Structural Survey

Sustainable competitiveness of aluminium building products

Christina Radlbeck Eszter Dienes Dimitris Kosteas

The Emerald Research Register for this journal is available at
www.emeraldinsight.com/researchregister

The current issue and full text archive of this journal is available at
www.emeraldinsight.com/0263-080X.htm

Sustainable competitiveness of aluminium building products

Christina Radlbeck, Eszter Dienes and Dimitris Kosteas
Institute for Building Materials and Construction, Technische Universität München, Munich, Germany

Abstract

Purpose – To explore the potential and weaknesses of aluminium building products in practice and to consider the material's competitiveness and sustainable performance.

Design/methodology/approach – The characteristics of aluminium are reviewed and data is collected from architects and materials' suppliers. These two groups are chosen because they have most influence on the builder's decision and consequently on the selection of the building material.

Findings – Standards addressing sustainability are currently being developed and will soon be obligatory for building and construction activities. These changes are also likely to have an impact on the conditions for competition.. Aluminium possesses high potential for sustainable building applications mainly due to its light-weight, durability, formability, low maintenance need and excellent recycling properties. From the perspectives of architects and providers, these facts are not known sufficiently yet. In addition no correlations between sustainability and the current competitiveness of aluminium building products are observed.

Research limitations/implications – The research has been carried out in Germany, which may limit the usefulness of the results elsewhere.

Practical implications – A useful information source for architects, engineers and providers of aluminium building products.

Originality/value – This paper identifies the current knowledge gap of architects and providers concerning the potential of aluminium in respect to the whole life-cycle as well as the use of sustainability to influence the competitiveness of aluminium products.

Keywords Construction materials, Metals, Architecture, Sustainable development, Competitive strategy, Germany

Paper type Research paper

Introduction

The beginning of sustainable development was presented by the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992. Then, sustainability was defined as a three-dimensional model combining environmental protection, economic efficiency and social responsibility in an equal way. Based on this definition, guidelines on how to realise sustainable development in practice have been developed for political, industrial and societal audiences. Consequently the building sector has been addressed in several international agreements such as Habitat II Agenda (UNCHS, 1996) and the 6th Environmental Action Programme of the EU (European Parliament and Council, 2002). In addition, several European and

This article is based on a project study (Hasselbeck *et al.*, 2004) of the Section for Light Metal Structures and Fatigue (Professor Kosteas) in cooperation with the Chair of Business Economics, Management, Logistics and Production (Professor Wildemann), Technische Universität München.

Structural Survey
Vol. 23 No. 2, 2005
pp. 131-137

0263-080X
DOI 10.1108/02630800510593693

international standards targeting sustainable building performance have been developed recently (Lützkendorf, 2004) – e.g. CEN TC89 "Thermal performance of buildings and building components"; CEN TC156 "Ventilation for buildings"; CEN TC169 "Light and lighting"; CEN TC228 "Heating systems in buildings"; and CEN TC247 "Building management". Within ISO TC207 the standard series 14000 guidelines for life-cycle analysis and environmental management are covered. In addition, criteria for the classification of building products will be provided soon. By ISO TC59 SC14 "Guidelines for life-cycle-costing" (= ISO 15686 Part 5), requirements for service life assessment and service life declaration in product standards will be given. Finally, the international standard "Sustainability in building construction" is currently being developed by ISO TC59/SC17. Thereby, general principles and terminology, sustainability indicators, building products and the evaluation of environmental effects of buildings will be covered.

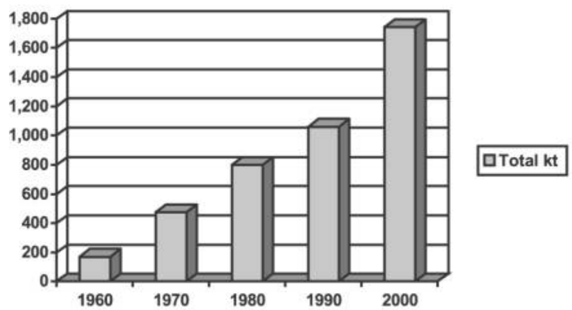
According to these standards and agreements, structures have to be efficient and functional over their whole lifetime, requiring minimum resources and causing minimum environmental burdens. Thus, planners, providers as well as builders are called upon to give consideration to, and optimisation of, sustainable aspects during building activities. A significant part in this development is the choice of the building material which has to provide high-quality while being non toxic, recyclable, cost-efficient and functional with minimal energy consumption during the whole life-cycle. In these aspects aluminium has high potential.

In the following discussion, the competitiveness, potential, difficulties and weaknesses of aluminium products are considered. Furthermore, correlations between competitiveness and sustainable performance are explored. This is done by analysing the characteristics of aluminium and by carrying out a survey of architects and materials' suppliers. These two groups were chosen because they have most influence on the builder's decision and consequently on the selection of the building material. Along with characteristics, tendencies and technical applicability, current market position and future potential for aluminium as a building material are presented.

Characteristics of aluminium as a building product

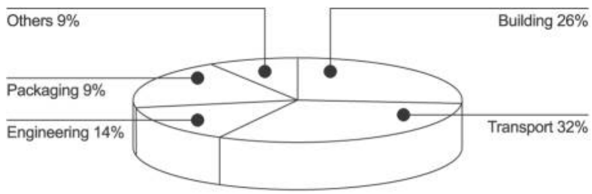
In the building sector the popularity of aluminium structures as load carrying elements as well as fixtures and fittings has increased significantly over the past 50 years (see Figure 1). In total, 26 per cent of all aluminium products are used for building applications (see Figure 2). The building sector also represents the largest customer of the extrusion market (51 per cent) and the market for rolled products (11 per cent) (European Aluminium Association, 2001).

Aluminium structures offer excellent properties as primary load carrying, as well as secondary or decorative, elements. First, there is its light weight (one-third of steel) together with high strength values. Depending upon the type of alloy, strength values within the range of steel are yielded. Other characteristics are presented by its functionality due to various alloys and extruded profiles, its natural corrosion resistance, formability, workability and flexibility. The benefits of aluminium are even more obvious when one considers the whole life cycle of the product. Aluminium is durable, low in maintenance costs and suffers no loss of quality during recycling with 95 per cent energy savings compared to initial production.



Source: Gerber (2004)

Figure 1.
Use of aluminium in European buildings since 1950



Source: European Aluminium Association (2001)

Figure 2.
Main end use markets for aluminium products in Europe, 2001

However, for the effective application of aluminium its disadvantages also have to be considered. These are susceptibility to deformations, the reduction of strength as a consequence of welding, and the risk of thermal bridges. In addition, the high energy consumption during primary production and the higher initial costs per weight compared to other materials have to be compensated by an efficient use phase and an optimised (de-) construction of the structure. It is then possible to put those unfavourable starting positions into perspective and yield an efficient life-cycle performance, which is often better than for other building materials.

In respect of design and execution several national and international guidelines are available. Currently, Eurocode 9 (2004) for the design of aluminium structures is developed to a full European Norm EN 1999. It contains a large number of alloys, includes progressive design procedures and covers marginal structural problems such as biaxial bending, interaction effects as well as design rules for fatigue design. Advice is also given in respect of welded aluminum structures. For manufacturing and quality assurance a separate new Eurocode (CEN TC 135 WG4) is being developed.

Survey

Based on a survey by (Hasselbeck *et al.*, 2004), aluminium building products were investigated concerning competitiveness and sustainable performance. The objective was firstly to identify current deficiencies and future potential of the products based on the planners' point of view and secondly to derive necessary corporate measures for providers.

To this end data were collected by questionnaire from 300 architects and by interviews with nine metal companies in Germany. In addition, first-hand practical insights into the aluminium construction business were gained through workshops with two small to medium-sized enterprises (SMEs) offering innovative aluminium solutions. The sample size of questioned architects, suggests that the survey is statistically representative of Upper-Bavaria one of the economically most powerful regions in Germany (and the administration district including Munich).

For architects, 16 questions were developed and divided into the categories, "General knowledge concerning aluminium building products" and "Personal view". The questionnaire for metal construction firms included 44 questions concerning "General business information", "Technical and design issues", "Environment", "Profitability", "Personal view", and "Sustainability and competition". In the latter category, the significance of sustainability for corporate management as well as corresponding strategic and operational measures were covered. All participants were asked to answer the questions based on their knowledge and practical experience. Approximately 55 per cent of the questioned architects and metal companies represented SMEs whereas the other participants belonged to larger companies.

Results

Both architects and metal companies designate doors, windows and facade systems as major application fields for aluminium (see Figure 3). In respect to facades, architects even use aluminium in 50-70 per cent of all systems they design. The main advantages of aluminium for architects are its light weight, long service life, low maintenance and the possibility of various surface treatments. High strength and positive environmental and economic characteristics such as recyclability, no toxicity and low cost-value ratio only have secondary relevance (see Figure 4). Nevertheless, the concept of sustainability is known to 77 per cent of the questioned architects. Furthermore architects forecast that the significance of life-cycle orientation and life-cycle costs in respect to investments will double until 2010.

The main reasons identified by the sample against the use of aluminium are its high initial cost, low strength and questionable fire resistance. These are followed by high resource consumption during production, bad ecological image, susceptibility to local

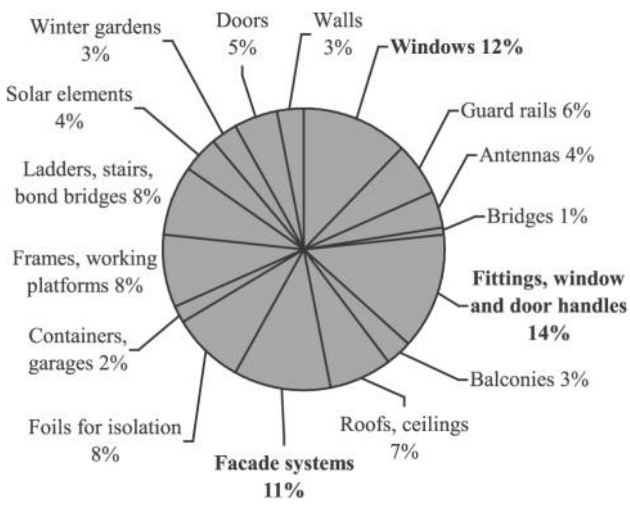


Figure 3.
Application of aluminium by architects

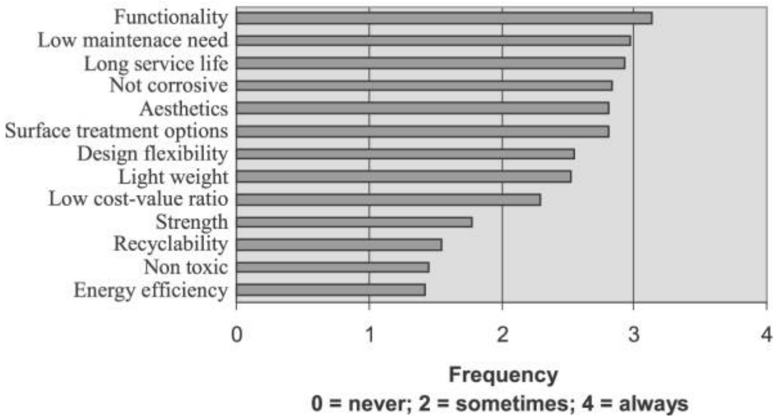


Figure 4.
Reasons for architects to specify aluminium

buckling, discrimination by public regulations (for example, the city of Munich prohibited the use of aluminium in public buildings (Munich, 2004)) and aesthetical reasons. Criticism in respect of ecology is, as always, based on missing knowledge about aluminium, i.e. architects complaining about the ecological performance are not aware of the excellent recycling characteristics. As essential development areas the architects suggest fire protection, resistance to punctual impact loads, surface design and individual cross sections. Further potential for future applications is identified for castings, load carrying structures, transparent design and roof sealing. Metal companies indicate in the category "Technical and design issues" low need for inspection, repair and customer service for their aluminium building products. Sources of information such as print-outs, internet, industrial organisations and information exchange between companies as well as between companies and research are evaluated as low and average. In contrast to this, the information exchange between companies and clients is considered as average and perfect. In respect of the category "Environment" 78 per cent of the participants either never or rarely experience ecological reproaches from customers, environmental organisations, media or other construction firms. However, in any case that it did occur, media played the most important role. Two companies indicate regular benchmarking of their aluminium products against other materials. The same companies assess environmental impacts on request of their customers. In general, 67 per cent of all metal companies sell their scrap to respectable dealers. However, only 33 per cent take back scrap from customers. The results of category "Profitability" show that 50 per cent of the companies never or rarely pursue any form of marketing. The other companies use trade fairs, brochures, internet, professional journals, public relations and personal recommendation. The concept of life-cycle cost analysis is only known to less than half of the participants and is barely applied in practice. Consequently, the documentation of costs, the identification of saving potential and the optimization of economic efficiency over the entire product life-cycle are rarely pursued. The category "Sustainability and competition" showed that the principle of sustainability is known to most companies but in fact none publishes sustainability reports and only one company is planning to do so in the near future. A total of 67 per cent of the participants do not anticipate any business development by considering sustainability in corporate management. The other 33 per cent consider the concept of sustainability merely as an opportunity for image improvements. Instruments, such as Life-Cycle-Assessment, and other methods, such as determining energy and material flows, are not available in most questioned companies. Therefore, it is not common practice yet to identify ecological problem areas and define respective priorities. In the category "Personal view" untapped application potentials are defined in the area of finishing and individual construction which requires a high level of formability, flexibility, light weight and modular construction.

Discussion

The survey results show future application potential for aluminium in the areas of load carrying structures, finishings, castings and individual cross sections. In addition, a substantial need for information is identified concerning environmental impacts, fire protection, resistance to punctual impact loads and surface treatment possibilities. Furthermore, a lack of information exchange within the aluminium industry is observed. Life-cycle thinking is largely missing. Investment decisions at present are still based on economic short-term orientation. In addition, no tendency can be observed towards considering environmental aspects because of legislative requirements or to improve competitiveness. Established recycling systems and long-term contracts between metal companies and scrap dealers are not in place yet. On the supply side, the main reasons for disregarding sustainable aspects are missing know-how and missing willingness to invest in appropriate instruments, such as life-cycle assessment, life-cycle cost analysis, environmental management etc. In general, large companies showed more interest in sustainable measures than SMEs. This is presumably due to more abundant funds and personnel capacity. In this respect, state and industrial organisations have the task of providing help with development and transfer of necessary methods and instruments to SMEs. In addition, it is necessary to distribute information about the advantages of sustainable business as well as sustainable products and to develop adequate tools. In the building sector there is, as yet, insufficient knowledge that sustainable corporate measures result in quantifiable benefits such as reduction of costs and emissions, increased client satisfaction and turnover, etc.

Summary

The tendency towards sustainable development is having an impact upon the building sector and this impact is only likely to grow in importance in the future. Since there exist only noncommittal agreements up to now, the realisation of sustainable aspects into building practice is still based on voluntary efforts. However, standards addressing sustainability are currently being developed and will soon be obligatory for building and construction activities. These include life-cycle-orientation, economic and environmental efficiency as well as high technical demands. For aluminium, this focus on sustainability might provide an opportunity to increase competitiveness. To compensate high cost and energy consumption during primary production it is necessary to evaluate aluminium products in respect of their whole life-cycle. This involves construction as well as use phase, recycling and disposal. By considering the efficient use phase and recycling credits, aluminium often performs better than other building materials. In practice, these facts are not known sufficiently yet. The results of the study show a lack of awareness about the basic material characteristics on the part of the architects. The concept of sustainability is neither applied by architects nor by metal companies. At least large metal companies plan such initiatives in the near future. However, no correlations between sustainability and current competitiveness for aluminium building products are observed. Architects and metal companies are therefore not yet prepared to capitalize on sustainability.

References

European Aluminium Association (2001), *Market Development 2001, Statistics*, available at: www.eaa.net, state (accessed November 2004), EAA, Brussels.

European Parliament and Council (2002), *Decision No 1600/2002/EC of the European Parliament and of The Council of 22 July 2002 Laying Down the Sixth Community Environmental Action Programme*, available at: http://europa.eu.int/comm/environment/newprg (accessed November 2004).

Eurocode 9 (2004), *prEN 1999-1-1: 2004: Design of Aluminium structures, Part 1-1: General Structural Rules. 2004*.

Gerber, J. (2004), "Energy and sustainability of aluminium fabricated products", paper presented at the ALFED Conference on Sustainability of Aluminium Products Used in Building Construction, London, 13 October.

Hasselbeck, A., Klein, D. and Riesemann, M. (2004), "Methoden für eine nachhaltig profitable Unternehmensführung zur Erhöhung der Wettbewerbsfähigkeit von Aluminiumbauprodukten", project study, Section for Light Metal Structures and Fatigue and Chair of Business Economics, Management, Logistics and Production, Technische Universität München, Munich.

Lützkendorf, T. (2004), "Sustainability in building construction – can new standards deliver answers to old questions?", *Journal of the International Association for Bridge and Structural Engineering*, Vol. 14 No. 3, pp. 186-8.

Munich (2004), *Ökologischer Kriterienkatalog*, Referat für Stadtordnung und Bauordnung, Stadtsanierung und Wohnungsbau, PLAN HA III/2, available at: www.muenchen.de/vip8/prod2/mde/_de/rubriken/Rathaus/75_plan/08_beratuservice/04_publikationen/oekokatalog/pdf/oekokatalogii.pdf (accessed December 2004).

UNCHS (1996), *Habitat II Agenda, Second United Nations Conference on Human Settlements, Istanbul, 3-14 June*, available at: www.earthsummit2002.org/toolkits/women/un-doku/un-conf/habitat.htm (accessed November 2004).