Research Programme of the Research Fund for Coal and Steel

FIre and Seismic performances of Hybrid fire WALLs in case of single-storey industrial and commercial steel buildings (FISHWALL)

Design of tests

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WP1: Analysis of regulation requirements, fire and seismic action applied to partition walls and design of tests

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ABSTRACT

It is well known that the intrinsic fire resistance of single-storey unprotected steel-framed buildings is largely sufficient to guarantee the evacuation of occupants in the event of fire. In consequence, for this type of building, the main concern of national fire regulations in Europe is how to prevent the spread of fire to the whole building. To achieve this objective, two performances shall be usually satisfied, namely, the appropriateness of constructive systems to ensure that there is no progressive collapse between fire compartments, and the efficiency of fire walls to stop the fire inside the initial compartment regardless of the state of structures exposed to fire. In practice, many constructional solutions can be implemented in order to preserve the integrity of the fire walls, while accepting that the fire exposed part of the structure may collapse. One of the most common solutions is to place a non-load bearing wall between two independent steel structures and to connect it to them by means of "fusible" links. In fire situation, these fusible links have to allow the wall to be disconnected from the structure affected by fire without endangering the separating function of the wall, which shall remain fixed to the steel structure on the other side of the wall and therefore not exposed to fire. However, due to the lack of corresponding scientific evidence, questions are being very often raised about the real efficiency of such systems in fire situation, which, in certain cases, have also to provide an adequate seismic resistance, if they are used in seismic areas.

Today, concrete or masonry wall solutions are frequently used for the compartmentation of buildings, predominately for low-rise commercial and industrial steel buildings. However, as an alternative, lightweight sandwich panels (comprising two thin flat metal faces and an insulated core) could become an appropriate steel fire wall solution, offering numerous benefits in comparison to other solutions, including fire resistance, durability, flexibility, easy dismounting and fast construction times. But, there is an evident lack of technical information about the adequate fire performance of such type of wall solutions when they are implemented in single-storey buildings with unprotected steel structure, which constitutes a major obstacle for their large use.

In this context, the overall goal of the FISWHALL project is to develop a design guidance and recommendations for an innovative hybrid fire wall solution based on lightweight steel-faced sandwich panels associated with unprotected steel structure under both fire and seismic actions, but considered individually. This will be achieved through the following specific tasks: i) Establishing of a full range of experimental evidence about the fire and seismic behaviour of the investigated hybrid fire wall solution by carrying out a number of tests; ii) Investigating intensively the fire and seismic performances of the above hybrid fire wall solution in combination with unprotected single-storey steel structures through a variety of parametric numerical studies by means of validated FE numerical models; iii) Developing both cost-effective and innovative "fusible" connection systems for fire walls to be used in combination with unprotected steel structures of single-storey buildings; and iv) Developing a design guidance and practical recommendations for the studied hybrid fire wall and fusible links solutions, on the basis of above studies, from which engineers can carry out very efficient design.

This deliverable gives a short description of all fire and seismic tests planned in the project. A more detailed description of both test specimens and test arrangements will be provided in relevant test reports.

1 INTRODUCTION

The aim of the project FISHWALL is to provide a hybrid steel-based fire wall solution using sandwich panels for single-storey buildings with unprotected steel structure. This fire wall is placed between two independent building structures and connect it to them by means of "fusible" systems. In case of fire event, the fusible systems will break and will allow the wall to be disconnected from the structure affected by the fire, without endangering the separating function of the wall, which remains fixed to the steel structure on the other side of the wall and therefore not exposed to the fire.

This deliverable gives a short description of all fire and seismic tests planned in the project. A more detailed description of both test specimens and test arrangements will be provided in relevant test reports and deliverables of tasks involving tests.

2 FIRE TESTS ON PARTITION FIRE WALLS

Four standard fire tests on partition fire walls are planned in the scope of task 2.1 of the current project. They are intended to investigate the fire performance of partition fire walls made of sandwich panels with span larger than the usually 3m fire-tested span. The test data will serve to check the rule proposed in Annex B of EN 15254-5 [1] to extend the span length of sandwich panels beyond 4 m.

During the process of finalizing the design of tests, project partners expressed concern about the success of the two fire tests initially planned in a horizontal furnace (the panels having to carry their own weight), as well as the possibility to compare the results from such tests to those of the reference fire tests (conducted on 3×3m walls). Consequently, all partners agreed to update the initial test programme, performing all the planned wall tests in the vertical furnace only.

2.1 Description of wall specimens

All the non-loadbearing wall specimens will have overall dimensions of 6m high, by 5m wide and 175 mm thick. They will be formed from five or six composite panels as illustrated in following figures, according to the panel orientation (vertical or horizontal). The walls will be mounted/arranged according to current application in practice into a test frame placed in the front of the furnace, so exposed to fire on one side only. One wall edge will be left unrestrained to incorporate a free edge (with a gap of 25 mm to 50 mm between the free edge of the wall and the test frame). This free edge will be filled with mineral insulation. Additional steel members made of IPE 240 steel profile and fire-protected with a panel encasement fabricated with the same sandwich panels as the ones constituting the walls will be used in two tests, allowing to test different span lengths (4, 5 or 6m) and to confirm the appropriate interaction between the panel encasement and the wall panels.

Some views of the wall specimens as well as construction details of the panel encasement solution are given in following figures. A more detailed description of the walls as well as the test arrangement will be given later in the relevant test reports.

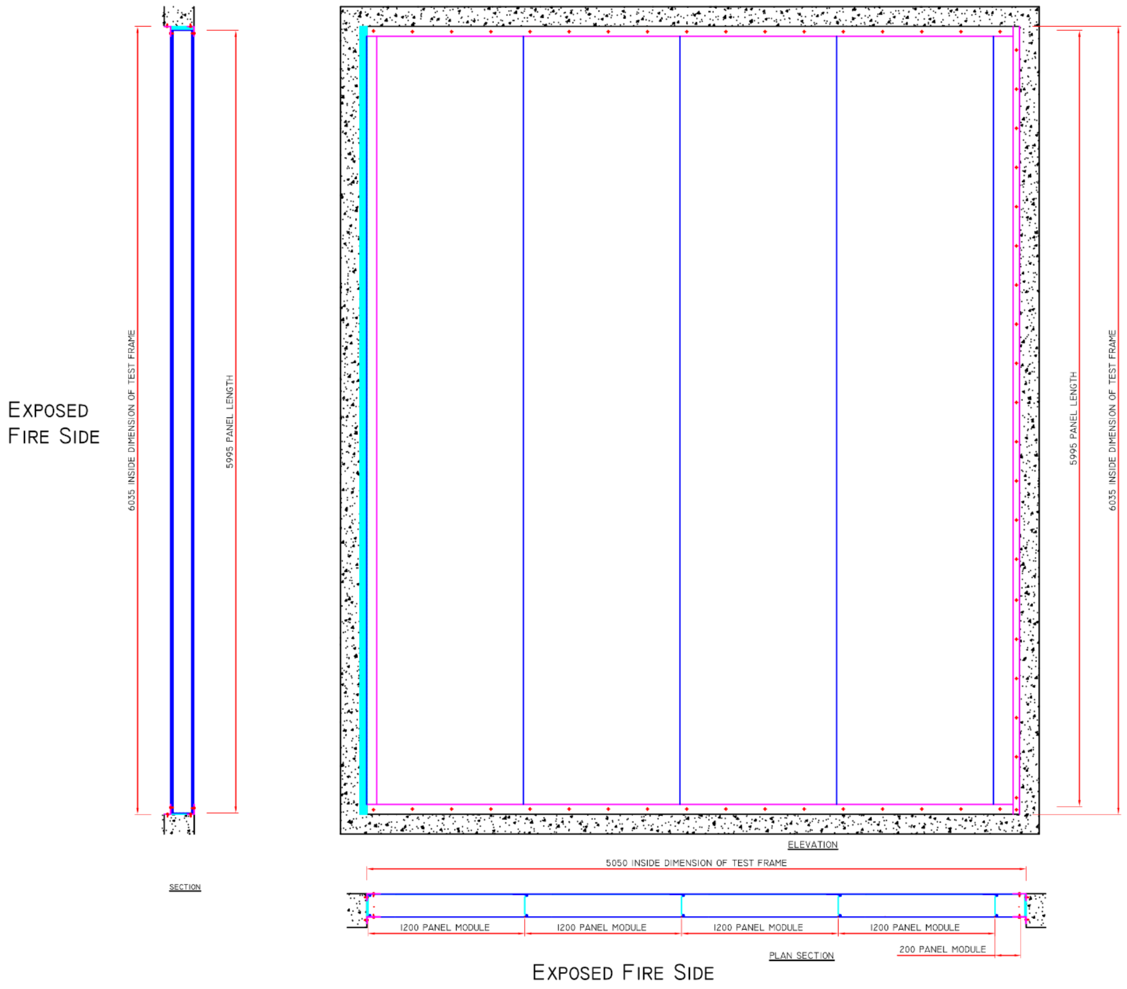


Figure 2.1: Elevation view of the wall specimen n°1

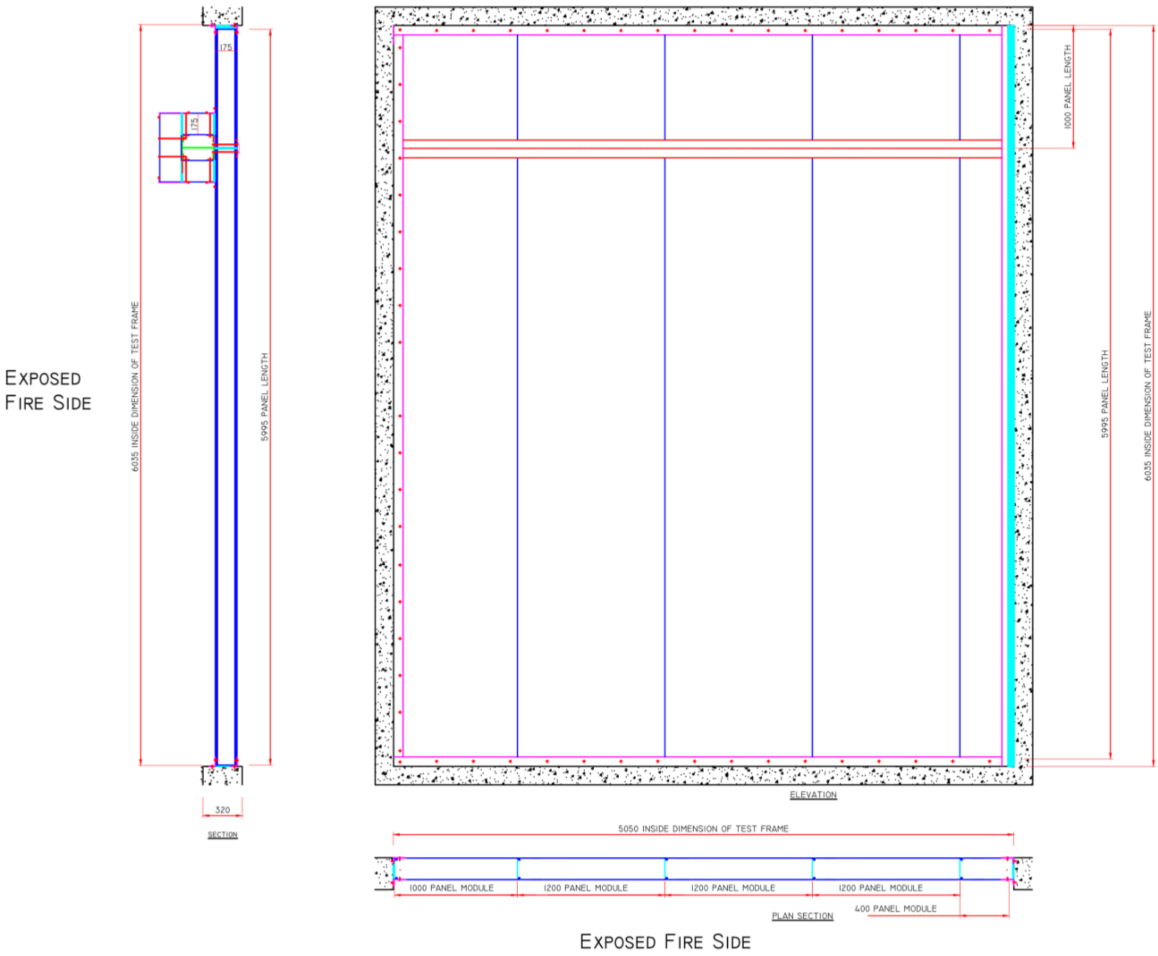


Figure 2.2: Elevation view of the wall specimen n°2

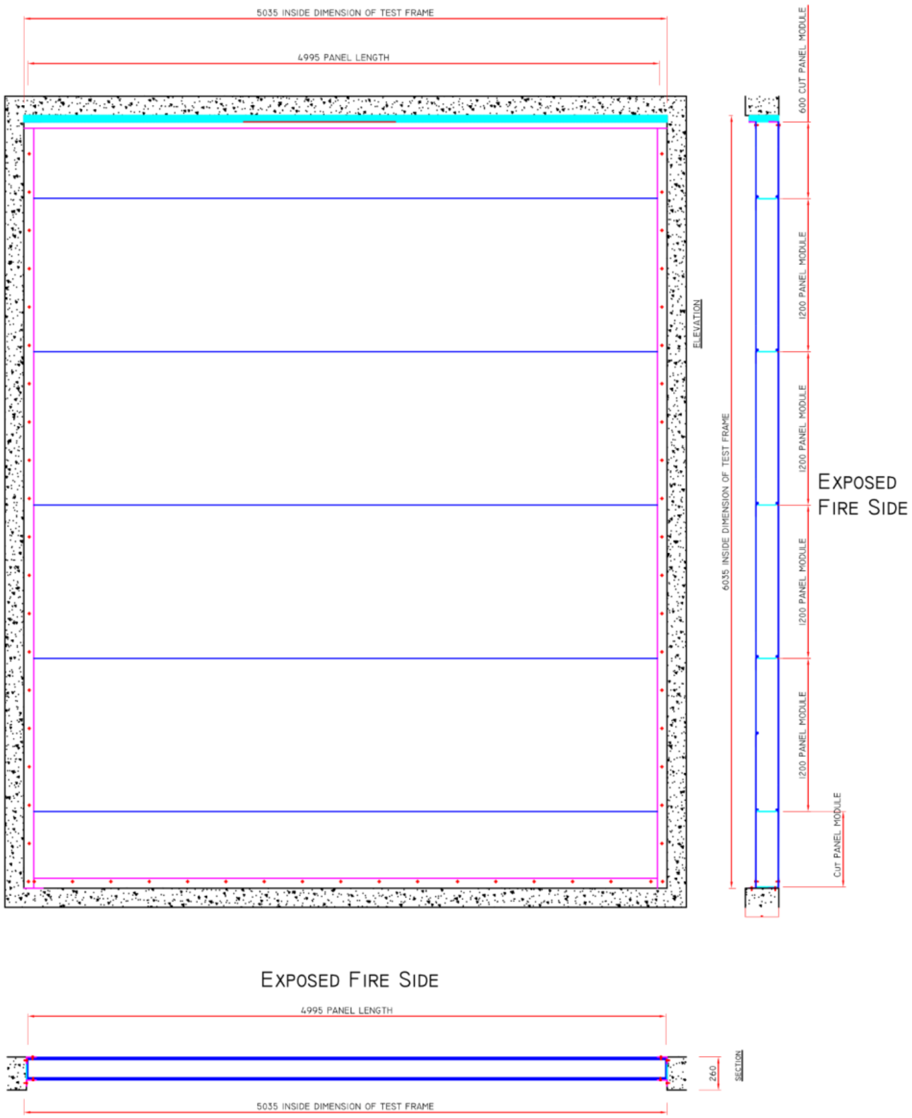


Figure 2.3: Elevation view of the wall specimen n°3

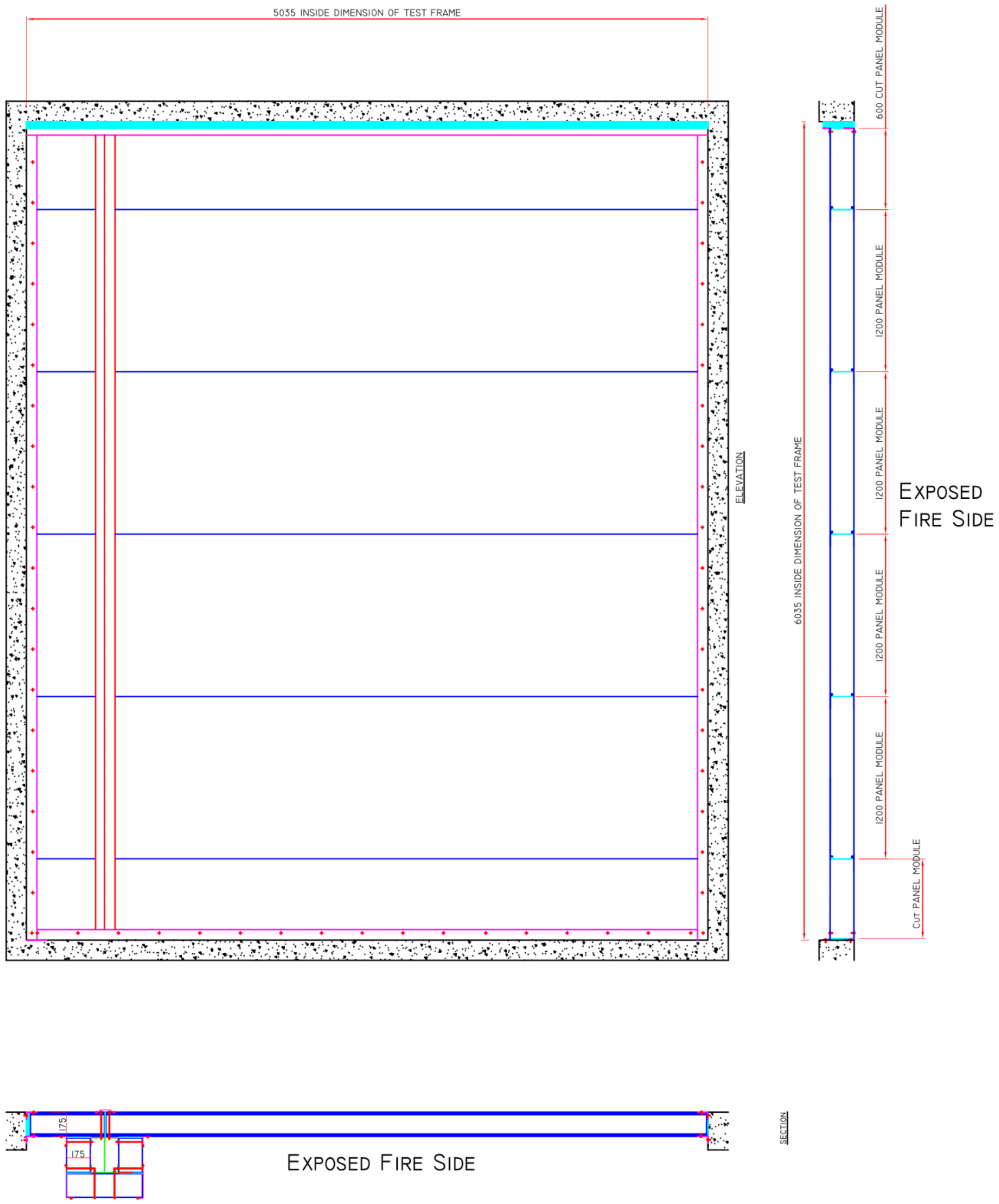


Figure 2.4: Elevation view of the wall specimen n°4

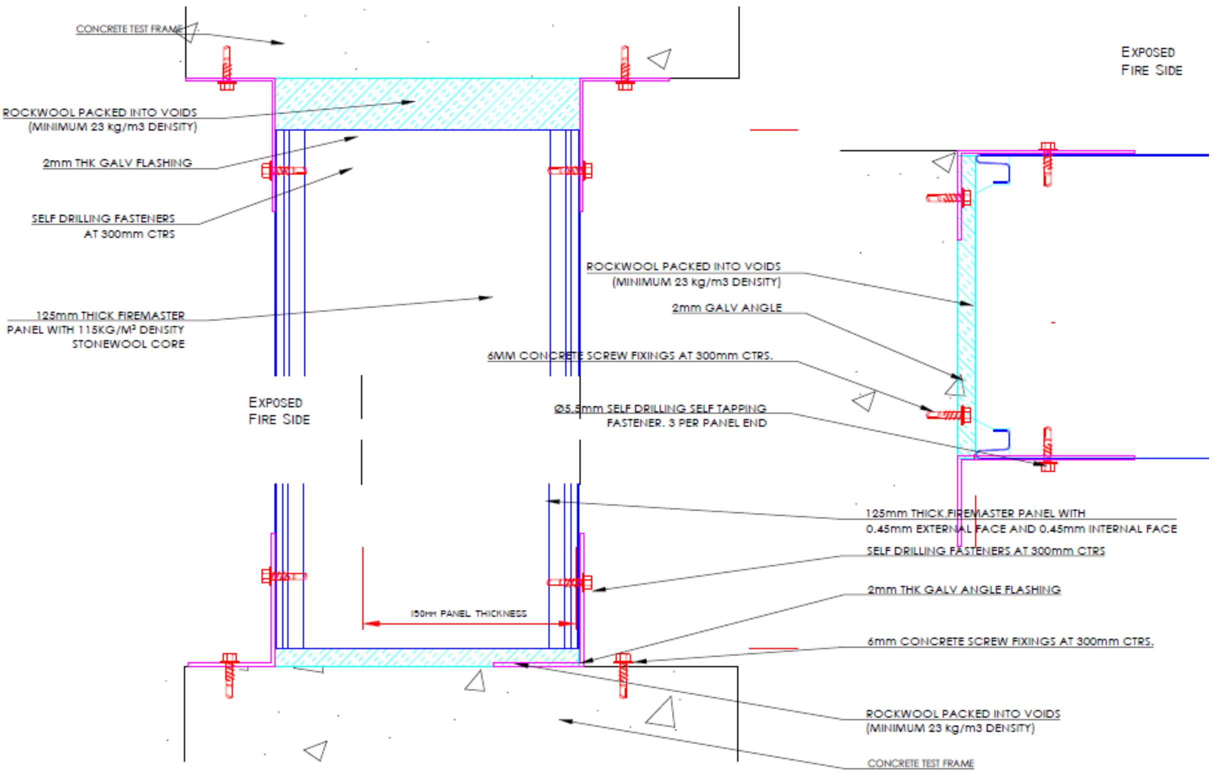


Figure 2.5: Construction details througt wall edges

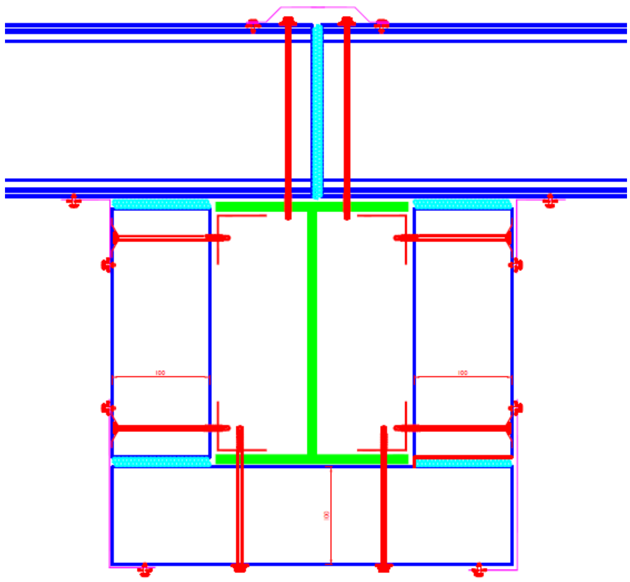


Figure 2.6: Construction details of panel encasement

2.2 Instrumentation

The aim of tests being to check the ability of the investigated wall system to prevent the spread of flame or smoke in a fully developed fire, the following aspects (performance criteria) will be determined during each test (according to standard EN 13501-2 [2]):

- Integrity separating function (E) - ability of the element of construction that has a separating function, to withstand fire exposure on one side only, without the transmission of fire to the unexposed side as a result of the passage of flames or hot gases;
- Thermal insulating separation function (I) – ability of the element of construction to withstand fire exposure on one side only, without the transmission of fire as a result of significant transfer of heat from the exposed side to the unexposed side;

For this purpose, a lot of instrumentation will be used:

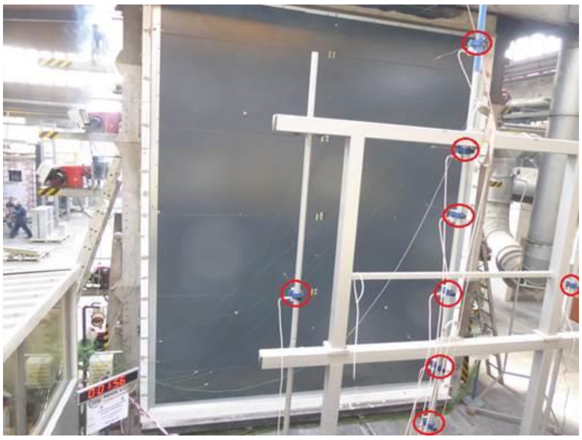
- Thermocouples will be provided to monitor the unexposed surface of the walls;
- The furnace will be controlled so that its mean temperature follows the ISO standard fire curve, using plate thermometers (suitably distributed within the furnace) located inside the furnace over a plan 100 mm from the surface of the walls

Further very important aspect is the deflection of the wall specimens. Consequently, the lateral deflection of walls will be also measured on different points during each test, using draw-wire displacement sensors (see Figure 2.7a). Moreover, joint openings will be evaluated visually from strips of tape measure placed at junctions between bordering panels (see Figure 2.7b).

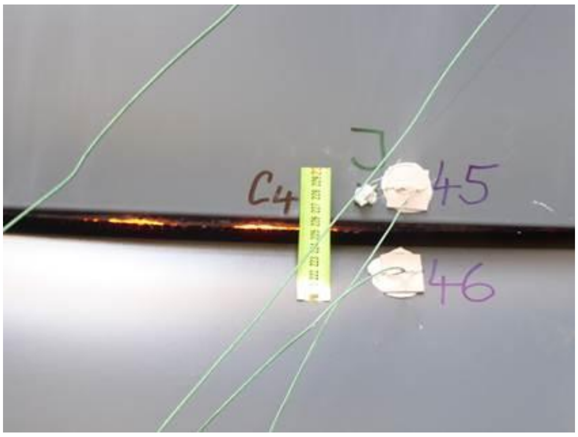
In addition, thermocouples will be installed to record the temperatures of steel members encased with sandwich panels.

The likely location of the various temperature and deflection measuring points on the exposed side of the wall specimens are illustrated in Figure 2.8 and Figure 2.9, according to the panel orientation.

The instrumentation for measurement of temperatures and deformation will comply with the requirements of EN 1363-1 [4].

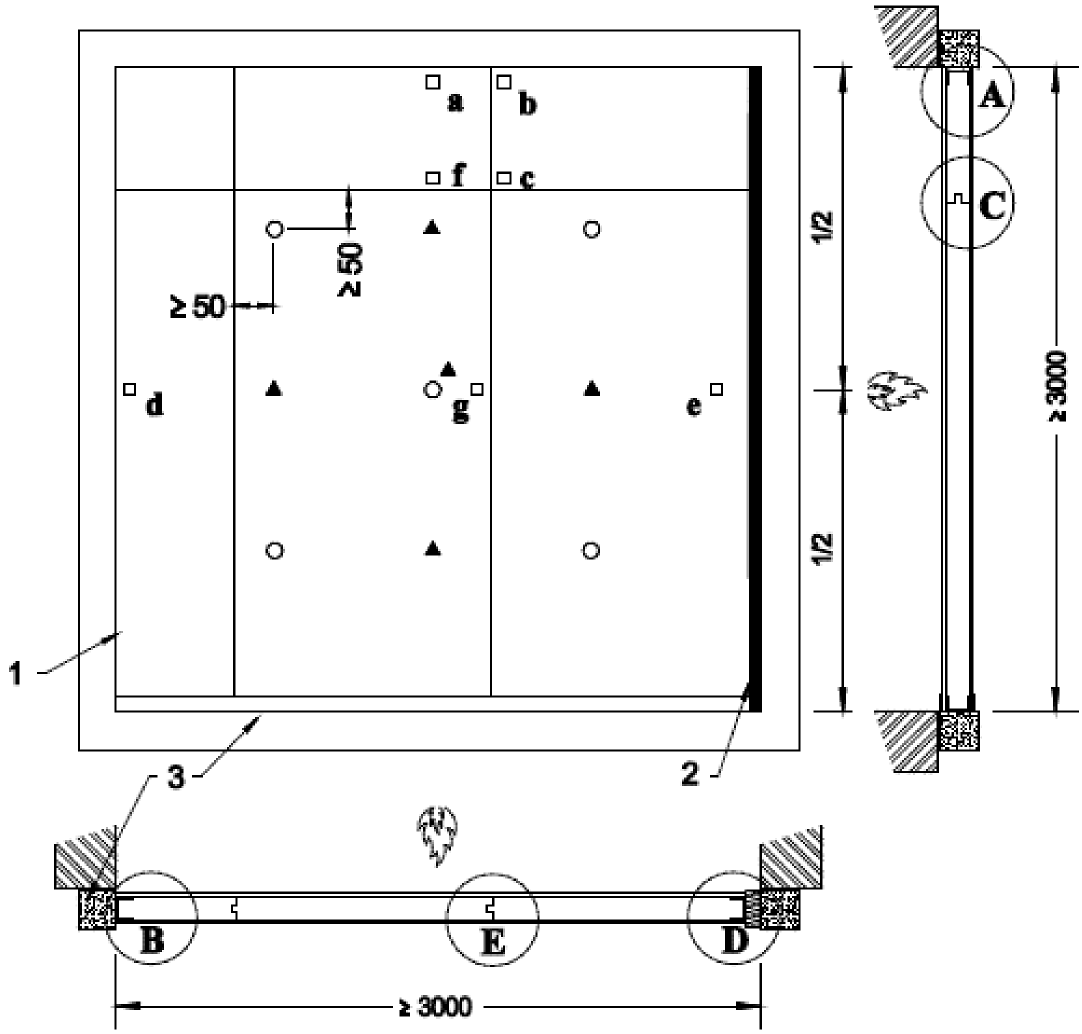


a) draw-wire displacement sensors



b) strips of tape measure

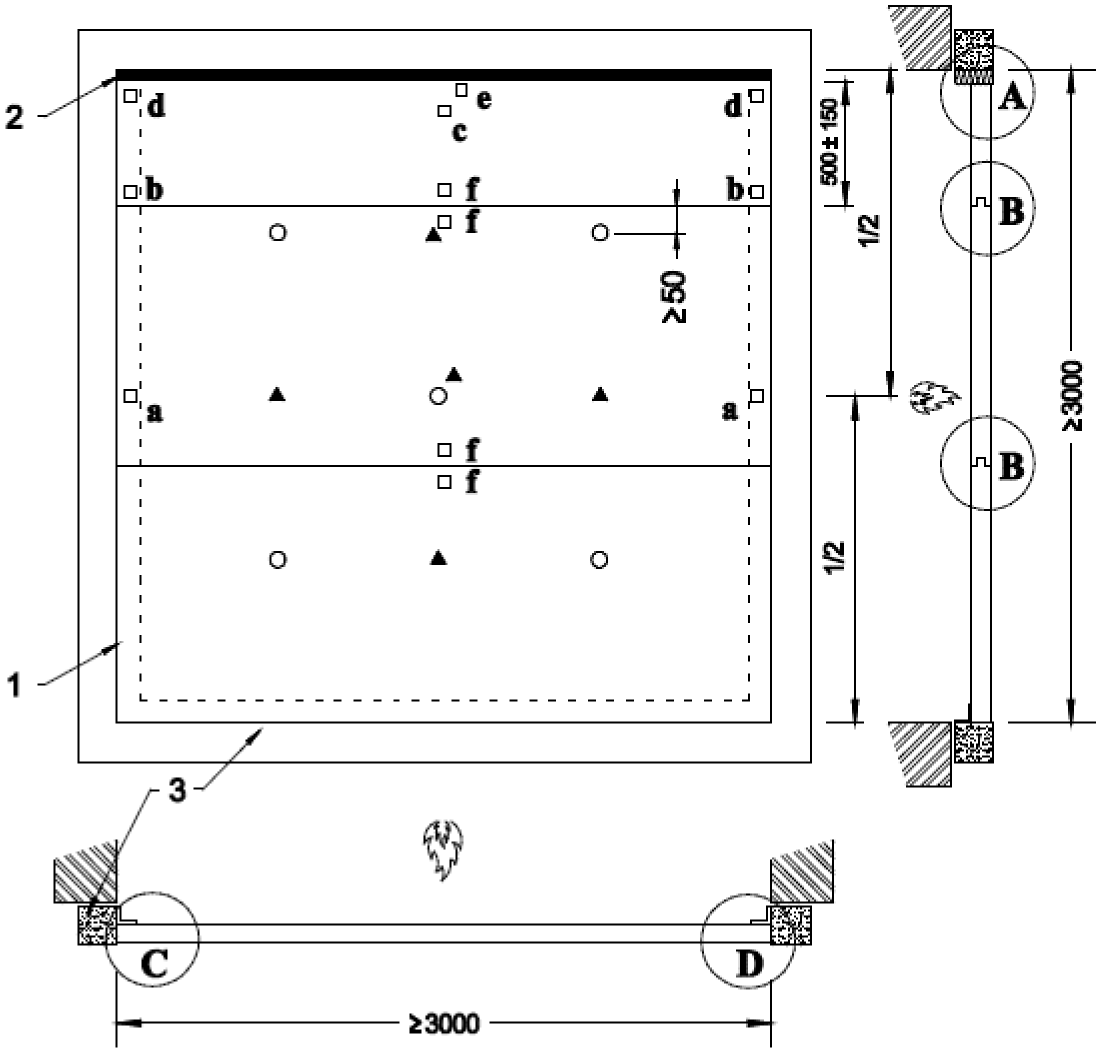
Figure 2.7: Example of instrumentation to measure the deformation ot tested walls



Key

- ○ positions for thermocouples for average temperature rise
- □ positions for thermocouples for maximum temperature rise (letters refer to thermocouples denoted by letter in 9.1.2.3)
- ▲ positions for deflection measurements
- 1 fixed edge
- 2 free edge
- 3 test frame

Figure 2.8: Unexposed side thermocouple positions and deflection measurement positions for walls with vertically spanning panels



Key

- ○ positions for thermocouples for average temperature rise
- □ positions for thermocouples for maximum temperature rise (letters refer to thermocouples denoted by letters in Annex B)
- ▲ positions for deflection measurements

1 fixed edge

2 free edge

3 test frame

Figure 2.9: Unexposed side thermocouple positions and deflection measurement positions for walls with horizontally spanning panels

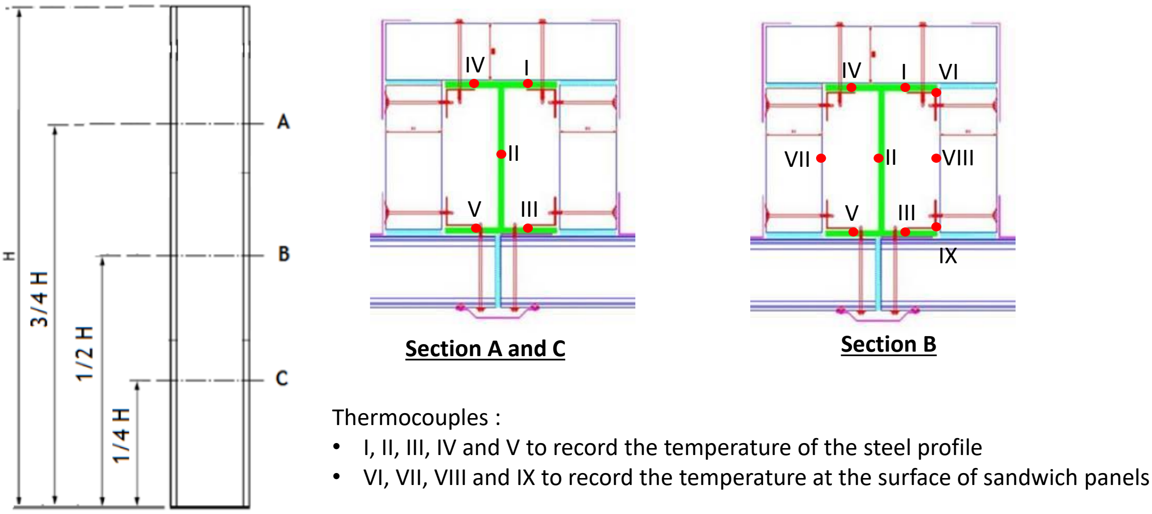


Figure 2.10: Thermocouple positions along steel members encased with sandwich panels

3 FIRE TESTS ON STEEL MEMBERS PROTECTED BY SANDWICH PANELS

Two fire tests will be made in accordance with the characterization methodology of protective materials as indicated by the European standard EN 13381-4[5] to measure the temperatures rises of steel members protected by sandwich panels subjected to standard fire, in function of their section factors, the panel thicknesses and the duration of the fire exposure. According to the standard, two pairs of loaded and unloaded I-shaped steel beams (with 3 fire exposed sides) as well as unloaded short I-shaped steel columns (with 4 fire exposed sides) will be tested.

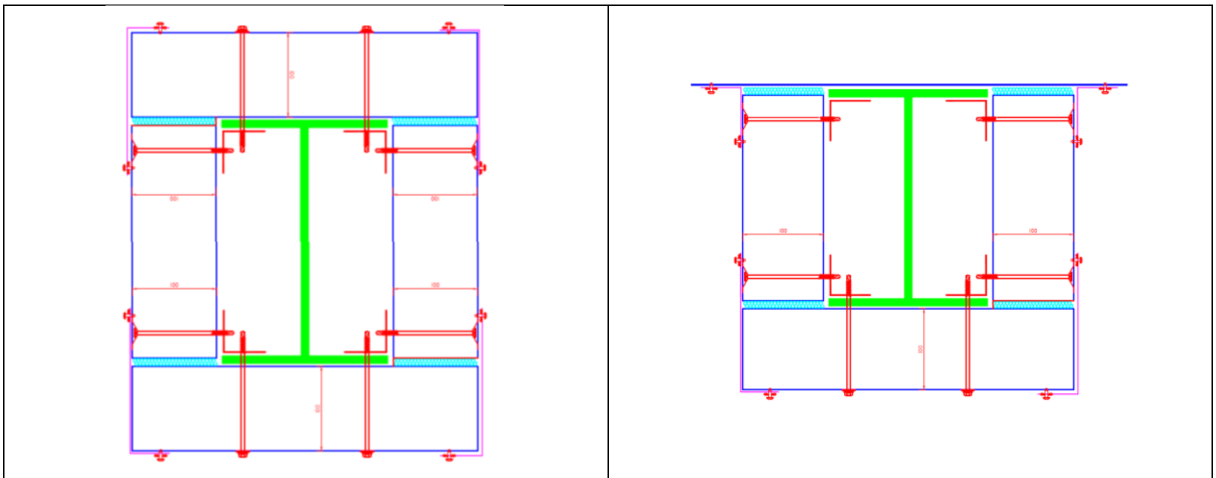
3.1 Description of test specimens

The dimensional characteristics of the test specimens are reported in Table 1. All specimens are I/H shaped steel members with shape factors ranging from 50m^{-1} to 220 m^{-1}. The short columns and beams will have 1 m long approximately, while the loaded beams will have a length of 4.7 m. The steel members will be fire-protected with an encasement system made of sandwich panels. The sandwich panels will be installed in such a manner to create a 3 (beams) or 4 sides (columns) protective box around the profiles. The panels will be fixed to steel members using screws and extra steel angles. The Figure 3.1 gives some constructional details of the encasement system that could be tested.

A more detailed description of the test specimens and the test arrangement will be given later in the relevant test reports.

Table 1: Dimensionnal caracteristics of test specimens

Steel member	Cross-section	Panel thickness (mm)	Length (mm)	Section factor (m^{-1})
Loaded beam	IPE 400	100	4700	121
Short beam	IPE 400	100	950	121
Loaded beam	IPE 400	300	4700	121
short beam	IPE 400	300	950	121
Short column	HEM 280	100	950	51
Short column	HEM 280	175	950	51
Short column	HEM 280	240	950	51
Short column	HEA 300	100	950	110
Short column	HEA 300	240	950	110
Short column	HEA 300	300	950	110
Short column	HEA 220	100	950	140
Short column	HEA 220	175	950	140
Short column	HEA 220	240	950	140
Short column	HEA 220	300	950	140
Short column	IPE 200	175	950	220
Short column	IPE 200	240	950	220
Short column	IPE 200	300	950	220



a) Encasement system for the columns
b) Encasement system for the beams

Figure 3.1: Construction details of the encasement sytem made of sandwich panels

Sandwich panels will be installed along the full length of the short members, without adjacent joints. On the other hand, the loaded beams will incorporate a peripheral joint that could be used in practice.

The steel members will be arranged on the test furnace as recommended in EN 13381-4. Following figures give a schematic view of construction details of the steel members.

The loaded beams will be simply supported. They will be subjected to two point loads by means of two hydraulic jacks. The loading will be designed to achieve, between the two loading points, a bending moment equal to 60% of the design moment resistance of beams calculated according to EN 1993-1-1 [12]. The loads developed by the hydraulic jacks will be kept constant until the beam deflection is equal to L/30 (L: beam span between supports).

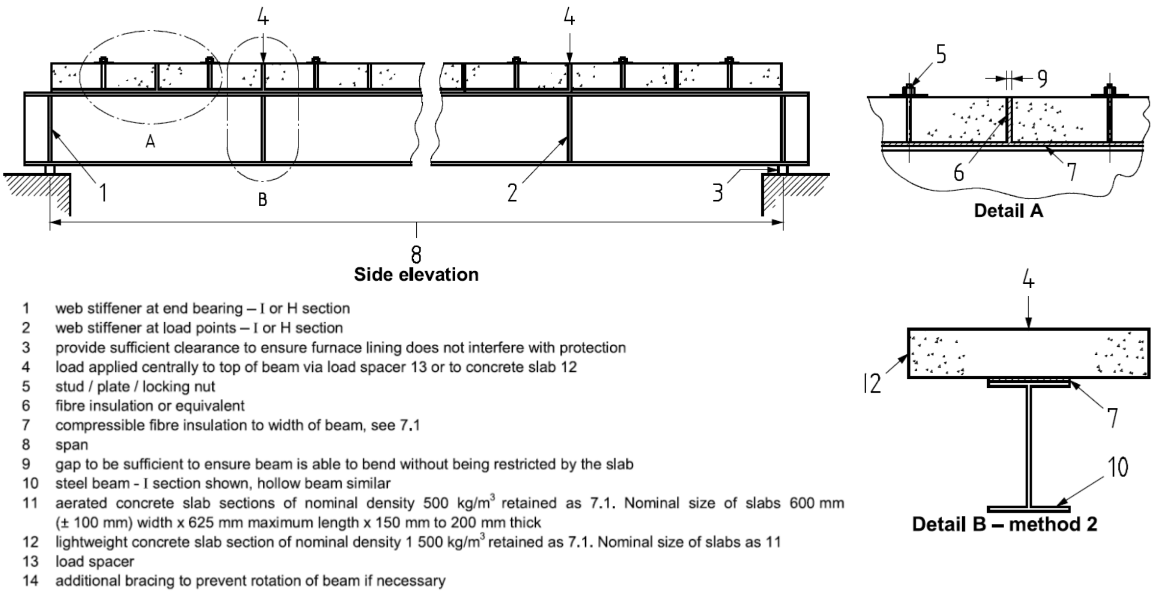


Figure 3.2: Construction details of loaded steel beams

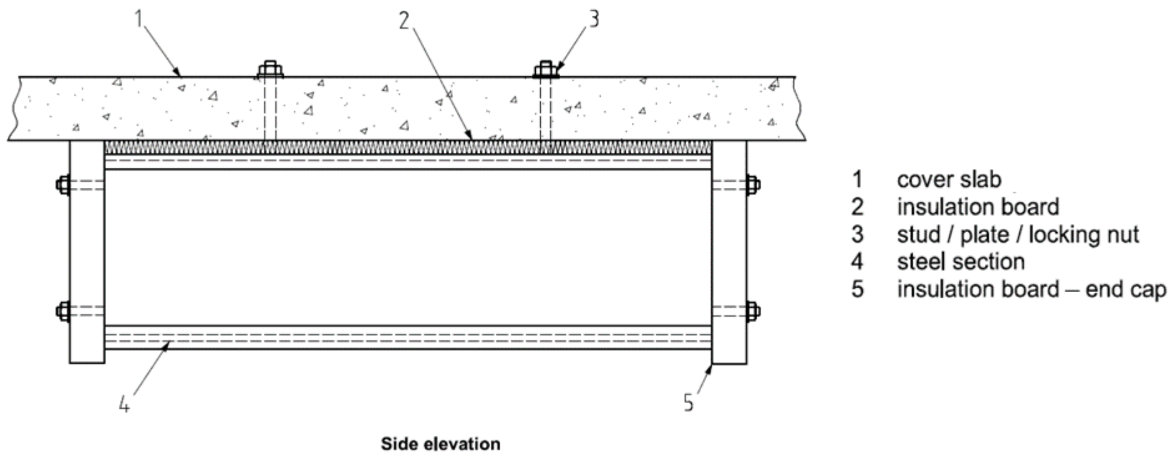


Figure 3.3: Construction details of short steel beams

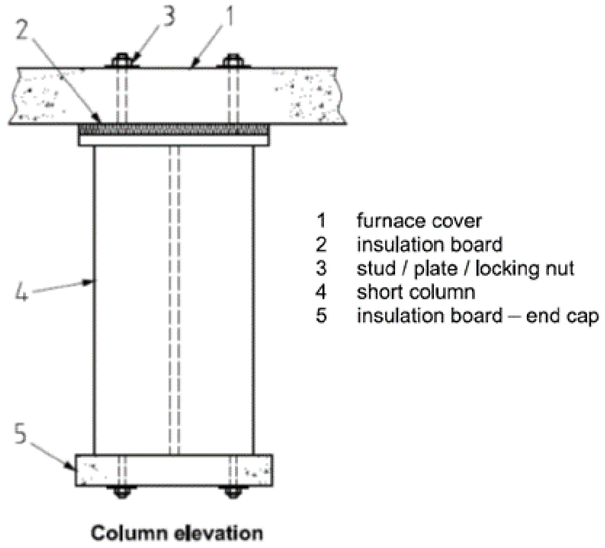


Figure 3.4: Construction details of short steel beams

3.2 Instrumentation

The instrumentation for measurement of temperatures (steel members and furnace), applied load and deformation will comply with the requirements of EN 1363-1 [4].

Following instrumentation will be used during the tests:

- Thermocouples will be provided to monitor the temperature of steel members;
- The deflection of loaded beams will be measured at mid-span, using displacement transducers;
- The furnace temperatures will be measured using plate thermometers suitably positioned along the loaded beams.

The likely location of all thermocouples along steel members are given in following figures.

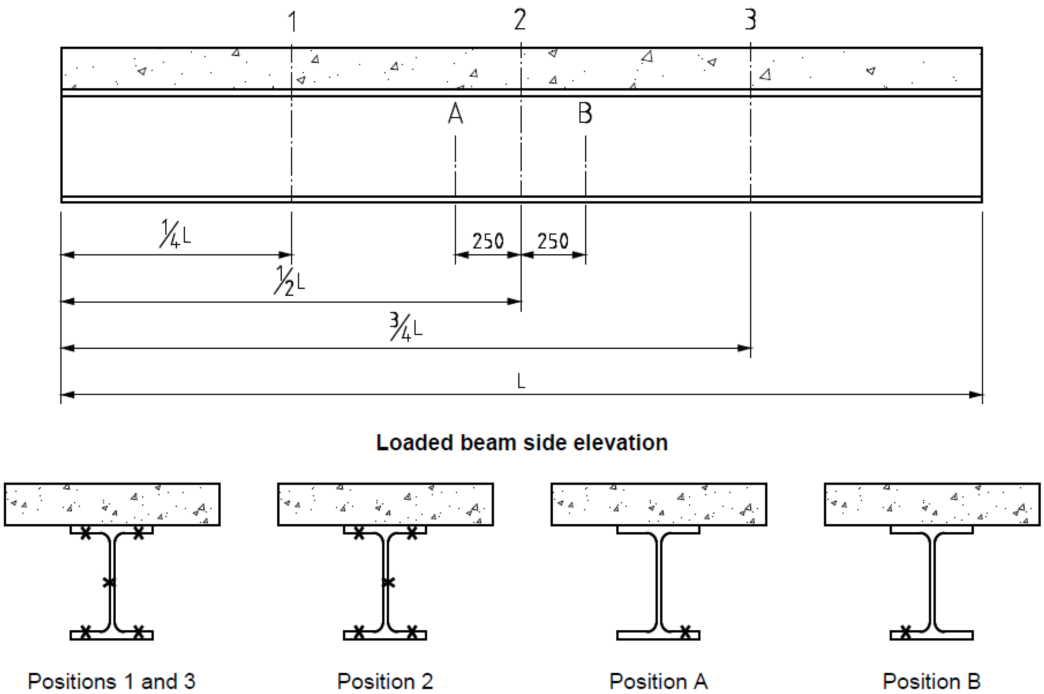


Figure 3.5: Thermocouple positions along the loaded beams

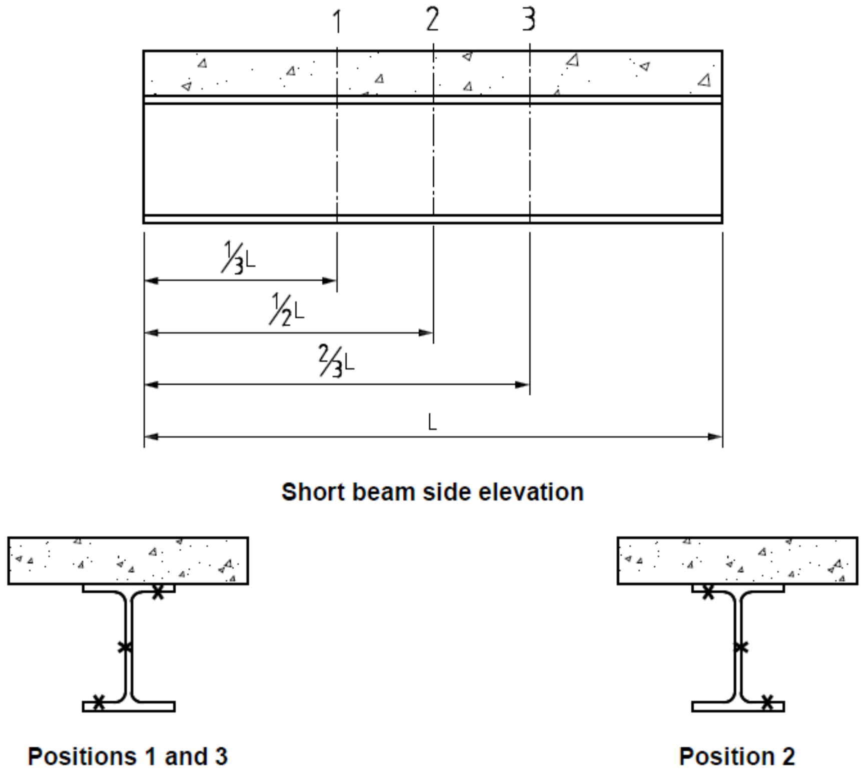


Figure 3.6: Thermocouple positions along the short beams

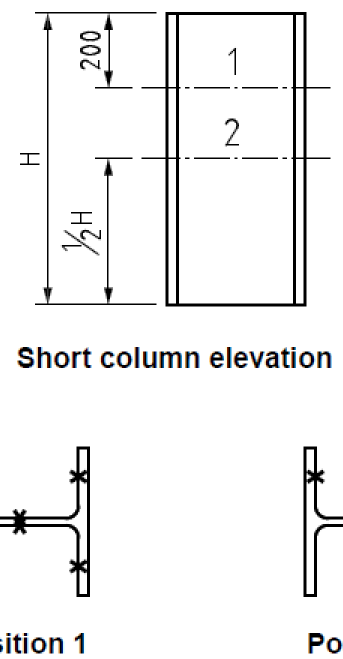


Figure 3.7: Thermocouple positions along the short columns

4 FIRE TESTS ON A FIRE WALL SOLIDLY ATTACHED TO AN UNPROTECTED STEEL STRUCTURE

In the scope of task 3.2, a fire test will be performed on a steel portal frame supporting a partition fire wall penetrated by two steel purlins supporting a flat roof with steel deck. The objective is:

- Firstly, to investigate the interaction of deforming purlins with a wall directly adjacent to a steel portal frame and to check that the panel-based fire protection along an appropriate length of purlins allows, as expected, preventing wall damage and subsequent spread of fire, particularly since the wall is only designed to support its own weight
- Secondly, to confirm that the temperature rise of penetrating members on the unexposed side of the fire wall is limited and fulfil the insulation performance criteria

4.1 Description of the test specimen

As illustrated in Figure 4.1, the test specimen will consist of two hot-rolled steel purlins penetrating a fire wall made of lightweight sandwich panels with 175 mm thick and providing a 120-minutes fire resistance (integrity and insulation). The wall will be exposed to ISO standard fire on one side only.

Regarding the test set-up, it can be mentioned that:

- The steel purlins will be made of IPE 200 in the most used steel grade S275. They will support each a steel roof decking having 1.5m width and 1mm thick, covered with an insulation made of mineral wool;
- The purlins will be supported by two steel beams acting as portal frames. They will be connected by means of steel cleats bolted to the beam top flange and the purlin web. Moreover, the possible uplift of the free end of purlins located on the unexposed side will prevented by a third steel beam, allowing to take account of a purlin continuity effect;
- On the fire-exposed side, the purlins will have a span of 6m approximately;
- The purlin spacing is fixed to 1.5m. The first purlin will be placed at the junction between two sandwich panels while the second one will be placed at mid-width of a panel (cf. Figure 4.3);
- On the fire exposed side, the purlins will be fire protected by a panel encasement system over 50 cm or 1m length from the fire wall, leaving the gaps under the steel deck unfilled. The panel encasement will be made from sandwich panels with 100 mm thick;

Some constructional details of the test specimen are shown on Figure 4.5. It can be noted that:

- The wall will be mounted/arranged according to current application in practice;
- The sandwich panels forming the wall will be installed vertically and will be fastened with screws to additional steel tubes or steel angles welded to the supporting beam. Fastenings of panels to steel profiles will be designed to carry the dead weight of the wall during fire;
- At the head of panels, any void formed between the panels and the steel deck will be filled with mineral wood;
- The used panel encasement solution will be the same as the one tested in the task 2.3. The end of the panel encasement will filled with mineral wool;
- A strip of mineral wool with cover flashings fixed to the wall panels will be positioned at the junction between the wall and each panel encasement;
- A wall opening will be managed at the level of purlins. It will be somewhat larger than the dimensions of the purlin cross-section and will be filled with mineral wool. The same mineral wool as the one of sandwich panels could be used.

Regarding the loading condition, since large deformation of the heated purlins is of interest, a vertical load of 15 kN will be applied at the purlins mid-span using dead weights. Moreover, adequate fixation providing hinges will be used between the dead weights and the purlins to prevent unwanted additional moments in the purlins.

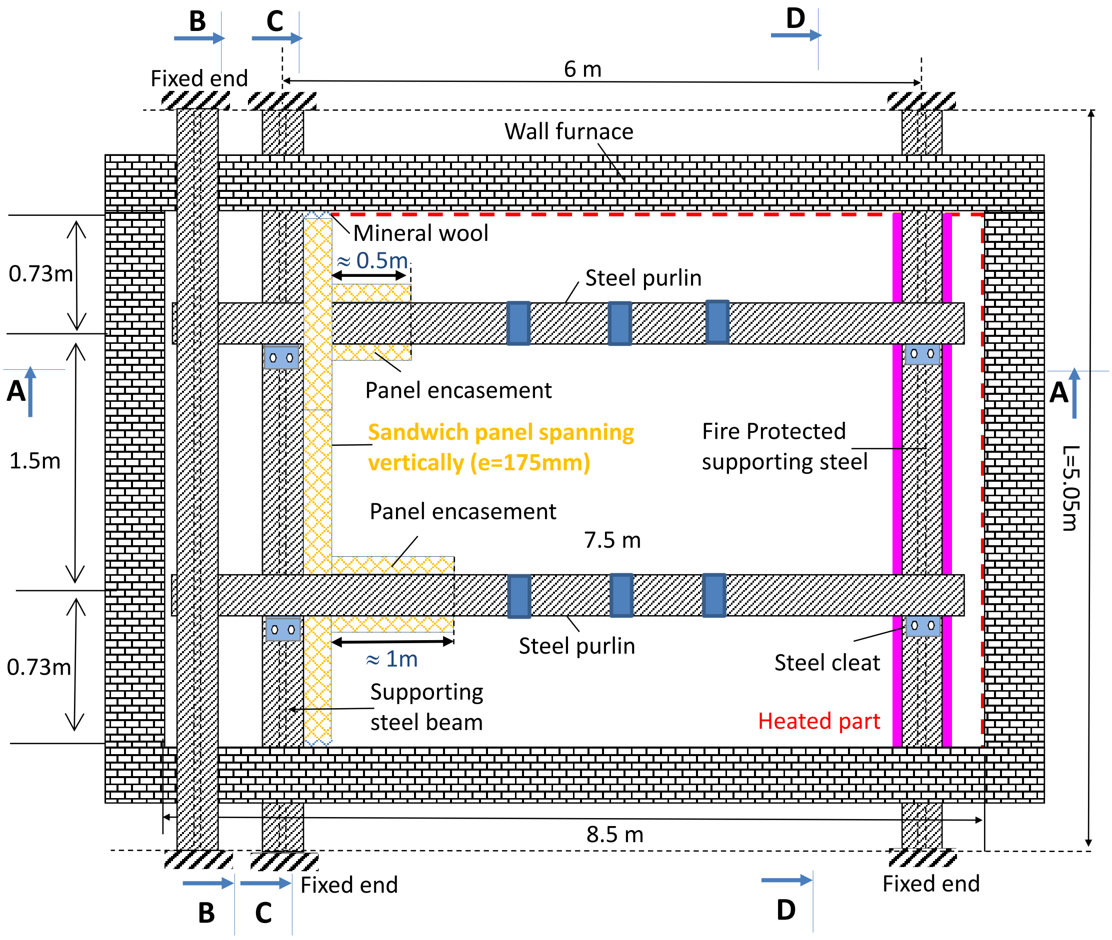


Figure 4.1: Top view of the test specimen

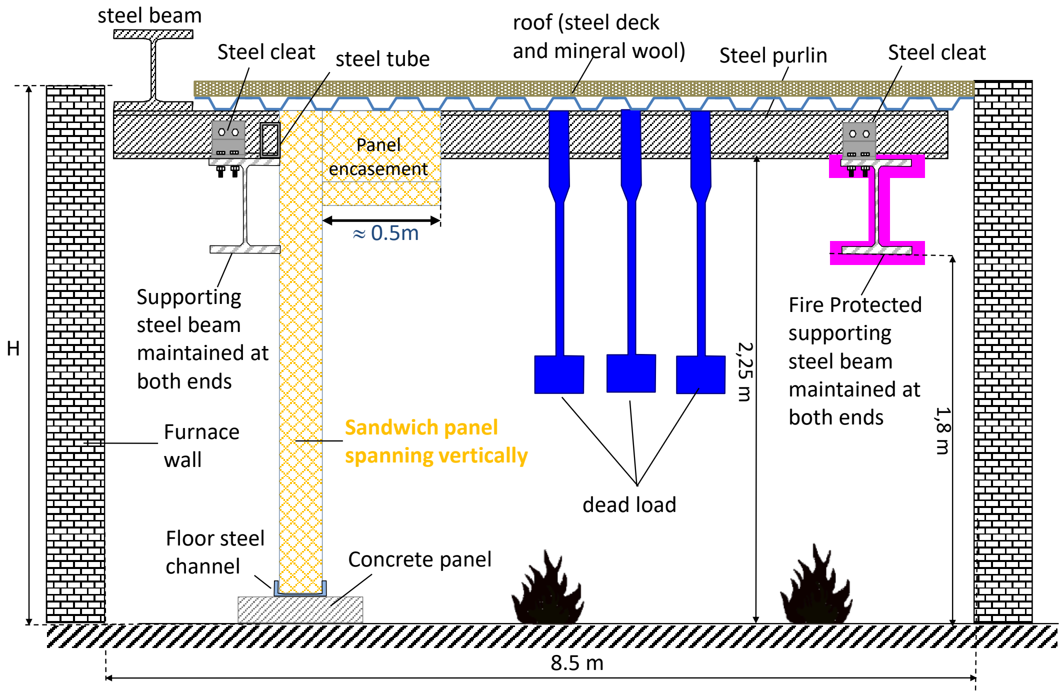


Figure 4.2: Elevation view A-A of the test specimen

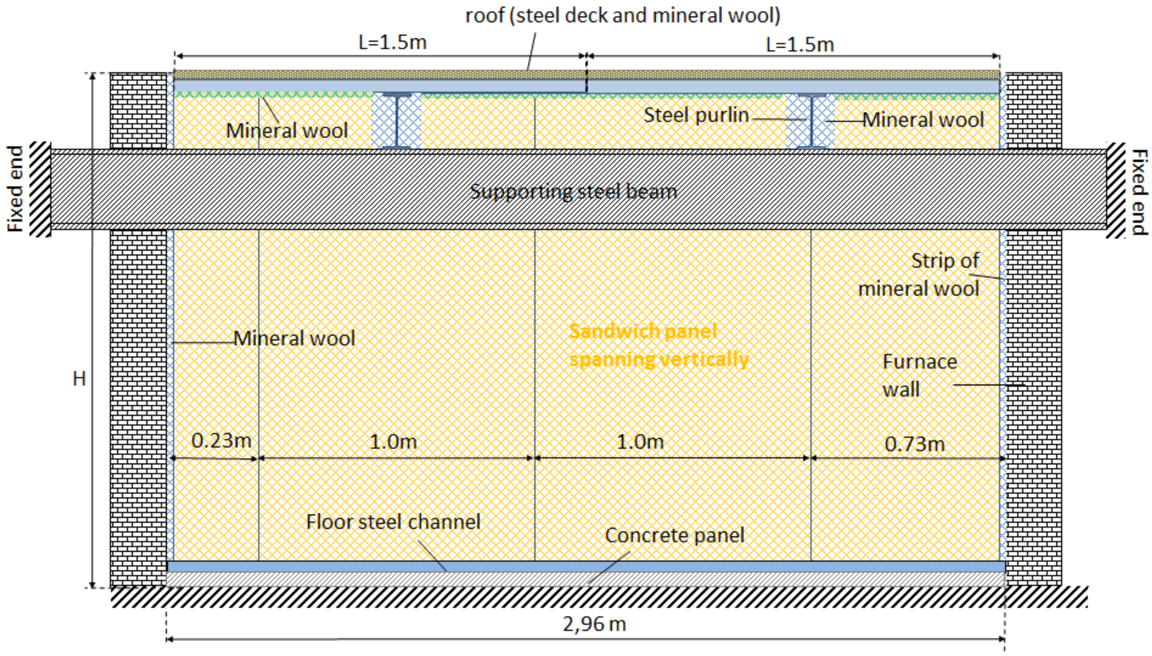


Figure 4.3: Elevation view C-C of the test specimen

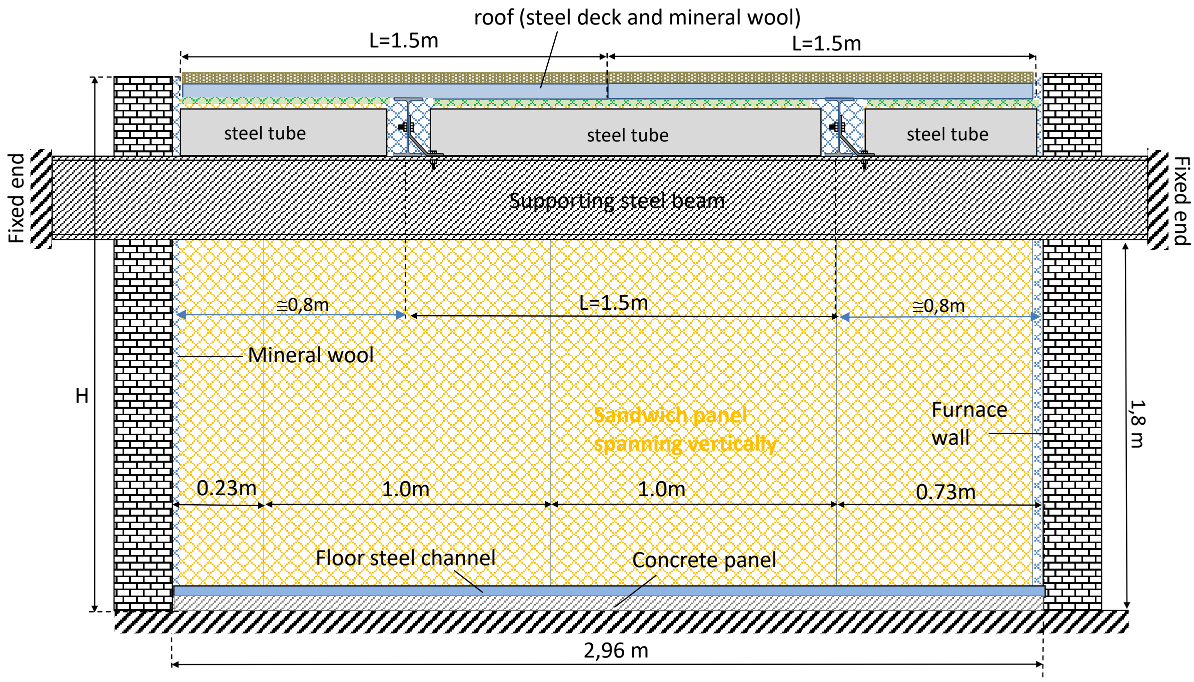


Figure 4.4: Elevation view B-B of the test specimen

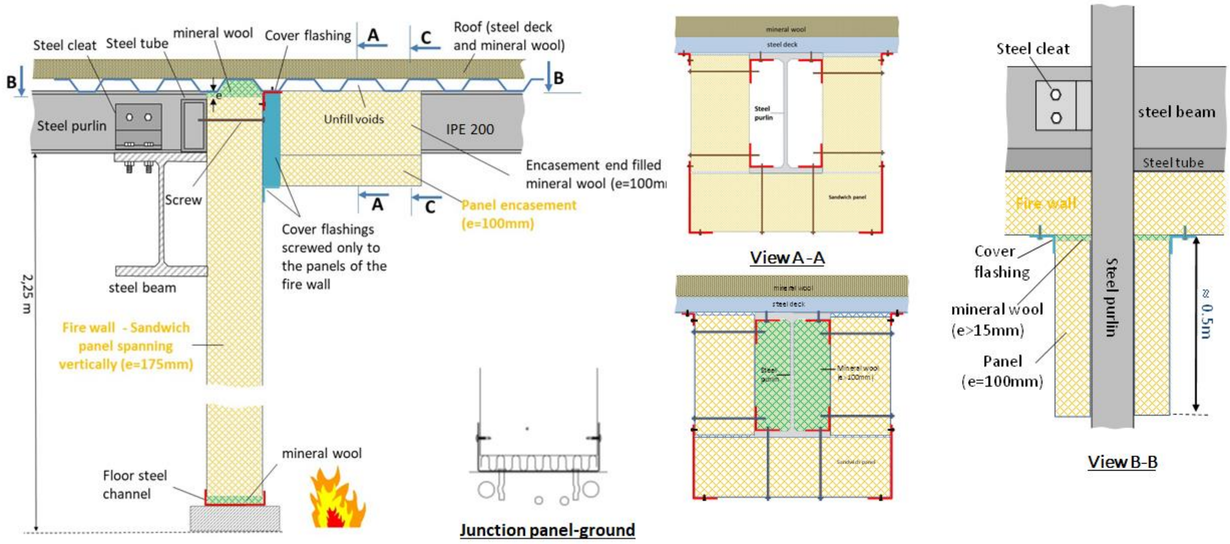


Figure 4.5: View of some detailing

4.2 Instrumentation

To obtain relevant data about its fire behavior, the test specimen will be implemented with many measurement devices to record both temperatures and displacements:

- The furnace temperature will be continuously measured with 12 plate thermometers placed at 100 mm below the purlins level (see Figure 4.6).
- Concerning the temperature recording in the specimen:
    - about 76 thermocouples will be installed in 7 cross-sections along each purlin (see Figure 4.7);
    - about 22 thermocouples will be installed on the unexposed side of the wall (see Figure 4.9).
- Two displacement transducers will be installed along each purlin, below the steel deck (so outside the furnace) to measure the vertical displacement of the purlins during the test (see Figure 4.10).

The instrumentation for measurement of temperatures (steel members and furnace), applied load and deformation will comply with the requirements of EN 1363-1 [4].

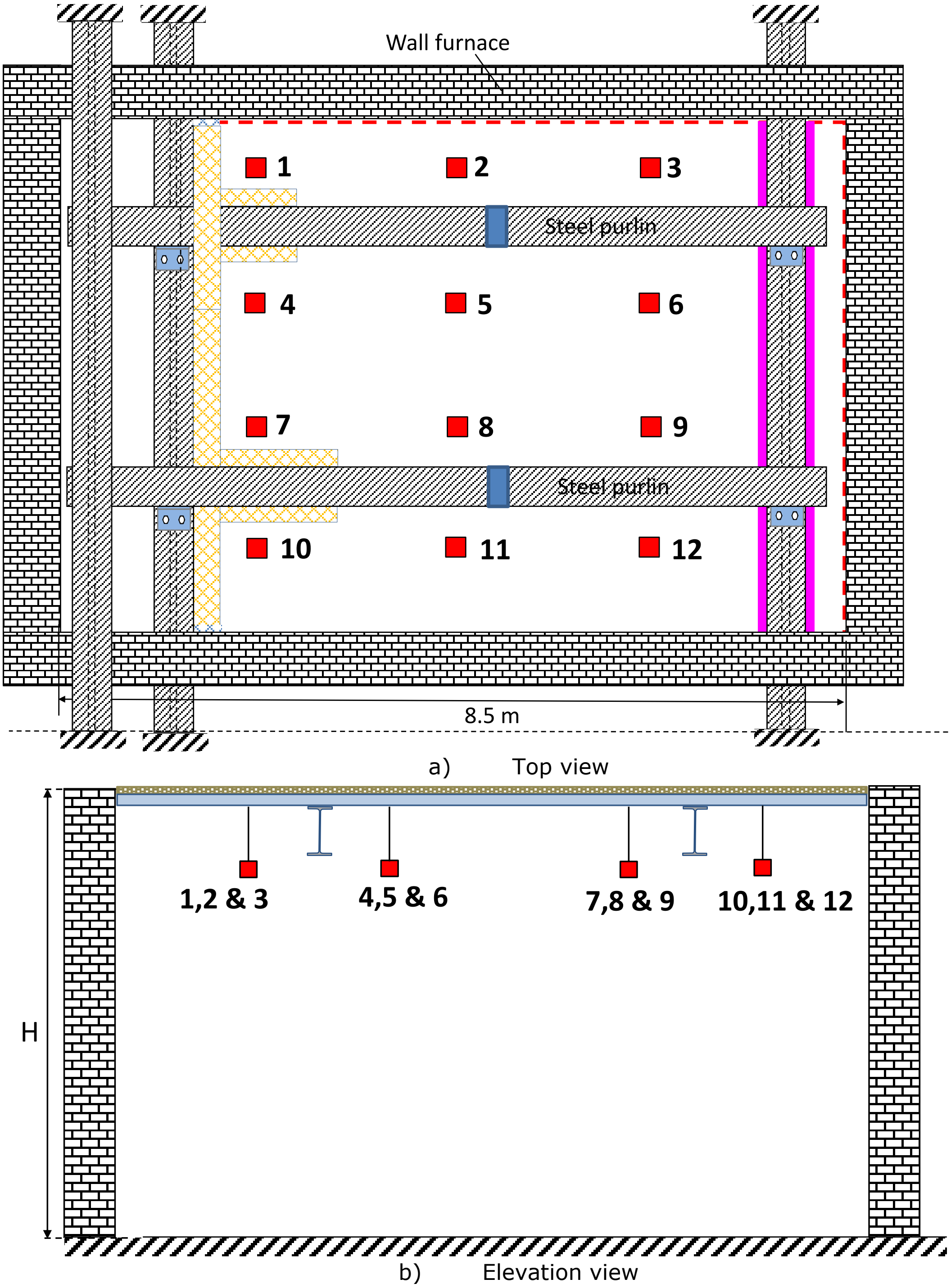


Figure 4.6: Location of plate thermometers inside the furnace

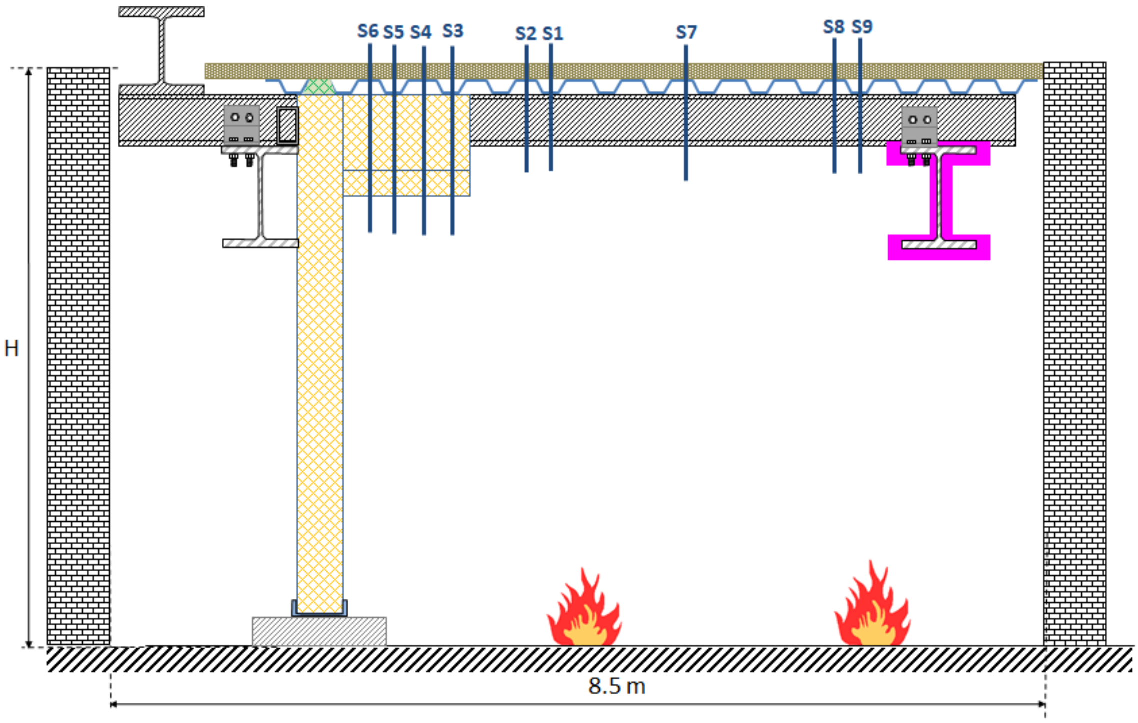


Figure 4.7: Location of the measuring cross-sections along each purlin

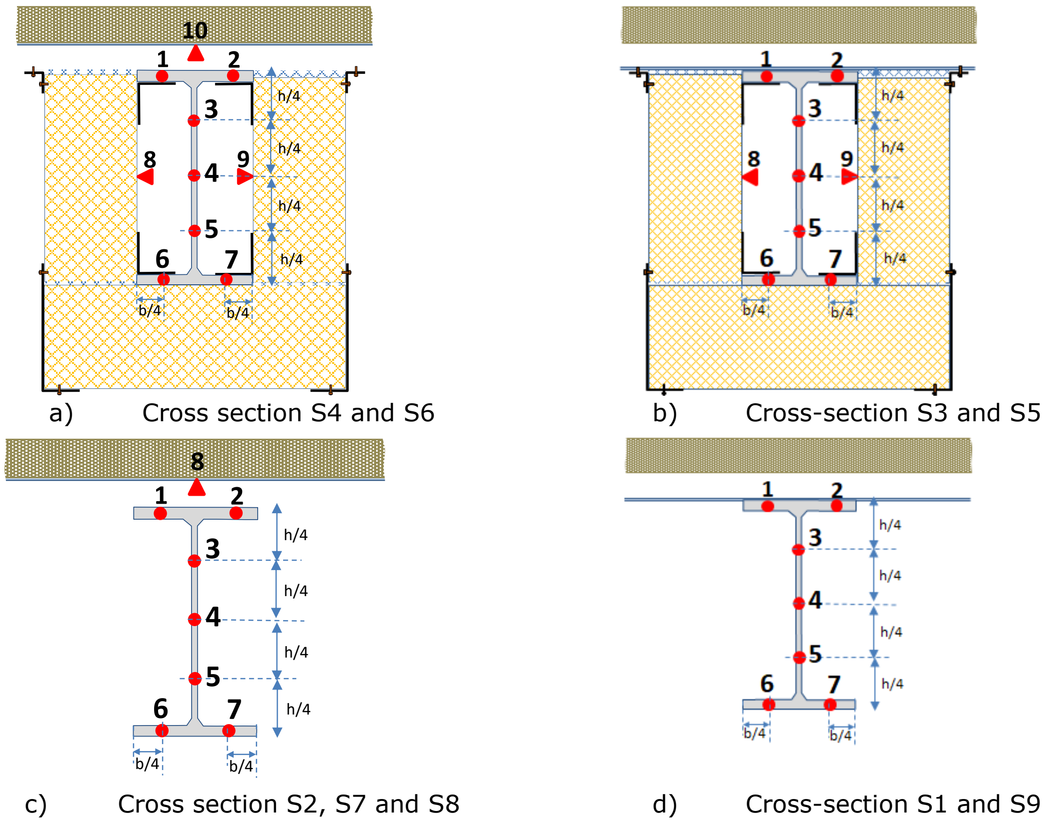


Figure 4.8: Location of thermocouples in purlin cross-sections

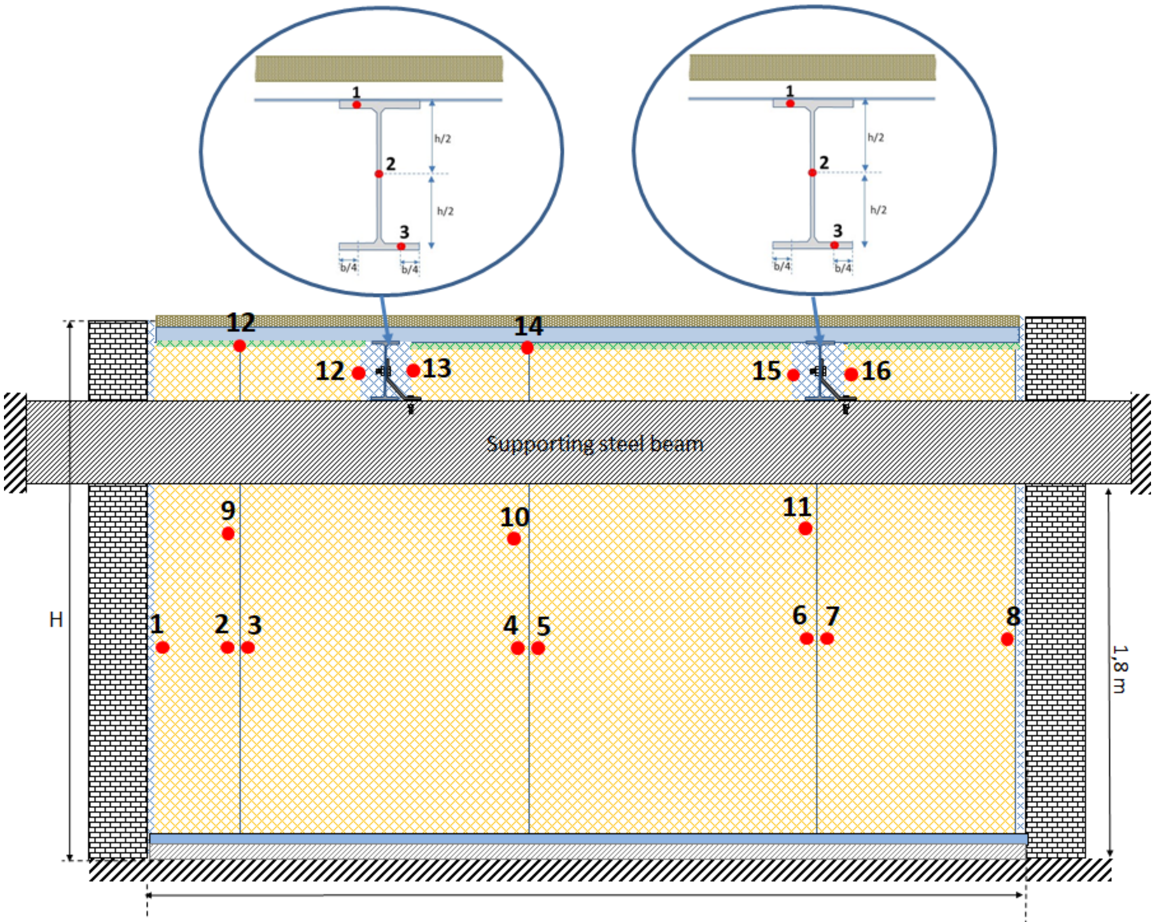


Figure 4.9: Thermocouple positions on the unexposed side of the wall

Transducer to measure the vertical displacement

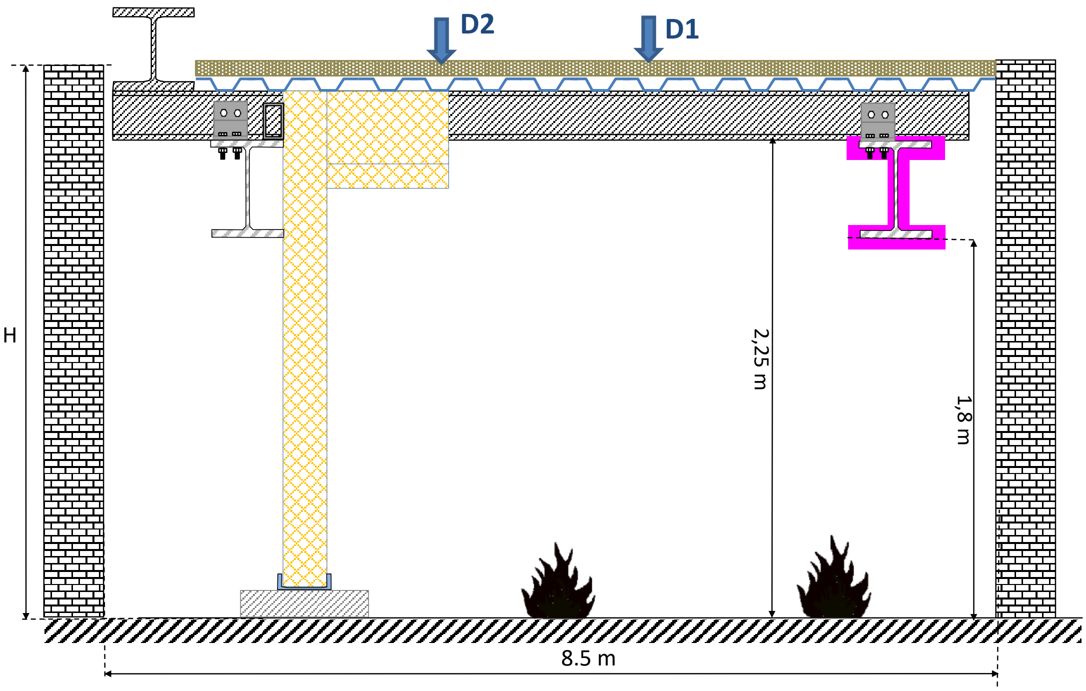


Figure 4.10: Location of displacement transducers along each purlin

5 FIRE TEST ON A WALL CONNECTED TO AN UNPROTECTED STEEL STRUCTURE BY MEANS OF "FUSIBLE" SYSTEMS

In the scope of task 3.5, a fire test will be conducted to investigate the fire performance of two different "fusible" link solutions based on common steel joints with aluminium bolts acting as the fusible component.

5.1 Description of the test specimen

The proposed test set-up and test specimen are schematically presented in following figures. The test specimen will consist of a fire wall made of lightweight sandwich panels with 175 mm thick spanning horizontally between two unexposed steel columns connected to two fire-exposed steel portal frames by means of two different "fusible" systems. Each steel portal frame will consist of a single steel column connected by a moment-resisting connection to a steel beam supported itself at one end by another steel beam protected against fire and adequately fixed at both ends outside the furnace. Regarding the "fusible" systems, it is planned to test the following solutions:

- The first one will consist of a Z-shaped steel profile and a steel channel arranged back to back and linked together with aluminium bolts (see Figure 5.4). The steel channel is attached to one of steel column supporting the panels by means of four threaded steel rods passing through the sandwich panels, while the Z-shaped steel profile is bolted to the column of the portal frame.
- The second one will consist of a steel angle bolted using aluminium bolts to a steel channel spanning between the portal frame columns (see Figure 5.5). The steel angle is attached to one of the steel column supporting the panels by means of four threaded steel rods passing through the panels.

"Fusible" systems were designed in normal conditions of use in accordance with Eurocode 3 part 1-1 [12], EN 1999-1-1 [9] and Eurocode 3 part 1-8 [11], considering that fire walls were implemented in the reference steel-framed buildings described in detail in the deliverable D1.1 of the project [6].

In addition, it can be noted that:

- The dimensions of steel frames have been chosen according to the common practice, taking into account the limited dimensions of the furnace and the availability of steel profiles at the time of design. The portal frame beams will have a span of 6m approximately while the portal frames spacing will be of 1.5m.
- The bottom end of all columns will be fixed using baseplates to concrete blocks placed on the ground floor of the furnace.
- The steel columns supporting the sandwich panels will cross thought the furnace top floor. Their top end will be adequately restrained against displacements (against both in-plane and out-of-plane horizontal displacements) using a steel beam.
- 7075 aluminum alloy bolts will be used.

Regarding the loading condition, since large deformation of the heated frames is of interest, a vertical load of 25 kN will be applied at the beam mid-span using dead weights. Adequate fixation providing hinges will be used between the dead weights and the beams to prevent unwanted additional moments in the portal frames.

It should be mentioned that at time of writing, the design of all steel connections, including beam-to-beam, beam-to-column and column-connection-on-bottom using concrete blocks are still ongoing. Complete detailing will be provided later in corresponding test report.

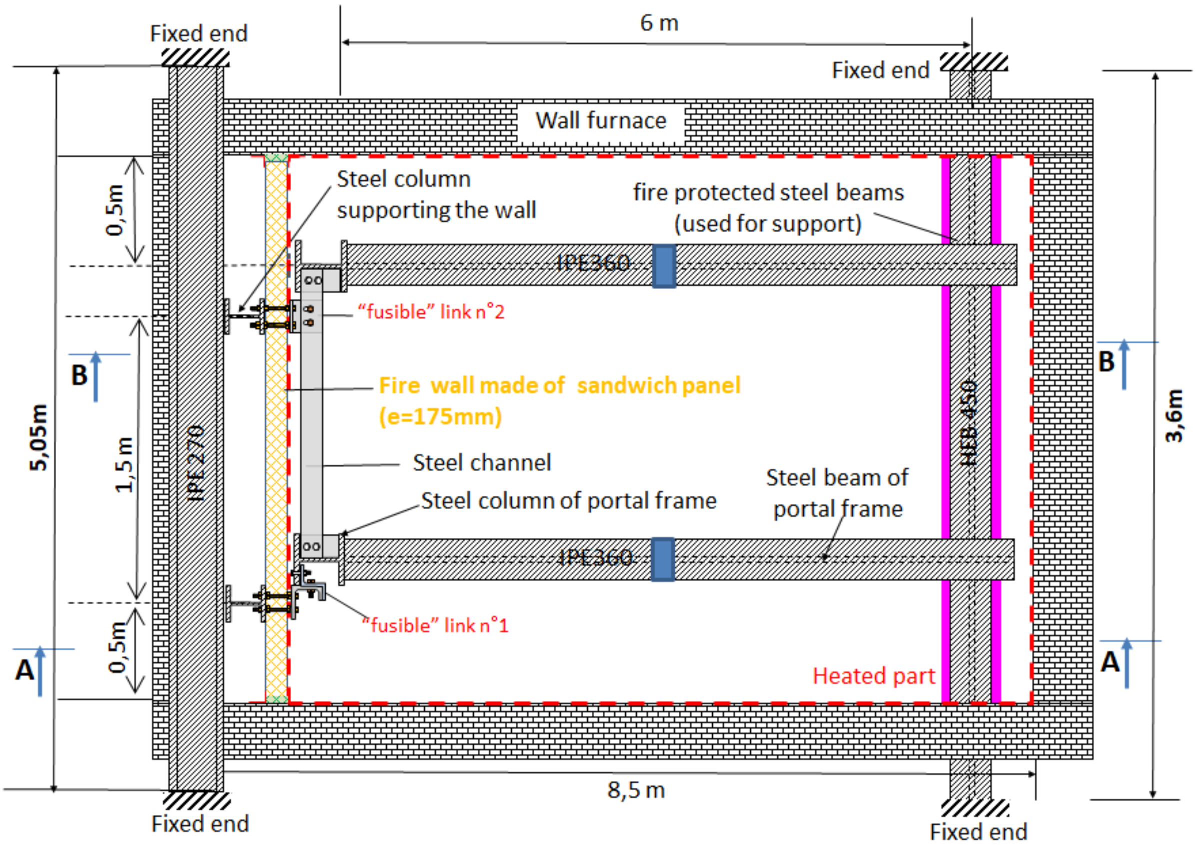


Figure 5.1: Top view of the test specimen

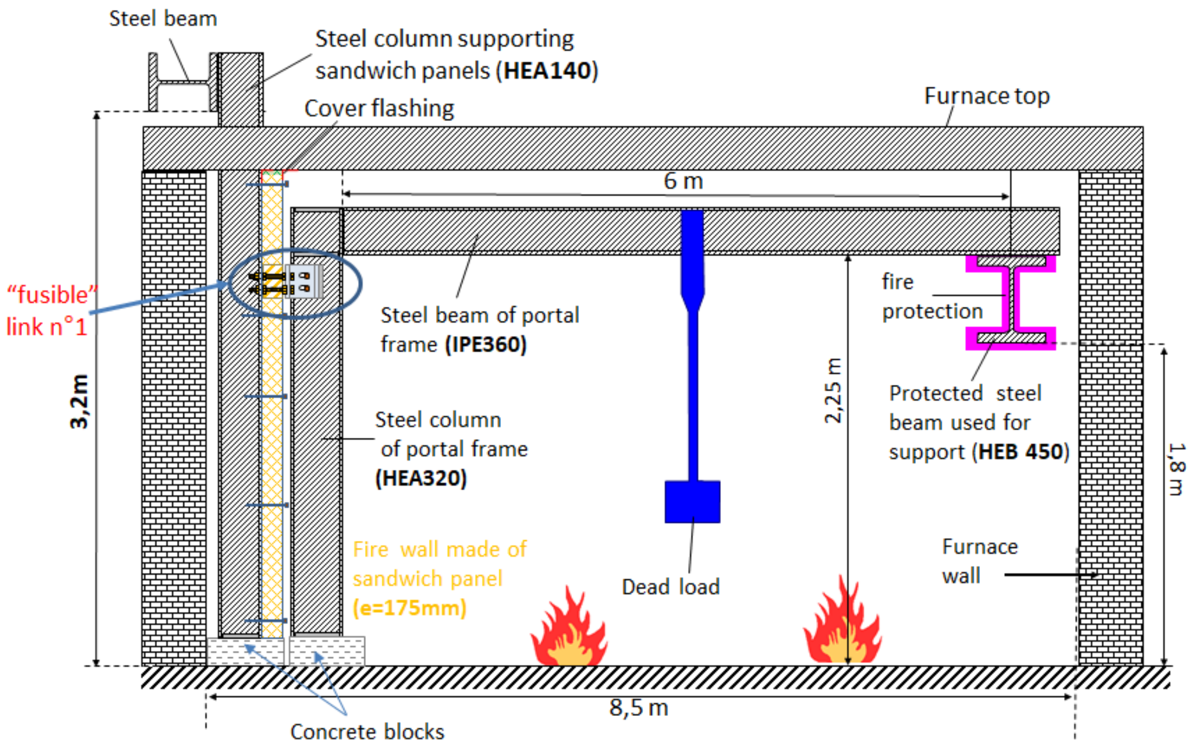


Figure 5.2: Elevation view A-A of the test specimen

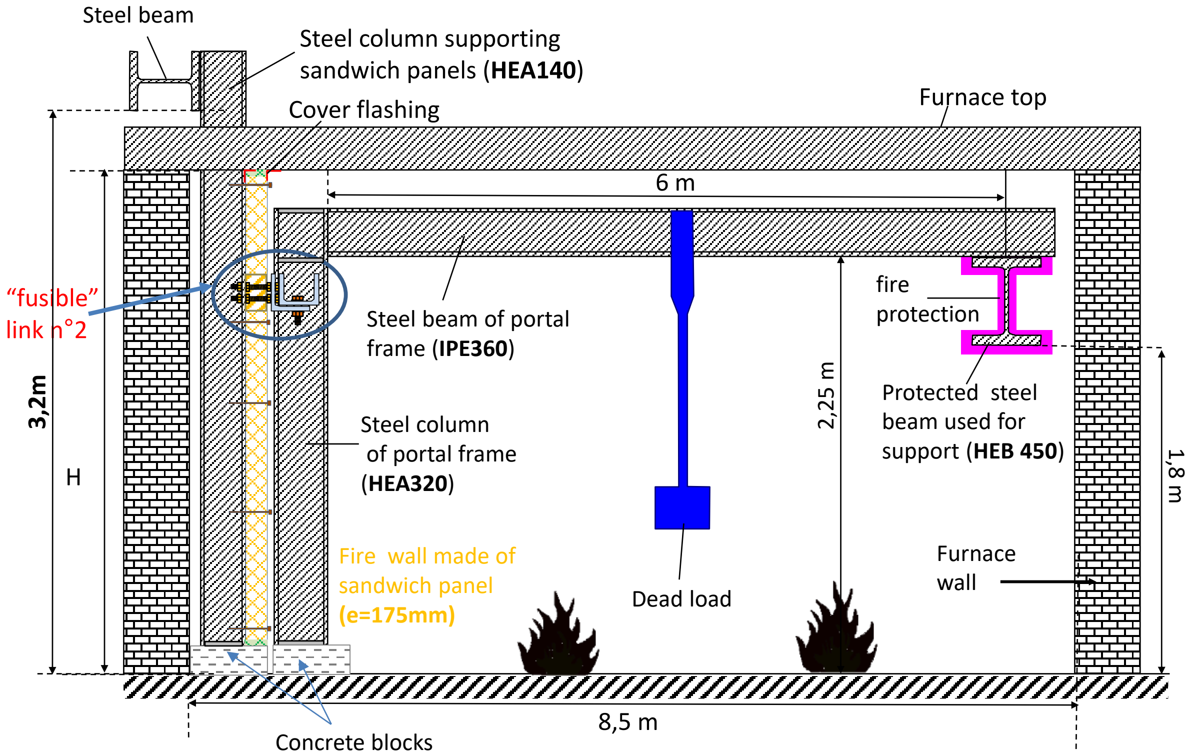


Figure 5.3: Elevation view B-B of the test specimen

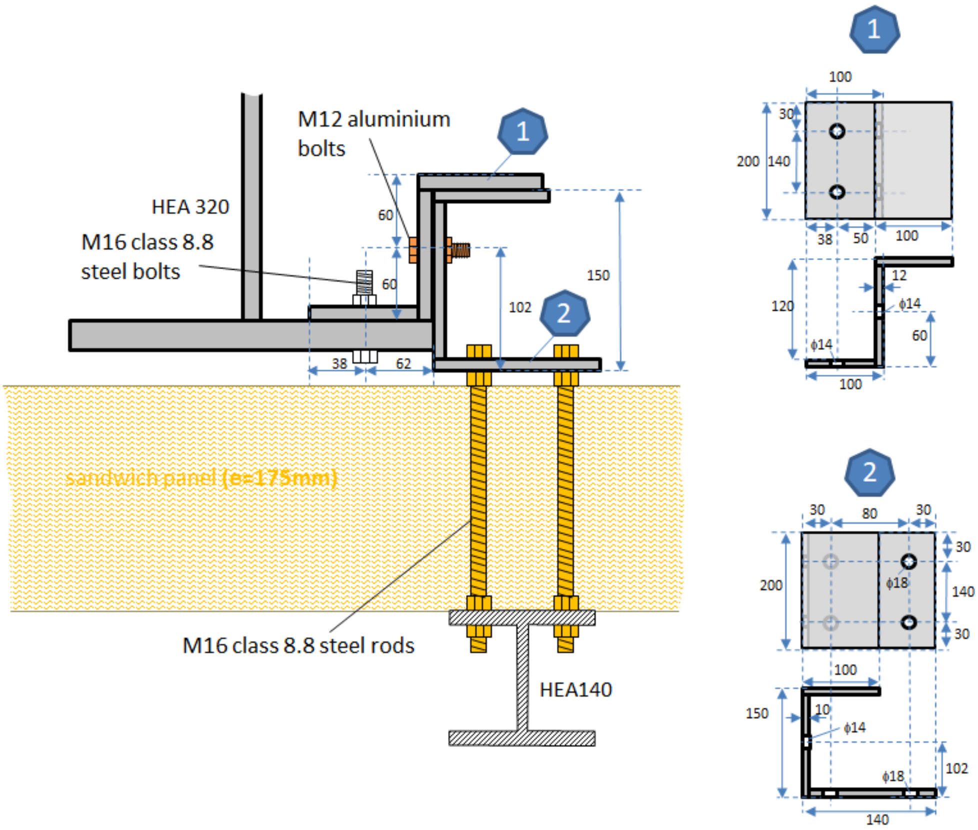


Figure 5.4: Dimensional characteristics of the first "fusible" system to be tested

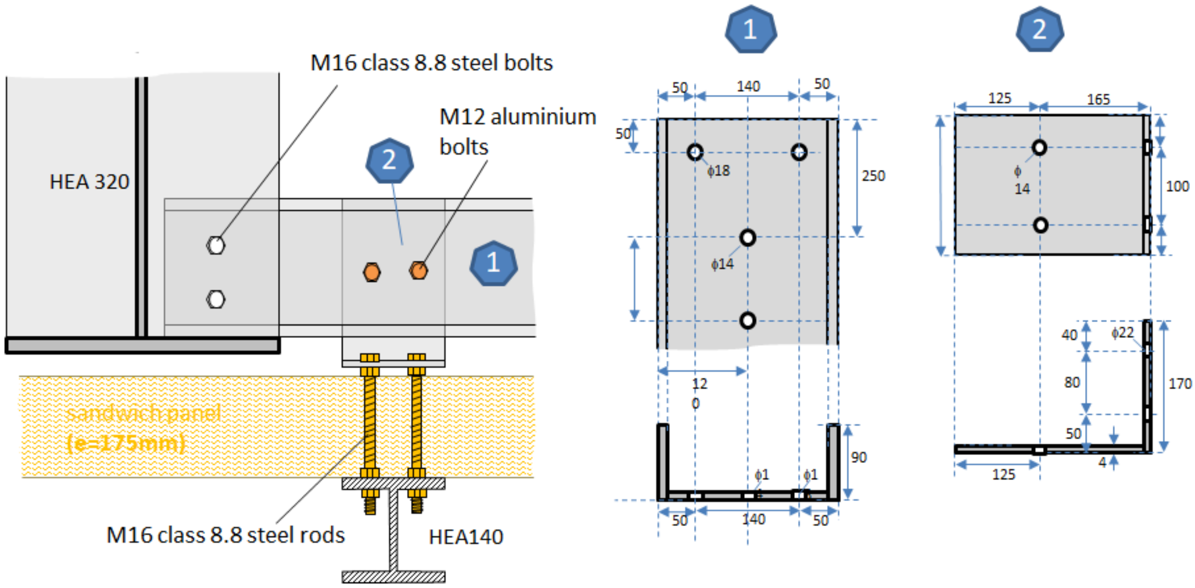


Figure 5.5: Dimensional characteristics of the second "fusible" system to be tested

5.2 Instrumentation

The test specimen will be implemented with many measurement devices to record both temperatures and displacements:

- The furnace temperature will be continuously measured with 12 plate thermometers placed at mid-height of the beams level (see Figure 5.6).
- Concerning the temperature recording in the specimen:
  - about 65 thermocouples will be installed in various cross-sections along each portal frame (see Figure 5.7 and Figure 5.8);
  - about 16 thermocouples will be installed on the unexposed side of the wall (see Figure 5.9)
- Stainless steel tube (or its equivalent) will be installed inside the furnace along each portal frame, to measure the vertical displacement at beams mid-span and the horizontal displacement at the columns top end (see Figure 5.10).

The instrumentation for measurement of temperatures (steel members and furnace), applied load and deformation will comply with the requirements of EN 1363-1 [4].

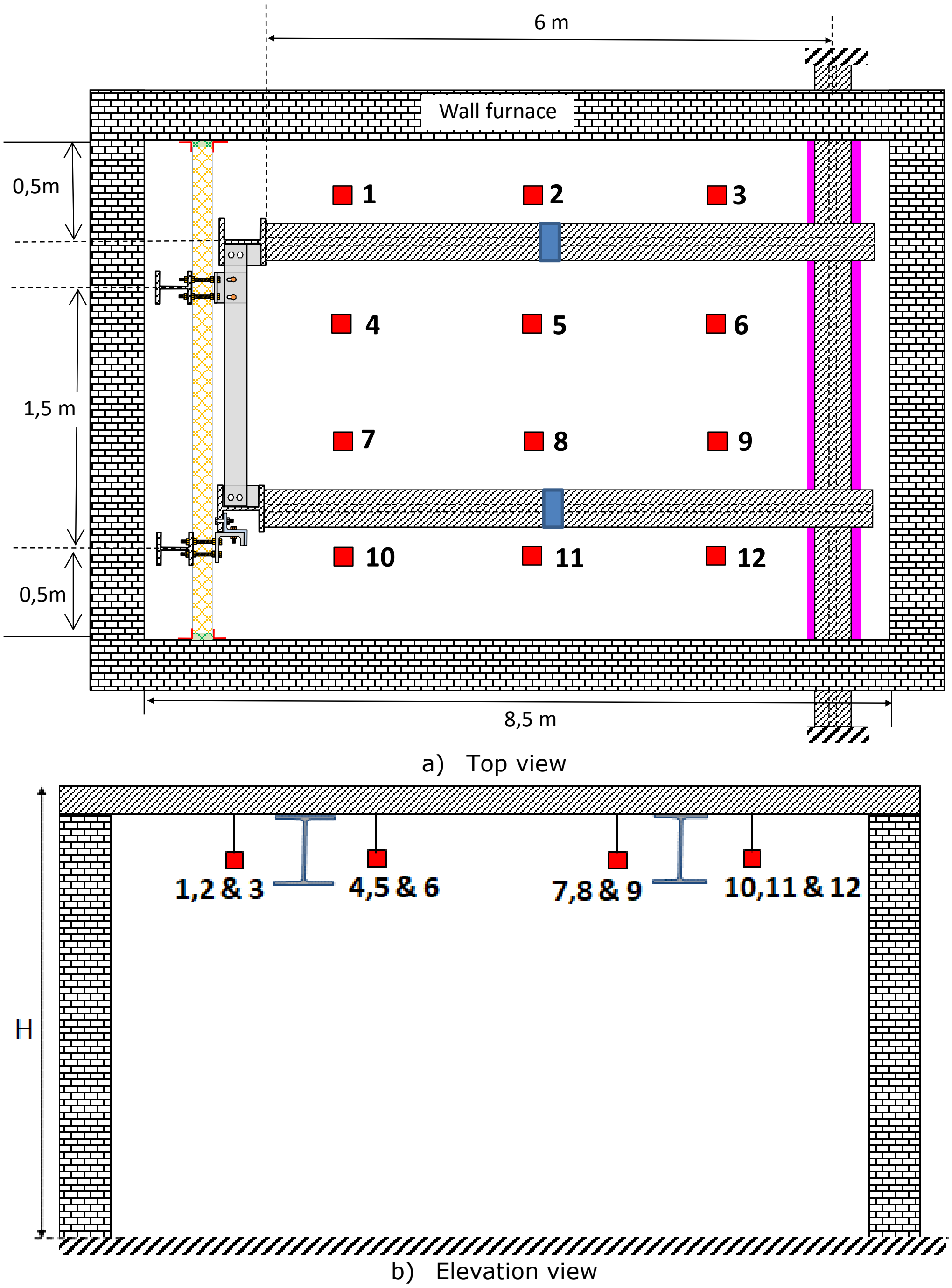


Figure 5.6: Location of plate thermometers inside the furnace

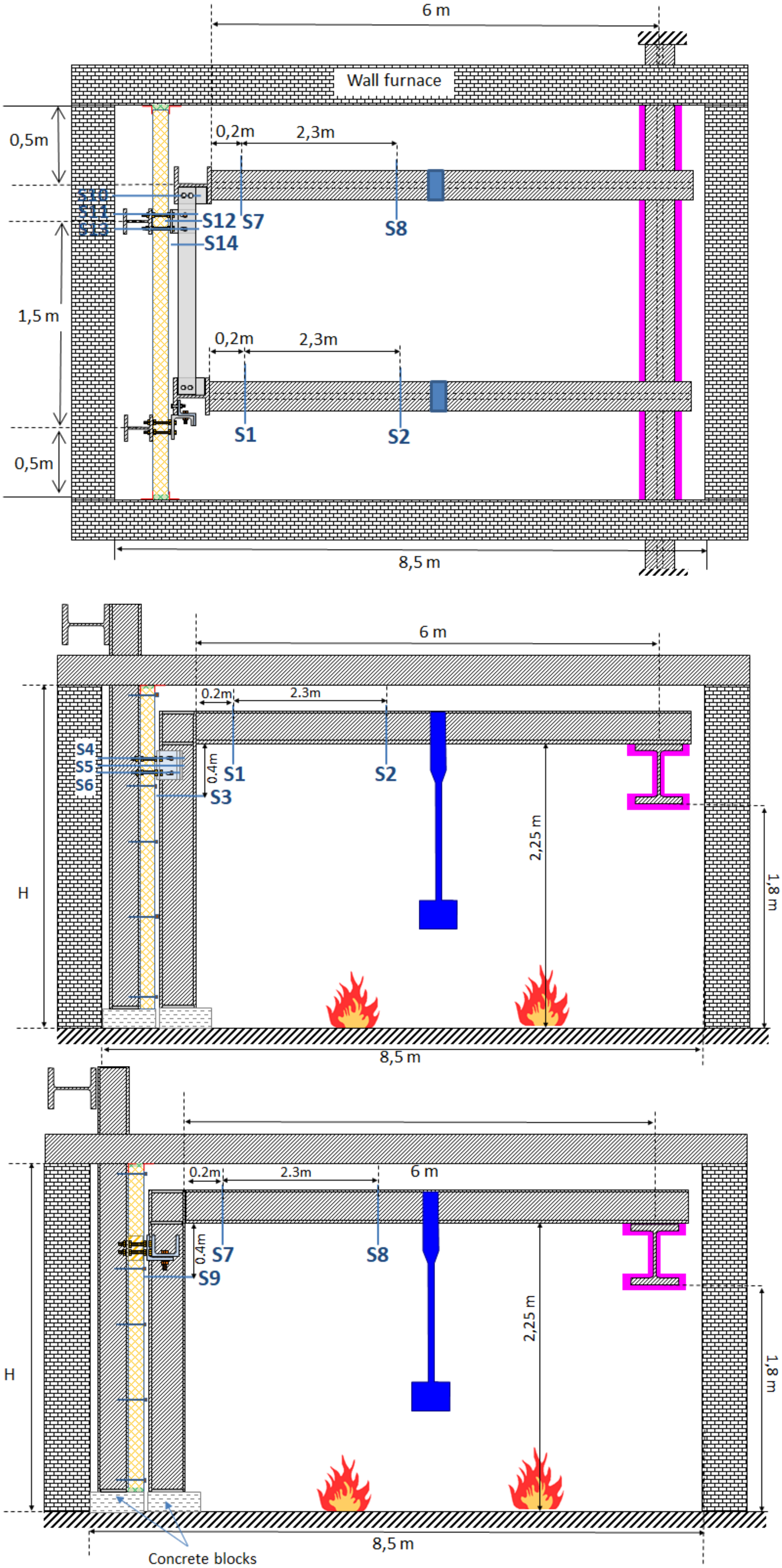
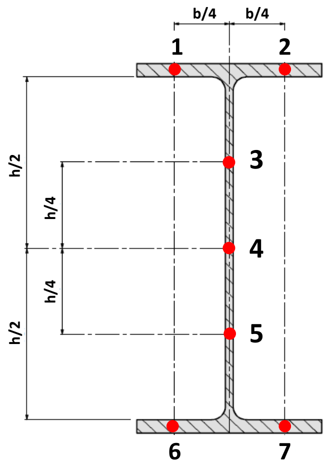
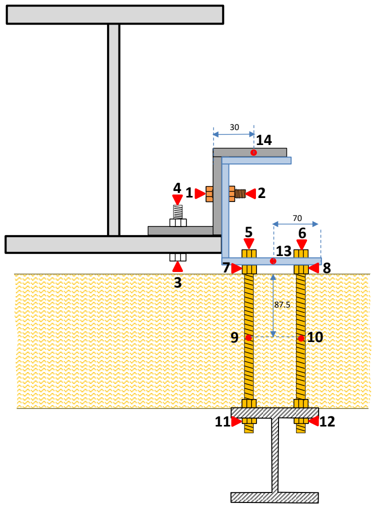


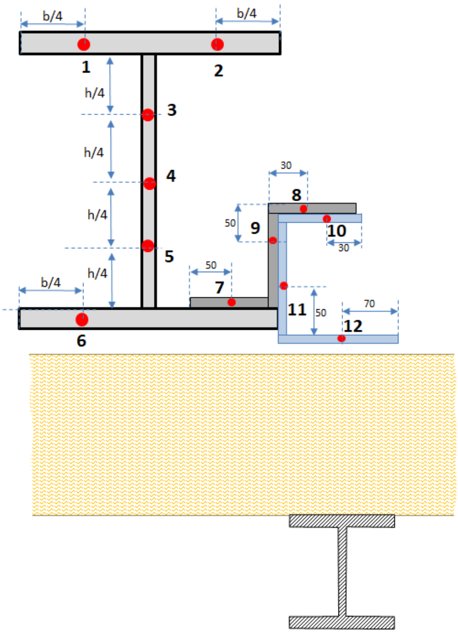
Figure 5.7: Location of the measuring cross-sections along the test specimen



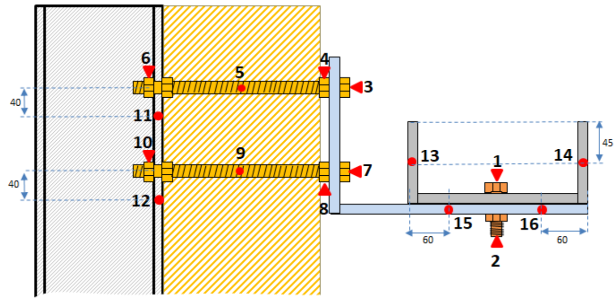
a) Cross section S1, S2, S3, S7, S8 an S9



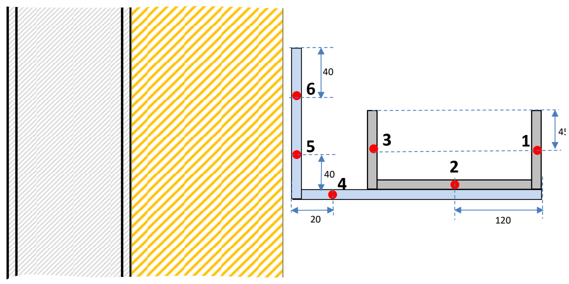
b) Cross-section S4 and S6



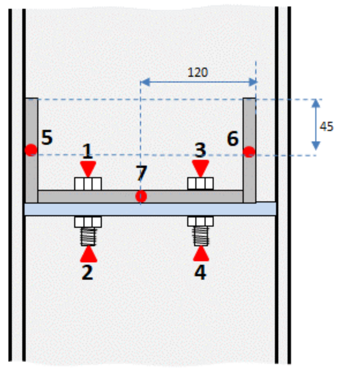
c) Cross section S5



d) Cross-section S11 and S13



e) Cross-section S12



f) Cross-section S10

Figure 5.8: Location of thermocouples in steel member cross-sections

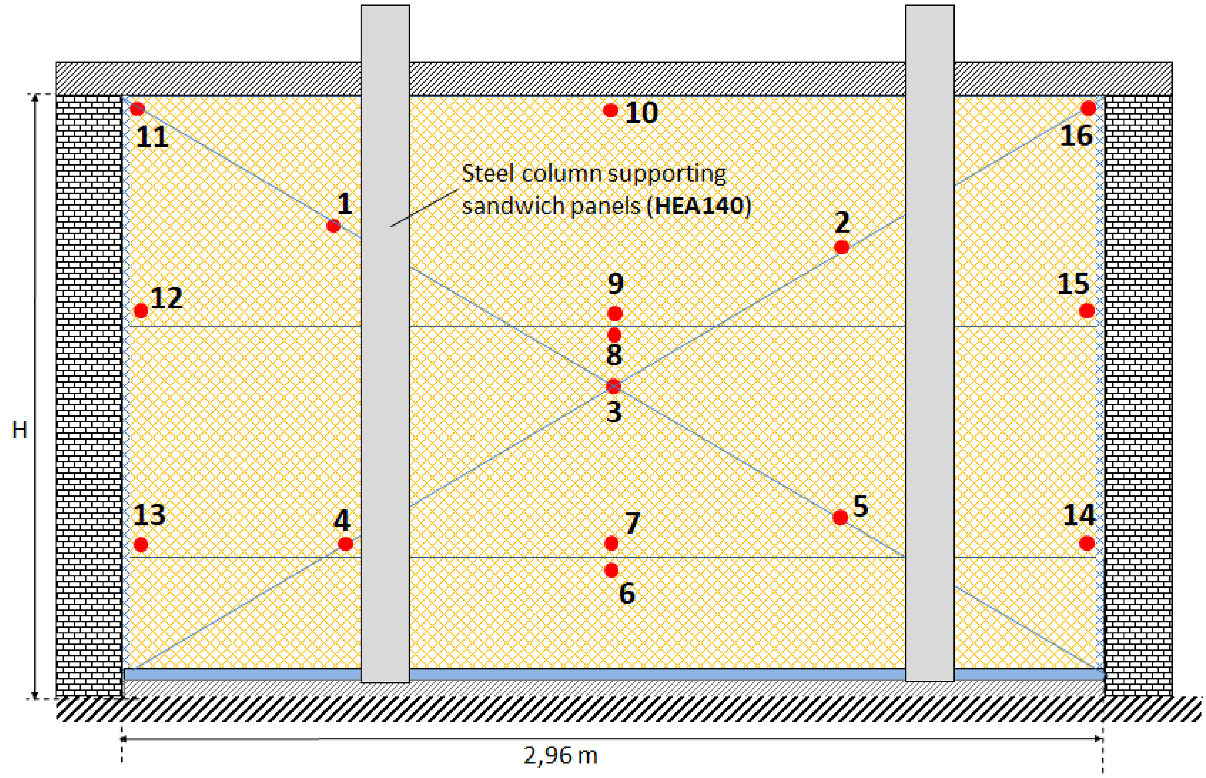


Figure 5.9: Thermocouple positions on the unexposed side of the wall

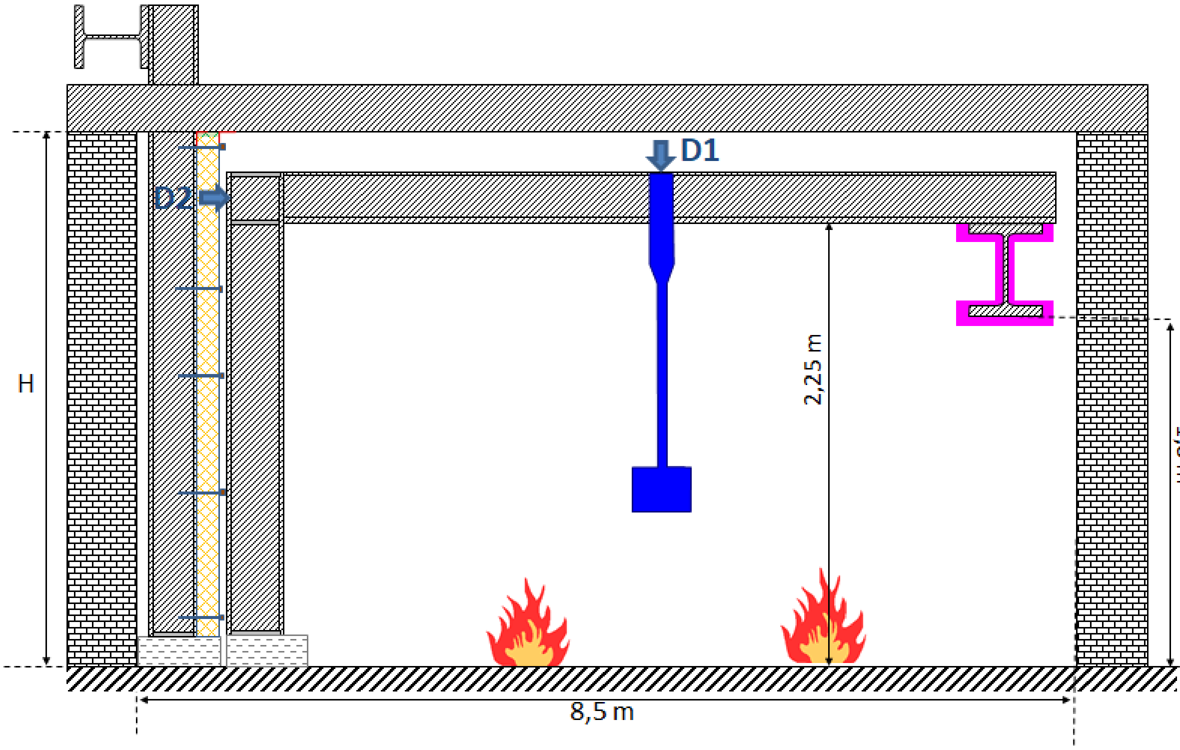


Figure 5.10: Location of displacement transducers along each portal frame

6 SEISMIC TESTS

In the scope of task 4.1, 24 tests (separated between monotonic and cyclic tests) will be conducted to investigate the seismic performance of three different "fusible" link solutions based on common steel joints with aluminium bolts acting as the fusible component.

The tests that are going to be performed are listed in Table 2. It should be noted that all test specimens will be tested under shear loading only, since the investigated "fusible" systems are designed so that the aluminium bolts are in shear. The maximum values of shear forces V_{Ed} applied during the tests (given in Table 2) has been selected from the FE analysis already performed by means of FE software SAP2000, whose results were described in the previous deliverable D1.3 of the project [7]. Moreover, the cyclic tests will be performed following the ECCS protocol [10].

Table 2: List of seismic tests

Test specimen	**Seismicity level**	**Bolts**	**Tests**
1	Low (V_{Ed} = 80 kN)	M12	2 monotonic tests 2 cyclic tests
2	Moderate (V_{Ed} = 180 kN)	M16	2 monotonic tests 2 cyclic tests
3	Moderate (V_{Ed} = 180 kN)	M16	2 monotonic tests 2 cyclic tests
3	Moderate (V_{Ed} = 180 kN)	M12	2 monotonic tests 2 cyclic tests
4	Moderate (V_{Ed} = 180 kN)	M12	2 monotonic tests 2 cyclic tests
5	Moderate (V_{Ed} = 180 kN)	M12	2 monotonic tests 2 cyclic tests

6.1 Short description of test specimens

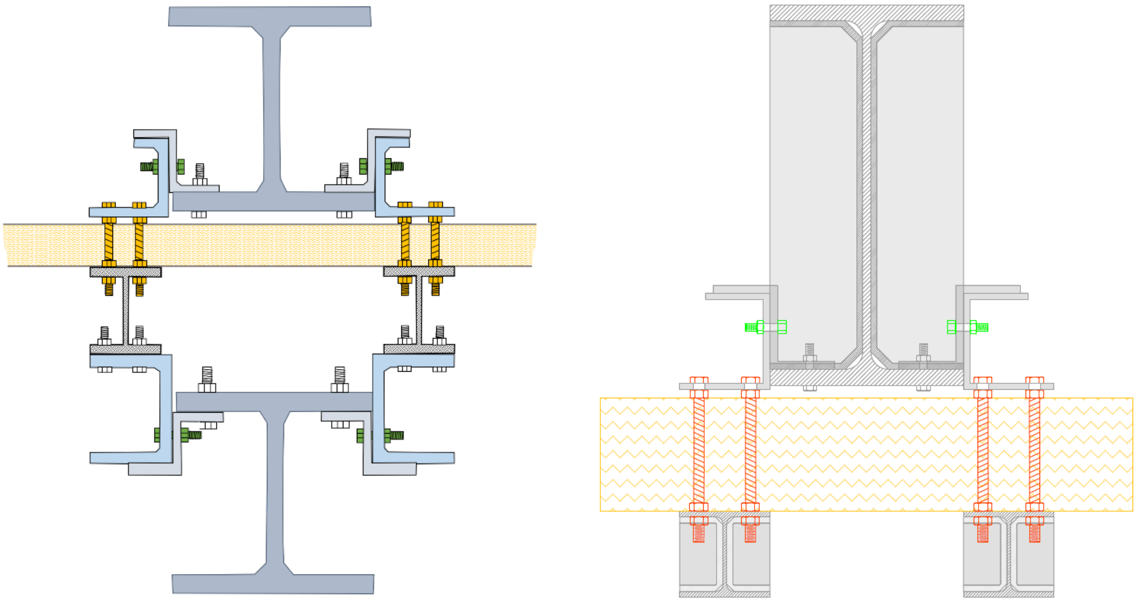
It should be mentioned that at time of writing, the sizing of steel profiles forming the investigated "fusible" systems is still ongoing. Complete detailing will be provided later in corresponding test reports. Two of the three "fusible" systems are similar to those tested in fire, but resized with respect to seismic forces selected for the tests.

6.1.1 Test specimen 1

The first specimen to be tested is illustrated in Figure 6.1. It is derived from the reference "fusible" system reported also in this figure, consisting of a Z-shaped steel profile and a steel channel arranged back to back and linked together with aluminium bolts.

The Figure 6.2 gives some details of the test specimen 1. As reported in Table 2, the specimen 1 will be tested with M12 aluminium bolts under a low seismicity shear force, which is about 80 kN. Consequently, the "fusible" link contains 6 M12 aluminium bolts (made from 7075 aluminium allow) to withstand this force.

The test specimen will be installed inside a reaction frame specifically designed for testing, as illustrated in Figure 6.3.



a) b)

Figure 6.1: Test specimen 1: a) Reference “fusible” system; b) Seismic detail

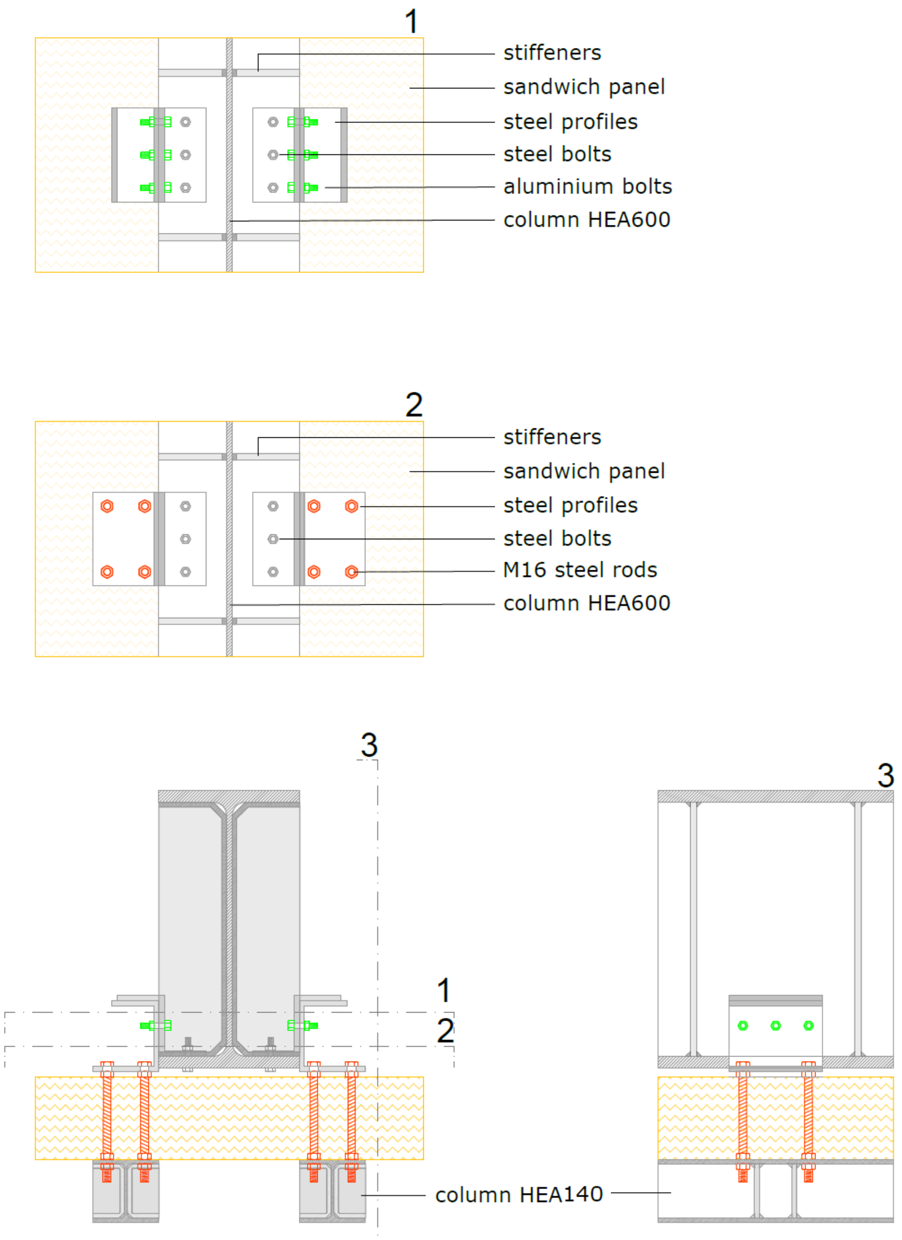


Figure 6.2: Some detailing of Test specimen 1

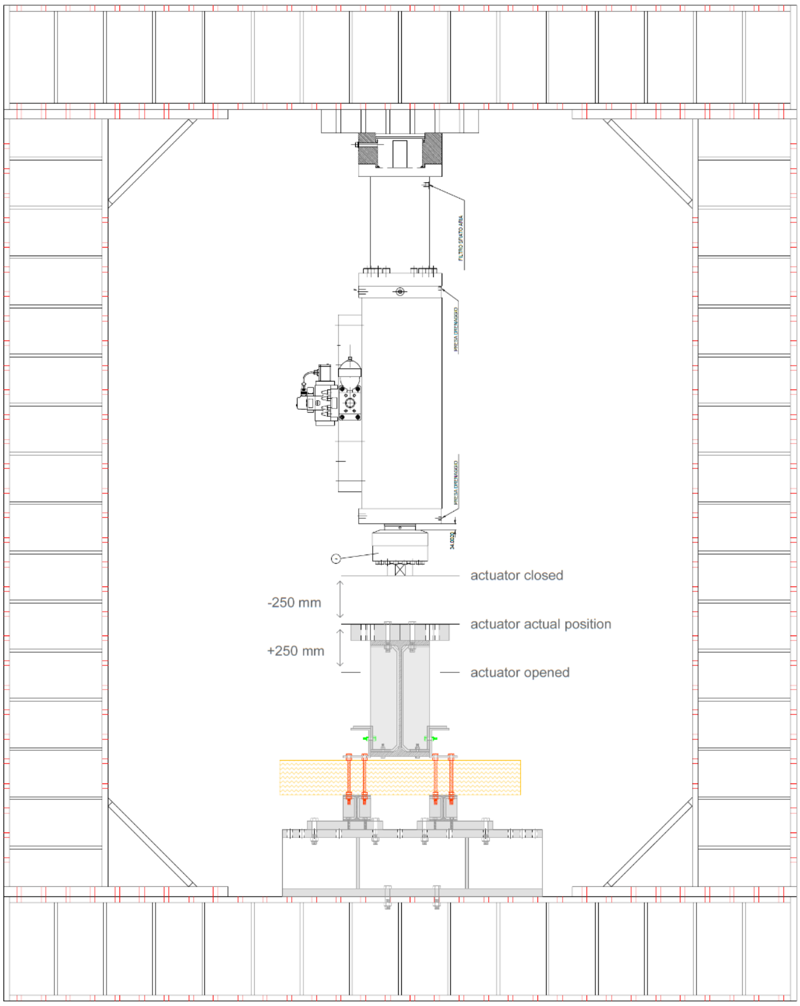


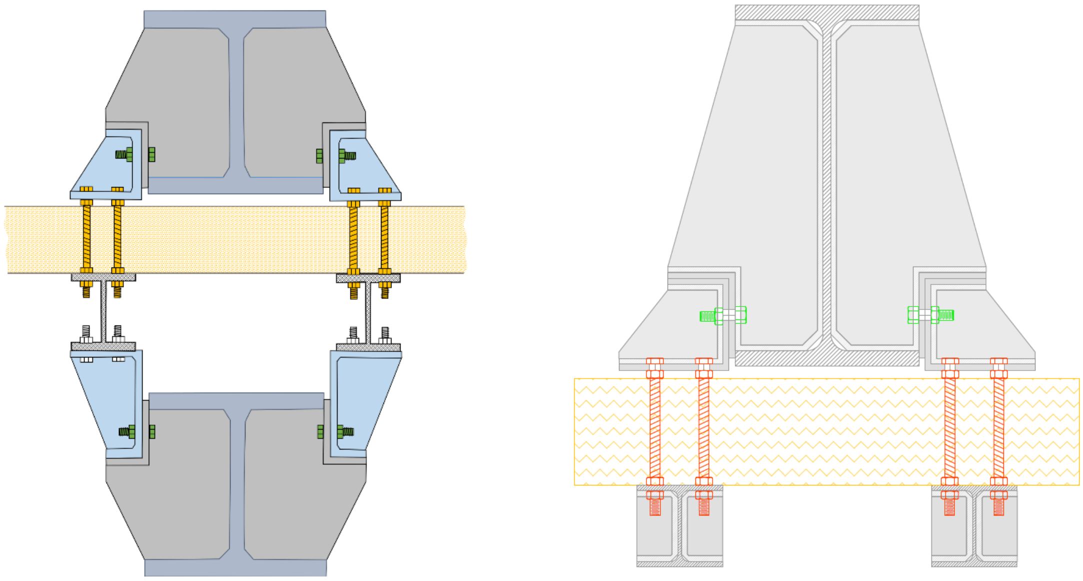
Figure 6.3: View of Test specimen 1 in the reaction frame

6.1.2 Test specimen 2

The second test specimen is illustrated in Figure 6.4. It is derived from the reference “fusible” system reported also in this figure.

Figure 6.5 gives some details of the test specimen 2. As reported in Table 2, the test specimen 1.2 will be tested with M16 aluminium bolts under a moderate seismicity shear force, which is about 180 kN. Consequently, the “fusible” link contains 6 M16 aluminium bolts (made from 7075 aluminium allow) to withstand this force.

Figure 6.6 give a view of the test specimen arranged in the reaction frame.



a) b)

Figure 6.4: Test specimen 2: a) Reference “fusible” system; b) Seismic detail

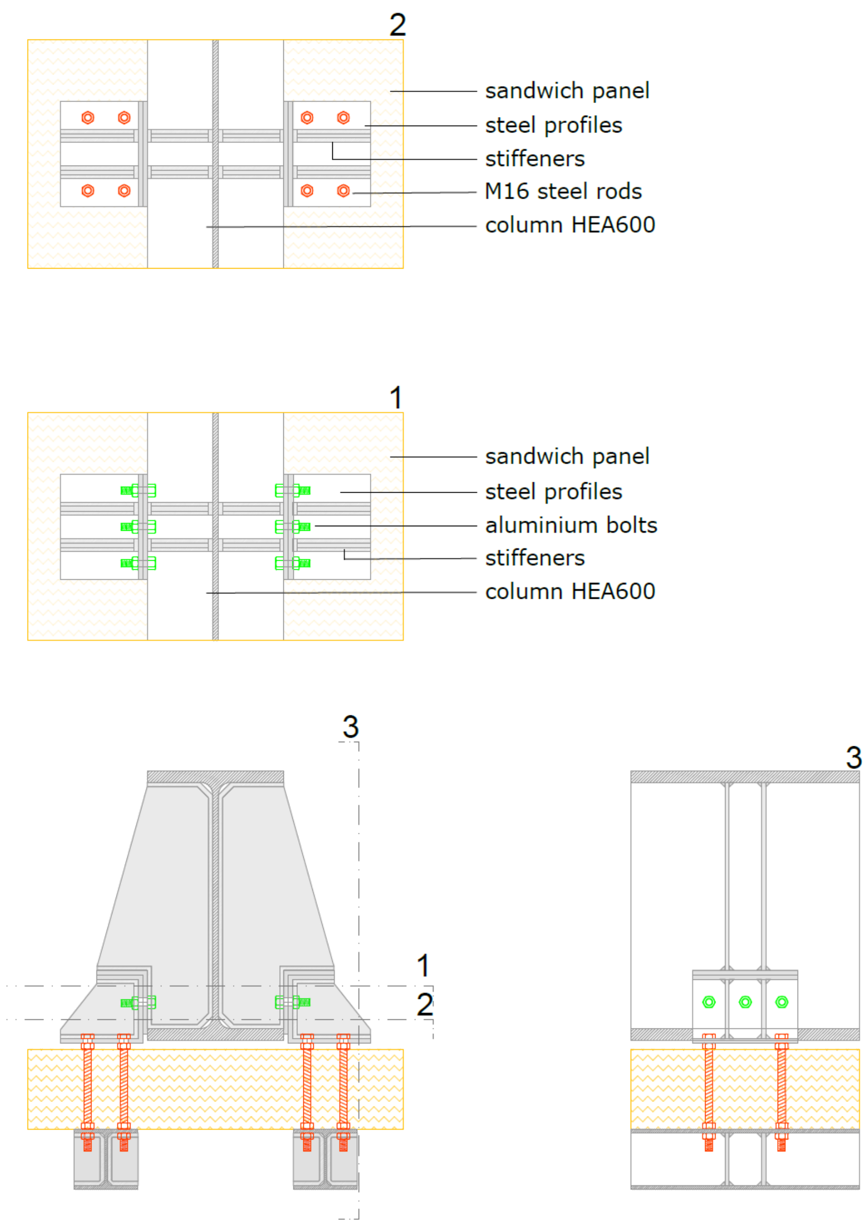


Figure 6.5: Some detailing of Test specimen 2

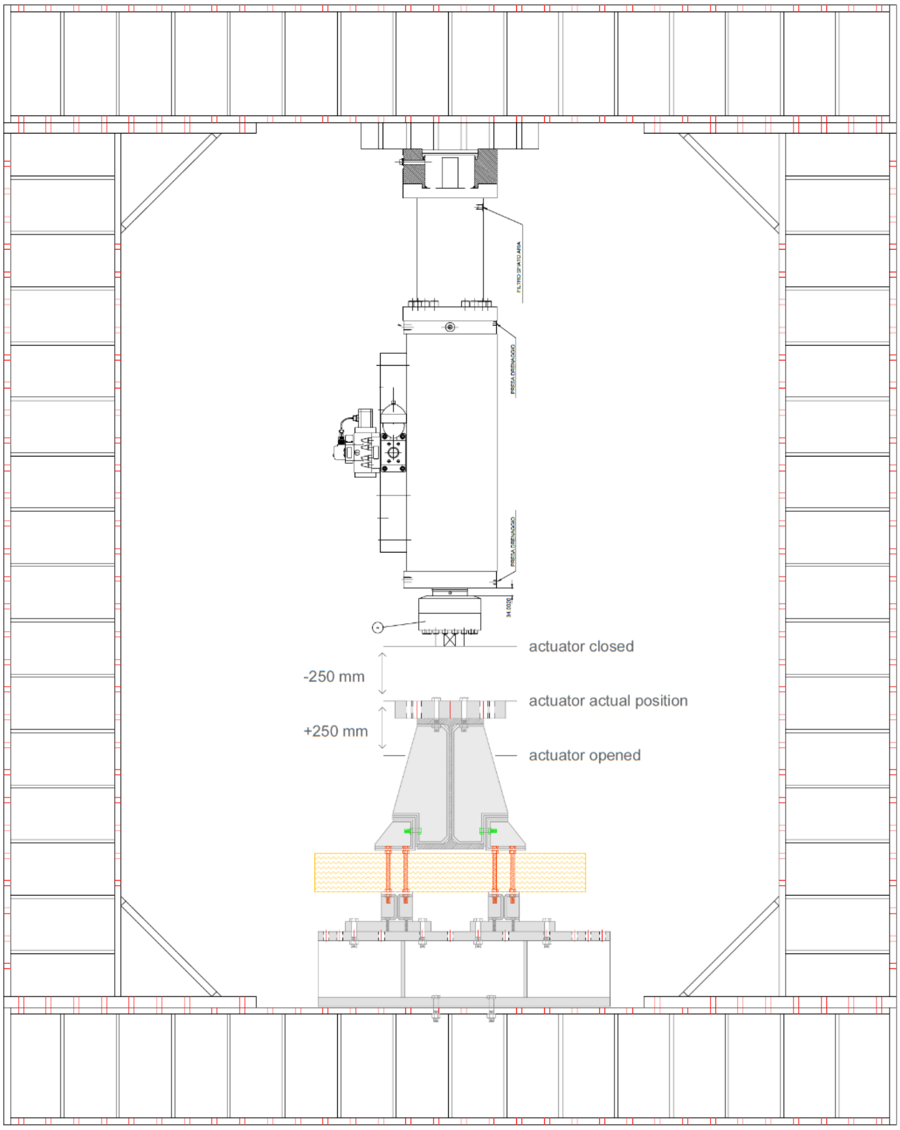


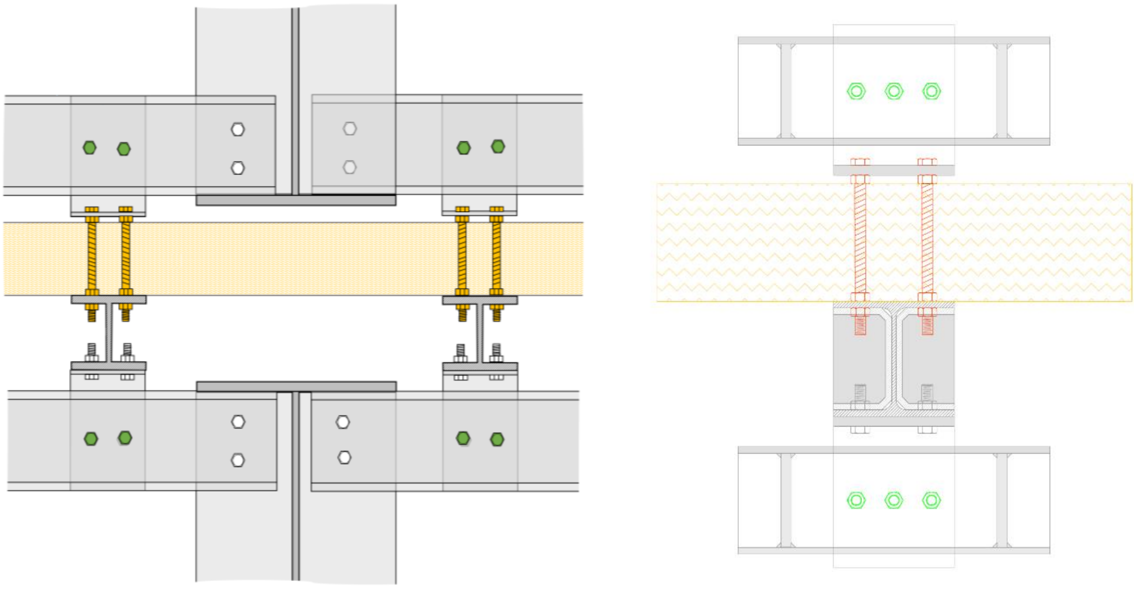
Figure 6.6: View of Test specimen 2 in the reaction frame

6.1.3 Test specimen 3

The third seismic detail is illustrated in Figure 6.7. It is derived from the reference "fusible" system reported also in this figure, consisting of a steel angle bolted by aluminium bolts to a steel channel spanning between the portal frame columns. The steel angle is attached to one of the steel columns supporting the panels by means of four threaded steel rods passing through the panels.

Figure 6.8 gives some details of the test specimen 3. As reported in Table 2, the test specimen 3 will be tested with either M16 or either M12 aluminium bolts under a moderate seismicity shear force, which is about 180 kN. To withstand these forces, in the first case, the "fusible" link contains 3 M16 aluminium bolts (made from 7075 aluminium allow) acting on two shear planes and in the second case 6 M12 aluminium bolts acting on two shear planes.

Figure 6.9 gives a view of the test specimen arranged in the reaction frame.



a) b)

Figure 6.7: Test specimen 3: a) Reference “fusible” system; b) Seismic detail

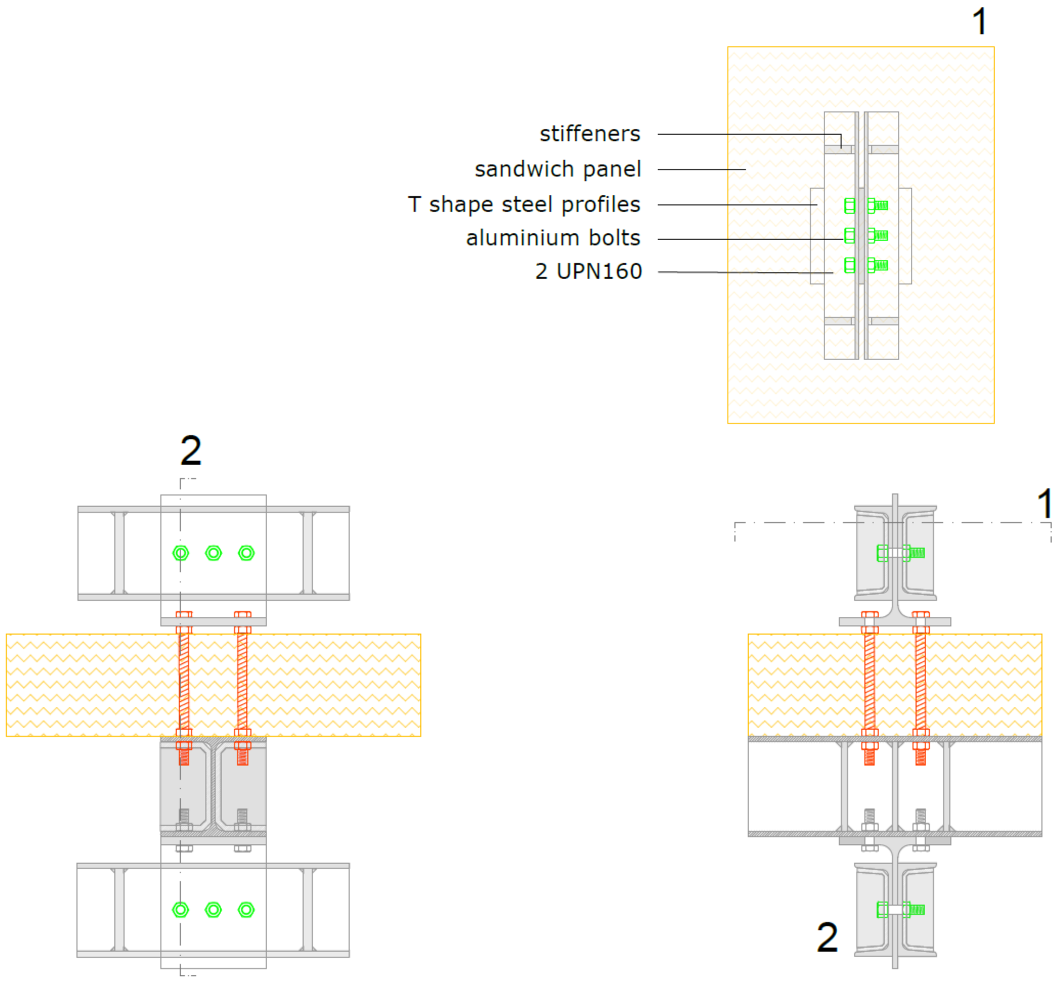


Figure 6.8: Some detailing of Test specimen 3

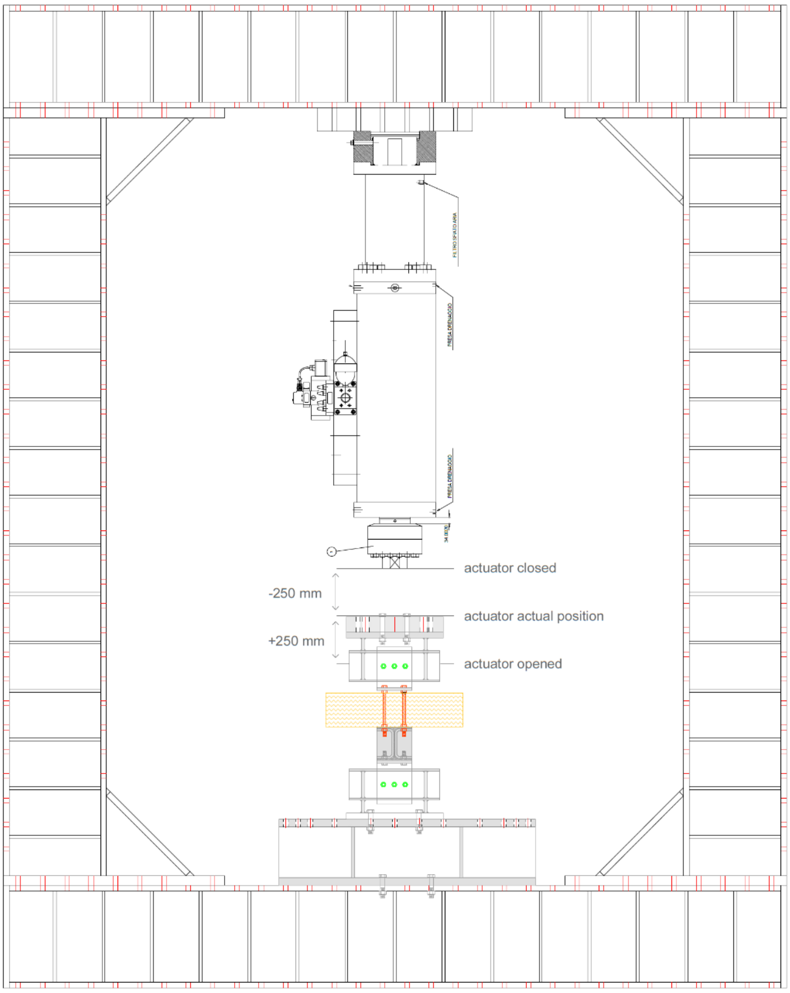


Figure 6.9: View of Test specimen 3 in the reaction frame

6.1.4 Test specimen 4

The fourth test specimen is derived from test specimen 3, starting from that one, to investigate the real behaviour of sandwich panels. The "fusible" system (including the steel rods) is doubled in a symmetric position, in comparison with the original one, to avoid any kind of eccentricity.

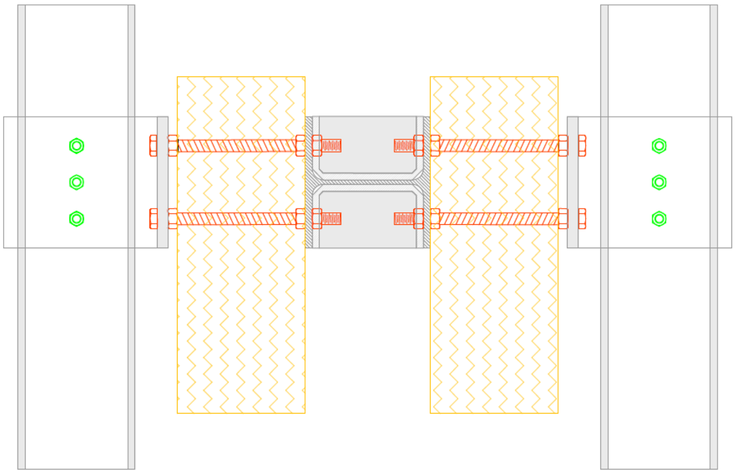


Figure 6.10: Test specimen 4

Figure 6.11 gives some details of the test specimen 4. As reported in Table 2, the test specimen 4 will be tested with M12 aluminium bolts under a moderate seismicity shear force, which is about 180 kN. Consequently, on each side the "fusible" link contains 3 aluminium bolts (made from 7075 aluminium allow) acting on two shear planes to withstand this force.

Figure 6.12 gives a view of the test specimen arranged in the reaction frame.

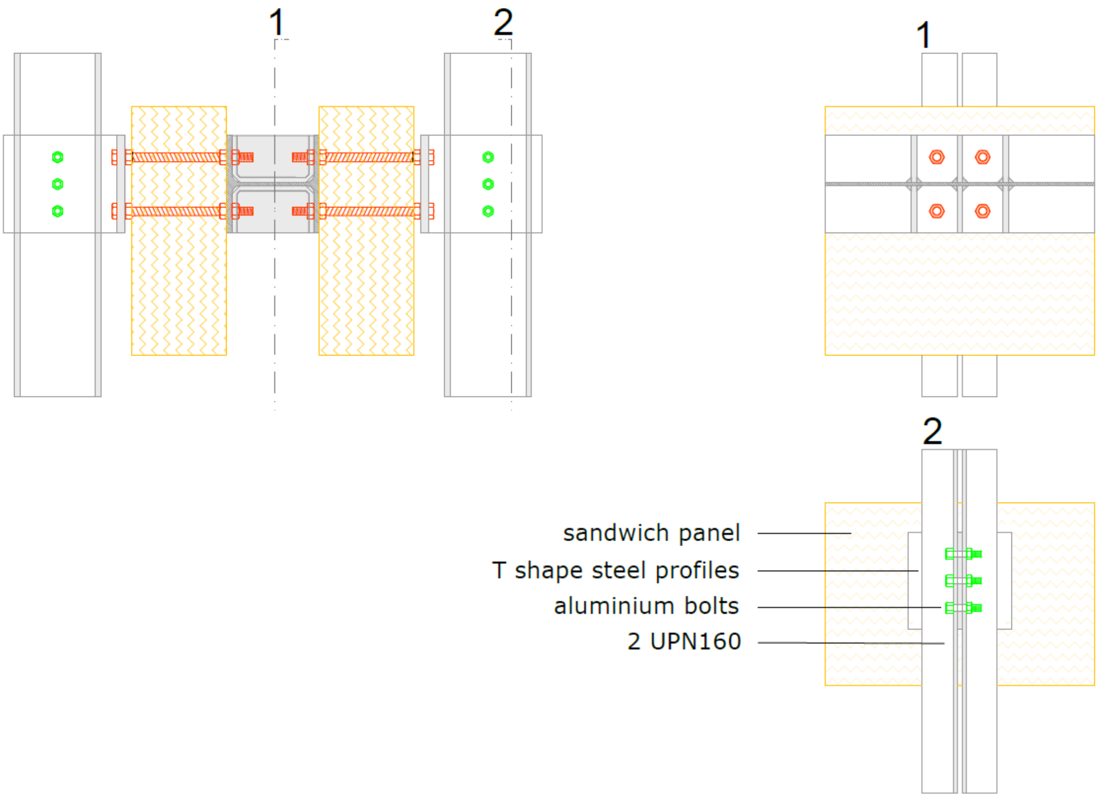


Figure 6.11: Some detailing of Test specimen 4

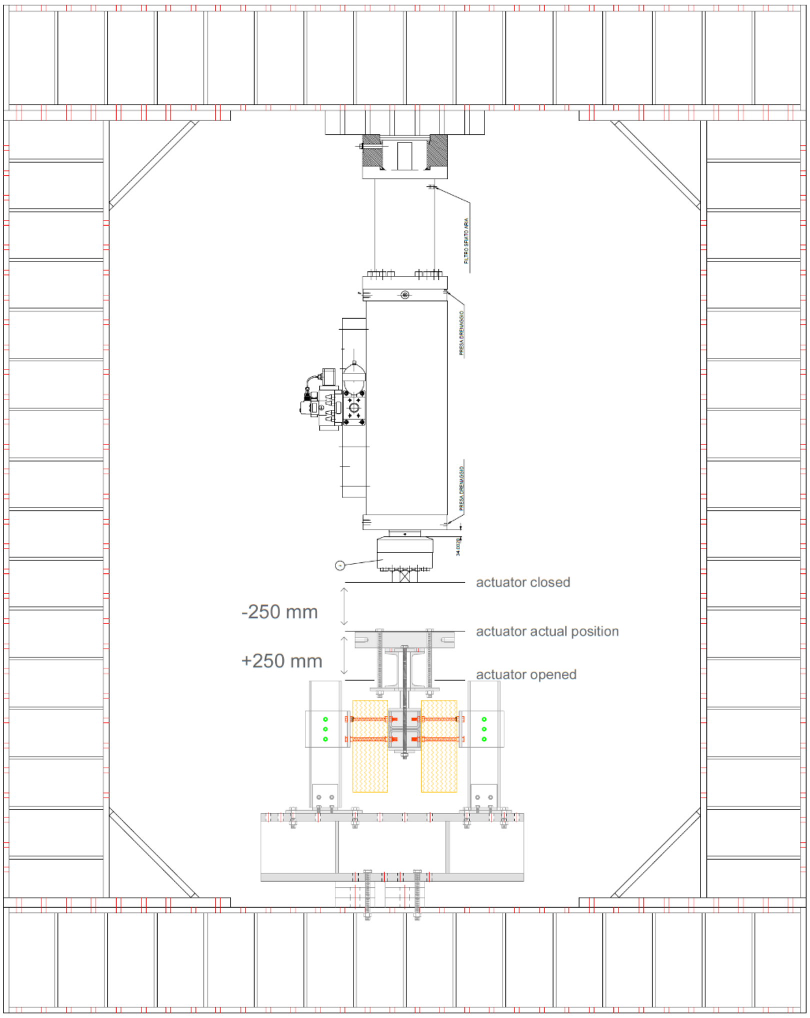


Figure 6.12: View of Test specimen 4 in the reaction frame

6.1.5 Test specimen 5

This last test specimen is derived from the previous one, removing the sandwich panel to understand the real behaviour of aluminium bolts in the investigated "fusible" system (see Figure 6.7).

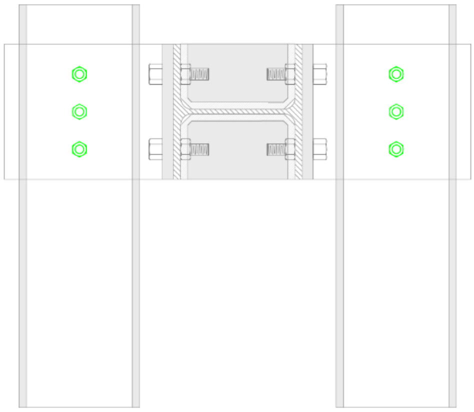


Figure 6.13: Test specimen 5

The following figures show some details of the test specimen and its arrangement in the reaction frame.

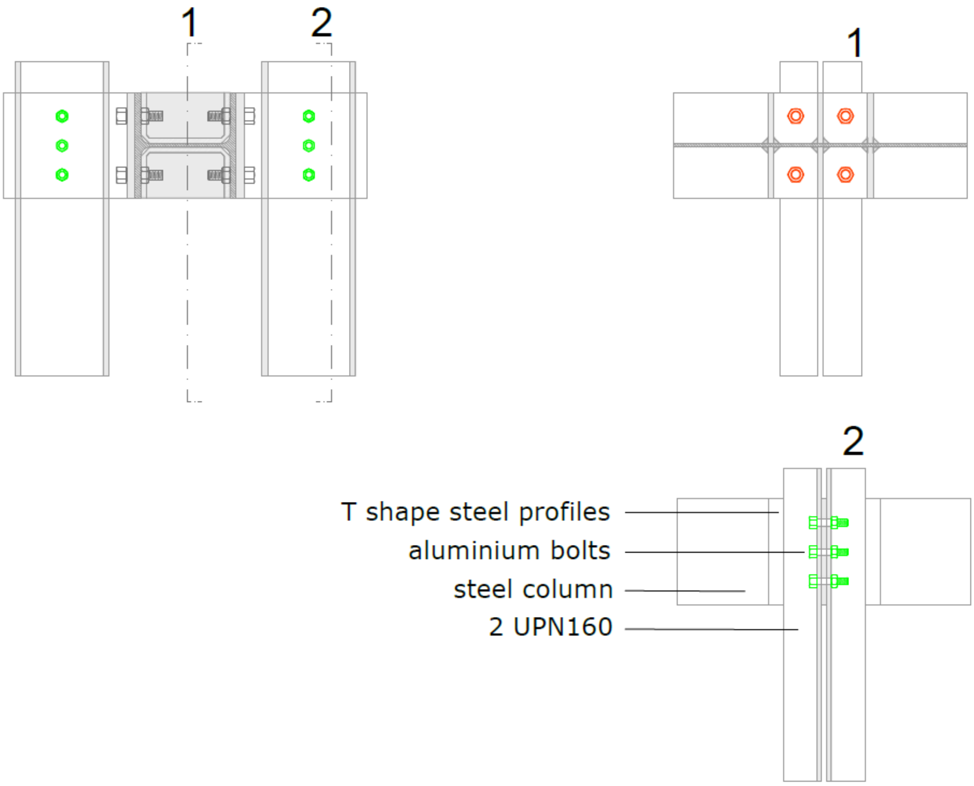


Figure 6.14: Some detailing of Test specimen 5

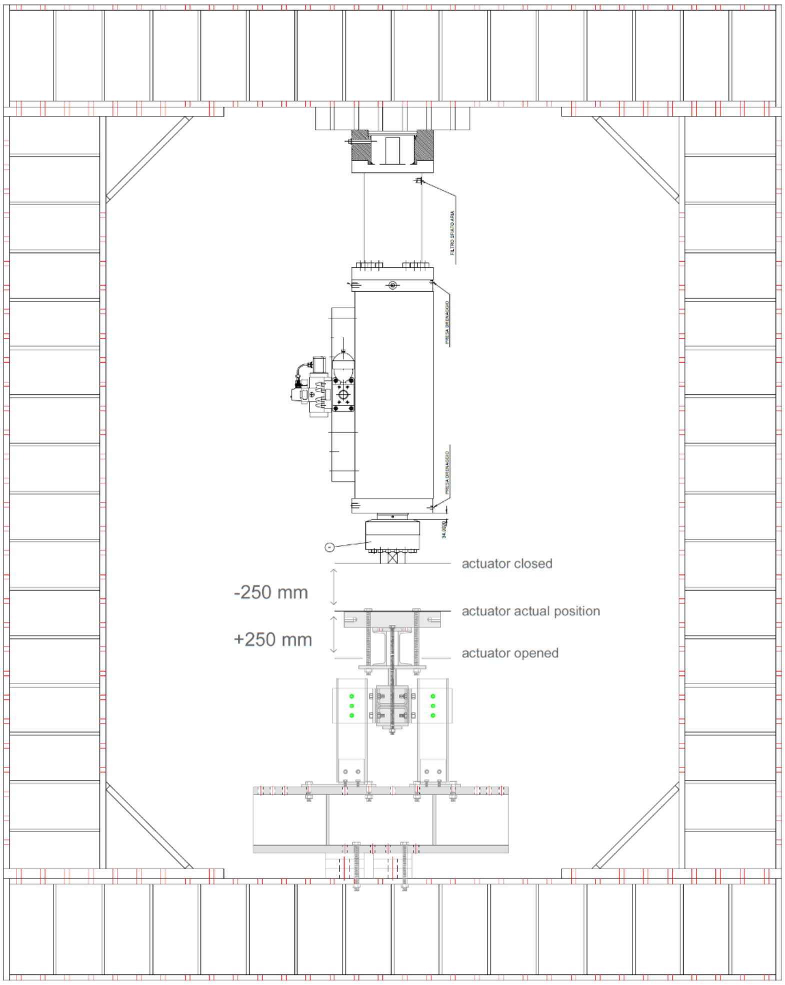


Figure 6.15: View of Test specimen 5 in the reaction frame

6.2 Instrumentation

The instrumentation that will be used during the tests is here below introduced:

- Localized strain gages will be used to record the deformation states of the components of interest of the tested fusible links, i.e. close to aluminium bolts;
- Localized displacement transducers will be used to measure relative displacements between the components of tested fusible links;

It should be mentioned that he reaction frame supports a hydraulic jack with a capacity of 1000 kN and a stroke length of ±250 mm. The jack has its own load cell as well as a displacement transducer that allows to record force-displacement curves.

From Figure 6.16 to Figure 6.20 the instrumentation location for each detail is shown.

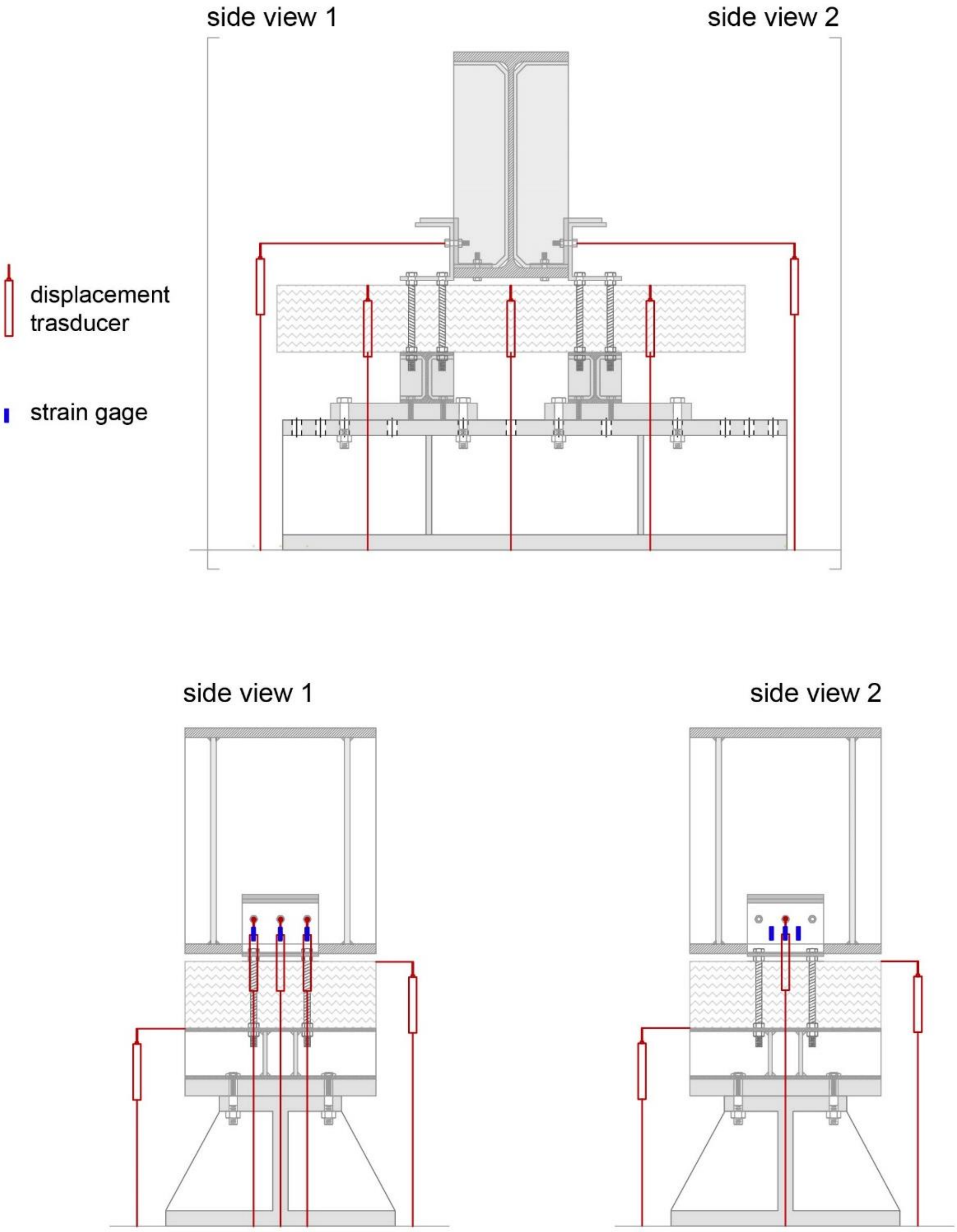
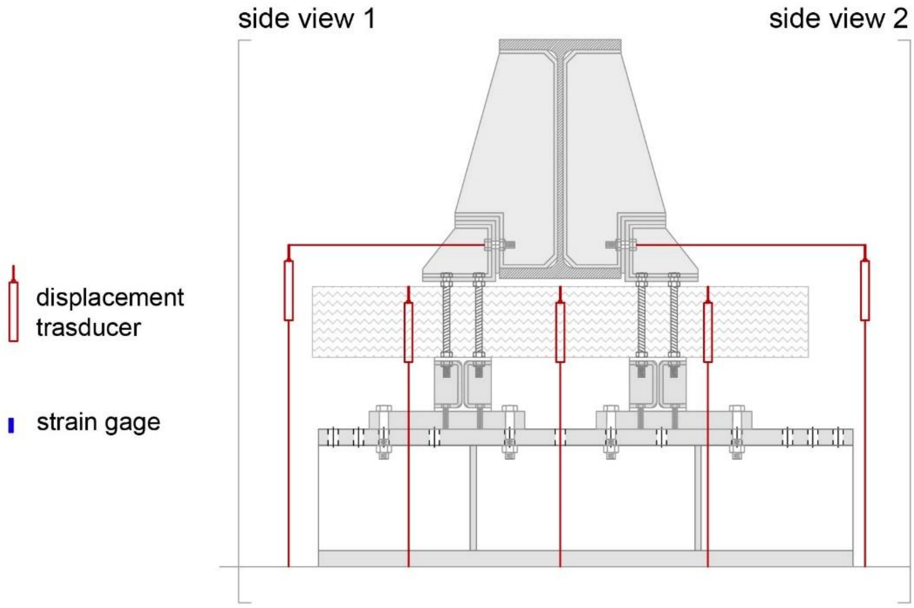


Figure 6.16: Test specimen 1 – instrumentation



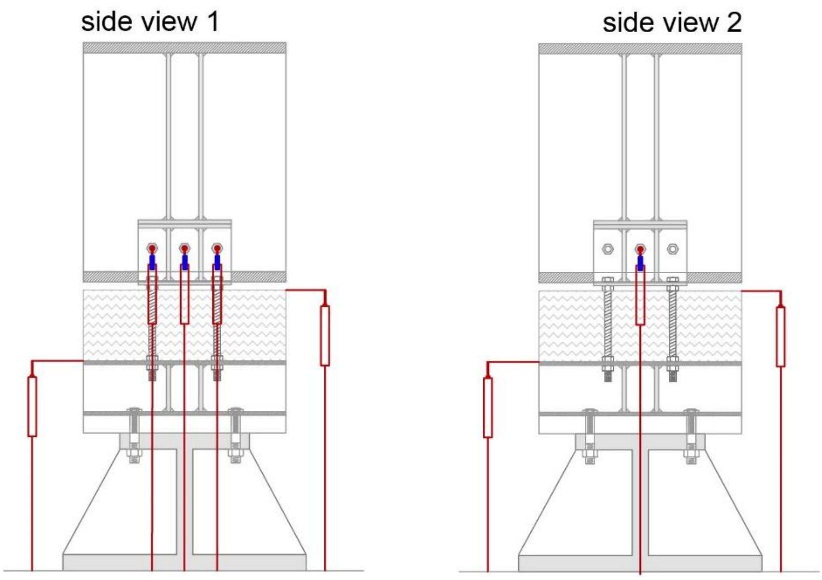
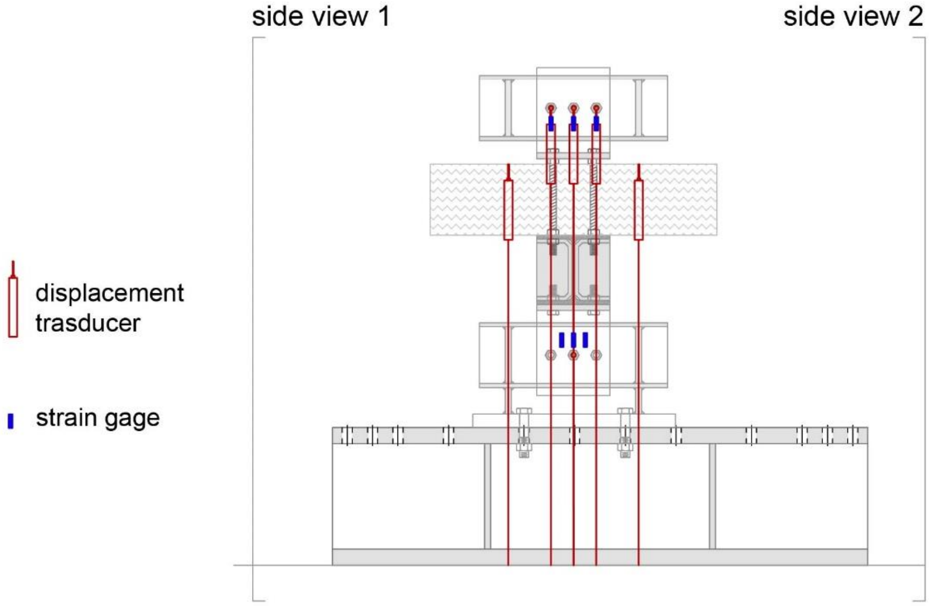


Figure 6.17: Test specimen 2 – instrumentation



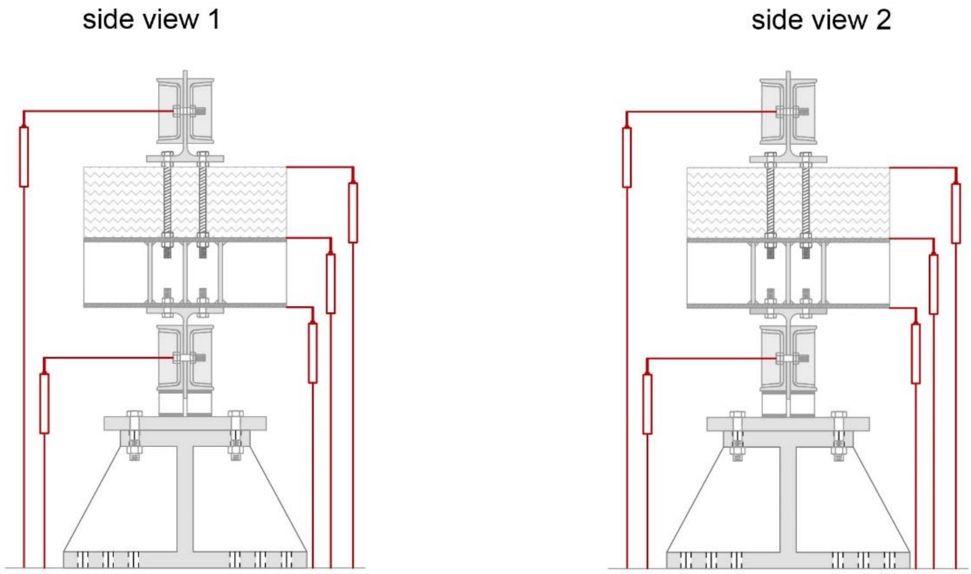


Figure 6.18: Test specimen 3 – instrumentation

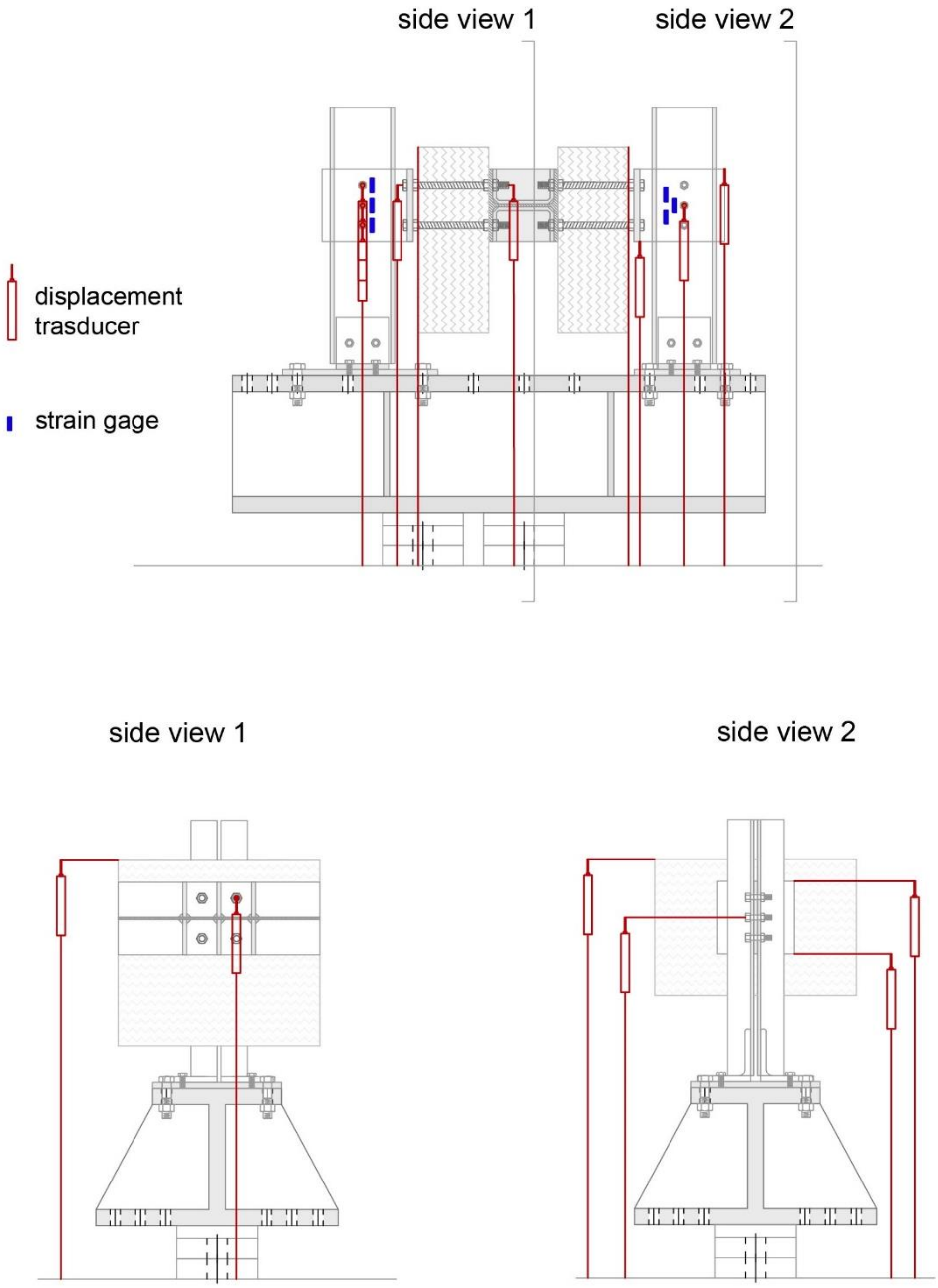


Figure 6.19: Test specimen 4 – instrumentation

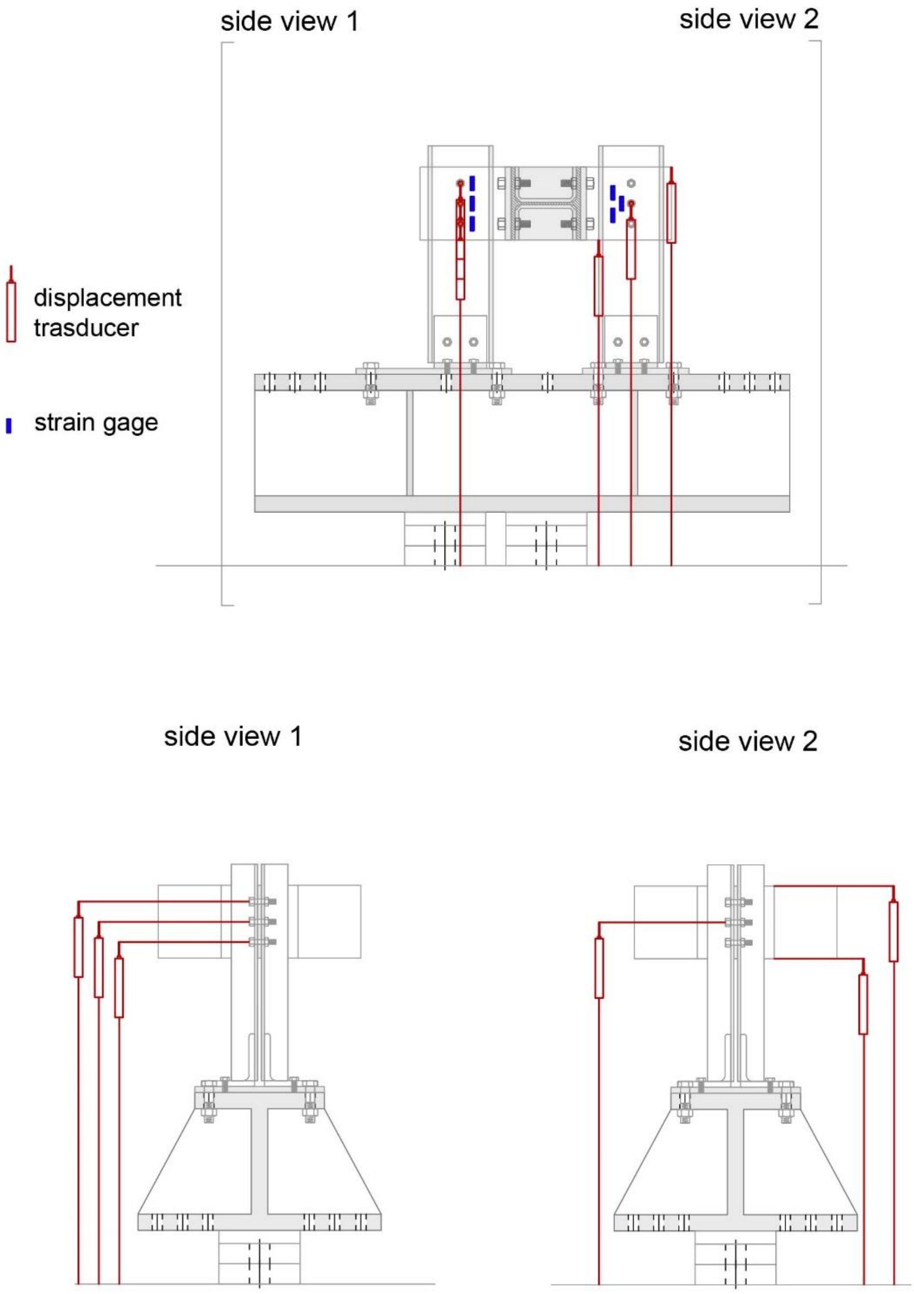


Figure 6.20: Test specimen 5 – instrumentation

7 CONCLUSIONS

This report aimed at summing up all fire tests and seismic tests planned in the project FISHWALL, giving information about tests specimens and tests arrangements.

It should be noted that test specimens could be still updated according to the results of numerical simulations using FE models, which are ongoing in time of writing. Final details of test specimens will be provided in corresponding test reports and deliverables of tasks involving tests.

8 REFERENCES

[1] EN 15254-5:2019 Extended application of results from fire resistance tests - Non-loadbearing walls - Part 5: Metal sandwich panel construction, 2019.

[2] EN 13501-2:2017 Fire classification of construction products and building elements - Part 2: Classification using test data from resistance fire tests, excluding ventilation services, 2017.

[3] EN 1364-1, Fire resistance tests for non-loadbearing elements - Part 1: Walls, 2017.

[4] EN 1363-1: Fire resistance tests - Part 1: General requirement, 2021.

[5] EN 13381-4: Test methods for determining the contribution to the fire resistance of structural members - Part 4: Applied passive protection to steel members, 2013.

[6] Deliverable D1.1: current practice for single storey steel framed building and review of fire and seismic regulations, RFSC project FISHWALL, 2020.

[7] Deliverable D1.3: Analysis of seismic behavior of single-storey buildings, RFSC project FISHWALL, 2020.

[8] ISO 209:2007 Aluminium and aluminium alloys - Chemical composition, 2007.

[9] EN 1999-1-1: Design of aluminium structures. Part 1-1: General structural rules, 2007.

[10] ECCS, Recommended Testing Procedure for Assessing the Behaviour of Structural Steel Elements under Cyclic Loads, first edition, 1986.

[11] EN 1993-1-8: Design of steel structures. Part 1-8: Design of joints, 2005.

[12] EN 1993-1-1: Design of steel structures. Part 1-1: General rules and rules for buildings, 2005.