Opportunities for the use of Aluminum in Vehicular Bridge Construction

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Summary

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1 - Introduction

Highway authorities across North America are currently being faced with significant and pressing bridge maintenance costs, as documented in several recent reports [A1,A2,B1-B3]. Reports published in the US estimate a need for $140 billion to be spent to upgrade the 600,000 existing US bridges – around 25% of which have been deemed to be either "structurally deficient" or "functionally obsolete" [B1]. In 2007, the total value of the bridges and roads in Canada was estimated to be $23.9 billion and $170.1 billion respectively [B2]. In 2005, the cost of upgrading and renewing our existing urban roads and bridges in Canada was estimated to be $66 billion [B3]. Recent bridge failures have drawn public attention to this concern (e.g. the Laval and Minnesota bridge collapses in 2006 and 2007). Less readily apparent than the high owner costs of bridge maintenance and the immediate and serious impacts of these recent bridge collapses, but arguably just as important, are the significant costs to the users and general public (e.g. user delay costs, environmental impacts) associated with the gradual deterioration of our bridge infrastructure and the continued use of functionally obsolete bridge infrastructure that is in need of upgrade or replacement. Within this context, the current report, which was prepared at the request of the Aluminum Association of Canada (AAC), focuses on the opportunities for increased aluminum use in vehicular bridge construction and the potential role that aluminum can play in addressing the maintenance challenges currently facing this industry.

2 - Use of Aluminum in Vehicular Bridges

Aluminum has been used in numerous vehicular bridge projects around the world, since it was first used in the Smithfield Street Bridge deck replacement in Pittsburgh in 1933. The longest span aluminum bridge in the world currently is the Arvida Bridge, constructed in Saguenay, Quebec in 1950 (see Figure 1 (left)).
Aluminum has also been used extensively for pedestrian bridge applications, in Europe, Japan, and North America (see Figure 1 (right)). In these applications, the reasons for choosing aluminum are the light weight and the aesthetic qualities and durability of the unpainted metal. Aluminum walkways are particularly popular in highly corrosive environments such as marine docks and industry plants [A3].

Figure 1. Arvida bridge in Saguenay, Quebec (left) , aluminum pedestrian bridge installation (right).

Much of the recent effort to introduce aluminum in vehicular bridge construction has focused on the development of replacement deck products [A4] (see Figure 2). The main reason for using aluminum in replacement decks is to increase the capacity of older bridges to carry modern truck loads by removing the heavy concrete deck and replacing it with a much lighter one. Severe deterioration of existing reinforced concrete decks due to heavy road salt use is another reason for employing this retrofitting approach.

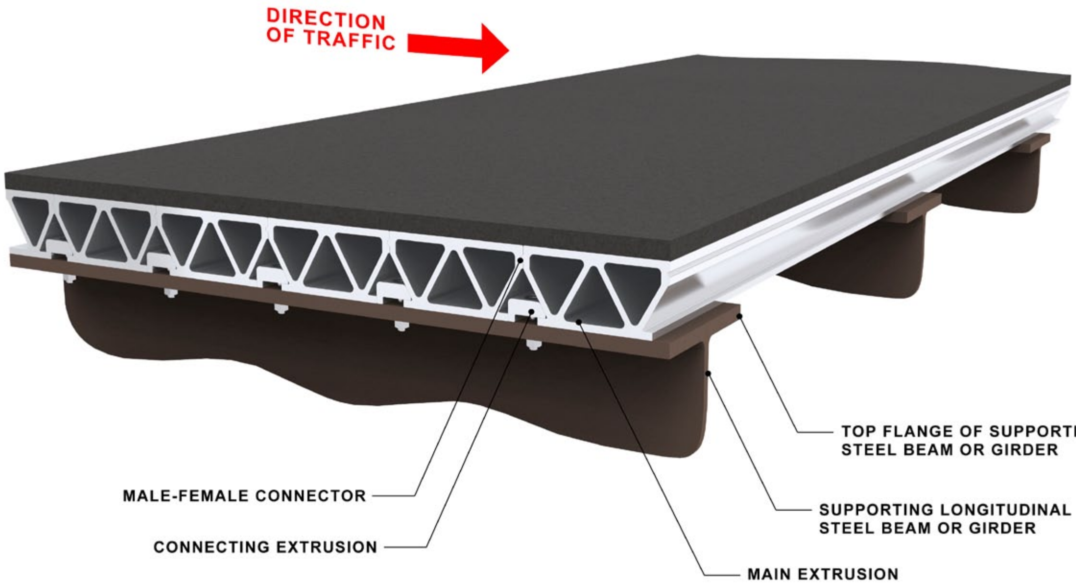

Figure 2. Extruded aluminum bridge deck system.

The primary structural members of a new vehicular bridge that can be fabricated out of aluminum include the deck and superstructure. Aluminum can be used exclusively or in combination with conventional construction materials. In addition to the primary structural members, there are a number of secondary bridge components that can and are frequently fabricated out of aluminum. These are illustrated in Figure 3.

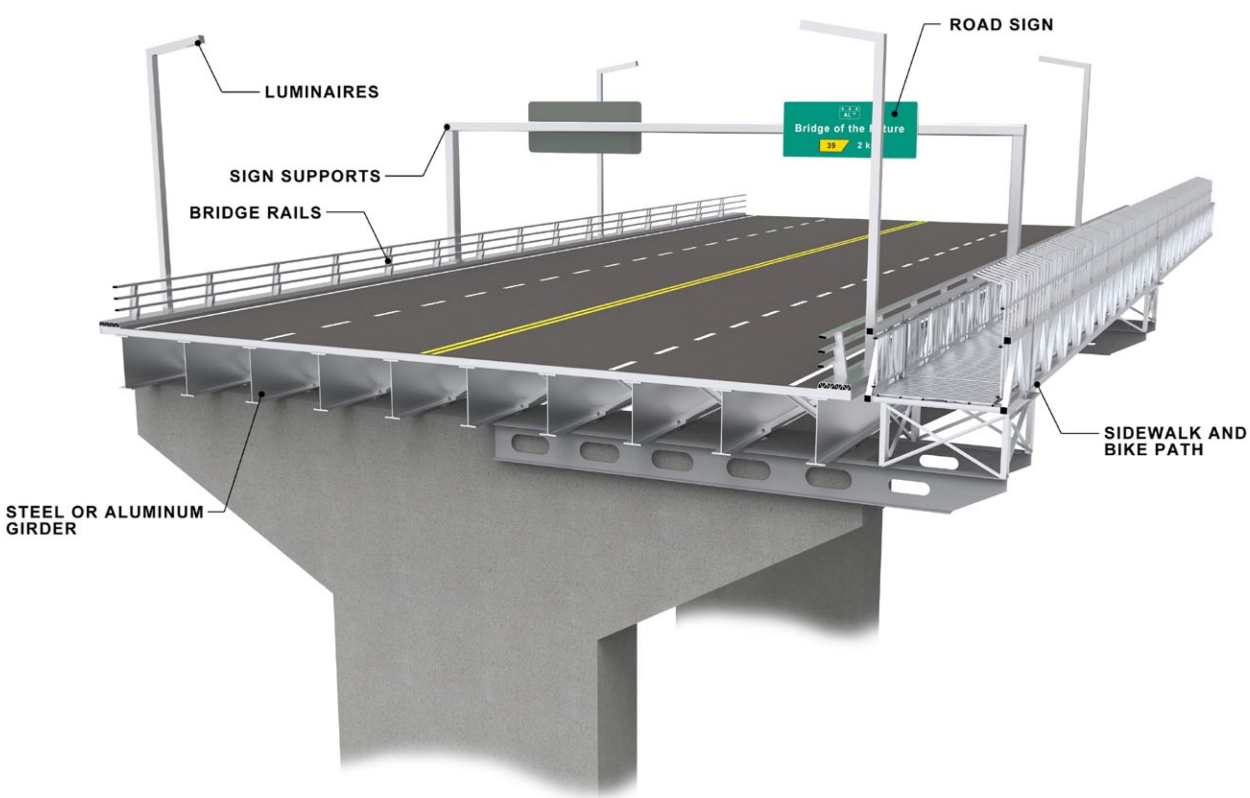

Figure 3. Use of aluminum in secondary bridge components.

3 - Summary and Conclusions

Based on the material presented in this report, the following conclusions are drawn:

1 - Aluminum has a track record of good performance in vehicular bridge applications dating back almost 80 years. The feasibility of constructing vehicular bridges entirely out of aluminum has been demonstrated in a number of projects. The most frequent and successful applications have included: replace deck retrofits and pedestrian, lift (or bascule), floating, and temporary bridges.

2 - A number of modern codes and standards are available for the design of aluminum bridges.

3 - From a materials perspective, the positive attributes of aluminum alloys include: light weight, high corrosion resistance, and extrudability. The best opportunities for aluminum use in vehicular bridges tend to be ones that exploit one or several of these positive attributes.

4 - The properties of aluminum that present the greatest challenges for structural applications include: its lower elastic stiffness and fatigue strength than steel, and the reduction in the local yield strength that accompanies welding for many aluminum alloys, and the higher initial material cost. These isssues can be mitigated through smart detailing, the use of modern friction stir welding (FSW) techniques where possible, and material selection on the basis of life-cycle cost.

5 - The opportunities for aluminum use in the retrofitting of existing bridges include: deck replacement, deck widening, sidewalk / bike path addition, and rapid bridge replacement projects.

6 - The primary structural members in new vehicular bridges that can be constructed out of aluminum include: bridge decks, longitudinal girders, diaphragms, and cross bracing. The benefits of aluminum use in these applications are most apparent in severe corrosion environments, when comparisons are made based on life-cycle costs incurred by all of the bridge stakeholders.

7 - Aluminum is currently being used for secondary bridge components, including: sidewalk and bike path support structures, luminaires, sign support structures, and bridge rails. In these applications, the primary benefits of aluminum are its light weight, durability, and aesthetic qualities.

References

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