IDEA

Innovations Deserving Exploratory Analysis Programs

Transit IDEA Program

Recoating Electrified Third Rail Cover Boards - Phase 2

Final Report for
Transit IDEA Project 59

Prepared by:
Arun Vohra, P.E.
MINI LLC
Bethesda, MD

June 2010

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Innovations Deserving Exploratory Analysis (IDEA) Programs Managed by the Transportation Research Board

This Transit IDEA project was funded by the Transit IDEA Program, which fosters development and testing of innovative concepts and methods for advancing transit practice. The Transit IDEA Program is funded by the Federal Transit Administration (FTA) as part of the Transit Cooperative Research Program (TCRP), a cooperative effort of the FTA, the Transportation Research Board (TRB) and the Transit Development Corporation, a nonprofit educational and research organization of the American Public Transportation Association (APTA).

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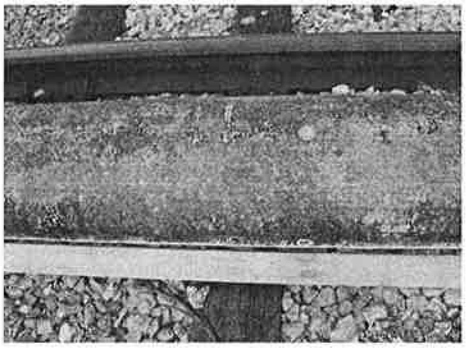
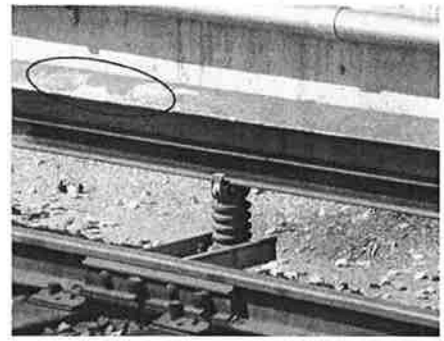


Deteriorated cover board,
Miami, July 2009

Cover board blown off along with third rail
during Hurricane Wilma, Miami, October 2005



BART Gel Coat deteriorated on cover board,
21 July, 2006

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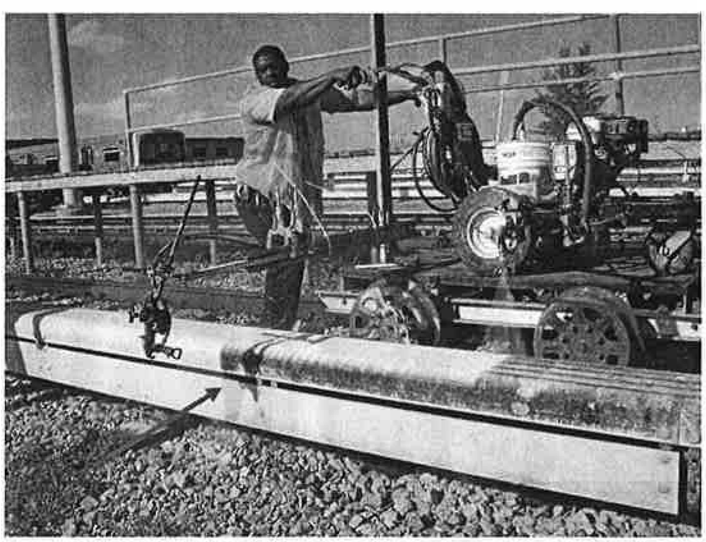

Higher speed recoating system, Miami, Oct 2009

Acknowledgements
The participation in this Transit IDEA project and the guidance of the following professional staff of transit agencies and subject matter experts and equipment manufacturers, has been valuable and is appreciated.

Transit Agencies:

- Miami Dade Transit, (MDT): Lee Emard, General Superintendent Track & Guideway , Rail Services; James Auld, Lead Rail Structure and Track Supervisor; Carl Wilt, Sabin Waterson and William Foissett, Track Repairers; Even Mombre, Painter; Harpal Kapoor, General Manager
- Metropolitan Atlanta Rapid Transit Authority (MARTA) : Rich Krisak, Assistant General Manager; Garry K. Free; Director of Facilities and Structures; Tim Elsberry, Manager of Track and Structures
- Bay Area Rapid Transit District (BART): Mark A. Pfeiffer, P.E., Group Manager; Michael O. Brown, Principal Engineer, Track Maintenance and Engineering

Subject matter experts and others:

- Specialty Products Inc, Scott James, Sales Manager, Seattle, WA
- NorCal cooling tower services, Orangevale, CA: David Lasky, President
- Custom Environmental IAP, LLC, Dahlonega, GA: Rick Harben, President
- Roof-Tek, Johnson Creek, WI: Guy Vance, President; Tom Meyer, Technical Director; Douglas Orcutt, Application Research Engineer
- Line-X Industrial Coatings, Force Mitigation, and Physical Security: Steve Decker, Technical Manager, Ridge, MD
- Carboline, Paul Kennington, Field Manager, Houston TX
- WIWA Custom Airless Spray Systems, Sandra Nelson, General Manager; Kieran Snow, Sales Manager, Norfolk, VA
- NLB Corp, Water Jetting Systems: Keith O'Hara, Technical Manager, Wixom, MI
- STO Corp, John Edgar, Technical Manager, Atlanta, GA
- Sherwin Williams Corp, Bob Spano, Industrial Coatings
- Rustoleum Corp, Jeff Hess, Industrial Coatings; Pete Fisher, Technical Services Dept, Chicago
- Florida Power and Light, Larry Vogt, West Palm Beach, Fl
- Jacksonville Electric Authority, Dennis M. Thomas, Jacksonville, FL
- Graco Corp, John Davis, Minneapolis, MN
- Harvey Berlin, Senior Program Officer, Transit IDEA Program, Transportation Research Board, Washington, DC

Expert Review Panel

This Transit IDEA project has been guided and reviewed by the expert review panel. The purpose of this panel is to provide guidance to the Principal Investigator for the IDEA product development and transfer of results to practice. The panel members' comments and recommendations have been incorporated into the project reports and plans for implementing the results of this Transit IDEA project.

Expert Review Panel members

Lee Emard, General Superintendent
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Miami, FL

Rich Krisak, Assistant General Manager; Garry K. Free; Director of Facilities and Structures; Tim Elsberry, Assistant Director of Track and Structures
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Executive Summary

This project builds on the successfully completed Transit IDEA Project 44, *Recoating Electrified Third Rail Cover Boards.* The purpose of this project is to test and demonstrate an operational high speed system to clean and recoat in-place the fiberglass reinforced plastic cover boards on electrified third rails for rail rapid transit systems. The problem is that the ultraviolet action of the sun on the cover board degrades the protective gel coat and delaminates the glass fibers. The weakened cover board can be blown away by high winds or fall on the third rail. Traction power is lost and the rail system shuts down.

Miami Dade Transit (MDT) participated in this project by testing of the high speed recoating system on their facilities. Other rail rapid transit systems, including Metropolitan Atlanta Rapid Transit Authority (MARTA) and the San Francisco Bay Area Rapid Transit District (BART) participated in reviewing the work in this project. This will make the results of this effort useful for transit systems.

Two high speed cleaning methods, a spray bar and a spinning bar, were considered. The purpose was to clean the cover board surface in one pass, before applying the coating. A pressure washing spray bar with 7 fan jet spray nozzles, was fabricated and tested. It was determined that the spray bar would need excessive water flow to properly supply all 7 nozzles.

An improved cleaning system was tested. A pressure washer was attached to a surface cleaner consisting of a swivel that had two hollow arms with an offset round jet nozzle at the ends. The reaction force of the water jets at the nozzles caused the arms to spin. The pressure washer was carried on a service vehicle and the surface cleaner was attached to an arm positioned on the cover board. The service vehicle was moved along the track to test clean a section of cover board. The dwell time and the standoff distance of the spinning water jets were found to clean the cover board satisfactorily in one pass.

Two high speed coating application methods, power roller and airless sprayer, were considered. The potential performance of a power roller was discussed with the MDT staff, but it was deemed to be too slow and inefficient and could not coat the curved surface at the corner of the cover board. Airless spray technology appeared to have the desirable attributes. An airless sprayer was carried on a service vehicle and moved along the track to test spray a section of cover board. For the nozzle used, the optimum standoff distance (distance between the nozzle tip and the surface) and the width of coating were determined. Attaching the nozzle to a fixed arm was found to be adequate to position the nozzle at an appropriate standoff distance, as the relative position of the rails and the cover board is fixed. The airless system was modified by attaching two nozzles to the pump to achieve full coverage of the top and side of the cover board. This setup was used as the basis for the design and development of the advanced recoating system.

It was determined that a water-based coating would be desirable because of the issues of cost and cleaning of the application equipment with solvent based coatings. Several alternative recoating materials were considered and three materials were selected. Coating adhesion tests were performed on two water-based coating products in accordance with the American Society for Testing and Materials (ASTM) standard test D 4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers, in cooperation with the coating manufacturers. Two surface coating materials were applied to cover board segments on the MDT track to evaluate their performance and assist MDT in selection for future application.

The work in this project to improve the pressure washing system for high speed cleaning of cover boards was considered to be successful by MDT staff.

IDEA Concept and Product

In the successfully completed previous Transit IDEA Project 44, a prototype recoating system was developed and attached to a service vehicle and successfully tested on the tracks of Miami Dade Transit (MDT).

The purpose of this Phase 2 project is to design and develop a higher speed recoating system and surface cleaning system. Two of the most appropriate coating technologies were considered. The options were power roller coating and airless spray coating and they were discussed in detail with MDT staff. Power roller coating can only coat a flat surface. Since the cover board has a flat top and a flat side meeting in a curved corner, a roller could not provide full coverage over the curved surface. Also, the roller coating process would be too slow. Therefore the power roller coating system was not deemed to be viable for this project.

Airless spray coating is able to coat curved surfaces and it was the application method selected for this project. The task was to use multiple nozzles to coat the entire top and side of the cover board surface completely in one pass with little or no overspray.

A coating material had to be selected. There are two types of coatings, water-based and solvent based. After discussion with MDT, it was determined that a water-based coating would be desirable, because it had lower cost, greater one-coat thickness and longer coating life, than a solvent based coating. Also, cleaning of the application equipment after using solvent based coatings would be cost prohibitive.

The Principal Investigator did a survey of coating products. The professional staff of two electric utility companies that routinely recoat fiberglass tanks and pipes with material properties similar to the cover board, were contacted to obtain the benefit of their experience. The professional staff of Florida Power and Light located in West Palm Beach, FL and Jacksonville Electric Authority, FL, were consulted as they have experience with recoating fiberglass tanks and pipes that are exposed to the sun like cover boards. A recommendation for one coating product was obtained. Several other water-based surface coating materials were considered. The manufacturers of two other coatings that appeared to be suitable were contacted and product information was obtained. Three products were selected. Three were applied to deteriorated cover board segments to evaluate their performance using standard test procedures. American Society for Testing and Materials (ASTM) coating adhesion tests were performed on the test segments, with the cooperation of the product manufacturer, to evaluate and to assist in selection of the appropriate coating material.

A higher speed advanced recoating system was designed and developed. Airless spray machines and nozzles made by two major manufacturers were investigated. The manufacturer that had a more suitable product line to meet the needs of this project was selected. The manufacturer's technical staff was contacted and a sprayer was selected where the volume output of the sprayer pump could meet the total volume capacity needed for the nozzles. The objective was to find a nozzle that had the ability to coat the top, and a second nozzle to coat the side surface of the cover board. The nozzles also had to have a sharp cutoff so that overspray was minimized to prevent wastage of coating material. Overspray on the surface of the third rail would be a major problem. The coating would interrupt the electric power supply to the collector shoe that slides on the third rail and conducts electric power to the traction motors in the rail cars, and the cars would not run.

An airless sprayer was matched to two sharp cutoff nozzles that had the ability to coat the top and side surfaces of the cover board. The sprayer and attached nozzles were carried on a service vehicle and moved along the track. By attaching the nozzles to two adjustable arms, each nozzle could be positioned at its appropriate standoff distance (distance between the nozzle tip and the surface). The positions of the nozzles were adjusted and a section of cover board was test sprayed to set the optimum standoff distance and the flat jet nozzle fan angle and width of coating. The airless system with two sharp cutoff nozzles was able to achieve full coverage of the top and side of the cover board without overspray coating the third rail or material being wasted.

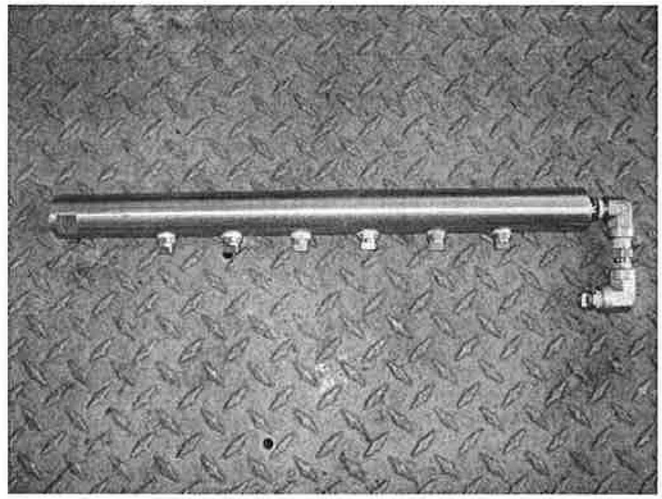

Fig 1. Spray bar with 7 nozzles

A cover board cleaning system was developed. The purpose was to clean the cover boards in place before applying the coating. Two high speed cleaning methods, a spray bar and a spinning bar, were considered. The purpose was to clean the cover board surface in one pass, before applying the coating. A pressure washing spray bar with 7 fan jet spray nozzles, was fabricated and tested. It was determined that the spray bar would need excessive water flow to properly supply all 7 nozzles and was deemed to be impractical with the equipment available.

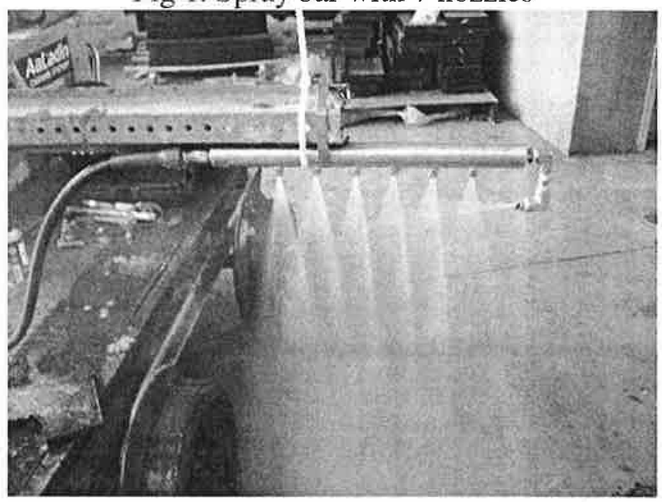

Fig 2. Spray bar with 7 nozzles for pressure washing

An improved cleaning system was tested. A pressure washer was attached to a surface cleaner consisting of a swivel that had two hollow arms with an offset round jet nozzle at the ends. The reaction force of the water jets at the nozzles caused the arms to spin. The pressure washer was carried on a service vehicle and the surface cleaner was attached to an arm positioned on the cover board. The service vehicle was moved along the track to test clean a section of cover board. The dwell time and the standoff distance of the spinning water jets were found to clean the cover board satisfactorily in one pass.

Fig 3. Spinning bar with 2 nozzles for improved cleaning

A meeting was convened with MDT professional staff, and a presentation made to them on the results of the higher speed recoating system developed at this stage of the project. The General Superintendent stated that MDT has spent significant funds to purchase many miles of new cover boards to replace weakened cover boards that were destroyed by Hurricane Wilma. MDT is in the process of installing the new cover boards and wants to apply the protective coating on them to prevent deterioration, failure and costly replacement again in the future. The result of the meeting was that the MDT staff was satisfied with the results.

Potential Impact on Transit Practice

The purpose of this project is to develop a high speed system to clean and recoat the fiberglass reinforced plastic cover board in place, on electrified third rails for rail rapid transit systems. The ultraviolet action of the sun on the cover board degrades the protective gel coat and then delaminates the glass fibers. The weakened cover board flutters excessively from the draft caused by trains and from high winds. The holes in the cover board for the retaining pins get enlarged and the pins can slip out. The cover board can drop on the third rail. The contact shoes, that slide on top of the third rail and provide power to the traction motors, can break off when they hit the dropped cover board. Traction power is lost and the rail system shuts down. This project has developed a high speed cover board recoating system that is attached to a service vehicle and demonstrated on the tracks of MDT Miami.

Description of Cover Boards in Transit Systems

(1) Miami Dade Transit, MDT

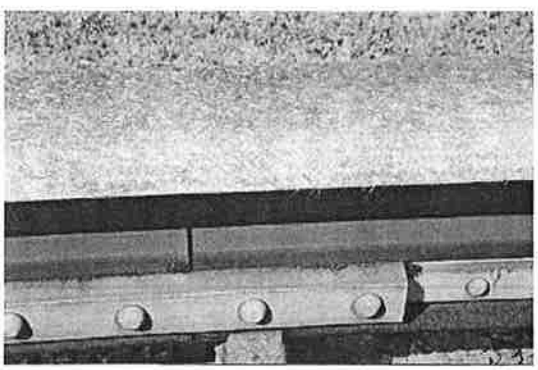

Fig 4. Delaminated glass fibers on cover board after UV damage to gel coat, Miami, Dec 2003

Fig 5. Weakened cover board blown off by Hurricane Wilma, Miami, October 2005

MDT, Miami has 57 miles of elevated and on grade track. The cover boards are severely deteriorated because MDT had no means to periodically recoat the cover boards in the past. MDT estimates that a crew of 8 workers at $41 per hour per worker can replace 1000 feet of cover board in an 8 hour shift. The labor cost is $2.60/foot of cover board. The estimated cost of a standard 10 foot piece of 14 inch wide cover board, contiguous 10 foot piece of 7 inch wide back drop, 2 brackets and retaining pins is $250. The labor and material cost is $ 27.60/foot of cover and side board. Fringe and night differential labor cost has to be added to the total cost of replacement. As a result of Hurricane Andrew in 1992 and Wilma in 2005, several miles of deteriorated cover

board were blown off and have not been replaced. Currently MDT has a cover board replacement project; estimated cost of replacement was $17 million for 53.3 miles of cover board including crossovers, pocket track and yards.

The cost of spray in place coating is about $2 per square foot. This equates to 2 x (14+7)/12 or $3.50 per lineal foot of cover and side board. Restoration at a cost of $3.50 per lineal foot is considerably cheaper than $27 per lineal foot for replacement.

(2) WMATA, Washington, DC

The WMATA's metrorail system has 220 miles of fiber reinforced plastic cover board of which about 106 miles are exposed to the sun. It appears that the cover boards are in need of recoating; otherwise they will need to be replaced in a few years at a cost of several million dollars.

(3) Maryland Transit Administration (MTA), Baltimore

The MTA rail rapid transit system in Baltimore has about 34 miles of cover board. It consists of a below ground section, an aerial section and a grade level section. The cover board in the tunnels also needs to be recoated per MTA management. A metal bracket holds the third rail cover board. The metal bracket is bolted to the rail tie. The cover board is made of fiberglass.

(4) BART, San Francisco Bay Area

The BART rail rapid transit system has about 268 miles of fiber reinforced plastic cover board, of which about 63 miles are in tunnels. BART has about 205 miles of cover boards that are exposed to the sun. BART recently spent about $10,000,000 to replace retaining pins with large washers under the heads, and added new hold down straps, on about 100 miles of cover board. The high cost is partly due to having to pay contract workers for a full 8 hour shift even though work can be performed for only 2 hours at night.

(5) MARTA, Atlanta

MARTA has about 98 miles of fiber reinforced plastic cover boards exposed to the sun. It appears that the cover boards are in need of recoating otherwise they will need to be replaced in a few years at a cost of several million dollars.

(6) LACMTA, Los Angeles

LACMTA has about 9 miles of fiber reinforced plastic cover boards exposed to the sun. It appears that the cover boards are in need of recoating otherwise they will need to be replaced in a few years at a cost of several million dollars.

(7) SEPTA, Philadelphia

SEPTA's rail rapid transit system has about 102 miles of cover board, of which about 39 miles are in tunnels. Different parts of SEPTA have different kinds of third rail and third rail cover boards,

resulting from the different systems that became part of SEPTA.

(8) New York City Transit (NYCT), Metropolitan Transportation Authority (MTA), New York City

The NYCT rail rapid transit system has 815 miles of cover board. This includes all mainline and yard track. The tunnel portion is 439 miles and the outdoor section is 376 miles. Cover boards are made of fiberglass or wood.

(9) MBTA, Boston

MBTA has 108 miles of rail rapid transit track, of which 14 miles are in tunnels. About 60 miles of track have third rail with cover board, the rest use overhead power supply. Cover boards are made of fiberglass.

Preliminary Cost Estimates of replacement and recoating of cover boards

TRANSIT AGENCY	TRACK MILES	Outdoor Miles/recoating needed	Cover Board Replacement cost @$27/foot *	Cover Board Recoating cost @ $3.50/foot *
MDT Miami	44	57	$8,125,920	$1,053,360
MARTA	104	98	$13,970,880	$1,811,040
NYCT	835	376	$53,602,560	$6,948,480
SEPTA	102	63	$8,981,280	$1,164,240
BART	268	205	$29,224,800	$3,788,400
WMATA	225	106	$15,111,360	$1,958,880
MTA, Baltimore	34	34	$4,847,040	$628,320
LACMTA	34	9	$1,283,040	$166,320
Total	1646	948	$135,146,880	$17,519,040

* Based on the preliminary unit costs, replacement of cover boards would be expected to cost significantly more than recoating cover boards.

There are no high speed systems for recoating cover boards. The problem is that the cover boards are difficult to clean and recoat because of the high voltage, access restrictions and limited time available to perform the work. Rail rapid transit systems routinely replace scores of cover boards every year at considerable cost.

Research and development of a cost-effective recoating system for cover boards is a challenge that has not been addressed. Manufacturers have not been willing to invest large amounts of money in research and development because of the high risk and the limited number of rail rapid transit agencies with cover boards for third rails. The level of complexity is increased because of the limited access and short time available to perform the work, typically 4 hours or less (some transit systems run 24/7) and the high voltage present. Also, harsh and abrasive cleaners and cleaning media cannot be used as they may damage the fiberglass cover board, or cause corrosion and malfunction of adjacent switches, sensors, and metal components. Most jurisdictions ban the use of cleaning chemicals because of environmental and health concerns.

The cover board recoating system will improve the safety of rail rapid transit systems. After the attacks on the Pentagon and the World Trade Center, people are more concerned about their security. Dropped cover boards breaking off contact shoes can result in backed up trains being stranded in dark tunnels. The cover board recoating system will enhance the public perception of a safe and secure rail transit system.

Concept and Innovation

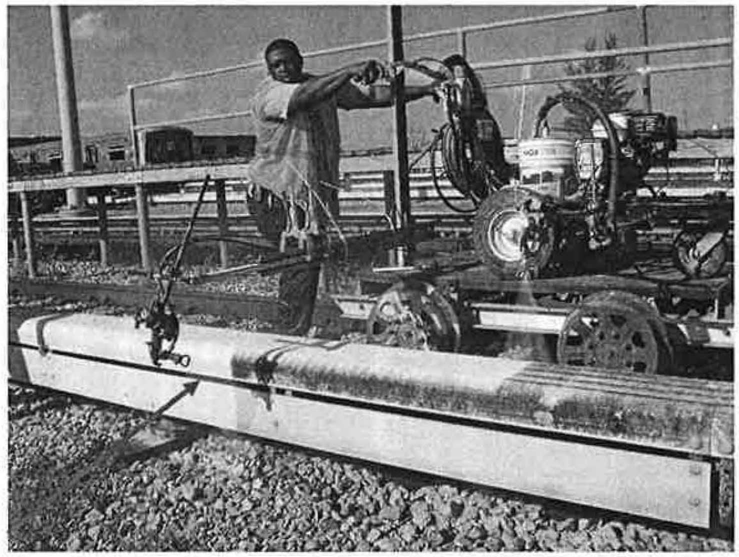

Fig. 6 Higher speed recoating system with 2 nozzles, at Miami Dade Transit

The higher speed recoating system being developed in this project is mounted on a service vehicle for in situ cover board recoating. Cover board cleaning using compressed air jets was adequate for cleaning moderately dirty cover boards to allow proper adhesion of the coating. This would be an alternative way for cleaning cover boards on elevated sections of track where water from pressure washing would fall on road traffic and cause problems. For very dirty cover boards, the most appropriate cleaning tool was found to be a pressure washing spinning bar with two nozzles that could clean the top or side surface of the cover board in one pass. It was determined that two adjustable arms holding sharp cutoff nozzles attached to an airless sprayer were sufficient for coating the entire top and side of the cover board in one pass. The spray application speed was deemed to be sufficiently high by MDT staff.

Investigation

In the previously completed Transit IDEA Project 44, MDT (Miami), BART and MARTA were visited to determine their cover board recoating needs. Two component Polyurea coatings were spray applied at BART and MARTA, but the materials, skill level and application equipment was cost prohibitive. A single component coating was applied at MDT and was considered to be an acceptable and practical solution.

In this Phase 2 project to develop a higher speed recoating system, the Principal Investigator worked closely with MDT, coating manufacturers, spray equipment and nozzle manufacturers and conducted coating adhesion tests on three products. Numerous conversations, e-mails and meetings with other advisors took place. Two sections of cover board were cleaned with a pressure washer connected to a spray bar with 7 cleaning nozzles. The pressure washer was not large enough to supply 7 nozzles and the cleaning was not fully satisfactory. A spinning bar with two nozzles was used in Stage 2 and found to provide satisfactory cleaning.

The cover board was test coated with an airless sprayer and one nozzle. This was able to coat either the side or top of the cover board and proved that the concept worked. Then an airless sprayer was connected to two properly sized nozzles that could coat the top and sides of the cover board in one pass. The coating application was successful.

Failure Mechanism of Fiberglass

Fiberglass or Fiberglass Resin Polyester (FRP) is polyester resin with reinforcing chopped strand mat (CSM) of glass fibers. The polyester resin does not have enough time to fully wet out or completely saturate the glass mat, as it sets in 10 – 15 minutes. This leaves tiny bubbles or voids on the product surface. The product is coated with a gel coat to protect it from the elements.

Ultraviolet (UV) rays from sunlight eventually erode the gel coat. Where there are voids on the surface, the glass fibers are exposed and experience fiber bloom. Water ingress into the void, enhanced by wicking action, followed by freeze thaw cycles, results in increased surface damage, exposed fibers and a weakened cover board.

Coatings to Restore Fiberglass

Cleaning the cover board by wire brushing was not appropriate as it will pull out the exposed fibers with consequent weakening of the cover board. Compressed air jets are generally adequate to clean moderately dirty cover boards. Very dirty cover boards can be cleaned by pressure washing using a spinning bar.

The optimum coating should able to be applied to the cover board on the track, dry to the touch about one hour, have good UV resistance properties, have adequate strength, bond well with the substrate, and be affordable.

Evaluation of Cover Board Recoating Systems

In the successfully completed Phase 1 Transit IDEA project 44, the MTA Baltimore, WMATA, BART, MARTA, MDT Miami, and LACMTA were visited to determine their cover board restoration needs and shown samples of applied coatings to the professional staff and obtain their comments. Discussions were held with the above transit agency staff to solicit their input, and identify requirements that would impact implementation, and address those requirements.

This report describes this Phase 2 project. It was determined that cleaning with a pressure washing spinning spray bar with two nozzles, and a single component water-based spray applied coating is satisfactory and cost-effective. Field testing was conducted at MDT.

Plans for Implementation

This report on the development of the higher speed prototype cover board recoating system conducted at MDT Miami was sent to BART and MARTA rail rapid transit systems for their review and consideration. The results will also be disseminated by the Principal Investigator to other interested transit agencies upon request. Following this project, the Principal Investigator plans to show the recoating system to equipment manufacturers for potential commercialization. A

big selling point is that the cost of recoating cover boards is estimated to be about one quarter of the cost of removing them and replacing them with new cover boards.

The participation of the several transit agencies identified above will make the results useful to transit systems with different kinds of cover boards.

Conclusions

It would be cost effective on most rail rapid transit systems to recoat fiberglass reinforced cover boards instead of removing them and replacing them with new cover boards. It was determined that compressed air jets were adequate for cleaning moderately dirty cover boards and allowed good adhesion of the coating. For very dirty cover boards, the most appropriate cleaning tool was pressure washing. It was determined that the most appropriate coating was a water-based single component.

Recoating of severely cracked and weakened fiberglass reinforced cover boards has to be considered on a case by case basis. In some situations, replacement will be necessary. Wood cover board restoration may or may not be cost effective, depending on the degree of dry rot. If the degree of rot has compromised the structural strength of the wood cover boards, it could be cheaper to replace them. It is recommended that all new cover boards be coated periodically to protect them and prolong their life using this in-place coating application technology.

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