Application of deformable aluminum alloys in the construction industry: current trends and future perspectives

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This work systematizes information on the application of aluminum alloys in construction, both domestically and internationally. It reviews key alloy grades utilized in the construction industry, highlighting the primary advantages of these alloys compared to traditional steel alloys commonly used in structural elements. The study examines the mechanical, performance, and weight characteristics of aluminum alloys and compares them with modern traditional construction materials, such as wood, steel, and concrete. The paper proposes future prospects for the use of deformable aluminum alloys in construction, with examples of applications in composite beams and columns, prefabricated engineering structures for various functional purposes, and shaped components. The findings confirm the feasibility and efficiency of using aluminum alloys for manufacturing both all-aluminum and composite structures. Practical recommendations are provided for their application across diverse construction sectors.

Key words: deformable aluminum alloys, aluminum composites, mechanical properties, beams, columns, bridges, temporary structures.

DOI: 10.17580/nfm.2024.02.12

Introduction

The application of deformable aluminum alloys in construction marks significant progress in modern building practices, driven by their unique properties, such as a high strength-to-weight ratio, corrosion resistance, and recyclability. Aluminum and its alloys are used extensively in industries including aviation, shipbuilding, railway transport, automotive, oil and chemical production, aluminum cookware manufacturing, packaging, electrical engineering, and increasingly, in construction. A pie chart depicting aluminum usage across various industrial sectors is shown in **Fig.** This chart is based on data from CRU, an independent analytics and consulting group focused on the mining, metallurgy, energy, and chemical sectors.

The highest consumption of aluminum, particularly in developed countries, is in transportation manufacturing, accounting for more than 26%. Construction ranks second, with approximately 30% of aluminum used in this sector in China and over 40% in Africa. These alloys are increasingly utilized in various structural components, window frames, and roofing systems, reflecting a growing trend toward lightweight, durable materials in the construction industry. Aluminum alloys are relatively new, high-performance materials for load-bearing and enclosing structures. Their primary advantage is their high specific strength compared to other building materials. For instance, the specific strength of aluminum alloy D16-T is 9460 m, exceeding the specific strength of wood by more than 5 times, concrete grade B25 by 1.5 times, and steel grade St.3 by 3.5 times.

Another advantage of these alloys is the ease of extruding profiles. Unlike the rolling of steel profiles, this process does not require costly rolling mills and allows for the production of a wide variety of profiles with virtually any cross-sectional shape. The most efficient profiles include angled, channel, *T*-shaped, and *I*-beams with reinforced edges, which enhance both the overall rigidity and local stability of the element.

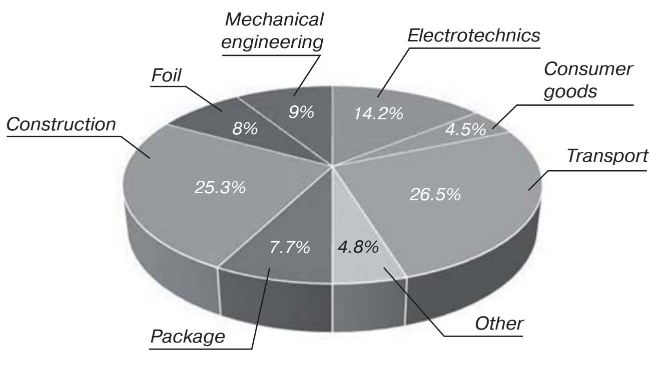


Fig. Pie chart of aluminum alloy applications in various industries (source – CRU, UK)

Given aluminum's high corrosion resistance – approximately 10 to 20 times greater than that of ordinary steel – its alloys are widely used in enclosure structures, including window frames, wall and roofing panels, transparent structures, and other applications exposed to aggressive environments. Alloys without copper exhibit the highest corrosion resistance. A thin oxide layer on the surface prevents the penetration of corrosion into the material. Aluminum structures are also highly earthquake-resistant, benefiting from reduced seismic loads compared to traditional steels used in construction.

Pure aluminum is rarely used in construction due to its low strength (tensile strength of 600–700 kg/cm^2, yield strength of 200–300 kg/cm^2, and ductility of 55–65%). However, aluminum readily forms alloys with other metals, resulting in superior properties compared to pure aluminum. These alloys are regarded as high-quality structural materials, offering heat resistance, weldability, corrosion resistance, and high strength. Aluminum alloys are scientifically categorized into two main types: wrought (pressure-treated) and casting alloys. Wrought alloys, in particular, are extensively used in construction. The strength of wrought alloys is enhanced through work hardening, thermal treatments, and alloying with elements such as zinc, manganese, copper, and magnesium.

Currently, the following standards govern the use of aluminum structures in construction worldwide: in the Russian Federation – SP 128.13330.2016 "Aluminum Structures"; in China – GB 50429 "Code for Design of Aluminum Structures"; in Europe - Eurocode 9 "Design of Aluminum Structures"; and in the United States – AA-2010 "Aluminum Design Manual".

The purpose of this review is to provide a scientific overview of research on the application of aluminum alloys in construction. The objects of study are aluminum, its alloys, and aluminum-based structures. The subject of the research is the current state and future prospects for the use of aluminum alloys in the construction sector.

Bibliometric analysis of the development of research in the field of aluminum structures

The scientific community has accumulated substantial experience in research and development within the field of aluminum structures. In [1], the authors examined the short-term structural behavior of ATC beams with bolted connections, observing failure modes under destructive loading associated with veneer splitting in the tensile zone and veneer delamination in the compression zone. Study [2] focuses on aluminum-wood composite beams with threaded connections, particularly addressing failure modes under collapse loading related to sudden tensile rupture, as well as the ultimate strength of the composite section and its operational stiffness. Numerical investigation and design of perforated SHS and RHS aluminum alloy columns are presented in [3]. Nonlinear FEM was validated against corresponding experimental results, which were used to conduct an extensive parametric study involving 594 samples with varying cross-sectional dimensions, overall length, and the diameters, number, and arrangement of circular holes. An innovative method for manufacturing aluminum foam sandwiches using reinforcing mesh as a mold is discussed in [4]. Work [5] demonstrates that material hybridization can enhance the rigidity and stability of the structure to overcome the limitations of wooden buildings under wind loads and increase ductility for seismic design where necessary.

The structural behavior of wood-aluminum composite beams under static loads is examined in [6]. Tests revealed that the proposed beams (wood-aluminum composite beams) exhibit excellent load-bearing capacity relative to their weight. It is demonstrated that the composite system of plywood and aluminum beams effectively mitigates local bending in aluminum beams. Study [7] shows that the overall structural characteristics of the proposed composite panel are significantly improved by leveraging the beneficial effects of composite action, thereby enhancing housing quality in informal settlements and rapidly urbanizing areas. In [8], experiments alongside numerical analysis were conducted to investigate the behavior of aluminum composite wooden beams under impact loads. The nonlinear finite element analysis performed using ANSYS LS DYNA version 13.0 produced results consistent with experimental findings. Study [9] introduces a new type of composite structure—aluminum-wood beams—and demonstrates that these structures offer advantages over other existing composite designs. Work [10] focuses on the bending tests of A-WPC reinforced beams, with results thoroughly analyzed and systematically studied, leading to the formulation of a calculation method for the bending capacity of beams. Study [11] experimentally investigates round hollow profiles made from aluminum alloys 6063-T5 and 6061-T6 under axial compression between fixed ends, presenting a comparison of column strength results against the strength provided in American, Australian/New Zealand, and European aluminum structure specifications. Experimental and numerical investigations on thin-walled aluminum alloy columns were conducted in [12] to assess their bending behavior and evaluate the accuracy of existing design methods. In [13], experimental and numerical studies on the deformation buckling of irregularly shaped thin-walled aluminum alloy rod columns under axial compression were performed, with LVDT used to measure initial geometric imperfections in six extruded aluminum alloy rods.

Study [14] investigates the structural characteristics of aluminum alloy columns with non-uniform inclination angles. The ultimate strength values obtained from experiments and finite element analysis were used to assess the applicability of existing codified standards. Research on the compression strength of H-shaped elements with a roof-like connection structure in an aluminum alloy lattice shell is presented in [15]. A thickness curve formula (Perry-type curve) for achieving adequate tensile strength in aluminum alloy 6082-T6 elements, which fail under bending and axial compression, is proposed in [16]. In [17], a comprehensive experimental program was conducted to examine the local tensile strength and subsequent tensile behavior of tubular aluminum alloy columns. A total of 15 test samples, fabricated from two heat-treated aluminum alloys (6061-T6 and 6063-T5), were produced by extrusion. In [18], a detailed experiment involving 29 extruded columns with box and L-shaped sections made from aluminum alloy 6082-T6 was carried out to study the stability behavior of these columns under eccentric loading. All box-section columns displayed overall deflection with minor deviations under eccentric compression, while local buckling was observed in columns with a high width-to-thickness ratio or a small thickness reduction factor. An experimental program examining the buckling behavior of high-strength (HS) aluminum alloy 7A04 columns under axial compression was conducted, in which 42 extruded L-shaped samples were designed and tested [19]. A modified design method was proposed to provide more accurate predictions of the longitudinal bending resistance of high-strength aluminum alloy columns.

The behavior under buckling and ultimate strength of aluminum alloy 6082-T6 columns with square and circular hollow cross-sections under eccentric compression is analyzed in [20]. An assessment of the accuracy of three design standards and the Direct Strength Method (DSM) demonstrated that the design provisions are conservative for predicting the ultimate strength of eccentrically compressed columns. It was found that DSM provides the most accurate strength predictions for eccentrically compressed columns, while AA-2010 and Eurocode 9 ranked second and third, respectively. In [21], the authors investigated the stress-strain state in structural joints represented by a connector formed from two steel plates joined in a "dovetail" shape, with aluminum alloy as the material, proving its high effectiveness. Study [22] highlights the potential and feasibility of enhancing the efficiency of steel structures by employing steel grades other than traditional ones. Various steel grades are considered, with an investigation into the stress-strain state of building structures under static load conditions. A large-scale study on the mechanical properties of aluminum matrix composites based on the Al – Si – SiC system, which hold potential for future application in construction, was conducted in [23]. In [24], researchers reviewed and analyzed the prospects for using aluminum matrix composites as a construction material within the context of current trends in the construction industry. The possibility of replacing standard aluminum alloys with aluminum matrix composites in the manufacturing of small-scale construction elements, such as connectors, was examined.

The work presented in [25] by a group of authors from China focuses on lattice frame structures made of aluminum alloy with dovetail connections, where the roofing panel is efficiently connected to the structural elements using a clamping connection. This design allows the roofing panels to contribute to the system's resistance against forces. In article [26], advancements in the design methods for elements made from Chinese aluminum alloy were investigated through an experiment involving 63 profiled aluminum alloy elements fabricated from Chinese aluminum alloy 6061-T6 under axial compression, yielding valuable experimental data. The study in [27] conducted shake table tests and seismic performance modeling of lattice shell structures made from aluminum alloys in both elastic and elastoplastic phases, demonstrating that the natural vibration period of the aluminum alloy lattice shell is greater than that of a steel lattice shell. The research in [28] evaluates the load-bearing capacity of planar structures and failure modes, revealing the mechanism by which prestressing enhances the performance characteristics of aluminum alloy beams.

The study presented in [29] explores the potential of aluminum-metal matrix composites (AMMC) as an alternative to traditional steel rods, highlighting their environmental sustainability and performance characteristics. Article [30] investigates the AAG connection, also known as the Temcor connection, which is a well-established method for constructing long-span spatial lattice structures using aluminum alloys. The test results indicate that AAG connections exhibit good impact resistance. In [31], the application of 3D printing for creating new designs using aluminum alloys is discussed, along with the use of fiber-reinforced polymers to enhance existing aluminum alloy structures. Article [32] introduces a novel steel-aluminum connection system for mega-lattice structures made of aluminum alloys for the first time. This connection can be effectively utilized for joining large-diameter pipes in complex spatial structures. The primary motivation behind the research in [33] is to investigate the advantages of aluminum material by weight in pin-connected structures (truss constructions). The findings led to the development of optimization algorithms that enable the identification of the most suitable design solutions utilizing both aluminum and steel materials.

The paper [34] presents a review of recent research on the mechanical properties of aluminum alloys under fire conditions and post-fire scenarios, as well as the structural characteristics of aluminum alloy constructions during fire, considering elements, connections, joints, and systems as a whole. Article [35] provides a comprehensive overview of research by discussing the presented experimental, numerical, and analytical studies related to structural aluminum alloys. In [36], tests were conducted to examine various connections between aluminum and wood to ensure the strength of the composite. This study considered four different types of connections and selected and discussed the optimal connection. Article [37] presents a numerical investigation of square cross-section columns made of aluminum alloy with boundary conditions at the ends. It is shown that the Eurocode provides conservative estimates, particularly for aluminum alloys of class B. In study [38], the stability loss characteristics under compression of *I*-section columns made of extruded aluminum alloy with fixed end pins were investigated both experimentally and numerically. The aim of study [39] is to utilize the finite element method (FEM) to examine the axial strength of prefabricated sections made from cold-stamped aluminum alloy. Article [40] conducted a comprehensive parametric study using a validated finite element model to explore the influence of modified flexibility, the number of screws, and the thickness of the section on the axial strength of prefabricated aluminum alloy channels.

General characteristics of aluminum alloy structures as a material for structural elements of buildings and structures

The requirements for materials used in aluminum alloy structures include processability, low cost, high strength of the metal and its joints, as well as durability. In turn, aluminum alloys are characterized by high strength, ease of extrusion, corrosion resistance, high seismic resistance, and fire resistance. This combination of properties allows for the creation of structures with various architectural forms and purposes.

The specific weight of deformable alloys ranges from 2.6 to 2.9 t/m^3, with a coefficient of thermal expansion of 23×10^{-6} and a Poisson's ratio of 0.3. Deformable alloys can be classified into the following groups: forging alloys (heat-resistant – "AK2, AK4"), high-strength alloys (aluminum-magnesium-zinc-copper – "B92, B95"), duralumin types (aluminum-magnesium-copper – "D1, D16"), aviation types (aluminum-magnesium-silicon – "AD31, AD33, AD-35, and AV"), magnalium types (aluminum-magnesium – "AMg"), aluminum-magnesium alloys ("AMts"), and technical aluminum ("A1").

However, from the perspective of construction applications, aluminum alloys also have disadvantages, primarily a low modulus of elasticity (71×10^4 MPa), a high coefficient of thermal expansion (0.000023 per °C), and increased complexity in the fabrication of joints. A distinguishing feature of aluminum alloys is the lack of a well-defined yield point, with the transition from the elastic to the plastic stage occurring gradually. The conventional yield strength is defined as the stress level at which the residual elongation is 0.2%.

The selection of alloy grades should be based on the following factors: strength, deformability, weight, durability, processability, plasticity, and the operational conditions of the structures. Aluminum metal structures are manufactured through processes such as extrusion, rolling, stamping, or drawing, which involve applying pressure to the deformable metal alloy.

Nearest foreign analogues of domestic grades of aluminum and aluminum alloys

In the construction industry, the following groups of aluminum alloys, differentiated by their chemical composition, are the most widely used:

Al – Cu – Mg alloys (D1, D6, D16, D18, etc.)
Al – Mn alloys (AMtsM)
Al – Mg alloys (AMg2M, AMg21/2H)
Al – Si – Mg alloys (AD31T, AD31T1, AD31T5)
Al – Zn – Mg alloys (1915, 1915T, 1925, 1925T)

Recently, there has been a noticeable trend in our country shifting from the use of duralumin to alloys of the aviation type and AMg type. In welded structures, alloys such as AMg6, AMg-61, AD33-T1, AV-T1, and B92-T are employed. For enclosing structures, alloys such as AMts, AMg, and AD31-T are utilized. For riveted structures, the following alloys are used: AD33-T1, AV-T1, D1-T, and D16-T.

Abroad, the following alloy grades are used for the fabrication of construction structures: 6061-T6, 2014-T6, 5083, 3004, AlCuMg, AlMgSi, and AlMgMn. Aluminum constructions have gained wide recognition there and are even used for the erection of particularly critical structures.

A summary table of deformable aluminum alloys used in construction in the Russian Federation and abroad, along with their key physical and mechanical properties, is presented below in the text **(Table 1)**.

Table 1
Deformable aluminum alloys in construction in Russia and abroad

Alloy grade		Physical properties		Mechanical properties	
Russian	Foreign	Volumetric weight, t/m^3	Ductility (comparative)	Tensile strength kg/mm^2	Yield strength, kg/mm^2
–	2S	–	high	9	3
A	Al-99	2.71	high	14	10
AMts	3S, AlMn	2.73	high	16.13	13.15
AMg	57S, AlMg3	2.67	high	25.20	21.10
AMg6	–	2.67	high	32	16
AMg61	–	2.68	high	40	24
AD31	6063	2.7	high	20	15
AD33	6061	2.7	high	27	23
AD35	–	2.7	medium	32	28
AV	AlMgSiF-32	2.69	medium	33	28
D1	AlCuMgF-40	2.8	medium	42	24
D16	AlCuMgF-44	2.8	medium	47	33
D18	–	2.8	well	30	17
V65	–	2.75	well	40	–
AK8	2014	2.79	low	49	38
V95	75S	2.85	medium	26	13
V92	–	2.85	high	36	20

In the construction of building structures, the following types of aluminum semi-finished products are utilized: extruded profiles and sheets. Sheet materials are produced either flat or profiled, with variations in thickness and height. Profiles are manufactured in the form of both extruded and bent profiles.

Aluminum alloys for the manufacture of monolithic and composite beams and columns

When discussing small spans, typical operating and installation conditions, as well as standard transportation conditions, the use of aluminum alloys in load-bearing structural elements proves to be limited in terms of technical and economic indicators. However, the application of aluminum alloys for medium and large span structures is quite reasonable. This is attributed to several factors:

1) the effectiveness of utilizing lightweight structural materials increases with span length;

2) the alloys exhibit effective resistance to aggressive environmental influences;

3) a reduction in the prices of aluminum alloys;

4) the development of new structural forms.

For beam coverings exposed to aggressive environments, the use of AMts, AMg, and AV alloys has been deemed appropriate. In our country, a standard riveted truss for a span of 36.0 meters has been developed. Despite its initial cost being 2.5 times higher than that of steel, considering operational expenses, its construction is expected to be recouped relatively quickly, approximately within 10 to 30 years.

In Yekaterinburg, a design for large-span coverings for overhead cranes with a lifting capacity of 15.0 tons has been developed. The dimensions of the building plan are 60×364 meters. The truss beams feature a diamond lattice and a height of 7.2 meters. The material for the chords is D16-T alloy, while AV-T1 alloy is used for the braces. For the shear section of the rolling mill, trusses with a span of 45.0 meters have been employed. The optimal height of the trusses has been accepted within the range of 1 : 7 to 1 : 9 of the covered span.

Projects for standard welded and riveted trusses with spans of 24.0 and 30.0 meters made from aluminum alloys have been developed for coverings in aggressive environments. These trusses are foldable, allowing them to be folded in half like a book, significantly simplifying their transportation from the manufacturing site to the construction site.

The use of structures made from the studied alloys also becomes highly rational under special operating conditions, such as seismic activity in the construction area, the presence of aggressive environments, and remote, hard-to-reach regions of the country.

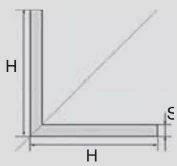
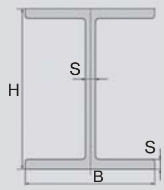
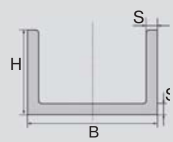
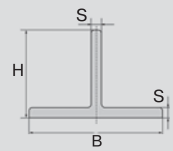
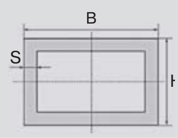
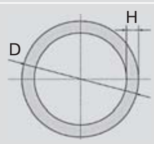
Abroad, structures made from aluminum alloys are primarily used in construction within aggressive environments and in modular pavilions. For instance, in the USA, conventional steel trusses for depot coverings with a span of 17.37 meters, exhibiting corrosion greater than 85%, were replaced with aluminum trusses made from AV alloy. In Germany, during the construction of a chemical industry complex, truss beams made from D1-T alloy with a span of 32.0 meters were installed.

In England, during the reconstruction of a depot, a beam covering consisting of beams with a span of 20.4 meters made from AV-T1 alloy, riveted with steel rivets, was employed.

In contemporary construction practice, pre-tensioned structures made from aluminum alloys have found application. In Yekaterinburg, a single-span industrial building with plan dimensions of 60×364 meters has been developed. Pre-tensioning in the trusses of the 60.0-meter span is achieved using steel cables with a diameter of 55 mm, which equalizes and reduces forces in all panels by 27–50%. As a result, the weight of the trusses is reduced by 13%, and the cost is decreased by 42% compared to a non-pre-tensioned truss. A known design features a truss with a span of 45.0 meters, laid out at a spacing of 12.0 meters, developed in our country. The cross-section of the truss elements consists of round tubes made from AMg6 alloy, with diameters ranging from 100 to 400 mm, while the pre-tensioning is accomplished using round steel 30XGS cables. Such a truss is lighter by 23% and cheaper by 32% compared to an analogous truss without tensioning.

For the fabrication of building structures from aluminum alloys, the following types of cross-sections, listed in **Table 2**, are predominantly utilized.

Table 2
Characteristics of standard aluminum alloy profiles

Name of profiles	Cross-section sketch	Profile dimensions	Cross-sectional areas, cm^2
Angles with equal and unequal flanges		12.7-204	0.4-97
I-beams		76-304	10.8-95
Channels		76-380	7.9-95
T-beams		25-125	1.7-296
Square and rectangular profiles		9.6-140	0.91-196
Round profiles		9.6-202	0.3-324

Aluminum alloys as a material for fast-constructed engineering structures of different functional orientation

Modular assembly enables the rapid construction and dismantling of aluminum structures, saving time and resources. Overall, such structures are quite innovative for creating unique spaces and play a crucial role in contemporary advertising, marketing, and organizational events. Numerous applications are known, ranging from exhibition stands and advertising banners to stages and podiums.

Aluminum trusses are utilized in exhibition and advertising projects. These trusses can be either rectangular or triangular in shape, providing design flexibility and allowing for the creation of structures in various shapes and sizes. With aluminum constructions, it is possible to erect arches, tunnels, and even multi-level structures, adding dynamism and volume to events.

Due to their light weight and strength, aluminum structures are easily transportable and quickly assembled, which is essential for organizing events with limited preparation time. Advertising frames serve as the foundation for banners, posters, and other promotional materials. They can be either stationary or mobile, allowing for use in various conditions and locations. Moreover, aluminum frames exhibit high resistance to corrosion and weather conditions, making them an ideal choice for outdoor applications.

The quickly erected aluminum structures have found application not only in the exhibition industry but also in the construction of temporary facilities such as pavilions, warehouses, retail points, and even temporary living modules. Thanks to the modular assembly system, these structures can be quickly assembled and dismantled, thereby saving time and resources.

A significant technological advantage of using aluminum alloys for quickly erected buildings is the simplification of the construction process, the transportation of factory-assembled structures to the construction site, reduced loads on foundations, and decreased labor intensity during assembly.

Due to the substantial reduction in weight, transportation and assembly costs for pavilions (such as those for fairs or exhibitions) and temporary tents are significantly lowered. Additionally, these structures can be temporarily used without the application of paint coatings. In Germany and Italy, such constructions are manufactured from tubular profile sections, while in England, they are made from pressed *I*-beams.

In Germany, fair pavilions made from tubular structures with a width of 24.0 meters, a length of 26.0 meters, and a height of 10.0 meters are common. The primary load-bearing structures of these pavilions consist of three-hinged arches. Another type of pavilion is constructed from truss frames made up of five assembled elements. The dimensions of such pavilions are 35.0 meters in length, 17.18 meters in width, and 7.6 meters in height. The chords and braces of the frames are made from round tubes with diameters of 63 mm and 38 mm, respectively. All assembly connections are bolted, and the posts are constructed from three-jointed tubes.

To achieve efficient joint design, a construction for the decking of prefabricated pavilions using tubular through trusses has been developed in Milan, Italy. These joints can be utilized for pipes of both the same and varying diameters (ranging from 25 to 48 mm). The material for the joint castings is an aviation-type alloy, and the manufacturing process employed is pressure die casting. Such joints are suitable for medium spans with nodes where the applied forces are relatively modest.

In Brussels, a one-story pavilion building for transportation has been constructed, with plan dimensions of 200×70 m and a height of 15 m. The elements of the roofing are made from an aluminum-magnesium-silicon alloy, featuring riveted lattice trusses with curved chords and diagonal bracing.

The frame structures produced by the company “Alframe” in England feature standard spans of 7.3, 9.75, and 12.1 m. The elements are fabricated from HE 10-WP alloy with a thickness of 0.7 mm.

The pavilion for the aluminum industry in Leipzig is well-known, with its load-bearing structures made from the AlMgSiF32 alloy, while the wall cladding is constructed from aluminum grade A199.

Aluminum alloys for roofing in prefabricated pavilions with medium spans have also been employed in the construction of a standard exhibition pavilion and the roof of the Sports Palace in Kyiv.

In England and the USA, aluminum is widely used for agricultural structures (such as greenhouses, hothouses, and milking facilities), which are operated under conditions of elevated humidity. For instance, a well-known greenhouse measures 27.5 m in length, 15.8 m in width, and 10.0 m in height, constructed from an aluminum-magnesium-silicon alloy. The columns, rafter structures, and supports for cow milking areas are primarily made from sheets with a thickness of 1.6 mm, while the double-ribbed wall cladding consists of sheets also with a thickness of 1.6 mm.

Numerous bridge spans constructed from aluminum alloys have been built abroad, with significant use of floating bridges in the USA. Notable examples include railway, roadway, and pedestrian bridges made from AlCuMg, AlCuSi, and AlMg alloys, with elements joined using welding and riveting.

In the USA, a bridge was constructed for the transportation of gravel from a quarry located on one side of a river to the other. The bridge spans 45.0 m and is 2.75 m wide, with the connections of the bridge truss tubes made using angle brackets.

In Sweden, a welded pedestrian beam bridge with a span of 42.1 m has been built across a lake between a dam and a hydropower station. The main beams, made from composite *I*-section, have a height of 1.3 m, upon which secondary beams with a height of 150 mm are laid.

In Switzerland, a 21.0 m long and 1.5 m wide pedestrian bridge of welded construction has been erected. The longitudinal (main) uncut beams and supports have channel sections, while the transverse beams are *I*-beams. Connections are made using galvanized bolts.

In the USA, a welded, uncut beam bridge for vehicular traffic has been constructed, with elements made from aluminum alloy grade 5456-H351. The width of the roadway is 8.37 m.

The assembly of aluminum structures is carried out using modular joint connections and also with the assistance of cantilever jigs.

Table 3
Standard Sherpa fastening elements

Type	Dimensions L/W/H (mm)	Notional representation	Characteristic loads
XS5...XS20	12×30×50...140		5kN...20kN
S5...S20	12×40×50...110		5kN...20kN
M15...M40	14×60×90...170		15kN...40kN
L30...L80	18×80×150...290		30kN...80kN
XL55...XL250	20×120×250...610		55kN...250kN
XL170...XL300	20×140×410...610		170kN... 300kN

Aluminum alloys as a material for shaped products for construction purposes

For the cladding of walls in residential and public buildings, as well as in unheated industrial structures, corrugated and ribbed panels are widely utilized; this is equally applicable to roofing materials.

In France, residential buildings have been developed featuring a prefabricated construction using aluminum alloys, branded as "Marabou". These homes are assembled from wall panels composed of two aluminum sheets, each 1 mm thick, with thermal insulation sandwiched between them. The cladding and insulation can either be installed piece by piece or delivered to the construction site in a pre-assembled form directly from the manufacturer. Due to the lightweight nature of the walls, approximately 5.0 kg/m^2, the vertical load-bearing structures of the building are significantly alleviated. The thermal insulation properties of such panels are nearly three times greater than those of a brick wall with a thickness of one brick. The thickness of the cladding sheets ranges from 0.52 to 1.52 mm, and the panel lengths vary from 3.72 to 9.0 m.

Aluminum alloys are most extensively used in the manufacture of window frames. Various profiles, both open and closed (tubular) types, are utilized for their production. The connection of profiles at joints is predominantly achieved through contact welding. In the USA, frames are primarily made from alloy grade 6063-T5. The designs of door frames and glass partitions are also diverse.

Globally, a wide range of components for buildings is produced, including handrails, thresholds, parapet slabs, drainage and windowsills, as well as suspended ceilings. The widespread use of the aforementioned products can be attributed to several factors: sufficient strength, high corrosion resistance, low specific weight, ease of shaping, architectural expressiveness, and simplicity of transportability.

For the connection of structural elements, Sherpa fasteners, developed in Austria, are widely employed. These consist of two aluminum components that form a rigid connection based on the principle of a classic "dovetail". The application range of Sherpa systems is quite broad, extending from the connection of wooden structures with materials such as steel or concrete to their use in the construction of winter gardens, carport canopies, and staircases. Standard fastening elements are presented in **Table 3** (materials taken from the catalog of the company www.sherpa-connector.com).

General conclusions about the prospects and advantages of aluminum alloys in the construction industry

Current innovations in the production and processing of aluminum alloys are enhancing the operational characteristics of these materials. Advanced technologies are employed to improve their formability, strength, and resistance to environmental degradation, making them suitable for a broader range of applications in the construction industry. These advancements support the growing trend of integrating lightweight materials into construction structures, thereby enhancing energy efficiency and overall building performance.

Despite these positive growth trends, challenges persist in the market, such as competition from alternative materials and fluctuations in raw material costs. However, the anticipated surge in demand for lightweight and sustainable building materials presents significant opportunities for the sector of deformable aluminum alloys. As regulations concerning emissions and fuel efficiency become more stringent, the adoption of aluminum alloys in construction is expected to increase, paving the way for ongoing innovations and market expansion.

Aluminum alloys offer a range of advantages that are making them increasingly popular in the construction sector. Their unique properties contribute to enhanced performance and durability in construction projects.

To address these challenges, further research is necessary in areas such as improving the reproducibility of additive manufacturing processes, understanding the fundamental properties of aluminum alloys, and developing quality assurance standards. Only through comprehensive research and collaboration can the full potential of deformable aluminum alloys in construction be realized, paving the way for innovations that meet mechanical requirements while ensuring safety and economic efficiency in all construction practices.

It is anticipated that the pace of technological innovations in aluminum alloys will accelerate, enhancing efficiency and enabling the development of high-performance alloys tailored for specific applications. Innovations in materials science, process optimization, and additive manufacturing technologies will expand the possibilities for producing lightweight and complex components, particularly in sectors such as construction. These advancements are crucial as the industry transitions to more stringent emissions regulations and resource conservation, necessitating the use of lightweight materials to enhance performance and cost-effectiveness.

In the study of aluminum alloys and composites, current research emphasizes their processing and characterization. Innovations in joining methods, such as diffusion bonding in the transitional liquid phase, pave the way for improved applications in both construction and manufacturing, ultimately broadening the scope of aluminum's application in modern architecture and infrastructure. The further development of these advanced materials opens promising prospects for the future use of aluminum in construction.

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