Comparative analyze of thermal and tension strength properties of Alpolic and Durabond aluminum composite panels, case study Tirana, Albania

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***Abstract*— The focus of the paper is the comparison between the two composite aluminum panels, respectively Alpolic and Durabond. The paper is going to explore their reaction when interacting with Tirana`s climatological factors and their tension strength through an experiment, in order to find out which panel displays the best performance.**

The construction urge is constantly evolving, especially in Tirana mostly because it is the main industrial and economical district of Albania. It is distinguished that innovative technology is being used in facades of the new buildings. One of the features that finds massive use in façade coating in the city is the application of ventilated facades equipped with external aluminum composite panels.

This paper is going to deal with two buildings with different typology of external coating, including the different types of aluminum panels. The analysis will focus on identifying each panels property such as: tension strength; their respond to various external factors; their thermal conductivity; and their manufacturing companies which have been selected and produce them.

Within this paper graphics displays of the records will be included, offering concentrated information and high level of reliability for both aluminum composite panels.

***Keywords*— Alpolic; Durabond; Tension strength; Comparative analyze; External climatological factors**

I. INTRODUCTION

A. History of aluminum panels

ACP dates back to 1960 where Swiss studies have created two aluminum sheets linked with other materials that formed genuine composite aluminum. Initially, they were used for signaling purposes. Aluminum panels had the first report on the market from the company ALUSINGEN. In 1980 it was considered a breakthrough in the architecture and construction industry. [1] [2] The development of advanced materials and their combination was introduced to fill the gaps and industrial market needs. Composite aluminum panels layers are joined in order to increase their efficiency in terms of weight, cost, quality and high structural performance. [3] The use of ventilated facades in Albania has started in the last two decades. Until the 90s the interest in the exterior architecture of buildings was minimal. Recently the aluminum ventilated facades have been used in Tirana in order to increase the architectural and in the same time the aesthetic performance of the city. In the last 5 years the use of aluminum panels has become a trend as a result of the advantages that these panels provide in terms of insulation, thermal performance, fire resistance, and light weight.

B. Structure of aluminum panels

The aluminum panel consists of two aluminum sheets and an inner core. The two aluminum sheets are prefabricated with a thickness of 0.5mm each. The total thickness of the panel goes up to 4 mm, which varies depending on their use. Aluminum panels are used in different types of buildings which are distinguished for their colors, sizes, and shapes. [2] Installation methods of these ACPs in the structure is done by: Wet Sealant Joint, Hanging Method, Dry Gasket Joint, Narrow Open Joint [5] The hanging method is one of the most common methods of installing ACP sheets. [4]

C. Behavior during a building fire, wind and corrosion

The globalization of the use of aluminum panels has increased significantly, especially their application in ventilated facades. In the last decade it is worth mentioning the fact that these facades in most cases were flammable and have had mass casualties and property burnings. In 2017, the Grenfell tragedy took place, where the initiative was taken to test every panel that would cover the facades of buildings. Although successive tests were performed, obtaining information on the burning capacity of the panels was difficult as the collection information was scarce. The fire behavior of facades lined with aluminum panels is under constant study. [6]

Aluminum Panel shows negative impact against wind and corrosion, only in cases when happen breakdown of matrix connections. The wind affects negatively because it scratches the panels. The force which various objects can strike the building has such consequences. [9] While corrosion rarely happens only when there is a defect during the processing of the matrix. In these cases, a reaction occurs between the reinforcement and the matrix. An interfacial phase is formed which may be anodic or cathodic to the panel and may undergo preferential corrosion. [10]

II. Comparative analyze between Alpolic and Durabond

Alpolic is an aluminum composite material composed of aluminum sheets and polyethylene cores or fire-resistant cores. These types of panels are applicable and in extensive progress in the field of architecture. Alpolic aluminum composite panels are suitable for ventilated facades with a sophisticated design, but also for interior or other exterior applications in the building. The product is ideal also for new renovation projects. The great efficacy of alpolic is closely related to some typical features of this product as follows [7]:

- Excellent flatness.
- Wide variety of colours and designs.
- Consistent colour and designs.
- High-quality surface coating with LUMIFLONTM.
- High rigidity.
- Low weight.
- High durability.
- Impact and fracture resistant.
- Corrosion, weather, UV-resistant.
- High flame resistant.
- 100% recyclable.

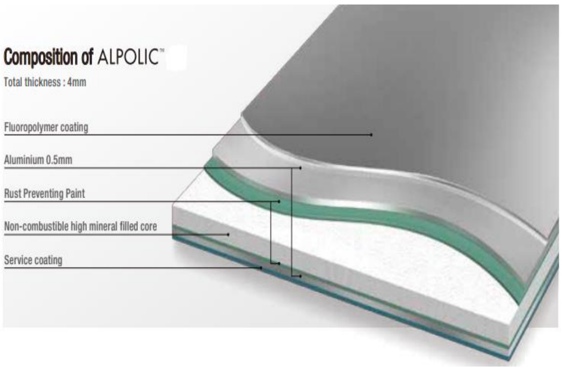

Fig. 1- Components of the Alpolic panel (Source [7])

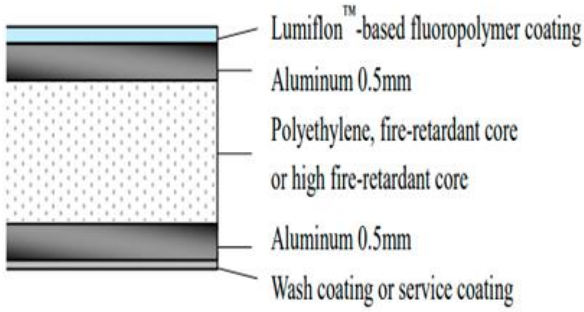

Fig. 2- Components of the Alpolic panel (Source [7])

Durabond Composite panel is a construction metal which consists of LDPE (low density polyethylene) matrix, and two aluminum plates, which cover the matrix. These three plates are adhered together by means of coating edge technology.

Although DURABOND composite panel is made of lightweight aluminum, it shows great performance and mechanical characteristics.

Despite the fact that it is lighter in weight and thinner compared to other composites used for facade, it has good mechanical characteristics and shows great performance. Some of its advantages are:

- Smooth surface
- Double panels
- Takes short time to install
- UV resistance
- Variety of colors and design
- Easy to carry
- Lighter in weight
- 100% recyclable
- Economic compared to its benefits
- Fire resistant

Aluminum upper sheet: 0.35 mm thick; aluminum lower sheet: 0.35 mm thick; LDPE: 3.2 mm thick; PVDF + protective tape + adhesive = 1 mm. Total thickness of composite panel 4 mm

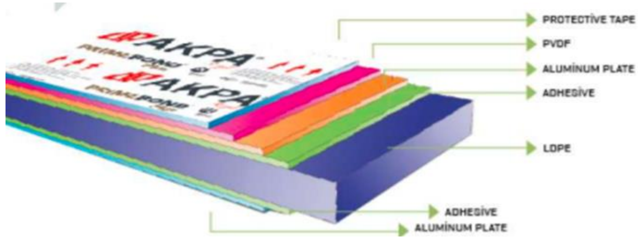

Fig. 3- Components of the Durabond panel (Source [8])

TABLE I

TEST DATA	ALPOLIC	DURABOND
0.2%Proof Stress	44.72N/mm^2	41.43N/mm^2
Modules of Elasticity	38500 N/mm^2	7793 N/mm^2
% Elongation	3.8	28.6
Bending Elasticity	42000 N/mm^2	49000 N/mm^2
Punching shear resistance	27600 KPa	10360 KPa
Sound Transmission Loss (Rw)	25 db	29 db

Table 1. Comparison of mechanical specifications between the composite panel of ALPOLIC and DURABOND (source Authors)

III. EXPERIMENT 1

The residential buildings taken in consideration are the Square 21 complex and the Future Home Residence, located in Tirana.

Fig. 3 – ``Square 21``, location: Tirana, Albania (Source: Google Map)

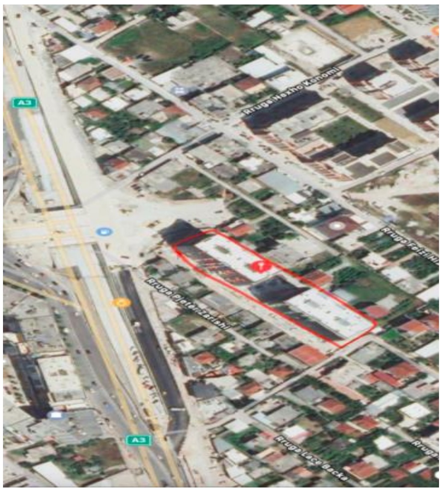

Fig. 4 – ``Future Home Residence``, location: Tirana, Albania (Source: Google Map)

Both buildings are equipped with ventilated facades, with external layer of aluminum composite panels but from different brands. The purpose of this experiment is comparative and evidentiary.

ALPOLIC and DURABOND aluminum composite panels are composite panels with physical-mechanical capabilities and similar characteristics, since their matrix composition and other layers are relatively similar.

ALPOLIC in its matrix has a polyethylene composition of 4 mm thick which is covered by 2 layers of thin aluminum on both sides, bottom and top.

DURABOND similar to ALPOLIC, its composite matrix consists of a layer 3.2 mm thick LDPE (low density polyethylene), which is also covered by two layers of 0.35 mm thick aluminum, both from below and above.

Due to the small differences of their matrix core, the experiment consists in the performance of both composite panels against temperature.

The experiment was performed using the Infrared Thermometer Temperature Gun MESTEK Non-Contact Laser Digital Thermometers with Color LCD Screen (-50℃ - 380℃) Adjustable Emissivity, which measures the temperature of the surface of the building, specifically, aluminum panels and the wall in the interior of the environment covered by the ventilated façade and by the composite panel. 4 specific measurements were performed at 4 different times, specifically at 8:00, 12:00, 16:00 and 20:00, is with a time interval between measurements of 4 hours.

Measurements were performed both on the surface of the facade of the aluminum panel ALPOLIC; DURABOND, as well as in the interior of the building.

Fig. 5.A-
Alpolic panel installed in the façade (Source: Authors)

Fig. 5.B- Detail of Alpolic installation (Source: Authors)

Fig. 5.C- Photo of the device used for the experiment (Source: Authors)

Fig. 5.D- Durabond panel installed in the façade (Source: Authors)

It should be noted that in the interior, there were no other devices with the function of cooling or heating the environment, to affect the increase or decrease of temperature on the wall surface.
Both wall cuts consist of an internal plaster composition, poor mortar, perforated brick, masonry-fixed membrane and stone wool.

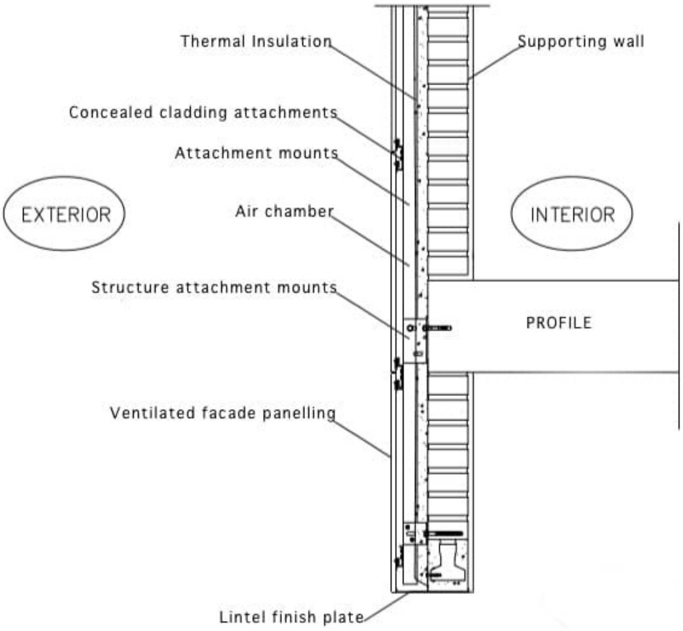

Fig. 6- Constituent layers of building facades (Source: Authors)

The duration of the experiment is 1 day and from the measurements performed, it results as follows:

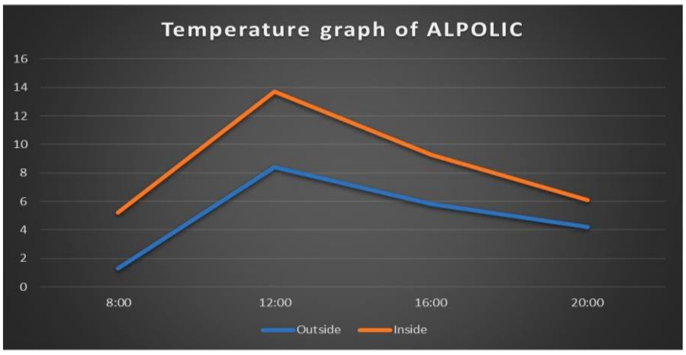

Chart 1 – External & internal temperature level measurements at Square

	8^{00}	12^{00}	16^{00}	20^{00}
Outside	1.3℃	8.4℃	5,8℃	4.2℃
Inside	5.2℃	13.7℃	9.3℃	6.1℃

21, Tirane, Albania. 26 January 2022, (Source: Authors)

Table 2. Comparison of temperatures at specific times of day in the indoor and outdoor environment where ALPOLIC panels are installed.(Source: Authors)

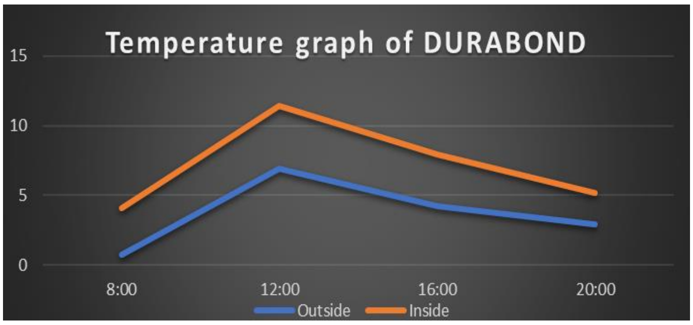

Chart 2 – External & internal temperature level measurements at Future Home Residence, Tirane, Albania. 26 January 2022, (Source: Authors)

	8^{00}	12^{00}	16^{00}	20^{00}
Outside	0.7°C	6.9°C	4.2°C	2.9°C
Inside	4.1°C	11.4°C	7.9°C	5.2°C

Table 3. Comparison of temperatures at specific times of day in the indoor and outdoor environment where DURABOND panels are installed. (Sourse:Authors)

IV EXPERIMENT 2

The objective of this experiment is to compare the tensile strength of the two panels mentioned above.

Fig. 7.A- The equipment used for the experiment (Source:Authors)

Fig. 7.B- The equipment used for the experiment (Source:Authors)

Fig. 7.C- Alpolic panel applied in the equipment (Source: Authors)

Fig. 7.D- Durabond panel applied in the equipment (Source: Authors)

From each panel are taken two samples specifically 2 thin strips with a thickness of 20 mm and the respective length of each panel were cut from the samples taken. The dimensions of the Alpolic panel are 18mmx4mmx307mm, with a section size of 72 mm2. Meanwhile the Durabond panel dimensions are 18mmx4mmx378mm, with a section area of 72 mm2.
The dimensions of the samples are selected in order to fulfill the standards for the experiment. They are caught by the machine's jaws, which have 50 mm at their ends, to ensure that the samples are inserted without being destroyed in the seized part.
The traction force begins at zero and gradually grows until the champion is destroyed. It has been reached the maximum traction force that the Alpolic and Durabond panels can resist at this precise moment.
According to the experiment the Alpolic works better in plastic phases and has a higher rigidity than Durabond. The way of its destruction is shown in the figures below.

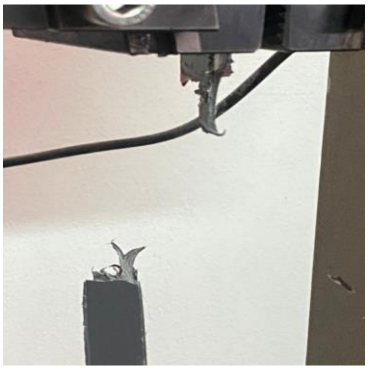

Fig. 8.A-Fracture point of Durabond panel (max resistance) (Source:Authors)

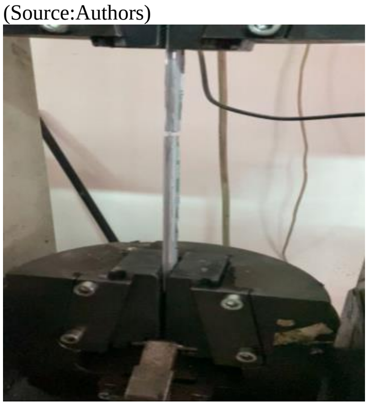

Fig. 8.B-Fracture point of Alpolic panel (max resistance) (Source:Authors)

On the other hand, Durabond panel works better in the elastic phase than in the plastic phase, furthermore the way it is destroyed has a specific shape.
The results of the experiment are shown below:

TENSILE STRENGTH IN METALLIC ELEMENT						
(UNI EN 10002&10065) REFERENCE BS 4483:2005						
PRISMATIC ELEMENTS OF ALUMINIUM-DURABOND COMPOSITE						
NO	Prism 18*4 [mm]	Length L [mm]	Width A [mm]	Height B [mm]	Nominal Cross-Sect.area (An) [mm²]	Tensile Strength (Rm) [N/mm²]
1	18*4	378	18.00	4.00	72.00	77.0
2	18*4	378	18.00	4.00	72.00	77.5

Table 4 – Durabond panel test results, (Source: ``A.L.T.E.A. & GEOSTUDIO 2000``)

TENSILE STRENGTH IN METALLIC ELEMENT						
(UNI EN 10002&10065) REFERENCE BS 4483:2005						
PRISMATIC ELEMENTS OF ALUMINIUM-ALPOLIC COMPOSITE						
NO	Prism 18*4 [mm]	Length L [mm]	Width A [mm]	Height B [mm]	Nominal Cross-Sect.area (An) [mm²]	Tensile Strength (Rm) [N/mm²]
1	18*4	307	18.00	4.00	72.00	75.1
2	18*4	307	18.00	4.00	72.00	72.2

Table 5 – Alpolic panel test results, (Source: ``A.L.T.E.A. & GEOSTUDIO 2000``)

V CONCLUSIONS

1-According to the first experiment, from the field temperature measurements carried out in the southwestern part of the facade, approximately in the same time frame, for both buildings with different composite aluminum panels, the "Alpolic" aluminum panel, performs better than Durabond in terms of thermal conductivity with an average difference of 1.5 ° C.

2-Based on the results obtained from the laboratory tests `` BS 4483`` it results that both Alpolic and Durabond aluminum panels have almost the same tensile strength with a very small difference in favor of Durabond.
It is worth mentioning the fact that the Durabond panel also works more in the elastic phase than in the plastic one, according to the performed experiment.

REFERENCES

[1]. AL179 AshTech Ashcolit:A4/Rajeshreddy Gudla
[2].Priyanka Mohaney,Er Gaurav Soni (2018) Aluminium composite panel as a facade material/ International Journal of Engineering Trends and Technology(IJETT)Vol.55Nr.2
[3].Rajeshkumar Gangaram Bhandare, Parshuram M. Sonawane(2013) Preparation of aluminium matrix composite by using stir casting method/International Journal of Engineering and Advanced Technology (IJEAT)/ISSN:2249–8958,Vol.3,Issue-2
[4].Stefano Bellucci/2020/ Processing methods and mechanical properties of aluminium matrix Composites/ Advances in Materials Science and Engineering / Vol. 2020 |Article ID 3765791
[5].Eric Guillaume,Talal Fateh,Renaud Schillinger,Roman Chiva,Sebastian Ukleja(2018)Study of fire behaviour of facade mock-ups equipped with aluminium composite material-based claddings, using intermediate-scale test method/ Wiley Online Library/Vol.42, Issue5
[6].Eric Guillaume, Talal Fateh, Renaud Schillinger, Roman Chiva, Sebastian Ukleja, Roy Weghorst(2018) Intermediate-scale tests of ventilated facades with aluminium-composite claddings/ Journal of Physics Conference Series1107(3):032007/DOI:10.1088/1742-6596/1107/3/032007
[7].Alpolic Technical Manual /2017Mitsubishi Chemical Corporation/No.L01343P3140.
[8]. Durabond Technical Data Sheet/ 2018 www.akpaas.com.tr
[9].Mahil Pathirana,Nelson Lam,Shihara Thimanthi Perera,Lihai Zhang,Dong Ruan,Emad Gad/ Modelling of damage to aluminium panels by windborne debris(2016) The 8th International Conference on Steel and Aluminium Structures (ICSAS 2016)
[10].Zamri Bin Yusoff, Shamsul Baharin Jamaludin, Khairel Rafezi Ahmad(2006)Corrosion of aluminium matrix composites/ National Metallurgical Conference (2006)/DOI:10.13140/2.1.1367.4880)