

ROAD AND PEDESTRIAN BRIDGES IN ALUMINUM

Executive Summary

**REPORT ON VISITS AND MEETINGS IN SWEDEN, HOLLAND,
AND THE UNITED STATES**

**IN EUROPE
FROM DECEMBER 2 TO DECEMBER 11 2014
IN THE UNITED STATES
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by

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Table of Contents

1. Introduction	3
2. People Encountered	3
3. Royal Institute of Technology of Stockholm Meeting and SAPA Visit, Finspang	3
4. Summary of Road and Pedestrian Bridges Visited	4
5. Preliminary Conclusions on the Technology Utilized in Sweden	4
6. Meetings in Holland and Bayards Visit	5
7. Summary of Road and Pedestrian Bridges Visited	6
8. Preliminary Conclusions on the Technology Utilized in Holland	7
9. Meetings with Aecom and Seacost and Bridge Visit in the United States	7
10. Preliminary Conclusions on the Technology Utilized in the United States	9
11. Questions Asked by MTQ, MTO, and Scott Walbridge	9
12. General Conclusions	10

1. Introduction

In early December 2014, **Jacques Internoscia**, of the *Aluminum Association of Canada* (AAC) and **Denis Beaulieu**, consultant, traveled to Europe to meet designers, manufacturers, and managers of aluminum road and pedestrian bridges in Sweden and Holland and to visit a number of these structures in order to prepare the ground for writing a report for a more official visit by a number of delegates in the fall of 2015.

A visit with similar objectives was held on February 26, 2015 in the United States. **Martin Hartlieb** of *AluQuébec* also participated in this visit.

2. People Encountered

Sweden: **Dr. Torsten Höglund**, retired professor of the Royal Institute of Technology, **Mikael Lindqvist** with *SAPA*, **Hans Pétrusson**, engineer from the *Swedish Transportation Administration*, **Bert Norlin**, professor at the *Royal Institute of Technology*, and **Lars Svensson**, developer of the *SAPA Bridge Decking System* (absent due to illness during our visit).

Holland: **Dick de Kluijver**, **Tjibbe van der Werff**, and **Dies W.S. Mackintosh**, three engineers with *Bayards*, **Dr. Frans Soetens**, retired professor from *TNO*, and **Dr. Johan Maljaars**, professor at *TNO*.

United States: **Greg Osberg** of *AlumaBridge*, **George C. Patton** with *Hardesty-Hanover*, **Ed Coholich** and **Mike Riley** with *LBFoster*, **David Graff** with *Parsons*, and **Steven Ballou** and **R. Randy Johnson** with *Seacoast*.

3. Royal Institute of Technology of Stockholm Meeting and SAPA Visit, Finspang

This meeting was to present alternative technology of replacing existing decks on road and pedestrian bridges with an aluminum bridge deck system formerly referred to as the *Svensson Deck* after its inventor. This system is now known as the *SAPA Bridge Decking System*, since it is *SAPA* who has been promoting it since the retirement of *Lars Svensson*.

The replacement of existing bridge decks with aluminum decks was very popular from 1987 to 2005, with almost 70 bridges rehabilitated during this period. Only ten bridges have been rehabilitated since 2005, which seems to be due to a lack of a succession plan following the retirement of the main developers (*Höglund* and *Svensson*).

The deck is formed from extruded profiles aligned transversely relative to the long axis of the bridge. Two main types of profiles are used depending on the span (see Figure 1). The width and depth of the smaller profile are 250 and 50 mm respectively (system 50) and those of the larger profile are 300 and 100 mm respectively (system 100). The first system is particularly suitable for the replacement of wooden decks and the second for the replacement of existing concrete decks. The profiles fit into one another and are held to the steel beams supporting them using fasteners bolted to the upper flanges of the beams. The completion of an entire bridge deck requires a large number of profiles, as shown in Figure 1.

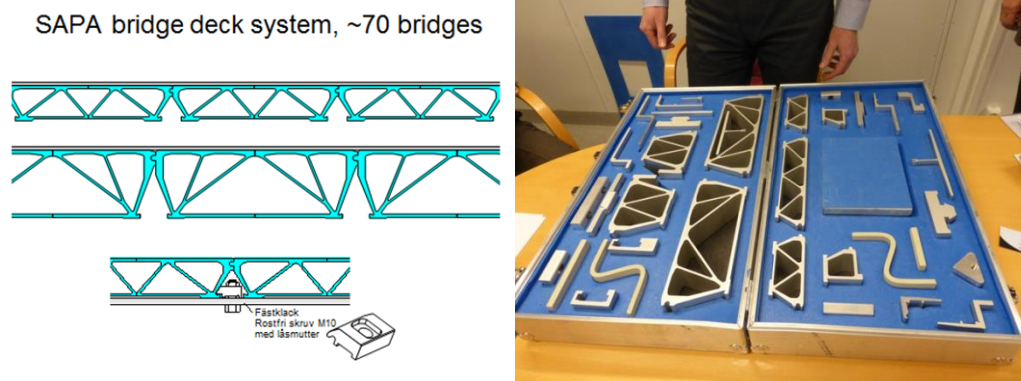


Figure 1 – SAPA Aluminum bridge deck system

The guided tour of the *SAPA* factory in Finspang was quick, but very impressive. *SAPA* has a large inventory of extrusion dies managed using robots. *SAPA* also has a huge friction stir welding machine for assembling panels 14.5 metres long by 3 metres wide. Currently, *SAPA* (in Sweden) preassembles panels for various applications, but has not yet developed an extruded profile bridge deck that could be friction stir welded, as is the case for *SAPA* in the United States. We had the overall impression that this is a major development, which will happen soon.

SAPA is jointly owned by *Orkla* and *Hydro* (both are equal stakeholders). The company operates in 40 countries, employs 23 000 people, and is headquartered in Oslo, Norway.

4. Summary of Road and Pedestrian Bridges Visited

Six bridges whose decks were replaced with the aluminum *SAPA* deck were visited. All are located near Stockholm: the **Tottnäs** bridge, the **Stallarholmen** bridge, the **Vilsta** bridges, the **Björnavad** bridge, the **Snövelstorp** bridge, and the **Venneberga** bridge. Examples of these bridges are shown in Figure 2.

The bitumen wearing surface on most of these bridges has a tendency, over time, to crack transversally vis-à-vis the joints between the sections, as shown in Figure 2.

5. Preliminary Conclusions on the Technology Utilized in Sweden

The *SAPA* deck system does not appear to lend itself well to the replacement of bridge decks on major roads. To date, all the bridges whose decks were replaced with new aluminum decks are located on secondary roads and many of these bridges are movable (i.e. lift or bascule) bridges.

It is time to modernize the concept by developing a new type of extruded profile, which would lend itself well to fabrication using the friction stir welding process in order to make larger panels for bridges, as is already the case in Holland and the United States. The *SAPA* factory in Finspang is already using this technology to produce panels and decks for other purposes. The problem of wearing surface cracking would be largely if not entirely resolved by this development.

The cracks in the wearing surface do not appear, however, to make the deck permeable to water, since it was seen that the superstructure under the visited bridge decks is not affected by corrosion. The membrane positioned at the base of the coating apparently remains intact.



Figure 2 – Examples of bridges visited and cracking of wearing surface

6. Meetings in Holland and Bayards Visit

Dick de Kluijver made a PowerPoint presentation of some very impressive structures made entirely of aluminum by *Bayards*: boats, heliports, drilling platform living quarters, buildings, bridges, etc. The company has existed and operated in the aluminum industry for 50 years. They have designed, manufactured, and built 26 aluminum road and pedestrian bridges since 2000. Bayards recently rehabilitated two 25 m span steel bridges using aluminum in Kentucky. A 10 mm epoxy/aggregate coating or a 10 cm asphalt layer (for American studded tires) is generally used as a wearing surface.

Bayards does not just replace wood or concrete bridge decking with aluminum decks. The company also partners with architects to design, manufacture and build new bridges entirely of aluminum. There is no standard system for the latter application, as there is, for all practical purposes, for replacement decks. The company has, in fact, different types of profiles for bridges.

Bayards promotes the friction stir welding of the extruded profiles for the fabrication of road and pedestrian bridges. The Bayards friction stir welding machine is one of the largest on the market today (Figure 3). Additionally, the fusion welding performed by Bayards is also very high quality, as shown in the same figure.



Figure 3 – Examples of friction stir welding and fusion welding by Bayards

Professors Soetens and Maljaars are long time collaborators with *Bayards*. They've participated in the implementation of several projects, including bridge projects, with this company. They confirm their availability to meet with researchers and students from the Aluminium Research Centre (REGAL: www.regal-aluminium.ca). They also work closely with Professors Magnus Langset and Oddstore Hopperstad of SINTEF at the University of Trondheim in Norway.

7. Summary of Road and Pedestrian Bridges Visited

Five road and pedestrian bridges manufactured, constructed, and installed by *Bayards* were visited, including: the **Westerdok** pedestrian bridge, the **Uiver** bridge, the **Maarszen** bridge/walkway, pedestrian bridges in the District of **Ijburg**, and the **Haringvlietbrug** bridge. All of these structures are located in or near Amsterdam or in the Rotterdam area. Figure 4 shows a view of the Westerdock and Maarszen pedestrian bridges, as examples of what *Bayards* is able to achieve.

All bridges and footbridges we visited in Holland are in very good condition including the wearing surfaces.

8. Preliminary Conclusions on the Technology Utilized in Holland

Unlike the standard technology used by *SAPA* in Sweden, for the replacement of existing bridge decks with aluminum decks, the approach favoured by *Bayards* is more versatile and diverse. It can be applied both in the replacement of existing bridge decks and the construction of new road and pedestrian bridges made entirely of aluminum. The concepts and profiles used for the various structures are tailored to customer needs. In addition, *Bayards* promotes the involvement of an architect in the design of the bridge. This results in significantly more attractive structures than those designed by engineers alone for which the main concern is often promoting the lowest bidder.



Figure 4 – Westerdok and Maarsen pedestrian bridges built by *Bayards*

9. Meetings with *Aecom* and *Seacost* and Bridge Visit in the United States

Current development efforts are limited to the replacement of existing roadway bridge decks with aluminum decks. However, it is possible that in the near future the team will go after projects involving the design and construction of bridges with aluminum used on other components. Since thousands of road bridge deck will be replaced in the years to come to the United States, it was strategically decided to focus on this niche for which the aluminum has undeniable advantages.

Greg Osberg has recently started his own firm, *AlumaBridge*, and in partnership with several collaborators, he has developed a new extruded 5 inch (130 mm) deep profile, more suitable than the 8 inch (200 mm) deep profile developed previously by *Reynolds Metals* to replace the aging steel grating found on thousands of movable bridges in the United States, particularly in Florida. The 8 inch profile and the new 5 inch profile are extruded by *SAPA* in Indiana and are friction stir welded using a brand new machine by *HF Webster* in Rapid City, South Dakota (Figure 5). A *Flexolith* wearing surface (low modulus epoxy coating and broadcast overlay system) produced by *Euclid Chemical* in Cleveland, OH (www.euclidchemical.com/) is then applied by *HRI Inc.* in Williamsport, PA (www.hriinc.com). The panels are finally shipped to the site by truck. The firm *LBFoster* develops the product in partnership with *AlumaBridge* and promotes it.



Figure 5 – Friction stir welded 5 inch bridge deck

A research program was set up with support from the *Florida Department of Transportation (FDOT)* to test the new 5 inch deck to allow accreditation for the replacement of steel deck grating on many mobile bridges in Florida. Aluminum deck, with an equivalent weight to the deck grating it replaces, was selected as the best option after considering several alternatives. It is this process that is currently underway in Florida under the supervision of George Patton.

Denis Beaulieu visited a bridge built in 1996 over the *Little Buffalo Creek*, on Route 58 near Clarksville, Virginia. The aluminum deck was designed to work compositely with four steel beams on which steel shear studs were welded, as illustrated in Figure 6.



Figure 6 – Steel-aluminum composite bridge over the *Little Buffalo Creek*, in Virginia

10. Preliminary Conclusions on the Technology Utilized in the United States

The team that has been built around the *AlumaBridge* company in the United States for developing and promoting aluminum bridge decks, is about to have two orthotropic deck designs recognized by different departments of transportation, in both the United States and Canada. Thousands of road bridges are targeted. Pedestrian bridges and other aluminum elements in road bridges are not being considered by this group for the moment. This field remains open to competition.

11. Questions Asked by MTQ, MTO, and Scott Walbridge

Our hosts answered more than 30 questions from the Ministries of Transport of Quebec and Ontario, as well as by **Dr. Scott Walbridge**, professor at the University of Waterloo.

12. General Conclusions

The technology used by *SAPA* for the rehabilitation of bridges in Sweden is different from that used by *Bayards* in Holland. In both cases, however, the extruded profiles of the deck are generally arranged transversely to the longitudinal axis of the bridge and rehabilitated decks consist of either wood decking or concrete slabs that have reached their end of their service life. In all cases, the need for lightness, impermeability, ease of maintenance, and replacement speed are the main criteria considered. While the Swedish technology is standardized and applied only to replacement decks, in Holland, *Bayards* is designing, manufacturing, and building all-aluminum road and pedestrian bridges that do not conform to a predetermined standard.

The friction stir welding of extrusions is used in the manufacture of aluminum decks for bridges in Holland and the United States. It is probably only a matter of time before the Swedes decide to adopt this new technology for the manufacture of a new type of bridge deck. *SAPA*, in Finspang are already using friction stir welding to manufacture panels and decks for other purposes and *AlumaBridge*, in the United States, has recently used this technology for the manufacture of its bridge decks, in partnership with *SAPA* and other stakeholders. Thus, the problem of cracks in the wearing surface observed in Sweden will ultimately be solved.

It is interesting to compare the Swedish and Dutch approaches to the Americans. The latter have their extrusions in the transverse or longitudinal direction of the bridge, according to the type of superstructure and use friction stir welding to form larger panels. This allows them to design orthotropic decks able to develop composite action with the support beams when required. Anti-slip assemblies made with high-strength bolts connecting the deck to the supporting beams allow the development of the composite action. The Americans are so far the only ones using this technology.

The objective of this exercise of meetings and visits, and the production of two reports, is to educate Quebec and Canadian policy makers to the use of aluminum in bridges and prepare a similar but more official tour for a delegation of people interested in the subject in the fall of 2015.