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Smart Building Construction with the Use of Aluminium

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Abstract
The aluminium element was discovered 200 years ago. After an initial period of technological development, aluminium alloys were used in many structural applications, including the civil engineering field. Aluminium is the second most widely specified metal in building after steel, and is used in all sectors from commercial building to domestic dwelling. This paper contains complete overview of use of aluminium in building construction. How it is beneficial in modern age building construction. This paper also contains the properties, advantages. Some question arises that whether aluminium is sustainable, fabricated for fast track, requires maintenance, are explained in detail in this paper.

Keywords: aluminium, structural applications, civil engineering, sustainable, fabricated.

I. INTRODUCTION

Aluminium was first used in quantity for building and construction in the 1920s. The applications were primarily oriented toward decorative detailing and art deco structures [1]. The breakthrough came in 1930, when major structures within the Empire State Building were built with aluminium (including interior structures and the famous spire). Today, aluminum is recognized as one of the most energy efficient and sustainable construction materials. The estimated recycled content of aluminium building materials used today is between 50 and 85 percent. Aluminium-intensive LEED-certified buildings have won awards for Platinum, Gold and Best-in-State sustainability across the country.

Aluminium is the second most widely specified metal in buildings after steel, and is used in all construction sectors, from commercial buildings to domestic dwellings. 40% of the UK annual production of aluminium is utilized within the construction industry, which equates to roughly 150,000 tonnes of aluminium per annum, of which approximately 65,000 tonnes is extruded products, and 25,000 tonnes sheet materials. The main market sectors are windows, roofing, cladding, curtain walling and structural glazing, prefabricated buildings, architectural hardware, H&V, shop fitting and partitions. Aluminium is also used extensively in plant, ladders and scaffolding. Primary smelter aluminium is pure and, as such, has a relatively low strength. For extrusions and other manufactured components, the material is alloyed to improve its strength, although even the most heavily alloyed wrought aluminium is still 92% pure [2]. The two series of alloys most widely used in construction are the 5000 series work hardened magnesium alloys and the 6000 series heat-treatable magnesium silicone alloys. The latter are more extricable and, therefore, offer greater scope for complex shapes. Silicone alloys (such as LM6) and manganese alloys (such as 3103) are also used for specific construction applications [3-4].

By selecting the right alloy, the designer is offered a wide range of properties including high strength (up to 400 MPa or 26 tonnes per sq

inch), low density, high thermal conductivity, and good forming and joining characteristics. The choice of the most appropriate alloy of the 6000 series for a particular extrusion depends on the nature of the task it has to perform. A balance has to be struck between strength, ease of forming and finish. The 6063 alloy, for instance, has good extrudability, corrosion resistance and surface finish; and is thus widely used in fenestration [5]. The properties of the individual alloys are amplified by the shape of the extruding die. Careful and knowledgeable design can take advantage of the ability of the extrusion process to distribute the material across the section to exactly where it is needed for a particular performance requirement.

II. Modern Building Construction Material

Modern building and construction is more than merely erecting buildings as functionally as possible. In addition to functional and economic criteria, aesthetic and design considerations together with ecological demands placed on building projects play an equally important role. This means the materials used are of major significance [6]. Aluminium, the building material for the modern age, established itself as an important factor in the building and construction industry during the course of the 20th century. Aluminium enables every possible architectural concept to be realised – regardless of whether it is a new build or a modernization. Possible applications range from façades and roof and wall manufacturers of Aluminium building products systems to interior decoration and the design of living are world leaders technologically – not least space, and include windows and doors, balconies because the companies have furthered the and conservatories development of modern windows and façades in the fields of surface treatment, thermal insulation and soundproofing, air conditioning and solar heating. With an annual domestic demand of about 500,000 tonnes, the building and construction industry is the second largest market for aluminium products in Germany. Its share of the total aluminium market is 15 percent.

Fig 1: Aluminium acts as supporting structure

These are the best prerequisites for aluminium putting its qualities as a modern, contemporary building material to full use in the 21st century as well.

III. Aluminium as building material

A. Strength versus weight

One of Aluminium's primary appeals to specifiers is its exceptional strength to weight ratio. At 2.7g/cm^2, Aluminium is 66% lighter than steel. It is also far less susceptible to brittle fractures [7]. Indeed, when aluminium and steel structures are compared, Aluminium's greater modulus of elasticity means that weight ratios of 1:2 are easily attained.

While Aluminium has a relatively high co-efficient of linear expansion, at 24 X 10-6/'C – in its pure form, the material's low modulus of elasticity (65,500N/mm^2 for 6063 alloy) enables temperature induced stresses to be accommodated. Indeed, these are generally far lower than in a comparable steel structure (M of E = 210,000N/mm^2). This is graphically illustrated by Aluminium's load deflection curve, which is continuous, without a yield point [8].

Aluminium sections are generally thinner and deeper than equivalent steel sections to achieve the required strength and rigidity since, Aluminium is not affected by moisture and aluminium windows do not warp, stick or rot. In door construction, typically using hollow section extrusions, sight lines are improved because multi-point locks and other door furniture can be fitted within the frame. This is in addition to the intrinsic lightness, strength and rigidity of Aluminium frames.

B. Low maintenance – low cost-in-use

While Aluminium has a natural, built-in durability (it forms a protective layer of oxide as soon as it is exposed to air), most Aluminium construction products are treated or coated. One way in which the oxidization process can be enhanced is anodization; an electrolytic process which increases the thickness of the natural oxide layer from 0.00001mm to between 0.005 and 0.025mm (25 Microns). This enhances the ability of Aluminium to withstand attack in aggressive environments. Natural anodizing results in a similar silvery finish to oxidized Aluminium, but it can also introduce a range of colours.

This is because, after anodizing, the surface film remains porous, allowing it to accept colouring agents, such as organic dies, pigments, electrolytes or metallic. Attractive gold, bronze, gray, black and even blue finishes are commonly achieved in this way. For a wider choice of colours, most specifiers opt for an electrostatically sprayed polyester powder coating. This is a common finish for curtain walling, rainwater goods and cladding panels, where the powder coating is used to provide resistance to the acidity of rainwater. In this process, charged paint particles are blown onto the extrusion (which has undergone a twelve-stage pre-treatment process) and then stove, at between 200 and 210'C, for 10 to 12 minutes. This provides a high quality surface with excellent adhesion, accurate colouration and very even film thickness.

C. Fabricated for the fast track

One of the principal reasons for Aluminium's enduring and growing popularity is its compatibility with today's fast track construction techniques and just-in-time ordering. Nowhere is this seen more clearly than in curtain walling, where the accuracy of factory finished sections allows rapid erection on site and, in him, allows internal finishing to proceed more quickly. The end result is earlier building occupancy and greater profit margins for the ultimate customer. Aluminium shop fronts, window systems and door assemblies offer comparable on-site benefits, which are now being enhanced by fabricators' computer-controlled machining rigs which can drill, miter, grind and countersink to exact tolerances enabling the easiest possible installation of ironmongery, glazing beads and other secondary components.

D. Guaranteed performance through quality control

Although basic material costs will always be important to specifiers, they should be balanced against the cost of fabrication and subsequent service performance. This is an area where Aluminium, being ideally suited to highly automate manufacturing procedures to exact tolerances, offers many benefits. Aluminium extrusions, for instance, are subjected to a rigorous quality regime, from hardness testing of the raw extrusion to conical bends, sawing, scratching, gouging, hammering and weight drops to guarantee coating performance. It is this combination of quality control, excellent cost in use and systems technology that has helped develop new markets for Aluminium systems companies in the health, education, leisure and

transport sectors where changes in the funding of building procurement, such as PFI and fund-holding schools has changed the emphasis from lowest capital cost to lowest cost in use. Specifiers are increasingly looking for effective systems solutions by involving system suppliers early in the design process to ensure the most elegantly engineered solution at the lowest cost.

E. Aluminium recyclable at end of building's life

The ability to recycle aluminium building products is also becoming more important as more building owners decide to deconstruct rather than demolish older buildings. Instead of simply going in with a wrecking ball, owners are now much more deliberate about how they take down a building in order to extract as much recyclable material as possible. By doing so, they not only retain the scrap value of a material such as aluminum but also eliminate the environmental impact and cost of dumping it in a landfill.

Aluminium recycling also reduces energy consumption. To produce aluminium from recycled material, for example, requires only 5% of the energy required to produce aluminium from bauxite. In addition, every ton of recycled aluminium saves four tons of bauxite.

F. Aluminium Can Be Formed into Variety of Shapes

Because it is ductile, aluminium can be formed into a number of shapes and profiles. Its uses are by no means limited to flat panels. Consequently, aluminium wall cladding systems can help create some of the most attractive and functional exteriors on buildings today. In addition, large wall panels, either flat or formed, require fewer joints, producing fast and economical installation. Aluminium wall systems are not meant for use only in new construction. Retrofit applications are viable as well, especially when an owner wishes to change the "image" of a building. Aluminium wall panels, especially composite panels, are ideal for re-cladding older structures, as well as providing contemporary design options for all types of new buildings.

IV. Properties, Advantages and Disadvantages

A. Properties

1) Durability

Aluminium building products are made from alloys, which are weather-proof, corrosion resistant and immune to the harmful effects of UV rays, ensuring optimal performance over a very long serviceable lifetime.

2) Design flexibility

The extrusion process offers an almost infinite range of forms and sections, allowing designers to integrate numerous functions into one profile. Rolled products may be manufactured flat, curved, shaped into cassettes, or sandwiched with other materials. In addition, aluminium can be sawed, drilled, riveted, screwed, bent, welded and soldered in the workshop or on the building site.

3) Hundreds of surface finishes

Aluminium can be anodized or painted in any colour, to any optical effect, using any number of surface touches, in order to meet a designer's decorative needs. Such processes also serve to enhance the material's durability and corrosion resistance, as well as providing an easy-to-clean surface.

4) High reflectivity

This characteristic feature makes aluminium a very efficient material for light management. Aluminium solar collectors can be installed to lower energy consumption for artificial lighting and heating in winter, while aluminium shading devices can be used to reduce the need for air conditioning in summer.

5) Fire safety

Aluminium does not burn and is therefore classed as a non-combustible construction material. Aluminium alloys will nevertheless melt at around 650°C, but without releasing harmful gases. Industrial roofs and external walls are increasingly made of thin aluminium cladding panels, intended to melt during a major fire, allowing heat and smoke to escape and thereby minimizing damage.

6) Optimal security

Where high security is required, specially designed, strengthened aluminium frames can be used. While the glass for such applications may well be heavy, the overall weight of the structure remains manageable thanks to the light weight of the aluminium frame.

B. Advantages

1) Lightweight

Aluminium is one of the lightest available commercial metals with a density approximately one third that of steel or copper.

2) Excellent Corrosion Resistance

Aluminium has excellent resistance to corrosion due to the thin layer of aluminium oxide that forms on the surface of aluminium when it is exposed to air

3) Strong at Low Temperatures

Whereas steel becomes brittle at low temperatures, aluminium increases in tensile strength and retains excellent toughness.

4) Easy to Work

Aluminium can be easily fabricated into various forms such as foil, sheets, geometric shapes, rod, tube and wire.

5) Easy Surface Treatment

For many applications, aluminium requires no protective or decorative coating; the surface supplied is entirely adequate without further finishing

C. Disadvantages

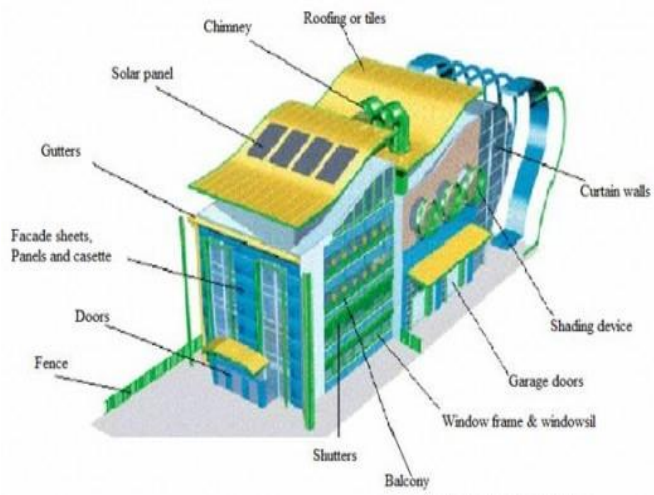
1) Thermal insulation was almost definitely insufficient: aluminium being a good thermal conductor.
2) Poor water proofing due to the inadequately designed/executed joints between the roof aluminium sheets
3) General noise caused by rain or hail falling on aluminium roof and wall sheets.

V. Applications

The best application can be obtained in some typical cases, which are characterised in getting profit at least of one of the main basic properties: lightness, corrosion resistance and functionality. The structural applications which best fit these properties in the field of civil engineering are the following:

1. Long-span roof systems in which live loads are small compared with dead loads, as in the case of reticular space structures and geodetic domes covering large span areas, like halls and auditoriums.
2. Structures located in inaccessible places far from the fabrication shop, for which transport economy and ease of erection are of extreme importance, like for instance electrical transmission towers, which can be carried by helicopter.
3. Structures situated in corrosive or humid environments such as swimming pool roofs, river bridges, hydraulic structures and offshore super-structures.
4. Structures having moving parts, such as sewage plant crane bridges and moving bridges, where lightness means economy of power under service.
5. Structures for special purposes, for which maintenance operations are particularly difficult and must be limited, as in case of masts, lighting

towers, antennas towers, sign motorway portals, and so on.



'Fig 2: Aluminium used in construction

VI. Opportunities for creative design

Whether it be office towers, congress centres or shopping arcades, museums or universities, airport terminals, railway stations, football stadiums or simply residential buildings, façades made from aluminium profiles and panels offer architects unlimited opportunities for creative architects unlimited opportunities for creative design. The 'personality' of many a modern building only manifests itself fully when building only manifests itself fully when aluminium is used. Just as skin protects the body, so aluminium façades protect buildings from the elements. They serve to keep out heat, cold, rain and noise and to provide a high level of comfort for the people living and working in the buildings. The outer skin of a modern building therefore has to satisfy numerous demands. The choice of façade type and supporting structure will depend on the specific requirements. With aluminium profile systems one can use classical mullion–transom façades, unitised façades, structural glazing, double- skin façades or special structures such as pyramids, polygons, barrel vaulting or round canopies. Aluminium is suitable even for large-surface use and for extreme loading, such as is found in high-rise buildings and television towers. In the world's current tallest skyscraper, the 508- metre high Taipei 101 in Taiwan, the façade elements enclosed in aluminium frames are capable of withstanding winds of up to 200 kilometers an hour as well as seismic shocks measuring 5 on the Richter scale. Even for less spectacular buildings, for example hospitals and concert halls, which demand a high degree of absorption of structure-borne and airborne noise, aluminium has proven its worth for support purposes.

Where 'sustainable' methods of building are concerned, modern façades need to fulfill greater demands with respect to energy savings, cost reductions and quality of life. Intelligent façade systems – in other words, systems that are characterised by automation and control of the façade elements – provide the best possible light conditions, air conditioning, solar shading, and energy storage and distribution The innovative double-skin façades used in modern aluminium–glass architecture are not only increasingly characterizing the face of large metropolises. They link the demands for hi- tech, ecology, aesthetics and vision in many ways. The additional glazing, which is positioned in front of a thermally insulated inner façade with leaves that can be opened, results in a considerable improvement in the energy efficiency of buildings; aluminium profiles are used for the structural frames of the glazing Compared with conventional buildings, the energy requirement can be reduced significantly. Additional benefits of double-skin façades are that they allow rooms to be ventilated naturally and that they improve the sound insulation with respect to outside noise.. By use of variable profile dimensions, the constructions can be adjusted to fit practically every possible installation. New mullion–transom connectors made from cast aluminium shorten erection times. Structural glazing, on the other hand, is characterised by a flush-fit appearance in

which the aluminium profiles are only visible from the room side. From the outside, the appearance is dominated by mirrored glass with intricate shaded grooves. These façades have a high degree of self-cleaning because the glazed areas are absolutely flush. They result in a large amount of the added value being transferred from the building site to the factory. Floor-to-ceiling prefabricated modules with integrated electrical components and short erection times enable the construction to proceed quickly and with the highest possible level of manufacturing quality. The profiles are usually developed to meet the specific needs of the particular building, for example with respect to fire protection and sound insulation. Unitised façades are usually made from aluminium profiles with thermal breaks because of the high proportion of special extruded profiles.

CONCLUSIONS

It is certain that Aluminium will become even more widely used in construction as pressure grows for buildings that are flexible, easy to maintain and offer low cost-in-use. There is certainly scope for growth in a wide variety of structural applications, such as supporting Aluminium sheet roofing on aluminium extruded roofing members. This growth is limited principally by a lack of understanding of Aluminium's true structural abilities.

No construction material is perfect. Timber is affected by moisture, requires maintenance, has limited structural capabilities and cannot be machined into complex shapes. Steel has a relatively poor strength to weight ratio, cannot be thermally broken, rusts in an untreated state and, under stress, is prone to brittle fractures. PVC is available in a limited range of colours, can suffer from polymer migration, does not have the inherent stiffness of metals, and has been attacked on environmental grounds by leading environmental NGOs.

Aluminium, while it has a relatively high initial energy cost, offers unparalleled manufacturing flexibility, the broadest ranges of finishes, an excellent strength-to-weight ratio, unlimited recyclables and has a far better environmental profile than many specifiers believe. Above all, it offers architects the most elegant and satisfying design solutions.

For many contemporary designers there are simply no alternative to Aluminium – the form dictates the material and the material facilitates the form. This fact alone will ensure the continued growth of Aluminium in construction.

References

1. E. Fregonara, R. Curto, M. Grosso, P. Mellan o, D. Rolando, J.M. Tulliani, "Environmental Technology, Materials Science, Architectural Design, and Real Estate Market Evaluation: A Multidisciplinary Approach for Energy-Efficient Buildings," *Journal of Urban Technology* 20: 4 (2013) 57–80. .
2. X. Zhou, F. Zheng, H. Li, C. Lu, An environment-friendly thermal insulation material from cotton stalk fibers, Energy Build.42(2010)1070–1074, http://dx.doi.org/10.1016/j.enbuild.2010.01.020.
3. Zargaran, A., Kim, H. S., Kwak, J. H. & Kim, N. J. Effects of Nb and C additions on the microstructure and tensile properties of lightweight ferritic Fe–8Al–5Mn alloy. *Scr. Mater.* **89**, 37–40 (2014)
4. Dursun, T. & Soutis, C. Recent developments in advanced aircraft aluminium alloys. *Mater. Des.* **56**, 862–871 (2014)

5. Dixit MK, Fernandez-Solis JL, Lavy S, Culp CH. Need for an embodied energy measurement protocol for buildings: A review Paper.*Renewable and Sustainable Energy Reviews* 2012;**16**(6):3730-3743.
6. E., Alaejos, P., Lobet, A., & Pérez, D. (2011). Effect of Recycled Sand Content on Characteristics of Mortars and Concretes. Journal of Materials in Civil Engineering, 23(4),414–422. doi:10.1061/(ASCE)MT.1943-5533.0000183.
7. Azhar, S., Carlton, W. A., Olsen, D., & Ahmad I. (2011). Building information modeling for sustainable design and LEED® rating analysis. *Automation in Construction*, 20(2), pp. 217-224.
8. Monahan J, Powell JC. An embodied carbon and energy analysis of modern methods of construction in housing: A case study using a lifecycle assessment framework. *Energy and Buildings* 2011;**43**(1):179-188.