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Team L01

EMSEAL BRIDGE EXPANSION JOINTS: PREVENTING DISASTER AND BUILDING A BETTER FUTURE

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Abstract—*With seasonal changes in temperature, bridges made of concrete can expand and contract with the extreme heat and cold, colliding and moving away from the roads connected to the bridge. These conditions compromise the structural integrity of the bridge and put the public's safety at risk. More than nine percent of bridges in over twenty states in the United States have structural deficiencies yet are still frequently used. Bridge joint expansion systems are the solution to this dilemma as they move with the bridge and prevent it from cracking and needing to be repaired. EMSEAL is a company that has taken this bridge joint innovation a step further. The product is a sealant that is meant to cover the gap between moving parts of a bridge and act as an expansion joint on its own; it also provides coverage from water to other expansion joint mechanisms that may be prone to corrosion. In this paper, we will discuss the further applications of EMSEAL's products and how these products are not only saving bridges from significant damage, but also providing structural support to roadways, curbs, sidewalks, etc. and how they could save states billions of dollars in repair costs. To emphasize the importance of this innovation we will discuss the event that occurred in July of 2018 when a railroad bridge in Syracuse, New York fell onto the road below it and the pedestrian bridge collapse in Detroit, Michigan in January 2019. We will provide further information regarding these collapses and analyze how, due to extreme temperatures, they eventually fractured and were structurally compromised. Following these examples, we will examine the effects of extreme weather conditions on the concrete of bridges in other parts of the United States and how the innovative technology of bridge expansion joints could prevent further disasters. Throughout the paper we will examine the sustainability of each expansion joint option and the impacts they have on society and the environment.*

Key Words—Bridge, Construction, EMSEAL, Expansion and Contraction, Expansion Joints, Strip-Seal, Sustainability

INTRODUCTION: AN INNOVATION AND MILLIONS OF BRIDGES

Bridge Expansion Joints are a key support in a bridge's infrastructure due to the near constant traffic most bridges experience. According the American Road and Transport Builder's Association (ARTBA) 2018 Deficient Bridge Report, there are 3,336,166,865 bridge crossings daily in the United States [1]. If every person was to cross over the same bridge in one day four times, that would mean there are about 834,041,716 people depending on brides daily. Since bridges are such an integral part in the lives of Americans, the government needs to fix all the currently damaged bridges and take any measure necessary to prolong the bridges' life. However, there is a dilemma the government has faced for years when trying to fix the issues of bridge infrastructure: the amount it will cost. Transportation for America stated, "$70.9 billion is needed to address the current backlog of deficient bridges…[while] states [have already] spent $8.1 billion of federal funds on repair and rehabilitation of bridges [in recent years]" [2]. States often do not have access to the amount of money needed to rebuild and guarantee safe bridges. Without functioning bridges, the American road transportation system would come to a standstill. Due to these financial issues and the dire need to use bridges, engineers needed to figure out a way to prevent bridge damage before it happens.

THE IMPORTANCE OF BRIDGES AND THEIR STRUCTURE

The Problems with America's Bridges

Bridges are deeply intertwined in the United States transportation system and have the potential to severely affect the accessibility of certain regions when structurally compromised. Morro Bay, for example, had their Pfeiffer Canyon Bridge, in Monterey County, California, closed for

eight months, and experienced a drop in tourism, which would never recover, even after the bridge reopened. This caused local businesses to struggle and desperately seek out events to attract tourists. A single bridge affected the whole community's economic state, and even pushed some businesses close to bankruptcy [3].

Bridges are continuously being shut down for repairs all over the United States because they have infrastructural issues. In the 2018 Deficient Bridge Report by ARTBA, 54,258 bridges from all fifty states are structurally deficient and all of them are to be shut down and fixed in the next five years [1]. This is an overwhelming problem in the United States because bridges that are deemed deficient, or unsafe, are being driven on this moment by people who do not know about their condition. All deficient bridges, even those not used by cars or trucks, can become a disaster. On July 5th, 2018, in Syracuse, New York, a railroad bridge experienced a five day long record-breaking heat wave which expanded the concrete and metal of the bridge until one of its walls broke into two parts. Those parts of the bridge, each weighing thirty tons, collapsed onto the busy roadway below; it was inches away from crushing multiple cars [4]. Even though the bridge did not physically injure anyone, it still could have deeply traumatized all the adults and children in the proximity of the thunderous collapse. On January 23rd, 2019, in Detroit, Michigan the abandoned 1903 Packard Plant footbridge experienced freezing temperature fluctuations. A worker in the neighboring building noticed bricks falling from the bridge and had requested the street be blocked off around 1 PM by police. Not long after the road being blocked off, the bridge collapsed due to the its unkept and unstable state [5]. The worker who noticed the falling bricks is commendable because without the police there, the footbridge would have fallen on cars and people, resulting in many injuries. The bridge was on the brink of collapsing and it was over top of a roadway which posed a hazard for the lives of the citizens that use the road below it.

WHY ARE EXPANSION JOINTS NEEDED ON AMERICA'S BRIDGES?

The Expansion and Contraction of Concrete

Even though concrete is a strong solid that can support thousands of pounds at a time, the material is still able to undergo the same expansion and contraction that flimsier materials are more readily expected to go through. In conditions of extreme heat or cold, concrete will expand or contract. The changes in temperature allow the molecules of the concrete to warp and manipulate the concrete's overall size [6]. Bridge designs are constructed assuming a temperature of roughly 64 degrees Fahrenheit, so any fluctuation above or below that temperature can cause morphing in the bridge's size; the 64 degrees benchmark can be adjusted to meet the average climate of a specific area [7]. The amount of moisture that the cement is exposed also affects its temperature. When the water mixes with certain compounds in the cement there may be endothermic or exothermic reactions where heat is either taken from or lost to the surroundings, in this case the cement. Certain types of cement are more susceptible to temperature changes, particularly those with shale, limestone, siliceous, etc. as they have larger coefficients of expansion (due to heat) than many other types of rock used in concrete [6]. However, even concrete mixtures that do not contain these compounds are able to expand and contract. Without a proper buffer zone preventing the concrete from running into other slabs, fissures can form in the rock and cause structural issues. The solutions to these concrete problems are bridge expansion joints that move with the concrete as the fluctuating temperature changes its size.

How Expansion Joints Improve the Sustainability of Bridges

Technical devices used to improve the structural integrity of bridges, such as the bridge expansion joint, have one main purpose. These structural accessories are utilized to prolongate the life of bridges and to maximize the safe use of infrastructure. Constantly collapsing bridges do not make for a sustainable future. In this way, EMSEAL and other companies that manufacture bridge expansion joints are contributing to the improvement of sustainable bridges and other aspects of transportation infrastructure. The sustainability of EMSEAL's products and the products of other bridge expansion joint manufacturers are analyzed on their ability to create a more environmentally friendly and economically stable future, one expansion joint at a time. These aspects of creating sustainable bridge expansion joints align with the American Society of Civil Engineers' dedication to sustainability which reads, "ASCE and its members are dedicated to ensuring a sustainable future in which human society has the capacity and opportunity to maintain and improve its quality of life indefinitely, without degrading the quantity, quality or the availability of natural, economic and social resources"[8]. Specifically, reducing the amount of funding needed to ensure the upkeep and necessary replacement of surface transportation infrastructure is an important aspect of boosting the sustainability of the BEJS product. In recent years, financial need for surface infrastructure has exceeded investment in surface transportation. In fact, there is a 1.1 trillion investment gap in the estimated funding necessary to repair and replace damaged surface infrastructure and the total funding needed for these fixes [1]. Additionally, the ASCE Infrastructure Report Card stresses that rehabilitation needs for bridges alone have risen to an estimated one hundred twenty-three billion dollars in the previous year [1]. With money spent on infrastructure and transportation ever on the rise, finding

solutions to lessen the economic impact are essential to the future of sustainable infrastructure. Although the cost-effective aspect of building bridge expansion joints is an integral aspect of making a product sustainable, environment factors should also be considered when addressing what makes a bridge expansion joint sustainable. Future paragraphs will evaluate the lack of sustainability in metal manufacturing processes as well as the emissions caused from commuter traffic and concrete production that affect the environment negatively. All in all, this paper defines sustainability as the ability to create not only a cost effective and economically friendly product but also one that positively impacts the environment.

SPECIAL SEALANT SECURES THE BEJS SYSTEM

Among the many innovative aspects of all EMSEAL's Bridge Expansion Joint systems— such as its astounding movement capabilities, impressive performance under extreme temperatures, and easy installation process— the BEJS system's special pre-compressed sealant is the star of EMSEAL's innovative expansion joints. Once the patented strip-seal technology is fitted into the joint gap (the void in the bridge in which EMSEAL's expansion joint is placed) and allowed to expand to the thickness of the gap, a thin band of silicone sealant is placed between the crevices on either side of the expansion joint [9]. Figure 1 shows the sealant in action bridging the gap on a busy roadway.

FIGURE 1 [9]
EMSEAL's Strip Seal Expansion Joint Fully Installed

Although the area in the concrete in which EMSEAL applies their sealant to a bridge expansion joint is not unique compared to other forms of bridge expansion joints and no more innovative, the sealant technology's chemical make-up and installation process is what sets this company apart from the others. EMSEAL creates a silicone-based sealant that differs greatly from the dated ethylene-vinyl acetate foams (EVA foams for short) or rubber compression seals that have been used unsuccessfully for years. Sealants such as EVA foams and rubber-based products are known for their softness and flexibility making them appear fit for applications in bridge expansion joints as well as other scenarios when extreme elasticity is needed. However, this is not the case. EMSEAL avoids the use of such faulty sealants that wear away consistently over time and cannot withstand the harsh conditions that bridge expansion joints must endure. Instead, EMSEAL focuses their efforts on creating a two-step sealant process in which two different, silicone-based sealants work together in order to preserve the longevity of the expansion joint and allow the strip seal to perform its duty: expanding and contracting with the changes in temperature [10]. The first step entails inserting a stronger silicone formula between the upper edge of the strip-seal foam and the substrate gap (a term meaning the, usually, concrete wall to which the expansion joint is sealed). Following the first sealant, a second, more flexible, silicone sealant is applied between the bellows of the BEJS system, also known as the cracks between the expansion joint and the epoxy-coated joint face [10]. Such an innovative, two step silicone-sealant process demonstrates EMSEAL's dedication to not only reinforcing the bond between the strip-seal foam and the substrate wall, but also ensuring a primary watertight seal at the curb's surface.

Dual Silicone Sealant Working in Combination with Pre-compressed Expansion Joints

EMSEAL's website explains that unlike other expansion joints that are inflated, liquid applied, or compressed, during installation the BEJS system does not depend on adhesion in tension. Instead, the materials in the sealant are "pre-compressed in the factory, ensuring that the spring energy of compression is always pushing back on the substrate" [10]. If this concept is hard to grasp, imagine how a foam mattress slowly expands once the application of pressure has subsided. The BEJS takes on this very same slowly growing model. When the expansion joint strip is first placed into the joint gap it is slightly smaller than the void. From there, the product slowly swells to fit the joint gap snugly but without causing excess pressure. On hot days the expansion progresses much faster than on cooler days. Overall, this balance of tensions achieved by EMSEAL's sealant and expansion joint technology works to help extend the lifespan of their products as well as set them apart from previous methods of sealing expansion joints.

Another sizable difference between the BEJS and other foam-based expansion joints is that "BEJS is held in compression by its packaging. When released it expands. BEJS, properly sized, is never under tension from the joint," as stated by EMSEAL's company website [10]. Again, the pre-compressed feature of the BEJS system allows

irregularities in the joint gap to be sufficiently filled and held watertight. Described as the key to its performance, this aspect of EMSEAL's sealant demonstrates the innovative packaging of pre-compressed expansions joints in combination with the dual silicone sealant technology. In this way, EMSEAL utilizes sealant technology that allows for an increase in the lifetime of their expansion joints through innovative watertight features created by their unique two-step silicone sealant installation process.

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Noteworthy Innovative Aspects of EMSEAL's Expansion Joint

While the sealant technology is an apparent source of innovation in EMSEAL's bridge joint expansion system, there are several other features that demonstrate technological breakthrough. For example, the BEJS demonstrates a non-invasive anchoring technology. This means there are no hard connections between metal and concrete within the BEJS system, whereas embedded pins, anchors, screws, bolts or tracks, trays, or rails can be found in other expansion systems; such expansion joints include the steel sliding plate joint and the steel finger expansion joint previously mentioned [7]. As shown by Figure 2, there are no steel rods drilled into the concrete to secure the sealant system.

FIGURE 2 [10]
Side-View of Strip Sealant Expansion Joint Installation

Instead of these harsh metal-to-concrete connections that can cause corrosion and damage to the structural integrity of the bridge, the BEJS expansive joint is secured to the joint faces by "1) backpressure of the foam; 2) the epoxy adhesive; and 3) the injected silicone sealant band at the joint face to foam and silicone bellows interface" according the EMSEAL's website [10]. This display of innovation in the BEJS mainly works to extend the longevity of the bridge's use and takes preventative measures against corrosion for both the joint system and the concrete to which it is connected.

EMEAL's website also boasts their company's innovative thinking when it comes to the continuity of seal offered by their bridge expansion joint systems and accessory products. As a result of their non-invasive anchoring technology, the BEJS can maintain its seal through any shifts in the plane and direction of the joint. For example, if a repair is needed on a bridge expansion joint that extends from the bridge deck onto a parapet wall, the BEJS would allow for a single seal to extend across the transformation of planes that the expansion joint must undergo. Specialized "transition" products manufactured by EMSEAL that are useful for connecting joint planes include "upturns and downturns." These connector pieces were the first expansion joints set at ninety degrees to guarantee a watertight seal [11].

Another noteworthy aspect of the BEJS technology is the fast installation process which can be easily arranged to preserve partial traffic flow. Because of the silicone-sealant's quick-setting nature, BEJS can provide a stable surface for driving within an hour of installation [12]. All these aspects of the BEJS contribute to the overall innovative nature of the advanced technological product successfully created by EMSEAL. From maintaining a watertight seal across variations in planes and joint directions to ease -of-installation and taking preventative measures against corrosion, the BEJS is working to benefit society through a greatly innovative and practical resolution to outdated forms of bridge expansion systems.

In addition to being an effective expansion joint on its own, EMSEAL's BEJS sealant can be used with different types of older expansion joints to extend their lifespan. Older versions of bridge expansion joint systems are typically made with metal and involve invasive steal spikes attached to the concrete. This type of installation makes faces of the concrete in the joint gap more likely to be corroded and cracked. The older, metal expansion joints themselves are also prone to corrosion and eventually need to be replaced. EMSEAL saw this issue and knew that their sealant was the solution. The sealant can be used with the older joints to make them water tight. Then, the concrete and the metal will not corrode as easily and the life of the joint is expanded. EMSEAL did not try to just replace the older joints with their new joint, as it would take a long time to remove the old joint, and instead made their product versatile enough to be used on its own and used with others to prevent structural failure in bridges [10].

Thermal Shock's Negative Effects Are Greatly Reduced

Additionally, it is important to emphasize how the company's joint system excels under conditions of thermal shock, which EMSEAL describes as the "rapid opening and closing of joints during large temperature swings," as a result of their sealant technology [10]. According to EMSEAL's quantitative measurements, the BEJS can expand or contract up to sixty percent of its size at room temperature depending

on what extreme weather conditions it is subject to. This process can occur somewhat quickly, which is important in case of an extreme temperature swing from hot to cold or the other way around. Without this feature of the BEJS system, the asphalt and other structural components of bridges would expand and contract without any cushion for the concrete's movements. This condition causes the concrete to crack as it runs into other components of the bridge, compromising the structural integrity of the bridge. Overall, the expansive and contractive properties of EMSEAL's strip sealant technology excels when compared to other technologies.

A FACELIFT FOR OLD AND FAILING JOINT SYSTEMS

Cost Effective as Well as Innovative

EMSEAL's bridge expansion joint system proves to be cost-effective in unique ways. For example, instead of creating their products with cost effective materials or processes that cut down on the overall cost of the BEJS system, EMSEAL worked to manufacture a product that saves funds by extending the lifetime of bridges and making previously BEJS systems easy to replace. Specifically, EMSEAL's expansion joint system works to prevent and decrease the maintenance costs of bridge bearings and support structures [9]. These two structural components of bridges, the bridge bearings and supports, serve an integral role in enabling movement and rotation of bridges. Additionally, these bridge parts work to ensure that pressure is evenly transferred between the superstructure and its supports. If the BEJS system works effectively and is able to lessen some of the stress that other bridge parts have to absorb, the expansion joint will successfully elongate the lifetime of bridges [11]. This will decrease costly bridge bearing repairs and other structural repairs that are needed after extended use.

On top of this, the easy installation of BEJS makes it ideal for the repair of damaged or worn bridges. The integrity of these structures can greatly improve after the installation of the BEJS system instead of having to completely rebuild these older structures to improve structural soundness. Lastly, some of the innovations previously touched upon play a role in extending the longevity of bridges such as the BEJS non-invasive anchoring technology and the watertight seal that prevents salt laden water from eroding crucial structural components of the bridge [10]. All in all, EMSEAL's expansion joint proves cost effective when improving the longevity of bridges.

Creating a More Sustainable Infrastructure and Maintaining Integrity

To continue, the BEJS system effectively increases the number of sustainable roadways across the United States because of the reduced need to reconstruct decrepit bridges and the quick installation process. In the United states alone, in the year of 2017, around 96.8 million metric tons of concrete were consumed, mainly in the construction industry [13]. This astounding statistic could be greatly lessened by reducing the number of new bridge constructions yearly. As a result, the EMSEAL's BEJS product is positively contributing to a more sustainable construction industry.

Additionally, the unnecessary emissions caused by cars waiting in traffic could be reduced as a result of EMSEAL's expansion joint quick installation process. As it is widely known, waiting in traffic because of construction delays slows many drivers' commutes significantly. The longer cars are on the road the longer their engines are running, and the more toxic gasses are being emitted into the atmosphere. Since the installation of BEJS takes only an hour, EMSEAL's product is working to lessen the negative effects of vehicle emissions on our planet. Below, in Figure 3, is a picture of the easy installation process for applying EMSEAL's strip sealant technology to a bridge.

FIGURE 3 [10]
Construction Worker Installing the Sealant Expansion Joint

In this way, EMSEAL is upholding its responsibility to the public and to the planet by doing everything possible to create a sustainable product. In fact, the American Society of Civil Engineers code of conduct outlines that, "Engineers whose professional judgment is overruled under circumstances where the safety, health and welfare of the public are endangered, or the principles of sustainable development ignored, shall inform their clients or employers of the possible consequences" [14].

In addition to helping the environment, EMSEAL's technology is improving the safety of people who use bridges under construction. On August 1st, 2007 in Minneapolis, Minnesota, a bridge on interstate 35W collapsed. The tragic event killed thirteen people. The bridge was under construction at the time, as it had been built in the 1960s, and due to the heavy machinery that stayed on the bridge during

the construction, the structure buckled. The load that the bridge could handle had been previously miscalculated [15]. EMSEAL does not take the risk of overloading the weight of bridge as their installation process requires no heavy machinery. There is no need for machines to drill into concrete or extra cement to be poured in order to stabilize the joint. The short installation time for the sealant also prevents huge traffic jams from adding the extra weight of the cars to a bridge for extended periods of time. This innovative installation process shows how EMSEAL is taking their responsibilities to the public seriously and how they show respect for the public's time.

Consequently, bridge expansion joints produced by EMSEAL are working constantly to maintain their integrity through reduction of emissions from vehicular traffic and the construction trucks that are used to perform the installation and by taking into consideration the safety and well-being of the public. In the end, EMSEAL's bridge expansion joint system proves innovatively superior because of the measures taken to improve sustainability through the reduction of vehicular pollution, conservation of concrete, and lessening the intensity of bridge repairs.

THE MECHANICS OF EXPANSION JOINTS AND THE SCIENCE BEHIND THEM

The Inner Workings of a Bridge Expansion Joint

All expansion joints, no matter the size or type, begin with the joint opening or expansion gap. This is the area in between the two concrete slabs that the expansion joint is connecting as can be seen in Figure 4. This figure is also showing parts that would be used to secure metal expansion joints in addition to the labeled joint opening.

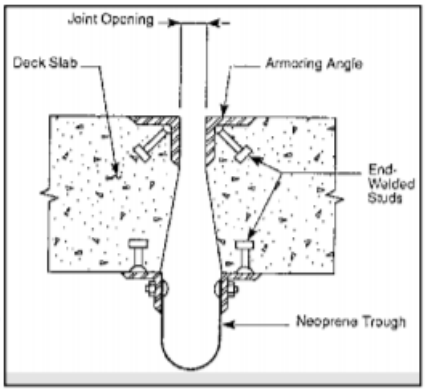

FIGURE 4 [16]
Standard Set-Up for a Metal Based Expansion Joint

The width of this gap is dependent on how much the bridge is expected to grow or shrink with each season; sizes range from less than one inch to over five inches [16]. The mechanism that sits between the two concrete slabs in the joint opening is the expansion joint system. To fit in the joint opening properly, expansion joints come in sizes small, medium, and large; where small joints can move a total of one and three-quarters inch, medium can move from that measurement up to five inches, and large can move over five inches. Multiple joints are kept in place by a metal anchor, typically made of steel, that consists of bolts that are driven into the concrete on either side and kept in place by an angled piece of the same metal that are contoured to the concrete at the edge of the joint opening. Some types of bridge expansion joints that are anchored like this are steel sliding plate joints, bolt-down panel joints, and steal finger joints [7].

The sliding plate joint consists of two steel plates that are placed atop of one another that glide across each other as the concrete moves as seen in Figure 5.

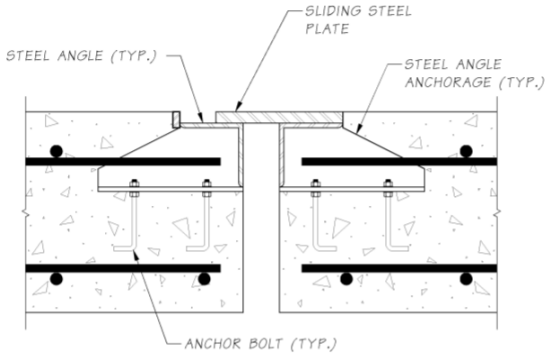

FIGURE 5 [7]
Fully Installed Sliding Steel Plate Expansion Joint

This expansion joint is an example of a medium size joint as its limits in movement are in the standard medium range. These expansion joints have been phased out of use in bridges and have been designated for use in only pedestrian or low weight bearing bridges. The metal used in this system can corrode due to acid rain and does not provide a good barrier between the rain and the concrete at the site of the joint making it susceptible to corrosion as well. Bolt-down panel joints are comprised of panels made from metals that are easily able to bend yet are still reinforced with a stronger metal, in this case steel, for support when being tread over in everyday use as seen in Figure 6.

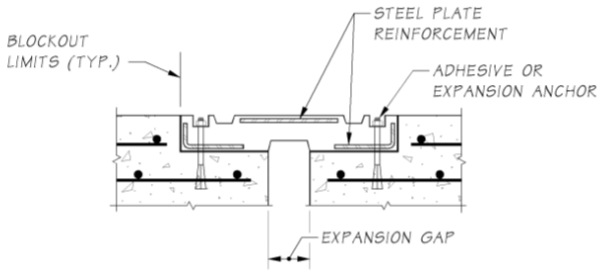

FIGURE 6 [7]
Fully Installed Bolt-Down Panel Joint

The panels are meant to undergo the stress and strain of bridge movement instead of the concrete itself. However, there were many durability concerns regarding the expansion joint, despite the strong metal support, and the joints in larger bridges began to fail fairly quickly. Many of these expansion joints have been replace by updated models and those on low traffic bridges are typically sealed to prevent corrosion and watched closely for damage. Steal finger joints are made of two steel plates with long interlocking grooves as seen in Figure 7.

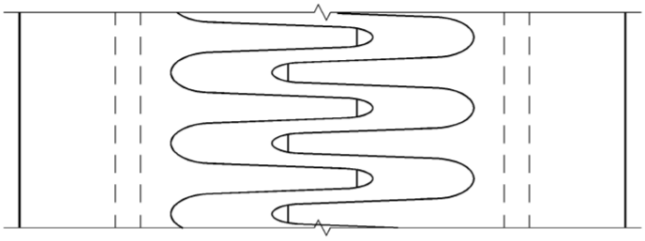

FIGURE 7 [7]
Steel Finger Joint (Top View)

This image is a top view of the joint, as opposed to a side view, like the previous figure, meant to showcase the interlocking fingers of the joint. The side view for this joint looks most similar to the steel sliding plate joint. As the concrete of the bridge expands and contracts, the fingers of the joint either lock together or move apart from each other while still providing a flat structure for vehicles to pass over. These expansion joints are great for covering large joint openings that other joint systems cannot fill; this is an example of a standard large expansion joint as its range is over five inches. However, this joint is typically made of the same materials as the steel sliding plate joint and therefore is prone to the same damages. In addition, the fingers of this joint system often get caught in snow plows and are seriously damaged. These damaged spikes then pose a threat to the tires of the vehicles that pass over the bridge [7].

The Science Behind Steel Corrosion

Steel needs few conditions to corrode and form rust: only water and air. The presence of water and air can cause the iron in the steel to form FeO(OH) or more commonly known as rust. Steel will rust immediately when exposed to these conditions and can only be delayed by coatings on the outside of the metal. To coat or plate the steel it must be dipped in a solution of other metal ions that may not be as strong as steel but do not rust like steel. There are three main elements that steel is typically coated with: zinc, chromium, and aluminum. Galvanized steel is made from dipping the steel in zinc, stainless steel from dipping in chromium, and aluminum steel from dipping in aluminum [17].

Even though rusting happens immediately, it can take two to three weeks for the naked eye to notice the effects. The steel used in the previously mentioned expansion joints have all been treated with chemicals to delay corrosion [17]. However, the expansion joints are constantly being driven over and stripped of their protective coating. Therefore, even if the steel is treated to prevent corrosion, it can still happen rapidly and compromise the expansion joint systems.

The Unsustainable Nature of Metal Expansion Joints

Each metal expansion joint mentioned has the same overarching issue, the corrosion of the metal of which the joint is made. This corrosion happens very easily to these joints and compromises the integrity of the joints in use. The issue has been realized in the industry as the use of the metal joints has been phased out of use in more recent years and replaced with their silicone counterparts [7]. However, there is still an issue that stands with the steel finger joint. This joint is often used when the gap between the concrete that needs to be joined is too large for a silicone replacement to fill. The replacement of such large joints can sometimes require that the concrete slabs surrounding them be completely replaced. It can take from 9-12 hours for the concrete to reach a suitable level or hardness for vehicles to be able to cross over [18]. Traffic during this construction period can cause vehicular transit to come to a standstill. Emissions from vehicles already produce one-third of air pollution in the United States and when vehicles are on the road longer than necessary, that fraction increases. This makes the air quality for people much worse in these heavy traffic areas and contributes to the overall depletion of the ozone layer [19].

Also, negatively impacting the environment is the creation of the steel expansion joints themselves. Steel is made from iron ore that is mined from the earth's crust and then paired with carbon in a blast furnace [20]. The digging in the ground to gain this iron ore is disruptive to every aspect of the environment that surrounds it. The waterways around the area being mined are easily polluted due to the mining process as heavy metals are often released into the water. The physical disruption of the land being mined can cause

sinkholes and significant soil erosion. The elements in the earth that are being surfaced and exposed to water and air due to mining can release toxic substances like lead, arsenic, etc. into the air and contribute to the poor air quality affecting many areas. All these things coupled together contribute to the massive impact mining has on the area's ecosystem. Animals homes are taken away and their water supply contaminated forcing them to find a new home and potentially overpopulate nearby areas [21].

Although steel finger expansion joints are an unsustainable, necessary evil, EMSEAL's strip seal expansion joint can help these steel expansion joint systems stay in use for a longer period. When the EMSEAL BEJS system is coupled with the steel finger joint, the corrosion of the steel joint is greatly reduced as the unit is now watertight and no longer completely open to the elements. Thus, the large expanse that the joint must fill is taken care of by the steel finger joint, and the longevity of the expansion joint by EMSEAL's strip sealant. The less the steel joints need to be replaced due to corrosion, the less the environment suffers because of it.

CONCLUSION: THE FUTURE OF BRIDGE EXPANSION JOINTS WITH BEJS

Bridges are involved in almost every commuter's life and their structural integrity has a direct impact on the safety and wellbeing of those that use them. With the number of bridges that are not structurally sound in the United States, there needs to be a quick, long lasting solution to improve the bridge's life. This not only saves materials for building new bridges but also the time of the people working on the bridge and those trying to use them. Aside from time, the safety of the bridge that people are crossing every day will be improved so that tragedies like those that occurred in Syracuse, New York and Detroit, Michigan never happen again.

Time and time again, EMSEAL's bridge expansion joint system proves its worth as a result of the technological breakthroughs and innovations that this product utilizes to help the greater good of the public. Its versatility as a standalone product and its ability to work in tandem with other expansion joints sets EMSEAL apart from other bridge specialization companies. The patented BEJS system makes leaps and bounds in the expansion joint's ability to prevent corrosion using non-invasive anchoring technology and a two-step silicone sealant process that safeguards against water damage to other integral bridge parts. Furthermore, EMSEAL's product is unmatched in terms controlling the expansion and contraction of bridge materials as a result of seasonal weather changes. Acting as a device to resist the structural shifts that naturally occur during the heat and cold, the BEJS system is constantly expanding and contracting to lengthen the lifespan of bridges across the nation. One installation at a time, the BEJS system is preventing the slow deterioration of healthy bridges into structurally deficient ones as well as bringing new life to older, previously damaged ones.

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