Using a Delphi Panel for Developing a Fire Risk Index Method for Multistorey Apartment Buildings

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Abstract:
This report contains a description of how Version 1.2 of the Risk Index method for assessing fire safety in multi-storey apartment buildings was developed. It specifically addresses how a Delphi panel of experts was used to help develop and fine-tune the index method. The report contains all communications to and from the Delphi panel and describes how answers were interpreted and how the current version of the method was gradually arrived at.

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Table of Contents

1. Overview and main references

This report describes the Delphi panel work within the project "Risk Assessment of Timber-frame Multi-storey Apartment Buildings Using a Risk Index method". The project is a part of the Nordic Wood project "Fire-safe Wood Frame Multi-storey Apartment Buildings".

The project has a **Project group**, with one member from each of the Nordic countries. There is also a **Delphi panel**, consisting of 5 experts from each Nordic country, in all 20 experts. The Project group formulates questionnaires, sends these to the Delphi panel and collects and summarises the results.

The main body of the report consists of the documents sent out to the Delphi panel. These document describe the background, goal, method and results arrived at in the project. Other reports describe the development of the structure of the index method (Larsson [1]), how an evaluation of the method was carried out (Hultquist and Karlsson [2]) and finally, a report of the index method containing helptexts to assist users in applying the method (Karlsson, [3]). All these documents, and some additional material, can be downloaded at http://www.brand.lth.se/frim-mab.

Six documents were sent to the Delphi panel:

D01: Introduction to the Delphi panel exercise. This document briefly introduces the Delphi panel exercise, discusses the organisation of the project, gives a general discussion on the structure of the index method and outlines the work to be done.

D02: Structure of the index method. This document introduces a preliminary structure of the index method prepared by the Project group and explains how this preliminary structure was arrived at. The Delphi group is asked to suggest changes and give comments to gradually allow the final structure to emerge.

D03: Structure of the full index method. This document gives a report on the results of the voting and comments on document D02 and introduces the resulting structure of the index method, called the Project group version of the index method.

D04: Assigning weights to Version 1.0 of the Index method. This document contains a report on the response of the Delphi panel to document D03 and the resulting index method, called Version 1.0. The letter further contains a description on how to assign weights to the Objectives, Strategies, Parameters and Sub-parameters of the index method.

D05: Round 2 - Assigning weights to Version 1.1 of the Index method. This document contains results from the first weighting exercise and discusses the consensus of the results. It also discusses what must be done in the second round of the weighting process. The document also contains the resulting index method, called Version 1.1.

D06: Results from Round 2 of the weighting exercise. This document briefly describes the results of the second round of the weighting exercise. The results were very similar to those from Round 1, with very slight changes in weights and an increase in consensus.

These documents are given in the Appendix to this report. Each document has page numbers referring to the document number; D01 has seven pages and therefore page numbers D01:1 to D01: 7, the other documents are marked accordingly.

The other main reports resulting from this project are:

[1] Larsson, D., "Developing the Structure of a Fire Risk Index Method for Multistorey Apartment Buildings", Report 5062, Department of Fire Safety Engineering, Lund University, Lund, 2000.

[2] Karlsson, B., Hultquist, H., "Evaluation of a Fire Risk Index Method for Multistorey Apartment Buildings", Report 3088, Department of Fire Safety Engineering, Lund University, Lund, 2000.

[3] Karlsson, B., "Fire Risk Index Method - Multistorey Apartment Buildings", Report I 0009025, Trätek, Stockholm, 2000.

2. General on results from the Delphi Process

The six documents given in Appendix A show how the structure of the index method gradually emerged and give results of the first round of the weighting process. The process went quite smoothly, the consensus was generally good and participation of the panel members was very good. The process did, however, take slightly longer time than was planned.

The Project group found that a part of the results from the first weighting exercise, Round 1, seemed somewhat "flat" and a second weighting exercise, Round 2, was therefore conducted. The Delphi panel was encouraged to assign weights in a different order than had been done in Round 1 (see instructions in Document D05).

The resulting weights from the two rounds were very similar, as is shown in Figure 1 below.

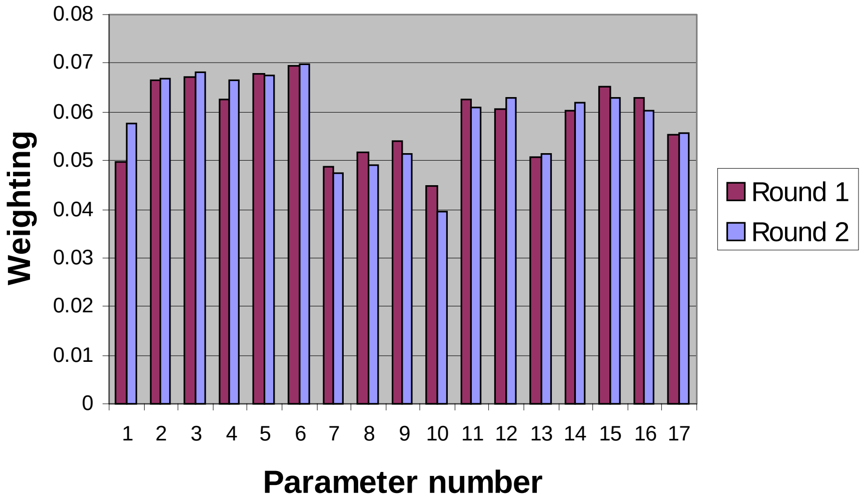

Figure 1. Results from the two rounds of the weighting exercise.

The only noticeable changes were that the overall weight for Lining materials (Parameter 1) increased slightly and the overall weight for Adjacent buildings (Parameter 10) decreased slightly.

When conducting Delphi panel work, it is important to consider consensus, which is some measure of the divergence of opinion. The Delphi panel may agree very strongly on some questions, which are then said to have good consensus. For other questions the distribution may be very flat, where the consensus is then said to be poor. Very many other situations may arise, the distribution of opinion may for example be bimodal, with two strong but opposite opinions.

In our case, two very different types of questions were put to the Delphi panel. On one hand, the panel was asked questions on the general structure of the method and would give answers in written format, not numerical format. It is not feasible to try to numerically determine consensus in this case, but in our case the Delphi panel was generally in agreement once the answers and suggestions for changes had been circulated a number of times.

On the other hand, the panel was asked to give weights and grades in numerical format. This opens up the possibility to measure consensus numerically. The measure of consensus is, however, not straight forward. Some workers have opted to express consensus in relatively complex mathematical form (Donegan, H.A., Dott, F.J., "An Analytical Approach to Consensus", Appl. Math. Lett., Vol. 4, No. 2, pp. 21-24, 1991). However, the measure of consensus will always be subjective since the choice of mathematical method and choice of limiting values will always be a subjective choice. In other words, it is not straight forward to define what "good" consensus and what "poor" consensus is.

Most often, consensus in Delphi panel work is assumed to have been achieved when a certain percentage of the votes fall within a prescribed range - for example, when the interquartile range is no larger than two units on a five-unit scale. In this work the first quartile, the median value and the third quartile were simply used as rough indicators of consensus. In general, consensus was assumed to have been reached if the interquartile range was no larger than two units on a five-unit scale. The average value was the accepted as the final grade.

The consensus in our case, after having performed two question rounds, must be seen to be fairly good. Out of the 99 numerical questions that were put to the panel, only 10% had a "unacceptable" consensus, where the interquartile range was ≥ 3 units. For more than half of these (6% of the total) the interquartile range was only slightly above 2 units, so the consensus in these answers were very close to being acceptable. No answers were "very bad", that is no answers had an interquartile range of > 4 units. One can therefore say that only around 4% of the answers had "poor" consensus.

In general, the consensus can therefore be said to be fairly good. The answers to the numerical questions are presented graphically in document D05, which is enclosed. The 1st quartile, median, 3rd quartile and average value are also presented in the graphs.

3. Version 1.2 of the Index Method and a Test Application

The current version (Version 1.2) of the index method is given in Appendix B. The document shows how the Parameters and Sub-parameters are assigned grades, depending on the fire safety measures provided in the building in question. On the last page the score is summarised resulting in a Safety Index. The highest given Safety Index is 5.0, and from there the Risk Index is calculated as: Risk Index = 5.0 - Safety Index.

Appendix C presents a preliminary test of Version 1.2 of the index method. A building project in Linköping, Sweden, named Orgelbänken, was chosen as a reference object. Two gradings were carried out; one using information of the building as it is now; and another assuming that the structural frame had been made of concrete.

The timber-frame building attained a risk index of 2.68 and the concrete-frame building got a risk index of 2.39. The risk index for the concrete building is therefore about 0.3 lower than for the timber-frame building. It is however possible to "compensate" for the lower timber-frame risk index in many different ways. An example would be to install a residential sprinkler system in the apartments and in the escape routes, which results in a decrease in the index for the timber-frame building to 2.35. Inspection of escape routes, information to occupants, installation of smoke control system are other examples of ways to increase the risk index.

A digital form of the method has also been developed. The digital form looks very similar to the document in Appendix B, but instead of writing in the numbers by pencil and doing all the multiplication and additions by hand, the user can simply start a digital Word97 document, and fill in the grades from the keyboard. The digital document then does all the mathematical manipulations automatically and calculates an index.

A far more detailed evaluation of the index method was also carried out, as reported by Hultquist and Karlsson [2].

4. General on results from the project

There are considerable difficulties in evaluating how well or how badly the obtained index method performs. Many of the fire risk attributes in a building are not measurable in a traditional quantitative sense, such as fire brigade capacity or general maintenance of the building. No specific design procedures are available for some of the fire problems that have been associated with timber-frame buildings, such as fire stops at joints and intersections. So even though the index method takes account of these important fire risk attributes, through grades arrived at by the Delphi panel, it is difficult to assess any degree of accuracy.

However, design methods and engineering models do exist for a number of the attributes that are taken into account in the index method, especially the attributes that have to do with occupant safety. Event trees and mathematical models can be combined to form a basis for a quantitative risk analysis (QRA) with respect to occupant safety in multistorey apartment buildings.

Therefore, to evaluate the index method, a quantitative risk analysis (QRA) based on an event tree was carried out on four multi-storey timber-frame buildings, recently constructed in four Nordic countries. Both the index method and the quantitative risk analysis were used to rank the buildings with respect to fire risk.

Two different risk indices were derived from the index method; one ordinary risk index where the original index method was used, and; a specially derived Occupant Escape risk index. The latter index was formed since it should compare better with the QRA, where the calculated risk only takes account of occupant safety.

The ordinary index method grades were given by a Delphi panel, where weights were given to Objectives such as "Life safety" and "Property protection" as well as different Strategies. The weights were then combined through matrix multiplication to form a single, final weight for each Parameter.

The Occupant Escape Risk Index (OE Risk Index for short) was formed by changing some of the Delphi panel weights to zero, such that the Property protection Objective was given a zero grade, as well as all Strategies that did not have to do with Occupant Escape. The matrix multiplication was performed and resulted in Parameter weights that only have to do with Occupant Escape.

Figure 2 shows the difference in the weights between the original Index Method and an index where Occupant Escape is only taken into account. The numbers show that even though some parameters may seem to be only associated with Property protection, the Delphi panel still feels that they are in some way linked to Occupant safety. For example, Parameter 9 (Attic) has a weight of 5.2% of the total fire safety while it gets a value of 3.2% with respect to Occupant safety. This reflects the intuition of the Delphi panel members with respect to the attics and the difference between different objectives and strategies.

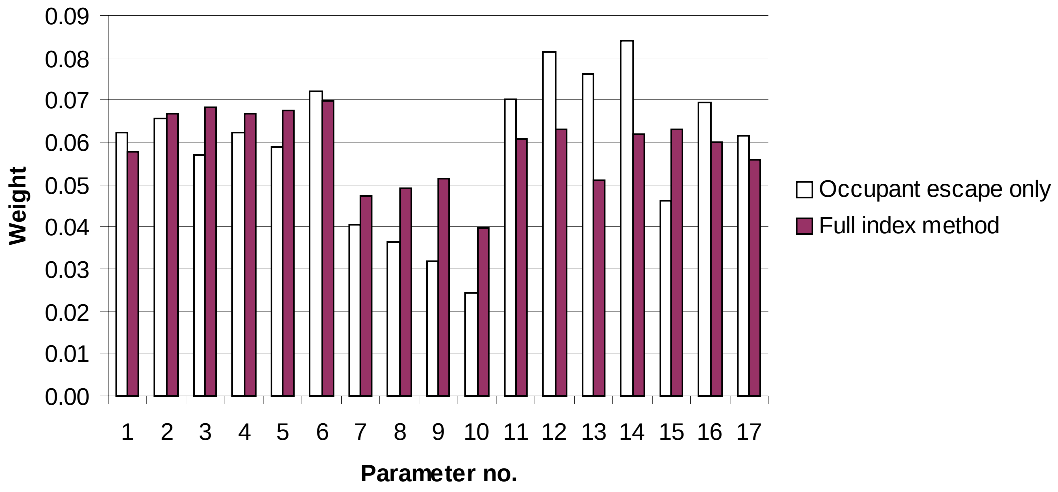

Figure 2 Parameter weights for Full Index Method and Index Method for Occupant escape only.

Four consultant engineers analysed four buildings in the Nordic countries, one in Sweden (Wälludden), one in Norway (Einmoen), one in Denmark (Casa Nova) and one in Finland (Viikki). They gave grades to all the parameters in the index method. Two risk indices could then be calculated; the ordinary Risk Index (using the original weights from the Delphi panel) and an Occupant Escape Risk Index (using the weights for Occupant Escape only). Simultaneously, a quantitative risk analysis (QRA) was performed on the same four buildings

Figure 3 shows how the ordinary Risk Index and the Occupant Escape Risk Index ranking compare to the QRA Expected Risk ranking calculated from the quantitative risk analysis.

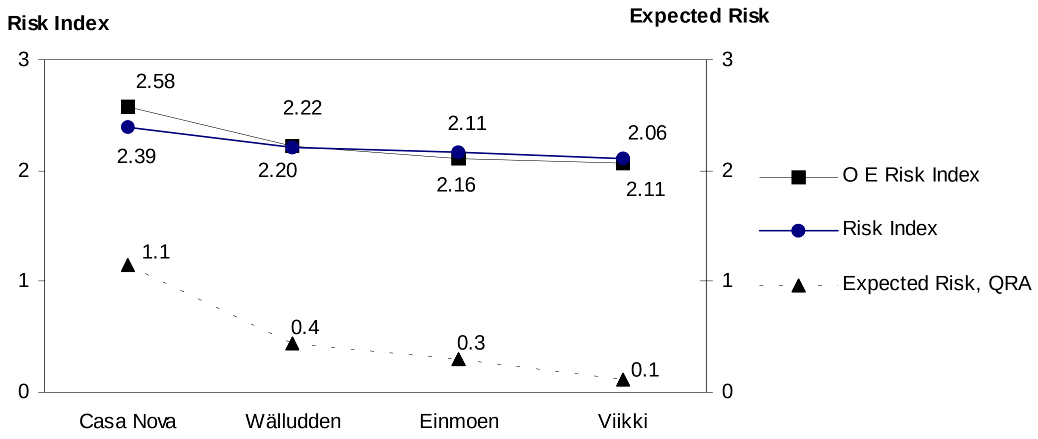

Figure 3. The diagram shows that the two Risk Indices rank the buildings in the same way that the QRA does, in spite of the great differences in the two methodologies.

Both methods ranked the buildings in the same way so the comparison showed a surprisingly good agreement, keeping in mind that the two methods are very different in nature. The result must therefore be seen to be very promising, but further work must be carried out to develop and fine-tune the index method.

5. Appendix A: Delphi Panel Communication, Documents D01, D02, D03, D04, D05 and D06

This Appendix contains the six written communications to the Delphi panel. The documents are

D01: Introduction to the Delphi panel exercise

D02: Structure of the index method

D03: Structure of the full index method

D04: Assigning weights to Version 1.0 of the Index method

D05: Round 2 - Assigning weights to Version 1.1 of the Index method

D06: Results from Round 2 of the weighting exercise.

Each document has page numbers referring to the document number; D01 has seven pages and therefore page numbers D01:1 to D01: 7, the other documents are marked accordingly.

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Addressee: Members of the Delphi panel for the project "Risk - Timberframe Buildings"

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Björn Karlsson

D01: Introduction to the Delphi panel exercise

The purpose of this document is to very briefly introduce the Delphi panel exercise to be carried out in the Nordic Wood Project "Risk Assessment of Timber-frame Multistorey Apartment Buildings" (for short: "Risk - Timber-frame Buildings"). The work will result in an index method for assessing fire safety in such buildings.

We divide the discussion here into:

1. General on the organisation of the project
2. General on the structure of the index method
3. General on Delphi panels
4. Planned work for our Delphi panel

For those of you who wish to have more information I enclose a report by Magnusson and Rantatalo [1], which is the pilot study for the project that we are now carrying out. The report gives,

a) An overview of risk assessment methods
b) A first outline of such a method for fire safety in timber-frame multi-story apartment buildings
c) A discussion on how such a method could be verified

You would be mostly concerned with points a) and b) above. The report also gives further references if you wish to look deeper into some of the background.

Action required: This document contains 7 pages of introductory information on the work we are about to undertake. We ask you to read it carefully and store it so you can refer to it later.

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1. General on the Organisation of the Project

The project is a part of the Nordic Wood project "Fire-safe Wood Frame Multi-storey Apartment Buildings - phase 2". That project has a **Steering group** which meets 2-3 times per year, we report our progress to the Steering group at these meetings.

Our part of the project, called "Risk Assessment of Timber-frame Multi-storey Apartment Buildings", has a **Project group**, with one member from each of the Nordic countries. The **Project manager** is Björn Karlsson who runs the project together with Daniel Larsson (a final year student at LTH), with Professor Sven Erik Magnusson (Brandteknik, LTH) as adviser. These three are also members of the Project group. A full list of the project group members is given in Appendix A.

The Project manager has two external advisers, Professor Jim Shields (University of Ulster, Northern Ireland) and Dr. John M. Watts (Fire Safety Institute, USA), who are both experts in the methods to be used in this project.

Suggestions for actions will be formulated by the Project manager and sent to the Project group, who will comment on the suggestions. The main purpose of the Project group is to prepare proposals for the Delphi group. The Project group meets 3-4 times per year.

2. General on the Structure of the Index Method

The index method will identify hierarchical levels of fire safety specification. We will here very briefly introduce the terminology.

First, the overall **Policy** for the index system is formulated. The policy may, for example, be formulated as "Fire safety performance for a wood frame building should be at least equivalent to that of a corresponding building with a non-combustible frame".

Then the primary **Objectives** will be identified (the primary objectives are often "Provide life safety" and "Provide property protection", as an example).

Then **Strategies** will be specified (typical strategies may be "Establish safe egress", "Control fire growth", etc).

Then the **Parameters** (and sub-parameters) will be identified. These are components of fire risk which are determinable by direct or indirect measure or estimate. Sometimes the parameters are broken into different **Survey items**, which are measurable in some way. A **Decision table** is often used to organise the survey items.

The parameters, sub-parameters and survey items are given **Grades,** reflecting the fire safety standard of a given parameter in a given building. Parameters get grades from 0 to 5, the highest grade being 5. Sub-parameters and Survey items can also have grades given by letters of the alphabet (N for no grade, L for low grade, M for medium grade, etc.).

To give an example of a Parameter, a sub-parameter, a Survey item, Decision tables and grades, we enclose Appendix B. The Parameter we have chosen as an example has been given the symbol P_2 and the name "Suppression system". As a result, a user of the index method will be able to give the parameter a grade, which will be fed into the overall index method.

Please note that the decision tables in Appendix B are only given as examples, the grades have been arbitrarily chosen by the Project manager. The purpose here is only to give the Delphi panel an idea of how measurable Parameters, Sub-parameters and Survey items can be graded.

Once the structure of the index method has been determined, first by the project group, then by the Delphi panel, the objectives, strategies and parameters must be given **Weights**. The Weights are determined by the Delphi panel. Questions like "How important is the Objective "Provide life safety" for the implementation of our Policy?" and "How important is the Objective "Provide property protection" for the implementation of our Policy?". Similarly, such questions will be asked about the Strategies and the Parameters.

As a result, each of the Parameters will have Weights which are linked to each of the Strategies and the Strategies will have Weights linked to each of the Objectives, etc. Thus, the relative importance of each parameter can be calculated through matrix multiplication, resulting in the index method, which is the aim of this work. This process is further described in the enclosed report by Magnusson and Rantatalo [1].

3. General on Delphi Panels

In their book "The Delphi Method - Techniques and Applications" (Addison-Wesley Publishing Company, 1975), Linstone and Turoff [2] define the Delphi technique as "Delphi may be characterised as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem".

They further describe this as a situation where "a small monitor team designs a questionnaire which is sent to a larger respondent group. After the questionnaire is returned the monitor team summarises the results and, based upon the results, develops a new questionnaire for the respondent group. The respondent group is usually given at least one opportunity to reevaluate its original answers based upon examination of the group response".

Shields [3] describes the process as:

1. Each member of the group responds anonymously to a previously prepared questionnaire to avoid undue influence of strong personalities;
2. There must be a review of the questionnaire results, and adjustments are invited whilst preserving anonymity;

3. Numerical responses are required which are to be analysed statistically and presented as a basis for consideration in the next Delphi round.

Magnusson and Rantatalo [1] further describe the Delphi technique in Annex 4 of their report.

In our work we shall try to adhere to the following guidelines:

a) We ask the panel members not to confer with each other on matters to do with the Delphi exercise. The panel members are, however, welcome to telephone, fax or e-mail to the Project manager or any member of the Project group (see contact details in Appendix A).
b) We will try to keep the work to be done by the panel to a minimum by preparing easily understandable questionnaires and by giving overviews of complex issues.
c) Each Delphi panellist has been chosen because of his or her expertise. We ask you to give us your subjective judgement on an issue that usually is poorly analysed and researched. Ideally, each panellist should simply make quick judgements, based on his or her experience and intuition. However, we shall provide references and background material, in case the panellist feels there is need for further information.
d) The Project group must not enforce a structure of the problem on the Delphi panel and at the same time the Delphi panel must be presented with a well-defined structure to allow effective communication. We shall strive for a suitable balance between the preparatory work carried out by the Project group and the work to be carried out by the Delphi panel.
e) The Delphi panel is asked to keep in mind that the index method is to be applied to medium rise, multi-story apartment buildings only. The method will therefore ignore a number of fire safety issues that are not relevant for such buildings.

Further, we must strive to produce a method that strikes the right balance between simplicity and comprehensiveness, since the method must be simple to use. Also, the human mind has a limited capacity to store information. The more comprehensive the method (with a large amount of Objectives, Strategies and Parameters), the greater the chances of confusion and disagreement. Our limitations will be discussed later.

4. Planned work for our Delphi panel

The Project group has now agreed on a preliminary structure of the index method, to be presented to the Delphi panel. The document is 20 pages, the 2 first pages describe the overall structure. Each of the steps listed below will be repeated once or twice or until consensus has been reached.

You will at first only concern yourself with the first two pages of the document mentioned above, which list the suggested Policy, Objectives, Strategies and Parameters. You will be asked for comments or additions.

When the overall structure of the method has been agreed upon, you will be asked to assign Weights to the Objectives, Strategies and Parameters.

Next you will be asked to give your opinions on the structure of the Sub-parameters, the Survey items and the Decision tables.

Finally, you will be asked to give your opinion on the Parameter grades. When consensus has been reached on this issue, our work is done.

We plan to have the work done before the summer. Since it is difficult to predict how long time each of the steps above may take, the Project group may have to make changes in our plans. If you have any questions, please do not hesitate to contact the Project manager or any of the members of the Project group (see Appendix A).

References

1. Magnusson, S.E., Rantatalo, T., "Risk Assessment of Timber-frame Multistorey Apartment Buildings. Proposal for a Comprehensive Fire Safety Evaluation Procedure", Report 7004, Department of Fire Safety Engineering, Lund University, 1998.
2. Linstone, H.A., Turoff, M., "The Delphi Method - Techniques and Applications", Addison-Wesley Publishing Company, Massachusetts, 1975.
3. Shields, T.J., "A Fire Safety Evaluation Points Scheme for Dwellings", University of Ulster at Jordanstown, Northern Ireland, 1991.

Appendix A: Project Group Members

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Appendix B: Example of how Parameters, Sub-parameters, Survey items and Decision Tables can be used in an Index Method

P_2. SUPPRESSION SYSTEM

DEFINITION: equipment and systems for suppression of fires

SUB-PARAMETERS:

Automatic sprinkler system
Type of sprinkler (N = no sprinkler, R = Residential sprinkler, O = ordinary sprinkler) and Location of sprinkler (A = in apartment, E = in escape route, B = both in apartment and escape route)

SURVEY ITEMS	DECISION RULES						
Type of sprinkler	N	R	R	R	O	O	O
Location of sprinkler	-	A	E	B	A	E	B
GRADE	N	?	?	?	?	?	H

(N = no grade, L = low grade, M = medium grade and H = high grade)

Portable equipment

N	None
F	Extinguishing equipment on every floor
A	Extinguishing equipment in every apartment

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES											
Automatic sprinkler system	N	N	N	L	L	L	M	M	M	H	H	H
Portable equipment	N	F	A	N	F	A	N	F	A	N	F	A
GRADE	0	?	?	?	?	?	?	?	?	?	?	5

(Minimum grade = 0 and maximum grade = 5)

(Observe that the "?" in the above tables are examples of grades yet to be given)

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D02: Structure of the Index Method

The purpose of this document is to introduce a preliminary structure of the index method for fire risk assessment of medium rise multistorey apartment buildings.

We shall discuss how the preliminary structure was developed by the Project group. To do this we will provide you with a number of earlier suggestions for the structure in Appendices A, B and C. Finally, we provide you with a graphical representation of a "Fire Safety Concepts Tree" in Appendix D.

After you have read this information you will be asked if you wish to add or delete something from the structure presented by the Project group. The question will be distributed through e-mail.

This document is divided into:

1. Development of the structure of the index method
2. Project group structure of the index method
    - Appendix A: Version 1 of the index method
    - Appendix B: Version 2 of the index method
    - Appendix C: Version 3 of the index method
    - Appendix D: Fire Safety Concepts Tree for our application

Action required: Please read the document carefully and build an opinion on whether the Project group structure can be accepted or if additions or deletions should be made. You are welcome to contact the Project group (see list in document D01) or the Project manager if you have questions. You will receive a questionnaire through e-mail in a few days where you will be asked for your opinion.

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1. Development of the Preliminary Structure of the Index Method

The present structure of the index method developed gradually, through consultations with previous work, with designers, with our External experts and in a number of meetings with the Project group. We shall briefly give the background in the following and refer to variations of the structure as the,

- Project group version
- Version 1
- Version 2
- Version 3

The Project group version is given in Section 2, Versions 1, 2 and 3 are given in Appendixes A, B and C, respectively.

Most index methods for assessing fire safety are derived by taking a cut set of the NFPA Fire Safety Concepts Tree [1]. Fault tree analysis uses a tree-like diagram to describe the relationships of events that can lead to a systems failure. Similarly, [1] uses such diagrams to show relationships of fire prevention and fire damage control strateg.ies.

Examples of fire safety strateg.ies shown in [1] are ignition prevention, limitation of combustibles, compartmentation, fire detection and alarm, fire suppression, and protection of exposed people or things. Some of these strateg.ies have been assumed to not apply in our case. For example, since we are concerned with apartment buildings we assume that we have no control over combustibles, except for lining materials.

Magnusson and Rantatalo [2] also used [1] as a basis for their suggestion of a structure. We shall call their structure Version 1 (see Appendix A). Version 2 (see Appendix B) was developed after we,

- Discussed the structure with a well known engineer with design experience.
- Constructed our own version of a Fire Safety Concepts Tree.
- Asked for comments from our external advisers.

Version 2 was discussed at a meeting with the Project group. After considerable discussion one of the Project group members suggested Version 3 (see Appendix C). After some e-mail communication between project group members and a second meeting with the Project group, the Project group version was developed (see Section 2).

The Project group has now unanimously agreed that this is the version we wish to send to the Delphi panel. We will now ask you to inspect these four versions of structure and consider whether you wish to accept the Project group version or you wish to add or delete something. The question will be distributed by e-mail.

In order to assist you to make your judgement we also enclose our version of the Fire Safety Concepts Tree (see Appendix D).

2. Project Group Version of the Index Method

This is a suggestion for a structure of the index method. The list below presents the overall policy and different decision levels; Objectives, Strateg.ies and Parameters. The parameter grades are calculated by using grading schemes. The grading schemes have been developed but are not presented here, the Delphi group will be asked for comments on the grading schemes later.

Policy:

Provide acceptable fire safety level in multistorey apartment buildings

Def: Apartment buildings shall be designed in a way that ensures sufficient safety in case of fire for persons being present in or on the buildings and for material values. This includes acceptable possibilities of rescuing people, and of performing extinguishing work. Apartment buildings shall be so located as to ensure that the risk of fire spreading to other buildings becomes acceptably low.

Objectives:

O_1 Provide life safety

Def: life safety of occupants in the compartment of origin, the rest of the building, outside and in adjacent buildings and life safety of fire fighters

O_2 Provide property protection

Def: protection of property in the compartment of origin, in the rest of the building, outside and in adjacent buildings

Strategies:

S_1 Control fire growth

Def: Controlling the fire growth by using active systems (suppression systems and smoke control systems) and the fire service.

S_2 Confine fire by construction

Def: Provide structural stability, control the movement of fire through containment, use fire safe materials (linings). This has to do with passive systems or materials that are constantly in place.

S_3 Establish safe eg.ress

Def: Cause movement of occupants and provide movement means for occupants. This is done by designing detection systems, signal systems, by designing escape routes and by educating or training the occupants. In some cases the design of the escape route may involve action by the fire brigade (escape by ladder through window).

S_4 Establish safe rescue

Def: Protect the lives and ensure safety of fire brigades officers during rescue. This is done by providing structural stability.

Parameters:

P_1 Linings in apartment

Def: Possibility of internal linings in an apartment to delay the ignition of the structure and to reduce fire growth

P_2 Suppression system

Def: Equipment and systems for suppression of fires

P_3 Fire service

Def: Possibility of external agencies to save lives and to prevent further fire spread

P_4 Compartmentation

Def: Extent to which floor areas are divided into fire compartments

P_5 Structure - separating

Def: Heat, smoke and fire resistance of building assemblies separating fire compartments

P_6 Doors

Def: Fire and smoke separating function of doors between fire compartments

P_7 Windows

Def: Windows and protection of windows, ie. factors affecting the possibility of fire spread through the openings

P_8 Facade

Def: Facade material, suppression system etc., ie. factors affecting the possibility of fire spread along the facade

P_9 Attic

Def: Prevention of fire spread to and in attic

P_{10} Surroundings

Def: Minimal separation distance from other building

P_{11} Smoke control system

Def: Equipment and systems for limiting spread of toxic and corrosive fire products

P_{12} Detection system

Def: Equipment and systems for detecting fires

P_{13} Signal system

Def: Equipment and systems for transmitting an alarm of fire

P_{14} Escape routes

Def: Adequacy and reliability of escape routes

P_{15} Structure - load-bearing

Def: Structural stability of the building when exposed to a fire

P_{16} Fire safety management

Def: Inspection and maintenance of fire safety equipment, escape routes etc. and education of occupants in suppression and evacuation

References:

1. NFPA 550, "Guide to the Fire Safety Concepts Tree", National Fire Protection Association, Quincy, 1994.
2. Magnusson, S.E., Rantatalo, T., "Risk Assessment of Timber-frame Multistorey Apartment Buildings. Proposal for a Comprehensive Fire Safety Evaluation Procedure", Report 7004, Department of Fire Safety Engineering, Lund University, 1998.

Appendix A: Version 1 of the index method

(taken from Magnusson and Rantatalo [2])

POLICY — What level of fire safety do we need in our building?

<u>Decision levels</u>

O: Objectives
S: Strategies
P: Parameters
S_I: Survey Items

Objectives

O_1: Provide life safety
O_2: Prevent fire spread from room of origin.
O_3: Prevent fire spread to the adjacent building.

Strategies

S_1 = Establish safe egress
S_2 = Establish safe rescue operation
S_3 = Control fire growth

Prevent fire spread through

S_4 = -room boundaries
S_5 = -joints and intersection
S_6 = -concealed spaces
S_7 = -window openings, facades
S_8 = -attic
S_9 = prevent ignition of structure
S_{10} = limit size of radiation to burning building

Parameters ($x_1 \dots x_{13}$)

Building:

P_1 = Loadbearing capacity
P_2 = Integrity E / insulation I
P_3 = Firestop at joints/intersections
P_4 = Firestop in concealed spaces
P_5 = Facade construction
P_6 = Fire stop in eaves
P_7 = Doors (self closing)

Fire protection system:

P_8 = Alarm system
P_9 = Detection system
P_{10} = Suppression system
P_{11} = Fire department capability and effectiveness
P_{12} = Management, surveillance and education
P_{13} = Safe separating distance

Comments on Version 1 of the Index Method

This structure was sent to the External advisers for comment. They remarked that using the Delphi technique for evaluation of Strategies versus Parameters might be difficult, due to the size of the matrix that would result (13*10 = 130 cells to be evaluated). Both suggested strongly that the Strategies should be fewer and more concentrated.

One External adviser specifically recommended that Strategies S_4 and S_5 be combined, as well as Strategies S_6 and S_8.

The strategy S_9 was found to be somewhat ambiguous for a number of reasons. It was assumed that this Strategy might be combined with Strategy S_4 (Prevent fire spread through room boundaries) since a part of its objective is to protect the structure (or load bearing material).

The Strategies were therefore reduced from 10 to 7.

During this stage a detailed structure of the Parameters, Sub-parameters, Survey items and Decision tables was initiated. During this work, a number of Parameters that had not been included in Version 1 were identified. The number of parameters therefore increased from 13 to 18.

This led to a matrix of Strategies versus Parameters of the size 7*18 = 126, which is still fairly large. It was, however, felt that the structure had been sharpened at the same time that more parameters had been taken into account.

This led to Version 2 of the index method (see Appendix B).

Appendix B: Version 2 of the Index Method

This is a suggestion for a structure of the index method. The list below presents different decision levels; Objectives, Strategies and Parameters. The parameter grades are calculated by using grading schemes (which are developed but not shown here).

Policy:

What level of fire safety do we need in our building?

Objectives:

O_1 Provide life safety
O_2 Prevent fire spread from room of origin
O_3 Prevent fire spread to adjacent building

Strategies:

S_1 Establish safe rescue operation
S_2 Establish safe egress
S_3 Suppress fire
S_4 Prevent fire spread through room boundaries
S_5 Prevent fire spread through concealed spaces and attic
S_6 Prevent external fire spread
S_7 Limit size of radiation from burning building

Parameters:

P_1 Load bearing capacity
P_2 Detection system
P_3 Alarm system
P_4 Integrity and insulation
P_5 Escape routes
P_6 Suppression system
P_7 Fire brigade
P_8 Internal linings
P_9 Doors
P_{10} Firestops at joints and intersections
P_{11} Firestops in concealed spaces
P_{12} Firestops in attic
P_{13} Facades
P_{14} Windows
P_{15} Safe separating distance
P_{16} Compartmentation
P_{17} Smoke control system
P_{18} Maintenance and education

Comments on Version 2 of the Index Method

Version 2 of the structure document was discussed with the Project group and the External advisers.

Both External advisers indicated that Objectives O_2 and O_3 were not independent of each other and that it might be more natural to simply divide the Objectives into two parts; Life safety and Property. As a result, this was suggested for Version 3.

Both External advisers emphasised the importance of having the Strategies as independent of each other as possible, in order to ease the weighting process for the Delphi panel. One suggested that the Strategies should have a greater reflection on the text in the Building Regulation.

As a result, the Project group discussed considerable changes to the Strategies. An International Standards Organisation document was also consulted (ISO TR 13387 Part 1 "Framework Document") as a check. One of the Project group members summarised the discussion and circulated Version 3 of the structure document. This member felt that the Objectives should be defined in a clearer way and therefore included some Sub-objectives.

During this work it was noted that the Parameters did not change much, even though the Parameter names changed somewhat and the order in which they were presented changed.

The result was Version 3 of the structure document (see Appendix C).

Appendix C: Version 3 of the Index Method

Objectives

O_1 Life safety
O_2 Property protection

Sub-objectives

L_1 Safety of occupants in the compartment of origin
L_2 Safety of occupants in the rest of the building
L_3 Safety of people outside and in adjacent buildings
L_4 Safety of fire fighters
E_1 Protection of property in the compartment of origin
E_2 Protection of property in the rest of the building
E_3 Protection of property outside and in adjacent buildings

Strategies

S_1 Prevent ignition
S_2 Control fire growth
S_3 Control yield of hazardous fire effluent (smoke & gaseous species)
S_4 Control the movement of fire effluent
S_5 Confine the fire (one room, one compartment, one building)
S_6 Provide safe egress
S_7 Provide safe rescue (defend in place first - provide safe egress when needed)

Parameters (techniques available/contributing - to be weighted and graded by relevance, availability, reliability and possibility to control))

P_1 Number & type of occupants
P_2 Fire safety management (maintenance & education)
P_3 Contents
P_4 Linings (& materials inside the structural elements possibly contributing to fire?)
P_5 Compartmentation - size, number & complexity of bldg layout…
P_6 Structure - load-bearing
P_7 Structure - separating (joints, cavities, penetrations, …)
P_8 Doors (between apartment and corridor/staircase)
P_9 Windows
P_{10} Facades
P_{11} Attics
P_{12} Escape routes (number, dimensions, how easy to use, materials, smoke control)
P_{13} Detection system
P_{14} Alarm system
P_{15} Smoke control (from the compartment of origin)
P_{16} Suppression system
P_{17} Fire brigade
P_{18} Surroundings (neighbouring buildings, landscape around the building)

Comments on Version 3 of the Index Method

Version 3 of the structure document was circulated to the Project group and discussed with one of the External advisers.

Experts in the Project group first commented on the structure through e-mail. The following gives some of the comments

- Some of the items are out of the control of building regulations, and can therefore be deleted, we have no control over them.
- With the sub-objectives in the system, the matrixes become far too large. The sub-objectives can simply be included in the definitions of the objectives.
- Strategy S_1 should be deleted. In an apartment building the Building Regulation has little or no control on sources of ignition.
- Strategy S_3 should be deleted. The Building Regulation has little or no control over the yield of hazardous fire effluent (for example how much HCL or CO a certain piece of furniture will produce when burning).
- Strategy S_4 seems very dependent on Strategies S_5 and S_6. The better you confine the fire (for example by construction), the better you control the movement of fire effluent. If you provide safe egress (for example by using smoke control systems, doors etc) you are controlling the movement of fire effluent. It is suggested that Strategy S_4 be deleted and that it be included in other strategies using definitions.

This resulted in 2 Objectives accompanied by definitions and 4 Strategies, with slightly different names and definitions.

Comments were also made on the Parameters. It was found that the suggested Parameters were very similar to those proposed earlier even though their order and names had changed somewhat.

Parameters P_1 and P_3 were deleted, since the Building Regulation has little or no control over them in apartment buildings (except for lining materials, which will be included in a separate parameter).

As a result, definitions were provided for the 2 Objectives, 4 Strategies and 16 remaining Parameters. A new document was now circulated to the Project group. The final document of the Project group version of the structure was then discussed in a one day Project group meeting.

Since then some small amendments have been made. The Project group unanimously agreed to send the version given in Section 2 to the Delphi panel.

Appendix D: Fire Safety Concept Trees for our Application

The Fire Safety Concepts Tree depicted here was developed using the strategies given in [1] as a basis. This version of the tree corresponds with Project group version of the structure of the index method. The tree is shown in Figures 1-8.

The aim of this Appendix, and Appendices A, B and C, is to provide the Delphi panel with enough information so that a judgement can be made on whether the structure in Section 2 can be accepted or whether additions or deletions should be made.

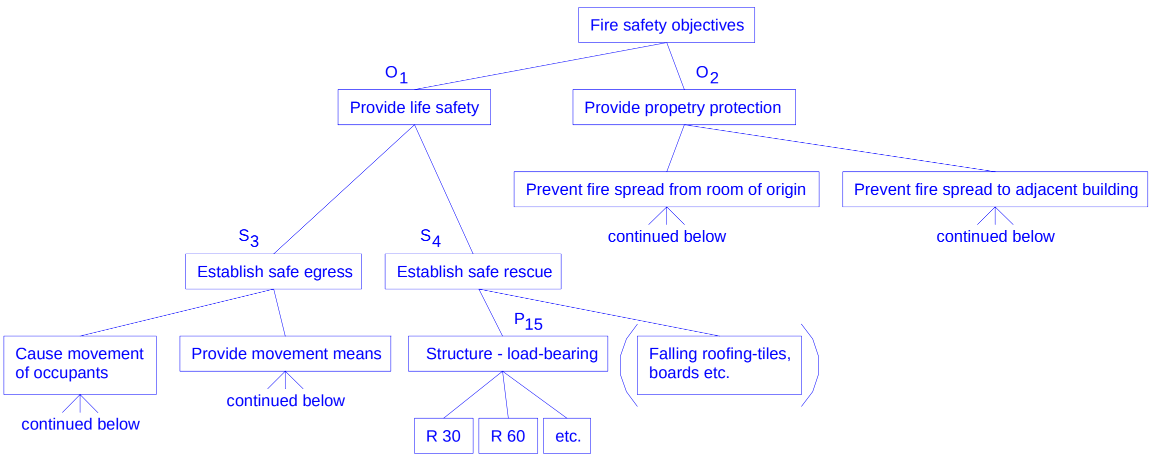

Figure 1: Fire Safety Objectives

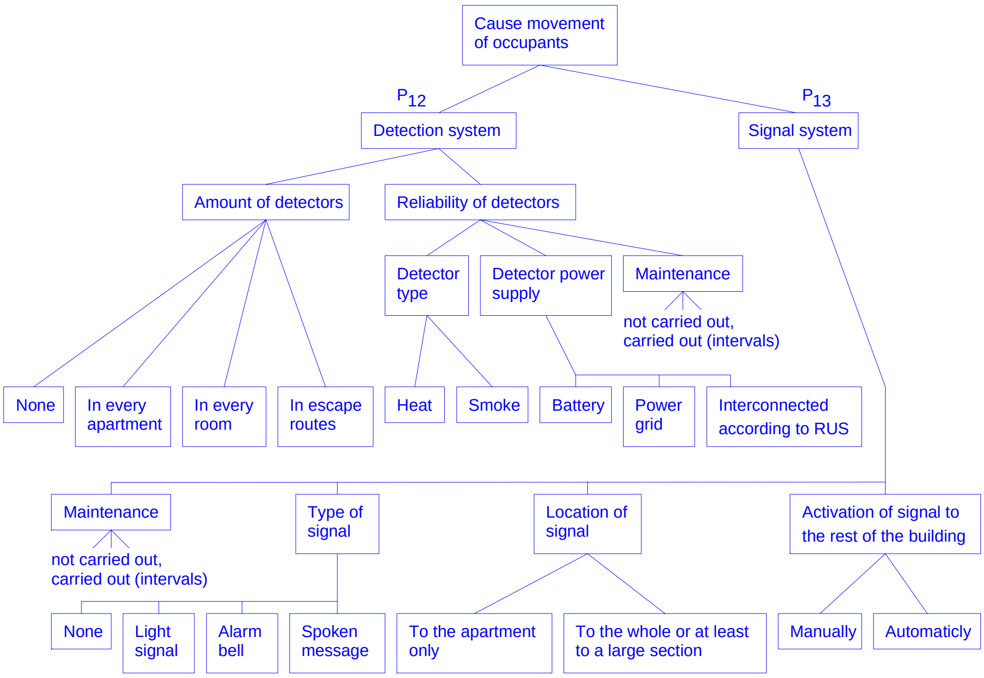

Figure 2: Cause Movement of Occupants

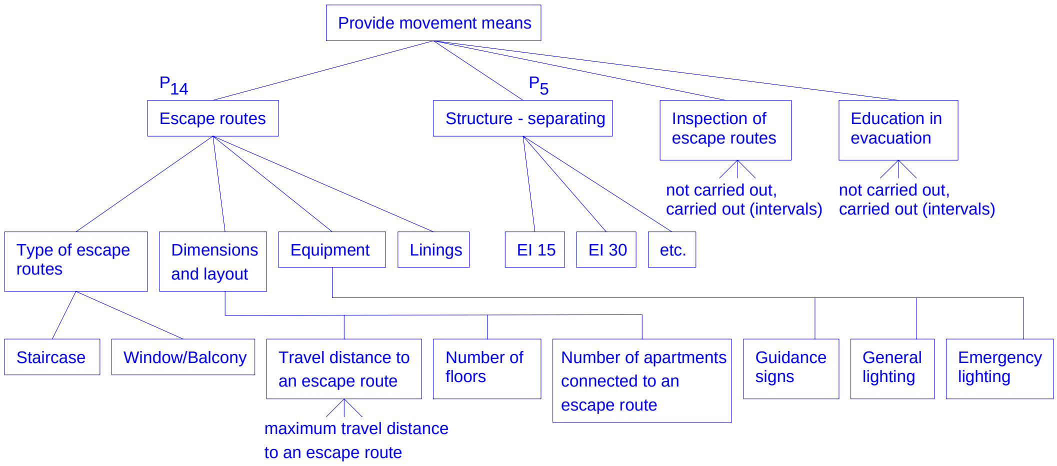

Figure 3: Provide Movement Means

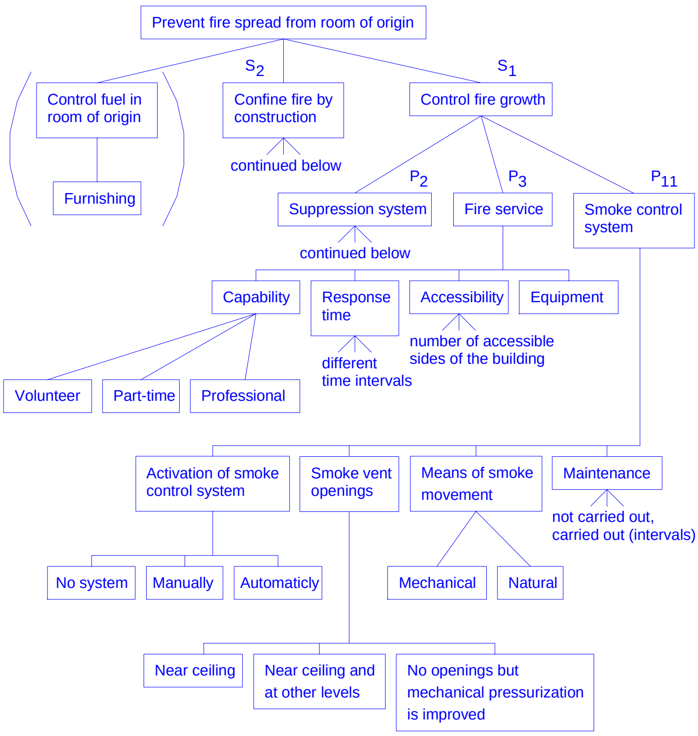

Figure 4: Prevent Fire Spread from Room of Origin.

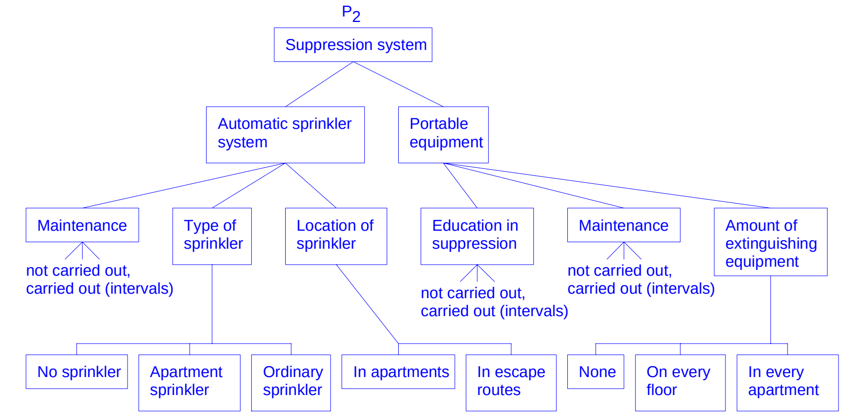

Figure 5: Suppression System.

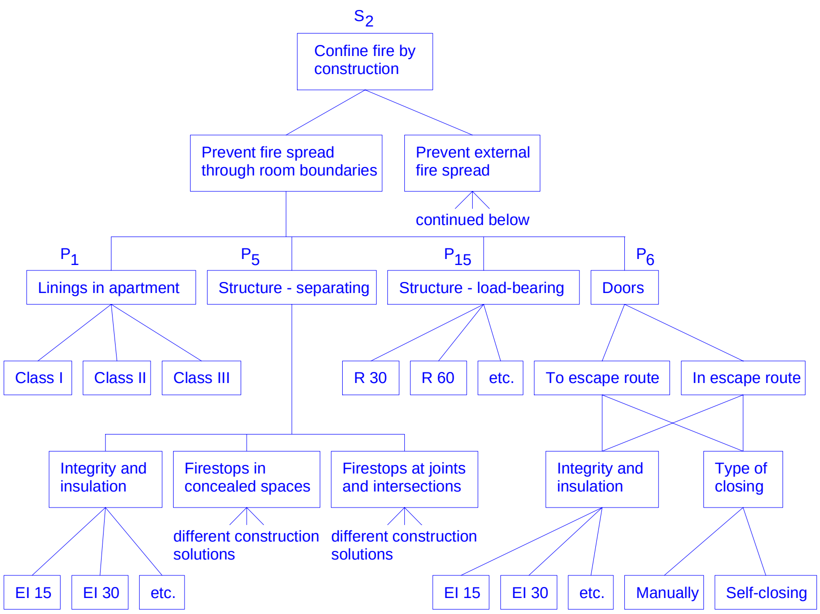

Figure 6: Confine Fire by Construction.

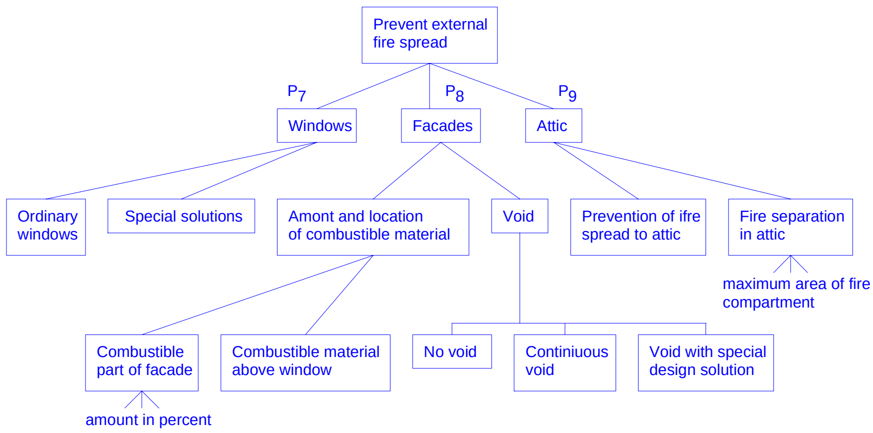

Figure 7: Prevent External Fire Spread

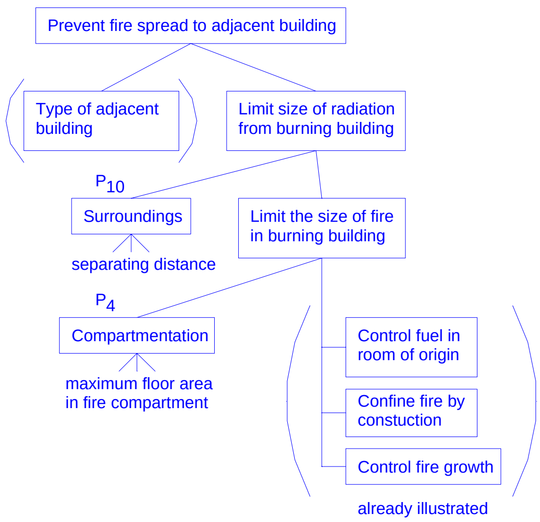

Figure 8: Prevent Fire Spread to Adjacent Building

99-03-29 99003BR/BK

Addressee: Members of the Delphi panel for the project "Risk - Timber-frame Buildings"

LUND UNIVERSITY

Department of Fire Safety Engineering
Björn Karlsson

D03: Structure of the Full Index Method

This letter contains,

1. A report on the results of the voting and comments on document D02: Structure of the index method.
2. The Project group version of the full index method.

The Delphi panel agreed on the main structure of the index method, but gave several comments. These comments have now been considered by the Project group and some small changes have been made to the main structure of index method.

The Project group version of the full index method is enclosed here, with all Parameters, Sub-parameters, Decision tables and Grading schemes. The document has been developed by the Project group and it's advisers during the last 6 months. The main challenge has been to identify different design options and expressing these in easily measurable quantities.

Action required: You do not need to read through the report on the response to document D02, the report is enclosed here for those who are interested. However, we ask you to consider the full index method in detail. You will not be asked to give grades or weights at this point, but you will be asked to comment on the structure of the Parameters, Sub-parameters, Decision tables and Parameter grades. My estimate is that this work should take roughly 4 hours, depending on your interest and your way of replying. Your comments can be sent to me through e-mail, you can fax hand-written notes to me or telephone me and give your comments orally. I will need your answer in two weeks time, or before Thursday 15th April.

Note: If you have mislaid documents, you can fetch them at our Web site, http://www.brand.lth.se/forskn/index.htm, choose Risk, then choose Timber-Frame Buildings - Risk "

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Response of Delphi Panel to Document D02 (990329)

This document gives the number of the Delphi panel member (random), his/her answer on agreement or not and his/her comments. Project group response to comments are also given. We received 17 answers.

1. **Answer:** Agreed

Comments:

a) Regarding P15 (load-bearing function) R30, R60 etc are not sufficient as parameters for timber structures. The aspect of survival of a burnout of the compartment is not covered, however this has an impact mainly on protection of property, safety of fire brigade and spread to other buildings. Here the relevant parameter is whether the load-bearing structure is completely protected from charring or not. There is a very weak relationship between classification and survival of structure in the actual range of R60 - R90. Perhaps this is sufficient.

Project group proposal:

a) This will be addressed later when looking at sub-parameters.

2. **Answer:** Agreed

Comments:

a) Jag anser att brandcellens innehåll av brännbart material är en viktig parameter. Om mångden giftiga gaser som bildas kan beg.ränsas ökar säkerheten bl.a. vid utrymning. Ni har uteslutit denna punkt eftersom vi inte kan reg.lera den i byggnormen. Detta argument tycker jag borde omprövas. Finner vi att det finns behov av att beg.ränsa användning av vissa material i t ex möbler för att därigenom minska mängden giftiga gaser borde det vara möjligt att påverka utvecklingen även om det inte sker i en byggnorm.

b) Följande punkter antar jag finns med bland de parametrar som Du angivit även om jag inte hittat dem beskrivna i ord; Dörrar i utrymningsvägar; öppningsfunktion, låsning och; Genomföringar, tätning

Project group proposal:

a) Fire load density is of course an important parameter, the Project group has therefore reconsidered this. We still find that we should not consider furniture etc, not only because the building regulations do not provide control, but also because interiors can change at any time and there is no inspection procedure for this.

b) Yes, there are provisions for this, we will consider this in detail in the next Delphi round.

3. **Answer:** Agree.

4. **Answer:** Agree.

5. **Answer:** Agree.

6. **Answer:** Agree.

Comments:

a) My only concern is that how the fire load, it's location, etc. parameters are taken into account. Am I correct that those are given for the panel? If yes, how the possible sensitivity of results against those parameters can be estimated? Possibly you should ask the panel members within which limits of the parameters the given answer is still valid.

b) Of course this sensitivity aspect should/could be used throughout the exercise!

Project group proposal:

a) See 1. above. Again, this is an important parameter. However, Fire load density can change with time and is not regularly controlled. We must assume that Fire load density is a statistical parameter, such numbers are available in the literature for apartments. The statistics give the 80^{th} percentile and the range. The answer to this question is: yes, we assume that the Fire load density is a given parameter for apartments, with a known range.

b) The Delphi panel will be providing considerable information on the weights of different aspects of fire safety.

7. **Answer:** Do not agree.

Comments:

a) The policy defined on page 3 contains several objectives, which are not mentioned in the section on Objectives. Here "rescuing people" is not mentioned and only "life safety" is mentioned whereas in the policy safety for persons can be interpreted more general containing eg. also persons health. I suggest that there is agreement between the formulation of policy and objectives.

b) In Version 3, there is a division into objectives and sub-objectives. This division is much clearer than what is defined in "Project group version of the index method" given on page 3. With the definitions given on page 3 the Delphi panel will have to consider eg. life safety of occupants as well as for fire fighters. The weighting between the 2 groups will be hidden in the subjective answers from the Delphi panel. It might be clearer (and require more work) to split the objectives as done in version 3. I suggest that.

c) Objectives O1 comprises also life safety of occupants in the compartment of origin. This is maybe wise to consider, but it is normally assumed that the life of persons in the compartment of origin is lost. So let it be.

d) In the strategy S4 - Establish safe rescue it is written "This is done by providing structural stability". Should it be added which part of the structure should have the sufficient stability, eg. the escape routes? I suggest that.

Project group proposal:

a) Yes, the policy definition should be shortened very much and the definitions given in the objectives instead. These must have the same meaning.

b) It is correct that it is clearer to divide life safety into sub-objectives. However, not only does it require more work, but much more work. The Delphi group will then have to consider 2*7*4*16 or about 900 weight factors (900 questions to answer) instead of 2*4*16 = 128 weight factors.

c) No comment

d) The Project group suggests that we talk generally about structural stability, since fire brigade personnel may need protection in other spaces than escape routes.

8. **Answer:** Agree.

9. **Answer:** Agree.

Comments:

a) Comparing the structure in section 2 with the ones shown in appendix A to C I believe that two more parameters should be added in section 2: Concealed spaces and joints. I believe these two parameters to be of great importance for the strategy S2 and I do not think they are covered sufficiently by parameter P5.

Project group proposal:

a) The concealed spaces and joints are sub-parameters which are very prominent in the P5 parameter. The Project group is certain that they will be sufficiently covered by parameter P5, since it will be made very clear that these sub-parameters belong there. The issue will be revisited when we consider the parameters.

10. **Answer:** Agree

11. **Answer:** Agree

Comments:

a) Policy Apartment måste defineras bättre. Man borde inkludera studentbostäder, gruppbostäder och äldrebostäder
b) S4 Firebrigade officers, är detta den korrekta termen för vanlig brandman?
c) Man borde lägga in S5 Prevent fire to start. Byggreg.ler har t.ex. krav på imkanaler, eldstäder, skorstenar och el-installationer. Man borde också ta hänsyn till brevlåder och tidningar i trapphus vad gäller antändning.
d) P4 lägenheter som omfattar 2plan då är inte bjälklaget är en brandcellsgräns
e) Ventilationssystemet finns inte nämnt.

Project group proposal:

a) For the moment, we shall only consider ordinary apartments. Some adjustments will probably be made in the next part of the project so that other types of apartments may be included.
b) We will use the term Fire brigade personnel.
c) The proposed strategy S5 caused much discussion in the Project group. The following points were made:
   - Most of the "prevent ignition" strategy must be ignored since we have no control over the interior of the building (except for linings).
   - Fire places, Flues (imkanaler) and chimneys are a very small part of the "prevent ignition" strategy
   - Fire places, Flues (imkanaler) and chimneys are either made to standard (for example Fire places must have a slab of non-combustible material in front of it, with a certain dimension) or they are not made to standard (in that case they will not be built). It will be too detailed to have sub-parameters which are; a) Fire place with very much non-combustible

material around it, b) fire place made to standard and c) fire place not made to standard.
- The same applies to Flues and chimneys, it will be too detailed.
- The electric installation will either be made to standard or it will not. If it is not made to standard, the house will not be built. We have little possibility to divide this into; el-installation done a) better than to standard, b) to standard, c) to sub-standard.
- The houses we are considering are about to be built or are very recently built. We will not be applying the method to quite old timber-frame buildings (typically with chimneys and flues and a boiler room in the cellar)
- We therefore propose that these issues (imkanaler, chimneys, electric installation, etc) be ignored in the method and thereby, that all apartment buildings have the same probability of ignition.

d) We will change the definition in P4 so that "floor" is replaced by "building space".
e) The Project group is not certain if a special parameter for ventilation system should be included or not. The group will seek responses and suggestions from experts and Delphi panel.

12. **Answer:** Agree.
Comments:

a) However I would to like to add some items to the parameters. P8 could be facades and balconies. Then I suggest that one parameter is added for different kind of cavities (in floors, in partitions, in external walls). And what about service installations like pipes, ducts and their penetration seals.

Project group proposal:

a) All of these items are addressed in the sub-parameters. We shall discuss this in detail in the next step.

13. **Answer:** Agree
Comments:

a) Strategies: Preventing fire spread from one building to another should include in strategies if not in objectives. This is a major problem and after all the reason why building regulations are so strict to wooden buildings. In my opinion problems in one building are practically solved, but especially when we are talking about wooden facades there is a lot to be solved. In present version it is difficult to include parameter P10 in any strategies. Even if it is included in S2, it has a minimal effect to building risk index when we are comparing different buildings. One can point out that this strategy is not totally independent of others. All other strategies are not independent either. eg.. S3 is dependent of S1 (active systems affect both controlling fire and safe egress). Controlling fire growth is not independent of construction (active fire fighting uses passive systems). And so on. Seems to me that it is very difficult to keep all strategies totally independent.
b) Parameters: P10 Def: minimum instead of minimal.
c) Other comments: Delphi panel seems to be an interesting method to solve this kind of problem. Still, we are going to spend many long hours with several questions, like defining values for table 2.3 in Magnusson & Rantatalo report.

Project group proposal:

a) The Project group has discussed this in detail before. Facades are included in O2 (property protection), but not clearly enough in S2 (confine fire by construction). We will add the words "and facades" in the definition of S2, so it becomes "use fire safe materials (linings and facade materials)".
b) Minimal will be changed to minimum
c) Correct.

14. **Answer:** Agree.

Comments:

a) Policy: Jag anser skrivningen bra. Jag anser dock att definitionen att "Apartment building shall be so located..." bör ändras bör ändras till "...located and designed..." för att arbetet ska bli praktiskt användbart. Enbart avstånd som skydd för brandspridning till annan byggnad är ju en icke önskvärd beg.ränsning.
b) Strateg.ies: Här har arbetet med att minimera antalet strateg.ier gått för långt. Vi vet att röken är det som tar flest människoliv i dagens bränder. Här får den en underordnad roll. Det talas om "fire growth" och "confine fire" men det är inte detsamma som att hindra rökspridning. Jag håller inte helt med kommentarerna till version 3 på sidan 11 angående Strategy S4. Visst innebär en bättre beg.ränsning av branden en bättre beg.ränsning av röken, men de kan inte likställas. Det kan som exempel vara svårt att värdesätta rökventilation av trapphus, eller rökspridning via tröskelfria dörrar. Visserligen är detta med smoke management mer aktuellt för andra byggnadstyper, men värderingen är viktig för att nya ideer ska få en chans. Det är en viktig strateg.i att hindra rökspridning!
c) Jag vill också komplettera definitionen av föreslagen strateg.i S4 med " .. and prevent rapid unexpected fire spread and collapse of building parts". Jag syftar här på ej primärt bärande delar som trappor, takfötter och tunga undertak. Jag avser också brandspridning i dolda utrymmen som kanske klarar utrymningen men blir en fälla vid brandsläckningen.
d) Parameters: P11. Är det viktigt med "corrosive"? I så fall måste det utvärderas. Ta bort det föreslår jag. P14. Jag saknar möjligheten att ge extra poäng för antalet utrymningsvägar. Det är ingen oväsentlig del.

Project group proposal:

a) The Policy definition should be simplified and re-written. The details should be given in the Objectives definitions.
b) The prevent smoke spread strategy can only be implemented by either using active systems (S1) or passive systems (S2). The Project group found that it would be very difficult to assign weights to a specific strategy for smoke transport, that uses and combines strategies S1 and S2. We found that the system becomes much clearer without a specific strategy on smoke spread. We are confident that the panel members will give appropriate weights bearing this in mind.
c) We will add "and prevent rapid unexpected fire spread and collapse of building parts" to the definition of S4. This is, however, very difficult to measure or to rate. We will address that problem in the next round.

d) P11: Corrosive has to do with property protection. It is however a very small part of the parameter since toxicity is most important. We agree and propose to strike the words "and corrosive" since it is of relatively small importance. P14: This is implemented in the sub-parameters, we will discuss this soon.

15. **Answer:** Agree

16. **Answer:** Agree

17. **Answer:** Agree

Comments:

a) Ta bort eller starkt förenkla Definition of Policy eftersom definitionen kommer sedan i Objectives
b) Call S1 Control fire growth using active systems
c) Call Parameter 10 Adjacent buildings or Adjacent structural works

Project group proposal:

a) The Policy definition will be simplified and re-written. The details should be given in the Objectives definitions.
b) The Project group proposes to call S1 "Control fire growth using active systems"
c) The Project group proposes to call P10 Adjacent buildings.

"Risk - Timber-frame Buildings" - Project Group Structure of the Full Index Method (990330)

This is a suggestion for a structure of the Index method. The list below presents different decision levels; Objectives, Strategies and Parameters. The parameter grades are calculated by using the grading schemes presented in this paper. In the grading schemes the two lowest decision levels are used; Sub-Parameters and Survey Items. Currently, we shall only consider ordinary occupancies, later we may expand to include occupancies such as homes for the elderly.

Policy:

Provide acceptable fire safety level in multistorey apartment buildings

Def: Multistorey apartment buildings shall be designed in a way that ensures sufficient life safety and property protection in accordance with the objectives listed below.

Objectives:

O_1 Provide life safety

Def: Life safety of occupants in the compartment of origin, the rest of the building, outside and in adjacent buildings and life safety of fire fighters

O_2 Provide property protection

Def: Protection of property in the compartment of origin, in the rest of the building, outside and in adjacent buildings

Strategies:

S_1 Control fire growth by active means

Def: Controlling the fire growth by using active systems (suppression systems and smoke control systems) and the fire service.

S_2 Confine fire by construction

Def: Provide structural stability, control the movement of fire through containment, use fire safe materials (linings and facade material). This has to do with passive systems or materials that are constantly in place.

S_3 Establish safe egress

Def: Cause movement of occupants and provide movement means for occupants. This is done by designing detection systems, signal systems, by designing escape routes and by educating or training the occupants. In some cases the design of the escape route may involve action by the fire brigade (escape by ladder through window).

S_4 Establish safe rescue

Def: Protect the lives and ensure safety of fire brigades personnel during rescue. This is done by providing structural stability and preventing rapid unexpected fire spread and collapse of building parts.

Parameters:

P_1 Linings in apartment
Def: Possibility of internal linings in an apartment to delay the ignition of the structure and to reduce fire growth

P_2 Suppression system
Def: Equipment and systems for suppression of fires

P_3 Fire service
Def: Possibility of external agencies to save lives and to prevent further fire spread

P_4 Compartmentation
Def: Extent to which building space is divided into fire compartments

P_5 Structure - separating
Def: Heat, smoke and fire resistance of building assemblies separating fire compartments

P_6 Doors
Def: Fire and smoke separating function of doors between fire compartments

P_7 Windows
Def: Windows and protection of windows, ie. factors affecting the possibility of fire spread through the openings

P_8 Facade
Def: Facade material, suppression system etc., ie. factors affecting the possibility of fire spread along the facade

P_9 Attic
Def: Prevention of fire spread to and in attic

P_{10} Adjacent buildings
Def: Minimum separation distance from other buildings

P_{11} Smoke control system
Def: Equipment and systems for limiting spread of toxic and corrosive fire products

P_{12} Detection system
Def: Equipment and systems for detecting fires

P_{13} Signal system
Def: Equipment and systems for transmitting an alarm of fire

P_{14} Escape routes
Def: Adequacy and reliability of escape routes

P_{15} Structure - load-bearing
Def: Structural stability of the building when exposed to a fire

P_{16} Maintenance and information
Def: Inspection and maintenance of fire safety equipment, escape routes etc. and information to occupants in suppression and evacuation

Grading schemes

P_1. LININGS IN APARTMENT

DEFINITION: Possibility of internal linings in an apartment to delay the ignition of the structure and to reduce fire growth

PARAMETER GRADE:
This refers to the worst lining class (wall or ceiling) that is to be found in an apartment.

LINING CLASS						GRADE
Suggestions to Euroclasses	Typical products	DK	FIN	NO	SWE	
A1	Stone, concrete	A	1/I	In1	I	5
A2	Gypsum boards	A	1/I	In1	I	
B	FR woods	A	1/I	In1	I	
C	Textile wall cover on gypsum board		1/II	In2	II	
D	Wood (untreated)	B	1/- 2/-	In2	III	
E	Low density wood fibreboard	U	U	U	U	
F	Some plastics	U	U	U	U	0

(Minimum grade = 0 and maximum grade = 5)

P_2. SUPPRESSION SYSTEM

DEFINITION: Equipment and systems for suppression of fires

SUB-PARAMETERS:

Automatic sprinkler system
Type of sprinkler (N = no sprinkler, R = residential sprinkler, O = ordinary sprinkler) and Location of sprinkler (A = in apartment, E = in escape route, B = both in apartment and escape route)

SURVEY ITEMS	DECISION RULES						
Type of sprinkler	N	R	R	R	O	O	O
Location of sprinkler	-	A	E	B	A	E	B
GRADE	N						H

(N = no grade, L = low grade, M = medium grade and H = high grade)

Portable equipment

N	None
F	Extinguishing equipment on every floor
A	Extinguishing equipment in every apartment

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES											
Automatic sprinkler system	N	N	N	L	L	L	M	M	M	H	H	H
Portable equipment	N	F	A	N	F	A	N	F	A	N	F	A
GRADE	0											5

(Minimum grade = 0 and maximum grade = 5)

P_3. FIRE SERVICE

DEFINITION: Possibility of external agencies to save lives and to prevent further fire spread

SUB-PARAMETERS:

Capability of responding fire service

CAPABILITY OF RESPONDING FIRE SERVICE	GRADE
No brigade available	0
Volunteer	
Part-time	
Professional	5

(Minimum grade = 0 and maximum grade = 5)

Response time of fire service to the site

RESPONSE TIME (min)	GRADE
> 20	0
15 – 20	
10 – 15	
5 – 10	
0 – 5	5

(Minimum grade = 0 and maximum grade = 5)

Accessibility (ie. number of sides of the building (0 - 4) that are accessible by the fire service ladder trucks)

ACCESSIBLE SIDES	GRADE
0	0
1	
2	
3	
4	5

(Minimum grade = 0 and maximum grade = 5)

Equipment (ie. if the ladder lengths are adequate in relation to the building height or not?)

SATISFACTORY EQUIPMENT	GRADE
No	0
Yes	5

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

$(a \times \text{Capability} + b \times \text{Response time} + c \times \text{Accessibility} + d \times \text{Equipment})$

where a, b, c and d represent the potential importance of each sub-parameter.
The range is 0 - 100 and the sum $a + b + c + d = 100$.

a =
b =
c =
d =

P_4. COMPARTMENTATION

DEFINITION: Extent to which building space is divided into fire compartments

PARAMETER GRADE:

MAXIMUM AREA IN FIRE COMPARTMENT	GRADE
> 200 m^2	0
100 – 200 m^2	
50 – 100 m^2	
< 50 m^2	5

(Minimum grade = 0 and maximum grade = 5)

P_5. STRUCTURE - SEPARATING

DEFINITION: Heat, smoke and fire resistance of building assemblies separating fire compartments

SUB-PARAMETERS:

Integrity and insulation

INTEGRITY AND INSULATION (EI)	GRADE
EI < EI 15	0
EI 15 ≤ EI < EI 30	
EI 30 ≤ EI < EI 45	
EI 45 ≤ EI < EI 60	
EI 60 ≤ EI	5

(Minimum grade = 0 and maximum grade = 5)

Firestops at joints, intersections and concealed spaces

STRUCTURE AND FIRESTOP DESIGN	GRADE
Timber-frame structure with voids and no firestops	0
Joints, intersections and concealed spaces are specially designed for preventing fire spread and deemed by engineers to have adequate performance.	
Joints, intersections and concealed spaces have been tested and shown to have endurance in accordance with the EI of other parts of the construction.	
Ordinary design of joints, intersections and concealed spaces, without special consideration for fire safety.	
Homogenous construction with no voids	5

(Minimum grade = 0 and maximum grade = 5)

Penetrations
Penetrations between separating fire compartments

PENETRATIONS	GRADE
Penetrations with no seals between fire compartments	0
Non-certified penetrations between fire compartments	
Certified penetrations between fire compartments	
Special installation shafts or ducts in an own fire compartment with certified penetrations to other fire compartments	
No penetrations between fire compartments	5

(Minimum grade = 0 and maximum grade = 5)

Combustibility
Combustible part of the load-bearing construction

COMBUSTIBLE PART	GRADE
Both load-bearing structure and insulation are combustible	0
Only the load-bearing structure is combustible	
Only the insulation is combustible	
Both load-bearing structure and insulation are non- combustible	5

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(a × Integrity and insulation + b × Firestops at joints, intersections and concealed spaces + c × Penetrations + d × Combustibility)

where a, b, c and d represent the per cent importance of each sub-parameter.
The range is 0 - 100 and the sum a + b + c + d = 100.

a =
b =
c =
d =

P_6. DOORS

DEFINITION: Fire and smoke separating function of doors between fire compartments

SUB-PARAMETERS:

Doors leading to escape route
Integrity and insulation (= EI)
(A = EI < EI 15, B = EI 15 ≤ EI < EI 30, C = EI 30 ≤ EI < EI 60, D = EI ≥ EI 60)
and Type of closing (M = manually, S = self-closing)

SURVEY ITEMS	DECISION RULES							
Integrity and insulation	A	A	B	B	C	C	D	D
Type of closing	M	S	M	S	M	S	M	S
GRADE	0							5

(Minimum grade = 0 and maximum grade = 5)

Doors in escape route
Integrity and insulation (= EI)
(A = EI < EI 15, B = EI 15 ≤ EI < EI 30, C = EI 30 ≤ EI < EI 60, D = EI ≥ EI 60)
and Type of closing (M = manually, S = self-closing)
If no doors are needed in the escape routes the highest grade (H) is received.

SURVEY ITEMS	DECISION RULES								
Integrity and insulation	A	A	B	B	C	C	D	D	-
Type of closing	M	S	M	S	M	S	M	S	-
GRADE	0								5

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(a $\times$ Doors leading to escape route + b $\times$ Doors in escape route)

where a and b represent the per cent importance of each sub-parameter.
The range is 0 - 100 and the sum a + b = 100.

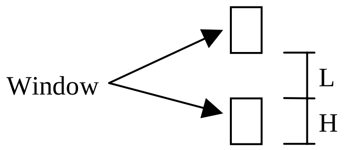
a =
b =

P_7. WINDOWS

DEFINITION: Windows and protection of windows, ie. factors affecting the possibility of fire spread through the openings

SUB-PARAMETERS:

Relative vertical distance
This is defined as the height of the window divided by the vertical distance between windows



Relative vertical distance, R = H/L
(A = R < 1, B = R ≥ 1)

Class of window
(C = window class < EI 15, D = window class ≥ EI 15, E = special design solution or window class ≥ EI 30)

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES					
Relative vertical distance	A	A	A	B	B	B
Class of window	C	D	E	C	D	E
GRADE	0					5

(Minimum grade = 0 and maximum grade = 5)

P_8. FACADES

DEFINITION: Facade material, suppression system etc., ie. factors affecting the possibility of fire spread along the facade

SUB-PARAMETERS:

Combustible part of facade

COMBUSTIBLE PART	GRADE
> 40 %	0
20 – 40 %	
< 20 %	
0 %	5

(Minimum grade = 0 and maximum grade = 5)

Combustible material above windows

COMBUSTIBLE MATERIAL ABOVE WINDOWS?	GRADE
Yes	0
No	5

(Minimum grade = 0 and maximum grade = 5)

Void
Does there exist a continuous void between the facade material and the supporting wall?

TYPE OF VOID	GRADE
Continuous void in combustible facade	0
Void with special design solution for preventing fire spread	
No void	5

PARAMETER GRADE:

(a × Combustible part of facade + b × Combustible material above windows + c × Void)

where a, b and c represent the per cent importance of each sub-parameter.
The range is 0 - 100 and the sum a + b + c = 100.

a =
b =
c =

P_9. ATTIC

DEFINITION: Prevention of fire spread to and in attic

SUB-PARAMETERS:

Prevention of fire spread to attic (eg. is the design such that ventilation of the attic is not provided at the eave? The most common mode of exterior fire spread to the attic is through the eave. Special ventilation solutions avoid this.)

N	No
Y	Yes

Fire separation in attic (ie. extent to which the attic area is separated into fire compartments)

MAXIMUM AREA OF FIRE COMPARTMENT IN ATTIC	GRADE
No attic	H
< 100 m^2	
100 – 300 m^2	
300 – 600 m^2	
> 600 m^2	L

(N = no grade, L = low grade, M = medium grade and H = high grade)

PARAMETER GRADE:

SUB-PARAMETERS	**DECISION RULES**						
Prevention of fire spread to attic	N	N	N	Y	Y	Y	Y
Fire separation in attic	N	L	M	N	L	M	H
GRADE	0						5

(Minimum grade = 0 and maximum grade = 5)

P_{10}. ADJACENT BUILDINGS

DEFINITION: Minimum separation distance from other buildings

PARAMETER GRADE:

DISTANCE TO ADJACENT BUILDING	GRADE
< 6 m	0
6 – 8 m	
8 – 12 m	
12 – 20 m	
> 20 m	5

(Minimum grade = 0 and maximum grade = 5)

P_{11}. SMOKE CONTROL SYSTEM

DEFINITION: Equipment and systems in escape routes for limiting spread of toxic fire products

SUB-PARAMETERS:

Activation of smoke control system

N	No smoke control system
M	Manually
A	Automatically

Smoke vent openings

C	Smoke vent openings near ceiling
O	Smoke vent openings near ceiling and at other levels
P	No openings, but mechanical pressurisation is provided

Means of smoke movement

M	Mechanical ventilation
N	Natural ventilation

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES										
Activation of smoke control system	N	M	M	M	M	M	A	A	A	A	A
Smoke vent openings	-	C	C	O	O	P	C	C	O	O	P
Means of smoke movement	-	M	N	M	N	-	M	N	M	N	-
GRADE	0										5

(Minimum grade = 0 and maximum grade = 5)

P_{12}. DETECTION SYSTEM

DEFINITION: Equipment and systems for detecting fires

SUB-PARAMETERS:

Amount of detectors
Detectors in apartment (N = none, A = at least one in every apartment, R = at least one in every room) and Detectors in escape route (N = no, Y = yes)

SURVEY ITEMS	DECISION RULES					
Detectors in apartment	N	N	A	A	R	R
Detectors in escape route	N	Y	N	Y	N	Y
GRADE	N					H

(N = no grade, L = low grade, M = medium grade and H = high grade)

Reliability of detectors
Detector type (H = heat detectors, S = smoke detectors) and Detector power supply (B = battery, P = power grid, BP = power grid and battery backup)

SURVEY ITEMS	DECISION RULES					
Detector type	H	H	H	S	S	S
Detector power supply	B	P	BP	B	P	BP
GRADE	N					H

(N = no grade, L = low grade, M = medium grade and H = high grade)

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES								
Amount of detectors	N	L	L	L	M	M	M	H	H	H
Reliability of detectors	-	L	M	H	L	M	H	L	M	H
GRADE	0									5

(Minimum grade = 0 and maximum grade = 5)

P_{13}. SIGNAL SYSTEM

DEFINITION: Equipment and systems for transmitting an alarm of fire

SUB-PARAMETERS:

Type of signal
Light signal (N = no, Y = yes) and Sound signal (N = no, A = alarm bell, S = spoken message)

SURVEY ITEMS	DECISION RULES					
Light signal	N	N	N	Y	Y	Y
Sound signal	N	A	S	N	A	S
GRADE	N					H

(N = no grade, L = low grade, M = medium grade and H = high grade)

Location of signal
Do you just receive a signal within the fire compartmentation or is it also possible to warn other occupants?

A	The signal is sent to the compartment only.
B	It is possible to send a signal to the whole building or at least to a large section of the building.

Activation of signal to the rest of the building
If the answer above is B; how is the signal being sent to the rest of the building?

M	Manually
A	Automatically

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES									
Type of signal	N	L	L	L	M	M	M	H	H	H
Location of signal	-	A	B	B	A	B	B	A	B	B
Activation of signal to the rest…	-	-	M	A	-	M	A	-	M	A
GRADE	0									5

(Minimum grade = 0 and maximum grade = 5)

P_{14}. ESCAPE ROUTES

DEFINITION: Adequacy and reliability of escape routes

SUB-PARAMETERS:

Type of escape routes
Staircase (A = one staircase may be used as an escape route, B = escape route leading to two independent staircases, C = direct escape to two independent staircases) and Window/Balcony (A = windows and balconies can not be used as escape routes, B = one window may be used as an escape route, C = at least two independent windows may be used as escape routes, D = the balcony may be used as an escape route, E = at least one window and the balcony may be used as escape routes)

SURVEY ITEMS	DECISION RULES												
Staircase	A	A	A	A	B	B	B	B	C	C	C	C	C
Window/Balcony	B	C	D	E	B	C	D	E	A	B	C	D	E
GRADE	0												5

(Minimum grade = 0 and maximum grade = 5)

Dimensions and layout
Maximum travel distance to an escape route (A < 10 m, B = 10 – 20 m, C > 20 m), Number of floors (A ≤ 4, B = 5 – 8) and Maximum number of apartments per floor connected to an escape route (A ≤ 4, B ≥ 5)

SURVEY ITEMS	DECISION RULES											
Travel distance to...	A	A	A	A	B	B	B	B	C	C	C	C
Number of floors	A	A	B	B	A	A	B	B	A	A	B	B
Number of apartments...	A	B	A	B	A	B	A	B	A	B	A	B
GRADE	0											5

(Minimum grade = 0 and maximum grade = 5)

Equipment
Guidance signs (A = none, B = normal, C = illuminating light), General lighting (A = manually switched on, B = always on) and Emergency lighting (A = not provided, B = provided)

SURVEY ITEMS	DECISION RULES											
Guidance signs	A	A	A	A	B	B	B	B	C	C	C	C
General lighting	A	A	B	B	A	A	B	B	A	A	B	B
Emergency lighting	A	B	A	B	A	B	A	B	A	B	A	B
GRADE	0											5

(Minimum grade = 0 and maximum grade = 5)

Linings
This refers to the worst lining class (wall or ceiling) that is to be found in an escape route (excluding the small amounts allowed by building law).

LINING CLASS						GRADE
Suggestions to Euroclasses	Typical products	DK	FIN	NO	SWE	
A1	Stone, concrete	A	1/I	In1	I	5
A2	Gypsum boards	A	1/I	In1	I	
B	FR woods	A	1/I	In1	I	
C	Textile wall cover on gypsum board		1/II	In2	II	
D	Wood (untreated)	B	1/- 2/-	In2	III	
E	Low density wood fibreboard	U	U	U	U	
F	Some plastics	U	U	U	U	0

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(a × Type of escape routes + b × Dimensions and layout + c × Equipment + d × Linings)

where a, b, c and d represent the per cent importance of each sub-parameter.
The range is 0 - 100 and the sum a + b + c + d = 100.

a =
b =
c =
d =

P_{15}. STRUCTURE - LOAD-BEARING

DEFINITION: Structural stability of the building when exposed to a fire

SUB-PARAMETERS:

Load-bearing capacity

LOAD BEARING CAPACITY (LBC)	GRADE
LBC < R 30	0
R 30 ≤ LBC < R 60	
R 60 ≤ LBC < R 90	
R 90 ≤ LBC	5

(Minimum grade = 0 and maximum grade = 5)

Combustibility
Combustible part of the load-bearing construction

COMBUSTIBLE PART	GRADE
Both load-bearing structure and insulation are combustible	0
Only the load-bearing structure is combustible	
Only the insulation is combustible	
Both load-bearing structure and insulation are non- combustible	5

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(a × Load-bearing capacity + b × Combustibility)

where a and b represent the per cent importance of each sub-parameter.
The range is 0 - 100 and the sum a + b = 100.

a =
b =

P_{16}. MAINTENANCE AND INFORMATION

DEFINITION: Inspection and maintenance of fire safety equipment, escape routes etc. and information to occupants on suppression and evacuation

SUB-PARAMETERS:

Maintenance of fire safety systems ie. detection, alarm, suppression and smoke control system

MAINTENANCE OF FIRE SAFETY SYSTEMS	GRADE
Carried out less than every three years	0
Carried out at least once every three years	
Carried out at least once a year	
Carried out at least twice a year	5

(Minimum grade = 0 and maximum grade = 5)

Inspection of escape routes

INSPECTION OF ESCAPE ROUTES	GRADE
Carried out less than every three years	0
Carried out at least once a year	
Carried out at least once every three months	
Carried out at least once per month	5

(Minimum grade = 0 and maximum grade = 5)

Information to occupants on suppression and evacuation

Written information (A = no information, B = written information on evacuation and suppression available in a prominent place in the building, C = written information distributed to new inhabitants) and
Drills (D = suppression drill carried out regularly, E = evacuation drill carried out regularly, F = suppression and evacuation drills carried out regularly)

SURVEY ITEMS	DECISION RULES								
Written information	A	A	A	B	B	B	C	C	C
Drills	D	E	F	D	E	F	D	E	F
GRADE	0								5

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(a × Maintenance of fire safety systems + b × Inspection of escape routes + c × Information),
where a, b, and c represent the per cent importance of each sub-parameter. The range is 0 - 100 and the sum a + b + c = 100.
a =
b =
c =

99-06-07 99004BR/BK

Addressee: Members of the Delphi panel for the project "Risk - Timber-frame Buildings"

LUND UNIVERSITY

Department of Fire Safety Engineering
Björn Karlsson

D04: Assigning Weights to Version 1.0 of the Index Method

This letter contains,

1. A description on how to assign weights to the most recent version of the Index method (Version 1.0).
2. A report on the response of the Delphi panel to document D03: Structure of the full index method.
3. The resulting Version 1.0 of the Index method

The Delphi panel agreed on the structure of the index method, but gave several comments. These comments have now been considered by the Project group and some changes have been made to the index method. The Project group has also given grades to the sub-parameters. Now the weights of the Objectives, Strategies and Parameters are required, and the weights in the grading equations of Parameters P_3, P_5, P_6, P_8, P_{14}, P_{15} and P_{16}.

Action required: You do <u>not</u> need to read through the report on the response to document D03, the report is enclosed here for those who are interested.

We ask you to read about the weighting process in this letter. We then ask you to look at Parameters P_3, P_5, P_6, P_8, P_{14}, P_{15} and P_{16} and give weights to the variables in the grading equations at the bottom of the page (variables a, b, and sometimes c and d) Please fill in the tables in Appendix A.

We then ask you to look at pages 1 and 2 in Version 1.0 of the Index method and give your weights to the Objectives, Strategies and Parameters as discussed in this letter. Please fill in the tables in Appendix B.

You are also welcome to offer further comments on the structure of the method and on the sub-parameter grades (which were given by the Project group).

My estimate is that this work should take roughly 4 hours, depending on your interest and your way of replying. Your comments can be sent to me through e-mail, you can fax hand-written notes to me or telephone me and give your comments orally. I will need your answer in two weeks time, or before Thursday 25th June.

Note: If you have mislaid documents, you can fetch them at our Web site, http://www.brand.lth.se, choose Forskning, choose Risk, then choose Timber-Frame Buildings – Risk.

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Assigning Weights to Version 1.0 of the Index Method

We will first ask you to assign weights to the grading equations for parameters P_3, P_5, P_6, P_8, P_{14}, P_{15} and P_{16}. Here the scale is 0% - 100%, but the sum of the weights for each parameter must be 100%.

We will then ask you to assign weights to the Objectives, Strategies and Parameters. Here the scale is 0 – 5, but the sum of the weights is not important.

1. Assigning weights to the grading equations for P_3, P_5, P_6, P_8, P_{14}, P_{15} and P_{16}.

Please turn to page 5 in Version 1.0 of the Index method. This shows Parameter P_3, Fire Service. Assign weights to the three sub-parameters: Capability, Response time and Accessibility and equipment.

Ask yourself: “How important is Capability in relation to the other two sub-parameters?” Your answer can be somewhere in the range 0% - 100%, but the sum of all three weights must be 100%. Do the same with the other sub-parameters and fill in the table in Appendix A.

2. Assigning weights to the Objectives, Strategies and Parameters.

We will here have to consider three levels in the hierarchy, these are,

- Objectives/Policy (2 weights must be assigned)
- Strategy/Objective (8 weights must be assigned)
- Parameter/Strategy (68 weights must be assigned)

Objectives/Policy: When assigning weights to Objectives you ask yourself “How important is Objective 1 (provide life safety) for achieving the Policy (provide acceptable fire safety level…)”. Here, you use a scale of 0 – 5 and the sum of the weights is not important.

The scale can be thought of as being the following:

0 = No influence at all
1 = Only of very slight importance
2 = Not important
3 = Important
4 = Very important
5 = Extremely important

As an example, let us imagine that Delphi member X feels that “Providing life safety” is extremely important for achieving our Policy, and that “Providing property protection” is important. This member will then give the following weights:

Objectives/Policy

	Policy
O1	5
O2	3

Note that the sum of the weights is not an issue!

Strategy/Objective: We then carry on to consider Strategies/Objectives. We must ask the following 8 questions:

1. How important is it to control fire growth by active means if we wish to provide life safety? (S_1/O_1)
2. How important is it to control fire growth by active means if we wish to provide property protection? (S_1/O_2)
3. How important is it to confine fire by construction if we wish to provide life safety? (S_2/O_1)
4. How important is it to confine fire by construction if we wish to provide property protection? (S_2/O_2)
5. How important is it to establish safe egress if we wish to provide life safety? (S_3/O_1)
6. How important is it to establish safe egress if we wish to provide property protection? (S_3/O_2)
7. How important is it to establish safe rescue if we wish to provide life safety? (S_4/O_1)
8. How important is it to establish safe rescue if we wish to provide property protection? (S_4/O_2)

We then fill our answers in the following table:

Strategy/Objectives

	O1	O2
S1		
S2		
S3		
S4		

Parameter/Strategy: We must now ask 64 questions, so only the first few will be shown here:

1. How important are linings in apartments if we wish to control fire growth by active means? (P_1/S_1)
2. How important are linings in apartments if we wish to confine fire by construction? (P_1/S_2)
3. How important are linings in apartments if we wish to establish safe egress? (P_1/S_3)
4. How important are linings in apartments if we wish to establish safe rescue? (P_1/S_4)

etc.

We can then fill our answers in a table

Parameters/Strategies

	S1	S2	S3	S4
P01				
P02				
P03				
P04				

Etc, etc

All three tables are given in Appendix B. Please fill in these and return to us.

Appendix A: Weighting of Sub-parameters in P_3, P_5, P_6, P_8, P_{14}, P_{15} and P_{16}

P_3, Fire Service

	Sub-parameter	% importance
a	Capability	
b	Response time	
c	Accessibility and equipment	

Sum = 100%

P_5, Structure - Separating

	Sub-parameter	% importance
a	Integrity and insulation	
b	Firestops at joints, intersections and concealed spaces	
c	Penetrations	
d	Combustibility	

Sum = 100%

P_6, Doors

	Sub-parameter	% importance
a	Doors leading to escape route	
b	Doors in escape route	

Sum = 100%

P_8, Facades

	Sub-parameter	% importance
a	Combustible part of facade	
b	Combustible material above window	
c	Void	

Sum = 100%

P_{14}, Escape route

	Sub-parameter	% importance
a	Type of escape routes	
b	Dimensions and layout	
c	Equipment	
d	Linings and floorings	

Sum = 100%

P_{15}, Structure – Load Bearing

	Sub-parameter	% importance
a	Load-bearing capacity	
b	Combustibility	

Sum = 100%

P_{16}, Maintenance and Information

	Sub-parameter	% importance
a	Maintenance of fire safety systems	
b	Inspection of escape routes	
c	Information	

Sum = 100%

Appendix B: Weighting of Objectives, Strategies and Parameters

Objectives/Policy

	Policy
O1	
O2	

Strategy/Objectives

	O1	O2
S1		
S2		
S3		
S4		

Parameters/Strategies

	S1	S2	S3	S4
P01				
P02				
P03				
P04				
P05				
P06				
P07				
P08				
P09				
P10				
P11				
P12				
P13				
P14				
P15				
P16				
P17				

Response of Delphi Panel to Document D03 (990607)

This document contains all comments and answers from 15 Delphi group members to document D03 “Structure of the full index method”. The comments were extremely helpful in developing the index method, resulting in what we now call Version 1.0. Many changes were made, but some changes must wait until the method has been tried in practice. In Phase 2 of the project we propose to investigate the feasibility of introducing some of these changes.

This page contains a summary of the main changes, several smaller changes were made and are described in the comments. Additionally, the Project group gave suggested grades to all sub-parameters.

Summary of changes made:

- P_1 Linings in apartment: Mainly small changes in the Finnish classes.
- P_2 Suppression system: Small editorial changes.
- P_3 Fire service: More or less completely redone, by suggestions from the Delphi panel.
- P_4 Compartmentation: Area range enlarged.
- P_5 Structure – separating: Slight change in definition, a number of editorial changes.
- P_6 Doors: Slight change in definition.
- P_7 Windows: Slight change in definition, a number of editorial changes.
- P_8 Facade: No change.
- P_9 Attic: No change.
- P_{10} Adjacent buildings: Change in definition and small editorial changes.
- P_{11} Smoke control system: One sub-parameter deleted as suggested by a number of Delphi members.
- P_{12} Detection system: Slight change in sub-parameter definition, some editorial changes.
- P_{13} Signal system: One sub-parameter deleted (activation of signal to rest of building, manual/automatic)
- P_{14} Escape routes: Several corrections and change of symbols, flooring added.
- P_{15} Structure - load-bearing: Small editorial changes
- P_{16} Maintenance and information: No changes.
- P_{17} Ventilation system: A new parameter as suggested by Delphi members earlier.

Delphi Member Comments

Delphi Member 1

Comments:

a) P_1: Row FIN (Finland) is wrong: untreated wood is 2/- (no 1/- !!!), D?, untreated particle board, plywood and fibre board (hard and medium), are 2/- , D?, low density fibre board (under 350 kg/m3) is in Finland -/- , E?
b) P_3: Is the range correct? If I understand right, the range 100 is possible to get on many ways.
c) P_4: Perhaps the m^2 values should be enlarged?
d) P_7: Are these values too easy/light?? The windows are so dangerous in the fire situations, that we must get a better solution than current regulations. More safe fire resistance windows will also result in better heat insulation and better sound insulation than current regulation.
e) P_{10}: The highest value should perhaps be > 25 m (instead of > 20 m).
f) P_{14}: See comment a), Row FIN is wrong.
g) P_{15}: The table on Combustibility may be too hard/tight.
h) P_{16}: The highest grade should perhaps be ”Carried out at least three times a year” = 5?

Project Group Proposal:

a) Correct, this has now been amended.
b) The range can be 0-1 or, if expressed as a per cent, 0-100%.
c) Yes, we have now extended this (see comments from Delphi members 5, 6 and 15).
d) The importance will be reflected in the weighting.
e) The Project group discussed this at length, 20m is perhaps too short, we will discuss this further.
f) Thank you, this is now corrected.
g) This can be amended by giving b a low value.
h) This was discussed in the project group and the general feeling is that we should not change this.

Delphi Member 2

Comments:

a) I generally agree with the structure of the parameters, sub-parameters, decision tables and grades. The decision tables are easy to understand and the grading system simple to use. The only specific comment I have is, that for P_5, P_8 and P_{15} the class of combustibility of the facades, structures and insulation will influence the grading. Therefore I suggest to include the class of the combustible products as for lining materials. Only to differ between combustible and non-combustible is too narrow.

Project Group Proposal:

a) The Project group finds this an interesting proposal, and will consider the inclusion of class in P_5, P_8 and P_{15} for the next version of the Index method (Phase 2 of this project).

Delphi Member 3

Comments:

a) P_7: Windows: A very important factor effecting fire spread outside is the window area. This should be included in the parameters.
b) P_8: Facade: It would necessary to define a sub-parameter to present different grades for the two basic cases of flashover fire and external fire source.

c) P_8: Facade: In the grades it is divided only to non-combustible (=A1, A2 in Euroclasses) and combustible (meaning wood, which is D class); how about class levels C and B?
d) P_8: Facade: Combustible material above window: should be defined on which level this 'yes/no' is valid.
e) P_8: Facade: Voids: It makes a difference where the void leads to (and if there is some concern of hazard/for instance if the requirement is that there should be no fire spread to the attic).
f) P_{14}: Escape routes: Linings: Add floorings; especially important for staircases.
g) P_{15}: Structure - load-bearing: Define the combustibility

Project Group Proposal:

a) Very many geometric parameters are important here. When trying to isolate the greatest importance, the Project group decided on window height and height to the above window. We will consider this further in Phase 2.
b) Traditionally, test methods for facades have concentrated on internal fire source. The external case is considered less severe. We will not consider the external source here, but will keep an eye on the possibility.
c) Good point, this increases complexity somewhat but should be considered in Phase 2.
d) This is quite relevant. However, very many different geometrical solutions are possible with respect to facades and the Project group suggests that we only have this very simple division into two cases.
e) This is quite relevant, but again, the solutions are infinite and the Project group favours this simple division.
f) Yes, we have now included floorings.
g) Definition will be given in the User's guide.

Delphi Member 4

Comments:

a) P_3, Fire Service: The sub-parameter Capability indicates a difference in quality between a part-time and a volunteer fire brigade. There is no reason for such a difference. Some countries have part-timers and some have volunteers because the legislation and tradition for organisation of fire services are different from country to country. As a fire fighting group the part-timers and volunteers are very similar. I propose a change to three alternatives: 1. No brigade available, 2. Part-time/volunteer, 3. Professional.
b) P_3, Fire Service: An important sub-parameter will be if the fire fighters can operate inside a building in fire or not. That means if they are competent breathing apparatus users ore not. This will be of importance both for saving lives and prevention of fire spread. I propose a new sub-parameter which reflects this.

Project Group Proposal:

a) These comments are very relevant and correct. This parameter has now been changed considerably, based on this and other Delphi member comments.
b) Same as proposal a) above.

Delphi Member 5

Comments:

a) P_3: Do all fire brigades have smoke divers? Access to water is also an important factor, how does this appear?
b) P_4: The method is applicable to apartments only. I assume that each apartment is a fire cell. Is it really so that a small apartment is more safe than a large apartment?

c) P_5: For how long should Integrity and insulation be upheld? Assuming all apartments to have an equal fire load (per floor area), will the safety be better the longer this is upheld? The fuel is limited and may not last the long times given in the table.
d) P_5: Combustibility: I assume this refers to the structure of the separating construction and not the load-bearing construction. Does combustibility have any influence then? But this could possibly be addressed through the grading later.
e) P_7: The relative relationship between window height and vertical distance is simple but is this the whole truth? Doesn't the width have an influence, especially if both windows have different widths?
f) P_8: When discussing facades, there have been discussions on horizontal hindrance, like balconies, that stop or hinder the flames in travelling up the facade. Will this not be taken account of?
g) P_{10} should be formulated differently. An alternative to separating distance between buildings is to build a separating wall to hinder fire spread, for example a fire wall. P_{10}: Is the distance really the only parameter? How do you grade a fire wall?
h) P_{14}: Dimensions and layout: Is the grading correct? Short distance, few floors and few apartments is the best case, not the worst as shown in the table. See also comment below.
i) P_{14}: Linings: Doesn't the floor material have any influence?
j) P_{15}: From a load-bearing aspect I am not certain if we can say that a non-combustible construction (for example steel beam) is more safe than a combustible construction (for example laminated timber beam). I am sceptical with respect to combustibility. In our functionally based codes combustibility of load-bearing constructions has lost influence. Here we take this up again. Should this be done? Another aspect that needs to be looked at is the contribution of the whole construction to the fire load, not only the load-bearing part.
k) I have a problem with the logic of having a risk index where a high number represents a safe construction and a low number a less safe construction. It is more logical that a low number represents low risk.

Project Group Proposal:

a) Yes, correct. See proposal a) and b) from Delphi member 4.
b) Apartments have similar fire load/m^2, small apartment therefore a smaller total fire load. The Project group wants to keep this parameter unchanged.
c) Yes, we give higher grades to long Integrity and insulation. The times may be somewhat long, but the Project group supports this.
d) ????
e) There are very many geometrical configurations possible here. The Project group found that the single most important parameter was the relative distance to the next window. Width does also come into this, we will look a bit closer into this in Phase 2. See also proposal a), Delphi member 3.
f) This is an important factor, especially for balconies. This will be addressed in Phase 2.
g) A valid comment. For now, we will change the definition and say that a fire wall is equivalent to an 8m distance, and consider this parameter further in Phase 2.
h) Very good point. This will be corrected.
i) Correct, we have now added this.
j) This is a very important discussion. Why is steel more safe than laminated timber if they both have the same performance when tested? The project group wants this in, the importance can be given in the constants a and b.
k) We have followed what is common in other index methods for fire safety. The Project group therefore proposes no change. But we understand this point very clearly and will discuss it in Phase 2.

Delphi member 6

Comments:

a) P_2, Suppression system: In the parameters for Portable equipment one does not distinguish between hoses and hand-held extinguishers. I feel that it may be more difficult to extinguish a fire with a hand-held extinguisher than with a hose. Could this be distinguished?

b) P_3, Fire service: Ladder-trucks can be a help in the rescue and extinguishing work, but it is not good to put too much emphasis on the accessibility of a ladder-truck. Parked cars and other objects are often a hinder for ladder-trucks, even though there is unrestricted access in theory.

c) P_4, Compartmentation: I do not think that the size of the fire cell constitutes a great difference in the risk for fire spread through fire cells, this can possibly have some influence if the apartments are larger than $200m^2$ or larger (can be more difficult to extinguish). There are other parameters that are more important, for example vertical distance through windows and possible constructional faults in the separating structure. Life safety should be the same in large and small apartments if there are alarm systems and detectors.

d) P_5, Structure – separating: Is a lower class than EI30 really used in our type of construction? Is combustible insulation really used sometime? If these are not commonly used in design, they should not be shown here.

e) P_6, Doors: Fire-classed doors in our types of buildings are mainly stairway doors. Is it realistic to have doors in the stairway that have a lower class than EI30?

f) P_7, Windows: The vertical distance through windows in difference fire cells is decisive for how quickly the fire spreads. Usually the fire will spread quicker on the facade than inside the building, if we assume that the fire cells do not have faults. Fire-classed glass in the facade in apartments is generally not used since one must be able to open the windows. I feel that sprinklers should be taken account of in this parameter. If the building has a sprinkler system I feel that there is little need to set demands on heights or fire classes where the sprinkler operates.

g) P_9, Attic: Just a note: In Norway, $400m^2$ is the maximum floor area for a fire cell in an attic

h) P_{11},Smoke control system: I feel that one should not have an automatic start or opening of ventilation in stairways, if this creates under-pressure in the stairway. One should rather use pressurisation.

i) P_{15}, Structure - load-bearing: Is a lower load-bearing class than R30 really ever used in our type of building?

Project Group Proposal:

a) This is a valid point and has briefly been discussed earlier in the Project group. We will not make changes now, but discuss this further in the next Phase.

b) Very good point, this has now been changed, see proposal a and b from Delphi panel member 4

c) Delphi panel member x also has this feeling. The importance of this can be toned down in the weighting process.

d) This was discussed at some length by the Project group. There are some differences in regulation and practice in the Nordic countries, which indicate that we should not make changes here. But we will have a look at this and some of the following points in the next Phase.

e) See proposal d)

f) This is a very valid point and has been discussed in the Project group. It may be clearer to bring the sprinkler into this parameter, but instead the sprinklers influence can instead be enhanced when giving weights to the parameters (giving sprinkler a high weight for controlling fire growth). See also proposal e) from Delphi member 5 and proposal a) from Delphi member 3.

g) We use $600m^2$ due to other national regulations.

h) A valid point, but some combinations of these active tactics are often used in design, so we shall leave this as it is.

i) See proposal d)

Delphi Member 7

Comments:

a) P_5, Structure – separating: In the definition you mention heat resistance and smoke resistance. EI and E do not provide any smoke tightness.
b) P_5, Structure – separating: In table Firestops... the second and the fourth box could change places.
c) P_5, Structure – separating: Table Combustibility... This must be question of separating structures and not load-bearing structures.
d) P_6, Doors: Here again I have difficulties to understand smoke separation. EI or E classed doors are not necessarily smoke separating.
e) P_6, Doors: Table Doors in.... I have difficulties to understand what are doors IN escape route. That is probably because I do not know what you mean by the definition escape route in this project.
f) P_7, Windows: What about open windows. In our regulations about dwellings it is said that in every dwellingroom there has to be at least one window that can be opened.
g) P_8, Facade: Balconies should also be mentioned here.
h) P_{14}, Escape routes: There should be a definition for escape route. Types A and C are clear but not type B. What is in that case escape route and what is maximum travel distance? Is there some kind of corridor and is this corridor part of the escape route or not?
i) P_{14}, Escape routes: Table Dimensions ..should be the other way round.

Project Group Proposal:

a) This is correct, we have dropped smoke from the definition.
b) Yes, you are correct, we will change this.
c) Yes, you are correct, we will change this.
d) Correct, see proposal a) above.
e) We will define escape routes better in the User's guide
f) Yes this is the most common way of designing apartment buildings; windows that can be opened. But the option for closed windows is still there.
g) Yes, balconies and such measures should be taken into account, we shall do this in Phase 2
h) Yes, we will define escape routes better, see proposal e)
i) Yes, you are correct, we will change this.

Delphi Member 8

Comments:

a) P_1 (and P_{14}): Not only the materials but also the surfaces should be included here. This should also include different rooms in the apartment (the definition in P_5 could be changed to a different separation that "fire compartment”).
b) P_2: If portable equipment is mentioned then risers (stigrör or stigarledning) should also be mentioned. Sprinklers in other compartments, such as garbage rooms, could also be mentioned.
c) P_3: Water supply for fire brigade use is not specified,
d) Whether the brigade is volunteer, part-time or professional is not a very good measure of amount, equipment and endurance.
e) P_3: Distance from brigade parking to the entry is also relevant, the number of accessible sides for ladders is irrelevant and should be changed to a question on whether the ladders can reach the necessary rescue openings. The question on ladder length seems superfluous, either the house may not be built (building regulation) since the height is greater then the brigade ladder capacity or the brigade must buy ladders that fill the demand.

f) P_3: The possibility for the brigade to bring hoses to the apartment through for example “durchsigt” or stairway windows may also be of relevance.
g) P_4: The internal division into rooms does also have an influence on fire spread and possibilities for reaching a window or a door. In the Danish traditional regulation this is $150m^2$.
h) P_6: Self-closing (to what degree) should be defined. Doors leading to escape route – is this in or between fire compartments?
i) P_7: This assumes that the windows lie in a row directly above one another, which is not at all always the case. The question of windows in corners etc has an influence, as well as balconies etc.
j) P_8: The amount of combustible material and whether this is above the windows, is of such great importance that the two first sub-parameters should be combined.
k) P_9: Fire spread to the attic does not just happen through the eaves, this can also happen through stairways, ducts and penetrations. Should the fire spread be “to and from” the attic?
l) P_{10}: 2,5 – 5 and 10 m are the traditional numbers used in Denmark (even though there is no higher wisdom behind these numbers)
m) P_{11}: If by “Natural ventilation” you also mean exits through for example balconies where a smoke control system has no meaning, then the grading is wrong.
n) P_{12}: Can the combination of P_2 and P_{12}, with for example sprinkler in the apartment and smoke detectors in the escape routes, be given the necessary weights, using this division?
o) P_{13}: The activation of “signal system” can be through suppression and detection system as well as manually. How is the possible alarm to the fire brigade included in the different variations of the above?
p) P_{14}: I need an explanation of what is meant by “windows and balconies can/can not be used as escape routes”. Should the person be able to draw attention, be able to be saved by the fire brigade, be able to self reach safety or be able to keep safe on the balcony?
q) P_{14}: Distance to escape route: Is this inside the apartment or from the apartment to the stairway? Shouldn’t the case where access to the staircase is through a protected lobby or where the staircase is also connected to other building parts, such as cellar or garbage room?

Project Group Proposal:

a) The EU is currently considering the inclusion of “Fire Protection Ability” (tändskyddande beklädnad) into their system, we will await the outcome. The Project group considered it too complex to consider each room in the compartment, we will stick to fire compartments.
b) Yes, risers (rising main, stigrör (Danish), stigarledning (Swedish)) can be designed into the building, this could be an option. We will consider including this in the next Phase.
c) The Project group considered this and found that the supply regulations in the Nordic countries are fairly standardised and there would be small differences in this term.
d) Yes, you are right, we will change the parameter.
e) Yes, you are right, we will change the parameter
f) Yes, we will consider this in the next Phase, see proposal b) above.
g) Yes, but the choices are very many, we will not change this.
h) We will consider whether we divide self-closing into different categories in the next Phase. This is an important sub-parameter. Escape routes will be better defined in the User’s guide.
i) The geometric possibilities are far too many here, we will keep this assumption.

j) This can be taken account of trough the weighting process and by assigning numbers to a, b and c at the bottom of page 12.
k) We have specially looked at the spread risk through the eaves, since this is relatively common. We have here assumed that the attic is separated from the rest of the building as the building code requires in all the Nordic countries. Fire spread through joints, penetrations, etc, is reflected in other parameters. This will be reconsidered in Phase 2.
l) Yes, the numbers were discussed in the Project group and the Nordic members suggested these numbers, we will keep them
m) Yes, a definition or some guidance should be provided here, these must be designed smoke vents.
n) Yes, the necessary weights can be given and should reflect this. We will keep an eye on this aspect and see that it comes out reasonably.
o) There are very many combinations here, we will keep it as it is. The Project group discussed the possibility of direct alarm to the fire brigade from apartment buildings and found that it was not realistic, due to factors such as false alarms, etc. We will discuss this further.
p) Some guidance may be needed here. In some cases, a secondary escape route is allowed through windows and balconies depending on the fire brigade ladder capacity. This is what is meant here.
q) The escape route distance must be defined better. We have used the BBR94 definitions here, this must be clearly stated.

Delphi Member 9

Comments:

a) General comment: There are several sub-parameters and survey items, which do not meet the building codes. I suppose that’s the way it is meant to be, because we are searching a different approach to problem. Still, there shall not exist a possibility to use solutions below certain minimum level. That is, for example, using plastics in P4 and P14, penetrations without any seals and voids without firestops in P5 and leaving smoke control system out in P11 and so on...
b) P_1: Disagree: this parameter is impossible to control. Untreated wood falls in class 1/- only in special cases, not always in 2/- either. There are only few methods which makes FR-wood to fall in class 1/I.
c) P_2: It’s difficult to judge, which combination is better than another in the first table. Anyway, it’s clear that for example ordinary sprinkler only in escape routes is worse than residential sprinkler in both A and E. I propose that we leave out option to use sprinkler only in E. My suggestion to the first table is: N R O R O - A A B B
d) P_3: Response time itself is not able to save lives or buildings. It is important to have enough manpower to save people and to extinguish the fire. I suggest that we modify the definition of second table: Response time of fire service to have manpower of 1+3+18 on site.
e) P_3: Third and fourth table should be combined. There is no meaning to access to all sides, if we don’t have ladders. If the ladder length is not adequate, it will lead to grade 0 in accessibility table.
f) P_3: In big fires it is important to have very much water. I suggest that we add a table of water pipes where hydrants are connected. Classification could be something like this:

<Ø200 grade 0
Ø200 - 300
Ø300 - 400
Ø400 - 600

>Ø600 grade5

g) Yes, Ø600 is a huge pipe, but in case there are several building in fire you simply need tons of water. This is a suggestion of our fire officers.
h) P_7: E = tested special design solution or ...
i) P_7: If A=R<1, then A is better than B and A and B are in wrong order in parameter grade table.
j) P_7: Combination AE certainly works better than BC in parameter grade table. I suggest that we modify the table as follows:

   A B A B A B
   C C D D E E
k) P_{10}: I suggest that the lower part of table is modified as follows:

   20 - 40 m
   40 m grade5
l) In a big fire especially with wooden facades even 40m separation distance is not enough.
m) P_{11}: There shall be a smoke control system in escape routes. So delete the first option in the first table.
n) P_{11}: Combine tables 2 and 3 as follows:

   N - Natural ventilation trough openings near ceiling
   M - Mechanical ventilation
   NP - Natural ventilation with pressurisation
   MP - Mechanical venting + pressurisation
o) Natural ventilation works best when there are no openings between ground level and ceiling level. Mechanical ventilation works better than natural during windy days and inversion.
p) P_{12}: There is no meaning to put detector in every room. Also, it is better to have one detector in every apartment and in escape routes than in every room without escape routes. Modify the table as follows:

   N N A R A R
   N Y N N Y Y
q) P_{13}: There is no idea with signal system without any signal. Delete the NN combination in first table.
r) P_{13}: It's not a good idea to automatically send alarm (especially with smoke detectors) to whole building. Delete the third table.
s) P_{14}: This is a mess. A and B are in the wrong order in number of floors and apartments. You should not have more than 5 floors in these buildings. There is no logic in second table.
t) P_{14}: See comments in P_1.

Project Group Proposal:

a) Yes, this is a very valid comment and the issue was discussed in detail in the Project group. The index method is mainly intended for use in the Nordic countries, but is also to be used internationally. Since building codes are very different, it is sometimes difficult to decide what to include. There are also some inconsistencies between the parameters, as to what is included. Another reason for having unacceptable design details in the method is that we can use the weighting to see how important certain fire protection issues may or may not be. This should be reviewed very carefully in Phase 2.
b) Yes, there are some inconsistencies between the Finnish system and the EU system, this has now been amended. Otherwise, the Project group believes that this parameter can be checked.
c) The issue of whether sprinkler only in E should be omitted was discussed in the Project group and we wish to keep it there. The order of the letters in the

decision table is sometimes not directly from low to high, and in this case it is not so. So we will keep it like this for the moment.

d) Yes, you are right, this has now been changed.
e) Yes, you are right, this has now been changed.
f) Initially the Project group assumed water supply not to vary very much within the Nordic countries. But other comments (see comment a), Delphi member 5) indicate that we should consider this for Phase 2.
g) Yes, we will add the word “tested” in the description.
h) Yes, you are correct. We will simply switch the L and H in the equation and then it will be correct.
i) See proposal h). This is amended now.
j) This was discussed in the Project group, we will leave it as it is for now but discuss the possibility of change in Phase 2. See also proposal e), Delphi member 1.
k) Good point, but we will leave it as it is even though this does not fulfil the building code. See proposal a) above.
l) Thank you, your proposal was very good and we have adopted it.
m) Correct, we have now changed this by saying “more than one detector in each apartment”
n) Yes this seems illogical but this is just so that a 0 grade is possible in the last table.
o) We have had this response from another Delphi member and will delete this. See proposal l), Delphi member 15.
p) Yes, you are right, we have now made the corrections.
q) See proposal a)

Delphi Member 10

Comments:

a) P_1: Linings in apartment. The definition is wrong here since it adds to the Euroclasses that they include protection of the material behind the linings (structure). This is because the classification only deals with reaction-to-fire material properties such as ignition, heat release and smoke production. Therefore the parameter grade should only be valid to “reduce fire growth” and not to “delay ignition of the structure”.

Project Group Proposal:

a) You are correct, there is really no “fire protection ability” included in the Euroclasses. However, materials that fall in classes A1, A2 and B do to some degree protect against structure ignition (A1 and A2 non-combustible) and we will therefore leave this here. Later, we will look at the possibility of including “fire protection ability” into the system.

Delphi Member 11

Comments:

a) P_5: The order should be changed in table "Structure and ..."
b) to 1 4 2 3 5 and in table "Combustible..." to 1 3 2 4

Project Group Proposal:

a) Yes, you are correct, this will be changed.

Delphi Member 12

Comments:

a) P_3: Fire service, sub-parameter Accessibility: Often the main problem is different obstacles like snow, wrong parked cars etc.

b) P_4: compartmentation: Should we take account of the shape of the compartment in some way (very simple or very complicated geometry)?
c) P_7: Windows: How do we take account of fire stops above or below windows (small sills that stick out from the facade)
d) P_9: Attic: How can we take account of different shapes of attics? Very high at the eaves, very low at the eaves. Similarly, very simple or very complicated geometry

Project Group Proposal:

a) Yes, this is correct, the parameter has now been changed.
b) Again the possibilities are very many and at the moment we must opt for simplicity.
c) Yes, good point, we must consider balconies in Phase 2.
d) A good question. The Project group found the complexity to be very great and we therefore decided on this simple division.

Delphi Member 13

Comments:

a) P_4: Compartmentation: Considering whether lives should be saved or not in the fire compartment, it would be natural to divide this into two levels:
    - Number of apartments in fire compartment 1, 2, 3……
    - Area m^2 <50, 50-150, >150
b) P_5: Structure-separating: Combustibility should be defined from f.ex. energy content and ignitability. Wood can be used as a reference
    - greater combustibility than wood
    - lesser combustibility than wood
c) P_6: Door: Doors can have higher EI than structure (EI≥EI60). This should not be.
d) P_7: Windows: Is this wrong? Should it be L/H and not H/L? I also think that it is the absolute height of L which controls this sub-parameter.
e) P_8: Facades: Sub-parameter SP2: Combustible material above windows: Couldn't Euroclass A or B be inserted into this table?
f) P_8: Calculation of the grade should be
    a*SP1 + b* SP2 + c*(5-SP2)
    - for example, if there is no combustible material, it doesn't matter if the material is above the window or not, and it doesn't matter if there is a void or not.
g) P15 Structure-load bearing: Combustibility, see comments to P_5

Project Group Proposal:

a) The Project group will consider this for Phase 2
b) Yes, a new level could be introduced into this sub-parameter where you first indicate the degree of combustibility and then which part of the structure this refers to. This increases complexity, we will consider this in Phase 2.
c) Yes, you are correct. Both separating structure and doors can now be EI>60.
d) Yes, you are correct, this has now been changed.
e) Yes, this could be necessary, we will consider this in Phase 2.
f) A good point, but this can be combined in many ways, the Project group favours no change for now. No combustible material above windows must be reflected in the weights a, b, c.
g) See proposal b) above.

Delphi Member 14

Comments:

a) P_1: Results from the Cone Calorimeter could be much more helpful here.
b) P_2: Sprinkler either works or not, residential sprinklers are designed to suppress a fire quickly, it doesn't get much better than that. Ordinary sprinkler creates more water

damage. If there is no combustible material in the escape routes, then you don't need sprinkler there.

c) P_5: Firestops at joints, intersections and concealed spaces: Performance criteria must be applied here.
d) P_5: Penetrations: What is a non-certified penetration? Do you mean a non-certified sealing system? Also, is it possible to build a dwelling without service penetrations between fire compartments?
e) P_5: Combustibility: This is not based on performance. Load bearing structures of wood is probably more sensitive to fire than bare steel.
f) P_6: Doors: This parameter depends very much on location and function of door. Type of closing is very important.
g) P_7: Windows: The height of the flames depend on the contents of combustibles
h) P_8: Facades, sub-parameter Combustible part of facade: To give a % is not enough, this depends very much on location.
i) P_{10}: Adjacent buildings: Depends on height and facade combustibility.
j) P_{12}: Detection system, sub-parameter Amount of detectors: Why should detectors be in escape routes?
k) P_{12}: sub-parameter Reliability of detectors: This depends on the situation.
l) P_{13}: Signal system, sub-parameter Type of signal: Light signal is not effective if people are asleep.
m) P_{14}: Escape routes: Anything worse than Class B should not be used in escape route
n) P_{15}: Structure - load bearing: Any structure in a multi-storey building must have a fire resistance of at least 60 minutes. Otherwise we cannot expect any rescue operation in case of a sever fire
o) See also comments on P_5
p) P_{16}: Maintenance and information: Inspections more than once a year adds very little to the safety.

Project Group Proposal:

a) Yes, we agree, but there is no accepted simple way of using the Cone results available now. This table is the best we can do for now. We will possibly add “fire protection ability” (tändskyddande beklädnad) later.
b) Yes, this may be true. But these possibilities do occur in practice although some options are seldom observed. The fact that ordinary sprinkler may not do more good than residential sprinkler must be expressed in the grades.
c) Performance criteria are of course the best way, but they demand calculations. We must provide a much easier way of judgement for the users of this method. Since the possible solutions are very many, the Project group has decided on this relatively simple format.
d) Yes, correct, we will change the wording and call this a non-certified sealing system. The possibility of a dwelling without penetrations was discussed by the Project group, this is a remote possibility but may be useful for giving grades.
e) Yes, this may be so, and the grading in the table reflects this. On performance, see proposal d).
f) Yes this is now corrected, see proposal h), Delphi member 8.
g) Yes, this is so. But specifying contents would be too detailed.
h) Yes, the location is of great importance. The Project group has discussed this at length and has tried to express this by having two sub-parameters, one with % and one with location. The possible geometric configurations are far to numerous for a more detailed specification.
i) Yes, this is true. The Project group discussed this at length but found that the combinations of height and combustible part were very many. The group opted for this simple solution. We will have a closer look at this parameter in Phase 2.
j) The project group discussed this as a possible way of signalling to other apartments.
k) Yes, it does. The Project group found that there are some general trends indicating that it is suitable to organise the sub-parameter according to the table.

l) Yes, correct, light signals only work if people are awake, there was a considerable discussion in the Project group on deaf people and this item is therefore included. But instead, light signal only gets no grade.
m) Yes, this is correct, but in some of the parameters we go beyond what is allowed in the building codes. The Project group must further discuss the connection between the index method and the building code.
n) See n) above.
o) See d) above.
p) The Project group discussed this, there was some difference in opinion on this number but we agreed and will leave it as it is. The importance can be given by grades or weights.

Delphi Member 15

Comments:

a) General: I would like to suggest a mayor structural change, even though this may be too late now. The parameters can really be divided into two groups a) building specifics and b) systems for fire safety. I would much rather see parameters that have to do with the cellar, the attic, the apartments, the escape routes and the stairways. These then have sub-parameters that have to do with linings, suppression systems, compartmentation, structure, doors. windows, smoke control, detection, signal systems. Other parameters would be fire service, facade, adjacent buildings, escape routes and maintenance and information. This could possibly be considered in future work.
b) Also the class E is nowhere mentioned, only EI. Some building parts have only E class.
c) P_1 Linings: Ignition resistance (tändskyddande beklädnad) is missing here. Should be incorporated.
d) P_2 Suppression system: Residential sprinkler has a low RTI value (quick response time) and low capacity but ordinary sprinkler has high capacity and either high or low RTI value. Could one specify this in terms of low/high RTI and low/high capacity?
e) P_3 Fire service: Volunteer/part-time/professional is not a good way to describe capability. This should rather be a) Fire fighting capability only outside the building, b) Fire fighting capability but no smoke diving capability c) Fire fighting and smoke diving capabilities d) Simultaneous fire fighting, smoke diving and external rescue by ladders.
f) P_3: Accessibility should be called Accessibility and equipment and should be divided into a) All windows accessible by fire service ladder b) one window in each apartment is accessible by fire service ladders c) less than one window in each apartment accessible by fire service ladders. Sub-parameter Equipment can then be deleted.
g) P_3: Fire service, the definition should replace "external agencies" with "fire services"
h) P_4 Compartmentation: This should have a larger range, I suggest > 400 m^2 as the largest area.
i) P_7 Windows: this should be called "Windows and other facade openings"
j) P_{11} Smoke control systems: remove "and corrosive" from definition on page 2
k) P_{11}: Smoke vent openings: The second term should be “Smoke vent openings not near ceilings but at other levels. Smoke ventilation does not work well if you have an opening at the ceiling and also at other levels, the pressure drop will diminish the flow of smoke out.
l) P_{13}: Activation of signal to the rest of the building: I don’t think that an automatic signal to the rest of the building works in practice, remove this option.
m) P_{14}: Type of escape route: You should add another type of staircase: staircase through a protected lobby.

Project Group Proposal:

a) This is an interesting suggestion, we know that there are specific design solutions in different parts of the building (cellar, attic, etc). Before making any changes in this direction we must try to apply the method. The Project group will consider this very seriously in the next Phase.
b) Yes, we will change this where we can, especially in P_7 Windows. But there are some overlaps where it would be to complex to take account of both EI and E.
c) Yes, fire protection ability, see comment a) from Delphi member 2.
d) Yes, we will consider this seriously for the next version.
e) Thank you, a very good proposal, we have now adopted it.
f) Thank you, a very good proposal, we have now adopted it.
g) Yes, this will be done.
h) This was discussed in the Project group and we found that an apartment area of $200m^2$ is rarely exceeded in practice. However, some kind of a common area in the apartment building might exceed this limit. We will consider this for the next phase.
i) Yes, we will change this.
j) Yes, this will be done.
k) Yes, we have now changed this, se also proposal l), Delphi member 9.
l) Yes, we have now removed this, see also proposal o), Delphi member 9.
m) This was discussed in the Project group, due to differences in regulations between the Nordic countries we will leave this for the moment but will strongly consider changing this in the next Phase.

Risk - Timber-frame Buildings

Version 1.0 of the Index Method (990607)

This is Version 1.0 of the Risk Index method for timber-frame buildings. The list below presents different decision levels; Objectives, Strategies and Parameters. The parameter grades are calculated by using the grading schemes presented in this paper. In the grading schemes the two lowest decision levels are used; Sub-Parameters and Survey Items. Currently, we shall only consider ordinary occupancies, later we may expand to include occupancies such as homes for the elderly.

Policy:

Provide acceptable fire safety level in multistorey apartment buildings

Def: Multistorey apartment buildings shall be designed in a way that ensures sufficient life safety and property protection in accordance with the objectives listed below.

Objectives:

O_1 Provide life safety

Def: Life safety of occupants in the compartment of origin, the rest of the building, outside and in adjacent buildings and life safety of fire fighters

O_2 Provide property protection

Def: Protection of property in the compartment of origin, in the rest of the building, outside and in adjacent buildings

Strategies:

S_1 Control fire growth by active means

Def: Controlling the fire growth by using active systems (suppression systems and smoke control systems) and the fire service.

S_2 Confine fire by construction

Def: Provide structural stability, control the movement of fire through containment, use fire safe materials (linings and facade material). This has to do with passive systems or materials that are constantly in place.

S_3 Establish safe egress

Def: Cause movement of occupants and provide movement means for occupants. This is done by designing detection systems, signal systems, by designing escape routes and by educating or training the occupants. In some cases the design of the escape route may involve action by the fire brigade (escape by ladder through window).

S_4 Establish safe rescue

Def: Protect the lives and ensure safety of fire brigades personnel during rescue. This is done by providing structural stability and preventing rapid unexpected fire spread and collapse of building parts.

Parameters:

P_1 Linings in apartment
Def: Possibility of internal linings in an apartment to delay the ignition of the structure and to reduce fire growth

P_2 Suppression system
Def: Equipment and systems for suppression of fires

P_3 Fire service
Def: Possibility of fire services to save lives and to prevent further fire spread

P_4 Compartmentation
Def: Extent to which building space is divided into fire compartments

P_5 Structure - separating
Def: Heat, smoke and fire resistance of building assemblies separating fire compartments

P_6 Doors
Def: Fire and smoke separating function of doors between fire compartments

P_7 Windows
Def: Windows and protection of windows, ie. factors affecting the possibility of fire spread through the openings

P_8 Facade
Def: Facade material, suppression system etc., ie. factors affecting the possibility of fire spread along the facade

P_9 Attic
Def: Prevention of fire spread to and in attic

P_{10} Adjacent buildings
Def: Minimum separation distance from other buildings

P_{11} Smoke control system
Def: Equipment and systems for limiting spread of toxic fire products

P_{12} Detection system
Def: Equipment and systems for detecting fires

P_{13} Signal system
Def: Equipment and systems for transmitting an alarm of fire

P_{14} Escape routes
Def: Adequacy and reliability of escape routes

P_{15} Structure - load-bearing
Def: Structural stability of the building when exposed to a fire

P_{16} Maintenance and information
Def: Inspection and maintenance of fire safety equipment, escape routes etc. and information to occupants in suppression and evacuation

P_{17} Ventilation system
Def: Extent to which the spread of smoke through the ventilation system is prevented.

Grading Schemes

P_1. LININGS IN APARTMENT

DEFINITION: Possibility of internal linings in an apartment to delay the ignition of the structure and to reduce fire growth

PARAMETER GRADE:
This refers to the worst lining class (wall or ceiling) that is to be found in an apartment.

LINING CLASS						GRADE
Suggestions to Euroclasses	Typical products	DK	FIN	NO	SWE	
A1	Stone, concrete	A	1/I	In1	I	5
A2	Gypsum boards	A	1/I	In1	I	5
B	Best FR woods (impregnated)	A	1/I	In1	I	4
C	Textile wall cover on gypsum board		1/II 2/-	In2	II	3
D	Wood (untreated)	B	1/-	In2	III	2
E	Low density wood fibreboard	U	U	U	U	1
F	Some plastics	U	U	U	U	0

(Minimum grade = 0 and maximum grade = 5)

P_2. SUPPRESSION SYSTEM

DEFINITION: Equipment and systems for suppression of fires

SUB-PARAMETERS:

Automatic sprinkler system
Type of sprinkler (N = no sprinkler, R = residential sprinkler, O = ordinary sprinkler) and Location of sprinkler (A = in apartment, E = in escape route, B = both in apartment and escape route)

SURVEY ITEMS	DECISION RULES						
Type of sprinkler	N	R	R	R	O	O	O
Location of sprinkler	-	A	E	B	A	E	B
GRADE	N	M	L	H	M	L	H

(N = no grade, L = low grade, M = medium grade and H = high grade)

Portable equipment

N	None
F	Extinguishing equipment on every floor
A	Extinguishing equipment in every apartment

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES											
Automatic sprinkler system	N	N	N	L	L	L	M	M	M	H	H	H
Portable equipment	N	F	A	N	F	A	N	F	A	N	F	A
GRADE	0	0	1	1	1	2	4	4	4	5	5	5

(Minimum grade = 0 and maximum grade = 5)

P_3. FIRE SERVICE

DEFINITION: Possibility of external agencies to save lives and to prevent further fire spread

SUB-PARAMETERS:

Capability of responding fire service

CAPABILITY OF RESPONDING FIRE SERVICE	GRADE
No brigade available	0
Fire fighting capability only outside the building	1
Fire fighting capability but no smoke diving capability	2
Fire fighting and smoke diving capability	4
Simultaneous fire fighting, smoke diving and external rescue by ladders	5

(Minimum grade = 0 and maximum grade = 5)

Response time of fire service to the site

RESPONSE TIME (min)	GRADE
> 20	0
15 - 20	1
10 - 15	2
5 - 10	3
0 - 5	5

(Minimum grade = 0 and maximum grade = 5)

Accessibility and equipment (ie. number of windows (or balconies) that are accessible by the fire service ladder trucks)

ACCESSIBILITY AND EQUIPMENT	GRADE
Less than one window in each apartment accessible by fire service ladders	0
At least one window in each apartment accessible by fire service ladders	3
All windows accessible by fire service ladder	5

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(a × Capability + b × Response time + c × Accessibility and equipment)

where a, b and c represent the per cent importance of each sub-parameter.
The range is 0 - 100% and the sum a + b + c = 100%.

a =
b =
c =

P_4. COMPARTMENTATION

DEFINITION: Extent to which building space is divided into fire compartments

PARAMETER GRADE:

MAXIMUM AREA IN FIRE COMPARTMENT	GRADE
> 400 m^2	0
200 - 400 m^2	1
100 – 200 m^2	2
50 – 100 m^2	3
< 50 m^2	5

(Minimum grade = 0 and maximum grade = 5)

P_5. STRUCTURE - SEPARATING

DEFINITION: Fire resistance of building assemblies separating fire compartments

SUB-PARAMETERS:

Integrity and insulation

INTEG.RITY AND INSULATION (EI)	GRADE
EI < EI 15	0
EI 15 ≤ EI < EI 30	1
EI 30 ≤ EI < EI 45	3
EI 45 ≤ EI < EI 60	4
EI 60 ≥ EI	5

(Minimum grade = 0 and maximum grade = 5)

Firestops at joints, intersections and concealed spaces

STRUCTURE AND FIRESTOP DESIGN	GRADE
Timber-frame structure with voids and no firestops	0
Ordinary design of joints, intersections and concealed spaces, without special consideration for fire safety.	1
Joints, intersections and concealed spaces have been tested and shown to have endurance in accordance with the EI of other parts of the construction.	2
Joints, intersections and concealed spaces are specially designed for preventing fire spread and deemed by engineers to have adequate performance.	3
Homogenous construction with no voids	5

(Minimum grade = 0 and maximum grade = 5)

Penetrations
Penetrations between separating fire compartments

PENETRATIONS	GRADE
Penetrations with no seals between fire compartments	0
Non-certified sealing systems between fire compartments	1
Certified sealing systems between fire compartments	2
Special installation shafts or ducts in an own fire compartment with certified sealing systems to other fire compartments	3
No sealing systems between fire compartments	5

(Minimum grade = 0 and maximum grade = 5)

Combustibility
Combustible part of the separating construction

COMBUSTIBLE PART	GRADE
Both separating structure and insulation are combustible	0
Only the insulation is combustible	2
Only the separating structure is combustible	3
Both separating structure and insulation are non- combustible	5

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(a × Integrity and insulation + b × Firestops at joints, intersections and concealed spaces + c × Penetrations + d × Combustibility)

where a, b, c and d represent the per cent importance of each sub-parameter.
The range is 0 – 100% and the sum a + b + c + d = 100%.

a =
b =
c =
d =

P_6. DOORS

DEFINITION: Fire separating function of doors between fire compartments

SUB-PARAMETERS:

Doors leading to escape route
Integrity and insulation (= EI)
(A = EI < EI 15, B = EI 15 ≤ EI < EI 30, C = EI 30 ≤ EI < EI 60, D = EI ≥ EI 60)
and Type of closing (M = manually, S = self-closing)

SURVEY ITEMS	DECISION RULES							
Integrity and insulation	A	A	B	B	C	C	D	D
Type of closing	M	S	M	S	M	S	M	S
GRADE	0	1	1	3	2	4	3	5

(Minimum grade = 0 and maximum grade = 5)

Doors in escape route
Integrity and insulation (= EI)
(A = EI < EI 15, B = EI 15 ≤ EI < EI 30, C = EI 30 ≤ EI < EI 60, D = EI ≥ EI 60)
and Type of closing (M = manually, S = self-closing)
If no doors are needed in the escape routes the highest grade (H) is received.

SURVEY ITEMS	DECISION RULES								
Integrity and insulation	A	A	B	B	C	C	D	D	-
Type of closing	M	S	M	S	M	S	M	S	-
GRADE	0	1	1	3	2	4	3	5	5

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(a × Doors leading to escape route + b × Doors in escape route)

where a and b represent the per cent importance of each sub-parameter.
The range is 0 - 100% and the sum a + b = 100%.

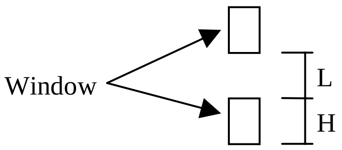
a =
b =

P_7. WINDOWS

DEFINITION: Windows (and other facade openings) and protection of these, ie. factors affecting the possibility of fire spread through the openings

SUB-PARAMETERS:

Relative vertical distance
This is defined as the height of the window divided by the vertical distance between windows



Relative vertical distance, R = L/H
(A = R < 1, B = R ≥ 1)

Class of window
(C = window class < E 15, D = window class ≥ E 15, E = tested special design solution or window class ≥ E 30)

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES					
Relative vertical distance	A	A	A	B	B	B
Class of window	C	D	E	C	D	E
GRADE	0	3	5	2	5	5

(Minimum grade = 0 and maximum grade = 5)

P_8. FACADES

DEFINITION: Facade material, suppression system etc., ie. factors affecting the possibility of fire spread along the facade

SUB-PARAMETERS:

Combustible part of facade

COMBUSTIBLE PART	GRADE
> 40 %	0
20 – 40 %	2
< 20 %	3
0 %	5

(Minimum grade = 0 and maximum grade = 5)

Combustible material above windows

COMBUSTIBLE MATERIAL ABOVE WINDOWS?	GRADE
Yes	0
No	5

(Minimum grade = 0 and maximum grade = 5)

Void
Does there exist a continuous void between the facade material and the supporting wall?

TYPE OF VOID	GRADE
Continuous void in combustible facade	0
Void with special design solution for preventing fire spread	3
No void	5

PARAMETER GRADE:

(a × Combustible part of facade + b × Combustible material above windows + c × Void)

where a, b and c represent the per cent importance of each sub-parameter.
The range is 0 - 100% and the sum a + b + c = 100%.

a =
b =
c =

P_9. ATTIC

DEFINITION: Prevention of fire spread to and in attic

SUB-PARAMETERS:

Prevention of fire spread to attic (eg. is the design such that ventilation of the attic is not provided at the eave? The most common mode of exterior fire spread to the attic is through the eave. Special ventilation solutions avoid this.)

N	No
Y	Yes

Fire separation in attic (ie. extent to which the attic area is separated into fire compartments)

MAXIMUM AREA OF FIRE COMPARTMENT IN ATTIC	GRADE
No attic	H
< 100 m^2	M
100 – 300 m^2	L
300 – 600 m^2	L
> 600 m^2	L

(N = no grade, L = low grade, M = medium grade and H = high grade)

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES							
Prevention of fire spread to attic	N	N	N	N	Y	Y	Y	Y
Fire separation in attic	N	L	M	H	N	L	M	H
GRADE	0	1	2	5	2	3	4	5

(Minimum grade = 0 and maximum grade = 5)

P_{10}. ADJACENT BUILDINGS

DEFINITION: Minimum separation distance from other buildings. If the buildings are separated by a fire wall this is deemed to be equivalent to 8 m distance.

PARAMETER GRADE:

DISTANCE TO ADJACENT BUILDING, D	GRADE
$D < 6$ m	0
$6 \le D < 8$ m	1
$8 \le D < 12$ m	2
$12 \le D < 20$ m	3
$D \ge 20$ m	5

(Minimum grade = 0 and maximum grade = 5)

P_{11}. SMOKE CONTROL SYSTEM

DEFINITION: Equipment and systems in escape routes for limiting spread of toxic fire products

SUB-PARAMETERS:

Activation of smoke control system

N	No smoke control system
M	Manually
A	Automatically

Type of smoke control system

N	Natural ventilation through openings near ceiling
M	Mechanical ventilation
PN	Pressurisation and natural ventilation for exiting smoke
PM	Pressurisation and mechanical ventilation for exiting smoke

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES								
Activation of smoke control system	N	M	M	M	M	A	A	A	A
Smoke vent openings	-	N	M	PN	PM	N	M	PN	PM
GRADE	0	2	2	3	3	4	4	5	5

(Minimum grade = 0 and maximum grade = 5)

P_{12}. DETECTION SYSTEM

DEFINITION: Equipment and systems for detecting fires

SUB-PARAMETERS:

Amount of Detectors
Detectors in apartment (N = none, A = at least one in every apartment, R = more than one in every apartment) and Detectors in escape route (N = no, Y = yes)

SURVEY ITEMS	DECISION RULES					
Detectors in apartment	N	N	A	R	A	R
Detectors in escape route	N	Y	N	N	Y	Y
GRADE	N	L	L	M	H	H

(N = no grade, L = low grade, M = medium grade and H = high grade)

Reliability of detectors
Detector type (H = heat detectors, S = smoke detectors) and Detector power supply (B = battery, P = power grid, BP = power grid and battery backup)

SURVEY ITEMS	DECISION RULES					
Detector type	H	H	H	S	S	S
Detector power supply	B	P	BP	B	P	BP
GRADE	L	M	M	M	H	H

(N = no grade, L = low grade, M = medium grade and H = high grade)

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES									
Amount of detectors	N	L	L	L	M	M	M	H	H	H
Reliability of detectors	-	L	M	H	L	M	H	L	M	H
GRADE	0	1	2	2	2	3	3	3	4	5

(Minimum grade = 0 and maximum grade = 5)

P_{13}. SIGNAL SYSTEM

DEFINITION: Equipment and systems for transmitting an alarm of fire

SUB-PARAMETERS:

Type of signal
Light signal (N = no, Y = yes) and Sound signal (N = no, A = alarm bell, S = spoken message)

SURVEY ITEMS	DECISION RULES					
Light signal	N	Y	N	N	Y	Y
Sound signal	N	N	A	S	A	S
GRADE	N	L	H	L	M	H

(N = no grade, L = low grade, M = medium grade and H = high grade)

Location of signal
Do you just receive a signal within the fire compartmentation or is it also possible to warn other occupants?

A	The signal is sent to the compartment only.
B	It is possible to send a signal manually to the whole building or at least to a large section of the building.

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES						
Type of signal	N	L	L	M	M	H	H
Location of signal	-	A	B	A	B	A	B
GRADE	0	1	2	3	4	4	5

(Minimum grade = 0 and maximum grade = 5)

P_{14}. ESCAPE ROUTES

DEFINITION: Adequacy and reliability of escape routes

SUB-PARAMETERS:

Type of escape routes
Staircase (A = one staircase may be used as an escape route, B = escape route leading to two independent staircases, C = direct escape to two independent staircases) and Window/Balcony (D = windows and balconies can not be used as escape routes, E = one window may be used as an escape route, F = at least two independent windows may be used as escape routes, G = the balcony may be used as an escape route, H = at least one window and the balcony may be used as escape routes)

SURVEY ITEMS	DECISION RULES												
Staircase	A	A	A	A	B	B	B	B	C	C	C	C	C
Window/Balcony	E	F	G	H	E	F	G	H	D	E	F	G	H
GRADE	0	1	1	3	2	3	3	4	4	5	5	5	5

(Minimum grade = 0 and maximum grade = 5)

Dimensions and layout
Maximum travel distance to an escape route (A < 10 m, B = 10 – 20 m, C > 20 m), Number of floors (D ≤ 4, E = 5 – 8) and Maximum number of apartments per floor connected to an escape route (F ≤ 4, G ≥ 5)

SURVEY ITEMS	DECISION RULES											
Travel distance to...	C	C	C	C	B	B	B	B	A	A	A	A
Number of floors	E	E	D	D	E	E	D	D	E	E	D	D
Number of apartments...	G	F	G	F	G	F	G	F	G	F	G	F
GRADE	0	1	2	2	3	3	4	4	4	4	5	5

(Minimum grade = 0 and maximum grade = 5)

Equipment
Guidance signs (A = none, B = normal, C = illuminating light), General lighting (D = manually switched on, E = always on) and Emergency lighting (F = not provided, G = provided)

SURVEY ITEMS	DECISION RULES											
Guidance signs	A	A	A	A	B	B	B	B	C	C	C	C
General lighting	D	D	E	E	D	D	E	E	D	D	E	E
Emergency lighting	F	G	F	G	F	G	F	G	F	G	F	G
GRADE	0	3	3	4	2	4	3	4	2	4	3	5

(Minimum grade = 0 and maximum grade = 5)

Linings and floorings

This refers to the worst lining or flooring class that is to be found in an escape route (excluding the small amounts allowed by building law). For Euroclasses A1, A2 and B, the flooring must have at least class D_f, if not the linings and floorings grade is according to Euroclass C.

LINING CLASS						GRADE
Suggestions to Euroclasses	Typical products	DK	FIN	NO	SWE	
A1	Stone, concrete	A	1/I	In1	I	5
A2	Gypsum boards	A	1/I	In1	I	5
B	Best FR woods (impregnated)	A	1/I	In1	I	4
C	Textile wall cover on gypsum board		1/II 2/-	In2	II	3
D	Wood (untreated)	B	1/-	In2	III	2
E	Low density wood fibreboard	U	U	U	U	1
F	Some plastics	U	U	U	U	0

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(a × Type of escape routes + b × Dimensions and layout + c × Equipment + d × Linings and floorings)

where a, b, c and d represent the per cent importance of each sub-parameter.
The range is 0 - 100% and the sum a + b + c + d = 100%.

a =
b =
c =
d =

P_{15}. STRUCTURE - LOAD-BEARING

DEFINITION: Structural stability of the building when exposed to a fire

SUB-PARAMETERS:

Load-bearing capacity

LOAD BEARING CAPACITY (LBC)	GRADE
LBC < R 30	0
R 30 ≤ LBC < R 60	2
R 60 ≤ LBC < R 90	4
R 90 ≤ LBC	5

(Minimum grade = 0 and maximum grade = 5)

Combustibility
Combustible part of the load-bearing construction

COMBUSTIBLE PART	GRADE
Both load-bearing structure and insulation are combustible	0
Only the insulation is combustible	2
Only the load-bearing structure is combustible	3
Both load-bearing structure and insulation are non- combustible	5

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(a × Load-bearing capacity + b × Combustibility)

where a and b represent the per cent importance of each sub-parameter.
The range is 0 - 100% and the sum a + b = 100%.

a =
b =

P_{16}. MAINTENANCE AND INFORMATION

DEFINITION: Inspection and maintenance of fire safety equipment, escape routes etc. and information to occupants on suppression and evacuation

SUB-PARAMETERS:

Maintenance of fire safety systems ie. detection, alarm, suppression and smoke control system

MAINTENANCE OF FIRE SAFETY SYSTEMS	GRADE
Carried out less than every three years	0
Carried out at least once every three years	2
Carried out at least once a year	4
Carried out at least twice a year	5

(Minimum grade = 0 and maximum grade = 5)

Inspection of escape routes

INSPECTION OF ESCAPE ROUTES	GRADE
Carried out less than every three years	0
Carried out at least once a year	1
Carried out at least once every three months	3
Carried out at least once per month	5

(Minimum grade = 0 and maximum grade = 5)

Information to occupants on suppression and evacuation

Written information (A = no information, B = written information on evacuation and suppression available in a prominent place in the building, C = written information distributed to new inhabitants) and
Drills (D = suppression drill carried out regularly, E = evacuation drill carried out regularly, F = suppression and evacuation drills carried out regularly)

SURVEY ITEMS	DECISION RULES								
Written information	A	A	A	B	B	B	C	C	C
Drills	D	E	F	D	E	F	D	E	F
GRADE	0	1	2	3	3	4	4	4	5

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(a × Maintenance of fire safety systems + b × Inspection of escape routes + c × Information)

where a, b, and c represent the per cent importance of each sub-parameter. The range is 0 - 100% and the sum a + b + c = 100%.
a =
b =
c =

P_{17}. Ventilation system

DEFINITION: Extent to which the spread of smoke through the ventilation system is prevented.

PARAMETER GRADE:

TYPE OF VENTILATION SYSTEM	GRADE
No specific smoke spread prevention through the ventilation system	0
Central ventilation system, designed to let smoke more easily into the external air duct than ducts leading to other fire compartments. The ratio between pressure drops in these ducts is in the order of 5:1	2
Ventilation system specially designed to be in operation under fire conditions with sufficient capacity to hinder smoke spread to other fire compartments	3
Ventilation system with a non-return damper, or a smoke detector controlled fire gas damper, in ducts serving each fire compartment.	4
Individual ventilation system for each fire compartment	5

(Minimum grade = 0 and maximum grade = 5)

99-08-13 99005BR/BK

LUND UNIVERSITY

Addressee: Members of the Delphi panel for the project "Risk - Timber-frame Buildings"

Department of Fire Safety Engineering
Björn Karlsson

D05: Round 2 - Assigning Weights to Version 1.1 of the Index Method

This letter contains,

1. A report on the results of the first weighting exercise. The enclosed documents "Round 1: Weights for Sub-parameters" and "Round 1: Weights for Objectives, Strategies and Parameters" contain the full results of the first Delphi round, and Section 1 of this letter summarises the findings. Section 2 of this document discusses what must be done in Round 2.
2. Appendix A and B contain two new forms to fill in if you wish to change your weights having seen the group result (a copy of your earlier weights is enclosed).
3. We also include Version 1.1 of the index method, for your reference.

In summary, we can say that the weighting for the sub-parameters in P_3, P_5, P_6, P_8, P_{14}, P_{15} and P_{16} went very well and there was good consensus.

Most of the weights for the Objectives, Strategies and Parameters had reasonable consensus, but the weighting of the Parameters seems to be far too "flat". For example, parameter P_1 (Linings) seems to stand for 4.9% of the total fire safety while parameter P_2 (Suppression system) stands for 6.7%. The Project group has an intuitive feeling that P_1 should be lower and P_2 should be higher. The results are discussed in Section 1 of this letter and Section 2 discusses how we will conduct a second round.

Action required: Please read through Sections 1 and 2 of this letter for information on the results of Round 1 of the weighting process and for instructions on how to proceed.

Look through the enclosed documents "Round 1: Weights for Sub-parameters" and "Round 1: Weights for Objectives, Strategies and Parameters". You should concentrate on the latter, since the Sub-parameter weighting's went quite well.

Following the text in Section 2, fill in new weights in the enclosed forms (Appendix A and B) and fax this back to us. We will need your answer in early September and will contact you individually on the telephone or through e-mail to discuss the matter.

A preliminary version of the index method (Version 1.1) is now available at the web site mentioned below. We also enclose this document for your reference.

Note: If you have mislaid documents, you can fetch them at our web site, http://www.brand.lth.se, choose Forskning, choose Risk, then choose Timber-Frame Buildings – Risk.

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1. Summary of Results from Round 1

The full results are given in the enclosed documents "Round 1: Weights for Sub-parameters" and "Round 1: Weights for Objectives, Strategies and Parameters". These documents report all Delphi member results and give the average, the first quartile, the mean and the third quartile for each weight given.

To quickly explain some of the terminology, consider the following series of 16 numbers: 3 3 4 5 2 3 1 2 4 4 2 2 4 3 2 2

We now put the numbers in order: 1 2 2 2 2 2 2 3 3 3 3 4 4 4 4 5
There are 16 numbers so the value of the first quartile is 2 (average of the values in position 4 and 5), indicating that 25% of the values are not lower than 2. Similarly the value of the third quartile is 4, indicating that 75% of the values are not higher than 4. The mean value is 3 (which is the average of the values in position 8 and 9). The average value is the sum of all the numbers divided by 16.

1.1. Results from giving weights to Sub-parameters in P_3, P_5, P_6, P_8, P_{14}, P_{15} and P_{16}.

Assigning weights to the grading equations for parameters P_3, P_5, P_6, P_8, P_{14}, P_{15} and P_{16} went quite well. The full results are given in the enclosed document "Round 1: Weights for Sub-parameters".

The average results are shown below (eg.. 0.31 stands for 31% of the importance):

P3 (Fire service): (0.31 × Capability + 0.47 × Response time + 0.22 × Accessibility and equipment)
P5 (Structure-separating): (0.35 × Integrity and insulation + 0.28 × Firestops at joints, intersections and concealed spaces + 0.24 × Penetrations + 0.13 × Combustibility)
P6 (Doors): (0.67 × Doors leading to escape route + 0.33 × Doors in escape route)
P8 (Facade): (0.41× Combustible part of facade + 0.30 × Combustible material above windows + 0.29 × Void)
P14 (Escape routes): (0.34 × Type of escape routes + 0.27 × Dimensions and layout + 0.16 × Equipment + 0.23 × Linings and floorings)
P15 (Structure-load-bearing): (0.74 × Load-bearing capacity + 0.26 × Combustibility)
P16 (Maintenance and information): (0.40 × Maintenance of fire safety systems + 0.27 × Inspection of escape routes + 0.33 × Information)

The consensus is generally good, but you may wish to have a closer look at P6 (a and b) and P15 (a and b). If you wish to change your weights, please fill in the form in Appendix A and fax it to us.

1.2. Results from Giving Weights to the Objectives, Strategies and Parameters

Assigning weights to the Objectives and Strategies went reasonably well. However, weighting the Parameters did not go as smoothly. We shall discuss how to deal with this later in this section. The results are shown in the enclosed document "Round 1: Weights for Objectives, Strategies and Parameters".

Figure 1 in the document shows the weights for Objectives versus Policy, with a very good consensus, resulting in O1 = 4.8 and O2 = 3.2. Normalising this we find that Objective 1 (Provide life safety) stands for 4.8/(4.8+3.2) = 60% and Objective 2 (Provide property protection) stands for 3.2/(4.8+3.2) = 40% of the importance for reaching our Policy.

Figure 2 of the document shows the Strategies versus O1 (Provide life safety) and Figure 3 shows the Strategies versus O2 (Provide property protection). The consensus is quite good in Figures 2 and 3, the worst consensus is for S4/O2, but is still deemed acceptable.

The average results are the following:

For O1 (Provide life safety)

S1 (Control fire by active means)	25%
S2 (Control fire by construction)	22%
S3 (Establish safe egress)	29%
S4 (Establish safe rescue)	23%

For O2 (Provide property protection)

S1 (Control fire by active means)	33%
S2 (Control fire by construction)	37%
S3 (Establish safe egress)	11%
S4 (Establish safe rescue)	19%

Moving now to the weights for the Parameters, the Project group feels that the results are too "flat". There are mainly two reasons for this:
The directions on how to give weights, provided in document D04, were not clear enough. The directions should have been clearer and weights should have been given in a slightly different order.
The whole scale of weights from 0 to 5 was not used much, Delphi members tended to use the weights 3 to 5.

Section 2 will discuss how this may be amended. Meanwhile, we shall view the current results. By multiplying the Objectives/Policy vector (a 2×1 vector) by the Strategies/Objectives matrix (a 4×2 matrix) we get a Strategies/Policy vector (a 4×1 vector). Multiplying this by the Parameters/Strategies matrix (a 17×4 matrix) we get a Parameters/Policy vector (a 17×1 vector). When we normalise this vector (so the sum of all the values is 1.0) and it then shows us how important each Parameter is for our Policy.

The details of these vector and matrix manipulations are summarily discussed in the project application document, available at our web site. Figure 2 below gives a schematic of these vector and matrix manipulations.

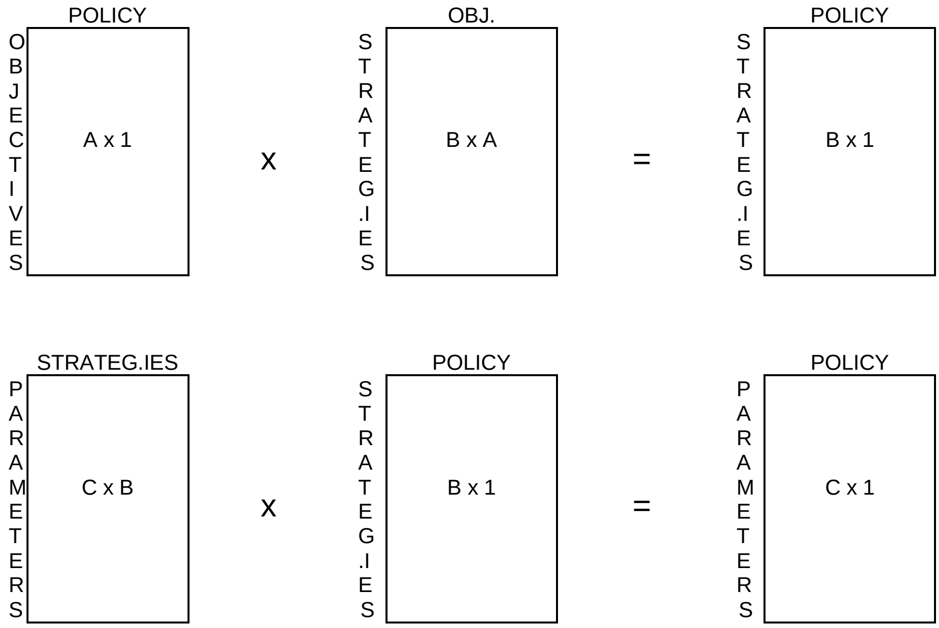


Figure 2: Schematic of matrix multiplication

The averaged Parameter weights results of Round 1 are the following:

P01 (Linings)	4.97%
P02 (Suppression system)	6.66%
P03 (Fire service)	6.71%
P04 (Compartmentation)	6.24%
P05 (Structure-separating)	6.79%
P06 (Doors)	6.94%
P07 (Windows)	4.87%
P08 (Facade)	5.17%
P09 (Attic)	5.41%
P10 (Adjacent buildings)	4.49%
P11 (Smoke control system)	6.26%
P12 (Detection system)	6.07%
P13 (Signal system)	5.06%
P14 (Escape routes)	6.02%
P15 (Structure-load-bearing)	6.53%
P16 (Maintenance and info)	6.28%
P17 (Ventilation system)	5.54%
Sum:	**100%**

As stated above, the Project group feels that these results are somewhat "flat" and we would therefore like to give somewhat different advice on how to fill in the Parameters/Strategies tables. This is outlined in Section 2 below.

Round 2 of the weighting exercise

In the Delphi process, it is customary to circulate the results from the questionnaires to allow the members of the panel to revise their input.

2.1. Assigning Weights to the Grading Equations for P_3, P_5, P_6, P_8, P_{14}, P_{15} and P_{16}

The consensus for the Sub-parameter weights is generally good (as seen in the enclosed document "Round 1: Weights for Sub-parameters". The worst consensus is for P6 (a and b) and P15 (a and b), but is still deemed to be acceptable. If you wish to change your Sub-parameter weights, please fill in the form in Appendix A and fax it to us.

2.2. Assigning Weights to the Objectives, Strategies and Parameters

The weighting of Objectives versus Policy and Strategies versus Objectives went quite well and the consensus was mostly very good. The consensus for S4/O2 is the odd one out. Please inspect Figure 3 in the document "Round 1: Weights for Objectives, Strategies and Parameters". S4/O2 has a 1st quartile of 0 and a 3rd quartile of 3, which shows quite a wide spread in the results. The consensus here is questionable so we ask you to have a special look at this value.

Now for the Parameters versus Strategies: The Project group felt that the Parameter weights (shown in the 17×4 matrix) were somewhat "flat" and we must therefore ask you to specifically look at these weights and fill in the Parameters/Strategies table.

But this time, instead of considering P01 (Linings) first and consider the weight it has for Strategies S1, S2, S3 and S4, we ask you to do this in a different order. We ask you to look at Strategy S1 and consider the weights for all Parameters, P1 to P17.

In other words, instead of filling in the table horizontally,

Parameters/Strategies

	S1	S2	S3	S4
P01				

we ask you to fill it in vertically, as follows:

Parameters/Strategies

	S1
P01 (Linings)	
P02 (Suppression system)	
P03 (Fire service)	
P04 (Compartmentation)	
P05 (Structure-separating)	
P06 (Doors)	
P07 (Windows)	

P08 (Facade) P09 (Attic)	
P10 (Adjacent buildings)	
P11 (Smoke control system)	
P12 (Detection system)	
P13 (Signal system)	
P14 (Escape routes)	
P15 (Structure-load-bearing)	
P16 (Maintenance and info)	
P17 (Ventilation system)	

Ask yourself:

- If we wish to control fire growth by active means (S1), which parameters are extremely important? These parameters should get the weight 5.
- If we wish to control fire growth by active means (S1), which parameters are very important? These parameters should get the weight 4.
- If we wish to control fire growth by active means (S1), which parameters are of medium importance? These parameters should get the weight 3.
- If we wish to control fire growth by active means (S1), which parameters are of little importance? These parameters should get the weight 2.
- If we wish to control fire growth by active means (S1), which parameters are of very slight importance? These parameters should get the weight 1.
- If we wish to control fire growth by active means (S1), which parameters are of no importance? These parameters should get the weight 0.

Fill in the values in the Properties/Strategies table given in Appendix B.

You then consider the next strategy (S2: Confine fire by construction) and answer similar questions as above. Proceed similarly with Strategies S3 and S4. Write the values in the Properties/Strategies table in Appendix B.

Once you have filled in the values, please consider the consensus from Round 1. The consensus in Round 1 was particularly bad for P10/S3, P12/S4 and P13/S1. Please look at these three closely when assigning the weights in Appendix B. The consensus was not very good for P8/S1, P8/S4, P13/S4, P14/S1, P14/S2, P15/S1, P17/S1. Please have a special look at these values.

The work is to be finished in early September. The Project group will contact you by telephone or e-mail to inform you of a more specific deadline.

Appendix A: Weighting of Sub-parameters in P_3, P_5, P_6, P_8, P_{14}, P_{15} and P_{16}

P_3, Fire Service

	Sub-parameter	% importance
a	Capability	
b	Response time	
c	Accessibility and equipment	

Sum = 100%

P_5, Structure - Separating

	Sub-parameter	% importance
a	Integrity and insulation	
b	Firestops at joints, intersections and concealed spaces	
c	Penetrations	
d	Combustibility	

Sum = 100%

P_6, Doors

	Sub-parameter	% importance
a	Doors leading to escape route	
b	Doors in escape route	

Sum = 100%

P_8, Facades

	Sub-parameter	% importance
a	Combustible part of facade	
b	Combustible material above window	
c	Void	

Sum = 100%

P_{14}, Escape route

	Sub-parameter	% importance
a	Type of escape routes	
b	Dimensions and layout	
c	Equipment	
d	Linings and floorings	

Sum = 100%

P_{15}, Structure – Load Bearing

	Sub-parameter	% importance
a	Load-bearing capacity	
b	Combustibility	

Sum = 100%

P_{16}, Maintenance and Information

	Sub-parameter	% importance
a	Maintenance of fire safety systems	
b	Inspection of escape routes	
c	Information	

Sum = 100%

Appendix B: Weighting of Objectives, Strategies and Parameters

Objectives/Policy

	Policy
O1	
O2	

Strategy/Objectives

	O1	O2
S1		
S2		
S3		
S4		

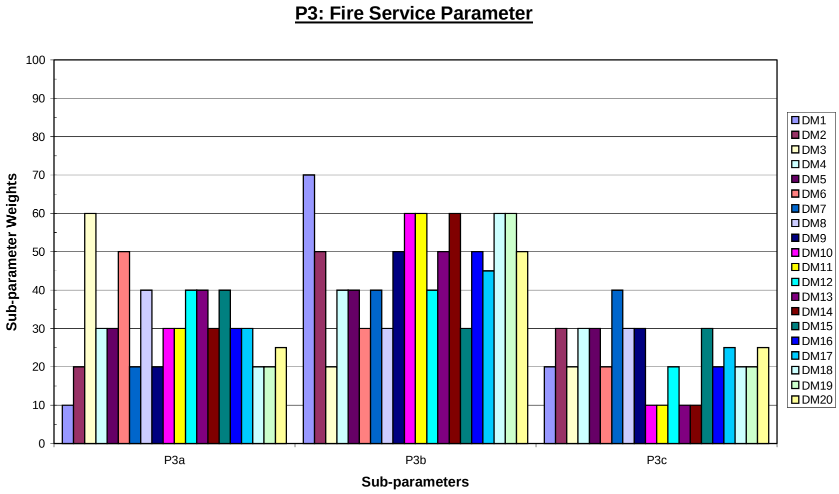
S_1 = Control fire growth by active means
S_2 = Confine fire by construction
S_3 = Establish safe egress
S_4 = Establish safe rescue

Parameters/Strategies

	S1	S2	S3	S4
P01 (Linings)				
P02 (Suppression system)				
P03 (Fire service)				
P04 (Compartmentation)				
P05 (Structure-separating)				
P06 (Doors)				
P07 (Windows)				
P08 (Facade)				
P09 (Attic)				
P10 (Adjacent buildings)				
P11 (Smoke control system)				
P12 (Detection system)				
P13 (Signal system)				
P14 (Escape routes)				
P15 (Structure-load-bearing)				
P16 (Maintenance and info)				
P17 (Ventilation system)				

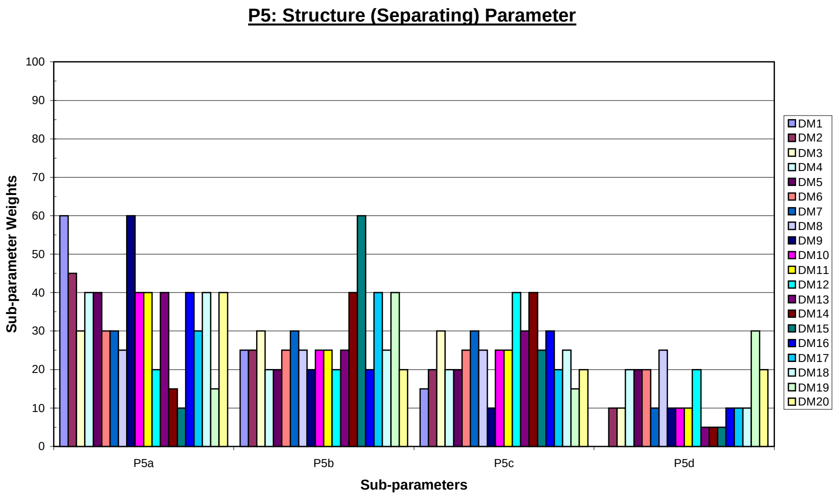
Round 1: Weights for Sub-Parameters

(Contents: Figures 1 - 7)



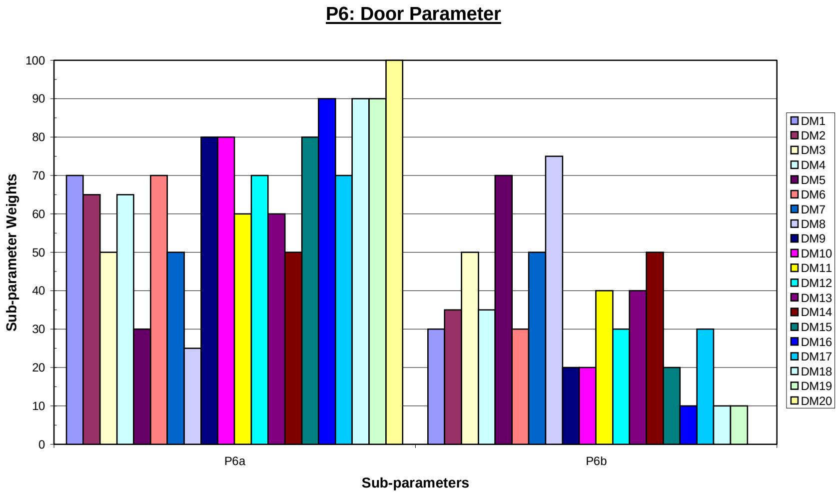
Parameter Summary Values	
	P3a
Average	30.75
1st Quartile	20
Median	30
3rd Quartile	40
	P3b
Average	46.75
1st Quartile	40
Median	50
3rd Quartile	60
	P3c
Average	22.5
1st Quartile	20
Median	20
3rd Quartile	30

Figure 1: Fire Service Parameter Weighting's



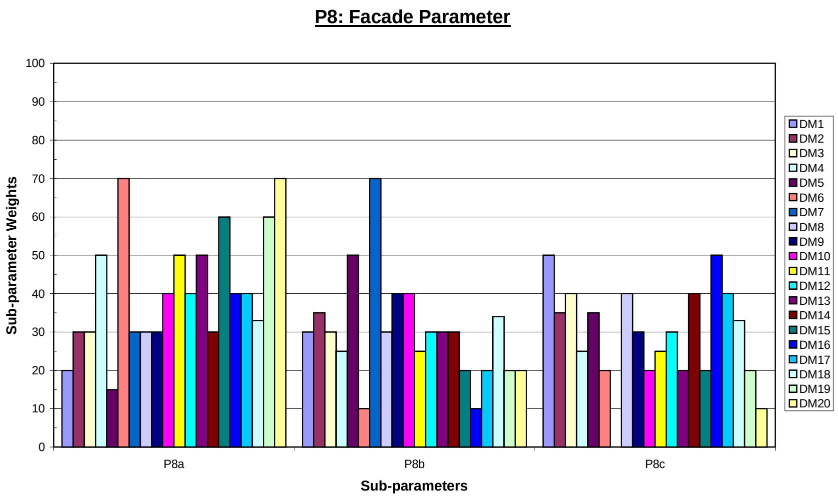
Parameter Summary Values	
	P5a
Average	34.5
1st Quartile	28.75
Median	40
3rd Quartile	40
	P5b
Average	28
1st Quartile	20
Median	25
3rd Quartile	30
	P5c
Average	24.5
1st Quartile	20
Median	25
3rd Quartile	30
	P5d
Average	13
1st Quartile	10
Median	10
3rd Quartile	20

Figure 2: Structure (Separating) Sub-Parameter Weighting's



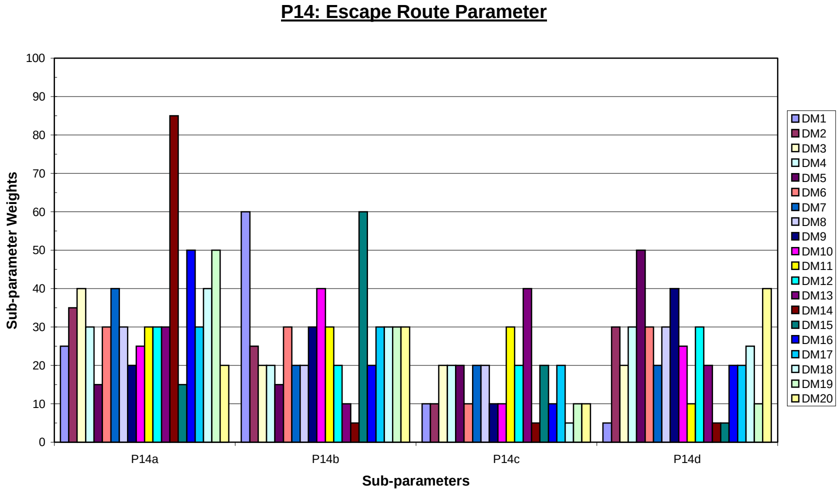
Parameter Summary Values	
	P6a
Average	67.25
1st Quartile	57.5
Median	70
3rd Quartile	80
	P6b
Average	32.75
1st Quartile	20
Median	30
3rd Quartile	42.5

Figure 3: Door Sub-Parameter Weighting's



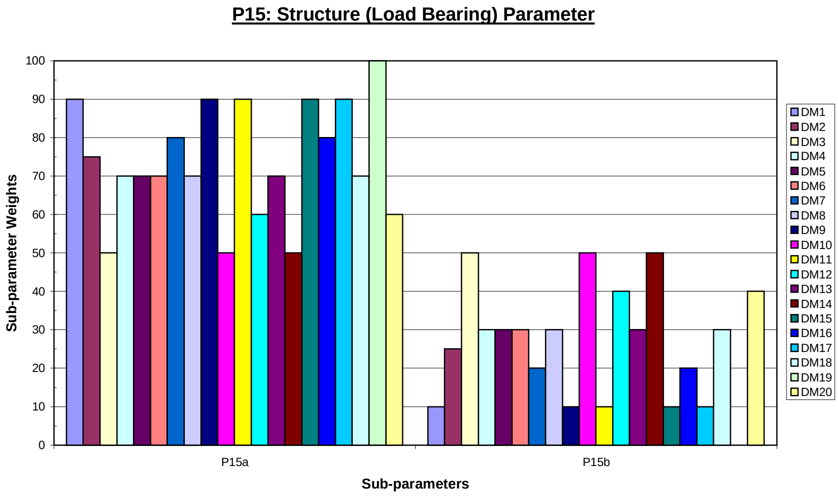
Parameter Summary Values	
	P8a
Average	40.9
1st Quartile	30
Median	40
3rd Quartile	50
	P8b
Average	29.95
1st Quartile	20
Median	30
3rd Quartile	34.25
	P8c
Average	29.15
1st Quartile	20
Median	30
3rd Quartile	40

Figure 4: Facade Sub-Parameter Weighting's



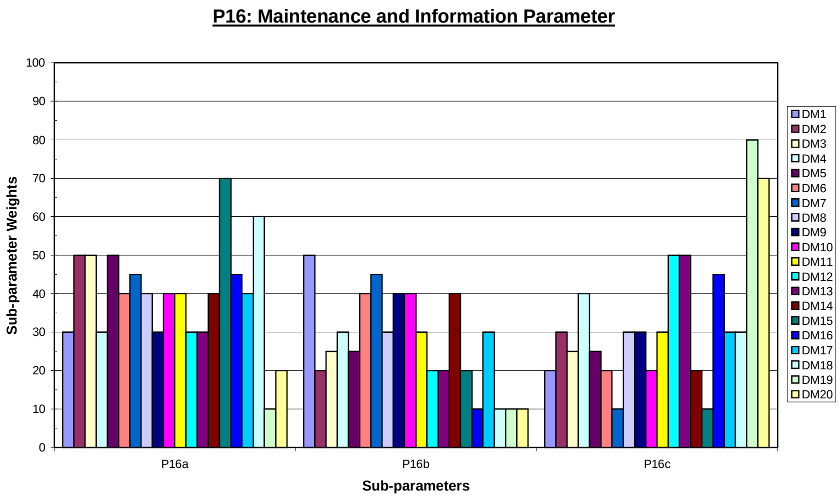
Parameter Summary Values	
	P14a
Average	33.5
1st Quartile	25
Median	30
3rd Quartile	40
	P14b
Average	27.25
1st Quartile	20
Median	27.5
3rd Quartile	30
	P14c
Average	16
1st Quartile	10
Median	15
3rd Quartile	20
	P14d
Average	23.25
1st Quartile	17.5
Median	22.5
3rd Quartile	30

Figure 5: Escape Route Sub-Parameter Weighting's



Parameter Summary Values	
	P15a
Average	73.75
1st Quartile	67.5
Median	70
3rd Quartile	90
	P15b
Average	26.25
1st Quartile	10
Median	30
3rd Quartile	32.5

Figure 6: Structure (Load Bearing) Sub-Parameter Weighting's

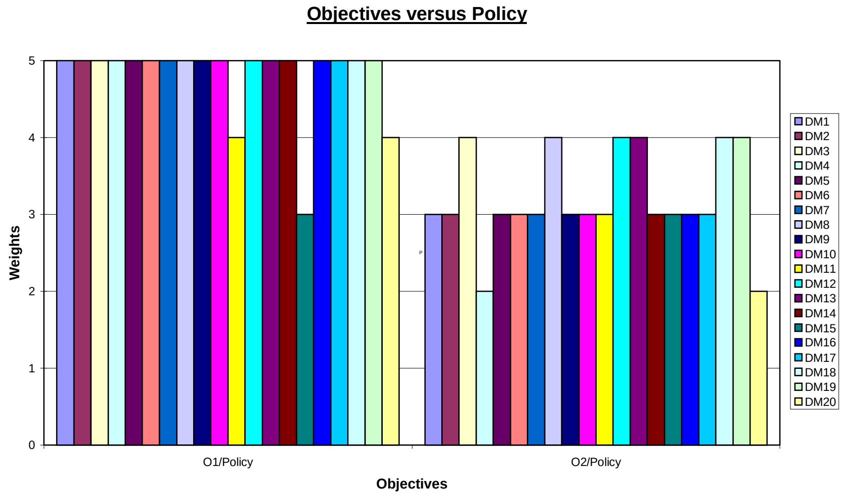


Parameter Summary Values	
	P16a
Average	39.5
1st Quartile	30
Median	40
3rd Quartile	46.25
	P16b
Average	27.25
1st Quartile	20
Median	27.5
3rd Quartile	40
	P16c
Average	33.25
1st Quartile	20
Median	30
3rd Quartile	41.25

Figure 7: Maintenance and Information Sub-Parameter Weighting's

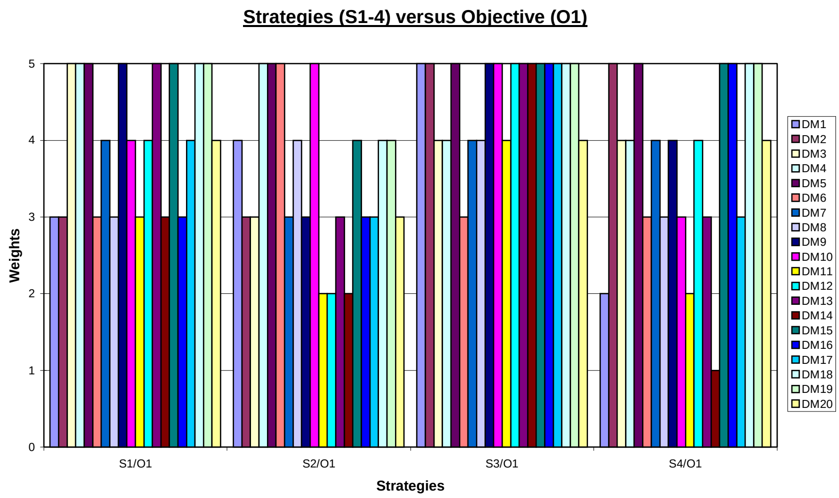
Round 1: Weights for Objectives, Strategies and Parameters

(Contents: Figures 8 - 27)



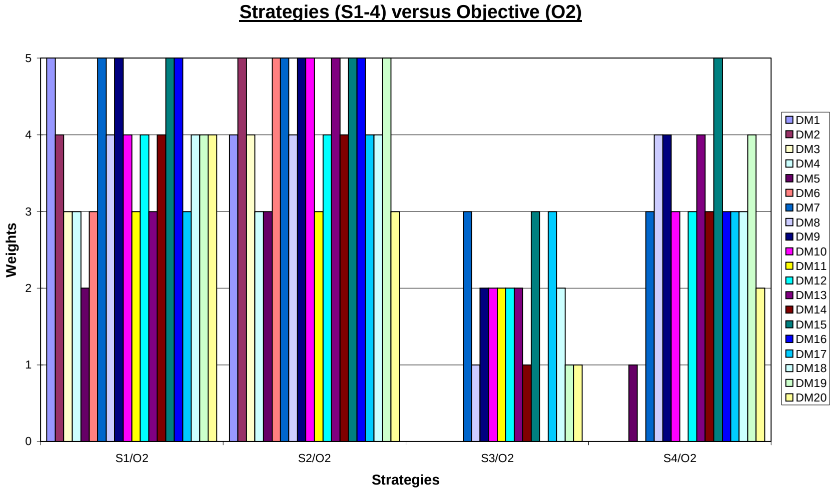
Summary Values	
	O1/Policy
Average	4.8
1st Quartile	5
Median	5
3rd Quartile	5
	O2/Policy
Average	3.2
1st Quartile	3
Median	3
3rd Quartile	4

Figure 8: Objective versus Policy Weighting's



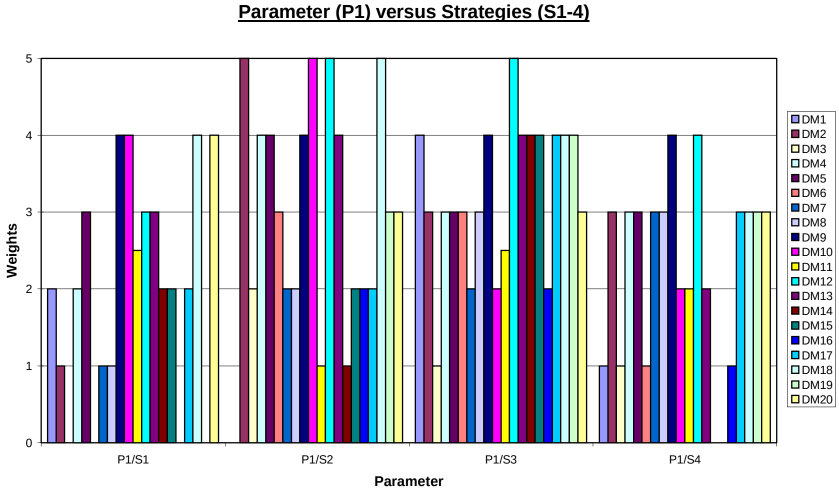
Summary Values	
	S1/O1
Average	4.05
1st Quartile	3
Median	4
3rd Quartile	5
	S2/O1
Average	3.5
1st Quartile	3
Median	3
3rd Quartile	4
	S3/O1
Average	4.6
1st Quartile	4
Median	5
3rd Quartile	5
	S4/O1
Average	3.7
1st Quartile	3
Median	4
3rd Quartile	5

Figure 9: Strategies versus Life Safety Objective (O1) Weighting's



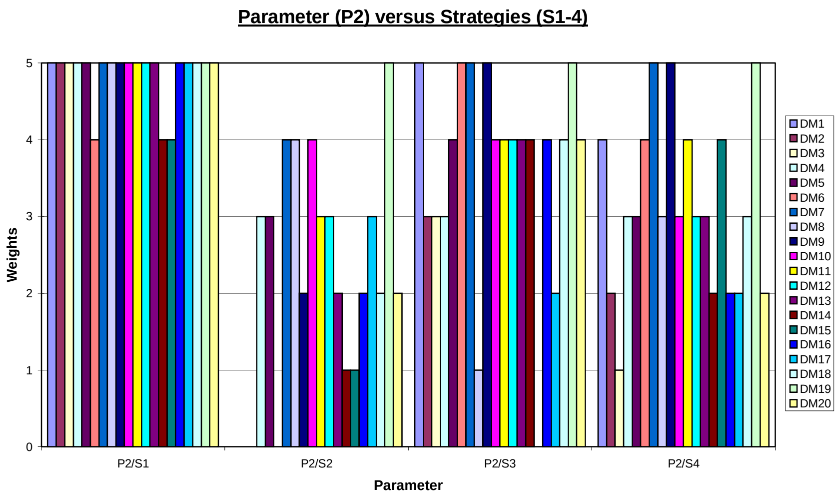
Summary Values	
	S1/O2
Average	3.85
1st Quartile	3
Median	4
3rd Quartile	4.25
	S2/O2
Average	4.25
1st Quartile	4
Median	4
3rd Quartile	5
	S3/O2
Average	1.25
1st Quartile	0
Median	1
3rd Quartile	2
	S4/O2
Average	2.25
1st Quartile	0
Median	3
3rd Quartile	3.25

Figure 10: Strategies versus Property Protection Objective (O2) Weighting's



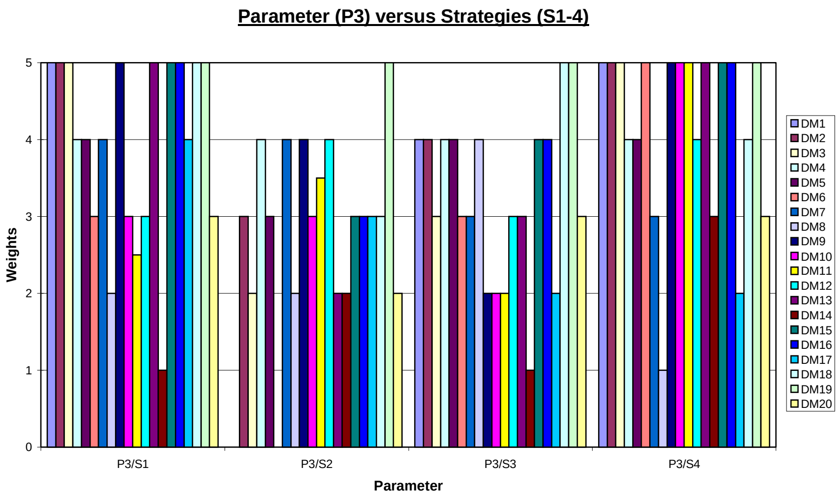
Summary Values	
	P1/S1
Average	2.025
1st Quartile	1
Median	2
3rd Quartile	3
	P1/S2
Average	2.95
1st Quartile	2
Median	3
3rd Quartile	4
	P1/S3
Average	3.225
1st Quartile	2.875
Median	3
3rd Quartile	4
	P1/S4
Average	2.25
1st Quartile	1
Median	3
3rd Quartile	3

Figure 11: Apartment Lining Parameter (P1) versus Strategies Weighting



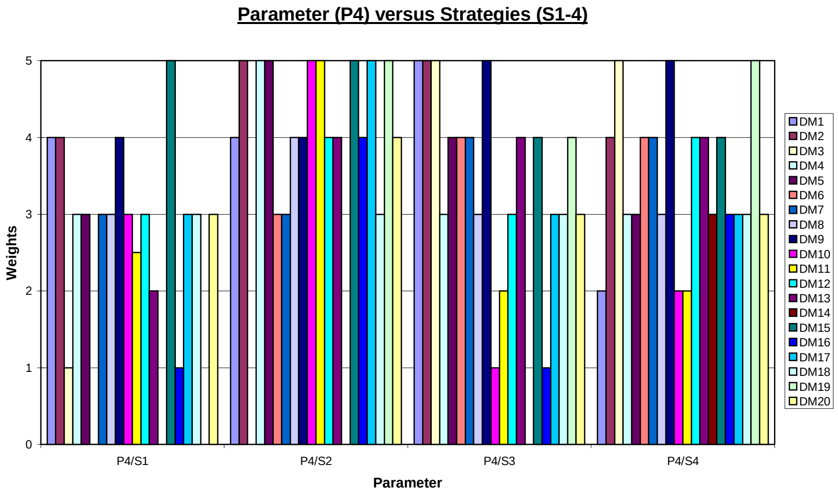
Summary Values	
	P2/S1
Average	4.85
1st Quartile	5
Median	5
3rd Quartile	5
	P2/S2
Average	2.2
1st Quartile	1
Median	2
3rd Quartile	3
	P2/S3
Average	3.65
1st Quartile	3
Median	4
3rd Quartile	4.25
	P2/S4
Average	3.15
1st Quartile	2
Median	3
3rd Quartile	4

Figure 12: Suppression System Parameter (P2) versus Strategies Weighting



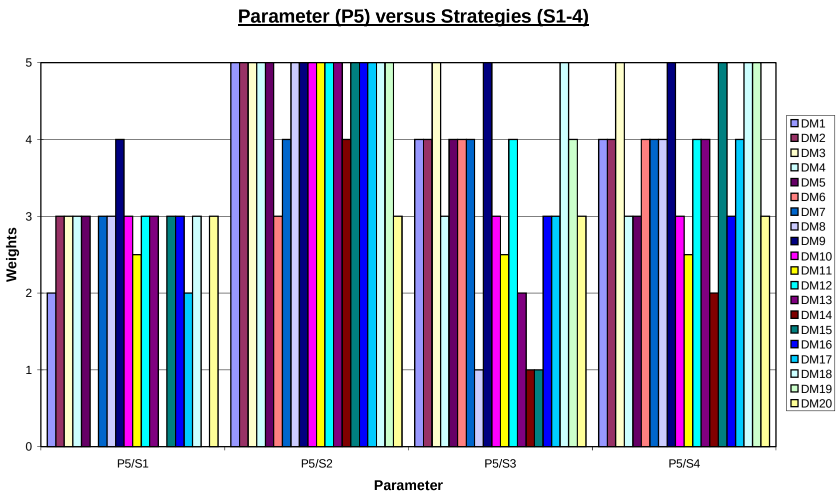
Summary Values	
	P3/S1
Average	3.925
1st Quartile	3
Median	4
3rd Quartile	5
	P3/S2
Average	2.775
1st Quartile	2
Median	3
3rd Quartile	3.625
	P3/S3
Average	3.25
1st Quartile	2.75
Median	3
3rd Quartile	4
	P3/S4
Average	4.15
1st Quartile	3.75
Median	5
3rd Quartile	5

Figure 13: Fire Service Parameter (P3) versus Strategies Weighting



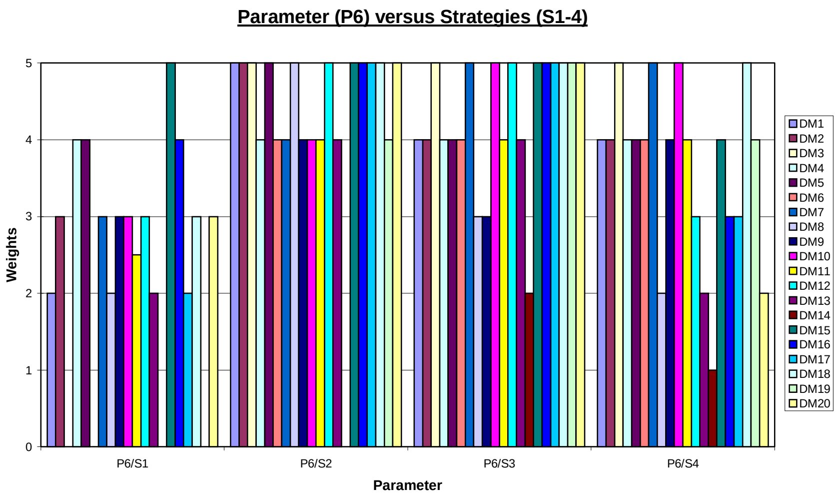
Summary Values	
	P4/S1
Average	2.525
1st Quartile	1.75
Median	3
3rd Quartile	3
	P4/S2
Average	3.85
1st Quartile	3.75
Median	4
3rd Quartile	5
	P4/S3
Average	3.3
1st Quartile	3
Median	3.5
3rd Quartile	4
	P4/S4
Average	3.45
1st Quartile	3
Median	3
3rd Quartile	4

Figure 14: Compartmentation Parameter (P4) versus Strategies Weighting



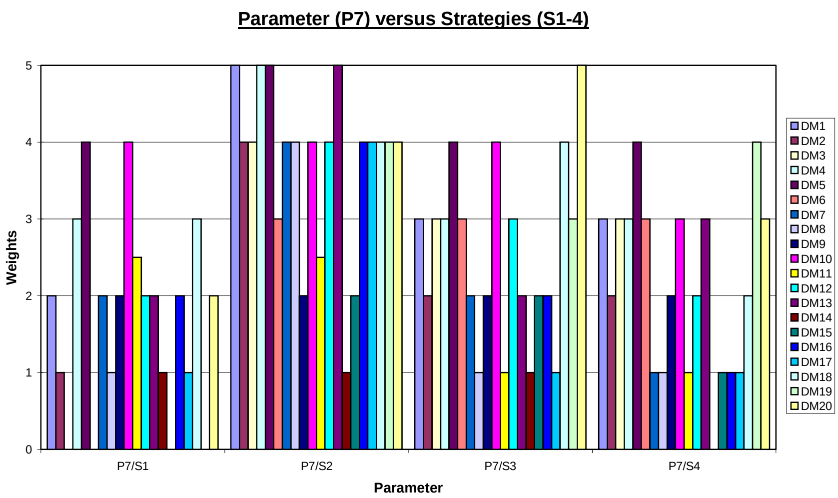
Summary Values	
	P5/S1
Average	2.475
1st Quartile	2.375
Median	3
3rd Quartile	3
	P5/S2
Average	4.7
1st Quartile	5
Median	5
3rd Quartile	5
	P5/S3
Average	3.275
1st Quartile	2.875
Median	3.5
3rd Quartile	4
	P5/S4
Average	3.825
1st Quartile	3
Median	4
3rd Quartile	4.25

Figure 15: Structure (Separation) Parameter (P5) versus Strategies Weighting



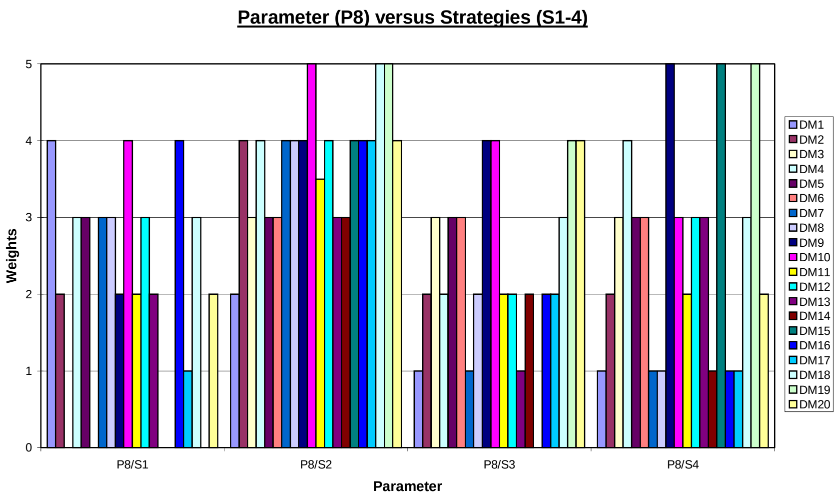
Summary Values	
	P6/S1
Average	2.425
1st Quartile	2
Median	3
3rd Quartile	3
	P6/S2
Average	4.355
1st Quartile	4
Median	5
3rd Quartile	5
	P6/S3
Average	4.3
1st Quartile	4
Median	4.5
3rd Quartile	5
	P6/S4
Average	3.6
1st Quartile	3
Median	4
3rd Quartile	4

Figure 16: Door Parameter (P6) versus Strategies Weighting



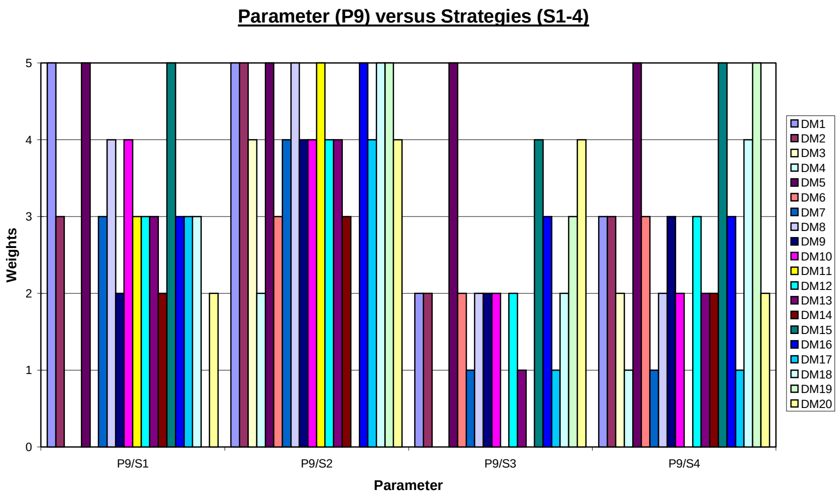
Summary Values	
	P7/S1
Average	1.725
1st Quartile	1
Median	2
3rd Quartile	2.125
	P7/S2
Average	3.725
1st Quartile	3.75
Median	4
3rd Quartile	4
	P7/S3
Average	2.55
1st Quartile	2
Median	2.5
3rd Quartile	3
	P7/S4
Average	2.15
1st Quartile	1
Median	2
3rd Quartile	3

Figure 17: Window Parameter (P7) versus Strategies Weighting



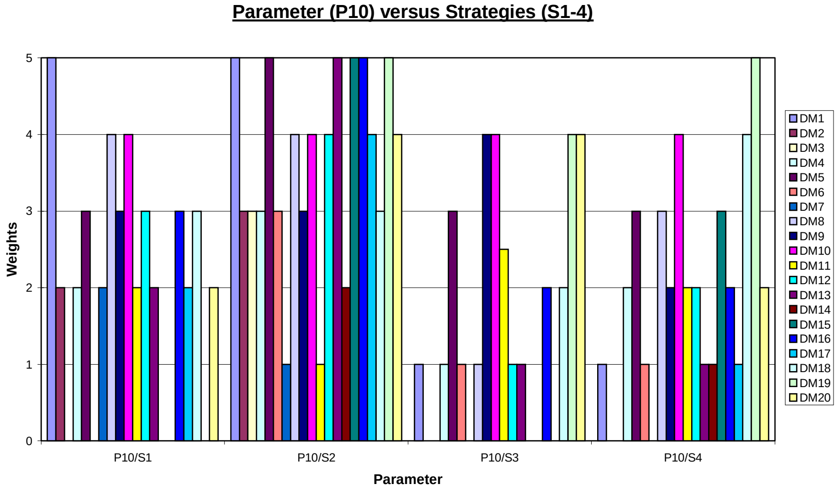
Summary Values	
	P8/S1
Average	2.05
1st Quartile	0.75
Median	2
3rd Quartile	3
	P8/S2
Average	3.775
1st Quartile	3
Median	4
3rd Quartile	4
	P8/S3
Average	2.35
1st Quartile	2
Median	2
3rd Quartile	3
	P8/S4
Average	2.6
1st Quartile	1
Median	3
3rd Quartile	3

Figure 18: Facade Parameter (P8) versus Strategies Weighting



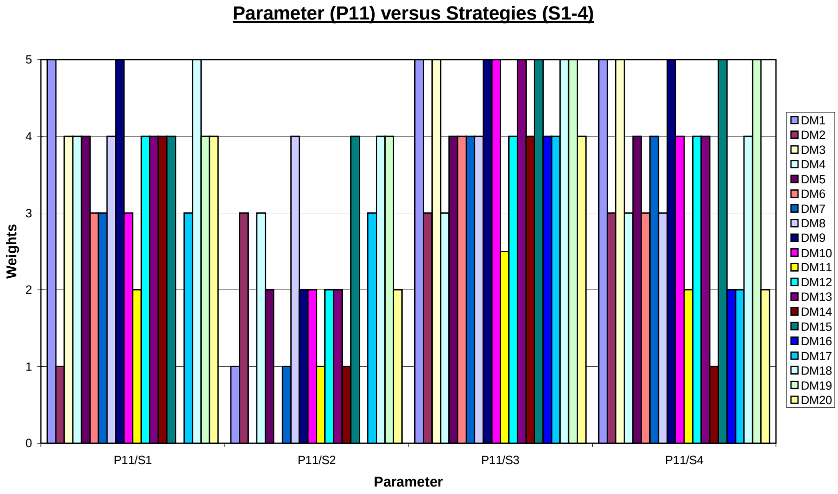
Summary Values	
	P9/S1
Average	2.65
1st Quartile	2
Median	3
3rd Quartile	3.25
	P9/S2
Average	4
1st Quartile	4
Median	4
3rd Quartile	5
	P9/S3
Average	1.9
1st Quartile	1
Median	2
3rd Quartile	2.25
	P9/S4
Average	2.6
1st Quartile	2
Median	2.5
3rd Quartile	3

Figure 19: Attic Parameter (P9) versus Strategies Weighting



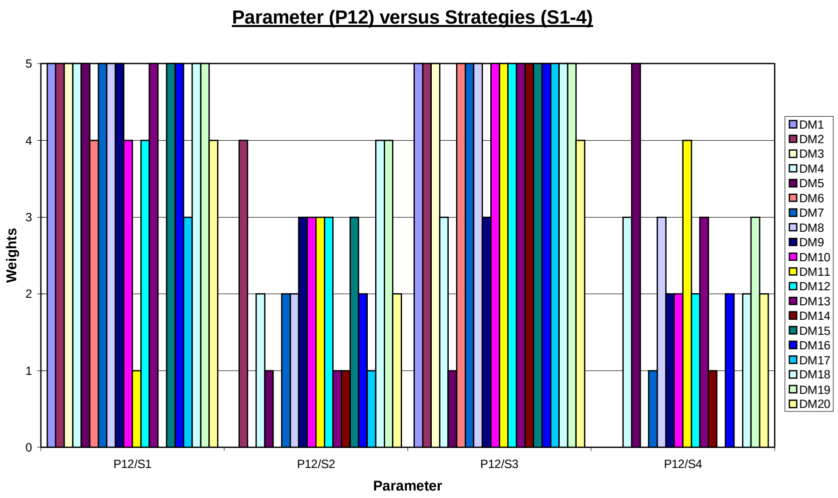
Summary Values	
	P10/S1
Average	2.1
1st Quartile	1.5
Median	2
3rd Quartile	3
	P10/S2
Average	3.6
1st Quartile	3
Median	4
3rd Quartile	5
	P10/S3
Average	1.575
1st Quartile	0
Median	1
3rd Quartile	2.625
	P10/S4
Average	1.95
1st Quartile	1
Median	2
3rd Quartile	3

Figure 20: Adjacent Buildings Parameter (P10) versus Strategies Weighting



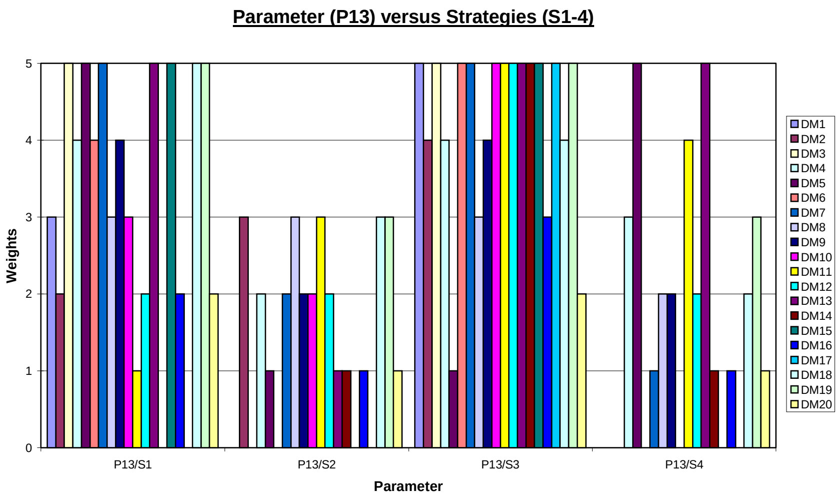
Summary Values	
	P11/S1
Average	3.5
1st Quartile	3
Median	4
3rd Quartile	4
	P11/S2
Average	2.05
1st Quartile	1
Median	2
3rd Quartile	3
	P11/S3
Average	4.225
1st Quartile	4
Median	4
3rd Quartile	5
	P11/S4
Average	3.5
1st Quartile	2.75
Median	4
3rd Quartile	4.25

Figure 21: Smoke Control System Parameter (P11) versus Strategies Weighting



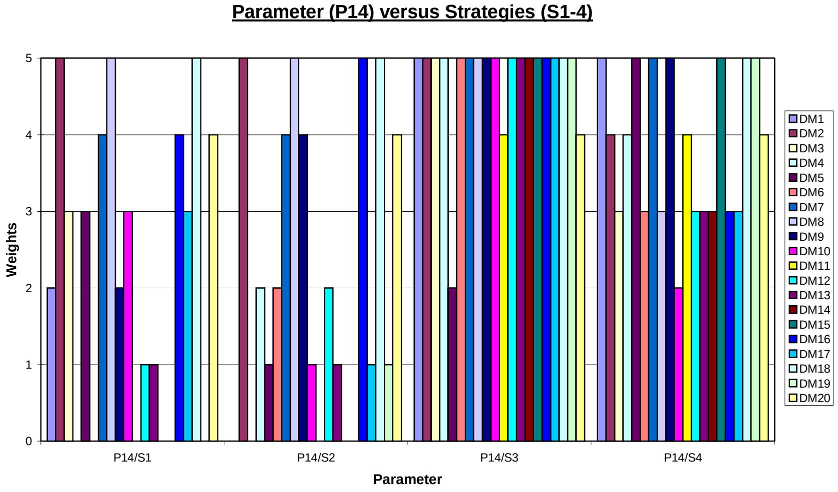
Summary Values	
	P12/S1
Average	4.25
1st Quartile	4
Median	5
3rd Quartile	5
	P12/S2
Average	2.05
1st Quartile	1
Median	2
3rd Quartile	3
	P12/S3
Average	4.55
1st Quartile	5
Median	5
3rd Quartile	5
	P12/S4
Average	1.75
1st Quartile	0
Median	2
3rd Quartile	3

Figure 22: Detection System Parameter (P12) versus Strategies Weighting



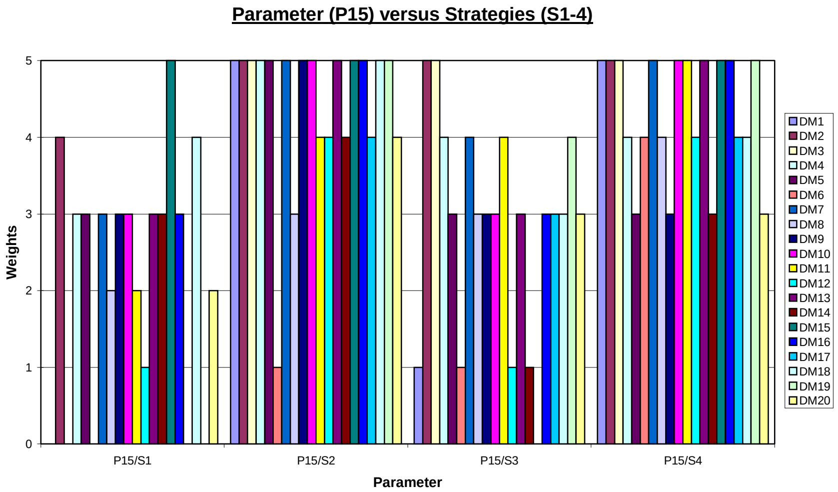
Summary Values	
	P13/S1
Average	3.25
1st Quartile	2
Median	3.5
3rd Quartile	5
	P13/S2
Average	1.5
1st Quartile	0.75
Median	1.5
3rd Quartile	2.25
	P13/S3
Average	4.25
1st Quartile	4
Median	5
3rd Quartile	5
	P13/S4
Average	1.6
1st Quartile	0
Median	1
3rd Quartile	2.25

Figure 23: Signal System Parameter (P13) versus Strategies Weighting



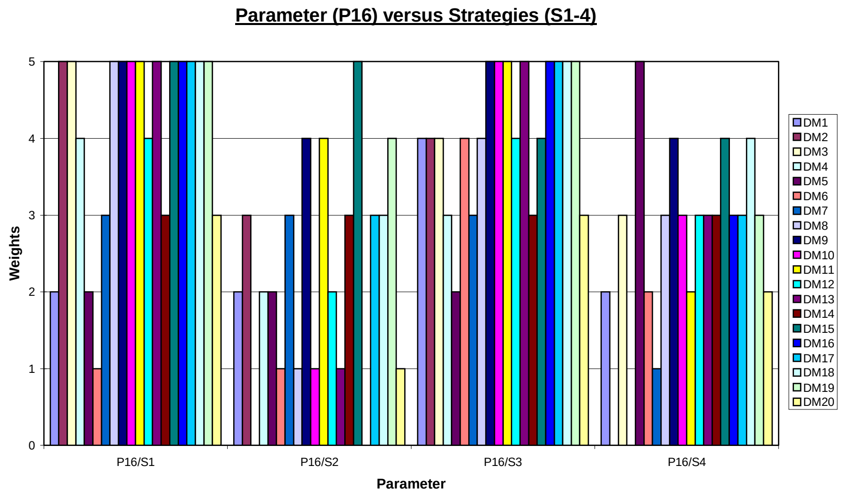
Summary Values	
	P14/S1
Average	2.25
1st Quartile	0
Median	2.5
3rd Quartile	4
	P14/S2
Average	2.15
1st Quartile	0.75
Median	1.5
3rd Quartile	4
	P14/S3
Average	4.75
1st Quartile	5
Median	5
3rd Quartile	5
	P14/S4
Average	3.85
1st Quartile	3
Median	4
3rd Quartile	5

Figure 24: Escape Routes Parameter (P14) versus Strategies Weighting



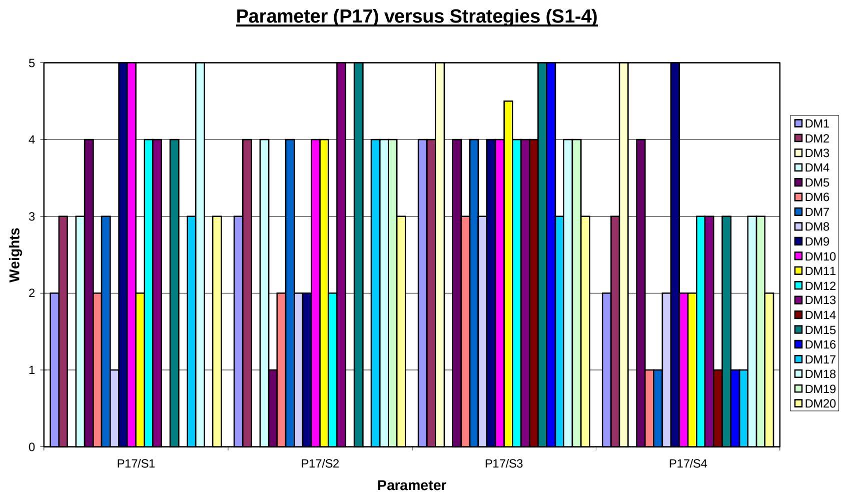
Summary Values	
	P15/S1
Average	2.2
1st Quartile	0.75
Median	3
3rd Quartile	3
	P15/S2
Average	4.45
1st Quartile	4
Median	5
3rd Quartile	5
	P15/S3
Average	2.85
1st Quartile	2.5
Median	3
3rd Quartile	4
	P15/S4
Average	4.3
1st Quartile	4
Median	4.5
3rd Quartile	5

Figure 25: Structure (Load Bearing) Parameter (P15) versus Strategies Weighting



Summary Values	
	P16/S1
Average	4.1
1st Quartile	3
Median	5
3rd Quartile	5
	P16/S2
Average	2.25
1st Quartile	1
Median	2
3rd Quartile	3
	P16/S3
Average	4.1
1st Quartile	3.75
Median	4
3rd Quartile	5
	P16/S4
Average	2.65
1st Quartile	2
Median	3
3rd Quartile	3

Figure 26: Maintenance and Information Parameter (P16) versus Strategies Weighting



Summary Values	
	P17/S1
Average	2.65
1st Quartile	1.75
Median	3
3rd Quartile	4
	P17/S2
Average	2.85
1st Quartile	2
Median	3.5
3rd Quartile	4
	P17/S3
Average	3.775
1st Quartile	3.75
Median	4
3rd Quartile	4
	P17/S4
Average	2.35
1st Quartile	1
Median	2
3rd Quartile	3

Figure 27: Ventilation System Parameter (P17) versus Strategies Weighting

99-11-11 99005BR/BK

Addressee: Members of the Delphi panel for the project "Risk - Timber-frame Buildings"

LUND UNIVERSITY

Department of Fire Safety Engineering
Björn Karlsson

D06: Results from Round 2 of the Weighting Exercise.

This letter contains a report on the results of the Round 2 of the weighting exercise. The enclosed documents "Round 2: Weights for Sub-parameters" and "Round 2: Weights for Objectives, Strategies and Parameters" contain the full results of the second Delphi round.

To summarize, the resulting weights from the two rounds were very similar, as is shown in Figure 1 below.

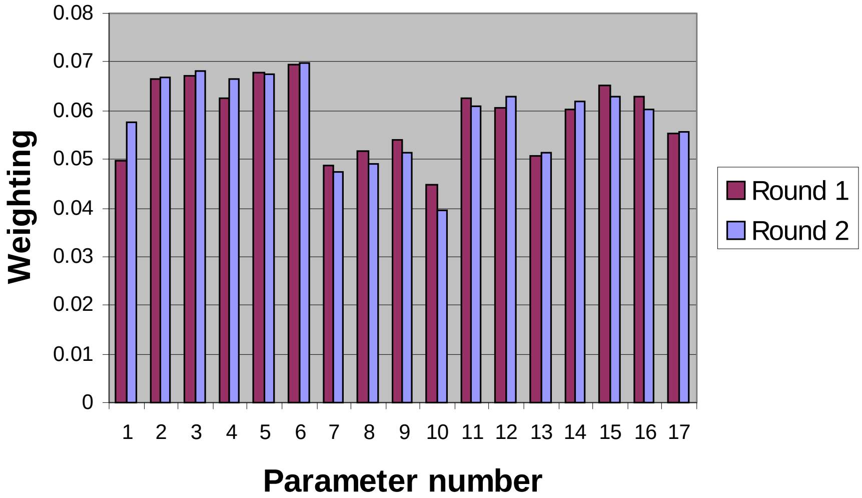


Figure 1 Results from the two rounds of the weighting exercise.

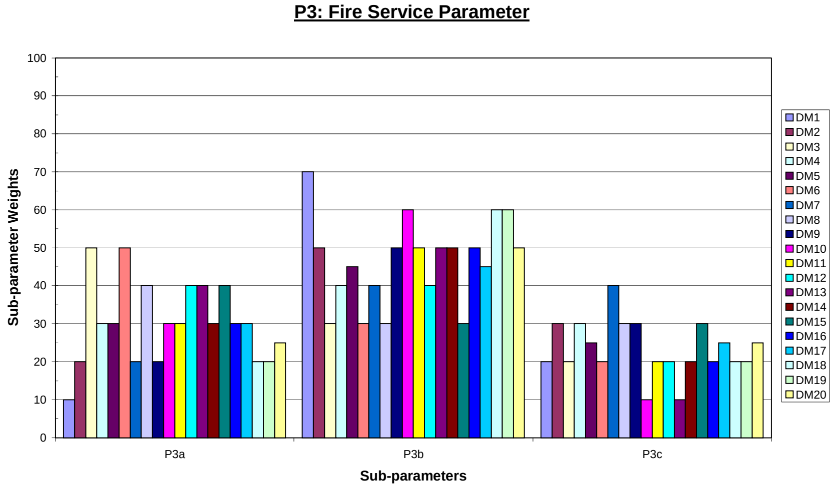
The only noticeable changes were that the overall weight for Lining materials (Parameter 1) increased slightly and the overall weight for Adjacent buildings (Parameter 10) decreased slightly.

The consensus (the degree to which the Delphi panel agrees on an issue) had already been deemed satisfactory after Round 1, the consensus increased slightly in Round 2.

Action required: There is no action required by the Delphi panel at this stage. The method will now be tested extensively and suggestions for improvements be made. If the proposed changes are considerable, a final Delphi round may be necessary in mid-year 2000.

Your assistance has been deeply appreciated!

Round 2: Weights for Sub-Parameters



Parameter Summary Values	
	P3a
Average	30.25
1st Quartile	20.00
Median	30.00
3rd Quartile	40.00
	P3b
Average	46.50
1st Quartile	40.00
Median	50.00
3rd Quartile	60.00
	P3c
Average	23.25
1st Quartile	20.00
Median	20.00
3rd Quartile	30.00

Figure 9: Fire Service Parameter Weightings

Parameter Summary Values	
	P5a
Average	34.25
1st Quartile	28.75
Median	37.50
3rd Quartile	40.00
	P5b
Average	28.25
1st Quartile	25.00
Median	25.00
3rd Quartile	30.00
	P5c
Average	23.75
1st Quartile	20.00
Median	25.00
3rd Quartile	26.25
	P5d
Average	13.75
1st Quartile	10.00
Median	10.00
3rd Quartile	20.00

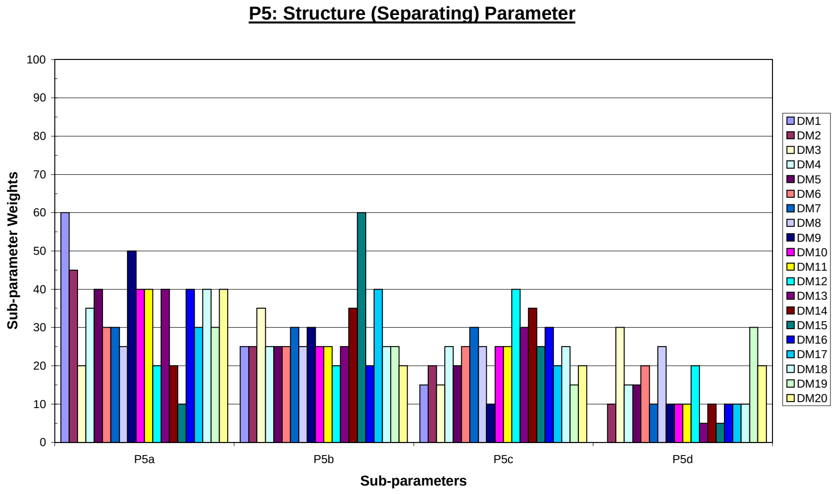
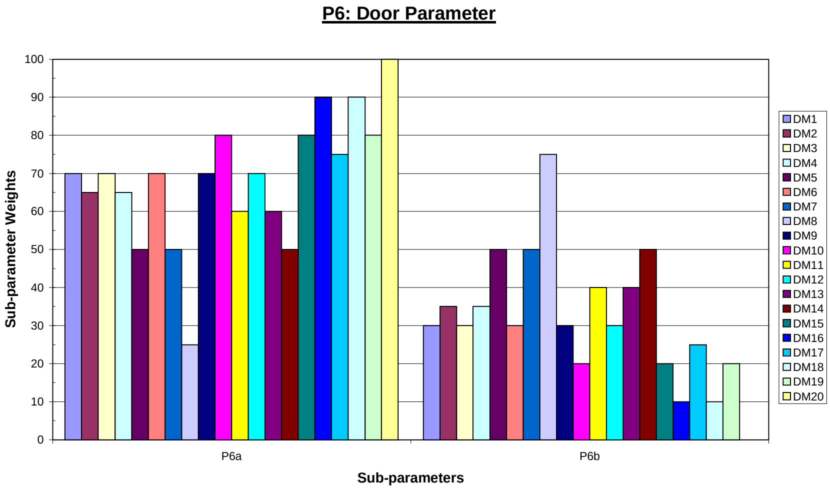
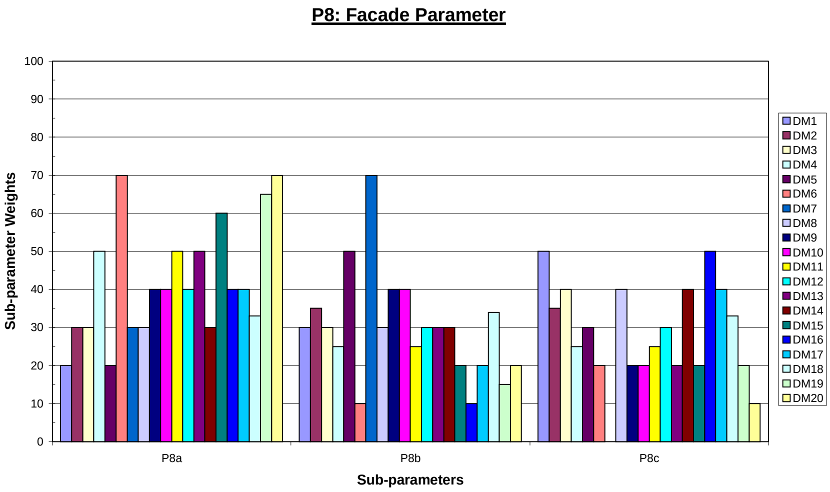


Figure 10: Structure (Separating) Parameter Weightings



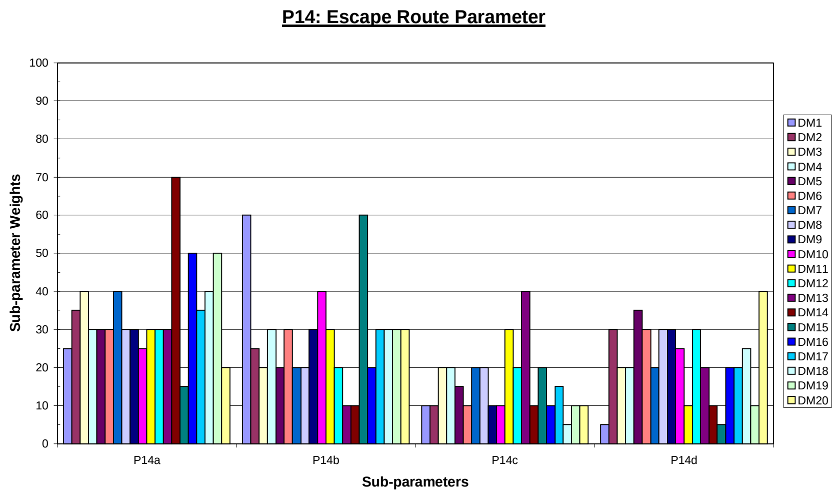
Parameter Summary Values	
	P6a
Average	68.50
1st Quartile	60.00
Median	70.00
3rd Quartile	80.00
	P6b
Average	31.50
1st Quartile	20.00
Median	30.00
3rd Quartile	40.00

Figure 11: Door Parameter Weightings



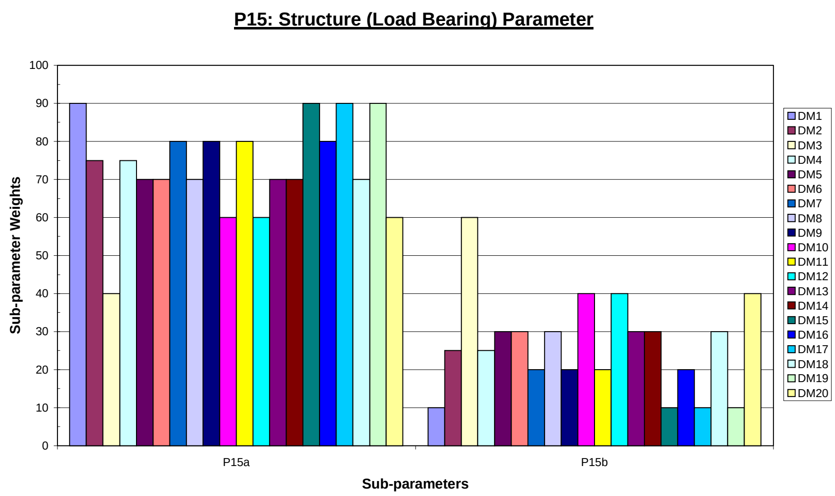
Parameter Summary Values	
	P8a
Average	41.90
1st Quartile	30.00
Median	40.00
3rd Quartile	50.00
	P8b
Average	29.70
1st Quartile	20.00
Median	30.00
3rd Quartile	34.25
	P8c
Average	28.40
1st Quartile	20.00
Median	27.50
3rd Quartile	40.00

Figure 12: Facade Parameter Weightings



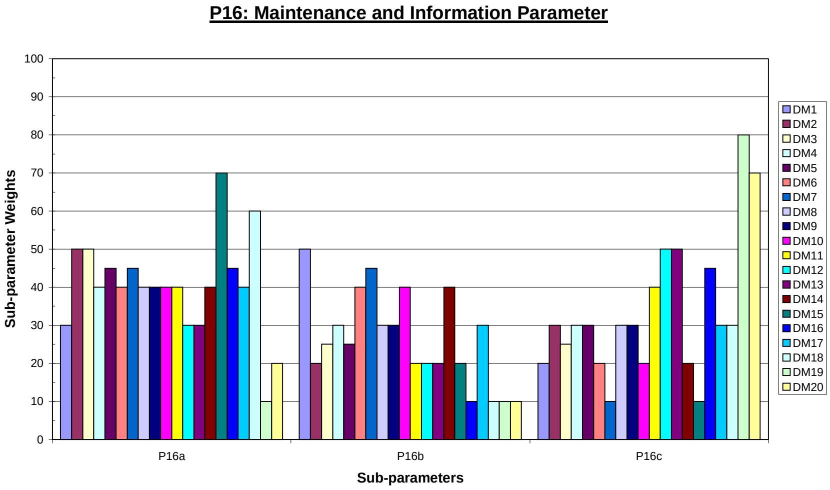
Parameter Summary Values	
	P14a
Average	34.25
1st Quartile	30.00
Median	30.00
3rd Quartile	40.00
	P14b
Average	28.25
1st Quartile	20.00
Median	30.00
3rd Quartile	30.00
	P14c
Average	15.75
1st Quartile	10.00
Median	12.50
3rd Quartile	20.00
	P14d
Average	21.75
1st Quartile	17.50
Median	20.00
3rd Quartile	30.00

Figure 13: Escape Route Parameter Weightings



Parameter Summary Values	
	P15a
Average	73.75
1st Quartile	70.00
Median	72.50
3rd Quartile	80.00
	P15b
Average	26.50
1st Quartile	20.00
Median	27.50
3rd Quartile	30.00

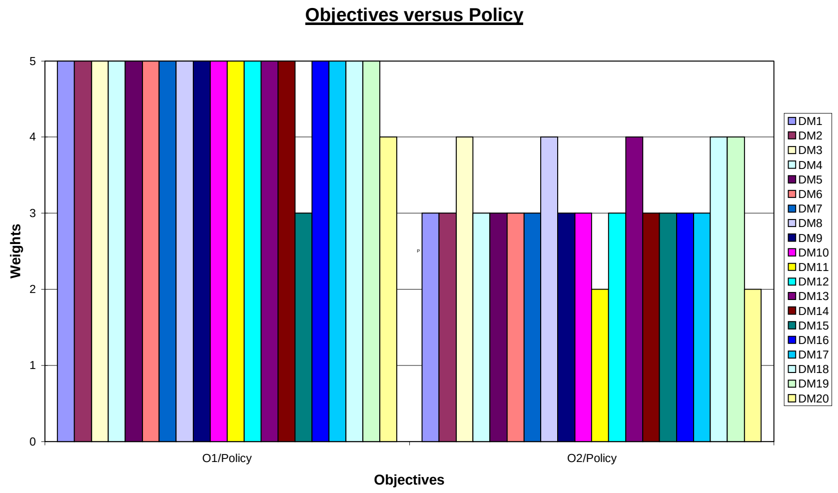
Figure 14: Structure (Load Bearing) Parameter Weightings



Parameter Summary Values	
	P16a
Average	40.25
1st Quartile	37.50
Median	40.00
3rd Quartile	45.00
	P16b
Average	26.25
1st Quartile	20.00
Median	25.00
3rd Quartile	32.50
	P16c
Average	33.50
1st Quartile	20.00
Median	30.00
3rd Quartile	41.25

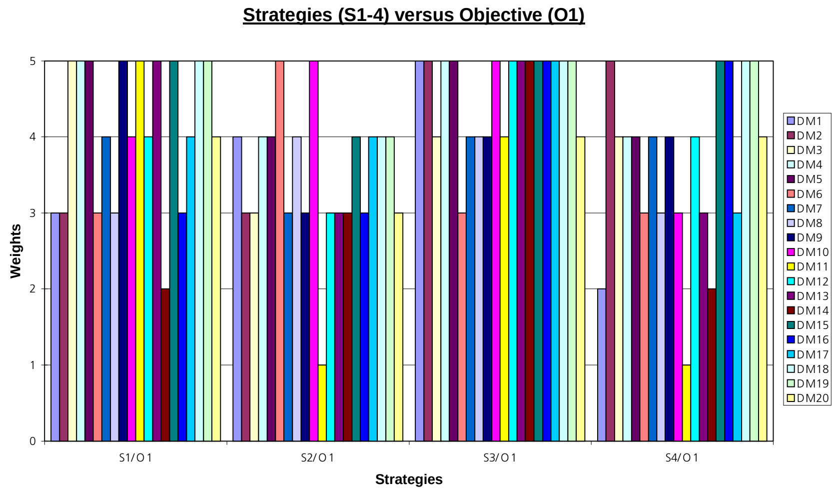
Figure 15: Maintenance and Information Parameter Weightings

Round 2: Weights for Objectives, Strategies and Parameters



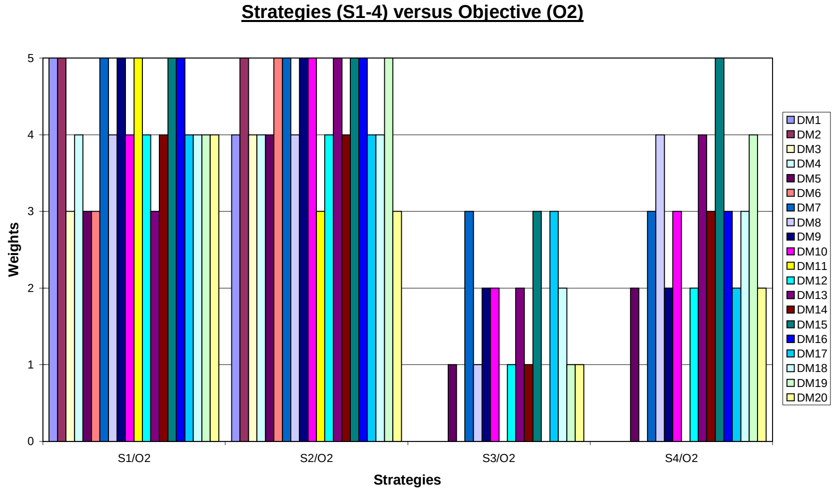
Summary Values	
	O1/Policy
Average	4.85
1st Quartile	5
Median	5
3rd Quartile	5
	O2/Poliy
Average	3.15
1st Quartile	3
Median	3
3rd Quartile	3.25

Figure 16: Objective versus Policy Weightings



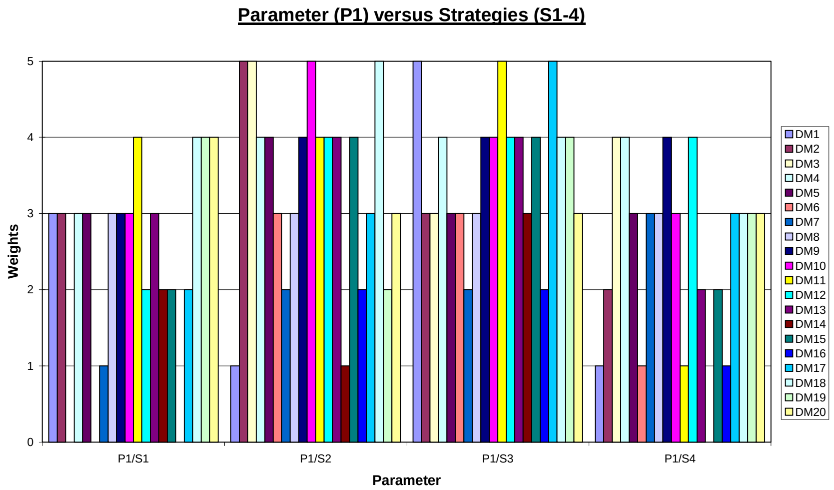
Summary Values	
	S1/O1
Average	4.1
1st Quartile	3
Median	4
3rd Quartile	5
	S2/O1
Average	3.5
1st Quartile	3
Median	3.5
3rd Quartile	4
	S3/O1
Average	4.6
1st Quartile	4
Median	5
3rd Quartile	5
	S4/O1
Average	3.65
1st Quartile	3
Median	4
3rd Quartile	4.25

Figure 17: Strategies versus Life Safety Objective (O1) Weightings



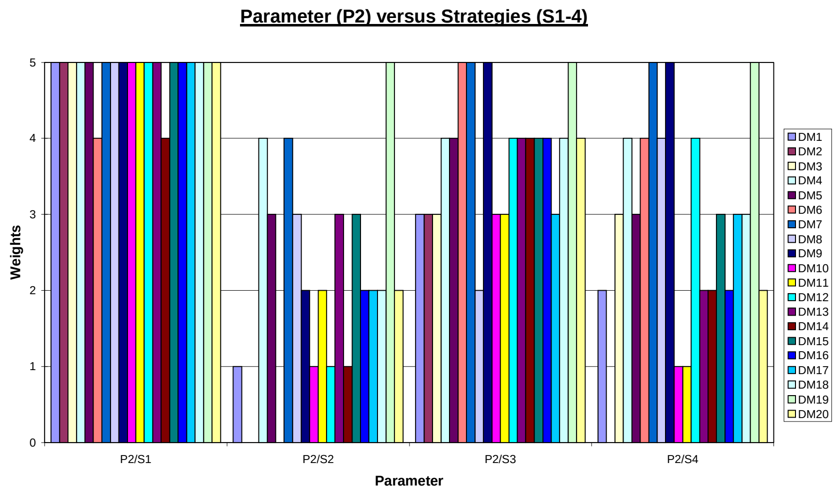
Summary Values	
	S1/O2
Average	4.15
1st Quartile	4
Median	4
3rd Quartile	5
	S2/O2
Average	4.35
1st Quartile	4
Median	4
3rd Quartile	5
	S3/O2
Average	1.15
1st Quartile	0
Median	1
3rd Quartile	2
	S4/O2
Average	2.1
1st Quartile	0
Median	2
3rd Quartile	3

Figure 18: Strategies versus Property Protection Objective (O2) Weightings



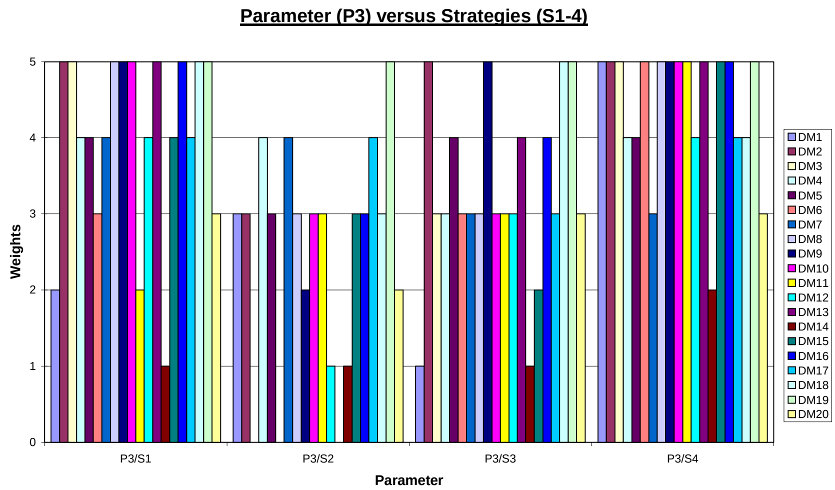
Summary Values	
	P1/S1
Average	2.45
1st Quartile	2
Median	3
3rd Quartile	3
	P1/S2
Average	3.4
1st Quartile	2.75
Median	4
3rd Quartile	4
	P1/S3
Average	3.6
1st Quartile	3
Median	4
3rd Quartile	4
	P1/S4
Average	2.5
1st Quartile	1.75
Median	3
3rd Quartile	3

Figure 19: Apartment Lining Parameter (P1) versus Strategies Weighting



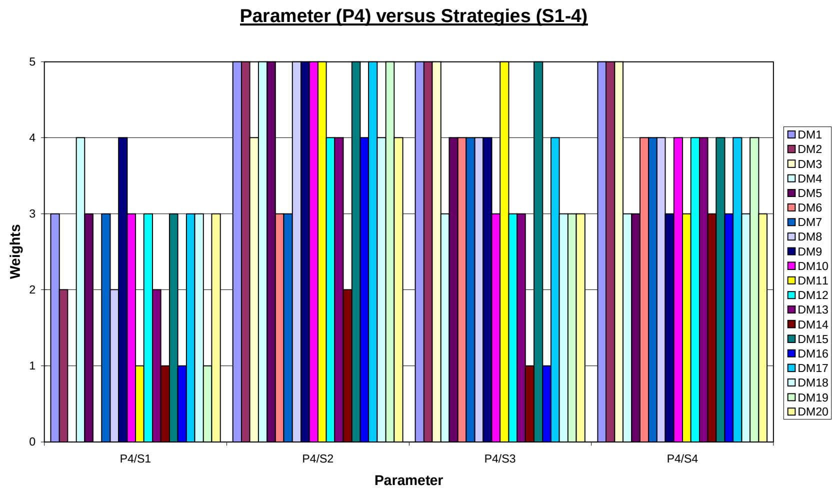
Summary Values	
	P2/S1
Average	4.9
1st Quartile	5
Median	5
3rd Quartile	5
	P2/S2
Average	2.05
1st Quartile	1
Median	2
3rd Quartile	3
	P2/S3
Average	3.8
1st Quartile	3
Median	4
3rd Quartile	4
	P2/S4
Average	2.9
1st Quartile	2
Median	3
3rd Quartile	4

Figure 20: Suppression System Parameter (P2) versus Strategies Weighting



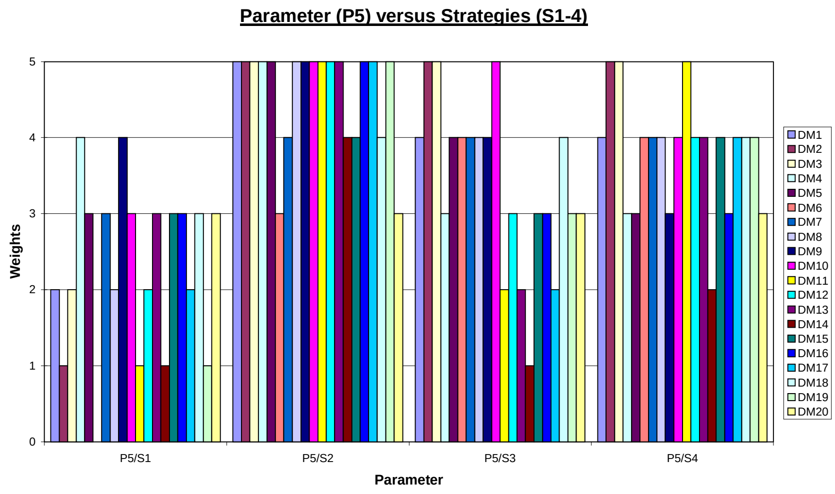
Summary Values	
	P3/S1
Average	4
1st Quartile	3.75
Median	4
3rd Quartile	5
	P3/S2
Average	2.5
1st Quartile	1.75
Median	3
3rd Quartile	3
	P3/S3
Average	3.3
1st Quartile	3
Median	3
3rd Quartile	4
	P3/S4
Average	4.4
1st Quartile	4
Median	5
3rd Quartile	5

Figure 21: Fire Service Parameter (P3) versus Strategies Weighting



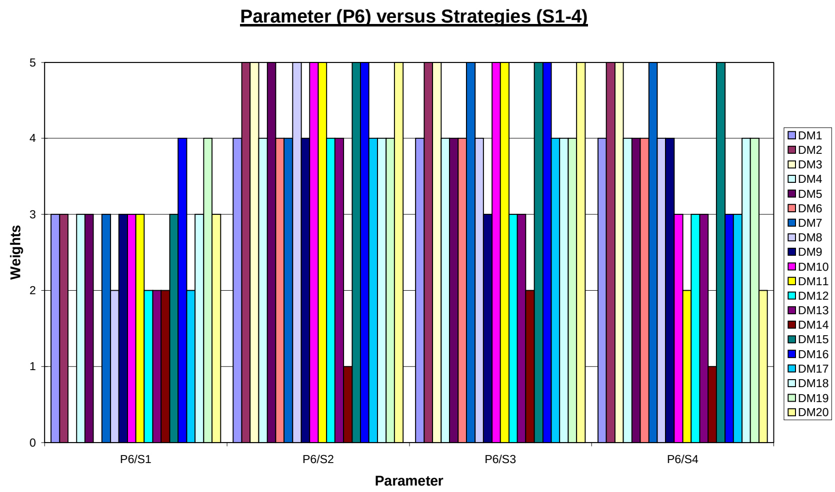
Summary Values	
	P4/S1
Average	2.25
1st Quartile	1
Median	3
3rd Quartile	3
	P4/S2
Average	4.35
1st Quartile	4
Median	5
3rd Quartile	5
	P4/S3
Average	3.6
1st Quartile	3
Median	4
3rd Quartile	4.25
	P4/S4
Average	3.75
1st Quartile	3
Median	4
3rd Quartile	4

Figure 22: Compartmentation Parameter (P4) versus Strategies Weighting



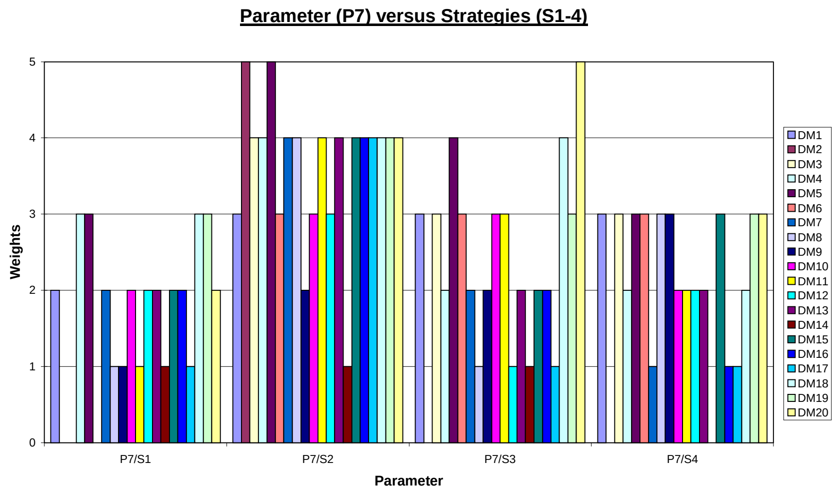
Summary Values	
	P5/S1
Average	2.3
1st Quartile	1.75
Median	2.5
3rd Quartile	3
	P5/S2
Average	4.6
1st Quartile	4
Median	5
3rd Quartile	5
	P5/S3
Average	34
1st Quartile	3
Median	3.5
3rd Quartile	4
	P5/S4
Average	3.8
1st Quartile	3
Median	4
3rd Quartile	4

Figure 23: Structure (Separation) Parameter (P5) versus Strategies Weighting



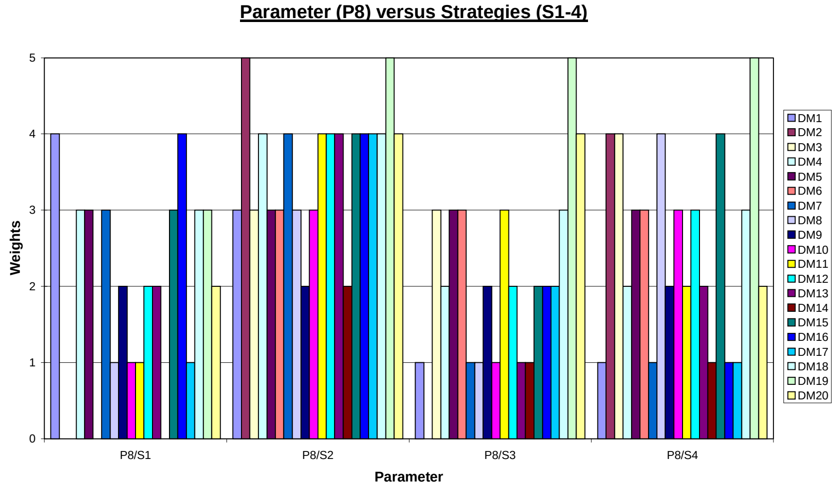
Summary Values	
	P6/S1
Average	2.55
1st Quartile	2
Median	3
3rd Quartile	3
	P6/S2
Average	4.3
1st Quartile	4
Median	4
3rd Quartile	5
	P6/S3
Average	4.15
1st Quartile	4
Median	4
3rd Quartile	5
	P6/S4
Average	3.6
1st Quartile	3
Median	4
3rd Quartile	4

Figure 24: Door Parameter (P6) versus Strategies Weighting



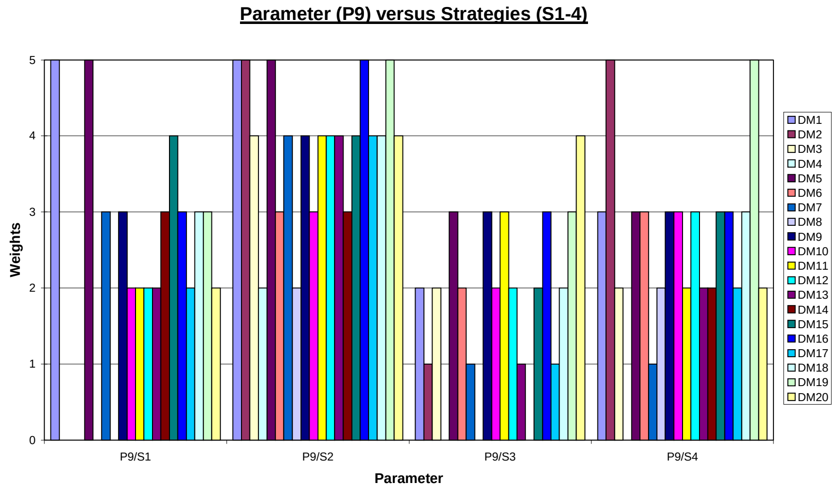
Summary Values	
	P7/S1
Average	1.65
1st Quartile	1
Median	2
3rd Quartile	2
	P7/S2
Average	3.65
1st Quartile	3
Median	4
3rd Quartile	4
	P7/S3
Average	2.35
1st Quartile	1.75
Median	2
3rd Quartile	3
	P7/S4
Average	2.1
1st Quartile	1.75
Median	2
3rd Quartile	3

Figure 25: Window Parameter (P7) versus Strategies Weighting



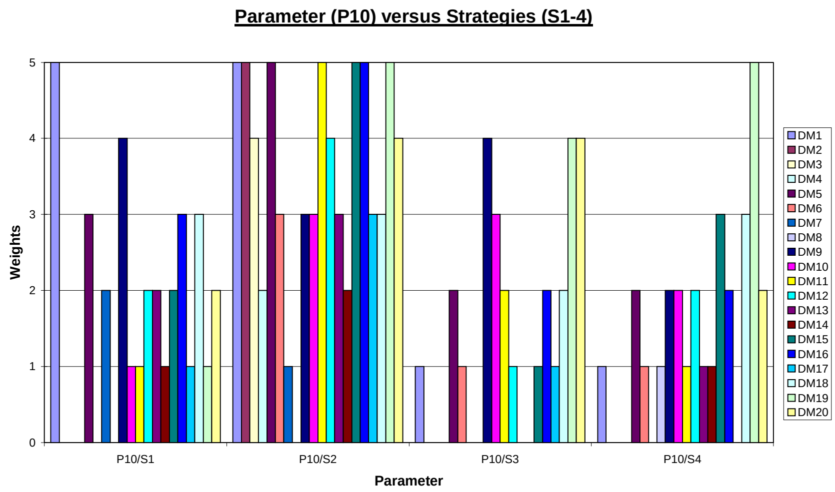
Summary Values	
	P8/S1
Average	1.9
1st Quartile	1
Median	2
3rd Quartile	3
	P8/S2
Average	3.6
1st Quartile	3
Median	4
3rd Quartile	4
	P8/S3
Average	2.1
1st Quartile	1
Median	2
3rd Quartile	3
	P8/S4
Average	2.55
1st Quartile	1.75
Median	2.5
3rd Quartile	3.25

Figure 26: Façade Parameter (P8) versus Strategies Weighting



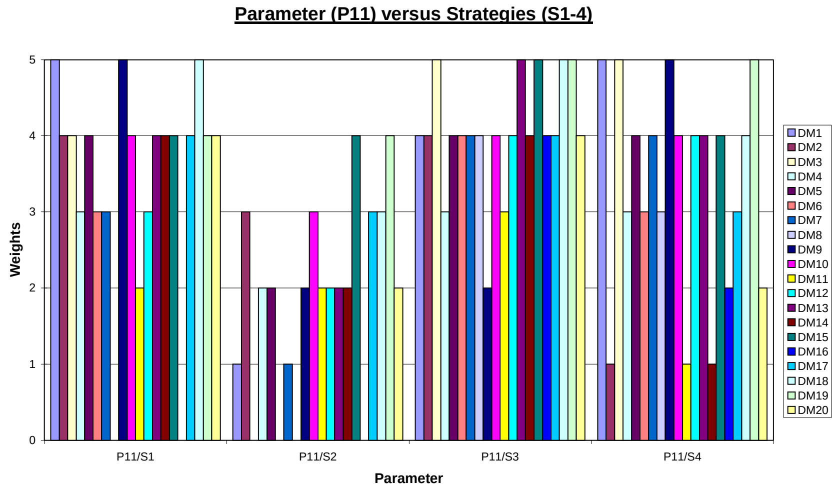
Summary Values	
	P9/S1
Average	2.2
1st Quartile	1.5
Median	2
3rd Quartile	3
	P9/S2
Average	3.9
1st Quartile	3.75
Median	4
3rd Quartile	4.25
	P9/S3
Average	1.85
1st Quartile	1
Median	2
3rd Quartile	3
	P9/S4
Average	2.6
1st Quartile	2
Median	3
3rd Quartile	3

Figure 27: Attic Parameter (P9) versus Strategies Weighting



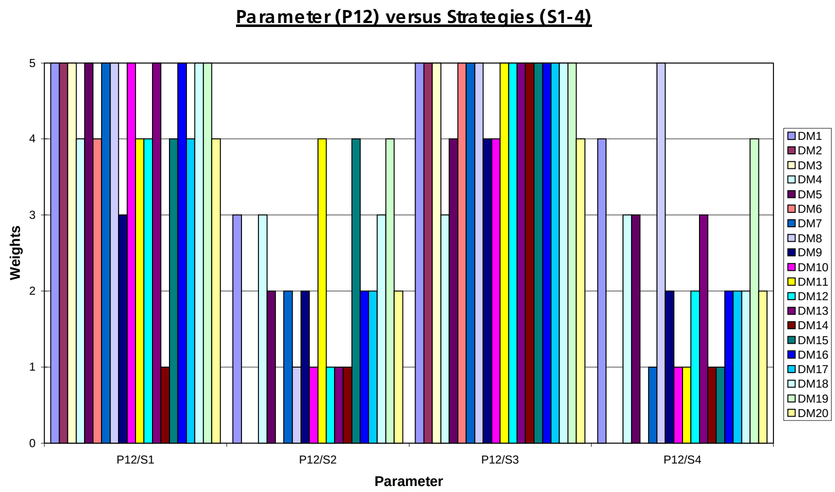
Summary Values	
	P10/S1
Average	1.65
1st Quartile	0.75
Median	1.5
3rd Quartile	2.25
	P10/S2
Average	3.5
1st Quartile	3
Median	3.5
3rd Quartile	5
	P10/S3
Average	1.4
1st Quartile	0
Median	1
3rd Quartile	2
	P10/S4
Average	1.45
1st Quartile	0.75
Median	1
3rd Quartile	2

Figure 28: Adjacent Buildings Parameter (P10) versus Strategies Weighting



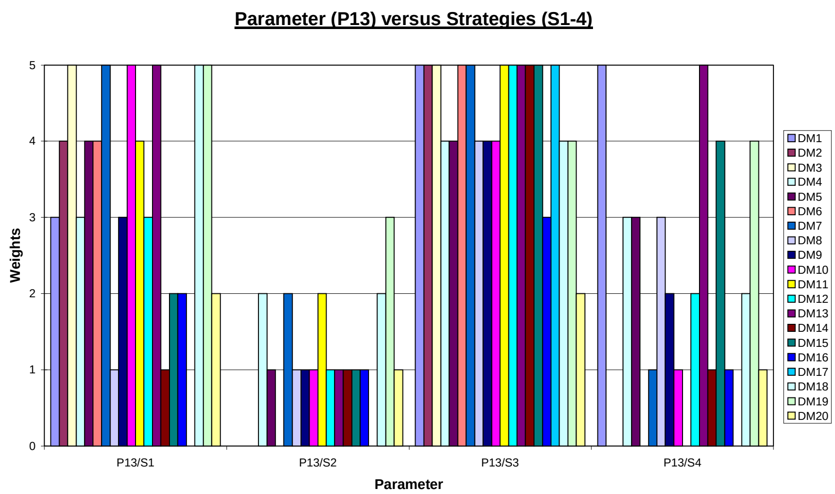
Summary Values	
	P11/S1
Average	3.45
1st Quartile	3
Median	4
3rd Quartile	4
	P11/S2
Average	1.9
1st Quartile	1
Median	2
3rd Quartile	3
	P11/S3
Average	4.05
1st Quartile	4
Median	4
3rd Quartile	4.25
	P11/S4
Average	3.35
1st Quartile	2.75
Median	4
3rd Quartile	4

Figure 29: Smoke Control System Parameter (P11) versus Strategies Weighting



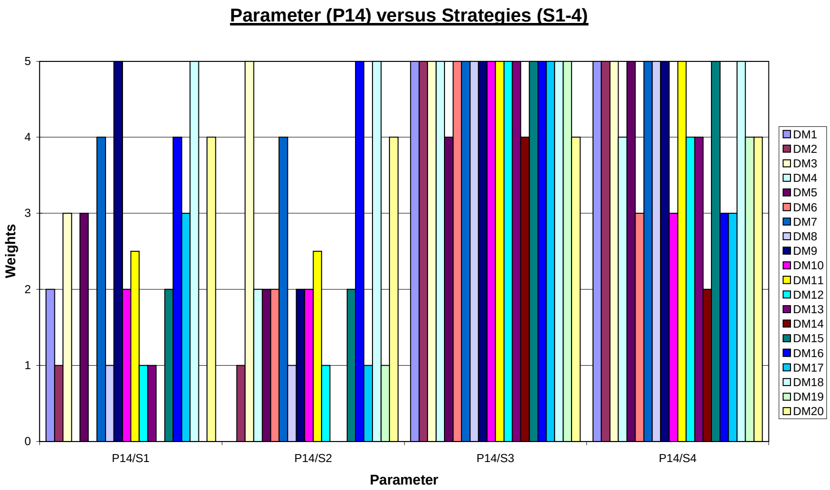
Summary Values	
	P12/S1
Average	4.35
1st Quartile	4
Median	5
3rd Quartile	5
	P12/S2
Average	1.9
1st Quartile	1
Median	2
3rd Quartile	3
	P12/S3
Average	4.7
1st Quartile	4.75
Median	5
3rd Quartile	5
	P12/S4
Average	1.95
1st Quartile	1
Median	2
3rd Quartile	3

Figure 30: Detection System Parameter (P12) versus Strategies Weighting



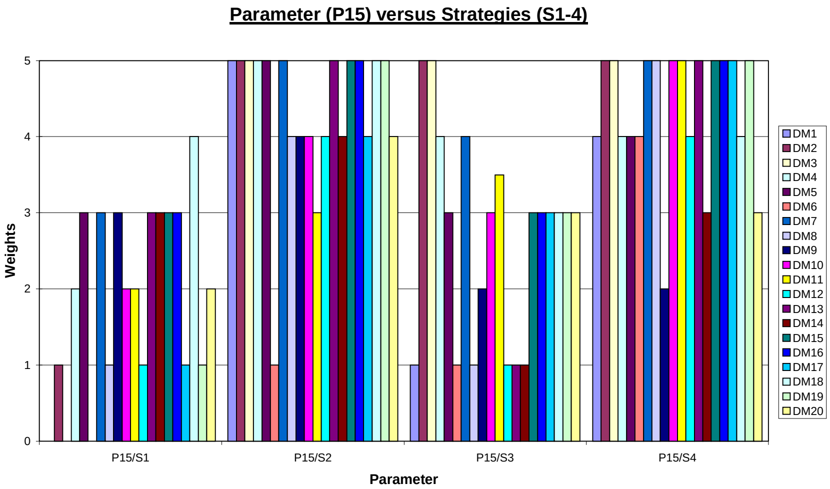
Summary Values	
	P13/S1
Average	3.3
1st Quartile	2
Median	3.5
3rd Quartile	5
	P13/S2
Average	1.05
1st Quartile	0.75
Median	1
3rd Quartile	1.25
	P13/S3
Average	4.4
1st Quartile	4
Median	5
3rd Quartile	5
	P13/S4
Average	1.9
1st Quartile	0.75
Median	1.5
3rd Quartile	3

Figure 31: Signal System Parameter (P13) versus Strategies Weighting



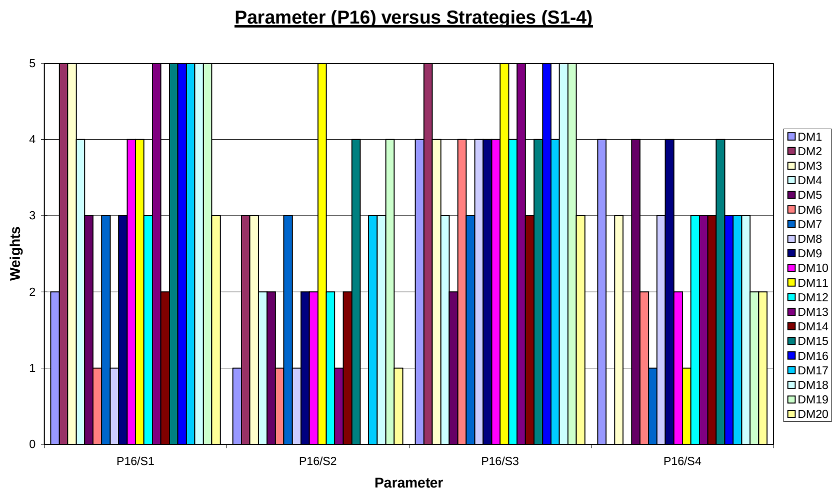
Summary Values	
	P14/S1
Average	2.175
1st Quartile	1
Median	2
3rd Quartile	3.25
	P14/S2
Average	2.125
1st Quartile	1
Median	2
3rd Quartile	2.875
	P14/S3
Average	4.85
1st Quartile	5
Median	5
3rd Quartile	5
	P14/S4
Average	4.2
1st Quartile	3.75
Median	4.5
3rd Quartile	5

Figure 32: Escape Routes Parameter (P14) versus Strategies Weighting



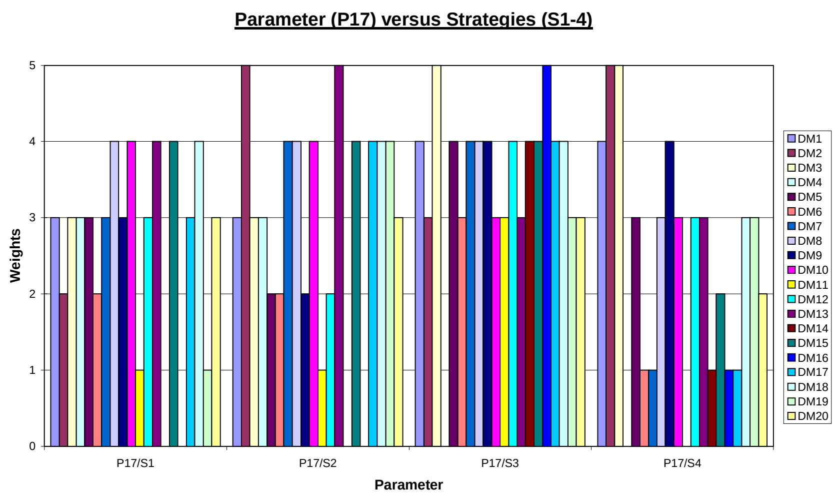
Summary Values	
	P15/S1
Average	1.9
1st Quartile	1
Median	2
3rd Quartile	3
	P15/S2
Average	4.35
1st Quartile	4
Median	5
3rd Quartile	5
	P15/S3
Average	2.675
1st Quartile	1
Median	3
3rd Quartile	3.125
	P15/S4
Average	4.35
1st Quartile	4
Median	5
3rd Quartile	5

Figure 33: Structure (Load Bearing) Parameter (P15) versus Strategies Weighting



Summary Values	
	P16/S1
Average	3.65
1st Quartile	3
Median	4
3rd Quartile	5
	P16/S2
Average	2.25
1st Quartile	1
Median	2
3rd Quartile	3
	P16/S3
Average	4
1st Quartile	3.75
Median	4
3rd Quartile	5
	P16/S4
Average	2.5
1st Quartile	2
Median	3
3rd Quartile	3

Figure 34: Maintenance and Information Parameter (P16) versus Strategies Weighting



Summary Values	
	P17/S1
Average	2.65
1st Quartile	2
Median	3
3rd Quartile	3.25
	P17/S2
Average	2.95
1st Quartile	2
Median	3
3rd Quartile	4
	P17/S3
Average	3.55
1st Quartile	3
Median	4
3rd Quartile	4
	P17/S4
Average	2.4
1st Quartile	1
Median	3
3rd Quartile	3

Figure 35: Ventilation System Parameter (P17) versus Strategies Weighting

6. Appendix B: Risk - Timber-frame Buildings: Version 1.2 of the Index Method

This is Version 1.2 of the Risk Index method for timber-frame buildings. The list below presents different decision levels; Objectives, Strategies and Parameters. The parameter grades are calculated by using the grading schemes presented in this paper. In the grading schemes the two lowest decision levels are used; Sub-Parameters and Survey Items. Currently, we shall only consider ordinary occupancies, later we may expand to include occupancies such as homes for the elderly.

Policy:

Provide acceptable fire safety level in multistorey apartment buildings

Def: Multistorey apartment buildings shall be designed in a way that ensures sufficient life safety and property protection in accordance with the objectives listed below.

Objectives:

O_1 Provide life safety

Def: Life safety of occupants in the compartment of origin, the rest of the building, outside and in adjacent buildings and life safety of fire fighters

O_2 Provide property protection

Def: Protection of property in the compartment of origin, in the rest of the building, outside and in adjacent buildings

Strategies:

S_1 Control fire growth by active means

Def: Controlling the fire growth by using active systems (suppression systems and smoke control systems) and the fire service.

S_2 Confine fire by construction

Def: Provide structural stability, control the movement of fire through containment, use fire safe materials (linings and facade material). This has to do with passive systems or materials that are constantly in place.

S_3 Establish safe egress

Def: Cause movement of occupants and provide movement means for occupants. This is done by designing detection systems, signal systems, by designing escape routes and by educating or training the occupants. In some cases the design of the escape route may involve action by the fire brigade (escape by ladder through window).

S_4 Establish safe rescue

Def: Protect the lives and ensure safety of fire brigades personnel during rescue. This is done by providing structural stability and preventing rapid unexpected fire spread and collapse of building parts.

Parameters:

P_1 Linings in apartment
Def: Possibility of internal linings in an apartment to delay the ignition of the structure and to reduce fire growth

P_2 Suppression system
Def: Equipment and systems for suppression of fires

P_3 Fire service
Def: Possibility of fire services to save lives and to prevent further fire spread

P_4 Compartmentation
Def: Extent to which building space is divided into fire compartments

P_5 Structure - separating
Def: Fire resistance of building assemblies separating fire compartments

P_6 Doors
Def: Fire and smoke separating function of doors between fire compartments

P_7 Windows
Def: Windows and protection of windows, ie. factors affecting the possibility of fire spread through the openings

P_8 Facade
Def: Facade material and factors affecting the possibility of fire spread along the facade

P_9 Attic
Def: Prevention of fire spread to and in attic

P_{10} Adjacent buildings
Def: Minimum separation distance from other buildings

P_{11} Smoke control system
Def: Equipment and systems for limiting spread of toxic fire products

P_{12} Detection system
Def: Equipment and systems for detecting fires

P_{13} Signal system
Def: Equipment and systems for transmitting an alarm of fire

P_{14} Escape routes
Def: Adequacy and reliability of escape routes

P_{15} Structure - load-bearing
Def: Structural stability of the building when exposed to a fire

P_{16} Maintenance and information
Def: Inspection and maintenance of fire safety equipment, escape routes etc. and information to occupants in suppression and evacuation

P_{17} Ventilation system
Def: Extent to which the spread of smoke through the ventilation system is prevented.

P_1. LININGS IN APARTMENT

DEFINITION: Possibility of internal linings in an apartment to delay the ignition of the structure and to reduce fire growth

PARAMETER GRADE:
This refers to the worst lining class (wall or ceiling) that is to be found in an apartment.

LINING CLASS						GRADE
Suggestions to Euroclasses	Typical products	DK	FIN	NO	SWE	
A1	Stone, concrete	A	1/I	In1	I	**5**
A2	Gypsum boards	A	1/I	In1	I	**5**
B	Best FR woods (impregnated)	A	1/I	In1	I	**4**
C	Textile wall cover on gypsum board		1/II 2/-	In2	II	**3**
D	Wood (untreated)	B	1/-	In2	III	**2**
E	Low density wood fibreboard	U	U	U	U	**1**
F	Some plastics	U	U	U	U	**0**

(Minimum grade = 0 and maximum grade = 5)

Resulting grade:

P_2. SUPPRESSION SYSTEM

DEFINITION: Equipment and systems for suppression of fires

SUB-PARAMETERS:

Automatic sprinkler system
Type of sprinkler (N = no sprinkler, R = residential sprinkler, O = ordinary sprinkler) and Location of sprinkler (A = in apartment, E = in escape route, B = both in apartment and escape route)

SURVEY ITEMS	DECISION RULES						
Type of sprinkler	N	R	R	R	O	O	O
Location of sprinkler	-	A	E	B	A	E	B
GRADE	N	M	L	H	M	L	H

(N = no grade, L = low grade, M = medium grade and H = high grade)

Portable equipment

N	None
F	Extinguishing equipment on every floor
A	Extinguishing equipment in every apartment

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES											
Automatic sprinkler system	N	N	N	L	L	L	M	M	M	H	H	H
Portable equipment	N	F	A	N	F	A	N	F	A	N	F	A
GRADE	**0**	**0**	**1**	**1**	**1**	**2**	**4**	**4**	**4**	**5**	**5**	**5**

(Minimum grade = 0 and maximum grade = 5)

Resulting grade:

P_3. FIRE SERVICE

DEFINITION: Possibility of fire services to save lives and to prevent further fire spread

SUB-PARAMETERS:

Capability of responding fire service **(P_{3a})**

CAPABILITY OF RESPONDING FIRE SERVICE	**GRADE**
No brigade available	**0**
Fire fighting capability only outside the building	**1**
Fire fighting capability but no smoke diving capability	**2**
Fire fighting and smoke diving capability	**4**
Simultaneous fire fighting, smoke diving and external rescue by ladders	**5**

(Minimum grade = 0 and maximum grade = 5)

Response time of fire service to the site

RESPONSE TIME (min)	**GRADE**
> 20	**0**
15 - 20	**1**
10 - 15	**2**
5 - 10	**3**
0 - 5	**5**

(Minimum grade = 0 and maximum grade = 5)

Accessibility and equipment (ie. number of windows (or balconies) that are accessible by the fire service ladder trucks) **(P_{3c})**

ACCESSIBILITY AND EQUIPMENT	**GRADE**
Less than one window in each apartment accessible by fire service ladders	**0**
At least one window in each apartment accessible by fire service ladders	**3**
All windows accessible by fire service ladder	**5**

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(0.31 × Capability + 0.47 × Response time + 0.22 × Accessibility and equipment)

Resulting grade:

P_4. COMPARTMENTATION

DEFINITION: Extent to which building space is divided into fire compartments

PARAMETER GRADE:

MAXIMUM AREA IN FIRE COMPARTMENT	**GRADE**
> 400 m^2	**0**
200 - 400 m^2	**1**
100 – 200 m^2	**2**
50 – 100 m^2	**3**
< 50 m^2	**5**

(Minimum grade = 0 and maximum grade = 5)

Resulting grade:

P_5. STRUCTURE - SEPARATING

DEFINITION: Fire resistance of building assemblies separating fire compartments

SUB-PARAMETERS:

Integrity and insulation (P_{5a})

INTEG.RITY AND INSULATION (EI)	**GRADE**
EI < EI 15	**0**
EI 15 ≤ EI < EI 30	**1**
EI 30 ≤ EI < EI 45	**3**
EI 45 ≤ EI < EI 60	**4**
EI ≥ EI 60	**5**

(Minimum grade = 0 and maximum grade = 5)

Firestops at joints, intersections and concealed spaces (P_{5b})

STRUCTURE AND FIRESTOP DESIGN	**GRADE**
Timber-frame structure with voids and no firestops	**0**
Ordinary design of joints, intersections and concealed spaces, without special consideration for fire safety.	**1**
Joints, intersections and concealed spaces are specially designed for preventing fire spread and deemed by engineers to have adequate performance.	**2**
Joints, intersections and concealed spaces have been tested and shown to have endurance in accordance with the EI of other parts of the construction.	**3**
Homogenous construction with no voids	**5**

(Minimum grade = 0 and maximum grade = 5)

Penetrations (P_{5c})
Penetrations between separating fire compartments

PENETRATIONS	**GRADE**
Penetrations with no seals between fire compartments	**0**
Non-certified sealing systems between fire compartments	**1**
Certified sealing systems between fire compartments	**2**
Special installation shafts or ducts in an own fire compartment with certified sealing systems to other fire compartments	**3**
No penetrations between fire compartments	**5**

(Minimum grade = 0 and maximum grade = 5)

Combustibility (P_{5d})
Combustible part of the separating construction

COMBUSTIBLE PART	**GRADE**
Both separating structure and insulation are combustible	**0**
Only the insulation is combustible	**2**
Only the separating structure is combustible	**3**
Both separating structure and insulation are non- combustible	**5**

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(0.35 × Integrity and insulation + 0.28 × Firestops at joints, intersections and concealed spaces + 0.24 × Penetrations + 0.13 × Combustibility)

Note: If grade for penetrations = 0, then the parameter grade = 0

Resulting grade:

P_6. DOORS

DEFINITION: Fire separating function of doors between fire compartments

SUB-PARAMETERS:

Doors leading to escape route (P_{6a})
Integrity and insulation (= EI)
(A = EI < EI 15, B = EI 15 ≤ EI < EI 30, C = EI 30 ≤ EI < EI 60, D = EI ≥ EI 60)
and Type of closing (M = manually, S = self-closing)

SURVEY ITEMS	DECISION RULES							
Integrity and insulation	A	A	B	B	C	C	D	D
Type of closing	M	S	M	S	M	S	M	S
GRADE	**0**	**1**	**1**	**3**	**2**	**4**	**3**	**5**

(Minimum grade = 0 and maximum grade = 5)

Doors in escape route (P_{6b})
Integrity and insulation (= EI)
(A = EI < EI 15, B = EI 15 ≤ EI < EI 30, C = EI 30 ≤ EI < EI 60, D = EI ≥ EI 60)
and Type of closing (M = manually, S = self-closing)
If no doors are needed in the escape routes the highest grade is received.

SURVEY ITEMS	DECISION RULES								
Integrity and insulation	A	A	B	B	C	C	D	D	-
Type of closing	M	S	M	S	M	S	M	S	-
GRADE	**0**	**1**	**1**	**3**	**2**	**4**	**3**	**5**	**5**

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(0.67 × Doors leading to escape route + 0.33 × Doors in escape route)

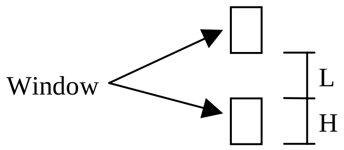
Resulting grade:

P_7. WINDOWS

DEFINITION: Windows (and other facade openings) and protection of these, ie. factors affecting the possibility of fire spread through the openings

SUB-PARAMETERS:

Relative vertical distance
This is defined as the height of the window divided by the vertical distance between windows



Relative vertical distance, R = L/H
(A = R < 1, B = R ≥ 1)

Class of window
(C = window class < E 15, D = window class ≥ E 15, E = tested special design solution or window class ≥ E 30)

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES					
Relative vertical distance	A	A	A	B	B	B
Class of window	C	D	E	C	D	E
GRADE	**0**	**3**	**5**	**2**	**5**	**5**

(Minimum grade = 0 and maximum grade = 5)

Resulting grade:

P_8. FACADES

DEFINITION: Facade material and factors affecting the possibility of fire spread along the facade

SUB-PARAMETERS:

Combustible part of facade (P_{8a})

COMBUSTIBLE PART	GRADE
> 40 %	**0**
20 – 40 %	**2**
< 20 %	**3**
0 %	**5**

(Minimum grade = 0 and maximum grade = 5)

Combustible material above windows (P_{8b})

COMBUSTIBLE MATERIAL ABOVE WINDOWS?	GRADE
Yes	**0**
No	**5**

(Minimum grade = 0 and maximum grade = 5)

Void (P_{8c})
Does there exist a continuous void between the facade material and the supporting wall?

TYPE OF VOID	GRADE
Continuous void in combustible facade	**0**
Void with special design solution for preventing fire spread	**3**
No void	**5**

PARAMETER GRADE:

(0.41$\times$ Combustible part of facade + 0.30 $\times$ Combustible material above windows + 0.29 $\times$ Void)

Resulting grade:

P_9. ATTIC

DEFINITION: Prevention of fire spread to and in attic

SUB-PARAMETERS:

Prevention of fire spread to attic (eg. is the design such that ventilation of the attic is not provided at the eave? The most common mode of exterior fire spread to the attic is through the eave. Special ventilation solutions avoid this.)

N	No
Y	Yes

Fire separation in attic (ie. extent to which the attic area is separated into fire compartments)

MAXIMUM AREA OF FIRE COMPARTMENT IN ATTIC	GRADE
No attic	H
< 100 m^2	M
100 – 300 m^2	L
300 – 600 m^2	L
> 600 m^2	N

(N = no grade, L = low grade, M = medium grade and H = high grade)

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES							
Prevention of fire spread to attic	N	N	N	N	Y	Y	Y	Y
Fire separation in attic	N	L	M	H	N	L	M	H
GRADE	**0**	**1**	**2**	**5**	**2**	**3**	**4**	**5**

(Minimum grade = 0 and maximum grade = 5)

Resulting grade:

P_{10}. ADJACENT BUILDINGS

DEFINITION: Minimum separation distance from other buildings. If the buildings are separated by a fire wall this is deemed to be equivalent to 8 m distance.

PARAMETER GRADE:

DISTANCE TO ADJACENT BUILDING, D	**GRADE**
D < 6 m	**0**
6 ≤ D < 8 m	**1**
8 ≤ D < 12 m	**2**
12 ≤ D < 20 m	**3**
D ≥ 20 m	**5**

(Minimum grade = 0 and maximum grade = 5)

Resulting grade:

P_{11}. SMOKE CONTROL SYSTEM

DEFINITION: Equipment and systems in escape routes for limiting spread of toxic fire products

SUB-PARAMETERS:

Activation of smoke control system

N	No smoke control system
M	Manually
A	Automatically

Type of smoke control system

N	Natural ventilation through openings near ceiling
M	Mechanical ventilation
PN	Pressurisation and natural ventilation for exiting smoke
PM	Pressurisation and mechanical ventilation for exiting smoke

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES								
Activation of smoke control system	N	M	M	M	M	A	A	A	A
Smoke vent openings	-	N	M	PN	PM	N	M	PN	PM
GRADE	**0**	**2**	**2**	**3**	**3**	**4**	**4**	**5**	**5**

(Minimum grade = 0 and maximum grade = 5)

Resulting grade:

P_{12}. DETECTION SYSTEM

DEFINITION: Equipment and systems for detecting fires

SUB-PARAMETERS:

Amount of detectors
Detectors in apartment (N = none, A = at least one in every apartment, R = more than one in every apartment) and Detectors in escape route (N = no, Y = yes)

SURVEY ITEMS	DECISION RULES					
Detectors in apartment	N	N	A	R	A	R
Detectors in escape route	N	Y	N	N	Y	Y
GRADE	N	L	L	M	H	H

(N = no grade, L = low grade, M = medium grade and H = high grade)

Reliability of detectors
Detector type (H = heat detectors, S = smoke detectors) and Detector power supply (B = battery, P = power grid, BP = power grid and battery backup)

SURVEY ITEMS	DECISION RULES					
Detector type	H	H	H	S	S	S
Detector power supply	B	P	BP	B	P	BP
GRADE	L	M	M	M	H	H

(N = no grade, L = low grade, M = medium grade and H = high grade)

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES									
Amount of detectors	N	L	L	L	M	M	M	H	H	H
Reliability of detectors	-	L	M	H	L	M	H	L	M	H
GRADE	**0**	**1**	**2**	**2**	**2**	**3**	**3**	**3**	**4**	**5**

(Minimum grade = 0 and maximum grade = 5)

Resulting grade:

P_{13}. SIGNAL SYSTEM

DEFINITION: Equipment and systems for transmitting an alarm of fire

SUB-PARAMETERS:

Type of signal
Light signal (N = no, Y = yes) and Sound signal (N = no, A = alarm bell, S = spoken message)

SURVEY ITEMS	DECISION RULES					
Light signal	N	Y	N	N	Y	Y
Sound signal	N	N	A	S	A	S
GRADE	N	L	M	H	M	H

(N = no grade, L = low grade, M = medium grade and H = high grade)

Location of signal
Do you just receive a signal within the fire compartmentation or is it also possible to warn other occupants?

A	The signal is sent to the compartment only.
B	It is possible to send a signal manually to the whole building or at least to a large section of the building.

PARAMETER GRADE:

SUB-PARAMETERS	DECISION RULES						
Type of signal	N	L	L	M	M	H	H
Location of signal	-	A	B	A	B	A	B
GRADE	**0**	**1**	**2**	**3**	**4**	**4**	**5**

(Minimum grade = 0 and maximum grade = 5)

Resulting grade:

P_{14}. ESCAPE ROUTES

DEFINITION: Adequacy and reliability of escape routes

SUB-PARAMETERS:

Type of escape routes (P_{14a})
Staircase (A = one staircase may be used as an escape route, B = escape route leading to two independent staircases, C = direct escape to two independent staircases) and Window/Balcony (D = windows and balconies can not be used as escape routes, E = one window may be used as an escape route, F = at least two independent windows may be used as escape routes, G = the balcony may be used as an escape route, H = at least one window and the balcony may be used as escape routes)

SURVEY ITEMS	DECISION RULES												
Staircase	A	A	A	A	B	B	B	B	C	C	C	C	C
Window/Balcony	E	F	G	H	E	F	G	H	D	E	F	G	H
GRADE	**0**	**1**	**1**	**3**	**2**	**3**	**3**	**4**	**4**	**5**	**5**	**5**	**5**

(Minimum grade = 0 and maximum grade = 5)

Dimensions and layout (P_{14b})
Maximum travel distance to an escape route (A < 10 m, B = 10 – 20 m, C > 20 m), Number of floors (D ≤ 4, E = 5 – 8) and Maximum number of apartments per floor connected to an escape route (F ≤ 4, G ≥ 5)

SURVEY ITEMS	DECISION RULES											
Travel distance to...	C	C	C	C	B	B	B	B	A	A	A	A
Number of floors	E	E	D	D	E	E	D	D	E	E	D	D
Number of apartments...	G	F	G	F	G	F	G	F	G	F	G	F
GRADE	**0**	**1**	**2**	**2**	**3**	**3**	**4**	**4**	**4**	**4**	**5**	**5**

(Minimum grade = 0 and maximum grade = 5)

Equipment (P_{14c})
Guidance signs (A = none, B = normal, C = illuminating light), General lighting (D = manually switched on, E = always on) and Emergency lighting (F = not provided, G = provided)

SURVEY ITEMS	DECISION RULES											
Guidance signs	A	A	A	A	B	B	B	B	C	C	C	C
General lighting	D	D	E	E	D	D	E	E	D	D	E	E
Emergency lighting	F	G	F	G	F	G	F	G	F	G	F	G
GRADE	**0**	**3**	**3**	**4**	**2**	**4**	**3**	**4**	**2**	**4**	**3**	**5**

(Minimum grade = 0 and maximum grade = 5)

Linings and floorings (P_{14d})
This refers to the worst lining or flooring class that is to be found in an escape route (excluding the small amounts allowed by building law). For Euroclasses A1, A2 and B, the flooring must have at least class D_f, if not the linings and floorings grade is according to Euroclass C.

LINING CLASS						GRADE
Suggestions to Euroclasses	Typical products	DK	FIN	NO	SWE	
A1	Stone, concrete	A	1/I	In1	I	**5**
A2	Gypsum boards	A	1/I	In1	I	**5**
B	Best FR woods (impregnated)	A	1/I	In1	I	**4**
C	Textile wall cover on gypsum board		1/II 2/-	In2	II	**3**
D	Wood (untreated)	B	1/-	In2	III	**2**
E	Low density wood fibreboard	U	U	U	U	**1**
F	Some plastics	U	U	U	U	**0**

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(0.34 × Type of escape routes + 0.27 × Dimensions and layout + 0.16 × Equipment + 0.23 × Linings and floorings)

Resulting grade:

P_{15}. STRUCTURE - LOAD-BEARING

DEFINITION: Structural stability of the building when exposed to a fire

SUB-PARAMETERS:

Load-bearing capacity (P_{15a})

LOAD BEARING CAPACITY (LBC)	**GRADE**
LBC $<$ R 30	**0**
R 30 $\leq$ LBC $<$ R 60	**2**
R 60 $\leq$ LBC $<$ R 90	**4**
R 90 $\leq$ LBC	**5**

(Minimum grade = 0 and maximum grade = 5)

Combustibility (P_{15b})
Combustible part of the load-bearing construction

COMBUSTIBLE PART	**GRADE**
Both load-bearing structure and insulation are combustible	**0**
Only the insulation is combustible	**2**
Only the load-bearing structure is combustible	**3**
Both load-bearing structure and insulation are non- combustible	**5**

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(0.74 $\times$ Load-bearing capacity + 0.26 $\times$ Combustibility)

Resulting grade:

P_{16}. MAINTENANCE AND INFORMATION

DEFINITION: Inspection and maintenance of fire safety equipment, escape routes etc. and information to occupants on suppression and evacuation

SUB-PARAMETERS:

Maintenance of fire safety systems ie. detection, alarm, suppression and smoke control system **(P_{16a})**

MAINTENANCE OF FIRE SAFETY SYSTEMS	**GRADE**
Carried out less than every three years	**0**
Carried out at least once every three years	**2**
Carried out at least once a year	**4**
Carried out at least twice a year	**5**

(Minimum grade = 0 and maximum grade = 5)

Inspection of escape routes (P_{16b})

INSPECTION OF ESCAPE ROUTES	**GRADE**
Carried out less than every three years	**0**
Carried out at least once a year	**1**
Carried out at least once every three months	**3**
Carried out at least once per month	**5**

(Minimum grade = 0 and maximum grade = 5)

Information to occupants on suppression and evacuation **(P_{16c})**

Written information (A = no information, B = written information on evacuation and suppression available in a prominent place in the building, C = written information available in a prominent place and distributed to new inhabitants) and
Drills (D = no drills, E = suppression drill carried out regularly, F = evacuation drill carried out regularly, G = suppression and evacuation drills carried out regularly)

SURVEY ITEMS	DECISION RULES											
Written information	A	A	A	A	B	B	B	B	C	C	C	C
Drills	D	E	F	G	D	E	F	G	D	E	F	G
GRADE	**0**	**1**	**1**	**2**	**1**	**3**	**3**	**4**	**2**	**4**	**4**	**5**

(Minimum grade = 0 and maximum grade = 5)

PARAMETER GRADE:

(0.40 $\times$ Maintenance of fire safety systems + 0.27 $\times$ Inspection of escape routes + 0.33 $\times$ Information)

Resulting grade:

P_{17}. Ventilation system

DEFINITION: Extent to which the spread of smoke through the ventilation system is prevented.

PARAMETER GRADE:

TYPE OF VENTILATION SYSTEM	**GRADE**
No specific smoke spread prevention through the ventilation system	**0**
Central ventilation system, designed to let smoke more easily into the external air duct than ducts leading to other fire compartments. The ratio between pressure drops in these ducts is in the order of 5:1	**2**
Ventilation system specially designed to be in operation under fire conditions with sufficient capacity to hinder smoke spread to other fire compartments	**3**
Ventilation system with a non-return damper, or a smoke detector controlled fire gas damper, in ducts serving each fire compartment.	**4**
Individual ventilation system for each fire compartment	**5**

(Minimum grade = 0 and maximum grade = 5)

Resulting grade:

Results

(Risk Index – Timber frame Buildings: Version 1.2)

Parameter Summary Table

Parameter	Weight	Grade	WEIGHTED GRADE
P1	0.0576		
P2	0.0668		
P3	0.0681		
P4	0.0666		
P5	0.0675		
P6	0.0698		
P7	0.0473		
P8	0.0492		
P9	0.0515		
P10	0.0396		
P11	0.0609		
P12	0.0630		
P13	0.0512		
P14	0.0620		
P15	0.0630		
P16	0.0601		
P17	0.0558		
Sum	1.0000		
		SAFETY INDEX	
		RISK INDEX = 5.0 – SAFETY INDEX	

Maximum individual grade is 5.0. Maximum Safety Index is 5.0, corresponding to a minimum Risk Index of 0.

7. Appendix C: Application of the Index Method to a Reference Object

This Appendix is taken from a draft report by Daniel Larsson, where he applies Version 1.2 of the Index method to a reference object. The purpose has been to visualise general differences between the combustible and the non-combustible building. Apart from the construction material, the conditions have to be the same for the buildings. This will make the weaknesses of the timber-frame building appear. It is also possible to find different ways to compensate for the “deficiencies” of a timber-frame building and thereby to reach the same, or an even higher, level of fire safety as for the non-combustible building. Comments on the method are given in *italics* when appropriate.

7.1. Description of the Reference Object

As reference object a building project in Linköping, Sweden, named Orgelbänken, has been chosen. This apartment building was built in 1995/1996 as a sort of pilot project in the resumed Nordic timber-frame construction. In this chapter, parameter grades for the existing timber-frame building and a corresponding, imaginary, concrete building are presented. The estimates made in this chapter have been based on information found in drawings and in the book “Flervånings trähus”, published by Nordic wood in 1997. Ulf Persson, Skanska Teknik in Malmö, has also contributed with valuable information.

Before going through each parameter maybe a brief description of the building is suitable. Orgelbänken consists of a single building with 4 floors and 36 apartments. The building has got an attic but no basement. The apartments are connected to two separate stairwells by access balconies. The load-bearing construction is carried out of wood, indoors covered by gypsum boards. Wood panel is the facade material in access balconies and in stairwells and plaster in the rest of the building. Further details about Orgelbänken may be found in the abovementioned report, “Flervånings trähus”.

7.2. Parameters

The two buildings (combustible frame and non-combustible frame) were found to receive grades as below. Comments are made where it has been found necessary.

P_1 Linings in apartment

Timber-frame building	5
Concrete building	5

Comment:

- Gypsum boards / concrete

P_2 Suppression system

Timber-frame building	0
Concrete building	0

Comment:

- Automatic sprinkler system: N
  Type of sprinkler: N
  Location of sprinkler: -
- Portable equipment: N

There is no suppression equipment in the building.

P_3 Fire service

Timber-frame building	3.62
Concrete building	3.62

Comment:

- Capability: 5
- Response time: 3
- Accessibility and equipment: 3

Parameter grade: $0.31 \times 5 + 0.47 \times 3 + 0.22 \times 3 = 3.62$

A problem appears when giving a grade to Sub-parameter "Accessibility and equipment". It is possible that every window in the two long sides are accessible, however if the building also got inaccessible gable windows it immediately gets a lower grade then a similar building without those windows.

P_4 Compartmentation

Timber-frame building	2
Concrete building	2

Comment:

Are fire compartments like stairwells also included in this parameter?
If they are, do we summarise the building space on every floor?

P_5 Structure - separating

Timber-frame building	3.44
Concrete building	4.28

Comment:

- Integrity and insulation: 5 (?)
- Firestops at joints, intersections and concealed spaces: 2 (timber-frame) / 5 (concrete)
- Penetrations: 2
- Combustibility: 5

Parameter grade: $0.35 \times 5 + 0.28 \times 2 + 0.24 \times 2 + 0.13 \times 5 = 3.44$ (timber-frame)
Parameter grade: $0.35 \times 5 + 0.28 \times 5 + 0.24 \times 2 + 0.13 \times 5 = 4.28$ (concrete)

In Orgelbänken, EI 60 has been used in separating constructions, except for the separating walls in the attic (EI 30). Do we receive the grade 5 or just 3 for "Integrity and insulation"?

P_6 Doors

Timber-frame building	2.66
Concrete building	2.66

Comment:

- Doors leading to escape route: 2
  Integrity and insulation: C
  Type of closing: M
- Doors in escape route: 4
  Integrity and insulation: C
  Type of closing: S

Parameter grade: $0.67 \times 2 + 0.33 \times 4 = 2.66$

Just the doors in the stairwells are self-closing. The grades above depend on how escape routes will be defined in "The users guide to the Index method".

P_7 Windows

Timber-frame building	2
Concrete building	2

Comment:

- Relative vertical distance: B
- Class of window: C
  L/H > 1

A problem here is the apartment doors and the balcony doors which are placed with a smaller vertical distance than the windows. The doors are however separated with access balconies and balconies respectively. (The apartment doors also have EI 30 classification.)

P_8 Facades

Timber-frame building	1.69
Concrete building	5

Comment:

- Combustible part of facade: 2 *(?)* (timber-frame) / 5 (concrete)
- Combustible material above windows: 0 *(?)* (timber-frame) / 5 (concrete)
- Void: 3 (timber-frame) / 5 (concrete)

Parameter grade: $0.41 \times 2 + 0.30 \times 0 + 0.29 \times 3 = 1.69$ (timber-frame)
Parameter grade: $0.41 \times 5 + 0.30 \times 5 + 0.29 \times 5 = 5$ (concrete)

In Orgelbänken the combustible part of the facade is 20 %, however the combustible material is located in access balconies and in stairwells. The rest of the building has got non-combustible facade. Is a too low grade given?

P_9 Attic

Timber-frame building	1
Concrete building	1

Comment:

- Prevention of fire spread to attic: N

- Fire separation in attic: L

Ventilation is provided at the eave.
Is it impossible to receive the Parameter grade 0? (> 600 m² has to result in no grade, =>N)

P_{10} Adjacent buildings

Timber-frame building	2
Concrete building	2

P_{11} Smoke control system

Timber-frame building	0
Concrete building	0

Comment:
- Activation of smoke control system: N
- Type of smoke control system: -

There is no smoke control system in the building.

P_{12} Detection system

Timber-frame building	2
Concrete building	2

Comment:
- Amount of detectors: L
  - Detectors in apartment: A
  - Detectors in escape route: N
- Reliability of detectors: M
  - Detector type: S
  - Detector power supply: B

There are smoke detectors (battery) in every apartment.

P_{13} Signal system

Timber-frame building	4
Concrete building	4

Comment:
- Type of signal: H (?)
  - Light signal: N
  - Sound signal: A
- Location of signal: A

How is it possible to receive a higher grade without light signal ?
($N + A \Rightarrow H$, $Y + A \Rightarrow M$)

P_{14} Escape routes

Timber-frame building	2.83
Concrete building	3.52

Comment:
- Type of escape routes: 3

Staircase: A
Window/Balcony: H

- Dimensions and layout: 5
  Maximum travel distance to an escape route: A
  Number of floors: D
  Maximum number of apartments per floor connected to an escape route: G
- Equipment: 0
  Guidance signs: A
  General lighting: D
  Emergency lighting: F
- Linings and floorings: 2 (timber-frame) / 5 (concrete)

Parameter grade: $0.34 \times 3 + 0.27 \times 5 + 0.16 \times 0 + 0.23 \times 2 = 2.83$ (timber-frame)
Parameter grade: $0.34 \times 3 + 0.27 \times 5 + 0.16 \times 0 + 0.23 \times 5 = 3.52$ (concrete)

Floors in access balconies are carried out of wood.

P_{15} Structure load-bearing

Timber-frame building	3.74
Concrete building	4.26

Comment:

- Load-bearing capacity: 4 *(?)*
- Combustibility: 3 (timber-frame) / 5 (concrete)

Parameter grade: $0.74 \times 4 + 0.26 \times 3 = 3.74$ (timber-frame)
Parameter grade: $0.74 \times 4 + 0.26 \times 5 = 4.26$ (concrete)

R 60 is used for almost whole building but with exception of staircases (R 30). Do we receive the grade 4 or just 2 for "load-bearing capacity"?

P_{16} Maintenance and information

Timber-frame building	0
Concrete building	0

Comment:

- Maintenance of fire safety systems: 0
- Inspection of escape routes: 0
- Information: 0
  Written information: A
  Drills: D

D = "suppression drill carried out regularly", but in this case no drills are carried out at all.

P_{17} Ventilation system

Timber-frame building	0
Concrete building	0

Index calculation

To calculate the fire risk index we must first calculate the safety index, S, which has a maximum value of 5.0, where a high value indicated high safety. The risk index is then calculated as: Risk Index = 5.0 - S.

The safety index can be calculated according to the following formula:

$$S = \sum_{i=1}^{n} w_i \, x_i$$

where

S = safety index (maximum = 5.0)
w_i = final weight for Parameter i
x_i = parameter grade for Parameter i

$S = 0.0576 \times x_1 + 0.0668 \times x_2 + 0.0681 \times x_3 + 0.0666 \times x_4 + 0.0675 \times x_5 + 0.0698 \times x_6 + 0.0473 \times x_7 + 0.0492 \times x_8 + 0.0515 \times x_9 + 0.0396 \times x_{10} + 0.0609 \times x_{11} + 0.0630 \times x_{12} + 0.0512 \times x_{13} + 0.0620 \times x_{14} + 0.0630 \times x_{15} + 0.0601 \times x_{16} + 0.0558 \times x_{17}$

The existing timber-frame building has got the following grades:

Parameter	wi	xi	Si
P1	0.0576	5	0.2880
P2	0.0668	0	0.0000
P3	0.0681	3.62	0.2465
P4	0.0666	2	0.1332
P5	0.0675	3.44	0.2322
P6	0.0698	2.66	0.1857
P7	0.0473	2	0.0946
P8	0.0492	1.69	0.0831
P9	0.0515	1	0.0515
P10	0.0396	2	0.0792
P11	0.0609	0	0.1218
P12	0.0630	2	0.1260
P13	0.0512	4	0.1536
P14	0.0620	2.83	0.1755
P15	0.0630	3.74	0.2356
P16	0.0601	0	0.0000
P17	0.0558	0	0.1116
		Safety Index:	2.3181
		Risk Index = 5.0 - Safety Index:	2.6819

This results in a risk index = 2.68

The corresponding concrete building has got the following grades:

Parameter	wi	xi	Si
P1	0.0576	5	0.2880
P2	0.0668	0	0.0000
P3	0.0681	3.62	0.2465
P4	0.0666	2	0.1332
P5	0.0675	4.28	0.2889
P6	0.0698	2.66	0.1857
P7	0.0473	2	0.0946
P8	0.0492	5	0.2460
P9	0.0515	1	0.0515
P10	0.0396	2	0.0792
P11	0.0609	0	0.1218
P12	0.0630	2	0.1260
P13	0.0512	4	0.1536
P14	0.0620	3.52	0.2182
P15	0.0630	4.26	0.2684
P16	0.0601	0	0.0000
P17	0.0558	0	0.1116
Safety Index:			2.6132
Risk Index = 5.0 - Safety Index:			2.3868

This results in a risk index = 2.39

The risk index for the concrete building is about 0.3 lower than for the timber-frame building. It is however possible to “compensate” for the higher timber-frame risk index in many different ways. By for example installing a residential sprinkler system in the apartments and in the escape routes the risk index for the timber-frame building decreases to 2.35. Inspection of escape routes, information to occupants, installation of smoke control system are other examples of ways to lowering the risk index.