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# Aluminum Bridge Decks Mounted to Galvanized Steel: Potentially a Superstructure With An Indefinite Life

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## Introduction:

On June 23, 1997 a fifty five foot long by thirty two foot wide aluminum bridge deck working compositely with four galvanized steel girders opened on U.S. Route 58E in southern Virginia. The 1997 Reynolds Metals Company (RMC) deck installation was part of a Virginia Department of Transportation (VDOT) rehabilitation project to widen the bridge from a 23 foot roadway to a 28 foot roadway. The project reused the bridge's substructure. The near isotropic design was the culmination of a $5 million research and development program that began in June of 1994 at Reynolds Metals Company (RMC).

RMC started with an evaluation of an aluminum orthotropic deck deployed in 1966 on the Smithfield Bridge in Pittsburgh, PA. In the summer of 1994 that orthotropic deck was being replaced after ~26 years of service. The 1966 deck was largely successful although it did incur some wearing surface problems and fatigue cracks caused by partial penetration, one sided welds.

The 1997 RMC installation featured a 25 pound per square foot, lightweight aluminum deck that facilitated the reuse of the substructure which would otherwise have been inadequate to support any additional concrete surfacing. The installation represents the pinnacle of the aluminum bridge deck technology up to that time and may be the first bridge deck that can endure 100 years of service. The bridge deck, girders and wearing surface have performed well on the busy highway with substantial truck traffic. The structure may have provided lessons in how to design for an indefinitely sustainable bridge.

Little Buffalo Creek Bridge - US 58E (Pictures taken in November of 2010)

## Sapa Acquires Technology (through purchase of Alcoa extrusion plants)

In April of 2009 Sapa embarked upon a mission to redeploy the 1997 RMC technology with improvements. After a thorough review of what went right, what went wrong and how the design could be improved, it was decided that the deck would no longer be arc welded together. Friction Stir (FS) welding is now the cutting edge technology for welding aluminum. The FS weld process offers a number of benefits which will be described later. It was also decided that the attachment system and the longitudinal splices would be merged to occur at a girder to enable better staged construction. Further, the attachment system would rely upon slip critical friction connections to effect composite behavior in lieu of the grout used previously on the 1997 RMC installation.

As the Sapa effort evolved other discoveries were made regarding the past performances of aluminum bridge decks and it is now clear that the potential exists to develop an aluminum to galvanized steel connection system that is so corrosion resistant it may be possible to develop a bridge that can be sustained for an indefinite period of time.

## Indefinite Sustainability

Roughly 50 years ago bridges were designed to provide a 50 year life. The design criteria was based on a belief that in 50 years the bridge would have become obsolete and to design for a longer life would be wasteful. It is also apparent that the engineers designed accurately using this objective because 50 years seems to be the life we are getting out of these bridges in the Northeast US.

Now a large proportion of our bridges are approaching or exceeding this 50 year design life and have become a major burden to the U.S. taxpayer. In retrospect we are now planning for 100 year design lives. The analysis now centers on how to provide coatings and/or concrete rebar coverage to endure for 100 years. It is also important to note that we have not figured out how to design a concrete deck that can exceed 30 years in the face of deicing salts and most have concluded that designing for a 100 year design concrete bridge deck is not economically feasible. In contrast an aluminum deck can likely be designed to last 100 years and beckons one to contemplate even longer lives. Instead of 50 to 120 years why not consider an indefinite life?

Consider a design life for a bridge predicated on the premise that if the design has true infinite fatigue life (for the stress ranges its components will have to endure), and corrosion controlled so that a loss of material strength could be prevented on an indefinite basis, then the bridge could potentially be designed to last indefinitely. Every component; from the abutments, bearings and bolts, to the zinc coatings must be designed to either meet or allow for replacement in order to sustain an indefinite life, and what has been learned with the aluminum isotropic deck implies that such a design criteria may be achievable.

What is being suggested is the concept of designing using an indefinitely sustainable criteria expecting it to last in excess of 100 years so long as it is properly maintained with repairs; preferably on an infrequent basis, enabling the indefinite performance life. Indefinitely sustainable does not mean the bridge will last forever without repairs and maintenance, but it does mean that if the wearing surface could be rejuvenated, the corrosion controlled through a coating or sacrificial system that protects the major components from corrosion, then with the right material thicknesses, maintenance and supporting systems then it could provide an indefinitely sustainable bridge.

## The Little Buffalo Creek Bridge (deployed 6-23-1997)

The major components of the Little Buffalo Creek Bridge include:

- The 3/8" thick wearing surface which has lasted 15 years with minor repairs.
- The aluminum deck itself made of 6063-T6 corrosion resistant aluminum that requires no paint.
- The grouted composite connection between the deck and the girders.
- The galvanized steel girders.
- The longitudinal splices where the 3 subassemblies were coupled together to make the 32' width.
- The substructure (foundations, wing walls, abutments).

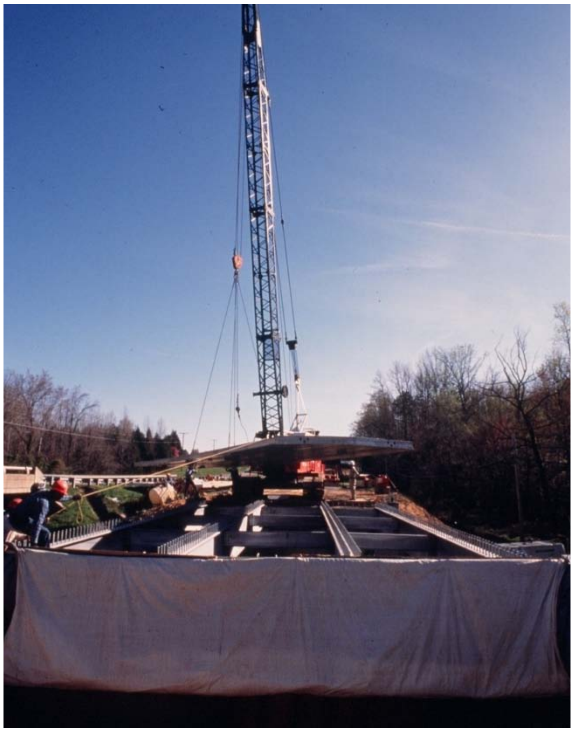
How likely are each of these components for becoming indefinitely sustainable?

## Composite Connection (deck to girder grouted connection used in 1997)

The deck to girder composite connection was acquired through the use of shear studs embedded inside three aluminum voids flooded with grout. The photographs that follow illustrate how the shear studs were used with the girder (just as they are with concrete) and how they were allowed to penetrate the bottom of the deck. The three holes at the end of the aluminum deck allowed the three voids to be pumped full of grout in the field to complete the connection.

Immediately after installation VDOT tested the bridge to validate composite behavior. It has been over 15 years since the bridge opened. So how has the grouted connection performed?

Little Buffalo Creek Bridge - US 58E (Shear studs on left and opening through which grout was pumped is on the right. Pictures taken in spring of 1997)



Little Buffalo Creek Bridge - US 58E (Center deck panel being positioned in left photo, deck to girder connection without grout in right photo. Pictures taken in spring of 1997)

Little Buffalo Creek Bridge - US 58E illustrating the grout condition at the deck to girder connection. Pictures taken in March of 2011

Overall the grout condition in 2011 appears to be good; however, this grouted connection is believed to be the weak link in the design. Whenever the grout fails the bridge deck will need to be removed, the grout removed from inside the voids (expected to be very difficult) and then reinstalled. The time involved will cause major user costs and thus this design is not believed to be an indefinitely sustainable system. The grout also requires a cure time which elongates the installation time.

## Aluminum Deck (used in 1997)

Except for areas of mild galvanic corrosion where there is a steel to aluminum connection (which will be discussed later under the subheading "Corrosion") the deck has performed as predicted without paint. The 6061-T6 alloy does not require paint even when exposed to deicing chemicals and this performance has been documented on numerous occasions.

According to the AASHTO LRFD code the deck used on the Little Buffalo Creek was designed to provide infinite fatigue life under the stress range induced by an HS-20 truck considering the system 1, system 2, and system 3 design conditions. System 1 is how the deck behaves compositely with the girders, system 2 is how it behaves between girders (the isotropic aluminum deck can handle HS-20 loads with a girder spacing of 9 feet, and provide support for a cantilever of 3.5 feet), and system 3 deals with the crushing tire patch load. It is the system 3 loading that usually dominates the design for this deck. For this reason, the welds are a major concern.

The aluminum deck for the Little Buffalo Creek Bridge was arc welded together in such a way that a category C weld detail was accomplished on both the top and bottom flanges. The thickness provides compliance to meet an infinite fatigue life. It is because the top and bottom flanges are continuous in both directions that the deck behaves isotropically being 90% as strong transversely as it is longitudinally.

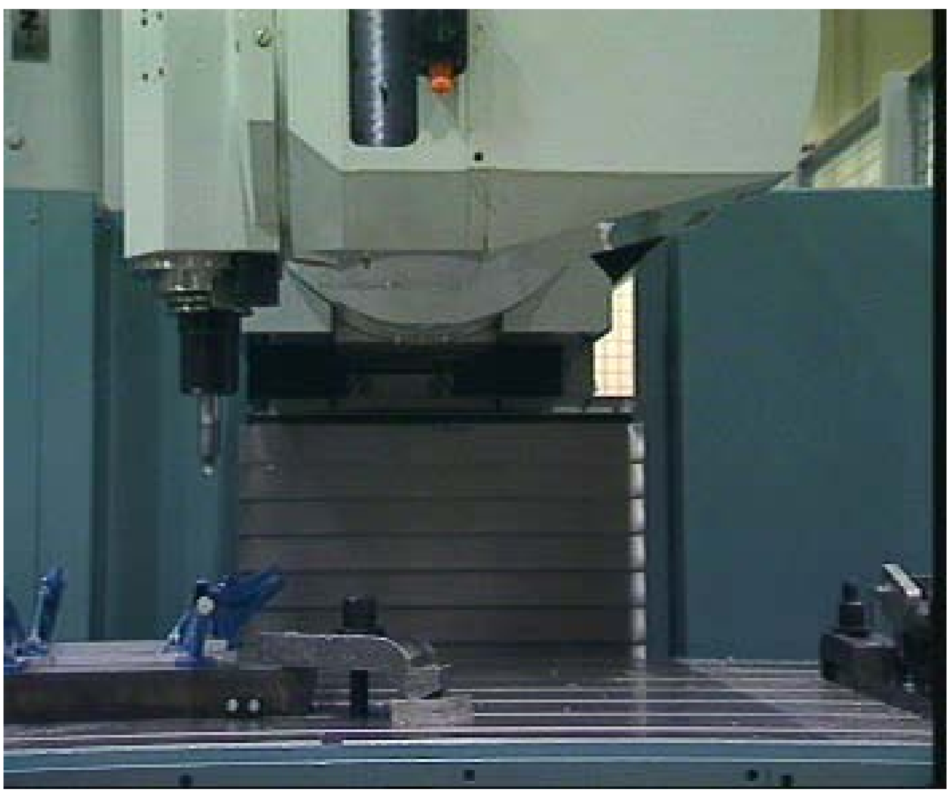
Since the deck is very corrosion resistant without paint and has been designed to provide infinite fatigue life, the aluminum deck can be considered to be indefinitely sustainable so long as corrosion does not reduce the load resisting material strengths. It is also important that any new or different fabrication procedure not affect fatigue resistance such as Friction Stir welding.

Arc welded deck being fabricated in late 1996

## Friction Stir (FS) Welding:

In the past the aluminum isotropic deck was fabricated using arc welding. Today a new fabrication process is used to join aluminum together. It is known as Friction Stir (FS) welding. This process was used to build the most recently deployed bridge (Sandisfield, MA) and will likely be used on all future aluminum bridge decks.

It was stated in the previous 'aluminum deck' section that unless a fabrication procedure is used that will compromise the design's ability to resist fatigue the design could be considered indefinitely sustainable. Without going into great detail (there have been hundreds of papers written about the FS weld process), FS welding provides a method that is more reliable than arc welding providing faster fabrication speeds with better uniformity. The process also provides welds with equal and usually greater strengths. Another advantage of the process is that only a small portion of the material actually becomes molten and the stirring action refines the metal grain structure improving the fracture toughness of the weld. The term 'toughness' deals with notch sensitivity in regard to fatigue and in the case of the 6063-T6 alloy, the FS weld is actually tougher than the parent material, and is far tougher than an arc weld. Properly applied FS welding achieves the same category C rating and will qualify for a category B weld with proper inspection. The FS weld is now tougher than previously built arc welds, and the process has reduced the cost to fabricate the deck significantly. For these reasons, FS welding has enhanced the aluminum isotropic deck's durability, strength, quality and price without compromising any of its other virtues. FS welding makes the aluminum deck more indefinitely sustainable.



A Friction Stir Welding Machine.

Aluminum bridge deck being Friction Stir Welded together.

Aluminum bridge deck after fabrication using Friction Stir Welding

## The Wearing Surface

The wearing surface on the Little Buffalo Creek Bridge is a major success story. It is a two part polyurethane epoxy with aggregate mixed in to make what is known to the infrastructure community as "polymer concrete." The idea of using the 3/8" thick system came from Michael Sprinkel of VDOT. The RMC team were informed that polymer concrete performed well when properly applied to concrete with very little wear. The RMC adhesion specialists working on the program were excited to learn this because they had a lot of experience applying polyurethane to aluminum; thereby, knowing how to acquire a good bond with a number of different surface preparation treatments.

The best known aluminum pretreatment system at that time was a hexavalent chrome system; however, the specialists at RMC were concerned that while legal at that moment, the hexavalent chrome system could  become outlawed causing a lead paint abatement like problem of which the infrastructure world is familiar. For that reason the hexavalent chrome pretreatment was used as a control system to compare alternatives. Tests were performed comparing pretreatment systems and polymer concretes. What was devised is a benign system that poses low risk to the workers applying the pretreatment initially, can be abraded safely in the field, and is of low risk to the workers repairing the system in the future.

The weakest link in the wearing surface system is how well the bond is affected by temperature and humidity. In the case of the Little Buffalo Creek Bridge and in all future aluminum isotropic bridge decks, the wearing surface is applied indoors where the environmental concerns of temperature, dirt and humidity can be controlled. In the past, the wearing surface which was applied indoors has performed well. What was shop applied to the Little Buffalo Creek Bridge and a previous orthotropic aluminum deck near Huntingdon, PA fifteen and sixteen years ago is still intact. What was field applied over the splices on the Little Buffalo Creek Bridge; however, is a different story.

There were failures at some of the field installed wearing surface installations on the Little Buffalo Creek Bridge that had to be repaired more than once early on. For this reason (and other reasons) the new deck design has eliminated the need for the field wearing surface installation. Nevertheless, reparability and replace-ability of the wearing surface are key factors if a bridge system is to be indefinitely sustainable, and what was learned from the Little Buffalo Creek Bridge repairs is very important.

The Little Buffalo Creek Bridge was built with the wearing surface applied prior to the deck shipment except for the areas over the splices. By design, the 12" wide splices were to have the wearing surface applied in the field. Even before the Little Buffalo Creek Bridge opened there were problems with the field installed wearing surface. It seems that while or immediately after the field installed wearing surface was complete a big thunderstorm rained on the deck. The team making the repairs reported that there was water between the wearing surface and the aluminum and likely caused the delamination. This failure before bridge opening seemed to be a bad omen; however, the initial repair coupled with one or two other repairs all made within the first few years of deployment associated with the splices has held up for 12 or more years. What needed repair initially has now proven reparability with an expectation of good performance. This is a feature of sustainability and the wearing surface applied to the aluminum deck is expected to be indefinitely sustainable since it can be applied in a similar way that polymer concrete is installed over concrete in the field. The only difference is the surface preparation that occurs at the metal surface. If the metal surface is exposed it will need a light abrading followed by a no rinse surface prep solution application. The surface prep solution is applied using a portable garden sprayer and dries quickly.

## Galvanized Steel Girders

The girders on the Little Buffalo Creek Bridge were galvanized as was all of the steel portion of the superstructure. These girders show no sign of corrosion after 15 years of service. The use of a magnetic paint gauge indicates that the galvanized coating well exceeds new thickness requirements. What is not known is how thick the zinc was initially so the rate of zinc consumption is unknown. Nevertheless, it is performing well and it has long been advertised by the galvanizing companies that these galvanized coatings can last 50 years or more. There are examples that validate their claims.

It is also understood from numerous sources that if the zinc coating gets thin, the patina (zinc oxide) on the surface can be abraded away and the zinc coating restored in the field. The field applied metalizing of the zinc can also be built up in thickness so as to exceed the performance of the original coating. This indicates that testing the thickness of the zinc on the galvanized or the metalized steel portion of the superstructure with restoration of the zinc coating every 50 or more years is an indefinitely sustainable system.

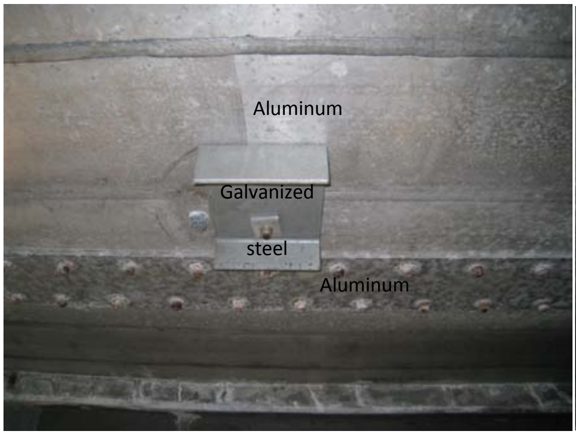
## Corrosion

The 1997 Little Buffalo Creek Bridge provided a number of inadvertent lessons of what to do and what not to do regarding bimetallic connections between aluminum, steel, and galvanized steel. The galvanized steel to aluminum connection is an unusual bimetallic connection. There are three metals involved which include the steel girder, the aluminum deck and the zinc that coats the steel. In terms of the galvanic series, the aluminum is the anode and is sacrificial to a steel bimetallic connection, the zinc is the anode and is sacrificial when bolted to either the steel or the aluminum, and when a galvanized steel member is in intimate contact with aluminum it is the galvanized steel that is the anode providing a significant voltage potential. This observation is important in understanding what this bimetallic or tri-metallic connection means in terms of corrosion aversion. Field observations of the Little Buffalo Creek Bridge indicate that as long as the galvanizing is present there is no apparent corrosion to the steel, the aluminum or the fastener holding them together.

The 1997 Little Buffalo Creek Bridge longitudinal splices make use of galvanized Huck bolts (called BOMs) which are one sided steel fasteners. They are essentially large rivets and they are used to hold aluminum to aluminum at the splice. The galvanizing is mechanically applied to the fastener because hot dip galvanizing would ruin their rivet like installation.

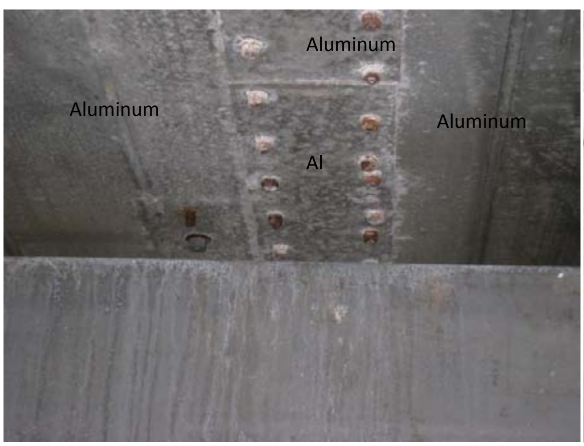
The following pictures illustrate the use of Huck bolts in the Little Buffalo Creek Bridge splice. As good fortune would have it, the same Huck bolts were also used to hold galvanized steel channels to the bottom of the deck. Eyebolts were used in the shop and in the field to move the deck assemblies from above and the eyebolt lifting points were reinforced with these galvanized channels to prevent damage to the deck. It is likely there was a mistake with the eyebolt length because it is evident the channels were pivoted out of the way to allow the eye bolt to have sufficient thread length for the nut to be installed beneath the deck. It is noteworthy that all of the Huck bolts, splices and galvanized channels have been subjected to the same environmental exposure since deployment with dramatically different corrosion results.

The galvanic series relationships are very apparent from a review of the following photographs and the lesson learned is that a bolted connection between aluminum and galvanized steel can be expected to be corrosion free so long as the zinc is present. Through periodic thickness checks combined with field metalizing it is possible to replenish the zinc coating whenever it becomes too thin. Therefore, an attachment system where aluminum is bolted to galvanized steel with a galvanized fastener can be made to last indefinitely.











Corrosion observations: Note the way the corrosion differs in regard to the Huck bolts (large rivet like fasteners common to all pictures above). In the case of the aluminum to aluminum splice plates (top left, top right, bottom left), it is the aluminum that is the anode and corrosion is present around the Huck bolts now that the mechanical galvanizing has been consumed. Note the absence of corrosion associated with the same identical fastener through the galvanized steel channel, and at the aluminum to galvanized steel interfaces (in all pictures above except bottom left).

## The New Design

The new aluminum deck system is the same as that used on the Little Buffalo Creek Bridge with a few exceptions. The differences are to make use of the lessons learned from the very successful 1997 Little Buffalo Creek Bridge and to make use of FS welding.

One design change includes the replacement of the grouted connection to allow direct bolting to the girders to provide composite behavior. The significance of the galvanized bolt connection of the deck to the galvanized girders means there is no cure time while also taking advantage of the corrosion lessons the 1997 Little Buffalo Creek Bridge has provided. Bolting also allows the field connections to coincide with a girder to enable better Accelerated Bridge Construction (ABC).

The aluminum extrusion profile has been mildly altered to allow for FS welding at the flanges otherwise the cross section is essentially the same. The deck still weighs 23 to 25 pounds per square foot (weight variation a function of the number of bolts and how much the wearing surface density varies).

## Movable Bridges and a 5" Deep Derivative of the 8" Deep Design

Since the wearing surface over the aluminum provides a closed deck system with excellent skid resistance, the deck’s lightweight, corrosion resistance without paint, and closed surface make it an excellent choice for use on new movable bridges, and for rehabilitating older movable bridge structures.

In a recent study an engineering firm in Florida has proposed that a 5" deep version of the current 8" deep deck could readily facilitate the replacement of 5" deep open steel grating on movable bridges. For this reason such a deck system will soon be available.

The previous deck installations take advantage of the composite behavior that can be attained using the steel structural members beneath the deck; however, the design can be used non compositely if desired. The fact that the deck will try to behave compositely needs to be considered in the design when rehabilitating using the aluminum isotropic bridge deck.

The aluminum isotropic deck can be easily adapted to replace the noisy, steering influencing, slick when wet, high maintenance, open steel grating on movable bridges. The system will provide a replacement deck that can provide an indefinitely sustainable design.

## Prefabricated Bridge Element Systems (PBESs) with the New Design

The lessons learned from the Little Buffalo Creek Bridge combined with the aluminum deck to lightweight, galvanized steel girders have created a new product. It is a Prefabricated Bridge Element System (PBES) which is essentially the entire superstructure for a bridge. The new design can now facilitate ABC better than any other known PBES and it is applicable to the movable bridge market.

Early in 2012 the technological sequel to that first isotropic aluminum bridge deck of 1997 was deployed in Massachusetts. The following pictures illustrate the sequence of the PBES installation. It is the epitome of ABC and is applicable to any rehabilitation project.

Alan Road Bridge installation (3 picture sequence): 1st picture is where old bridge has been demolished and the abutments repaired awaiting the PBES delivery, 2nd picture the aluminum deck to galvanized steel girders PBES arrives after over the road shipment, 3rd picture, PBES in position to be lifted and placed.

Alan Road Bridge installation (6 picture sequence) from top left to right: PBES being readied for lifting (note extreme 'boom out' condition of the crane), PBES being lifted with ease and moved toward abutments, then moved to its final position. From the initial crane lift until the deck was placed over the bearings, total elapsed time = 30 minutes.

In 1st of nine pictures above the contractor readied the site by demolishing the bridge and reworking the abutments. Then the PBES arrived on the afternoon of February 2, 2012 after having been shipped from eastern Ohio on January 31, 2012. The PBES was lifted and set over the bearings early the morning of February 3, 2012. Note the way the crane is able to boom out extensively due to the lightweight PBES. The crane's ability to pick and place the entire PBES from the shoreline is very enabling to contractors.

Alan Road Bridge over the Farmington River near Sandisfield, MA immediately after being placed over its bearings. This PBES + lifting apparatus + cables < 58 tons.

As stated previously, the new deck system makes use of essentially the same cross section with the same isotropic properties as that used on the Little Buffalo Creek. It is a very efficient design with a proven track record.

Cross section of the PBES shipped over the road from Cambridge, Ohio to Sandisfield, MA. The girders are spaced at 4'. The aluminum deck system is capable of supporting HS-20 loads with a 9' spacing and a 3.5' cantilever. (The weight could have been less).

The composite connection is now achieved using aluminum to steel friction connections as the deck is bolted directly to the steel using A-325 bolts. This has eliminated the non sustainable grout and allows for bolt replacement and connection serviceability in the unlikely case it is needed.


Slip Critical Connection using A-325 Bolts (Friction connections work with aluminum)

The bolts shown in the two photographs above are 3/4" diameter, A-325 galvanized steel high strength bolts that are heavy with galvanizing which provide a substantial amount of material for corrosion consumption. These bolts combined with the galvanized coating provide a long lasting, replaceable and thus sustainable corrosion preventive system.

The wearing surface remains the same. The following three photographs illustrate what was placed on the 1997 Little Buffalo Creek Bridge, what was placed on the Alan Road Bridge over the Farmington River near Sandisfield in 2012, and what else can be supplied in the last slide. Where the field applied wearing surface on the 1997 Little Buffalo Creek Bridge was installed is apparent in the picture to the left below in that it is of a different color. It is surprising that the color is so different in that all of the wearing surfaces use the same polymer and the only difference is the aggregate. All of the wearing surfaces used on the Little Buffalo Creek use silica sand aggregate. Nevertheless, where the wearing surface color is darker and 12" wide the field applied wearing surface was installed and where it is wider than 12" there was a repair.



Examples of polymer concrete wearing surfaces - the first is of a system installed in 1997 and subsequently repaired using silica sand. The picture is after 13.5 years of use. All of the above differ only in the type of aggregate used with basalt in the center photograph, and flint and basalt shown on the sample in the far right photograph.

## Reparability

In order for a bridge to be indefinitely sustainable it must also be repairable. Previously this reparability issue was discussed regarding the wearing surface, and the maintenance with restorability of the system's zinc coating for corrosion resistance, but what if the deck were damaged from collisions from the side or from above. What then?

The selected aluminum deck alloy can be field welded and plates added to cover damaged areas. These welds coupled with blind side fasteners such as Huck bolts could facilitate many repairs to the deck's surface. There would be a residual bump from the plate but this bump could be compensated for through the use of extra polymer concrete. The deck is stiff so some repairs could be field applied and expected to endure; however, in some cases these repairs would be only to facilitate a return to service with a subsequent need to replace the affected panel.

Because the deck is bolted together it is possible to unbolt and replace subassemblies. A replacement panel could be ordered and delivered in a few weeks with an expedited order. Because of the modular design it is expected that the repair could be effected in the field with reduced user costs.

The affected panel may be salvageable for use on other projects and as such could be worth as much as 70% of the new cost. If not then the aluminum is 100% recyclable and is still valuable. For these reasons (reuse or recycle) the aluminum deck is very sustainable.

## Conclusion

This paper describes a PBES comprised of a lightweight yet robust aluminum isotropic bridge deck complete with wearing surface mounted to a galvanized steel superstructure, and how this PBES may provide a bridge that is indefinitely sustainable. In essence, this paper is stating that with minimum maintenance and upkeep, such a system may last nearly forever! The key word is 'may' and what has been observed in the field with previous installations implies that this indefinitely sustainability concept is achievable using an aluminum deck, and if what was deployed in Massachusetts is not indefinitely sustainable, with careful monitoring and enhancements (like protective anodes) it may become indefinitely sustainable.

In 1961 an aluminum girder bridge was installed over the Appomattox River in Petersburg, VA (see photos on next page). It is still in place, works compositely with the concrete deck, has the aluminum girders bolted to steel bearings, and has never been painted.

All the evidence implies that if done correctly the aluminum to galvanized steel corrosion resistance symbiosis can be leveraged to provide a very long lasting bridge superstructure system that at the least will provide a service life that far exceeds any other materials available for such a structure today. Moreover, there exists numerous instances of aluminum infrastructure performance in excess of 50 years where this has been proven.


Route 36 Bridge over the Appomattox River in Petersburg, VA which was installed in1961. The bridge has never been painted. The aluminum girders are bolted directly to the steel bearings. The lesson being provided is keep the water out then the galvanic cell is never developed and it will not corrode.

At one bridge conference a very prominent and respected bridge engineer turned to the author of this paper and said "you want to repair and rehabilitate bridges and I want to replace them." The author has always respected this individual and also understands the bridge engineer's view point. What was implied is the author (according to the bridge engineer) wants to fix the bridge leaving it with compromised abilities and he (the bridge engineer) wants to fix them they way they should have been installed in the first place. That view point is typical with all engineers (including the author) in that they want to "make it right" but can we afford to go back and replace all of our aging infrastructure to try and make it perfect? Doesn't rehabilitating bridges with 23' roadways to provide 28' roadways while saving half or more of the replacement costs (not including user costs), and using ABC techniques to cut construction durations (and project durations) providing a structure that may last 100 years make it better for everyone?

Our infrastructure is suffering because state and federal politicians don't want to spend money fixing old infrastructure. The politicians fund rehabilitation projects only when they must. Not a lot of votes are obtained by fixing broken infrastructure unless it no longer works at all. Politicians prefer to be associated with building new infrastructure and when combined with the battle cry of many to balance the budget it is likely it will be a very long time before we catch up with the needs of our aging infrastructure.

Our interstate system was funded and started during the Eisenhower administration. It has been an immensely successful stimulus to the US economy rocketing the US to the very front of the world in terms of economic might. What our infrastructure system has provided the US economy is unmistakable; however, it is questionable whether it make sense to go back and replace everything using standard building techniques.

The FHWA has launched an "Every Day Counts Initiative" recognizing that shutting down and replacing old bridges causes huge user costs which causes a loss of tax revenue. The reduction in tax revenue is felt immediately in the next year and is likely impacted for years afterward. The FHWA also understands that the loss of revenue affects the US and State Treasuries. Reduced revenues at those levels means reduced budgets at every level.

The aluminum isotropic deck provides a method to rehabilitate old infrastructure to increase bridge capacity, and remediate functional obsolescence at a reduced first cost with large user cost avoidance. This reduces the first cost burdens to the DOT agencies, reduces the cost to the users, enhances tax revenue streams, and provides a system that can be sustained nearly indefinitely. Building new infrastructure with an aluminum deck is non competitive to typical construction techniques on a first cost basis but why not rehabilitate our existing infrastructure using PBESs like the aluminum deck mounted to galvanized steel where it makes sense saving money and time. We need to maintain the economic advantages provided to us during the Eisenhower administration while allowing for new construction for new infrastructure elsewhere to enhance our competitiveness.

The aluminum isotropic deck mounted to galvanized steel can provide a PBES superstructure that may well be indefinitely sustainable. It makes near term and long term sense to rehabilitate our infrastructure making use of innovative materials and structures such as the PBES described in this paper.

This final sequence of photos illustrates unequaled ABC capabilities through the use of an unequaled 28 ton PBES (essentially one lane of a 64' long bridge). From loading in eastern Ohio, to delivery and placement in western Massachusetts.