НАУЧНЫЕ ИССЛЕДОВАНИЯ СЛОЖНЫХ МЕХАНИЧЕСКИХ СИСТЕМ

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THE PROCESS OF THE CONSTRUCTION OF STRUCTURE AND FIXING GLASS ON THE CURTAIN WALLS

The article summaries the process of design and building of the curtain walls. The first part includes a brief description of the advantages of these constructions compared to the traditional ones. Profiles of ALUMIL S.A. Company have been taken as an example. Next part is focused on the most useful systems of the curtain walls and their constructive aspects. Active loads and deformations are defined. The last part includes data of the component parts of the curtain walls, their composition and ways of selection.

Introduction. This article draws attention to the design and construction. The advantages are also important for deep study and precise calculation for static and dynamic elements in continued facade as modern technology.

Systems and fundamentals. Construction of skyscrapers needs improvement or replacement of the classic constructive materials (brick and stone) with new ones, easier through mounting and lighter, like combination of glass and aluminum used for construction continued facade.

Such structures have the following advantages: overall structure can be constructed in a shorter period to accomplish the economic objectives. It is easy to fit the surrounding environment with the buildings, its fluxional and the constructive cost is relatively low. Materials used in such cases have a long life and maintenance expenses are low. Continued facade imposed the grandiosity to the end-users. They allow the natural light enter the buildings, make possible an open view from the inside, ensure very good insulation from noise and considerably reduce thermal exchange. All this benefits will assure only through a very good architectural project and precise calculation for the construction [9, 10].

The variety of ALUMIL S.A. series and profiles give us the conformity to construct even the most difficult forms and further to create new forms for the different difficult issues we face during the constructive process. Studies and projections done during the preparation phase, make us possible to accomplish the mounting phase and save considerable time during the montage period. Some of the construction we have realized are in figure 1 [1–3].

The aluminum profiles of ALUMIL S.A. are projected in the way that give the durability during the functions and guarantees. In such comfort conditions we realize an esthetic view, as in the models showed in figure 1, *a–d*, also constructing in the best way the slope surfaces, spherical surfaces, different inside and outside angle, etc.

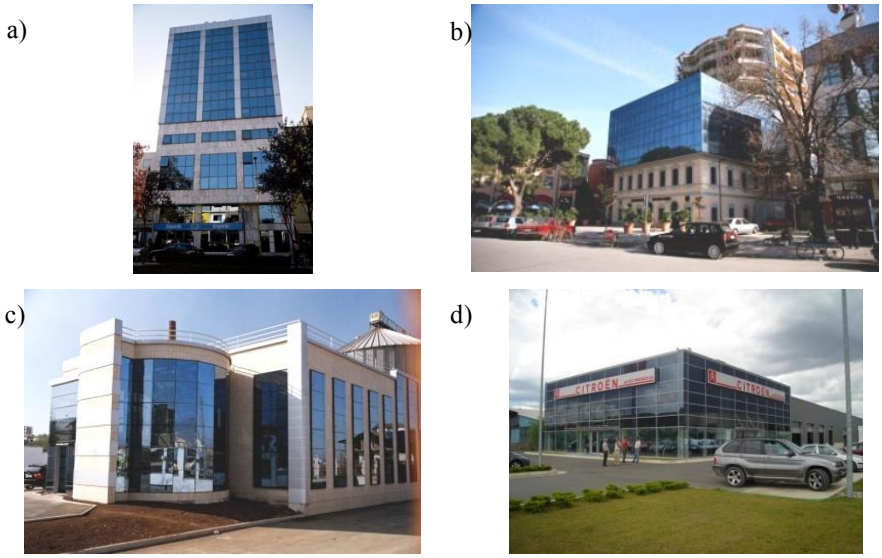


Figure 1 – Some of the construction we have realize

Facade systems. Construction of the continued facade needs in any case a special study and it is a very delicate job. Refer to this study we have decided on the view of the buildings, we have set the technical dimensions of construction and realized the proper engineering calculation which consists of careful static and dynamic calculations [4–7]. In order to accomplish the constructive calculation in the right way in accordance with produced diagrams, we have to follow each detail given and foreseen in the project for the building with the high precision. We have to realize calculation in order to face full and exactly all tensions occurred in the structure sourced from the tendencies for deformation and bending arrows as object construction. Aluminum profile dimension mainly depends on the mechanical pa-

rameters we have accepted such as glass weight, air depression, building architecture. Tolerances motivated from "economical" reasons are prohibited due to the undesirable high risks they can generate.

Standard Solar Facade Serial ALUMIL M1. The main vertical and horizontal columns are mounted in the inner side, then one or two glass layers (usually two layers) are captured with proper elastic elements and the cover that accomplished structure. From the outside you can see one aluminum strip 55 mm width which can be of different geometric forms and color in order to be fit with the architectural selection (figure 2, *a*, *b*). Such construction type has been successfully implemented at the building in Kavaja street (figure 1, *a*) and in the many others cases [1–2].

It is very easy to mount such facades compared to other types but they generate more problems during the maintenance period. Meantime we should be very careful during the insulation process.

a) b)

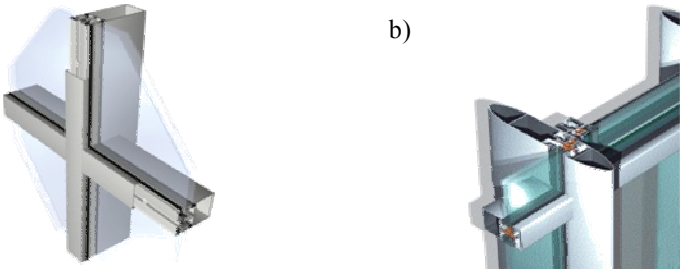


Figure 2 – Standard Solar Facade Serial ALUMIL M1

Semi Structural Solar Facade Serial ALUMIL M3. The difference from the above mentioned system consists in the outside view in both directions: vertical and horizontal, we can see just a small strip of aluminum, wide enough to ensure the glass keeping figure 3, *a*. Such construction type has been successfully implemented at the building in figure 3, *b* [1, 3].

a) b)

Figure 3 – Semi Structural Solar Facade Serial ALUMIL M3

Structural Solar Facade Serial ALUMIL M4. This is a well known type of continued facades «structural spacer glazing system» figure 4 it is very difficult to see the aluminum profile. We use special glue for the construction [1, 3].

In all above mentioned structures we can also use thermal aluminum profiles. They do not change any constructive elements or calculation, except the increasing thermal insulation ability of facades, figure 4, *b*.

a) b)

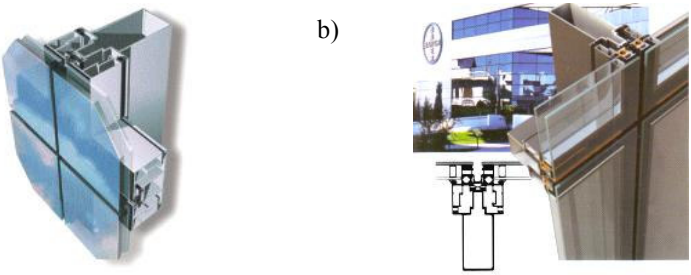


Figure 4 – Structural Solar Facade Serial ALUMIL M4

Acting loads and deformation.

a) loads sourced from the air compression are linked closely with building height, place and orientation, etc. [3–5];

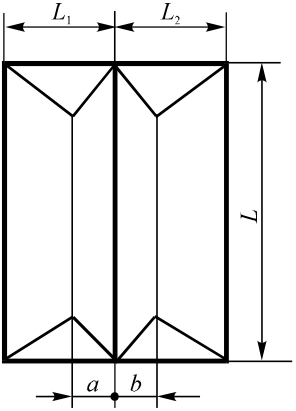
b) loads sourced from weights of the compound elements of the facades such are glass, panels, etc. These loads are categorized in two compounds which have their respective acting points in 1/2 and 1/10 of the horizontal columns. It is clear that the materials transmit their weight forces to holding profile; practically it is impossible to calculate the exact influence of those materials [3–5].

c) there is a minimum permit for bending arrow, showing the air pressure which should be less than 1/300 of the columns length (figure 1). Potential deformation permitted should be in that size that cannot act in the opening windows of facades and meantime to assure protection from water and air [3, 4].

Selection of the appropriate profile for the mullion. In the absence of a special agreement between the designer and the client, Euro code 9 sets specific limits in terms of deformation, which must not be exceeded. Based on Euro code (ENV 1999-1-1, Design of aluminum structures), the European EN 13830 makes special reference on the serviceability limits of aluminum structures concerning resistance to wind load.

Specifically for curtain wall mullions and transoms, the following limits for the elastic deflection have been set: L / 200 or 15 mm, whichever is less, where L is the length between supports. This selection of the proper profile was based on the condition for the maximum acceptable deflection of a beam supported at two $f \leq H / 200 \leq 15$ mm.

The following formula for the necessary moment of inertia results from this condition:



$$J_{\min} = \frac{q_w \alpha H^4}{1920 E f_{\max}} \cdot \left[25 - 40 \cdot \frac{\alpha^2}{H^2} + 16 \cdot \frac{\alpha^4}{H^4} \right],$$

$J_{\max}$ – moment of inertia;
q_w – wind load;
α – width $L/2$;
H – mullion height;
E – elasticity modulus;
$f_{\max}$ – maximum reflection;

The first step of the selection of the proper mullion profile must be the selection of the appropriate wind load value W_e, used for the calculation depending on the construction height and the influence of the wind pressure on the structure (table 1).

Table 1 – **Wind load values**

Structure Height, m	Wind pressure w, kN/m²	Wind load W_e for c = 1,2, kN/m²	Wind load W_e for c = 1,6, kN/m²
0–8	0,50	0,60	0,80
8–20	0,80	0,96	1,28
20–100	1,10	1,32	1,76

Parameter c is an additional safety factor:

$$W_e = c\ w,$$

c = 1,2 for non wind exposed building; c = 1,6 for wind exposed building.

In the table from the catalog we may use a recurrent moment of inertia of a mullion referring to a wind load of 1,0 kN/m² applied on one side of the structure. For any other wind load value, each cell of the table must be multiplied by this value. E.g. for a 0,6 kN/m² wind load value each cell of the table must be multiplied by a 0,8 factor.

Calculation. The calculation for the curtain walls is in figure 5. Data: building height 18 m; safety factor 1,6; length between supports 3,4 m; left side 0,8 m; right side 0,8 m.

For a 18 m building with a safety factor of 1,6 (for a wind exposed building), the design value of wind load is 0,8 kN/m². Using table 1 we get one value of the moment of inertia, so we have the same dimension for each side of the mullion. These values must be multiplied by 0,8. Then we add these values. Finally we se-

lect from the catalog table appropriate mullion profile keeping in mind that the moment of inertia I_x of this mullion must be greater than the sum $(I_1 + I_2)$.

In the table for $H = 3{,}4$ m and $L_1 = 0{,}8 / 2 = 0{,}4$ m, the moment of inertia is 85,7 cm^4, $I_1 = 0{,}8 \cdot 85{,}7 = 68{,}56$ cm^4, $I_2 = 0{,}8 \cdot 85{,}7 = 68{,}56$ cm^4.

From the table we select the profile M9951, which has a moment of inertia $I_x = 222{,}41$ cm^4 greater than the sum $(I_1 + I_2)$.

Figure 5 – Semi Structural Solar Facade Serial ALUMIL M3 alutherm

Continued Facade elements

Support. Supports are set in proper places, in horizontal and vertical lines, in accordance with construction conditions and controlling the facade plan. The plane control for supports is carried out simply through the common methods in vertical and horizontal directions and crosses the diagonals of the facade.

Aluminum columns are mounted to the supports in vertical way, in some cases we can mount even in horizontal line. They are mounting between two floors. Column length varies from 6 to 6,5 m and must have at least two anchorage points.

Project must assure some possibilities for small dislocation (up-down-front-behind) depending on the defects appeared from the construction facade level. This is the reason why they are produced with elliptical holes.

Materials are aluminum, thickness up to 8 mm, special content 6005 A F26 and of high durability.

Vertical and Horizontal aluminum parts. The base construction consists of aluminum profile, these are going up with facade in vertical waw (colons) and in horizontal. There are elements within columns which are cross-linked with columns.

The architectural study and statics as well as dynamic calculations on structure are decided on forms and dimensions of those parts.

The columns heights in figure 1 are linked directly with calculation. The height should be chosen at the very beginning and depends on loads and architectural area distances we can decide on horizontal lengths. The accepted expansion coefficient of the aluminum content parts used in profile production is based on formula $a = 23 \cdot 10^{-6}$ for each °C. Based on the expansion coefficient we should calculate a displacement of 1,4 mm per meter in the condition of temperature diapason from –10 up to +50 °C.

The width of columns is comfortable to using requirements. This dimension affects directly glass hold.

Axiliaries equipment for links. Equipment used for linking different aluminum parts is made from aluminum mark 6005A F26. It prevents any damage of those part from corrosion and is a guarantee of the sustainable linkage.

All screws contacting with aluminum are made from stainless or galvanized steel.

Hermetic rubber. All water flows must run in the direction of the outside of facade. In order to accomplish such condition the hermetic rubber must be set in the proper way.

All hermetic rubber used for assuring hermetically and elasticity purposes within aluminum parts and accommodating glass in the system is of high quality. The rubber being the most sensitive element and one of the most important element in assurance of hermeticity must have high durability of thermal characteristics for temperatures from –20 up to +80 °C.

It should have durability due to the fact of difficulties facing for changing, it should not change the characteristics during the time and maintain its elasticity in order to allow and follow the changes happening in other elements affected by natural temperature changes.

Parts from nylon. Between the supports and profiles we put nylon elements in profiles which allow small displacement caused by expansion, shrinkage, inevitable changes happening in concrete structure or in aluminum structure as well as different small movements or vice versa.

Thermal insulation of material set between the main columns and pressing plate offers a benefit in the heat transmitting coefficient at the level of 2,5 $W/m^2 \cdot K$.

Glass. Glass is the base element of facade. The main criteria in (gross) glass selection process are:

Glass durability against damages is mainly caused from air pressure. For that reason to calculate an element with maximal load (for example in the highest point) based on the maximum air pressing registered in the region we take into the glass width.

Selection of one, two or three glass layers depends on the requirements. In this point we should consider the atmospheric condition in region, thermal insulation as well as the acoustic noises in the surroundings area.

Within the two layers of glass there is a light aluminum frame. We stick the glass with special glue from the two sides of this frame. We should surround the inside and outside areas with special rubber. It should be set exactly between the glass and aluminum. The common insulation glass compounded from two layers with thickness 6mm and 4 mm, the distance between them must be 12 mm and the total thickness is approximately 22 mm [2, 3].

Conclusion:

1 Continued facade construction is imperative, especially for the high buildings or skyscrapers; we replace the classical materials with a combination of glass with aluminum.

2 Continued facade construction is a delicate entrepreneurship, it requires carrying out a detailed study which will guide the architectural solution and will help to choose the constructive dimension in accordance with calculation of acting forces.

3 Based on consumer requirements, economic restriction and detailed studies we make construction of such facades possible even in our country.

4 Realizing a careful selection process for construction as well as all other compound elements will make possible to achieve the optimal results as durability, hermetic and thermal insulation.

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РАЗРАБОТКА КОНСТРУКЦИИ И СПОСОБЫ МОНТАЖА СТЕКОЛ НАВЕСНЫХ ВЕНТИЛИРУЕМЫХ ФАСАДОВ

В статье рассмотрены способы проектирования и строительства стен вентилируемых фасадов. В первой части проанализированы преимущества этих конструкций по сравнению с традиционными. Для конкретизации взяты профили компании ALUMIL S. A. В следующей части рассмотрены наиболее часто используемые системы навесных вентилируемых фасадов, их конструктивные особенности, а также описаны нагрузки и деформации. Последняя часть содержит информацию о проектировании деталей фасадов и способах их подбора.

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