B2 DURABILITY AND LIFESPAN OF

ALUMINIUM STRUCTURES & BRIDGES

Monkeytoe

ALUMINIUM STRUCTURES IN PRACTICE

Aluminium as a structural material is favourable in many applications as it offers a durable, corrosion-resistant and lightweight structure. San Gioacchino Church and Shaftesbury Memorial Fountain are an example of numerous well-known aluminium structures which are in service for more than 100 years. Long term service of the Long Island bridge which is closely located near the marine environment is a piece of evidence of the durability of the aluminium bridge in a corrosive environment and sustained the traffic volume of 50 million vehicles per year. Apart from Galvanic corrosion around the steel bearing due to poor maintenance practices and understanding of this phenomenon, no other damage was observed in a total of 58 years of the service life of the bridge [1] [2]. A greater understanding of galvanic corrosion control has been developed since this was designed.

To illustrate the differences between steel and aluminium, consider two pedestrian bridges along the St. Lawrence River. The first, located in Verdun on the Island of Montreal, is an aluminium bridge built 18 years ago. The second is a steel and concrete bridge installed in 1988 in Longueuil, on the south shore. A few kilometres apart, they face the same climate and were designed for the same live load. The steel bridge has had regular maintenance with more than $1M NZD spent in the last 10 years in contrast the aluminium bridge has required none [3]. Moreover, overall lifecycle cost of aluminium over the entire life of structure is generally less than other materials as indicated in

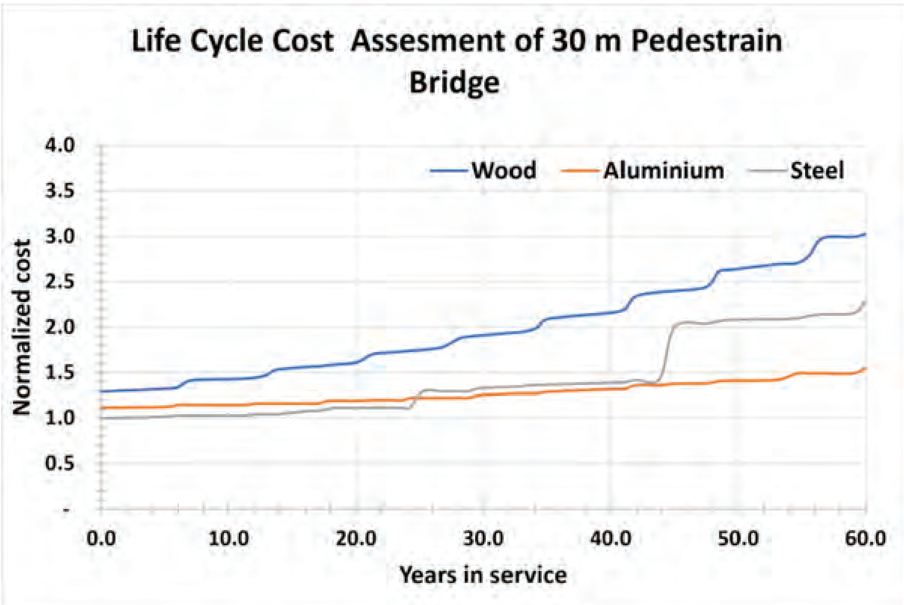

FIGURE 1: LIFE CYCLE COST ASSESSMENT OF 30M WOOD, ALUMINIUM AND STEEL PEDESTRIAN BRIDGE

These lessons have been well learned by most of the marine and offshore industry, particularly in Europe where the combination of stainless-steel fasteners was proved with a submerged aluminium buoy that was checked after 32 years in seawater with no maintenance. When removed, cleaned, and inspected the non-isolated 300 series stainless steel fasteners were fine as well as their structural integrity and it was cleared to return to service [5]. The effect of 300 series stainless steel coupled with aluminium was further tested by the manufacturer Hydro for 3 years showing negligible effects of corrosion in the most corrosive splash zone sea environment as can be seen in Figure 2 [5].

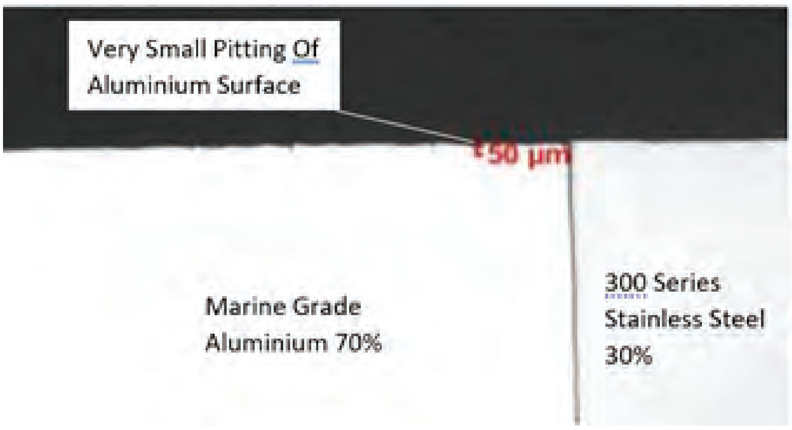

FIGURE 2: ALUMINIUM AND STAINLESS-STEEL MICROSCOPE VIEW AFTER 3 YEARS IN THE SPLASH ZONE

Monkeytoe Group has also had external rooftop structures in service for more than 16 years. These are located at a Dairy factory in Taranaki. This environment is subject to coastal salt spray, corrosive cleaning chemicals and tons of milk powder that fall on the site each day. In these conditions which are likely to be classed as C4 the structures continue to maintain their integrity without issue. The most corroded ones are sheltered from weather and are covered in corrosive factory deposits which haven't been cleaned but are still performing well, while the structures located in a rain-washed area are in good condition. This shows the benefit of washing aluminium in a maintenance cycle in highly corrosive environments.

FIGURE 3 PRODUCT INSTALLED IN A HIGHLY CORROSIVE DAIRY PLANT ENVIRONMENT 16 YEARS -NO CLEANING

FIGURE 4 PRODUCT INSTALLED ON DAIRY PLANT ENVIRONMENT WITH RAIN WASHING

MATERIALS

The Structures mentioned above all use alloys that are known as ‘marine grade aluminium’ (5xxx and 6xxx series aluminium alloys) these are commonly defined as have an A or B rating in external environments by ASTM and Eurocode 9 and do not require external protection of the surfaces in industrial and seacoast environments. These alloys are used extensively in marine environments across the globe particularly in Europe and North America where the structural integrity is strictly in compliance with renowned Eurocode 9, Aluminium Design Manual and DNV-GL Standards [6, 7, 8, 9]. These codes have been developed over the years with continuous lab testing and in-service structure monitoring and are wider in scope than the current AS/NZS standards relating to designing and constructing aluminium structures.

FASTENERS AND CONNECTIONS

ALUMINIUM TO ALUMINIUM

For all aluminium structures the connections are with fasteners which are generally not aluminium require care in selection. Extensive testing and experience by Hydro aluminium in Norway has shown that direct contact Stainless steel fasteners perform well for more than 30 years even submerged in saltwater [5]. This is described in the Aluminium design Manual that ‘Due to the oxide layer limits corrosion than would be otherwise expected based on the relative positions in the galvanic series for stainless steel and aluminium.’ [7]. Also, with all aluminium structures the difference between the surface areas of the fastener and parent materials means that while the aluminium can become the anode to the more noble stainless steel, the sheer surface area of the aluminium compared with the fasteners means there is no effect on the life of the structure. Proof of this can also be seen in the photos shown. The use of galvanised steel fasteners with aluminium, although recommended by some literature and standards (such as NZBC) will in the experience of Monkeytoe corrode rapidly due to the exposed area of the small fastener becoming an anode to the larger area of aluminium.

FIGURE 5 CONNECTIONS OF ALUMINIUM TO STAINLESS AFTER 16 YEARS OF DAIRY PLANT ENVIRONMENT

CONNECTIONS TO OTHER METALS

Due to its position on the Anodic table aluminium will typically act as an anode to other metal structures and require isolation with correct methods. This involves the mating surfaces being isolated by non-metallic spacers and the fasteners isolated from connection with both metals with isolating washers [10].

ROOFING IRON

Roofing Iron today is typically zincalume coated steel. This has a high proportion of aluminium in the makeup of the coating and as a result connection to aluminium is considered appropriate by the manufacturer Bluescope steel [11]. This was also verified by third part corrosion testing carried out for Monkeytoe which showed a representative Monkeytoe platform and roof structure directly connected suffered no galvanic corrosion while enduring the equivalent of approximately 15-25 years a highly corrosive environment [12].

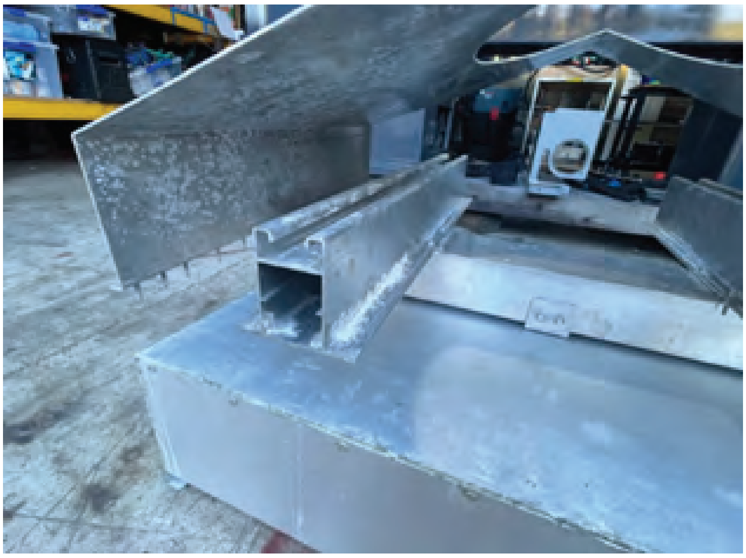

FIGURE 6 GALVANIC TEST PIECE AFTER TESTING SHOWING CORROSION TO PRODUCT

GALVANISED STEEL

While aluminium to aluminium connections is not recommended to use galvanised fasteners connection to galvanised structures is acceptable and is recognised by the Aluminium Design manual [7]

CONNECTIONS TO CONCRETE

As concrete has a high lime content which causes elevated PH levels on the surface aluminium is always isolated by a non-metallic spacer such as plastic or rubber on the contact surface. As concrete itself cannot cause galvanic corrosion, isolation of the fasteners from the aluminium is not necessary.

MAINTENANCE

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