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Research Paper

Aluminium in Architecture – Design & Technology

DESIGNING

KEYWORDS : Aluminum, Composite Material, Structural integrity, Design Philosophy

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ABSTRACT

In the era of communication and globalization it is hard to keep up with the constant progress of technology and innovation in architecture. Development of innovative materials and construction, has provided the possibilities of architectural expression, economic and ecological constraints which are clearly different from those of previous decades. In that context Aluminum, does not seem like the most progressive building material on the market today, but it must not be neglected architecturally. Appealing because of its abounded aesthetical qualities and great physical properties, it is its composites that triggered increased application in architecture. Composite materials based on aluminum are now widely used for a variety of applications on buildings such as external cladding, roofing and structural elements. This paper presents basic characteristic of aluminum aiming to promote and argue in favor of its application in architecture.

1.0.INTRODUCTION

We are at the point of the next generation of buildings, which with its various degrees of high technology, smart ecological behavior and intelligent use of materials, are even able to adjust themselves to suit the physical and environmental properties of the surroundings. Aluminum does not seem like a material that is in the same category of smart, sophisticated nanotechnology materials. However, great innovations in material and technology sector suppress the refined visual effect of aluminum, suitable for minimalistic contemporary expression of nowadays architecture.

It is important to investigate its design possibilities and promote its use because it is highly adaptable and a lot more flexible than steel or any other material. It can also be endlessly recycled, and there is no lack of supply. Additionally its light weight decreases the load on the bearing structure, with a density around one-third of that of steel or copper, making it one of the lightest commercially available metals. On the other hand its strength makes it suitable for a great variety of solutions. In its alloyed form it is a strong ductile metal and is very similar to structural steel. Its mechanical properties tend to be inferior to those of steel, with stronger alloys being comparable in strength but less ductile. Moreover its resistance to corrosion gives it special advantages: aluminum is perfect for regions with severe weather conditions. For today's sophisticated architecture, aluminum is highly rated with its clear aesthetical qualities and great strength. In order to use aluminum composite material we have to understand behavior to be able predict performance in both short term and long term.

This research aims to summarize basic principles and advantages of aluminum and its composites and present plusses and benefits of its use in architectural design. To do this, basic characteristics of aluminum and its composites are presented. Additionally, several projects are revised aiming to understand visual, functional, structural and economic gains of this material in architect.

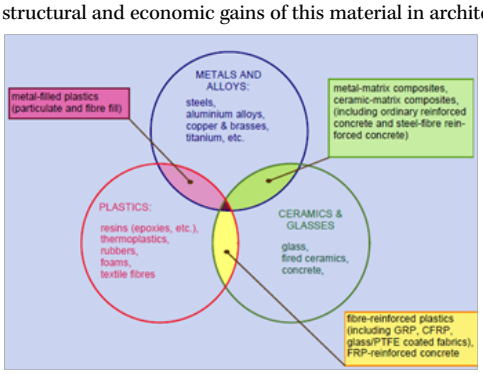

Figure 1. The evaluation of composites(Harris, 1999, p.6)

1.0. COMPOSITE MATERIALS BASED ON ALUMINIUM

Material is a medium which serves the architect to realize imaginary project. Every material has advantages and disadvantages. Main goal of composite material in general is to correct disadvantages with combination of at least two chemically distinct materials with a distinct interface separating the constituents. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties. When talking about aluminum based composite materials, this could include increased strength, decreased weight, higher service temperature, improved wear resistance, higher elastic modulus, controlled coefficient of thermal expansion, improved fatigue properties.

1.1.PROPERTIES OF ALUMINIUM COMPOSITE MATERIAL

Durable

Aluminum building products are made from alloys that are weather-proof, corrosion-resistant and immune to the harmful effects of UV rays, ensuring optimal performance over a very long lifetime. Aluminum composite material improve the outstanding resistance to corrosion even further. This makes it possible to use aluminum profiled sheets on a long-term basis without expensive servicing and maintenance work, even in extreme conditions.

Flexible

Aluminum's flexibility and formability guarantee unlimited design potential. (Figure 2.)The extrusion process offers an almost infinite range of forms and sections, allowing designers to integrate numerous functions into single profiles. Aluminium composite panel have high flexibility and they can provide different amazing shapes of the building.

Figure 2. 2008 Chilean Architecture BiennaleSantiago, Chile, Assadi & Pulido,Source http://greenbuilding.world-aluminium.org .

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Sympathetic - light and strong

The incredible high strength-to-weight ratio of aluminum makes it possible to design light structures with exceptionally stability. The use of aluminum provides architects with the means to meet required performance specifications, while minimizing expenditure on foundations. Thanks to the metal's inherent strength, aluminum window and curtain wall frames can be very narrow, maximizing solar gains for given outer dimensions. In addition to which, the material's light weight makes it cheaper and easier to transport and handle on site and reduces the risk of work-related injury. The wide variety of surface finishes and colors available, such as anodizing or coating, ensures that the high aesthetic demands made by architects can be fulfilled and the application potential of aluminum can be extended even further. Such processes also serve to enhance the material's durability and corrosion resistance, as well as providing an easy-to-clean surface. Maximizing the transparent areas of windows through the use of slender frames can also contribute to optimizing such solar gains. This increase in natural lighting is definitely beneficial for the occupants' comfort and wellbeing, while it also reduces the need for artificial lighting, contributing significantly to the building's sustainability.

Economic

Besides routine cleaning for aesthetic reasons, neither bare nor painted aluminum requires any maintenance, which translates into a major cost advantage over the lifetime of a product. The freedom of maintenance guarantees unlimited use and the possibility of a reliable cost analysis over the entire useful life. Thanks to the non-corrosion material composition, no securing or value-maintaining measures are necessary.

2.0. ALUMINIUM IN ARCHITECTURE

The first well known application in buildings dates back to 1898, when the dome of San Gioacchinos Church in Rome (Figure 3.) was clad in aluminum sheets. After that period architect Otto Wagner also had significant rule in the aluminum application. (Sustainability of Aluminium in Buildings, EAA)

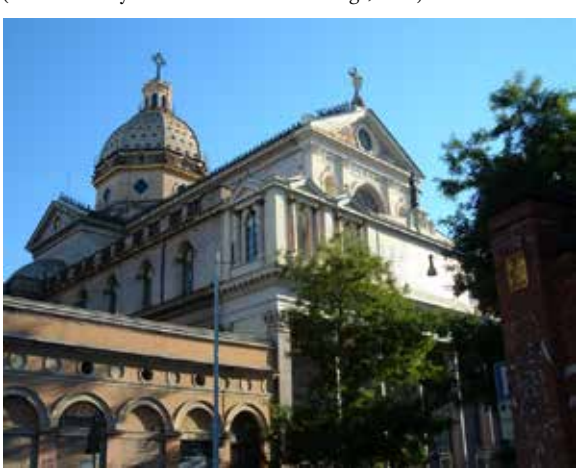

Figure 3. San GioacchinosChurch,Rome,1898,Source

He created new architectural style using aluminum panels for facade of the Die Zeit news agency building in Vienna. From 1904 to 1906, Wagner constructed the Postal Deposit Bank building. From that period aluminum became one of the emblems of style and modern design. (Sustainability of Aluminium in Buildings, EAA)

Figure 4. Empire State Building, New York, 1931, Source Internet

Aluminums use in construction began in around 1930s when landmark structures, such as Botanic Garden Conservatory in Washington, DC and the Chrysler and Empire State Building (Figure 4.) in New York were erected with aluminum structural components. Aluminum didn't really crack the construction market until after World War II, when aluminum was first used to clad buildings. Inventors and businessmen made a significant contribution, too. Francis Plym set up a metal window frame factory in shop windows. By 1937, 75% of his goods were made of aluminum, which is resistant to corrosion.

'Place, weight and time, these words became a mantra repeated during discussions about aluminum in the construction sector. By applying aluminum using various methods, an architect could expand a space of a building, reduce the weight of any structure and speed up the construction process. The main use of aluminum in the building industry are in the construction of windows, doors and facades, closely followed by roofs and walls. Other structural uses range from a glazed shop front to the superstructure of anything from a shopping Centre to a stadium. Aluminum can also be found in door handles, window catches, staircases, roller shutters and sun-shading systems, heating and air-conditioning systems and more recently in the support structures for solar panels, solar collectors and light shelves.

Globally, aluminum enjoys a high collection rate of 85% in the building industry. Today the global building market uses some 11 million tons of final aluminum products annually. However, the application of aluminum in the construction industry not only opens opportunities for the future, but also helps to save the past. In recent years, aluminum has been increasingly applied as a main material in the restoration and reconstruction of historical buildings.

4.0. RECYCLING PROCESS

Aluminum has been recycled since the metal first began to be used commercially in the opening decades of the 20th century. Recycling (Figure 5.) is a major consideration in continued aluminum use, representing one of the key attributes of this metal with far reaching economic, ecological and social implications. Recycling comes from two prime sources; scrap material from the production process and used material from products that have been removed or replaced.

The life cycle of aluminum is such that end-of-use products are rare, however almost all pre-production scrap is recycled .Only a small percentage of metal is lost during the actual recycling process, becoming aluminum oxide, which is a natural part of our environment. The recycling process itself only requires about 5% of the energy that was consumed in the production of primary aluminum. Aluminum components can usually be recycled in a single process using up to 95% less energy than the primary production process. (Sustainability of Aluminium in Buildings, EAA)

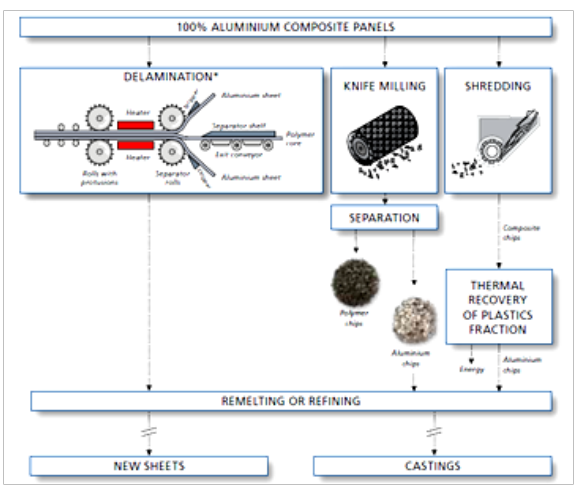

Figure 5. Recycling of Aluminum Composite Panels, Source Sustainability of Aluminium in Buildings, EAA)

As almost all aluminum used in construction is recycled, the considerable energy invested in the production of primary aluminum can be reinvested into other aluminum products. The purpose of recycling is to produce new high quality material from waste and used products in an economical and environment friendly manner. Aluminum recycling therefore contributes to the sustainable use of these alloying metals, such as copper, iron, magnesium, manganese, silicon, zinc and other elements. This effectively means that with a recycled metal production of 4.7 million tons, 230 000 tons of alloying elements are simultaneously conserved by the aluminum industry in Europe every year. (Aluminum Recycling in Europe, p.13) Therefore, aluminum scrap with an alloy composition corresponding to that of wrought alloys is separated whenever possible.

5.0. CONCLUSION

We live in a time when green architecture, zero-energy houses, sustainable technology become unavoidable part of the criteria for design. However, we have witnessed the fact that sustainability is today largely overused and exaggerated term. If we look back into the past and as an example took vernacular architecture we can say that we went back for a while. Man has consciously rejected natural materials, materials that meet certain climates. What distinguishes architecture of 21st century is not the idea of a new model of design, futurism, and deconstructionism. The only and truly greatest contribution to the present time are the new technologies and materials, which subsequently influence change in the design philosophy, theory and process. Composite materials based on aluminum are part of that new ideology. With the knowledge of material and their properties we will contribute to sustainable development and the use of materials in a way that the material is part of the concept, soul, not only the physical shell.

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