

2013: Coastal and Ocean Engineering ENGI.8751 Undergraduate Student Forum
Faculty of Engineering and Applied Science, Memorial University, St. John's, NL, Canada, March, 2013

Paper Code. 2013-Clark

The Sir Ambrose Shea Lift Bridge Replacement Project In Placentia, Newfoundland

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ABSTRACT

The town of Placentia is located on the western end of the Avalon Peninsula on the east side of Placentia Bay. Placentia consists of the amalgamated towns of Placentia, Jerseyside, Freshwater & Dunville and is the centre hub for the fishing industry. Settlement in the community dates back to the 1500's and has a rich history associated with the French, English, Irish and more recently the Americans. Harbours in the area are located inside the Northeast and Southeast arms which are connected to the sea by a small passageway commonly referred to as the gut. The gut separates the towns of Jerseyside and Placentia and there was always a need to cross the gut.

In olden times the gut was crossed by using French chaloupes to ferry people across to the other side. Later, with the invention of cars more sophisticated ferries were used as transport. When the American base was set up in nearby Argentia, during the Second World War, a pontoon bridge was built to cross the gut. Unfortunately, the bridge didn't last long with the rough tides and sea ice in the area. In the 1950's, a ferry capable of carrying several vehicles and passengers was used to cross the gut. Finally, plans were made in the late 1950's to construct a bridge across the gut that was capable of lifting up to accommodate vessel traffic, and in 1961 the Sir Ambrose Shea Lift Bridge was opened to the public.

Recently, this historic bridge surpassed its lifespan and has deteriorated to the point where weight restrictions for vehicular traffic were imposed. Temporary repairs to the bridge were carried out in the past year and the entire bridge is slated to be replaced. There have been challenges however in obtaining a contractor to construct the bridge at a reasonable cost.

This paper will highlight the economic advantages of having such a bridge in the region, a description of the project, and the challenges and lessons learned by constructing a bridge in the area.

1 INTRODUCTION

The town of Placentia is located on the western end of the Avalon Peninsula on the east side of Placentia Bay. Placentia is approximately a 130km, 90 minute drive from the capital of the province; St. John's, and the map below indicates its location.

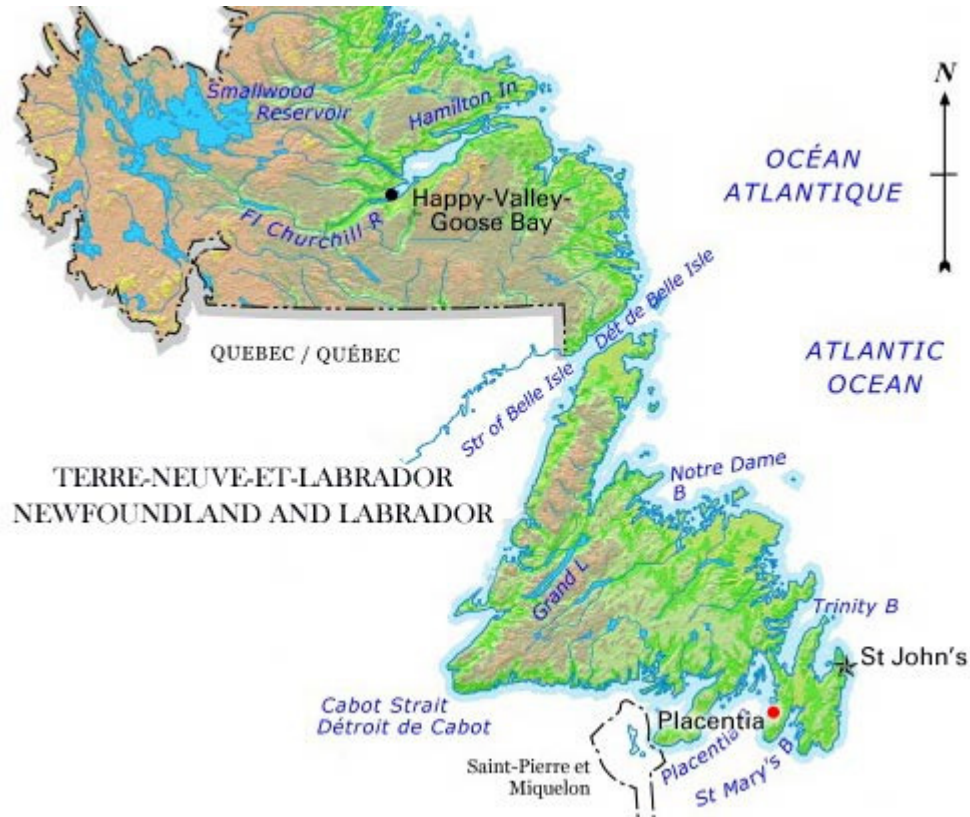


Figure 1: Location of Placentia [1]

The harbours beyond Placentia are unique, in that they are naturally sheltered from the ocean environment, making it an excellent location for a fishery. This, combined with an excellent beach for drying fish, and its militaristic advantages made Placentia the first permanent colony for the French in Newfoundland in 1662. [2]

Placentia became a battleground for the wars between the English and the French in the late 1600's until the Treaty of Utrecht was signed in 1713. This turned the possession of Placentia over to the English and the French resettled in the new French colony of Île Royale on Cape Breton Island. In the 20th century, Placentia benefited from the establishment of the US armed forces base in nearby Argentia during WWII. [3]

Access to the harbours inland is through a 100 foot passageway commonly referred to as 'the gut'. This causeway, poses a logistical problem in transportation as it creates a disconnect between the towns of Jerseyside and Placentia, but it is also necessary to maintain vessel traffic to the harbours beyond Placentia. There were many ideas implemented to solve this problem over the decades, including ferries and makeshift moveable bridges, but it was not until 1961 that the problem was solved with the completion of the Sir Ambrose Shea lift bridge (see picture on next page). This bridge could accommodate both vessel and vehicular traffic. [4]



Figure 2: The Existing Sir Ambrose Shea Lift Bridge [5]

Recently, this historic bridge has reached its lifespan and is deteriorating to the point where weight restrictions for vehicular traffic were imposed. Temporary repairs to the bridge were carried out in the past year and the entire bridge is slated to be replaced. There have been challenges however in obtaining a contractor to construct the bridge at a reasonable cost with the sole bid in 2012 coming in at \$19.25 million over budget. However, the contract for the bridge replacement was finally awarded on March 5, 2013 to HJ O'Connell Construction Limited for \$40.6 million. [6]

2 ECONOMIC OPPORTUNITIES

The Sir Ambrose Shea lift bridge provides an important connection to the region. Not only does it allow for a regional connection between the communities of Placentia and Jerseyside but it also provided an opportunity for regional co-operation. The promising economic prospects lead to the amalgamation of the towns of Placentia, Jerseyside, Freshwater, Dunville and Argentinia into the municipality of Placentia in 1994. This allowed these communities a chance to benefit from the services each provides, but also helped to grow the regions industries.

2.1 Services

The vibrant community of Placentia has a variety of services that all contribute to its continued success, as a regional hub in the province. Three of the most important amenities are its health care, schools and recreation facilities. The Placentia Health Care Centre is a state of the art facility that was built shortly after amalgamation and provides jobs to over 100 people in the region. The hospital has 10 acute care beds and 4 physicians providing locals with a hospital that is capable of treating numerous ailments. The presence of a nursing home in the region also means people who need long term medical attention can live in the region without having to go to larger centres like St. John's to receive the level of care necessary. Also, the area has a complement of schools offering education to youth in the region, including a brand new high school and a local College of the North Atlantic campus. This college offers an abundance of courses that are geared towards the local industries. Recreation in the town includes facilities for a variety of sports including soccer, baseball, hockey, and rowing. The existence of an assortment of recreational activities allows the community to continue an active lifestyle. Other

essential services in the town include a fire department, supermarkets, a bank, a post office, and an RCMP station. [2]

2.2 Tourism Industry

The rich history surrounding the 350 years of the community's existence yields itself to one of the fastest growing industries worldwide, tourism. Placentia, as the site of many battles between the English and the French in the late 1600's and the Early 1700's, and also the presence of the American base at Argentia in the 20th century, provides the community with a history that will intrigue visitors. There are many attractions to visit including an archaeological dig, the English's Fort Frederick, the lookout in Dunville, old buildings of cultural significance built in the early 1900's, and also nearby is the Cape St. Mary's ecological reserve. In addition, recreational activities are in abundance in the area such as kayaking, hiking, and swimming. Placentia also has an advantage one of the three ways tourists can enter the province by car, by way of the Argentia ferry. This makes Placentia one of the first stops for tourists and as a result the region has a thriving tourism industry. [2]

2.3 Emerging Industries

Argentia, as Placentia's industrial area, is experiencing tremendous growth. This is in large part due to the occupation in the past of Argentia by the US Armed Forces Northwest Atlantic Operations base. When the Americans left their base in the early 1990's their entire infrastructure and skilled workforce was left behind in the region. Industry in the area capitalized on this and has expanded to include businesses in metal fabrication, light manufacturing, information technology, and marine transportation. The diversification of the industries is also due to its unique location. Argentia, according to www.placentia.ca is an "ice-free deep water port with 2,100ft of berth space available with a strategic location in the centre of the world's shipping lanes". This has allowed Argentia to become a key player in the booming oil and gas sector in the province as it is now the industrial area for the Offshore Newfoundland Gas Pipeline. With the replacement of the Sir Ambrose Shea lift bridge the region can continue to service these industries effectively. [2]

3 CHALLENGES OF BUILDING A BRIDGE IN THE AREA

Building a bridge in a coastal area comes with complex design complications. Not only does one have to account for the natural deterioration of the bridge components but also the wave, tidal and storm action on that structure. Therefore, careful planning must be completed to ensure the bridge lasts to its expected lifetime with a consideration for the worlds changing climate. In addition, due to the Sir Ambrose Shea's cultural and historical significance in the region, it is also important to make the new bridge aesthetically pleasing and operationally efficient.

3.1 Deterioration of Bridges by Corrosion and Fatigue Cracking

Corrosion, the process by which metal degrades or rusts, is one of the major causes of deterioration in steel bridges. Corrosion is accelerated in an aggressive environment where the essential components of corrosion are present. The main two components are an electrolyte and oxygen. The electrolyte commonly consists of water with dissolved salts or other compounds dissolved in it creating a corrosion cell (see diagram below).

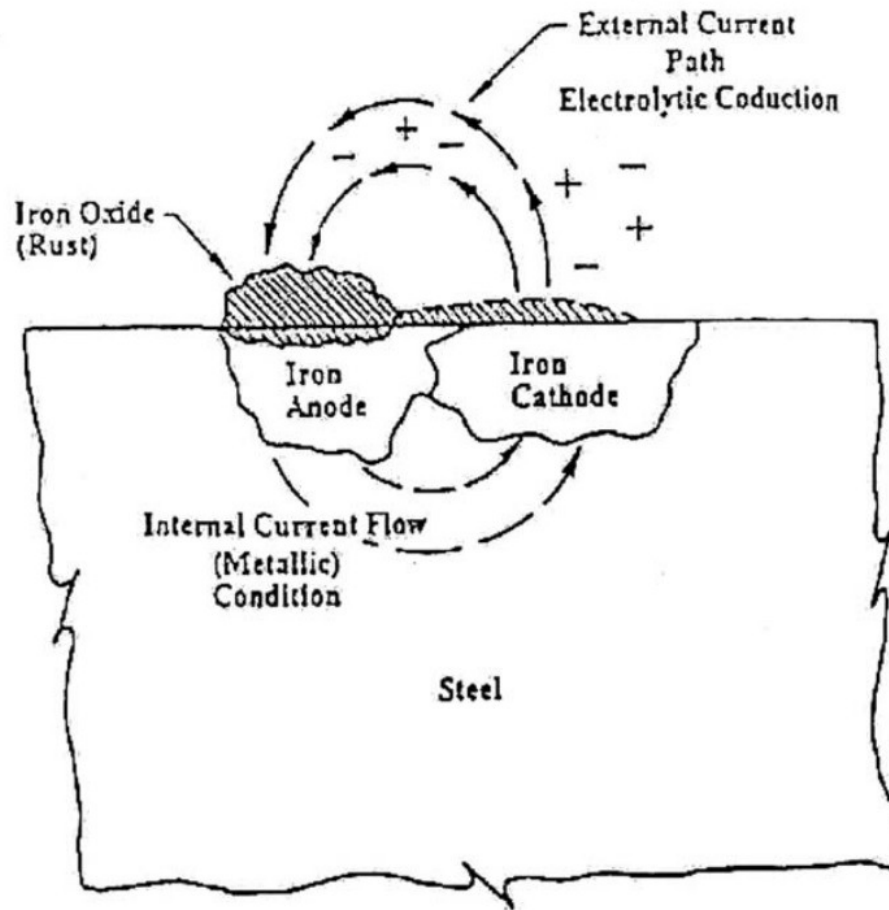


Figure 3: Illustration of Corrosion on Steel [7]

The corrosion reduces the strength of the steel section because there is less cross sectional area available for resisting loads of the structure. The results of an experiment conducted by Zahrai shows that “loss of strength is directly proportional to the loss in cross sectional area and components fail at the section of least cross sectional area”. [7]

Corrosion can be minimized by the application of various coatings, usually applied in 3 layers. The first of those layers is the primer which has good bonding qualities to ensure proper adhesion. The intermediate or second layer provides increased thickness to protect the steel. The final layer, the top coat, is tough and resilient to defend against corrosion. There are a variety of paint types that are appropriate for some or all of the paint layers including oil/alkyd paint, vinyl, epoxies, epoxy mastics, urethanes, zinc rich primers, and latex paint. Epoxies are one of the most common as it has excellent atmospheric exposure characteristics making it a good candidate to resist corrosion. It is important to know what paints have been used on the steel because if this is known then the same paint can be applied in the future when rehabilitation takes place.[8]

Another common phenomenon in bridges that must be considered in design is fatigue cracking. Fatigue cracking are the cracks that develop in the structure due to cyclic loading as vehicular traffic passes over the bridge. These concerns of cracking are only heightened when the bridge is old, has frequent truck traffic, and has the right ambient temperature conditions. Also contributing to fatigue cracking is: the type and quality of the details of the bridge structure, the magnitude of the stress range, and the load history of the bridge. [8]

The Sir Ambrose Shea Bridge certainly experienced deterioration in the later stages of its lifespan. The bridge, located in an aggressive sea environment, began to show evident signs of wear and tear due to corrosion and fatigue cracking. This ultimately led to the bridge having load restrictions on traffic travelling over the bridge until the proper remedial patchwork could be carried out to ensure its structural capability until a new bridge can be built.

3.2 Wave Loads on Bridge Structures

The location of the lift bridge in a wave environment means that there is loading on the structure due to those waves and must be considered when designing the structure. Waves can create 3 different loading scenarios on the bridge which are horizontal wave loading, uplift wave loading and inundation wave loading (as the figure indicates).

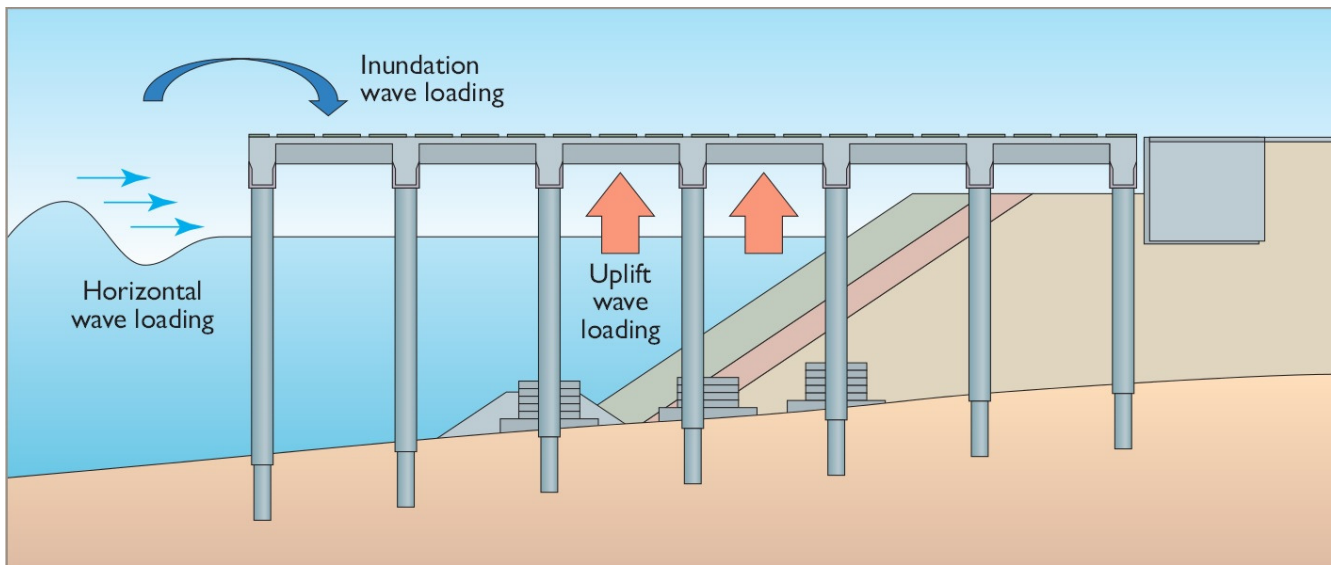


Figure 4: Types of Wave Loadings on Bridges [9]

As the forensic study indicates “structures with decks or larger horizontal elements such as piers and highway bridges may be more likely to fail under vertical wave loads which may be substantial when the deck elements are close to the water level”. [9]. Normally in the case of the Placentia lift bridge, the deck components would not be anticipated to experience these loads as the bridge height is high enough that these loads can be ignored. However, in extreme weather events like Hurricanes, wave action could affect the structures integrity. These extreme events combined with a changing climate could produce critical loads on the structure in the future. Sea rise due to melting of the polar ice caps by global warming could result in the water level rising by as much as .4m when combined with storm surges by the year 2050. [10] The resulting surge wave heights could be as high as 7 metres in major storms. This would bring the bridge below the height of the water resulting in impulsive and pulsating wave loads on the structure. When the wave load durations are similar to the resonance of the structure critical loads could result especially when these loads are not designed for. Therefore, to ensure that the next bridge that crosses the gut to Placentia is able to last its lifespan it is imperative to test a model of the structure for these wave loads. If this is not done, the designing engineer must ensure that the height of the bridge will always be greater than that of the water level in any weather event.

3.3 Bridge Scour Due to Currents

In the “gut”, tidal currents can attain a velocity of 4 knots. This action can cause local scouring of the bridge piers if not considered in design. Local scour results from horseshoe vortices forming at the base of the pier which transport sediment away from its base. The other type of vortex that forms is the wake vortex which also erodes sediment but loses its intensity with distance from the pier. The loss in strength in the vortex leads to the sediment depositing beyond the bridge pier. The following diagram explains the two phenomena.

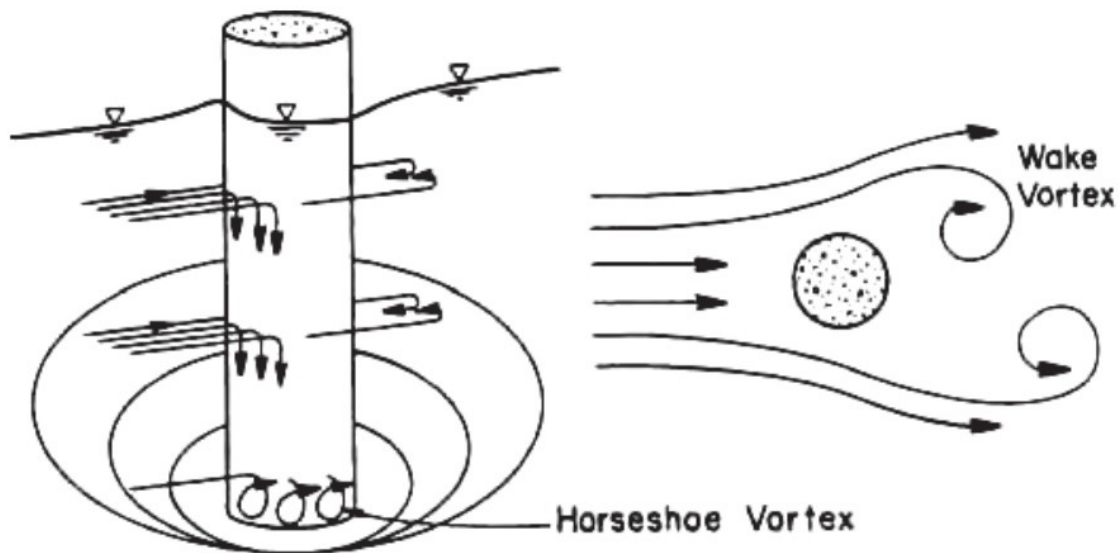


Figure 5: Bridge Scour Phenomena [10]

There are a variety of factors outline by the NCHRP report that affect the strength of scour action at piers and abutments which are: velocity of the approach flow, depth of flow, width of the pier, length of the pier if it is skewed to the flow, size and gradation of the bed material, angle of attack of the approach flow to the pier, shape of the pier, bed configuration, and ice formation or jams and debris.

To prevent scour, various countermeasures must be used. There are multiple preventative systems that can be implemented but they all include an armour layer, filter and termination details. The success of a countermeasure according to the NCHRP report is “dependant on the response of each component to hydraulic and environmental stresses throughout its service life”. Therefore, to prevent scouring it is necessary to inspect the bridge piers interaction with the sea bed to ensure that the chosen system is working effectively. [11]

3.4 New Bridge Design

The architectural and detailed design for the new lift bridge has been completed by Delcan and is pictured in Figure 6. Delcan states that has improved function and durability by “recognizing that simple and conventional operating systems bring the highest degree of reliability and minimize maintenance” and “determining that these conventional systems, both mechanical and electrical, should form the basis of the bridge design as much as practical”. Delcan in their design, were cognizant to minimize the exposure to the elements by having closed structural sections, and enclosing mechanical machinery. [12]



Figure 6: New Bridge Design

4 CONCLUSION AND LESSONS LEARNED

The original Sir Ambrose Shea lift bridge provided a vital passageway which contributed to the economic growth of the region. The design of a replacement bridge must still provide the same functions to the types of traffic it accommodates. A bridge located in this harsh sea environment means that it must be designed for a variety of factors including: corrosion protection, fatigue cracking, wave loading, and local scouring around bridge piers. At the same time, the new bridge must be functional and aesthetically pleasing. The discussion of these factors within this case study points to the lessons that should be applied in the new bridge design to ensure it will last for its designed lifespan. The current Sir Ambrose Shea Bridge surpassed its serviceability life and now must be replaced. This bridge's lifespan would have been longer if more inspections and remedial work were carried out throughout its life. This paper discusses the importance of counteracting corrosion by reapplying corrosive resistant paint to trouble areas and performing inspections on the pier foundations to ensure the countermeasures to local scour are succeeding. Also, careful consideration must be given to future climate changes which could affect the structure. Together with proper inspection and consideration of future design loads the new bridge will be an improvement to the current structure and hopefully extend its lifespan.

REFERENCES

- [1] www.thecanadianencyclopedia.com/articles/placentia
- [2] www.placentia.ca
- [3] www.heritage.nf.ca/exploration/placentia_text.html
- [4] www.laval.k12.nf.ca/placen.htm
- [5] www.thecharter.ca/Latest-news/2011-08-29/article-2731240/Bridge-options-to-be-re-evaluated/1
- [6] www.releases.gov.nl.ca/releases/2013/tw/0305n03.htm
- [7] S. M. Zahrai, “Cyclic Strength and Ductility of Rusted Steel Members” , University of Tehran, Tehran, Iran, and Department of Structural Engineering, Building and Housing Research Center, Tehran, Iran, Asian Journal of Civil Engineering (Building and Housing), Vol. 4, Nos 2-4 (2003) p. 135-148
- [8] M. Rossow, “Bridge Materials Inspection: Metal and Masonry (BIRM)”, Course No: S04-009, Continuing Education and Development Incorporated, Stony Point, NY
- [9] Alderson, Allsop, Cuomo, Duch Ne, De Ville Goyet, “Forensic Study of Wave Loads on a Pier in Belgium”, Institute of Civil Engineers, Civil Engineering 162 May 2009, p 25-32 Paper 800045
- [10] “Adapting to Climate Change”, Canada’s First National Engineering Vulnerability Assessment of Public Infrastructure, Appendix A : Case Studies - Town of Placentia, Newfoundland, Water Resources Infrastructure
- [11] P.F. Lagasse, P. E. Clopper, L. W. Zevenbergen, L. G. Girard, “Countermeasures to Protect Bridge Piers from Scour”, NCHRP Report 593, National Cooperative Highway Research Program
- [12] <http://delcan.com/articles/placentia-lift-bridge-replacement>