Czech language).

Best regards

Eva Stejfova

Product Contact Point for Construction

Ing. Eva Stejfova
Department of construction and construction materials

T +420 224 852 503
stejfova@mpo.cz

Na Frantisku 32, 110 15 Praha 1
www.mpo.cz

Poland, 29th of April, 2014

I am kindly sending an answer for your e-mails dated on 7th of April 2014 enclosed.

Team on Contact Point

Attached: 022_97_14.pdf

Pdf contains following information:

THE GENERAL OFFICE
OF BUILDING CONTROL
Construction Products Department

PRODUCT CONTACT POINT
for construction

Warsaw, 2014.04. 2

DWB/INN/022/5/14- 154
(DWB/INN/022/97/14)

Mrs
Louise Ericsäter
B Sc fire protection

louise.ericsater@fsd.se

In response to your e-mail dated on the 7th of April 2014, constituting a favour to deliver an English version of Polish *Building Law Act of 7 July 1994 – Dz. U.* (i.e. *Journal of Laws) of 2013, item 1409, as amended*, I kindly inform you that unfortunately we do not posses such a translation.

Simultaneously it should be noted that in Poland provisions mentioned in article 6 (3)e of Regulation No 305/2011 are above all those, which have been issued on the basis of art. 7 (2)1 or art. 7 (2)2 of aforesaid *Building Law Act*. See especially – issued on the basis of art. 7 (2)1 of *Building Law Act* – regulation of the *Minister of Infrastructure of 12 April 2002 on technical requirements, which shall fulfill buildings and their location (Dz. U. No 75, item 690, as amended)* where have been indirectly established requirements regarding to some kind of construction products in relation to fire protection. Into account should be taken especially provisions of Section VI *Fire safety* of this regulation.

What is more, requirements for some construction products were also established in – issued on the basis of art. 7 (14) of *Act of 24 August 1991 on the fire protection (Dz. U. of 2009, No 178, item 1380, as amended)* – regulation of the Minister of Interior and Administration of 20 June 2007 *on the list of products used for ensuring public safety or protecting health, life and property, and the principles of issuing admittance to use these products (Dz. U. No 143, item 1002, as amended)*, which concerns the possibility of using in Poland listed in this regulation products for which admittance for use have been issued in advance by Centrum Naukowo-Badawcze Ochrony Przeciwpożarowej im. Józefa Tuliszkowskiego – Państwowy Instytut Badawczy (CNBOP-PIB). Information on this subject and contact details of this body are available in English on the website: http://www.cnbop.pl/en

Additionally you may be interested in – issued on the basis of aforesaid *Act on the fire protection* – regulations of the Minister of Interior and Administration of:
- 7 June 2010 *on fire protection of buildings, other facilities and areas (Dz. U. No 109, item 719)* and
- 16 June 2003 *on agreement of construction design for fire protection (Dz. U. No 121, item 1137, as amended).*

Aforesaid legal acts are available – in Polish – on the website: http://isap.sejm.gov.pl/. For English version of these legal acts you should contact the relevant Ministries, which may have them, i.e. the Ministry of Infrastructure and Development and the Ministry of the Interior.

At the same time, I inform you that this letter does not constitute an official legal interpretation and it does not bind administrative authorities ruling in individual cases.

Director
of Construction Products Department

Elżbieta Janiszewska – Kuropatwa

Appendix D – Case Study 1 – Literature search

Czech Republic

Internet search
Primary search returned a link to the relevant ministry (www.uur.cz) on search page 5. Only the start page of the site was translated into English which meant it was not possible to navigate the website in English. The document could not be found or downloaded from the website.

No information was given regarding the actuality of the document.

On search page 7 a link to a document[6] referring to the "Decree No. 137/1998 Coll. of the Ministry for Regional Development of the Czech Republic about general Technical Requirements for construction." Using this string as a key word in an extended search provided a translation of the Building Act together with Decree No.137/1998. The ministry website alone was not enough to find the relevant regulation neither was it possible to find the document using the ministry's internal search function.

Contact via CPR
An email written in English to the official CPR was replied in English within seven business days, containing detailed information on the structure of legislative documents concerning construction in general all the way down to Fire Safety, see Appendix C. References to relevant acts and decrees were listed along with information where to require these documents. A translated version of Decree No. 23/2008 Coll. on the Technical Requirements for the fire protection of buildings (Republic u.d.) was received.

Status of document
Decree No. 23/2008 Coll. on the Technical Requirements for the Fire Protection of buildings were acquired in English via CPR contact. This Decree alone is not enough to perform a Fire Safety Design for a building as it refers to Czech technical standards (CSN). These standards are not available for free but have to be purchased from the www.unmz.cz webpage.

---

[6] Document was found on http://www.teicrete.gr/lei/PUB%2B/policies/Czech%20Republic.pdf

Denmark

Internet search

The relevant Building Regulations, BR 10 dated December 2010, adopted by the Danish Ministry of Economic and Business Affairs and the Danish Enterprise and Construction Authority were found as the second result of the primary search.

In the introduction to the Building Regulations 2010 (BR10) there is a very informative section on how to read the regulations. "The [BR 10] is divided into two columns. The column on the left (this column) contains the legal requirements, i.e. the legally binding regulations, and the column on the right contains guideline sketches and comments on the legal requirements."

In the mandatory provision section 5 there are general requirements for Fire Safety in the right column. In the side note in the introduction to this Chapter a set of general recommendations are referenced.

"For Fire Safety measures in traditional buildings, including single-family houses, terraced houses and holiday homes as well as agricultural buildings, see the Danish Enterprise and Construction Authority's "Eksempelsamling om brandsikring af byggeri" [Collated examples of Fire Safety measures in buildings]; and for more nontraditional buildings see the Danish Enterprise and Construction Authority's "Information om brandteknisk dimensionering" [Information on Structural Fire Design].

The introduction page also give a full description with webpages to relevant authorities, the Danish Enterprise and Construction Authority, Bygningsreglementet, and the Danish Building Research Institute, SBi. Bygningsreglement governs the Building Regulations and SBi has drawn up SBi Guidelines 230, Guidelines on Building Regulations 2010, to be used as a guideline of the Building Regulations.

Both documents are referenced to the same webpage, www.bygningsreglementet.dk

The primary search criteria's does not provide a link to the relevant department, Bygningsreglementet, but to the Danish Energy Agency, of http://www.ens.dk/en. The reason for this is most likely that Bygningsreglementet does not have a translated version of the webpage and therefore is not found on the first 10 pages using an English search.

Extended search for Bygningsreglementet returns the correct webpage but there is no information in English. This webpage was very sparse, it does not contain any information on the structure or hierarchy of the Building Regulations, and for some reason it is not possible to download pdfs from this page, the Chapters are shown as a read only.

The English version of the BR 10, an English version of the Guidelines to BR 10 and a Danish version of the Collated examples are all found easily via a search for BR 10, but they are all found on byggecentrum.dk, the Danish building information centre founded by the Danish Ministry of Economy and Business Affairs. This page does not have information regarding the use of documents or the hierarchy of the system.

The documents are found and the information in them is enough to understand how to use them, but the department webpages lack in information.

Contact via CPR
E-mail contacts were not answered within 3 weeks.

Status of document
The documents were partly translated to English, the BR 10 Building Regulations and the guidelines were translated, but the collated examples were only found in Danish. The examples were translated to English to a moderate degree of accuracy, and the version of BR 10 was helpful in understanding the structure. It would not be advised to use this translation for Fire Safety Design but the interpretations of them are as correct as needed to be used in a Case Study.

The relevant document, BR 10, was found via the primary search and the guidelines and examples were found via the extended search.

France

Internet search
The primary and extended search yielded no links to relevant ministry. There were several commercial websites listing the names of the two main regulations; Documents Techniques Unifiés (DTU) and Norme Francaise (NF). Changing key words searching for these documents in did not give any result and downloadable versions of these documents were not found. It is possible the documents can be downloadable but not from this type of search.

Contact via CPR
E-mail contacts were not answered within 3 weeks.

Status of document
The relevant documents were not found via the Internet search criteria.

Germany

Internet search
There were several commercial websites listing the main regulation; BauGesetzBuch (BauGB). Changing key words searching for these documents in English did not give any result from the relevant ministry.

In the primary search several commercial websites were found, but also an official webpage, Germany Trade and Invest (GTAI), Germany's economic development agency. It promotes business and technology and could be regarded as guide to the country for foreign investors. On the site www.gtai.de the structure of the laws and regulations was explained.

German law for planning and building reflects the autonomy of the federal states, or Bundesländer. There is a federal law, Bauplanungsrecht, a zoning law with the overall provisions for use of buildings, and each federal state then has their own Building Regulations, Bauordnung (BauO). The pdfs are not found on this site.

The site for GTAI provides information regarding the correct ministry for construction, the Bundesministereum fur Umwelt, Naturschutz, Bau und Reaktorsicherheit, found on http://www.bmub.bund.de/. The codes were not found as a download on this page.

Via the commercial websites baurecht.de and bauordnungen.de the links to BauGB and the local BauO for the states of Berlin and Bayern was found. The links was to the official websites of Bayern and Berlin and it could be determined that these were the last amended copies.

The PRC Lead market initiative report for Germany was also found through searching for BauO. The lead market initiative concerns sustainability and the country reports intended to screen national Building Regulations. The PRC country report describes the functions of the added information regarding Germanys Liste der Technische Baubestimmungen list of 'acknowledged technical rules for works' and the DIN Standards. /PRC report Germany, http://ec.europa.eu/enterprise/sectors/construction/studies/national-building-regulations_en.htm /

The list is published by DIBt (Deutsches Institut für Bautechnik on their website, and is named Bauregelliste, BRL. https://www.dibt.de.

The method of top-down search was not successful since the Ministry BMUB did not provide information for further search. The GTAI provided some useful information, but focused on the Bauplaningsrecht and did not mention BauGB or the BRL.

In summary the BauO lists requirements for type of Building Classes based on height, use and occupancy, and list requirements for Fire Barriers, exit stairways etc. The requirements are given in the form of ´feuerhemmend (Fire Resistant), ´feuerbeständig (Non-Combustible)` which the Bauregelliste then interprets to the classifications F 30, R 30 and so forth for different Construction Element. The Bauregelliste (BRL) also references the relating standards for each Construction Element. As an example the

BauO lists a large one storey retail building as a class 4 building. The load-bearing walls and Fire Barriers are required to be ‘hochfeuerhemmend (Highly Fire Resistant) and the BRL requests R 60 and EI 60 for these structures, with doors classified in EI_2 60-S_aC, in accordance with DIN EN 13501.

Contact via CPR
E-mail contacts were not answered within 3 weeks..

Status of document
The documents were not translated to English.

The relevant documents were not found via the Internet search criteria but required extensive searches.

After translation of the documents via Google it was determined that the interpretation is fairly accurate and can be used for Case Study.

The results from the search are conclusive that the right Building Code was attained, the Building Codes are translated to English to a moderate degree of accuracy. It would not be advised to use this translation for Fire Safety Design but the interpretation of them are as correct as needed to be used in a Case Study.

Italy

Internet search
The relevant ministry or department was not referenced on the primary search. On the first 10 pages no there were no ministries, departments, institutes or similar in Italy. The search only rendered responses for country comparisons regarding other aspects of the Building Code, such as energy use. No useful information on name on an Italian Building Code for further search, or reference to the relevant ministry was found.

The relevant documents could not be found through an extended search. It appears that Italian webpages does not rank high on a search with English search-words. Of the first 10 result pages less than five results were from webpages ending with .it.

Translating the search word fire safety + regulation into Italian sicurezza antincendio normative[7] did return a large number of webpages that seemed relevant, but the language barrier made it difficult to proceed with the search. A Suisse Building Code written in Italian was found and some of the key Fire Protection Terminology from that code was used but did not produce any results for Italian Building Codes or relevant department or ministry.

Some information on the general organisation of legislation was found.

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[7] fire safety + regulation when Google translates into Italian yields sicurezza antincendio normative

The organization and implementation of Building Regulations in Italy can be described as dysfunctional since there seem to be little connection between the intent of the law-makers and the implementation of the regulations on local level. Studies on sustainability show that legislation adopted in 1991 has had little impact in the actual practice of the building enterprises. Buildings completed in the late nineties have only slightly better energy performance than those completed in the eighties. (Gianluca Ruggieri 2009)

The reason for this is according to Lead Market Initiative (The Lead Market Initiative (LMI) and sustainable construction: Screening of national building regulations 2011) to some extent the fact that Building Regulations are written and adopted on a very communal level. Italy is divided into 20 regions, each region is then divided into provinces and then further into municipalities 'Comuni'. Although the example in this case regarding energy performance was a law on national level, the necessary local decrees where either not written or enforced. There are initiatives as the ITACA-protocol to work towards an improved implementation of sustainable decrees. A report on the implementation on Fire Safety in buildings has not been found but it is probable that there are similar structures and problems in all parts of Building Regulations. For this report the regulations found on official webpages will be evaluated as national Building Code although it may not be adopted by the various Comuni.

It was concluded that a personal contact with someone in a Comuni planning department would most likely give the relevant documents but this was outside the scope of the thesis.

Contact via CPR
An email written in English to the official CPR was replied in Italian within 5 business days, containing a link to a page with technical norms.[8]

The documents on the referenced webpage was an extensive description of how to design load-bearing Structures in buildings and bridges. Very well structured useful but it did not provide any information on Fire Regulations. A follow-up email to the contact regarding norms regarding Fire Safety was not answered. Further search on the webpage did not produce any useful documents.

Status of document
No documents relating to Building Regulations on Fire Safety were found.

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[8] The webpage was:
http://www.cslp.it/cslp/index.php?option=com_content&task=view&id=66&Itemid=20

Netherlands

Internet search
The relevant ministry (VROM, Ministry of Environment and Spatial Planning) was found on the primary search. There is an official website (http://www.bouwbesluitonline.nl/) provided by a company called BRIS[9]. They provide online information about all regulations and decrees regarding building, Bouwbesluit 2012 [Building Code 2012]. This task was assigned BRIS by VROM. The webpage is very interactive and all information are gathered in one place, with links to all necessary information. Information can also be found on VROMs webpage, www.vrom.bouwbesluit.com. The Building Code Bouwbesluit has detailed requirements on how to design a building and using google translate on the webpage results in a comprehensible text. For information on how to fulfil the requirements references are made to standards, these standards are not available for free but have to be purchased from the website.

No information was given in English.

Contact via CPR
E-mail contacts were not answered within 3 weeks.

Status of document
The documents were not translated to English.

The relevant documents were found via the Internet search criteria and did not require previous knowledge or personal guidance.

The results from the search are conclusive that the right Building Code was attained, the Building Codes are correctly translated to English, and that the interpretation of them are correct. The Building Code cannot be used in a Case Study since the referenced standards are not available for free but have to be purchased from the website.

Poland

Internet search
The relevant ministry was not referenced on the primary search. The Internet search showed one possibly relevant page, www.paiz.gov.pl. A link to documents on this page showed a translated excerpt of the Building Law. The translation did not contain the name of the document, so it could not be further investigated. The webpage was administrated by a state institution with the purpose of helping investors into the Polish market. No further information regarding relevant ministry or Polish name for the Building act was found on the webpage.

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[9] www.bris.nl

Extended search on Wikipedia for the organization and webpages of Polish Ministries resulted in the Ministry for Infrastructure, http://www.mir.gov.pl. The English version of the website did not refer to any publications for downloading or information on Building Law. Using Google translate lead to a section on Building Regulations and a link to the latest amended Building Code. http://dziennikustaw.gov.pl/DU/2015/443/1. The Building Code however does not contain or reference to the relevant code for Fire Construction. The relevant documents could not be found through an extensive Internet search.

Contact via CPR

An e-mail written in English to the official CPR was replied in English within 16 business days, containing a detailed memorandum with references to several Building Codes that would concern Fire Safety Regulations, Appendix C. The return e-mail also supplied a webpage where these documents could be easily downloaded, http://isap.sejm.gov.pl

The referenced regulations were No 305 prawo Budowlane(Building Act) 2011, No 109 item 719, June 7th 2010, No 121 item 1137, June 16th 2003, No 75 item 690, April 12th 2002 and No 178 item 1380 Aug 24th 1991.

After translation using google the No 305 Prawo Budowlane contained information regarding Building Permits, inspections and general requirements. Article 5 states that Construction Work should fulfil the basic requirements regarding Fire Safety.

No 75 item 690, “Technical Requirements to be met by buildings and their location” from them Ministry of Infrastructure was found to have classifications and requirements regarding Fire Safety. Section VI, paragraph 203 through 290, contains information regarding classification of buildings depending on height, use and occupancy. The translation is inconclusive but from previous knowledge the structure is recognised as Fire Safety Construction Requirements. It is not possible to use the result from Google Translate in order to perform a Fire Safety Design since too many vital words are not translated.

Example of translated item 690, paragraph 216:

“1) Je.eli bulkhead is cz'Ęcirˊ g.ównej supporting structure should spe.niaç tak.e load capacity up criteria fire (R) according to requirements the contained in col. 2 and 3 for each class po.arowej wear resistant building.

2) Class of fire concerns wear resistant belt with po.rˊczeniem mi'dzykondygnacyjnego the ceiling.

3) The requirements do not dotyczrˊ naĘwietli roof skylights, dormers and windows po.aciowych (with zastrze.eniem § 218), if the holes in the roof .aci zajmujrˊ not more than. 20% of its surface.

4) For the chambers of walls chute requirement that EI 60 and the chamber door chute - EI 30“

No 109 item 719, June 7th 2010, A Regulation of the Minister of interior and administration, “On fire protection of buildings, other buildings and grounds” was found to have regulations on fire hazards, for example how to store flammable liquids and how to keep egress routes free of debris. This regulation does not concern rating of Construction Products.

No 121 item 1137, A Regulation of the Minister of interior and administration, “On the reconciliation of the Construction Project in terms of fire protection”, was found to have regulations regarding the scope, procedure and principles of Construction Project in terms of fire protection. It listed the necessary part of design, such as classification of risk group, use and occupancy as seen in Item 690, and also described the requirements on experts and designers. This regulation does not address the specific rating or classification, but state that they have to be declared.

No 178 item 1380, was found to have regulations regarding the Prevention of fire and natural disaster, and fire and rescue operations.

Status of document

The relevant documents were found via the CPR email contact and did not require previous knowledge or personal guidance. The Internet search did not result in the relevant documents.

The documents found via the CPR contact were not translated to English.

The results are conclusive that the right Building Code was attained, but the Building Codes are not correctly translated to English just using Google Translate. The conclusion is they cannot be used in a Case Study.

Spain

Internet search
A relevan t website was found on the primary search. The top result lead to the website for El Código Técnico de la Edificación (CTE) [the Technical Building Code], www.codigotecnico.org. It is an official website which is sponsored by the Spanish government. CTE is a set of rules with the purpose of converting the Building act from normative into performance based. The site hosts approved documents and guidelines for construction of buildings. From the site it was possible to download the "Documento Básico SI Seguridad en caso de incendio" (basic document for Fire Safety) which is the set of documents that deal with Fire Safety.

Contact via CPR
An email written in English to the official CPR was replied in Spanish within 12 business days, containing a link to subscribe to news about Building Regulations. See Appendix C.

https://listas.csic.es/ietcc/wws/subscribe/actividades_construccion

A follow-up email with a question regarding the actual Building Code was not answered.

Status of document
The documents were not translated.

The information were available in English on the CTE-website. Search for the documents in English did not yield any result.

It was possible to find the relevant documents directly when searching. The translated versions of the documents were understandable and deemed fit to be a part of the Case Study.

Sweden

Internet search
The second and third hit in the primary search was to a page in English describing the structure of the Building Regulations, the hierarchy of the Swedish legislative system and a very helpful section on 'who does what', www.boverket.se. It seems that the agency have made a considerable amount of search engine optimization.

In Sweden the Parliament adopts the Planning and Building Act, which is then delegated to the government who adopts the Planning and Building Ordinance with more detailed regulations. The execution is then delegated to Boverket, which drafts provisions and recommendations, the Building Regulations. For some reason the English webpage has renamed the Act and Ordinance to the English abbreviation, and the original name of the legislation in Swedish is not explained which will make it more difficult in communication. The links for the Act and Ordinance and Regulations yield an older version, but it clearly states that these are outdated and also links the current ones but that have not yet been translated to English. The correct names in Swedish are then found, Plan- och Bygglagen, (PBL), Plan- och Byggförordningen, PBF and Boverkets Byggregler, BBR (Boverket´s Building Regulations). The information given is that the latest translated version is BBR 19, and the current version is BBR 22 amended to 2015. The BBR 22 is not accessible via the English page, a search will only yield BBR 19 and a broken link to later amendments. Returning to Google search and entering "BBR 22 + pdf" did return the correct document.

Contact via CPR
E-mail contacts were not answered within 3 weeks.

Status of document
The documents were partly translated to English, the older version BBR 19 was translated but not the latest version. The Building Code BBR 22 was translated to English to a moderate degree of accuracy, and the version BBR 19 was helpful in finding the correct section that concerns Fire Safety and to understand the hierarchy.

The relevant documents were found via an extended search since the BBR 22 could not be found on the original English version of the webpage.

United Kingdom

Internet search
The primary search showed three possibly relevant pages. At the government webpage http://www.planningportal.gov.uk/ there was a guide on how to receive planning permissions and a link to "Approved documents" where the document "Annex B Fire Safety" could be found. This contains interpretation of the Building Code and not the full Building Code. The second website, http://www.legislation.gov.uk/ , did not provide information on the structure of British regulation. The third try was via Wikipedia, where a comprehensive structure and links gave the information for an extended search, the relevant Building Codes were Building Regulation 2014 and that the interpretation was found in Approved document part B Fire Safety.

The information on the government webpage alone was not enough to find the relevant documents. After information was found on which documents to search for they were accessible on the government webpage and could be downloaded as a pdf-document in English.

Contact via CPR
E-mail contacts were not answered within 3 weeks.

Status of document
The documents were available in English.

The relevant documents were found via an extended Internet search criteria and did not require previous knowledge or personal guidance to find.

The results from the search are conclusive that the right Building Code was attained and that the interpretation of them are correct and can be used in a Case Study.