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Building Research Institute

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TECHNICAL OPINION

with regard to pieces falling off in the event of a fire
of façade solutions by AGS company

00879/19/Z00NZP

Warsaw, June 2019

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TŁUMACZ PRZYSIĘGŁY JĘZYKA ANGIELSKIEGO
NR TP/2709/05

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TECHNICAL OPINION
with regard to pieces falling off in the event of a fire of façade solutions by AGS company

No. of contracted job:	00879/19/Z00NZP
Principal:	AGS Sp. z o.o. ul. Kleszczowa 18, 02-485 Warsaw
Contractors:	
Team:	PhD Eng. Paweł Sulik
Verified by:	MSc Eng. Bartłomiej Sędłak
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NR TP/2709/05

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1 Formal grounds

— Order of AGS Sp. z o.o.;
— Contract no. 00879/19/Z00N ZP.

2 Legal and factual grounds

[1] Regulation by the Minister of Infrastructure of 12th April 2002 on technical conditions to be met by buildings and their locations (Journal of Laws of 2015 item 1422 and of 2017 item 2285).

[2] Letter from the Headquarters of the State Fire Department dated 30th September 2013, no. BZ-III-77/15-2/13, on the interpretation of requirements with regard to pieces of façade falling off during a fire.

[3] National Technical Evaluation ITB-KOT-2017/0097 An assortment of products to manufacture substructure of the AGS system to assemble ventilated façade cladding.

[4] Test of an external wall as to the façade pieces falling off during a fire, carried out in the Fire Research Laboratory of the Building Research Institute in Pionki on 29.06.2018, pursuant to an internal procedure.

[5] Documentation of Simson Panel Tack glue by Bostik company, of which: KOMO atest-met-productcertificaat SKG.0176.7094.01.ENG, technical file Simson Panel Tack HM, material safety data sheet of Simson Panel Tack HM.

[6] Documentation of gluing system by Dow Corning company, based on the DOWSIL 896 PanelFix adhesive - Proventus glue, of which: European Technical Evaluation ETA 17/0689, technical file DOWSIL 896 PanelFix, material safety data sheet of DOWSIL 896 PanelFix.

[7] Technical opinion ITB no. 02184.1/17/Z00NZP, with regard to a ventilated façade made up of products by the following companies: AGS - ISOVER - EQUITONE, as to its compliance with the requirements of §225 WT, of 17th October 2018.

[8] Technical documentation provided by the Principal.

3 Purpose and scope of the paper

Pursuant to § 216 of the Regulation [1], the requirement to be met by the manner façade cladding elements are mounted as described in § 225 of the Regulation [1], in the event of a fire, should be met by buildings with fire resistance of class B for the minimum of 60 minutes, and in the case of buildings with fire resistance of classes C and D, the requirement should be met for the minimum of 30 minutes. The purpose of the opinion is to evaluate façade claddings made of:

- sintered stone cladding, for example Kerlite, Laminam;
- panelling made of composites and aluminium or steel sheets;
- cladding made of glass reinforced concrete;
- cladding made of photovoltaic modules, with frames and frameless;
- cladding made of fibre-cement panels, for example Bluclad
- thermal insulation from rock wool and glass wool of varying densities;
- framing system to fix ventilated facades by AGS Sp. z o.o.,

in the context of paragraph § 225 of the Regulation [1], which imposes the following requirement:

> Components of façade cladding shall be fixed to the building's structure in a way that prevents them from falling off during a fire before the time limit prescribed for a given fire resistance class for the external wall, as set forth in § 226 subpara. 1, respectively for the fire resistance class of the external wall of the building they are fixed onto.

The test is supposed to compare many different constructional solutions, in order to identify the most reliable fire safety solution.
The scope of the paper covers: the formal and factual grounds, technical description based on the documentation provided by the Principal, description of the laboratory test carried out, evaluation and final comments.

4 Technical description

4.1 General description of AGS systems

The object of this description are ventilated façade systems by AGS company, composed of:

- AGS steel brackets, with an anti-corrosion coating, ZM type, mounted to the wall with custom-selected couplings according to a given wall material;
- AGS steel grid with anti-corrosion ZM coating;
- thermal insulation by ISOVER company;

Façade cladding:

- made of sintered stone, for example Kerlite 3.5 and 5.5 mm;
- panelling made of composites and aluminium or steel sheets;
- made of glass reinforced concrete;
- made of framed and frameless photovoltaic modules;
- made of fibre-cement panels, for example Bluclad.

Types of brackets applied in the system are presented in Fig. 1 and 2.
Types of shapes used to construct grids are presented in Fig. 3.
The mounting method for brackets and profiles is described in [7]. The final choice of the grid solution and mount brackets for AGS system depends upon the statistical calculations. However, Opinion no. 02184.1/17/Z00NZP [7] describes exhaustively other ranges of products which are tested in the identical scope. The results are presented in point 7 of this opinion.

4.2 Description of the test element

The test element is presented in Fig. 15
During the test of the area located directly above the window, the following bracket and grid solutions were tested, in the following variations:

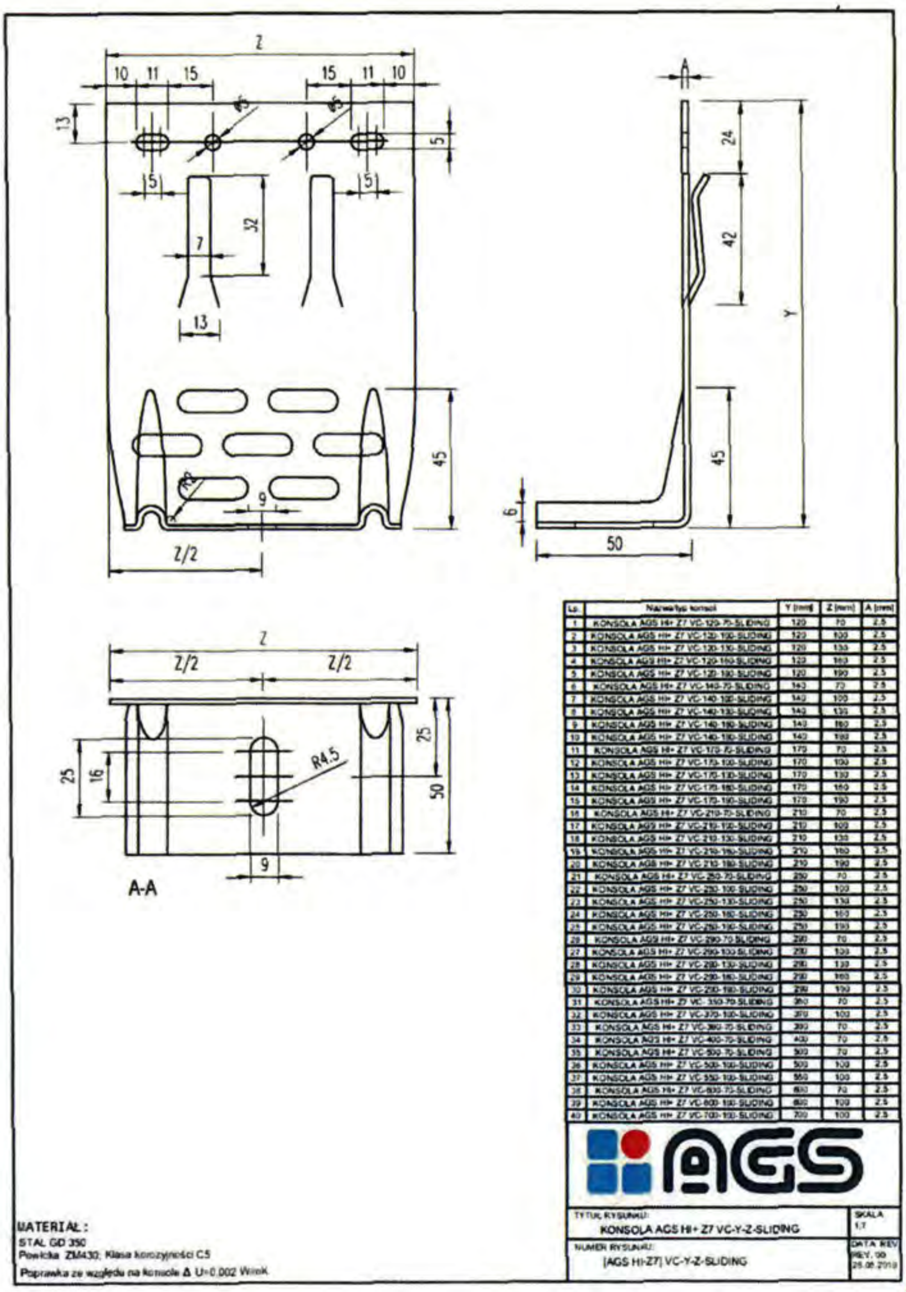
- passive steel brackets of the AGS system, type HI + 2,5 mm thick, combined with the steel grid, with anti-corrosion coating ZM, solution variants Z7 and Z8;
- aluminium brackets, 3 mm thick, without thermal insulation, with an aluminium grid;
- passive aluminium brackets with an aluminium grid; material of fire resistance class B-s3, d0 was used as a thermal break for the brackets, material of fire resistance class C-s2, d0 was not applied for comparative tests because it is a less effective solution in terms of durability during a fire).

Additionally, when designing the fragment of ventilated façade used for tests, the following test principles were assumed:

- the sets of products in the above-mentioned configurations were mounted directly above the tested window (in its central part), so that one half of the area exposed to fire was located in the glass wool insulation layer, density 20 kg/m^3, and the other half in the rock wool insulation, density 48 kg/m^3;

- a correct ventilating gap of 20 mm was assumed, as results from the Technical Conditions of the BRI between the insulation and the cladding. As a result of this, both a part of the brackets and the entire cross-section of the grid were protruding beyond the insulation;
- the façade was not protected against fire with additional boards from the bottom. No cladding for reveal;
- glass-reinforced concrete elements were applied as cladding for a given set (8-13 Fig. 15) 20 mm thick, each of which was mounted exclusively specifically for a given substructure solution.

Other cladding, along with its mounting method, type of grid and thermal insulation applied, have been presented in Fig. 6-15, however, boards no. 4, 7 (Fig. 15) were protruding slightly beyond the clearance of the window, boards 8-13 (Fig. 15) were located directly above the window, and boards 5 and 6 (Fig. 15) were located above the window in the second row, above the boards located directly above the window.



Lp.	Nazwa/typ konsoli	Y [mm]	Z [mm]	A [mm]
1	KONSOLA AGS HI+ Z7 VC-120-70-SLIDING	120	70	2.5
2	KONSOLA AGS HI+ Z7 VC-120-100-SLIDING	120	100	2.5
3	KONSOLA AGS HI+ Z7 VC-120-130-SLIDING	120	130	2.5
4	KONSOLA AGS HI+ Z7 VC-120-160-SLIDING	120	160	2.5
5	KONSOLA AGS HI+ Z7 VC-120-190-SLIDING	120	190	2.5
6	KONSOLA AGS HI+ Z7 VC-140-70-SLIDING	140	70	2.5
7	KONSOLA AGS HI+ Z7 VC-140-100-SLIDING	140	100	2.5
8	KONSOLA AGS HI+ Z7 VC-140-130-SLIDING	140	130	2.5
9	KONSOLA AGS HI+ Z7 VC-140-160-SLIDING	140	160	2.5
10	KONSOLA AGS HI+ Z7 VC-140-190-SLIDING	140	190	2.5
11	KONSOLA AGS HI+ Z7 VC-170-70-SLIDING	170	70	2.5
12	KONSOLA AGS HI+ Z7 VC-170-100-SLIDING	170	100	2.5
13	KONSOLA AGS HI+ Z7 VC-170-130-SLIDING	170	130	2.5
14	KONSOLA AGS HI+ Z7 VC-170-160-SLIDING	170	160	2.5
15	KONSOLA AGS HI+ Z7 VC-170-190-SLIDING	170	190	2.5
16	KONSOLA AGS HI+ Z7 VC-210-70-SLIDING	210	70	2.5
17	KONSOLA AGS HI+ Z7 VC-210-100-SLIDING	210	100	2.5
18	KONSOLA AGS HI+ Z7 VC-210-130-SLIDING	210	130	2.5
19	KONSOLA AGS HI+ Z7 VC-210-160-SLIDING	210	160	2.5
20	KONSOLA AGS HI+ Z7 VC-210-190-SLIDING	210	190	2.5
21	KONSOLA AGS HI+ Z7 VC-250-70-SLIDING	250	70	2.5
22	KONSOLA AGS HI+ Z7 VC-250-100-SLIDING	250	100	2.5
23	KONSOLA AGS HI+ Z7 VC-250-130-SLIDING	250	130	2.5
24	KONSOLA AGS HI+ Z7 VC-250-160-SLIDING	250	160	2.5
25	KONSOLA AGS HI+ Z7 VC-250-190-SLIDING	250	190	2.5
26	KONSOLA AGS HI+ Z7 VC-290-70-SLIDING	290	70	2.5
27	KONSOLA AGS HI+ Z7 VC-290-100-SLIDING	290	100	2.5
28	KONSOLA AGS HI+ Z7 VC-290-130-SLIDING	290	130	2.5
29	KONSOLA AGS HI+ Z7 VC-290-160-SLIDING	290	160	2.5
30	KONSOLA AGS HI+ Z7 VC-290-190-SLIDING	290	190	2.5
31	KONSOLA AGS HI+ Z7 VC-350-70-SLIDING	350	70	2.5
32	KONSOLA AGS HI+ Z7 VC-370-100-SLIDING	370	100	2.5
33	KONSOLA AGS HI+ Z7 VC-390-70-SLIDING	390	70	2.5
34	KONSOLA AGS HI+ Z7 VC-400-70-SLIDING	400	70	2.5
35	KONSOLA AGS HI+ Z7 VC-500-70-SLIDING	500	70	2.5
36	KONSOLA AGS HI+ Z7 VC-500-100-SLIDING	500	100	2.5
37	KONSOLA AGS HI+ Z7 VC-550-100-SLIDING	550	100	2.5
38	KONSOLA AGS HI+ Z7 VC-600-70-SLIDING	600	70	2.5
39	KONSOLA AGS HI+ Z7 VC-600-100-SLIDING	600	100	2.5
40	KONSOLA AGS HI+ Z7 VC-700-100-SLIDING	700	100	2.5

Fig. 1. Brackets of AGS system with ZM coating, type Z7 .

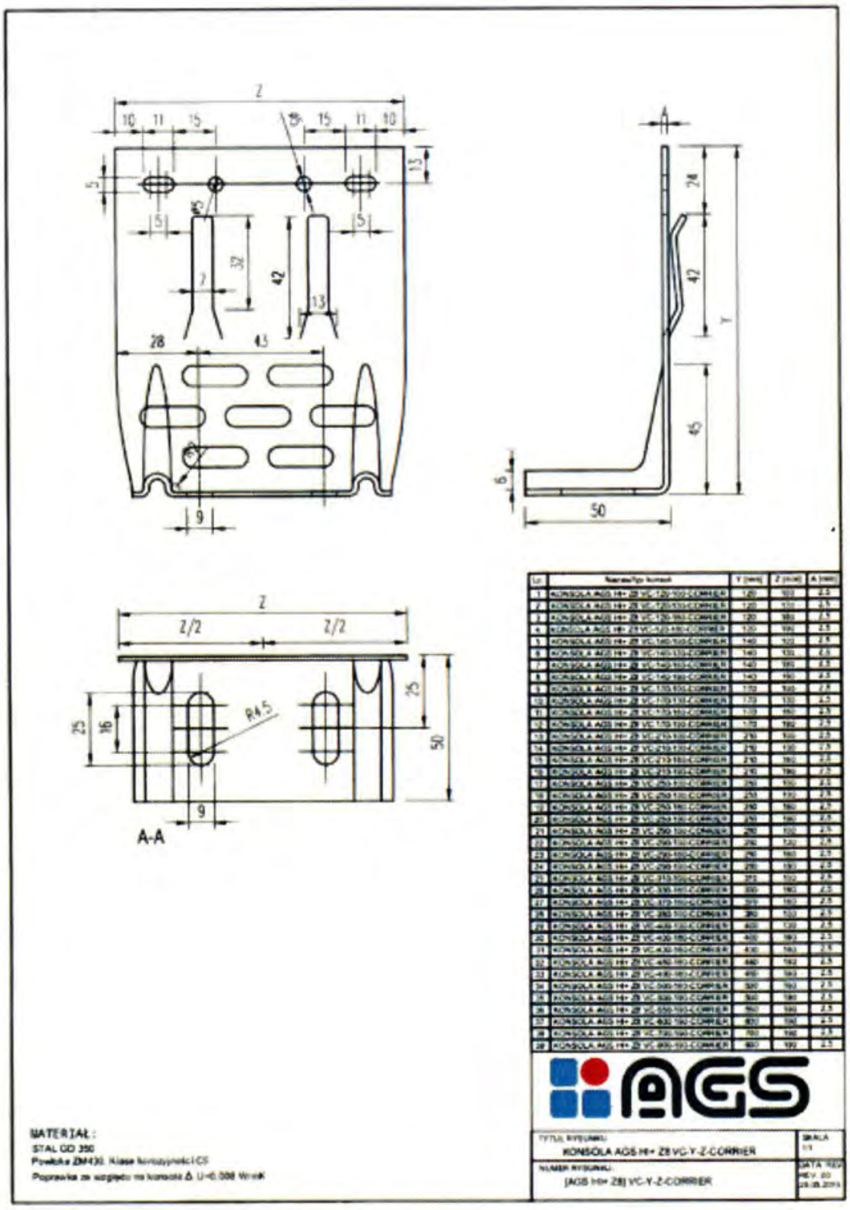


Fig. 2 Stainless AGS brackets, type 28

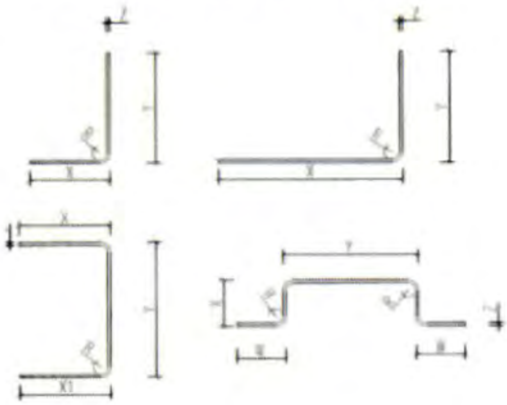


Fig. 3. Examples of steel shapes with anti-corrosion ZM coating, used to construct the AGS grid system.

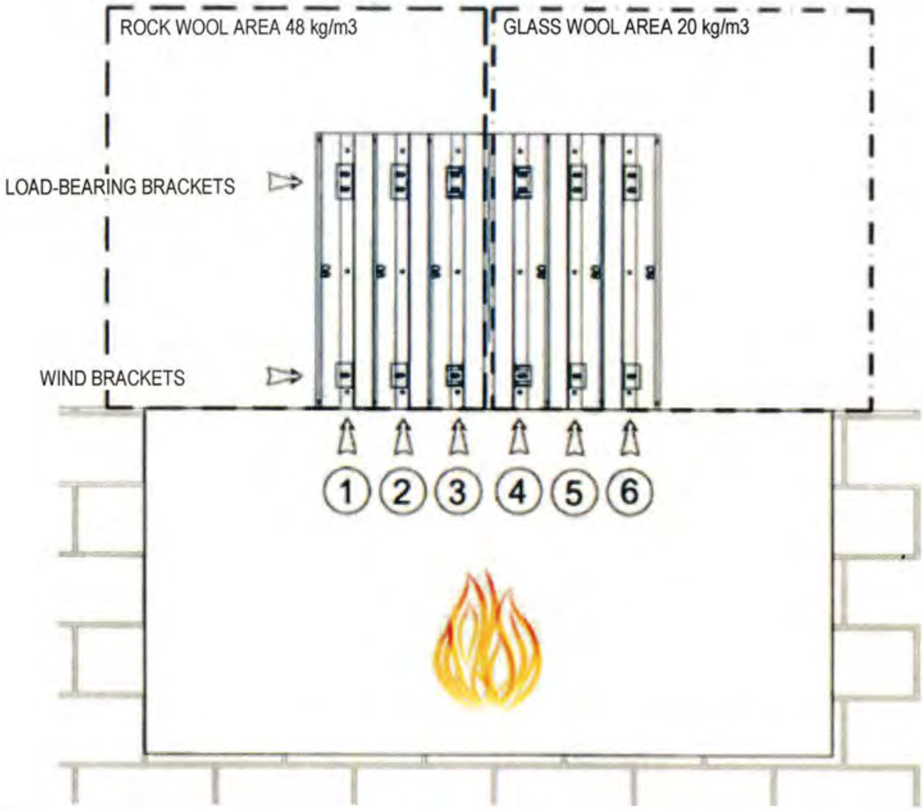


Fig. 4. Partition of the test element in terms of thermal insulation and designation of brackets

Numbers in Fig. 4 indicate the following technical solutions:

1 - Aluminium brackets without thermal insulation with aluminium grid in rock wool, density of 48 kg/m³;

2 - Passive aluminium brackets with aluminium grid in glass wool, density of 48 kg/m³;

3 - Passive steel brackets of AGS system combined with a steel grid with anti-corrosion ZM coating in rock wool, density of 48 kg/m³ ;

4 - Passive steel brackets of AGS system combined with a steel grid with anti-corrosion ZM coating in glass wool, density of 20 kg/m³;

5 - Passive aluminium brackets with aluminium grid in glass wool, density of 20 kg/m³;

6 - - Aluminium brackets without thermal insulation with aluminium grid in rock wool, density of 20 kg/m³.

Fig. 5. View of the brackets applied

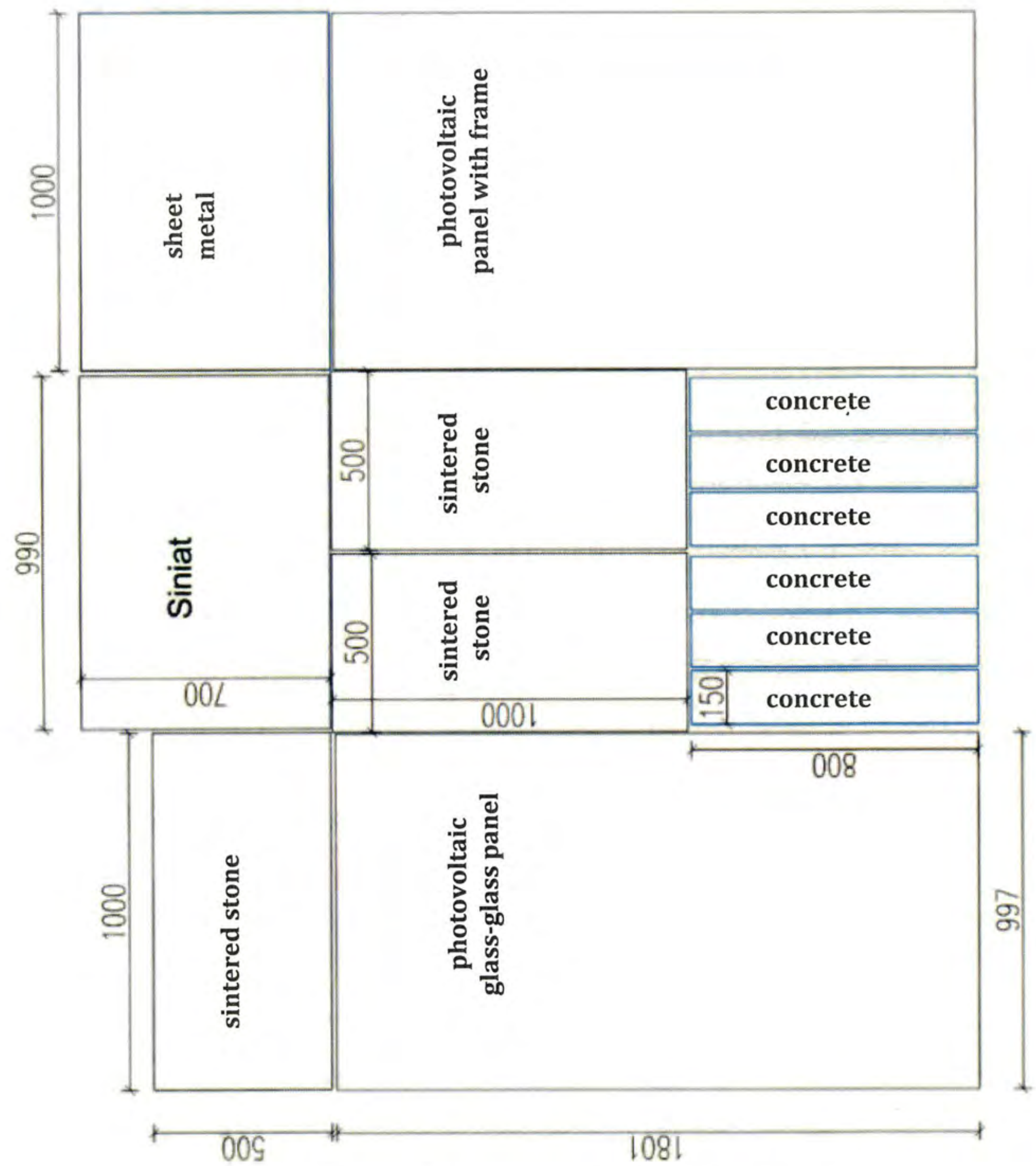


Fig. 6. Description and dimensions of the cladding applied

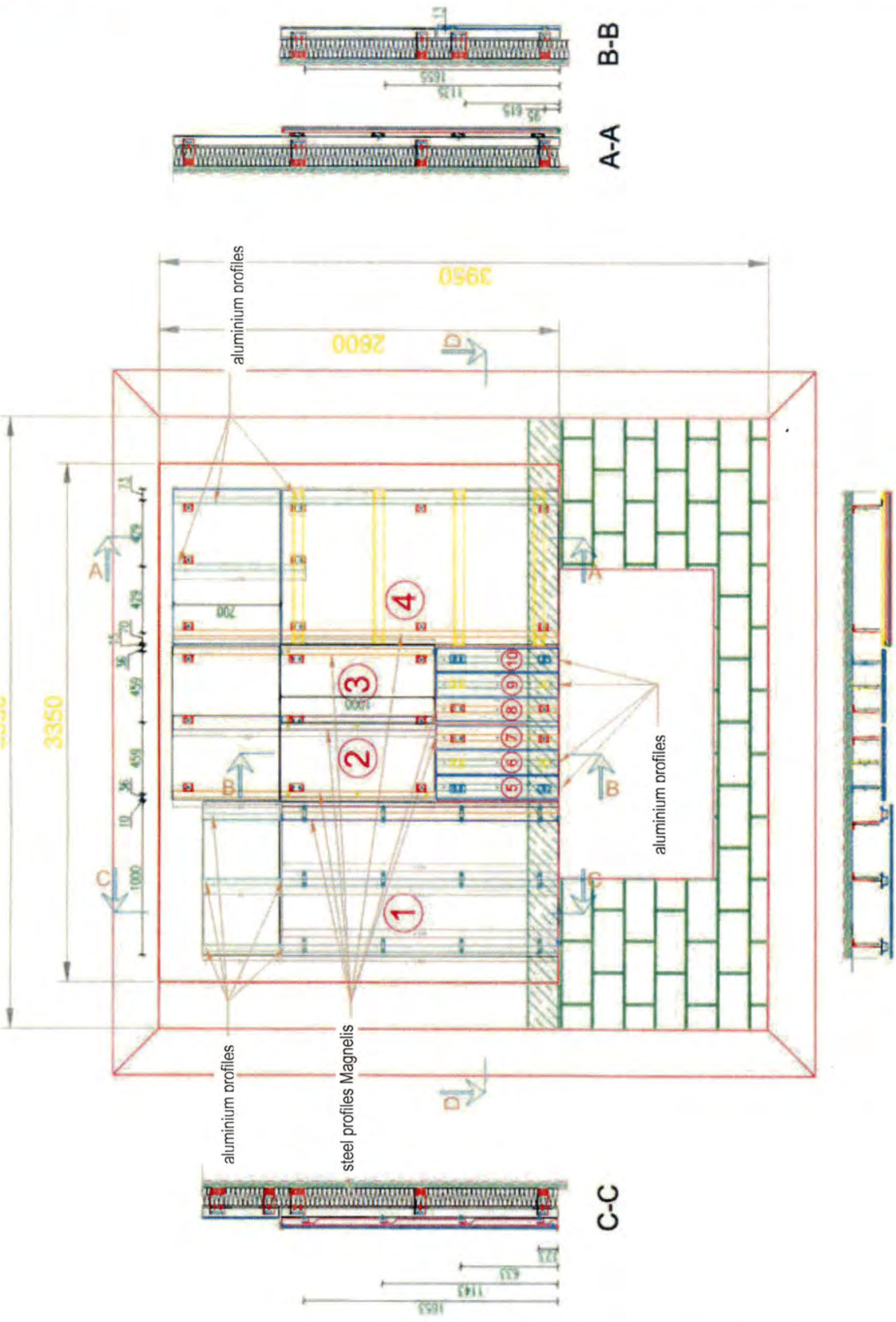


Fig. 7. View and cross-sections of the test element – description of cladding

Description of cladding

1. Photovoltaic glass-glass panel, glued to the grid (tie system):
   Profiles (from the left): aluminium/aluminium/steel with anti-corrosion ZM coating
   Load-bearing brackets: AGS HI+ Z8
   Wind brackets: AGS HI+ Z7
2. Sintered stone panel, 5.5 mm thick, riveted to the steel grid with anti-corrosion ZM coating
   Load-bearing brackets: AGS HI+ Z8
   Wind brackets: AGS HI+ Z7
3. Sintered stone panel, 3.5mm thick, glued and secured with two rivets mounted to the steel grid with anti-corrosion ZM coating.
   Load-bearing brackets: AGS HI+ Z8
   Wind brackets: AGS HI+ Z7
4. Photovoltaic panel with a frame, mounted with the use of A profile to the steel grid (from the left) with anti-corrosion ZM coating, (from the right) of aluminium.
   Load-bearing brackets: AGS HI+ ZB
   Wind brackets: AGS HI+ Z7
5. Glass-reinforced concrete panel, 20 mm thick, mounted to the aluminium profile
   Aluminium brackets without thermal insulation
6. Glass-reinforced concrete panel, 20 mm thick, mounted to the aluminium profile
   Passive aluminium brackets
7. Glass-reinforced concrete panel, 20 mm thick, mounted to steel profile, with an anti-corrosion ZM coating
   AGS brackets
8. Glass-reinforced concrete panel, 20 mm thick, mounted to the aluminium profile
   Aluminium brackets without thermal insulation
9. Glass-reinforced concrete panel, 20 mm thick, mounted to the aluminium profile
   Passive aluminium brackets
10. Glass-reinforced concrete panel, 20 mm thick, mounted to the aluminium profile with an anti-corrosion ZM coating.
    AGS brackets
11. Sintered stone panel, 3.5mm, glued to the aluminium grid.
    AGS brackets
12. Fibre-cement panel, 10 mm thick, mounted mechanically to the steel with anti-corrosion ZM coating.
13. Composite board glued to the aluminium grid.
    AGS brackets

Fig. 8. Description of claddings presented in Fig. 7.

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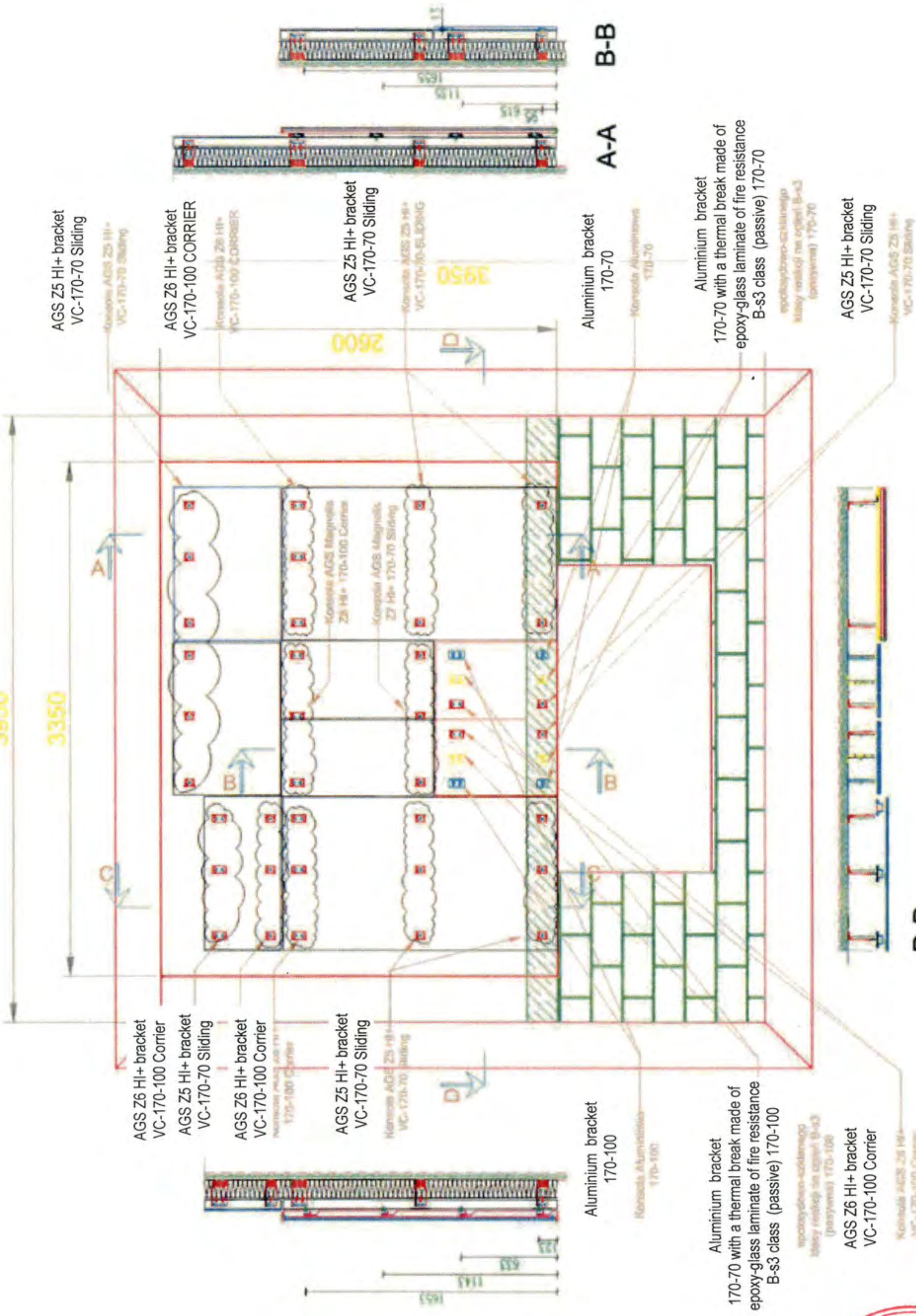

Fig.9 Diagramme of brackets distribution

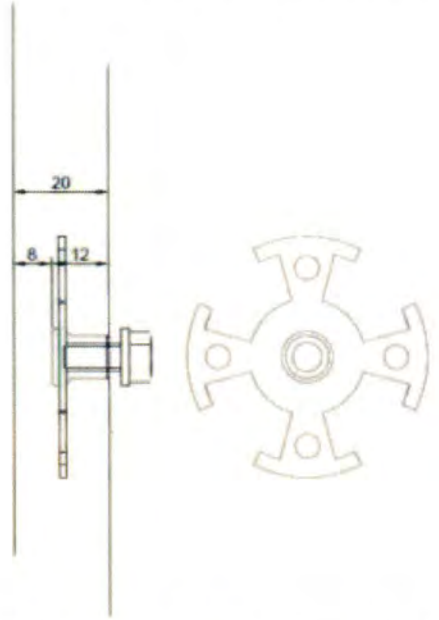

Fig. 10. Details of test elements - AGS coupling sunk in a GRC panel

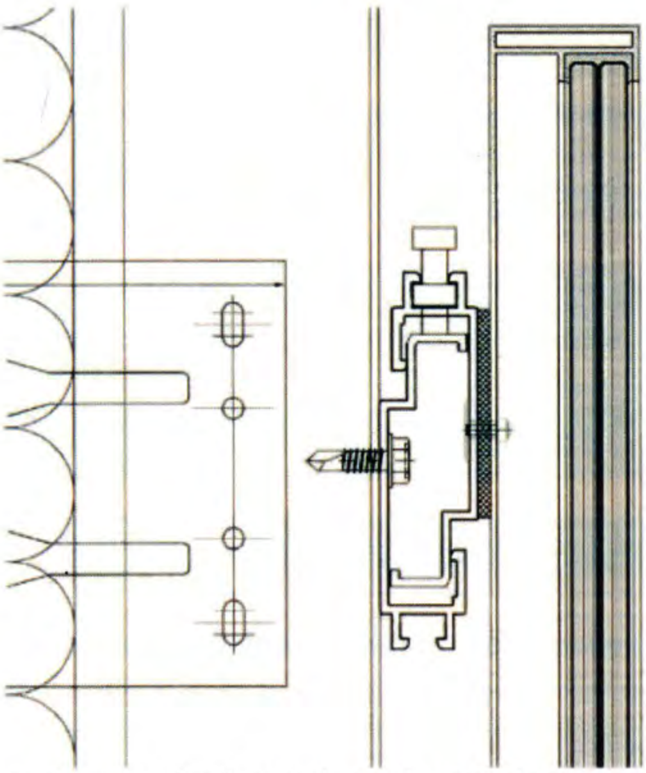

Fig. 11. Details of test elements – detail: mounting of photovoltaic module with a frame

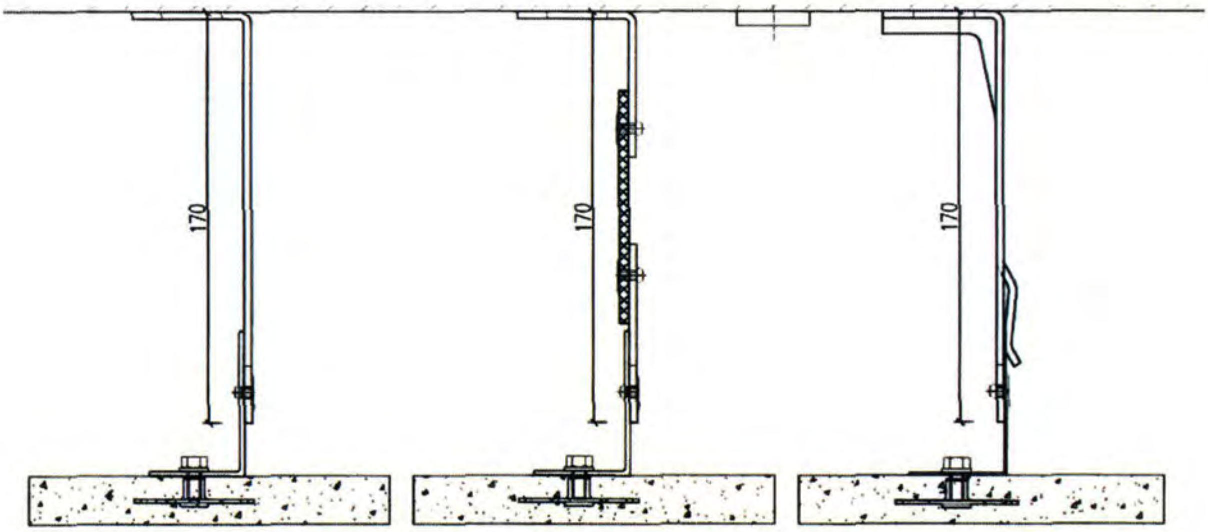

Fig. 12. Details of test elements – details: mounting of GRC panels to substructures in comparative tests

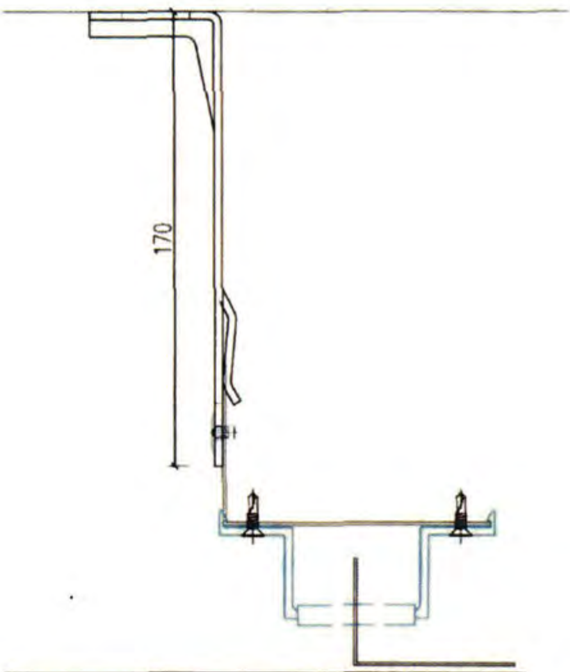

Fig. 13. Details of test elements – details: gluing of a frameless photovoltaic module to the steel structure with anti-corrosion ZM coating.

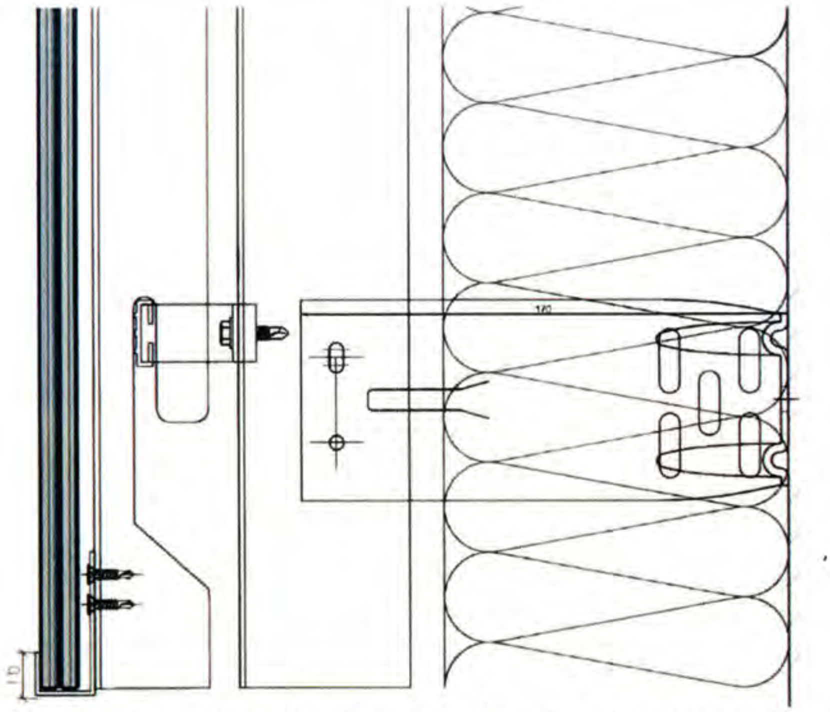

Fig. 14. Details of test elements - details of suspension for frameless photovoltaic modules to the steel structure with anti-corrosion ZM coating

5 Description of test

On 12th April 2019 in the Fire Research Laboratory of the Building Research Institute in Pionki, a test with regard to façade pieces falling off was carried out, at the request of AGS Sp. z o.o. The wall was manufactured pursuant to the description given in point 4 and Fig. 1-14. The test was carried out in the ambient temperature of 22.4°C and relative humidity of 46.0%. The test element was built between 9th-10th April 2019, on a custom-made (on 10th September 2018) and matured wall of cellular concrete, of 600 kg/m^3 type, mounted in a steel test frame.

We assumed a test scenario in which a fragment of façade is exposed to heating with the use of a gas-fired burner, of an intensity equivalent to an actual, regular fire in the room directly behind the facade (inside the building) (heating in accordance with the standard curve, defined in the research standards related to fire resistance), and in which the flames are spreading outside the window and act upon the façade.

A diagramme of the sample is presented in Fig. 15. Technical details are presented in Figures 1-14. Views of the sample during assembly and before the test are presented in Figures 16-20. View of the sample during the test is presented in Figures 21-40. View of the sample after the test is presented in Figures 41-46.

The following types of cladding were applied in the test:

- photovoltaic modules with and without frames, by ML SYSTEM Spółka Akcyjna joint stock company, Zaczernie 190 G, 36-062 Zaczernie; Mounting of the frameless modules was as follows: an L profile steel grid was attached to the steel brackets Z7, Z8 with the use of self-drilling screws or rivets, assembled together with adjustable suspensions, also made of steel. The cladding itself was glued to the additional grid, also made of steel, with custom-made milled elements for suspending. A system consisting of double-sided adhesive tape and glue was applied for gluing the cladding. However, as presented in Fig. 14 in this opinion, the modules were additionally supported locally from the bottom along the axes of the grid with steel profiles of C type, which were also screwed to the steel grid.

- sintered stone boards Karlite 3.5 mm and 5.5 mm manufactured pursuant to the provisions of the Technical Approval no. ITB AT-15-9508/2015;
- steel sheet panels, 2 mm thick, manufactured by AGS sp. z o.o. company;
- fibre-cement panel by Bluclad company, Siniat 10 mm thick;
- glass-reinforced concrete panel 20 mm thick, manufactured by B-loft Sp. z o.o. company, 2/1 Mariacka Street, 81- 383 Gdynia.

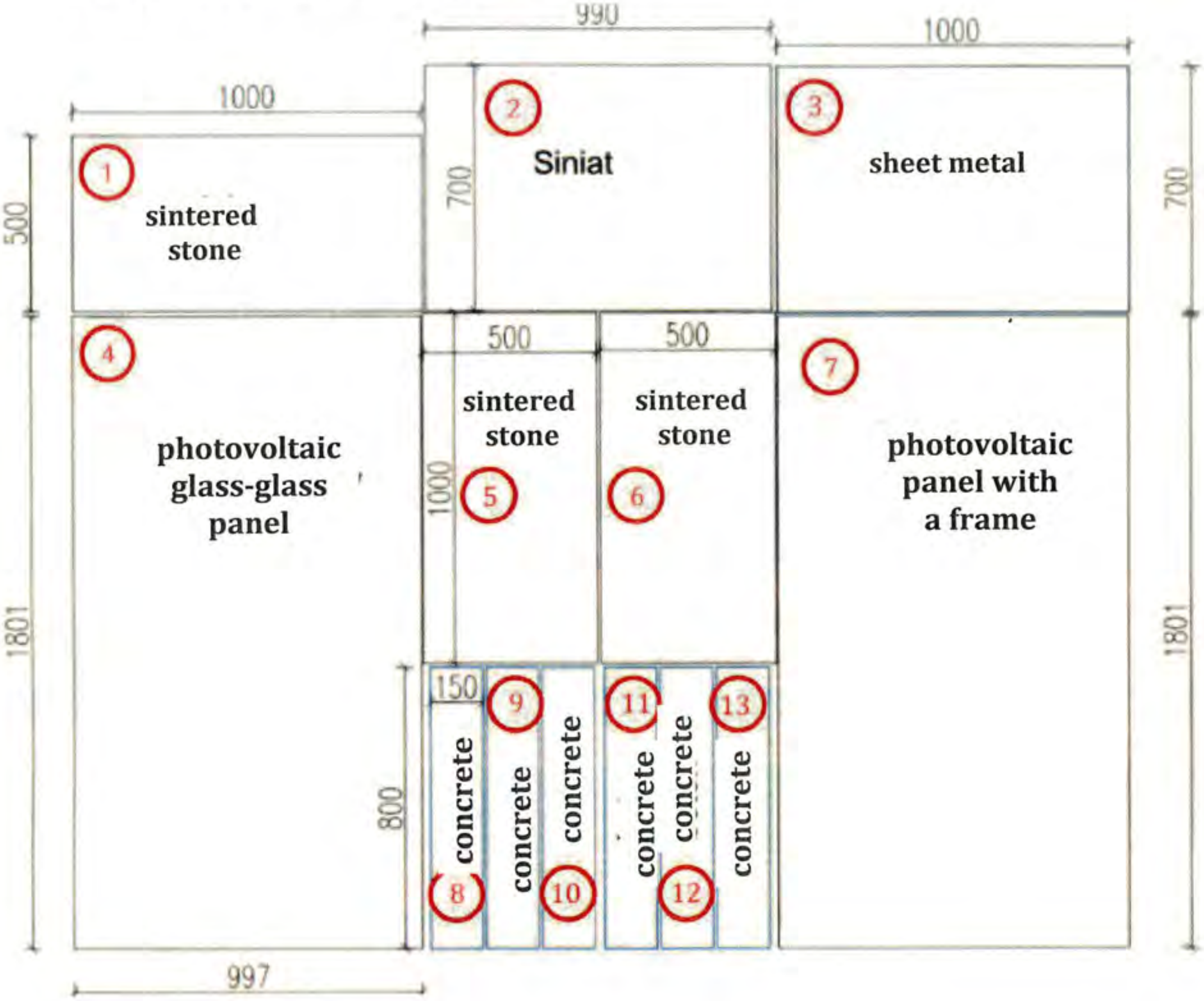

Fig 15. Numbers of types of cladding applied in the description

The following was observed during the test:

In the below description, types of cladding were numbered as indicated in Fig. 15.

- The test starts at 11:18 AM;
- in the 3rd minute, drops of aluminium are falling down;
- in the 3rd minute, there is loud noise, a piece of panel no. 12 "flies off";
- in the 4th minute, there is loud noise, a piece of panel no. 9 "flies off", mass of 1.25 kg;
- in the 5th minute, burning droplets are falling off element no. 4;
- in the 7th minute, burning droplets are falling off element no. 4;
- in the 8th minute, glass pane in element no. 4 breaks;
- in the 9th minute, a piece of board no. 12, mass of 2.55 kg falls off;
- in the 9th minute, a piece of board no. 6 falls down, mass of 0.30 kg;

- in the 10th minute, a fragment of panel no. 6 falls down, mass of 0.45 kg; the fire spreads outside the test element, behind the panels;
- in the 11th minute, small fragments of panel no. 4 fall down, elements continue to burn on the floor;
- in the 12th minute, a fragment of panel no. 13 falls down, mass of 5.40 kg;
- in the 13th minute, fire persists on the right edge of panel no. 4 and on the left edge of panel no. 7;
- in the 16th minute, a fragment of panel no. 9 falls down, mass of 1.60 kg;
- in the 19th minute, small fragments of element no. 4 fall down;
- in the 20th minute, a fragment of panel no. 6 falls down, mass of 0.20 kg;
- in the 25th minute, a fragment of panel no. 8 falls down, mass of 4.30 kg;
- in the 26th minute, small fragments of panel no. 5 fall down;
- 62'27" end of test, as agreed upon with the Principal.

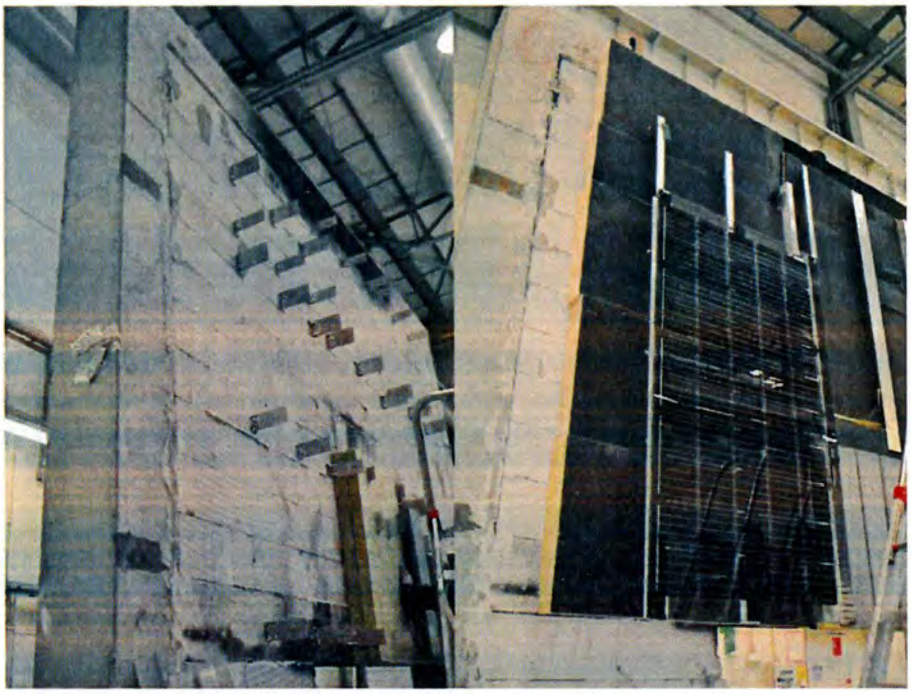

Fig. 16. View of brackets and cladding mounting

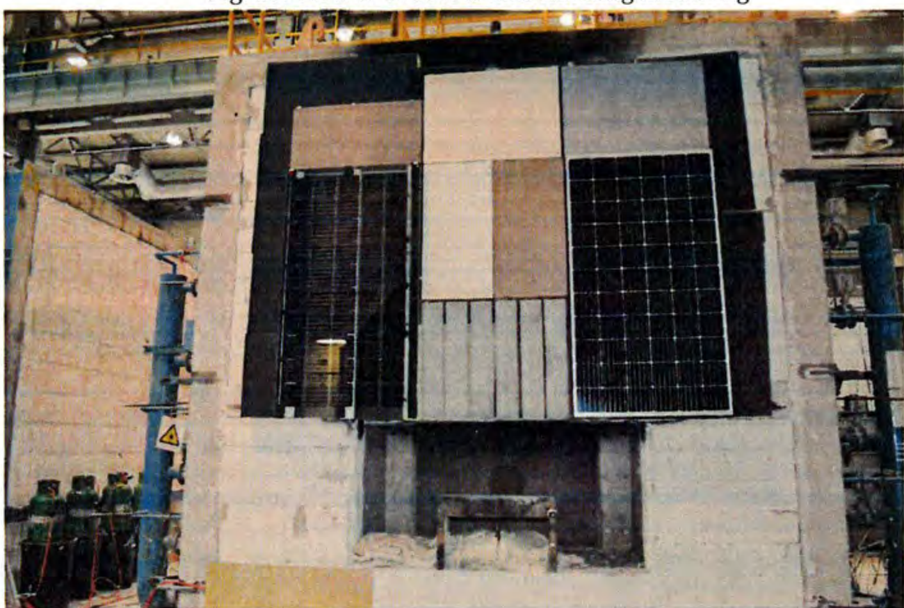

Fig. 17. View of the test element before testing

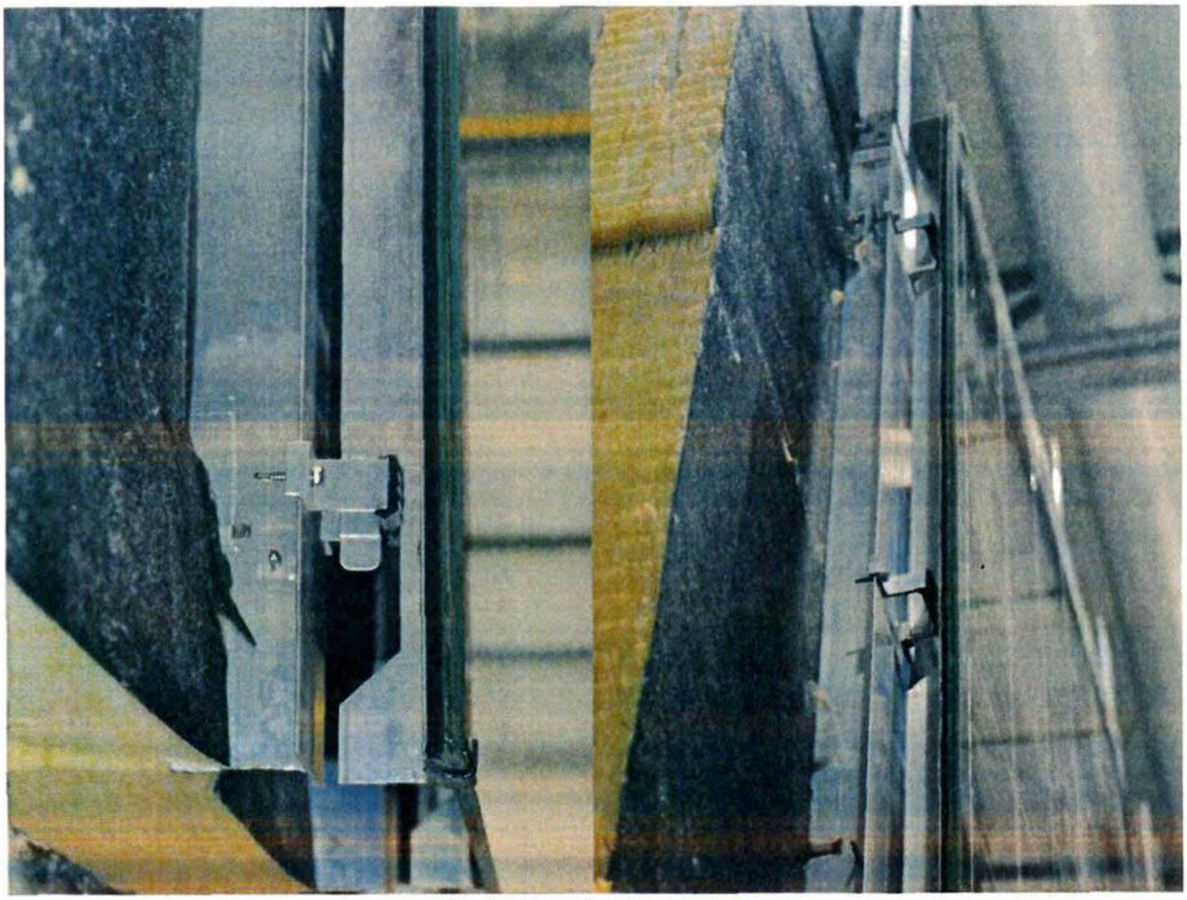

Fig. 18. Details of mounting

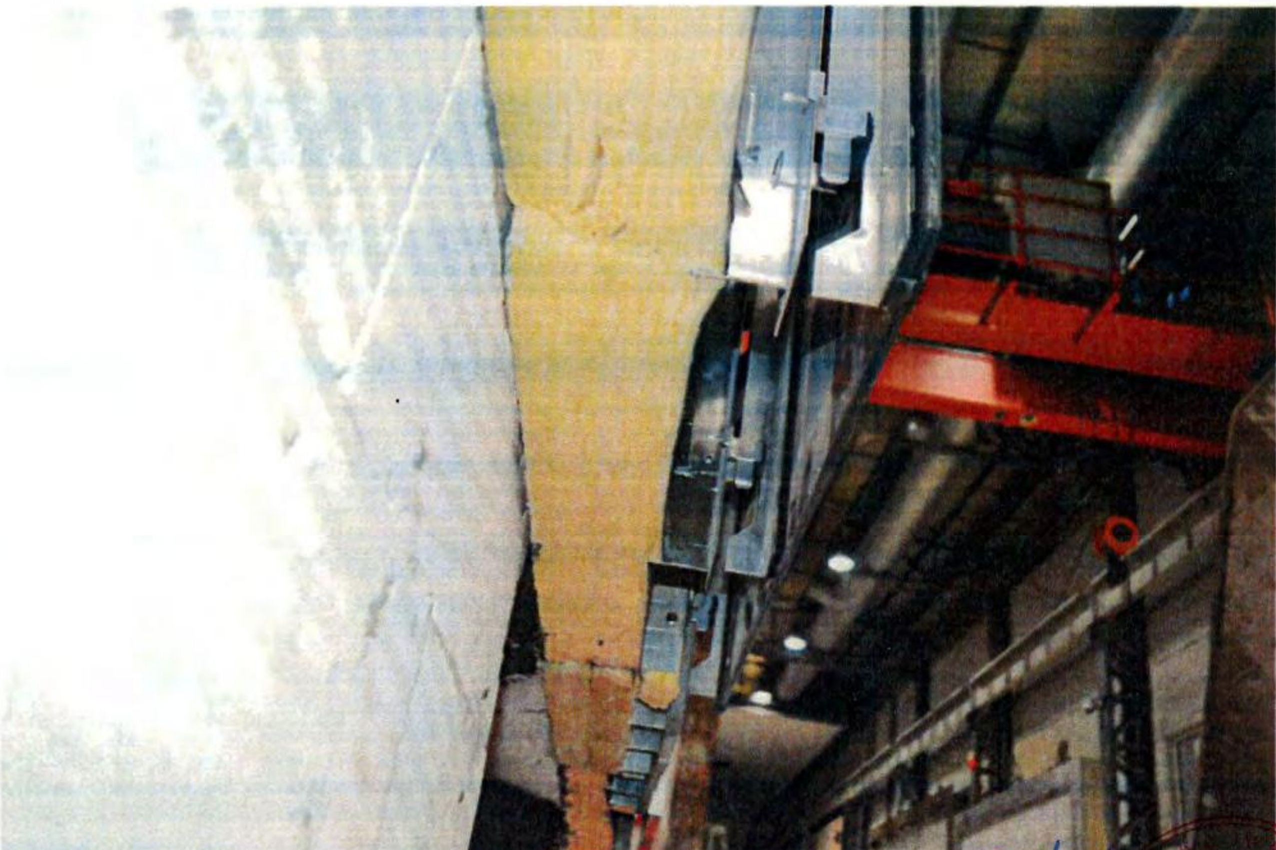

Fig. 19. Details of mountin

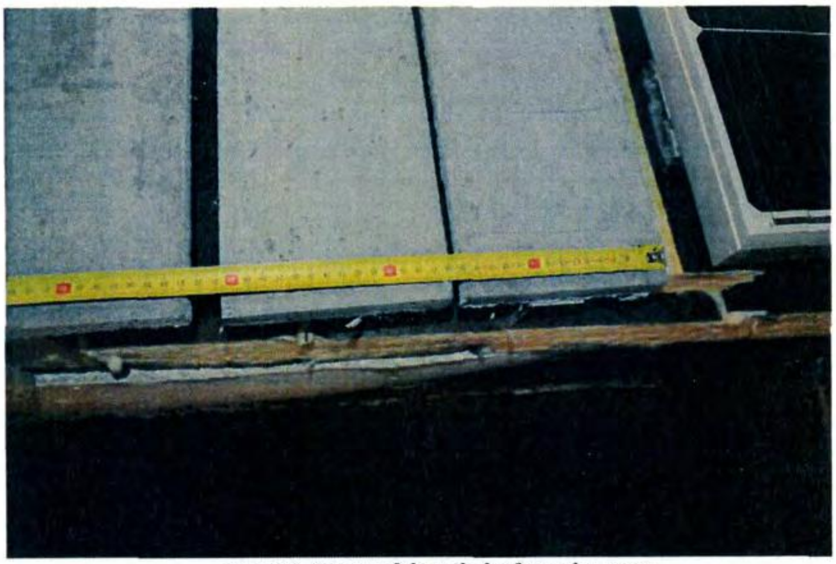

Fig. 20. View of details before the test

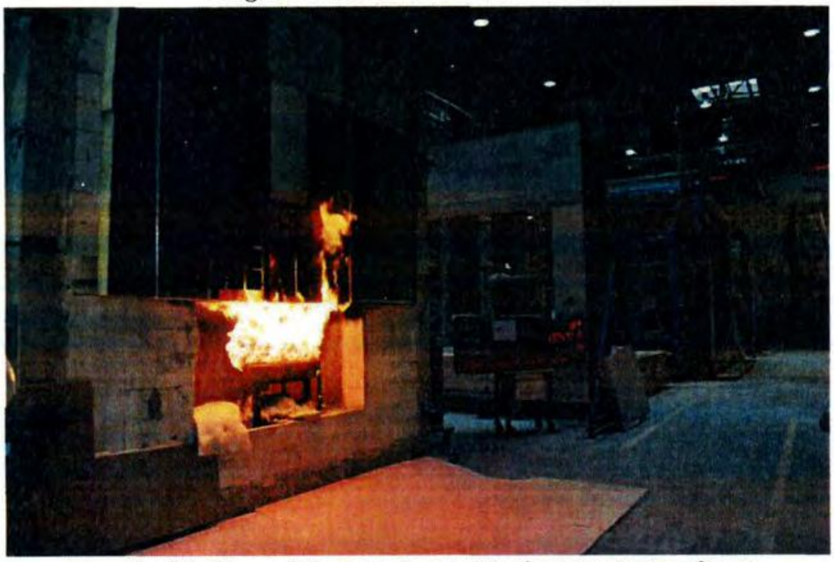

Fig. 21. View of the test element in the 1st minute of test

Fig. 22. View of the test element in the 2nd minute of test

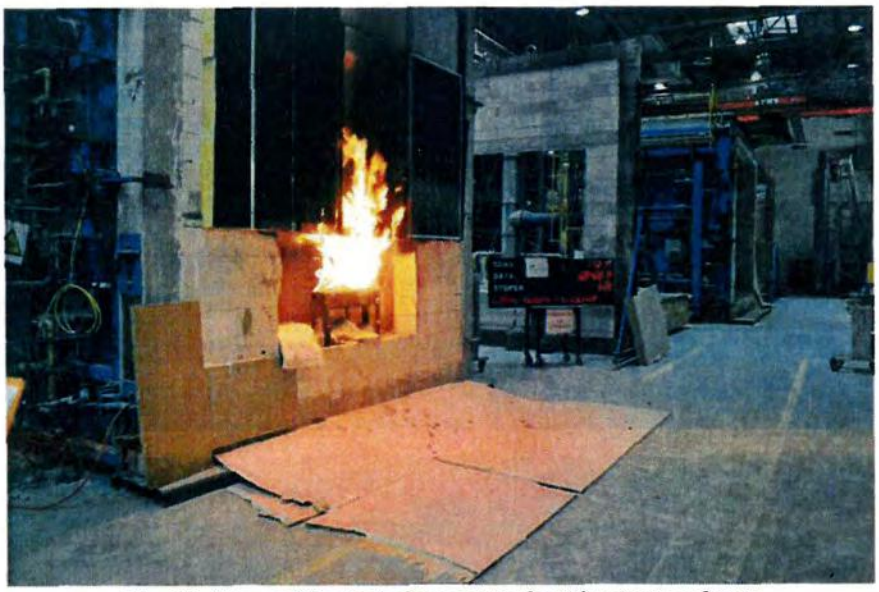

Fig. 23. View of the test element in the 4th minute of test

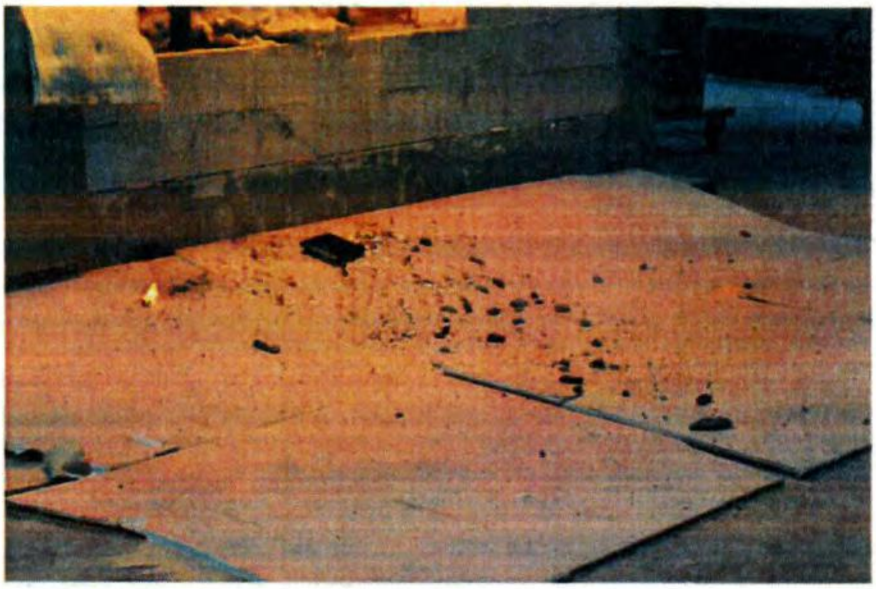

Fig. 24. Fragments which fell off in the 4th minute of test

Fig. 25. View of the test element in the 5th minute of test

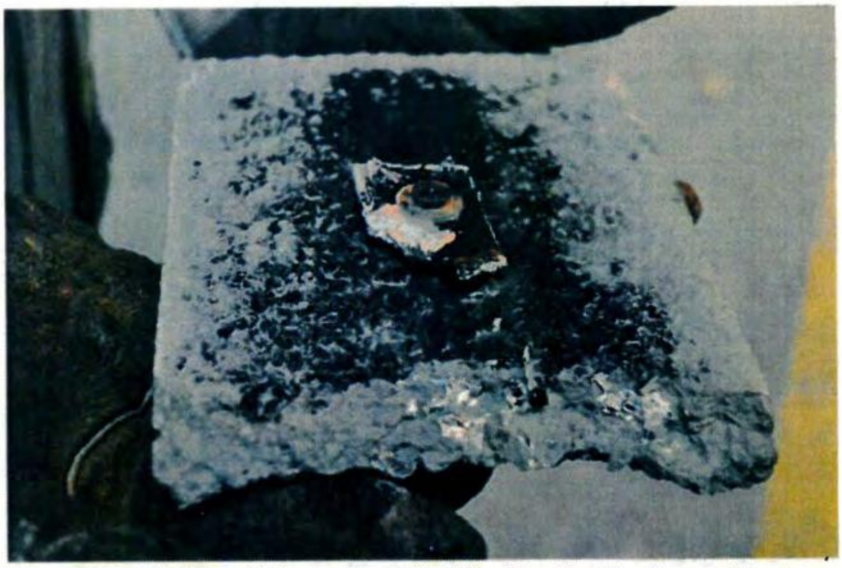

Fig. 26. View of elements which fell off in the 5th minute of test

Fig. 27. View of elements which fell off in the 8th minute of test

Fig. 28. View of elements which had fallen off before the 10th minute of test

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Fig. 29. View of the test element in the 11th minute of test

Fig. 30. View of the test element in the 12th minute of test

Fig. 31. View of elements which had fallen off before the 13th minute of test

Fig. 32. View of the test element in the 13th minute of test

Fig. 33. View of the test element in the 16th minute of test

Fig. 34. View of the test element which had fallen off by the 17th minute of test

Fig. 35. View of the test element in the 25th minute of test

Fig. 36. View of elements which had fallen off before the 26th minute of test

Fig. 37. View of the test element in the 32nd minute of test

Fig. 38. View of the test element in the 46th minute of test

Fig. 39. View of the test element in the 61st minute of test

Fig. 40. View of elements which fell off during the test – the weighed elements on the left

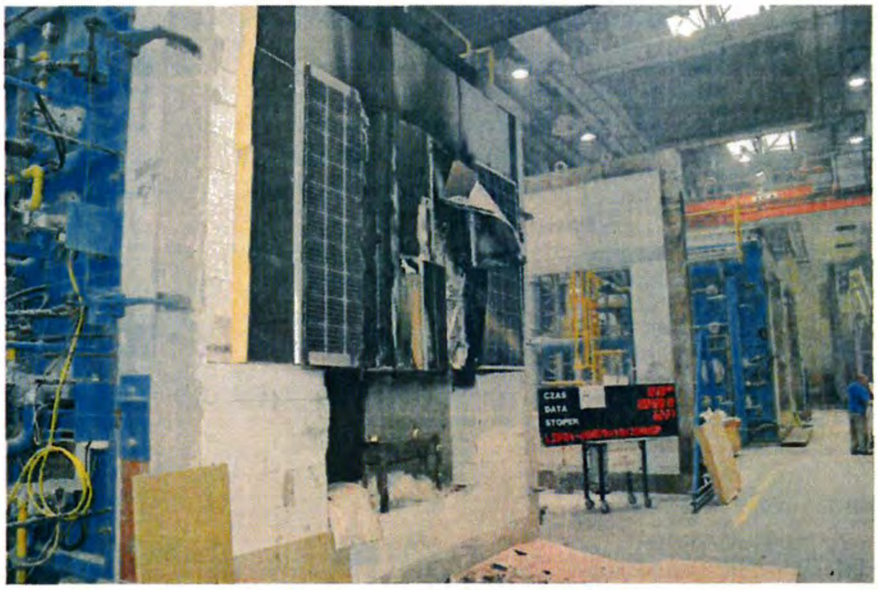

Fig. 41. View of the test element right after the test

Fig. 42. View of the test element after the test - details

Fig. 43. View of the test element after the test - details

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Fig. 44. View of the test element after the test - details

Fig. 45. View of the test element after the test - details

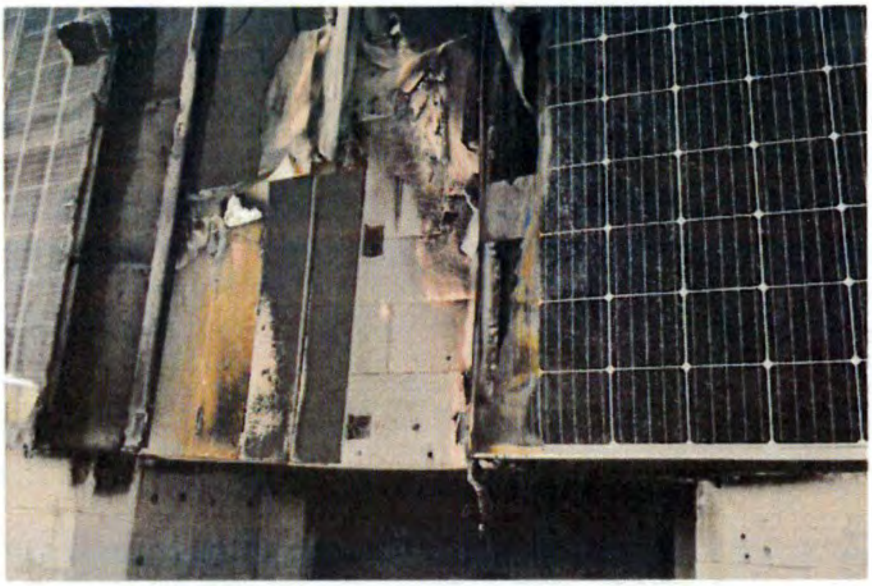

Fig. 46. View of the test element after the test - details

During the test, it was observed that fragments of panels crack and fall off. The details are provided in the description of the test and in the photos. Because of their location, the concrete panels numbered 8-13 in Fig. 15 were the most vulnerable to fire and temperature.
The support structure for the cladding, and the aluminium grid, located in the immediate reach of the burner, was being burned down gradually, dripping down in the form of burning droplets. Also the photovoltaic cladding, particularly element no. 4, was falling off in the form of burning fragments and droplets.
Apart from local deformations, the brackets maintained the integrity of their connection to the floor they were mounted to.
The glass wool directly above the burner, in the area of direct exposure to fire melted down completely. The rock wool became merely discoloured.

6 Analysis

The requirement resulting from the provisions of §225 [1] is intended to ensure the possibility of safe evacuation in the event of a fire, and effective rescue operations by the fire brigade teams. Considering the interpretation of the discussed provision by the Headquarters of the State Fire Service [2]:

> *"One should take into account all types of façade fragments (...) which can fall off during a fire on people who stay on the ground next to the building (...)"*

all the elements whose fragments may fall off and become a hazard shall be taken into account. Bearing in mind the types and varieties of facades actually in use in Poland, the very limited possibilities of a simultaneous compliance with all the basic requirements and the requirements of §225 [1], the Headquarters of the State Fire Service declared in its [2] interpretation:

> *"When assessing the fragments falling off façade cladding, one should consider their heat energy as an evaluation criterion. Elements of the size and heat able to cause injuries should be considered dangerous to the people being evacuated (...)"*

This provision means that it is admitted for low-heat energy elements to fall off etc. droplets of melted aluminium, small, round-shaped fragments of elevation cladding, etc., however, it is not admissible for large, sharp and heavy fragments of the façade to fall off, for example stone panels, concrete or ceramic panels, etc.
In consequence of the above, the Building Research Institute adopted an evaluation criterion of 5 kg for low and medium-high buildings (for a single falling element). Higher buildings shall always be subject to an individual assessment.

7 Technical evaluation of AGS ventilated façade systems

Based on the analysis of the obtained test results, the submitted technical documentation taken into account, it was evaluated that:

- **the fibre-cement panels** (of parameters not worse than those applied for the tests p. 5 described in opinion 02184/17/Z00NZP and in this paper), in the vertical arrangement, the load-bearing grid also in the vertical arrangement:

- located outside the clearance of the window, i.e. >300 mm, horizontally, from the vertical edge of the window, mounted with the use of adhesive agents: Bostik [5] or Proventus [6] glue, pursuant to the description given in points 4 and 5 of opinion no. 02184/17/Z00NZP and in this paper, to the AGS system substructure (stainless brackets, steel brackets with ZM coating, aluminium grid with or without steel reinforcement, steel grid with ZM coating), should keep their integrity in case of a fire, which means that proper conditions for the evacuation of people and work of rescue teams should be possible for a time no shorter than 120 minutes. Therefore in the light of § 225 of the Regulation by the Minister of Infrastructure of 12th April 2002 [1], such a solution shall be deemed safe;
- located in the clearance of the window, directly above it, i.e. up to 1000 mm from the upper edge of the window, mounted mechanically (rivets, threaded rivets, screws), with or without additional adhesive mounting (glued panels) with Bostik [5] or Proventus glue [6], pursuant to the description given in points 4 and 5 of the opinion 02184/17/Z00NZP and this paper, to the AGS system substructure (stainless brackets, steel brackets with ZM coating, aluminium grid without or with steel reinforcement, steel grid with ZM coating), can crack and break into relatively small pieces and fall off, which should be taken into account at the stage of designing. However, this should not be a danger for the evacuation of people and the work of rescue teams for the time no shorter than 120 minutes, and therefore in the light of § 225 of the Regulation of the Minister of Infrastructure of 12th April 2002 [1], this solution can be deemed safe. The opinion in this regard refers exclusively to low and medium-high buildings, pursuant to §8 [1].
- located in the clearance of the window >1000 mm from the upper edge of the window, or outside the clearance of the window, mounted mechanically (rivets, threaded rivets, screws), with or without additional adhesive mounting (gluing panels to the grid) with Bostik [5] or Proventus [6] glue, pursuant to the description presented in points 4 and 5, of opinion 02184/17/Z00NZP and this paper, to the AGS system substructure (stainless brackets, steel brackets with ZM coating, aluminium grid without or with steel reinforcement, steel grid with ZM coating), should maintain its integrity during a fire, which means that there should be proper conditions for the evacuation of people and work of rescue teams for the time no shorter than 120 minutes, and therefore in the light of § 225 of the Regulation of the Minister of Infrastructure of 12th April 2002 [1], this solution can be deemed safe.

– **sintered stone panels** (of parameters not worse than those applied in the test), in the vertical arrangement, load-bearing grid, also vertical:
  - located in the clearance of the window, but not directly above it, i.e. > 800 mm from the upper edge of the window, mounted mechanically (rivets, threaded rivets, screws), with or without additional adhesive mounting (glued panels) with Bostik [5] or Proventus glue [6], pursuant to the description given in points 4 and 5 of the opinion 02184/17/Z00NZP and this paper, to the AGS system substructure (stainless brackets, steel brackets with ZM coating, aluminium grid without or with steel reinforcement, steel grid with ZM coating), can break into relatively small pieces and fall off, which should be taken into account at the stage of designing. However, this should not be a

danger for the evacuation of people and work of rescue teams for the time no shorter than 60 minutes, and therefore in the light of § 225 of the Regulation of the Minister of Infrastructure of 12th April 2002 [1], this solution can be deemed safe. Opinion in this regard refers exclusively to low and medium-high buildings, pursuant to §8 [1].

- located outside clearance of the window, >300 mm horizontally from the vertical edge of the window, mounted adhesively with the use of Bostik [5] or Proventus [6] glue, pursuant to the description presented in points 4 and 5 of this paper, to the AGS system substructure (stainless brackets, steel brackets with ZM coating, aluminium grid without or with steel reinforcement, steel grid with ZM coating), should maintain its integrity during a fire, which means that there should be proper conditions for the evacuation of people or work of rescue teams for the time no shorter than 60 minutes, and therefore in the light of § 225 of the Regulation of the Minister of Infrastructure of 12th April 2002 [1], this solution can be deemed safe.
- located in the clearance of the window, >1800 mm from the upper edge of the window, or outside the clearance of the window, mounted mechanically (rivets, threaded rivets, screws), with or without additional adhesive mounting (gluing panels to the grid) with Bostik [5] or Proventus [6] glue, pursuant to the description presented in points 4 and 5 of this paper, to the substructure of AGS system (stainless brackets, steel brackets with ZM coating, aluminium grid without or with steel reinforcement, steel grid with ZM coating), should maintain its integrity during a fire, which means that there should be proper conditions for the evacuation of people or work of rescue teams for the time no shorter than 60 minutes, and therefore in the light of § 225 of the Regulation of the Minister of Infrastructure of 12th April 2002 [1], this solution can be deemed safe.

- **photovoltaic modules** (of parameters not worse than those applied for the test), in the vertical arrangement, load-bearing grid also vertical:
  - frameless modules located partially in the clearance of the window, but not directly above the source of fire, i.e. ≤ 300 mm horizontally from the vertical edge of the window, mounted adhesively with the use of Bostik [5] or Proventus [6] glue, pursuant to the description presented in points 4 and 5 of this paper, to the AGS system substructure (stainless brackets, steel brackets with ZM coating, aluminium grid without or with steel reinforcement, steel grid with ZM coating), will gradually melt down during a fire (this refers to the parts above the window) and fall down as small, burning pieces or droplets, which should be taken into account at the stage of designing. It is evaluated that this should not make impossible the evacuation of people and work of rescue teams for the time no shorter than 60 minutes, and therefore in the light of § 225 of the Regulation of the Minister of Infrastructure of 12th April 2002 [1], this solution can be deemed safe. Opinion in this regard refers exclusively to low and medium-high buildings, pursuant to §8 [1].
  - modules with frames located partially in the clearance of the window, but not directly above the source of fire, i.e. ≤ 300 mm horizontally from the vertical edge of the window,

mounted mechanically (rivets, screws), without additional adhesive mounting), pursuant to the description presented in points 4 and 5 of this paper, to the AGS system substructure (stainless brackets, steel brackets with ZM coating, aluminium grid without or with steel reinforcement, steel grid with ZM coating), will gradually melt down during a fire (this refers to the parts above the window) and fall down as small, burning pieces or droplets (however, the destruction is less widespread than in the case of frameless modules), which should be taken into account at the stage of designing. It is evaluated that this should not make impossible the evacuation of people and work of rescue teams for the time no shorter than 60 minutes, and therefore in the light of § 225 of the Regulation of the Minister of Infrastructure of 12th April 2002 [1], this solution can be deemed safe. Opinion in this regard refers exclusively to low and medium-high buildings, pursuant to §8 [1].

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- **composite panels** (of parameters not worse than those applied in the test), in the vertical arrangement, load-bearing grid also vertical):
    - located partially in the clearance of the window, but not directly above it, i.e. > 1800 mm from the upper edge of the window, mounted mechanically (rivets, screws), with or without additional adhesive mounting (glued panels) with Bostik [5] or Proventus glue [6], pursuant to the description given in points 4 and 5 of this paper, to the AGS system substructure (stainless brackets, steel brackets with ZM coating, aluminium grid without or with steel reinforcement, steel grid with ZM coating), may become deformed during a fire, melt and fall down as droplets, which should be taken into account at the stage of designing. However, this should not be a danger for the evacuation of people and work of rescue teams for the time no shorter than 60 minutes, and therefore in the light of § 225 of the Regulation of the Minister of Infrastructure of 12th April 2002 [1], this solution can be deemed safe.
- **steel cladding** (of parameters not worse than those applied in the test), in the vertical arrangement, load-bearing grid also vertical:
    - located partially in the clearance of the window, i.e. > 500 mm from the vertical edge of the window, and partially outside the clearance of the window, and > 1800 mm from the upper edge of the window, mechanically mounted (rivets, screws), with or without additional adhesive mounting (gluing panels) with Bostik [5] or Proventus glue [6], pursuant to the description given in points 4 and 5 of this paper, to the AGS system substructure (stainless brackets, steel brackets with ZM coating, aluminium grid without or with steel reinforcement, steel grid with ZM coating), should maintain its integrity during a fire, which means that there should be proper conditions for the evacuation of people and work of rescue teams in the time no shorter than 60 minutes, and therefore, in the light of § 225 of the Regulation of the Minister of Infrastructure of 12th April 2002 [1], this solution can be deemed safe.
- **glass-reinforced concrete panels** (of parameters not worse than those applied in the test), in the vertical arrangement, load-bearing grid also vertical:
    - GRC panels located directly above the clearance of the window, mounted mechanically with or without additional adhesive mounting (gluing panels to the grid) with Bostik [5] or Proventus glue [6], pursuant to the description given in points 4 and 5 of this paper, to the AGS system substructure (stainless brackets, steel brackets with ZM coating, steel grid with ZM coating) to the steel grid (tests with the aluminium grid were unsuccessful), càn become deformed for a fire (the grid), however, they will maintain their integrity. In consequence of the above, it is evaluated that this solution should not be a danger for the evacuation of people and work of rescue teams for the time no shorter than 60 minutes, and therefore in the light of § 225 of the Regulation of the Minister of Infrastructure of 12th April 2002 [1], this solution can be deemed safe.
    - since the criteria have been met by GPR cladding nr 10 i 11 in the window head area – which is most vulnerable to fire and heat, the above-mentioned GPR panels solution may be used across the entire façade.
- aluminium grids of AGS substructure systems, to which the above-mentioned panels are mounted, may gradually melt down and fall as small pieces or droplets, however, due to the stainless steel reinforcement strips in AGS profiles types T* and L*, they are able to provide a durability of mounting of 120 minutes, which should not pose a direct danger for the evacuation of people and work of rescue teams for a time no shorter than 120 minutes.

- The stainless steel brackets, steel brackets with anti-corrosion ZM coating and steel grid with anti-corrosion ZM coating of the AGS substructure systems to which the above-mentioned cladding is mounted, do not melt. As a result of this, they are able to provide a durability of mounting of 120 minutes, which should not pose a direct danger for the evacuation of people and work of rescue teams for a time no shorter than 120 minutes.
- The maximum spacing of mechanical couplings used for mounting the cladding vertically, and the maximum spacing of vertically laid grids must not exceed the dimensions given in this paper and in Fig. 8 of opinion 02184/17/200NZP.
- The minimum distance of holes for mechanical couplings from the edges of panels shall be compliant with the instructions provided by the cladding manufacturer.
- It is admitted to use as mechanical couplings (rivets, threaded rivets, anchors for mounting the brackets, etc.) the couplings specified in this document, in opinion 02184/17/Z00NZP and others, of the fire-resistance and durability parameters not worse than in the case of the above-mentioned ones.
- It is admitted to use other non-combustible rock mineral wool or glass wool as thermal insulation than those mentioned in the opinions, but with no less density, except for the brackets to mount the substructure (steel, stainless steel AGS systems), which may be placed in the thermal insulation layer made of rock mineral wool or glass wool of any density. In the case of AGS grid supported on steel brackets with ZM coating, or stainless steel ones, the grid does not have to be inside the insulation layer that protects against high temperatures. As a result of this, the maximum or minimum width of the air gap between the insulation layer and the façade cladding shall not be specified. The rock mineral wool or glass wool in the area of mounting does not require any additional mechanical mounting. This function is performed by the stainless steel brackets or steel brackets with ZM coating.
- The general rule for the above-panels is as follows: use mechanical couplings in the areas directly exposed to fire, where it is recommended to place them more densely in the case of cladding which is prone to cracking, and to use solutions to limit the spread of fire in the ventilation gap between the thermal insulation and the façade cladding, for example, by using steel sheet reveals.
- The grid and aluminium brackets, both non-passive and passive types, constructed and mounted together with cladding and insulation as described in point 4.2 (directly above the source of fire) did not maintain their durability even for 30 minutes, which is the minimum criterion for buildings of fire class C and D. However, this result was directly caused by the mounting method, and by the arrangement of the façade and its insulation, as described in point 4.2.

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8 Final comments

The technical evaluation shall be valid indefinitely, provided that no technical or material changes are made to the technical solutions of the **AGS** substructure systems. Opinion as to the selected solutions described in point 7 applies only to low and medium-high buildings, pursuant to §8 [1].

Drawn up by:

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Warsaw, 8th June 2019

(last page of the paper)

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