Innovative Technology for ADA Compliance and the Improved Safety of New Construction and Existing Track Crossings

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Abstract

Often times ADA (Americans with Disabilities Act) compliance is not met on existing or new track crossings, or unsafe conditions exist for bicyclist or wheelchairs as roadway are changed. Unfortunately, these non-compliant issues, or hazardous conditions, can be expensive to correct, and the design or function of the areas frequently interrupted to maintain safe and compliant conditions. New innovative materials developed to perform under track crossing conditions, and their performance properties that lead to their success in these conditions, is discussed. Future opportunities to provide improved safety and compliance with evolving standards and roadway still exist with these innovative materials.

INTRODUCTION

Places where the traveling public cross over active tracks, are places where extreme care in design and maintenance is needed to minimize injury, or even death. Even with published standards both by the U.S. Department of Justice (e.g., ADA), and public agencies or private railroads, each year people lose their lives, or are severely injured, while crossings tracks. Unfortunately, there is often a gap between the written construction standards and the field conditions that is the culprit in making track crossings hazardous.

A 22-yr old lady bicycled across America as a volunteer with a charitable agency and helped build several homes during her journey. Sadly, she suffered a severe fall trying to cross tracks when her tire became trapped in the crossing and is reminded of this accident by a scar. Recently, a 75-yr old man in a motorized wheelchair was crossing the railroad tracks when his wheel became stuck in the gap at the crossing. Only his screaming for help was able to save him when the quick action of a lady nearby cleared him from the tracks before his wheelchair was destroyed by a train. Sometimes dangerous crossing conditions are known by the railroad or transit agency, and due to limited track maintenance time or inadequate performing filler materials, the crossing remain unsafe for extended periods of time. Such is the case where a champion cyclist was injured at a crossing that was known to be hazardous for over 5 years. Now there is pending lawsuit for nearly a half-million dollars by the injured cyclist.

There are several variables that must be considered to create safe crossings for the public, as well as aligning these variables with the requirements of local and Federal standards. The focus of this paper is to understand how to make track crossing safer with a material design approach in order to achieve compliance to these standards and accommodating on-site conditions. There are intrinsic aspects of track crossing which are known to be dangerous as detailed by Mr. Green (Green, 2001). The dangerous areas addressed in this paper are; improper design/installation, maintenance of the crossing surface, the gap next to the rail, and perpendicular to the rail.

The crossing area which causes frequent injuries are gaps found perpendicular and parallel to track crossings. Both the DOJ (ADA standards, 2010) and FHWA (Rails-with-Trails, 2002) have addressed the field-side and flange-side gaps in detail, yet these areas still remain a danger to the traveling public. The flange-side gap found at crossings, which is located next to the rail on the inside of the track, must remain unencumbered for the wheel flange and is forever a present hazard to pedestrians and two-wheel traffic. In some circumstances, the flange-side gap can be filled with a rubber and compressed by streetcars to create a smooth transition. In situations where both of these gaps exist, field and flange-side, the risk of accidents for both two-wheel vehicles and pedestrians increase significantly, especially in areas where the crossing approach is less than 60 degrees (Bicycle Interactions, 2008).

The example in the paper shows this exact hazard as the bicycle path crosses a track at less than 90 degrees (Figure 5). In such cases, filling the field gap and widening the bikeway to allow sufficient width to cross the tracks at a safer angle, will improve the safety of these crossings. (Grade Crossing Handbook, 2007).

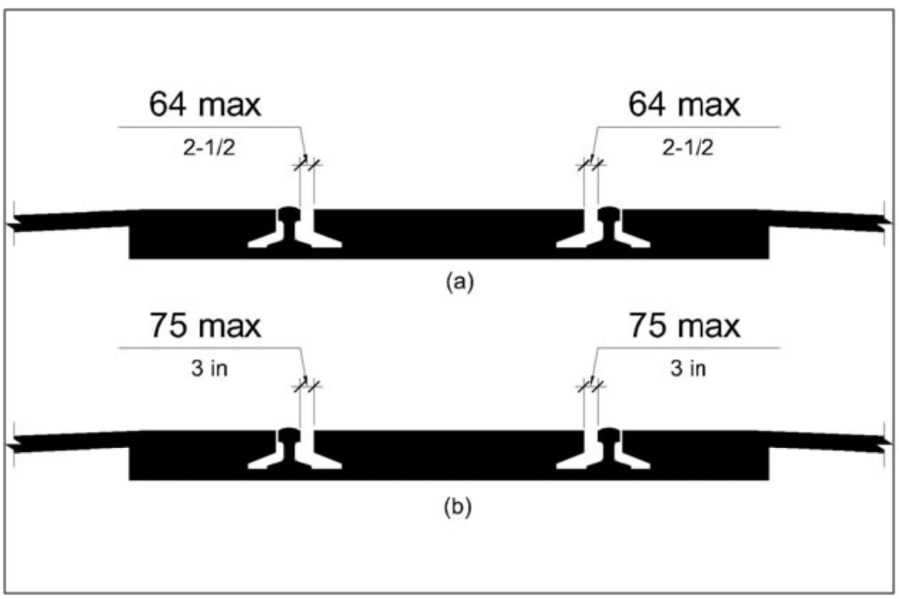

Figure 1: Flangeway widths, a = transit, b = freight. (Proposed Guidelines for Pedestrian Facilities, 2011)

Another significant safety concern at crossings is perpendicular-to-rail gaps. Unfortunately, these gaps are often found in the wheel path of two-wheel vehicles and wheelchairs, trapping these wheels in the gaps. In order to avoid this occurrence, the two-wheel vehicles will often time swerve into traffic to avoid falling into the perpendicular gaps. These perpendicular gaps just so happen to be at the same recommended right angle to the track that the FHWA and other agencies suggest for safely crossing tracks. "Railroad-highway grade crossings should ideally be at a right angle to the rails….The greater the crossing deviates from this ideal crossing angle, the greater is the potential for a bicyclist's front wheel to be trapped in the flangeway, causing loss of steering control" (Rails-with-Trails, 2002).

The most practical solution for resolving these two hazardous gaps, field-side and perpendicular gaps, has shown to be with an innovative field-applied material as shown in this paper.

Figure 2: Angled crossing.

Figure 3: Track crossing for vehicles, pedestrians, wheelchairs, and bicyclists.

Figure 4: Warning of angled track crossing.

Figure 5: Angled approach of bicyclist over gaps.

Gaps at track crossing and the hazardous conditions they cause are known by Design Engineers and construction plans attempt to address these hazardous with filling the gaps using asphalt. The Contractor is directed to fill these gaps with hot-mix asphalt and compact before opening to the public or rail traffic (NCTD Standard, 2005). In the past, the hot-mix asphalt may have been the best or most practical material for filling this gap area, but inspection of the filled area show the material is temporary at best, and the hazard of trapping wheels, or bicycles falling, still remains for these crossings. In the case of the champion cyclist who was injured at the crossing, the Railroad Company responded to his complaint and injury by dropping some asphalt in the gaps, but just after a week the material was missing. This is not surprising since hot-mix asphalt are amorphous in nature, difficult to compact in gaps, have low shear modulus, deform under load, and weakly bond to surrounding surfaces. The innovative field-applied material discussed in this paper has shown to offer a permanent solution to filling the hazardous gaps as a result of its thermoset nature, excellent adhesion, and resistance to deformation under a load.

Another challenge with repairing crossings, or filling hazardous gaps, is available track time for maintenance. Track time is often limited and installing traditional materials requires closing a track for extended periods of time, or working at night. The ideal case for improving, or maintaining safe track crossing conditions, is to perform the work without interruption of the train service. The innovative field-applied material shown in this paper, offers a rapid installation method and fast cure time to repair these gaps and other hazardous areas while the track is live. This method of installation has been difficult in the past due to the limited capabilities of repair materials and the high volume of vehicular and train traffic at crossings.

As the volume of traffic increase at crossings, and as more roads are built over tracks, the need for innovative materials and methods to quickly resolve safety concerns is clearly needed to keep the traveling public safe. The key components of the innovative material discussed in this paper are the ease of installation under live track conditions, electrical insulating properties, excellent adhesion to surfaces, semi-flexible, and aesthetic properties.

EXPERIMENTAL

Materials

The material used is an innovative blend of liquid polymers and solid materials which form an engineered composite capable of handling the performance requirements of this dynamic application. The polymer is composed of liquid polyurethane compounds which contain no volatile ingredients (no odor) and is created from natural oils derived from biobased products. The polyurethane compound is blended at an optimum level with an aggregate created from 100% post-consumer glass bottles which are crushed to a uniform 1-2 mm size.

Forming the innovative composite material is performed by mechanically mixing the liquid components with the aggregate and placing it in the gap until it is level to the surrounding surface. The material immediately begins curing once the components are combined to form a final product that is semi-flexible. The compressive strength of the innovative composite material builds rapidly, allowing the area to be open to traffic in a short period of time.

Track crossings have unique conditions unlike other roadway or walkway environments, and a material must possess the right combination of performance properties to be successful. The innovative material reported in this paper was formulated with specific performance properties to optimize the lifespan and application of the material. The material was created to offer the ability to withstand vibration and load deformation, electrical isolation, surface friction, and adhesion to the surfaces. Furthermore, packaging, handling, and curing time of the product were designed for rapid installation under live track conditions and capable of being re-opened to the traveling public within minutes. The performance properties of this material are found in Table 1.

Testing Procedures

The material was combined according to the manufacturer's recommendations. The gel time was measured according to ASTM C881 at 21°C. The volatile content was measured according to ASTM D2369 method E. The hardness was measured according to ASTM D2240 and all test samples were allowed to cure at ambient temperature for 7 days unless otherwise noted.

The tensile strength and percent elongation was measured according to D412, all samples were cast and allowed to cure at 70°C overnight before being tested. The compression strength was measured by ASTM C579 Method B, all samples were cast into 51mm cube molds with appropriate aggregate ratio, one set of samples were allowed to cure for 24 hours at ambient temperature before being tested and the other set was allowed to cure for 7 days at ambient temperature before being tested. The flexural strength was tested according to ASTM C580 Method A, all samples were cast into sheets with appropriate aggregates, then cut into the appropriate size and allowed to cure for 7 days at ambient temperature before being tested.

Adhesion bond strength was tested according to ASTM D7234; concrete samples were cut, washed, dried, and 20mm dollies were then adhered to the sample. Impact resistance was tested by ASTM D5628, samples were cast into neat sheets and cut into 152mm squared samples with a thickness of 9.5mm were cured at ambient temperature for 7 days before being tested.

Fatigue evaluation was tested per ASTM D7791 by producing cylindrical samples measuring 46.5mm inches in diameter, 46.5mm tall. Samples were cured overnight at 70°C before testing. Samples were compressed via sine wave, at a frequency of 5 Hz, and evaluated at a variety of stress amplitudes, in order to estimate fatigue limit and S-N properties. For the purpose of this testing, fatigue limit was defined as successfully surviving over three million cycles. Volume resistivity followed ASTM D257 using a 3.81mm sheet of material that was cured at 70°C for 24-hours.

Surface friction properties were evaluated with topping sand and after abrading. After testing, surfaces were abraded with a #60 orbital sander (to simulate abrasion in the field from normal wear) to the loss of at least 90% topping sand. Materials were tested in accordance with ASTM E303, using a Cooper British Pendulum Tester (serial 1422-03) with wetted substrate, at room temperature, and N=5, with results reported in British Pendulum Numbers (BPN).

RESULTS & DISCUSSION

An innovative composite material was chosen to fill the gaps in a track crossing with a history of accidents due to hazardous gaps next to the rail. The material was provided in the form of kits and mixed according to the manufacturer's recommendation. The material was used to fill the gap between the concrete panels and field side of the track at the pedestrian crossing for ADA compliance and improved safety of two-wheeled traffic. The available track time for this work was 15 minutes between trains and this was enough time for the crew to clean the gap and install the material. The installation was monitored for several months and found to be performing according the expectations and the hazardous gaps have been eliminated.

Table 1: Performance properties of an innovative composite material.

Description	Test Method	Result
Gel Time	ASTM C881	9 min
Volatile Content	ASTM D2369, Method E	0.4%
Durometer Hardness	ASTM D2240, A (D)	90 (45)
Tensile Strength	ASTM D412	11.7 MPa
Elongation	ASTM D412	90 %
Compressive Stress (24hr)	ASTM C579, Method B, 24 hr. cure ambient	9.2 MPa
Compressive Stress (7 day)	ASTM C579, Method B, 7 day cure ambient	12.0 MPa
Flexural Strength	ASTM C580, 7 day ambient cure	3.6 MPa
Bond Strength	ASTM D7234	276 MPa, substrate cohesive
Impact Resistance	ASTM D5628, 7 day cure ambient, tested at 24°C, -29°C.	0.82 N/mm^2 0.20 N/mm^2
Fatigue Limit	ASTM D7791	Pass 3 million cycles
Volume Resistivity	ASTM D 257, 24°C 50% RH, ohm-cm,	1.65 x 10^{13} ohm-cm
Surface Friction	ASTM E 303, topping sand (abraded)	101 ± 2 BPN (100 ± 2 BPN)

The method of installation included the following:

1. Cleaned surfaces with a high velocity blower (250 MPH / 700 CFM) blower, removed moist and loose materials, and rust between train intervals (15 min). Surfaces were wiped clean with a towel. Ends were capped and surrounding surface taped.
2. Mixed the material according to manufacturer's recommendations and staged the materials until track was available.
3. Immediately after train clears the track, pour and spread material within the gap area and leveled to the surrounding panel elevation. Apply black topping sand to refusal and clear area for train and re-open to the traveling public.

Figure 6: Hazardous field-side gap.

Figure 7: Staging material to fill gap on live track and traffic lanes.

Figure 8: Installing material.

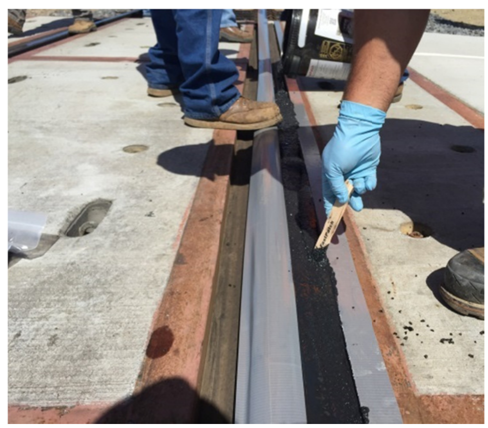

Figure 9: Leveling material.

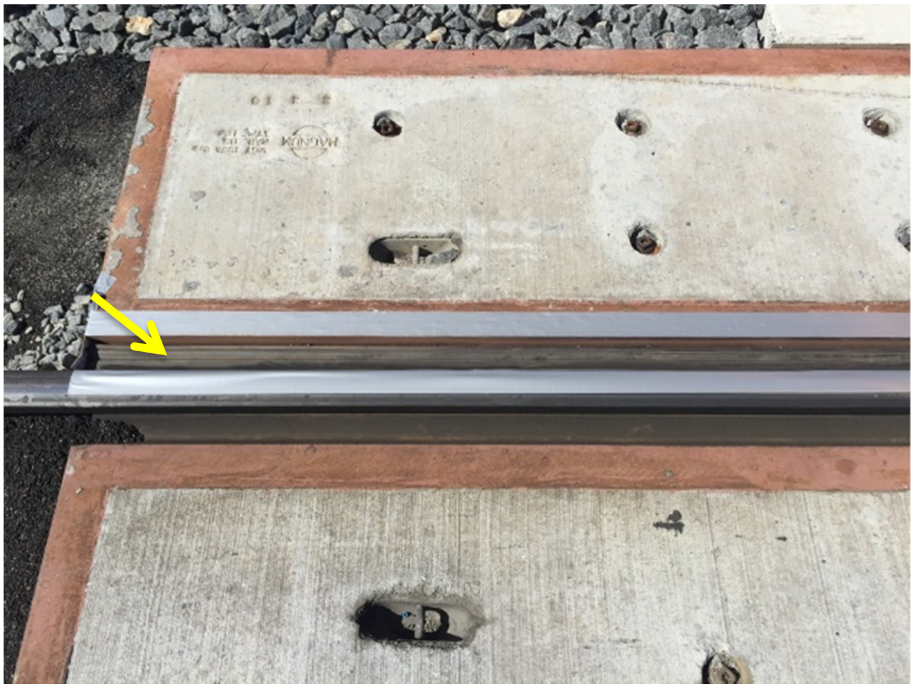
Figure 10: Unfilled hazardous gap (BEFORE).


Figure 11: Filled gap with innovative material (AFTER).

Figure 12: Crossing completed with innovative material.

CONCLUSION

As urban boundaries grow, and more streets and walkway are built over tracks, and as our track crossing infrastructure deteriorates under weather and high volume traffic, the need to maintain safe track crossings for the traveling public becomes a greater concern. Current materials and methods used to build and maintain these track crossing at a level of reasonable safety, require considerable time and interruption to travelers. Through research and designing of an innovative material, the cost and time has been considerably reduced to and improve the safety at track crossings and comply with ADA standards. Traditional materials have failed to meet the requirements as a temporary or long term solution, and through designing an innovative composite material with excellent adhesion, semi-flexible yet resistant to deformation, and electrical isolation properties; a long term solution with minimal interruption to the traveling public is now achievable.

ACKNOWLEDGEMENTS

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