

BS EN 15254-7:2012



BSI Standards Publication

Extended application of results
from fire resistance tests — Non-
loadbearing ceilings
Part 7: Metal sandwich panel construction

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National foreword

This British Standard is the UK implementation of EN 15254-7:2012.

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Foreword

This document (EN 15254-7:2012) has been prepared by Technical Committee CEN/TC 127 “Fire safety in buildings”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2012, and conflicting national standards shall be withdrawn at the latest by December 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

EN 15254 is divided into the following parts:

EN 15254-2, *Extended application of results from fire resistance tests — Non-loadbearing walls — Part 2: Masonry and Gypsum Blocks*

EN 15254-4, *Extended application of results from fire resistance tests — Non-loadbearing walls — Part 4: Glazed constructions*

EN 15254-5, *Extended application of results from fire resistance tests — Non-loadbearing walls — Part 5: Metal sandwich panel construction*

prEN 15254-6, *Extended application of results from fire resistance tests — Non-loadbearing walls — Part 6: Curtain walling*

EN 15254-7, *Extended application of results from fire resistance tests — Non-loadbearing ceilings — Part 7: Metal sandwich panel construction, [the present document]*

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1 Scope

This European Standard defines rules for extended applications, provides guidance, and, where appropriate, specifies procedures, for variations of certain parameters and factors associated with the design of internal non-loadbearing ceilings constructed of metal sandwich panels that have been tested in accordance with EN 1364-2.

This European Standard applies to self-supporting, double skin metal faced sandwich panels which have an insulating core bonded to both facings.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1363-1:2012, *Fire resistance tests — Part 1: General requirements*

EN 1363-2, *Fire resistance tests — Part 2: Alternative and additional procedures*

EN 1364-2:1999, *Fire resistance tests for non-loadbearing elements — Part 2: Ceilings*

EN 1993-1-2, *Eurocode 3. Design of steel structures — Part 1-2: General rules — Structural fire design*

EN 13501-2, *Fire classification of construction products and building elements — Part 2: Classification using data from fire resistance tests, excluding ventilation services*

EN 14509:2006, *Self-supporting double skin metal faced insulating panels — Factory made products — Specifications*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purpose of this document, the terms and definitions given in EN 14509:2006, EN 1364-2:1999, EN 1363-1:2012 and the following apply.

3.1.1

direct field of application of test results

outcome of a process (involving the application of defined rules) whereby a test result is deemed to be equally valid for variations in one or more of the product properties and/or intended end use applications

3.1.2

extended field of application of test results

outcome of a process (involving the application of defined rules that may incorporate calculation procedures) that predicts, for a variation of a product property and/or its intended end use application(s), a test result on the basis of one or more test results to the same test standard

3.1.3

factor

one of the possible variations that may be applied to a parameter

3.1.4

factor influence

one of the potential causes of a change in the fire resistance due to a factor

3.1.5

fastening, fixing

device that fastens the panels to a support structure or to the test frame

3.1.6

fixing system

system consisting of fastenings and other possible means used to fasten the panels to a support structure or to the test frame

3.1.7

length of assembly

length of the ceiling in the span (or panel length) direction in the reference test or in the end use application

3.1.8

width of assembly

width of the ceiling in the cross direction of the span (or panel length) in the reference test or in the end use application

3.1.9

reference test

fire resistance test on which the extended application is based and the results of which are used as the main source of data for the extended application

Note 1 to entry: The fire resistance test is in accordance with EN 1363-1 and EN 1364-2 and where applicable EN 1363-2.

3.1.10

stiching

device for fixing panels to panels in the longitudinal joint

3.1.11

span length

center to center distance between two consecutive supports to which the sandwich panel is fixed

3.1.12

support structure

construction onto which the panel ceiling is fastened in the end use application

3.1.13

test frame

frame containing the test construction for the purpose of mounting onto the furnace

3.2 Symbols and abbreviations

For the purposes of this document, the following symbols and abbreviations apply.

F_{Ed} catenary force acting on the fasteners

F_v vertical force due at g acting at the fastener

F_{Ed1} catenary force acting at the fastener at maximum temperature in the test

F_{Ed2} catenary force acting at the fastener at temperature for the increased span

F_{v1} vertical force due at g acting at the fastener at maximum temperature in the test

F_{v2}	vertical force due at g acting at the fastener at temperature for the increased span
L	span length
T	temperature
b	width of panel
g	panel weight per square meter
n	number of fasteners
p	relative end movement in the fastener
w	deflection of the ceiling
α	linear coefficient of thermal expansion

4 Establishing the field of extended application

4.1 General

An extended application analysis is required when the application differs in one or more parameters from the one tested and described in the test report and/or in the classification document, and which is not covered by the field of direct application of the classification document.

The extended application of the sandwich panels used as a non-loadbearing ceiling shall be based on the reference fire test results performed according to EN 1364-2. It may be complemented by one or more additional small or full-scale tests or by historical data. If historical data are used, they shall comply with the rules given in this document.

4.2 Assumptions in the extended application

The following assumptions are considered when evaluating extended applications for sandwich panels:

- the ceiling is required to possess fire resistance in the end-use condition (relevant classes are given in EN 13501-2);
- the ceiling is assumed to be exposed on the entire face of one side (either from above or below) to the standardised heating conditions given in the EN 1363-1 fire resistance test specification;
- the structure to which the ceiling is fixed does not deflect during the fire exposure period; this simulates the non-deflecting nature of the test frame which forms part of the furnace test apparatus;

NOTE In reality constructions deflect and this fact should be taken into account when designing the building and planning the constructional details.

- after delamination of the fire exposed facing, the dead load of the panels is carried by a support structure to which the ends of the sandwich panels are attached; the forces from the dead load will be distributed to the support structure by the panel fixings from which loadbearing capacity shall be evaluated;
- the support structure has at least the same loadbearing capacity, R, of the resistance to fire performance as the sandwich panel ceiling regarding integrity;
- the self weight of the facing and core is calculated from the volume and density of the materials;

- g) the calculation of the reduction in the strength properties of steel at elevated temperature shall be in accordance with EN 1993-1-2.

4.3 Assumed structural behaviour of a sandwich panel in fire

When one face of a sandwich panel assembly is exposed to fire, the following behaviour may be expected. Delamination of the fire-exposed face will occur after a couple of minutes in a fire. After delamination, the flexural strength of the assembly is lost and, unless both faces are restrained at the ends, the panels can collapse. The fastenings for the ends of the panels need to support the dead load of the whole panel for the entire fire resistance period. The behaviour slightly differs depending on the direction of the fire (from above or below). In both cases, the structure acts as a catenary construction.

NOTE Annex A illustrates typical behaviour of panels.

5 Rules for extended applications of the tested product

5.1 General

When performing extended applications for a tested ceiling, changes can occur either in the materials and/or in the construction. Both are dealt with in this standard. Table 1 and Table 2 list the changes which may or may not be made in an extended application assessment. The rules for the changes are either given in Table 1 or Table 2 or in 5.2 and 5.3.

Table 1 — Material changes relevant to extended application

Parameter	Factors	Factor influence on performance		Rules
		Integrity E	Insulation I	
Changes in metal facings	Chemical composition of coating	influence	no influence ^a	5.2.2.1
	Change from coated to non-coated metal	no influence	influence	5.2.2.1
	Sheet thickness	influence	no influence ^a	Valid up to +50 % of tested nominal thickness but no decrease is allowed for thicknesses below 0.5 mm and fixing capacity shall be checked
	Change from one metal to another	influence	influence	5.2.2.2
	Change in sheet geometry	influence	influence	5.2.2.3
Changes in adhesive	Amount	influence	influence	5.2.3
	Type	influence	no influence ^a	5.2.3
Changes in core material	Type	major influence	major influence	5.2.4
	Change in composition	major influence	major influence	5.2.4.2 - 5.2.4.7

^a It is understood that when a change in a factor can influence the integrity of a joint, there is a possibility that a change in leakage of hot gases or in joint geometry can also influence the temperature rise near the joint and therefore influence the insulation rating.

Table 2 — Constructional changes relevant to extended application

Parameter	Factors	Factor influence on performance		Rules
		Integrity E	Insulation I	
Span length	Decrease	no influence	no influence	Allowed
	Increase	influence	no influence ^a	5.3.1
Panel width	Decrease	no influence	no influence	Allowed
	Increase	influence	no influence ^a	Test results valid up to + 20 %
Panel thickness e.g. core thickness	Decrease/increase	influence	major influence	5.3.2
Joint construction	Type	major influence	major influence	5.3.3
	Stiching decreased	influence	influence	Not allowed
	Stiching increased	influence	influence	5.3.3
	Sealants	influence	influence	5.3.3
Fixing system	Type	major influence	no influence ^a	5.3.4
	Amount decreased	major influence	no influence ^a	5.3.4
	Amount increased	influence	no influence ^a	Allowed
	Protection decreased	major influence	influence	5.3.4
	Protection increased	influence	influence	Allowed
Length of assembly	Decrease	no influence	no influence	5.3.5
	Increase	influence	no influence ^a	5.3.5
Width of assembly	Decrease	no influence	no influence	5.3.5
	Increase	no influence	no influence	5.3.5
Support structure	Changes	influence	no influence ^a	5.5

^a It is understood that when a change in a factor can influence the integrity of a joint, there is a possibility that a change in leakage of hot gases or in joint geometry can also influence the temperature rise near the joint and therefore influence the insulation rating.

5.2 Variations in the materials of the product

5.2.1 General

Sandwich panels consist of three main materials: facing metal sheets, adhesive and core material. In the case of auto-adhesively bonded panels, the foamed core material also forms the adhesive layer during the foaming process.

Changes in the components of a panel can have influences on the fire resistance. The rules in Clause 5 apply to such changes.

5.2.2 Variations in the metal sheets

5.2.2.1 Variations in the coatings

The most essential property of the coating with regard to fire resistance is the emissivity on the non-exposed side. Normally the emissivity for a coated steel sheet is between 0,8 and 0,95. A change in emissivity of -10 % for a new coating compared to the tested one is thus allowed if there is at least a 10 % margin in the insulation

test result compared to the I-classification. Test results are always valid for coatings with higher emissivity values compared to the tested one. When a change in coating is made, the manufacturer of the coated sheet shall provide emissivity properties for the products.

A non-coated metal sheet can have an emissivity as low as 0,1. A change from a coated to a non-coated sheet is therefore not allowed. The same rule specified above for coatings applies also in this case. A decrease in emissivity of 10 % is allowed if the emissivities of the different sheets are known.

For changes in emissivity >10 %, surface temperatures can be estimated from small-scale tests in accordance with 6.1 where the surface temperatures of the new panel are compared to the one tested in the reference scenario. If appropriate calculation methods are available, the surface temperatures can also be calculated and compared, provided that temperature-dependent thermal resistance values for the core material are available.

The energy content of the coating on the exposed side is small and will not affect the fire resistance properties of the sandwich panel. Test results are valid for all coatings.

If modifications in the coatings on the non-exposed side are made, compared to the tested one, the ignitability of the modified coating shall be higher or equal to that tested. This can be checked by conducting small-scale tests according to 6.1. Test results are valid for all colours of the same type of coating.

5.2.2.2 Variations in the metal material

The following rules are valid for extended applications.

- 1) The test results are valid for all grades of tested normal steel, and if once tested as stainless steel for all grades of stainless steel. (A change from mild steel to stainless steel is not possible without conducting further tests.)
- 2) For other types of metals, the test result is valid for tested type only.
- 3) For panels with perforated facings on one or both sides of the panels, a test result achieved with a perforated facing is always valid for non-perforated facings in the same position as in the tested product. Test results for a product tested with non-perforated facings are valid only for a product with perforated facings on the fire exposed side where the perforation area is not greater than 25 % and where the reaction to fire class of the core material is A2-s1, d0 or better. Other changes are not allowed.

5.2.2.3 Changes in profile geometry of facing

The following rules are valid for extended applications.

- 1) For flat or small profiling (between 0 mm and 5 mm): test results are valid for any change.
- 2) For profiles greater than 5 mm: test results are valid for variations + 50 % of profile depth.

5.2.3 Variations in the adhesive

This paragraph is valid only for panels with adhesively bonded cores. The following rules apply for an adhesive with no strength at high temperatures (> 500 °C) which means that the metal sheet on the exposed side will disconnect from the core in the very beginning of a fire and the construction will lose its sandwich capability. For this reason, an organic adhesive cannot be changed to a non-organic one or vice versa.

Normally the energy content of the adhesive is small and will not affect the fire resistance properties of the sandwich panel. The following rules are valid for extended applications.

- 1) For gross calorific potential PCS value 0 MJ/m² to 4 MJ/m²: the results are valid for all adhesives when gross calorific potential PCS value stays between 0 MJ/m² and 4 MJ/m².

- 2) For gross calorific potential PCS value $> 4 \text{ MJ/m}^2$: the results are valid for gross calorific potential PCS values lower than the tested adhesive within manufacturing tolerances.
- 3) For gross calorific potential PCS value $> 4 \text{ MJ/m}^2$ and $> 1,15 \cdot \text{PCS}$: test results shall be reduced by the same % as the gross calorific potential PCS value is over the initial tested adhesive.

5.2.4 Variations in the core material

5.2.4.1 General

The following main core materials are used in sandwich panels: mineral wool (MW), polyurethane (PUR), extruded polystyrene (XPS), expanded polystyrene (EPS), phenolic foam and cellular glass. The behaviour of these core materials regarding fire is different and cannot be compared. Changes from one core material to another are therefore not allowed in any extended application. Variations within each core material group are allowed in accordance with the rules given in 5.2.4.2 to 5.2.4.7.

There are several factors in the different core materials that affect the fire properties of the core and of the sandwich panel. It is therefore not possible to extend the results from one core material producer to be valid for apparently similar materials from another producer.

5.2.4.2 Mineral wool (MW)

Mineral wool consists of stone wool and glass wool. Generally, the greater the density of the mineral wool the higher the flexural strength of the panel. Density will be dictated by room-temperature structural design requirements. However, variation in density affects the I-insulation value. The results are always valid for an increase in density in the density range 50 kg/m^3 to 150 kg/m^3 . A decrease in density is allowed down to -10 % of tested density.

Structural design will govern the orientation of fibres i.e. lamellas or slabs used in the panels. Changes in orientation of fibre have an influence on fire resistance and are therefore not allowed.

Gaps between the lamellas or ends of lamellas should be avoided. Test results are valid for panels with a decrease in the number of lamella joints.

The mass of fibre binder used per unit volume of MW is governed by room-temperature structural design. Because variations in binder content can affect the fire resistance properties, the following rules shall be followed:

- 1) A smaller amount of binder is always allowed compared to the tested one.
- 2) An increase in binder content of 2 % is allowed if the total amount of binder is below 10 %. For example, a result with 4 % binder is valid also for a core with 6 %. An increase is not allowed where the binder content is greater than 10 %.

The nature and proportions of materials used to manufacture the MW fibres shall not be different from those used in the reference test. Changes from one manufacturer to another are therefore not allowed. It is also important to note that test results for stone wool panels may never be used for glass wool panels and vice versa.

5.2.4.3 Polyurethane (PUR)

The test results are valid for the same chemical system and blowing agent. The test results are valid for +10 % of tested density.

5.2.4.4 Extruded polystyrene (XPS) and expanded polystyrene (EPS)

Small changes in chemical composition can have a great influence on the test results. The results therefore shall only be used for the tested panels. No extended application is allowed.

5.2.4.5 Phenolic foam

The test results are valid for the same chemical system and blowing agent. The test results are valid for + 10 % of tested density.

5.2.4.6 Cellular glass

Small changes in chemical composition can have a great influence on the test results. The results therefore shall only be used for the tested panels. No extended application is allowed.

5.3 Variations in the construction

5.3.1 Variations in span length

Two aspects of fire integrity shall be assessed. The first aspect shall be the ability of the whole panel assembly to resist collapse when the adhesive bond fails on the exposed side and the panels lose their flexural strength. To resist collapse, the ends of the panel facings shall be secured to the structure (the imaginary fire test frame in the extended application) using suspension details. Properly designed ceilings shall have both facings mechanically fastened (see typical solutions in Annex B) so they cannot collapse before the support structure collapses (see 5.5). The strength of these suspension details (e.g. steel cleats with fastenings) shall be able to carry the dead loads at the temperatures they attain from an increased load of a longer span panel. This can be achieved by increasing the amount of fixings based on the rules and calculation method given in Annex C of this standard.

The second aspect of integrity to be assessed shall be the ability of joints between adjoining sandwich panels to resist the passage of fire. This can be achieved by limiting the allowable deflection to be the same as the maximum deflection at failure in the test. The rules and calculation method are given in Annex C of this standard.

To enable an extension in the span length there shall be an overrun of at least 20 % subject to a minimum 10 min compared to the classification.

5.3.2 Variations in the panel thickness

Variations in panel thicknesses are due to changes in thickness of the core material. An increase in thickness will lead to a better insulation value and a test result shall therefore always be valid for thicker panels. If thicker panels are used, the loadbearing capacity of the end fixings shall be checked in accordance with Annex C due to the increased load. Decrease in thickness is not allowed.

If test results for three or more thicknesses are available, results for other thicknesses may be linearly interpolated between the data points if the failure mode (insulation or integrity) is the same for all test results. If the difference between the minimum and maximum thickness is less than 50% of the maximum thickness, two test results are enough.

Combined variations of both increase in thickness and increase in span length cannot be evaluated based on one test result only. At least test results for two different thicknesses are required for the evaluation of temperatures and deflections needed for the calculations in Annex C. If these results are not available, small-scale tests can be used to measure temperature increase for different thicknesses according to 6.1.

5.3.3 Variations in the joint construction

Even small changes in the joint construction can easily affect the integrity of the ceiling and shall not be allowed with the following exceptions.

- 1) An increase in the overlap in the metal facing at the joint is always allowed if other dimensions remain unchanged.
- 2) An increase in the amount of stichings is always allowed.
- 3) Tongue and groove joint in core material is allowed if tested as butted. Increase in the depth is always allowed but decrease is not allowed. Dimension changes in thicknesses of the tongue and groove are allowed up to +50 %.
- 4) Joints tested without sealants can always be sealed in the metal joint on the exposed side. If sealed on the non-exposed side, the ignition temperature of the sealant material shall be higher or equal to the tested one for EI-classified ceiling systems. For E-classified ceiling systems, only sealants with reaction to fire A2-s1,d0 or better shall be used on non-exposed side if tested without sealants.
- 5) If a construction is tested with sealing materials in the joints, test results shall only be valid for joints with the same type of sealing materials and shall not be valid for joints without sealants.

5.3.4 Variations in the boundary conditions and fixing system

Minor changes in the boundary conditions and fixing system are allowed provided that it can be shown that the bearing capacity is not reduced and the risk of collapse is not increased according to calculations given in Annex C. Minor changes include for example an increased amount of fasteners or an increased diameter of fasteners; but material itself cannot be changed.

Some fixing systems can be protected. An increase in protection ability is always allowed. If protection ability is decreased and the non-influence is shown for one panel type the result is valid also for other panel types.

A change in the boundary conditions and the fixing system will influence many parameters such as catenary forces and deflections and, based on these, also allowable span lengths. The standard configuration given in Annex B shall therefore always be used. The classifications are thus valid for all types of fixing systems in which bearing capacity is greater than the calculated catenary forces in the different classes and applications.

For dimensioning the support structure in the real buildings, the catenary forces for the different classes and applications shall be given in the extended application report.

5.3.5 Length and width of ceiling construction

The width of the ceiling can be freely increased if the mounting of the ceiling has been performed according to the test standard with one free edge.

There are ceiling systems on the market that require two free edges. These can be tested as in practice and the test results are valid for this application only. In these cases the width of the system can also be increased freely.

The length of the ceiling construction can be increased using intermediate support structures and taking into account the rules given in Clause 4 and in 5.3.1, 5.3.2 and 5.3.4.

5.4 Interaction between the factor influences

The situation with combined variations is always very complex and shall be considered case by case. To be able to combine variations there shall be an overrun of at least 20 % subject to a minimum 10 min compared to the classification.

5.5 Support structure

The panel assembly is a non-loadbearing ceiling and is always fixed to a support structure. The support structure is not normally included in the fire test but is essential to the functioning of the ceiling. In a fire test, the support structure is the test frame into which the assembly is mounted. The material of the frame can vary from one laboratory to another but it can be assumed that the frame is rigid without any significant deflections. In practice, the panel assembly can be fixed to different types of support structures. The test results shall be valid if the following requirements on the support structure are fulfilled.

- a) The support structure has at least the same fire resistance (R) classification time for loadbearing capacity as the panel assembly has for insulation and/or integrity.
- b) The thermal movements of the support structure do not impose any loads on the panel assembly that can affect the integrity properties of the tested ceiling.
- c) The fixing system shall have the sufficient loadbearing capacity (weight of panel and catenary force) to support the structure for the fire resistance period. For this requirement, the rules given in Annex C shall be used.

NOTE Annex B gives more detailed information about different support structures in practice together with mounting and fixing rules for the testing.

5.6 Heating conditions

This standard deals with extended application of sandwich panel ceilings tested according to EN 1364-2. Within this test method, the ceiling is exposed to fire, with the exposure being applied either

from below the ceiling, or

from above the ceiling.

The rules given in 5.1 to 5.5 are valid for both cases. Test results from a test with fire exposure from above the ceiling cannot be used for a situation with exposure from below the ceiling.

If a test is conducted according to the standard configuration in Annex B with exposure from below, the test result is directly valid also for exposure from above for panels with symmetrical joint geometry in cases according to Figures B.1 a), B.1 b) and B.1 e). For cases according to Figures B.1 c), B.1 d) and B.1 f), it shall be assured that the support structure and fixing systems above the ceiling are protected in such a way that the temperature increase in these will not influence the behaviour of the ceiling panels. It shall also be assured that the loadbearing capacity of the support structure and fixing system is sufficient not to collapse during the entire resistance to fire period of the ceiling. This evaluation shall include at least the following.

- a) The loadbearing structure, including the suspension system, has at least the same loadbearing capacity R of the resistance to fire performance as the ceiling regarding integrity.
- b) The loadbearing structure, including the suspension system, will not deflect during the fire resistance period. For the suspension system, this can be achieved by insuring that the maximum stress in vertically oriented components does not exceed 9 N/mm^2 for fire resistance periods up to and including 60 min. For fire resistances periods between 60 min and 120 min, the maximum stress is limited to 6 N/mm^2 .

6 Small scale tests and calculation methods

6.1 Small scale tests

For determining and comparing temperatures and insulation values for different constructions, it is possible to use small scale test furnaces. Where this has been suggested as a possibility in the rules in Clause 5, a furnace according to the requirements in EN 1363-1 but with minimum opening dimensions of 1 m x 1 m shall

be used together with the appropriate time-temperature curve and furnace pressure conditions used in the reference test. One test for each parameter change shall be used and the results shall always be compared to the reference construction tested in the same furnace.

6.2 Calculation methods

6.2.1 General

Calculation methods shall be confined to calculations of average temperature and loadbearing capacity of fixings. Wherever possible, temperature data shall be derived from fire tests. However, the results of computer models shall be acceptable when they have been adequately validated (thermally and mechanically) for the fire test conditions.

NOTE Integrity cannot be predicted with calculation methods.

6.2.2 Calculation of strength properties

To validate the loadbearing capacity of fasteners and fixing systems, the calculation method given in Annex C shall be used. Calculations of panel-fastening capacity shall be made for both metal sheets assuming that both can carry the full dead load of the panel in non-exposed condition and the load of the steel sheet only in exposed condition. The above rule is only valid for same amount and type of fixings on both sides. The grade and thickness of the steel sheet can be dimensioned for the calculations of the fixings and shall be included in the calculations of the fixing system.

6.3 Additional measurements to be carried out in the reference test

Some extended applications require additional measurements from the reference test. If these are needed, the sponsor shall ask for them when ordering the reference test.

The following data can be used and measured:

the deflections of the test specimen at mid-span.

7 Report of the extended application analysis

The extended application report shall be used in conjunction with the classification document as specified in EN 13501-2 and shall contain the following:

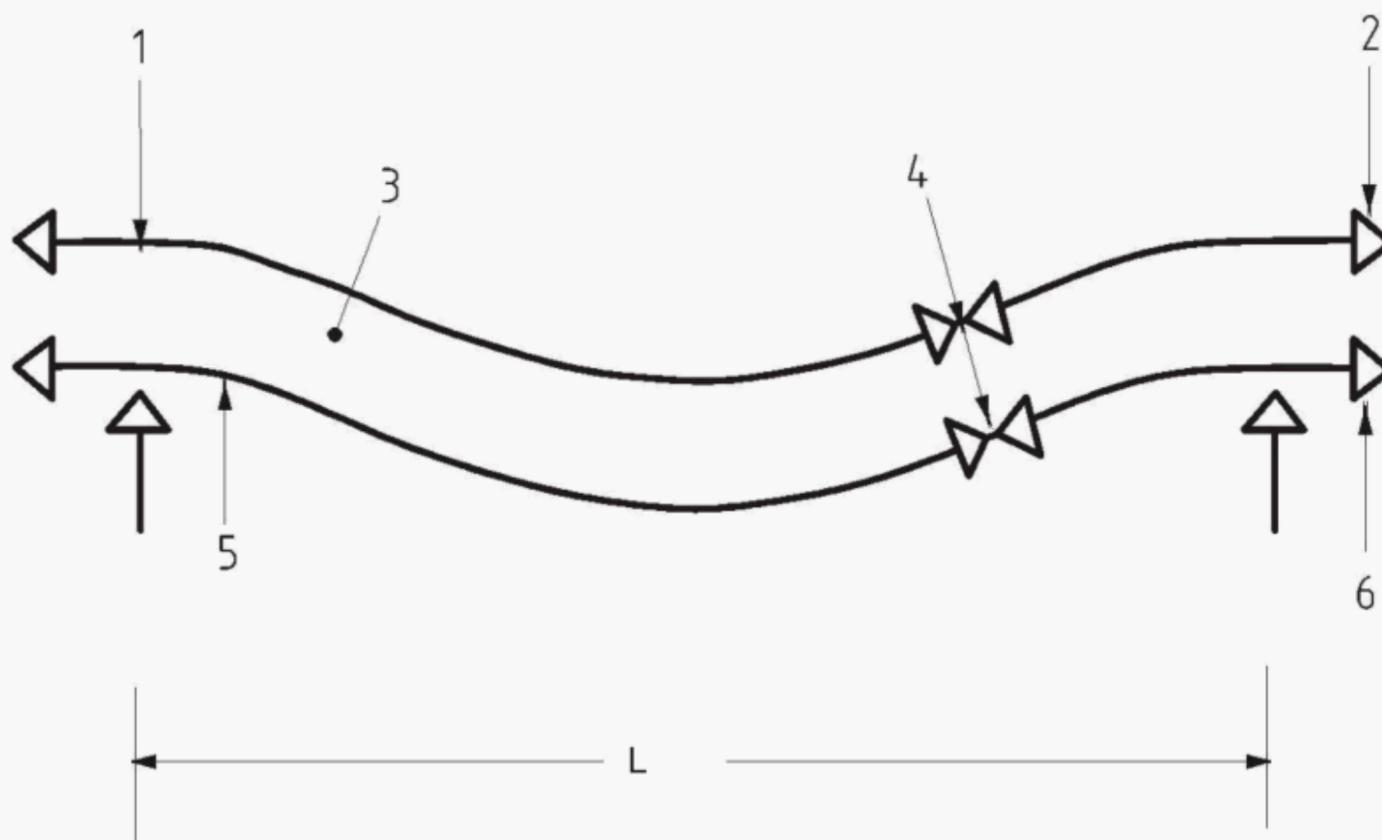
- a) the name and address of the body that produce the report;
- b) the name and address of the sponsor;
- c) the type of the assessed ceiling or ceilings, including a general description and any trade names of all the products involved;
- d) the reference of this extended application standard and a statement of conformity to this European Standard;
- e) the description of the change(s) to be made, including a clear statement of the proposed variations considered in the analysis which shall include previously requested changes;
- f) summary of the report(s) of the reference test(s) and previously granted extended applications;
- g) identification of the relevant parameter(s) and the list of the factors to be considered;

- h) the analysis of the influence of each relevant factor as well as of the interaction between the factor influences;
- i) the conclusion of the analysis;
- j) the catenary forces for dimensioning the support structures.

This shall allow the new/revised classification of the fire resistance as well as of the field of extended application of the changed design.

Annex A (informative)

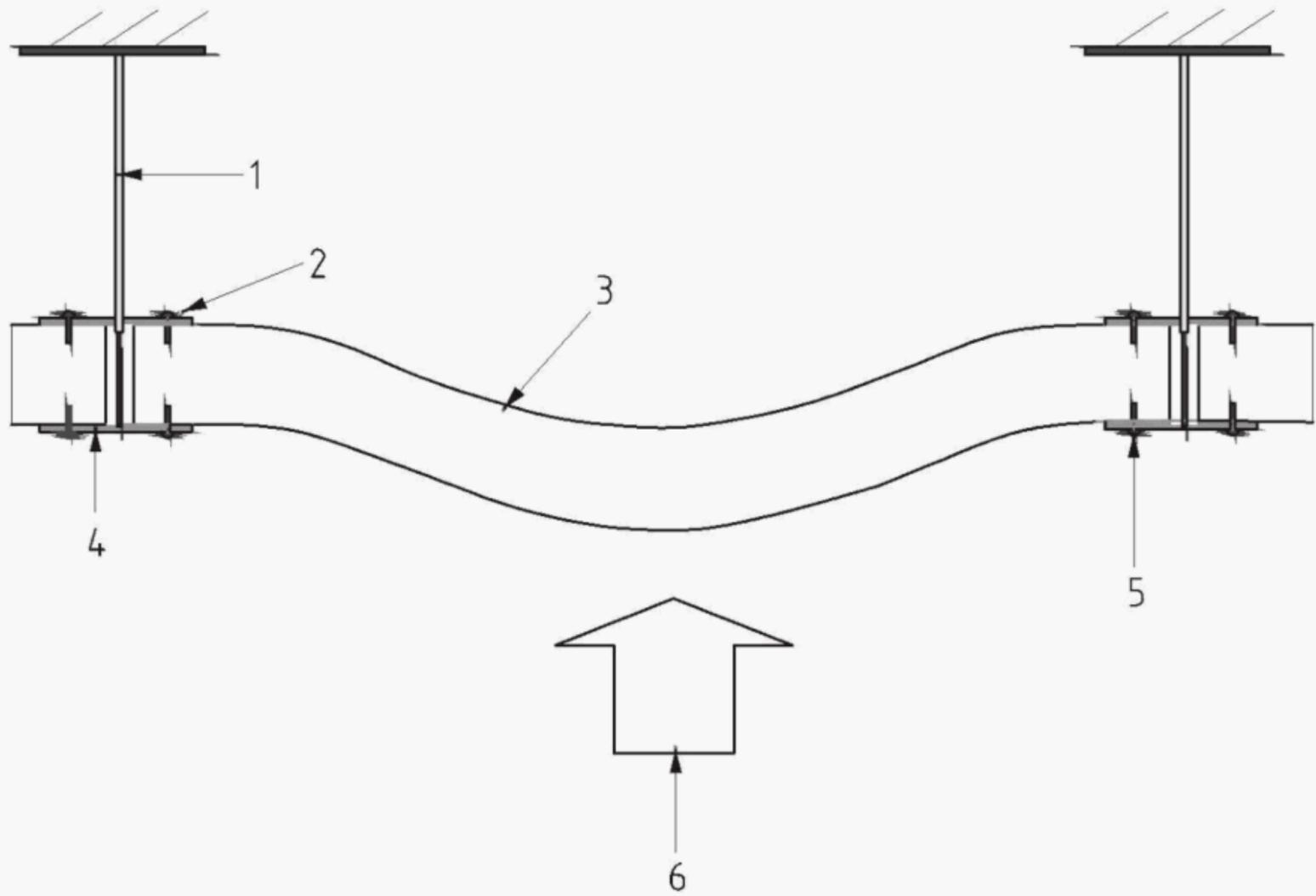
Typical behaviour of a sandwich panel ceiling when exposed to fire



Key

- 1 Upper facing
- 2 Horizontal force needed to form a catenary
- 3 Core
- 4 Tension forces
- 5 Lower facing
- 6 Note outward forces at ends of both facings
- L Span length

Figure A.1 Making the facings into catenaries



Key

- 1 Hanger
- 2 Local steel strap
- 3 Upper facing
- 4 Inverted T-section
- 5 Mechanical fasteners hold facings to T-section and straps
- 6 Fire

Figure A.2 Practical method of supporting ceiling panel

Annex B
(normative)

Typical examples of sandwich panel ceiling end fixings to support structure

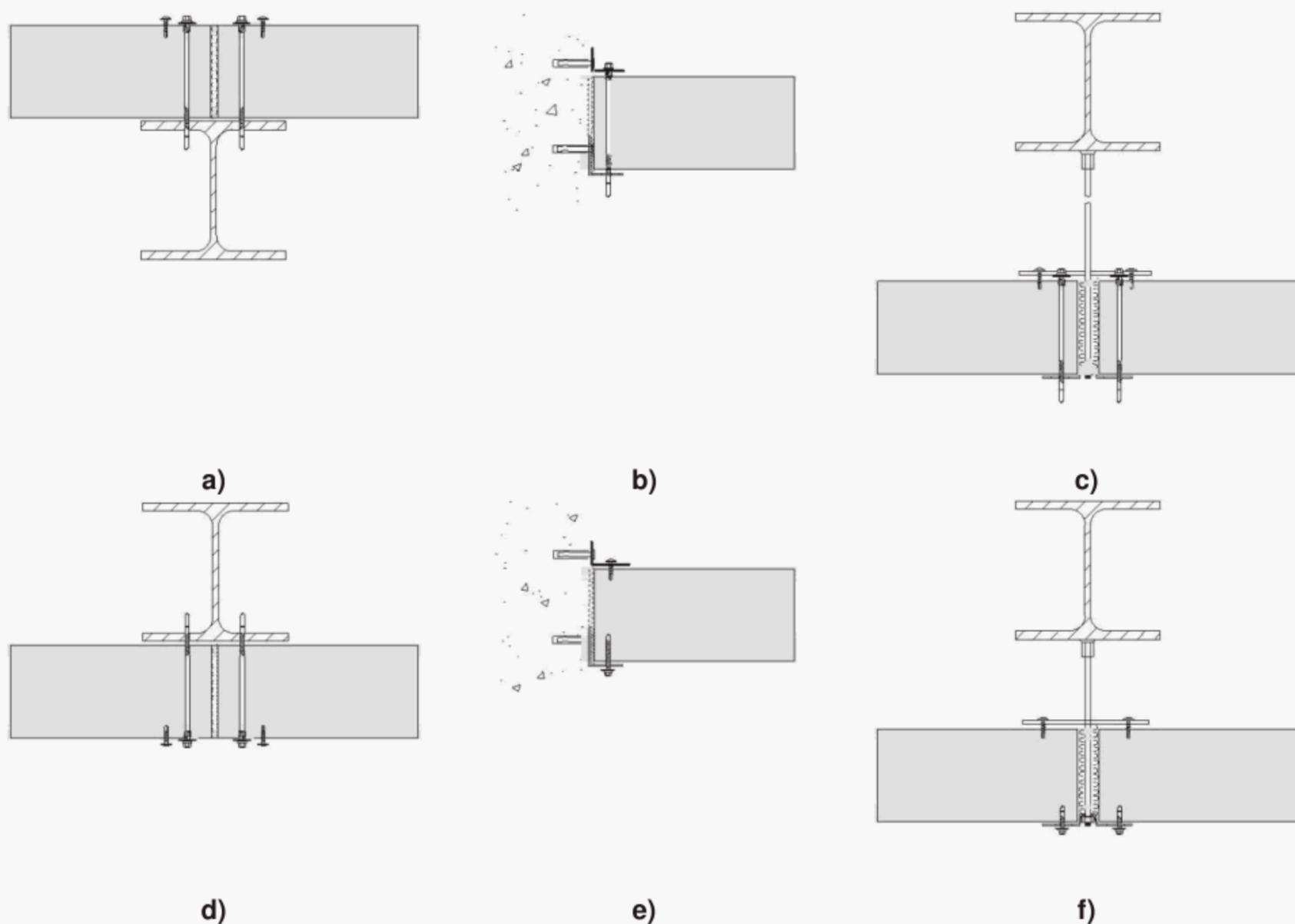


Figure B.1 End fixing solutions for sandwich panel ceilings to support structures

The support structures in the above figures are shown as I-beams or concrete walls. In reality, these structures can vary but in all cases they shall have at least the same R-classification as the EI-classification for the ceiling. These structures can be protected or non-protected to receive the stipulated classification. To prevent a ceiling to collapse in fire it is essential that both facings act as catenaries (see also Annex A). This can be achieved by using steel straps as shown in the figures.

Figures B.1 a), B.1 c), B.1 d) and B.1 f) are applicable also to multi-span panels where no panel to panel end joints are included but where the panel continues over the support without joint. In this case, the straps are unnecessary because the steel sheet functions in the same way.

For testing the configurations, Figure B.1 b) or B.1 e) shall be used.

In the examples in Figure B.1, the fixation area can also be protected with thermal insulation. If such thermal insulation is used, in the test the same thermal insulation shall also be used in end use conditions.

Annex C (normative)

Rules and calculation methods for extending the span length of sandwich panel ceilings

To enable an extension in the span length there shall be an overrun of at least 20 % subject to a minimum 10 min compared to the classification.

EXAMPLE Test result for a construction is 135 min. Overrun is < 20 % compared to EI 120 classification so allowed span length for this classification is according to direct application rules. Compared to EI 90 classification, the overrun is > 20 % and therefore an extension in span length is allowed for this fire resistance classification according to the rules below.

1) Calculation of allowable span length

The allowable span length can be calculated using Formula (C.1):

$$w = L(0,375\alpha T)^{1/2} + (0,375Lp)^{1/2} \quad (C.1)$$

where

- w deflection (m);
- α linear coefficient of thermal expansion of facing;
- T temperature rise of non-exposed facing (K);
- L span length of panel (m);
- p relative end movement (theoretical value to be calculated).

The calculation is then combined with the following procedure.

- a) Calculate p in the temperature of the wanted classification for the extended span using the temperature, deflection and span from the reference test in that temperature.
- b) Assuming that we can use the same deflection for the longer span that was the maximum deflection of the ceiling at failure in the reference test, calculate L in the wanted temperature using maximum deflection from the reference test and the above calculated p.
- c) This **span length** can be used if we consider fire resistance issues only; the maximum span length shall of course also be checked for normal condition as a sandwich construction.

2) Calculation of catenary force

Once the maximum deflection is known, the catenary force can be calculated using Formula (C.2):

$$F_{Ed} = gL^2/8w \quad (C.2)$$

where

- F_{Ed} catenary force (N/m);

- g panel weight (N/m²);
- L span length of panel (m);
- w deflection (m).

The number of fasteners shall then be increased according to Formula (C.3):

$$n_2 > n_1 * F_{Ed2} / F_{Ed1} \quad (C.3)$$

where

- F_{Ed1} the catenary force acting at the fastener at maximum temperature in the test calculated from Formula (C.2) (N/m);
- F_{Ed2} the catenary force acting at the fastener at temperature for the increased span calculated from Formula (C.2) (N/m);
- n_1 number of fasteners used in the test per meter;
- n_2 number of fasteners needed for the longer span per meter.

When the fastener takes the forces due at catenary force and the self weight of the panel, the interaction of these two loads shall be taken into account in the design of the fastener, according to Formula (C.4):

$$(n_1 * F_{Ed2}) / (n_2 * F_{Ed1}) + (n_1 * F_{v2}) / (n_2 * F_{v1}) \leq 1 \quad (C.4)$$

F_{v1} and F_{v2} can be calculated at actual spans from Formula (C.5):

$$F_v = gL / 2 \quad (C.5)$$

An example of the calculations is given below.

EXAMPLE

$$w = \sqrt{0,375\alpha \cdot T} + \sqrt{0,375 \cdot L \cdot p} \quad \alpha = 1,2 \cdot 10^{-5}$$

Panel = 21 kg/m² g_{Panel} = Panel · 9,81 g_{Panel} = 206,01 N/m²

EI90: w_{tot90 min} = 440 mm L_{90 min} = 5 000 mm

T_{90 min} = 160 °C

$$w_{dT90 min} = L_{90 min} \cdot \sqrt{0,375 \cdot \alpha \cdot T_{90 min}} \quad w_{dT90 min} = 134,2 \text{ mm}$$

$$w_{inc90 min} = \sqrt{w_{tot90 min}^2 - w_{dT90 min}^2} \quad w_{inc90 min} = 305,8 \text{ mm}$$

$$p_{90 min} = \frac{w_{inc90 min}}{0,375 L_{90 min}} \quad p_{90 min} = 49,9$$

$$L_{90 min} \cdot \sqrt{0,375 \cdot \alpha \cdot T_{90 min}} + \sqrt{0,375 \cdot L_{90 min} \cdot p_{90 min}} = 440 \text{ mm}$$

$$F_{Ed_{5,0m}} = \sqrt{\frac{g_{Panel} \cdot L_{90 min} \cdot 10^{-3}}{8}} \cdot \sqrt{\frac{w_{tot90 min}^2}{10^3}} \quad F_{Ed_{5,0m}} = 1 463 \text{ N/m}$$

EI60: w_{tot60 min} = 250 mm L_{60 min} = ?

T_{60 min} = 90 °C

$$w_{dT60 min} = L_{90 min} \cdot \sqrt{0,375 \cdot \alpha \cdot T_{60 min}} \quad w_{dT60 min} = 100,6 \text{ mm}$$

$$w_{inc60 min} = \sqrt{w_{tot60 min}^2 - w_{dT60 min}^2} \quad w_{inc60 min} = 149,4 \text{ mm}$$

$$p_{60 min} = \frac{w_{inc60 min}}{0,375 L_{90 min}} \quad p_{60 min} = 11,9$$

min

90 min

When the span is $L_{60\text{min}} = 10\,900\text{ mm}$, then:

$$w_{L_{60\text{min}}} = L_{60\text{min}} \cdot (0,375\alpha \cdot T_{60\text{min}}) + 0,375 \cdot L_{60\text{min}} \cdot p_{60\text{min}}$$

$$L_{60\text{min}} \cdot (0,375\alpha \cdot T_{60\text{min}}) + 0,375 \cdot L_{60\text{min}} \cdot p_{60\text{min}} = 439,9\text{ mm}$$

$$F_{Ed_{10,9\text{m}}} = \frac{g \cdot L_{60\text{min}}^2 \cdot 10^{-3}}{8 \cdot w_{60\text{min}}} \cdot 10^{-3}$$

$$F_{Ed_{10,9\text{m}}} = 6\,955\text{ N/m}$$

Bibliography

- [1] EN 1991-1-2, *Eurocode 1. Actions on structures — Part 1-2: General actions — Actions on structures exposed to fire*
- [2] EN 13501-1, *Fire classification of construction products and building elements — Part 1: Classification using data from reaction to fire tests*

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