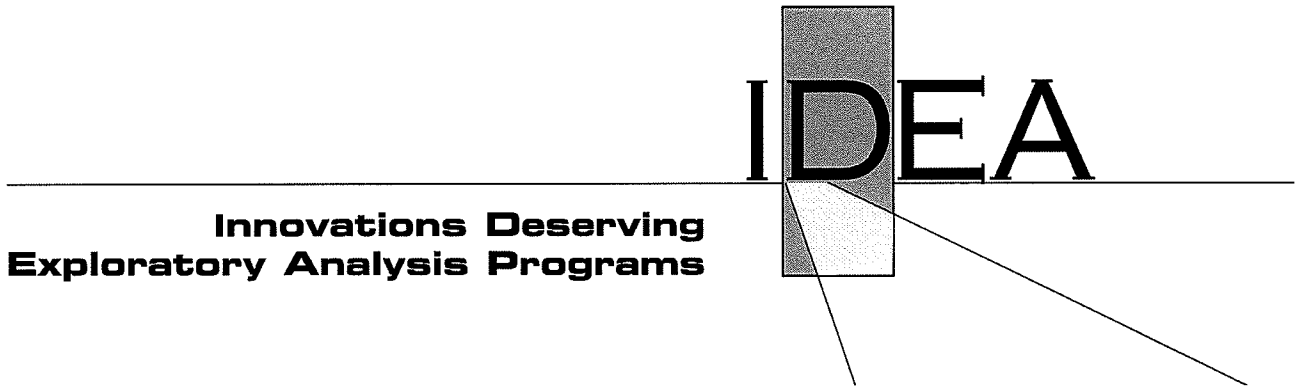

Transit IDEA Program

Cleaning and Recoating Electrified Third Rail Cover Boards

Final Report for
Transit IDEA Project 44

Prepared by:
Arun Vohra
Consulting Engineer
Bethesda, MD

July 2008

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).

The Transit IDEA Program is one of four IDEA programs managed by TRB. The other IDEA programs are listed below.

- NCHRP Highway IDEA Program, which focuses on advances in the design, construction, safety, and maintenance of highway systems, is part of the National Cooperative Highway Research Program.
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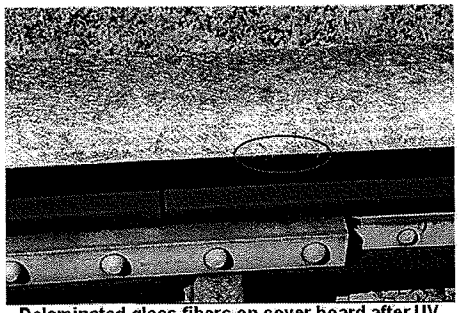
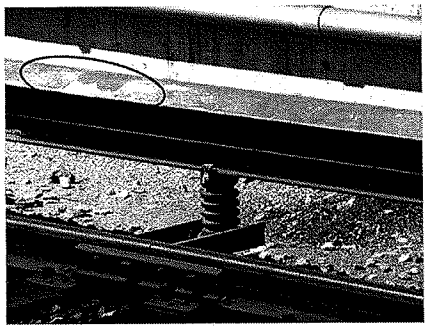


Delaminated glass fibers on cover board after UV damage to Gel coat, Miami, December 2003

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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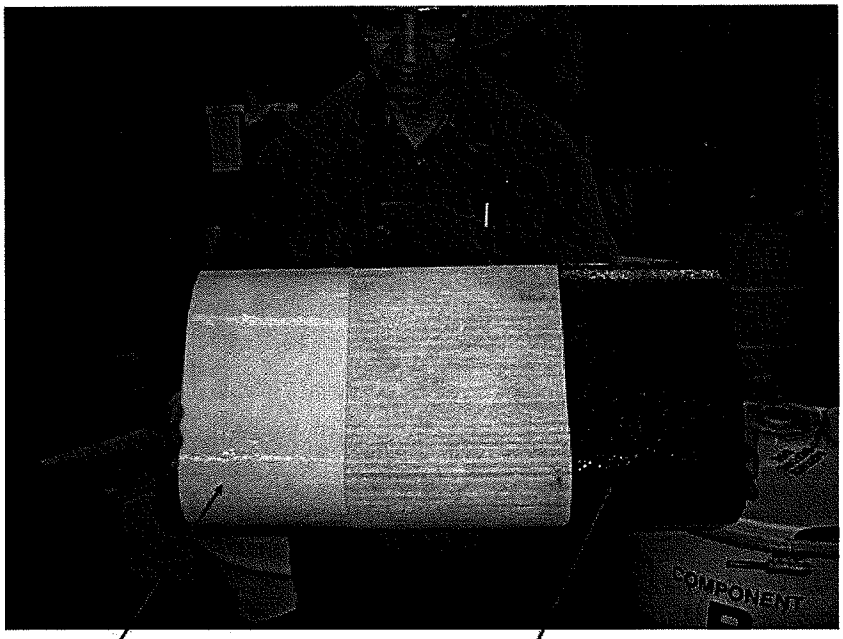

Acknowledgements

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; Bryan Holmes, Track Supervisor, Harpal Kapoor, General Manager
- Metropolitan Atlanta Rapid Transit Authority (MARTA) : Garry K. Free; Director of Facilities and Structures; Tim Elsberry, Assistant Director of Track and Structures
- Bay Area Rapid Transit District (BART): Mark A. Pfeiffer, P.E., Group Manager; Roger Avery, P.E., Group Manager Engineering Liason Maintenance and Engineering; Michael O. Brown, Principal Engineer, Track Maintenance and Engineering
- Maryland Transit Administration, (MTA), Baltimore: Michael S. Davis, Deputy Director of Metro Operations
- Los Angeles County Metropolitan Transit Authority: Ken Arvidson, Manager, Traction Power; Armando Almazan, Senior Traction Power Supervisor; Winston Dixon, Assistant Manager, Wayside Systems; Thomas A. Langer, P.E., Associate Engineer, Rail Technical Support and Integration; Gilbert Cabral, Associate Engineer, Rail Technical Support and Integration
- Washington Metropolitan Area Transit Authority (WMATA): Louis C. Testa, Assistant General Superintendent of Track and Structures and Systems Maintenance; Anthony J. Adams, Superintendent, Special Projects

Subject matter experts and equipment manufacturers

- 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
- 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.

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Executive Summary

The purpose of this Transit IDEA project was to develop a system to clean and recoat in place the fiberglass reinforced plastic cover boards on electrified third rails for rail rapid transit systems. Several surface coating materials were considered and applied to deteriorated cover board segments to evaluate and to select the appropriate coating material. This project included development, proof of concept, and prototype testing.

The problem is that 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 cover board is attached to holding brackets by pins. As the board flutters, the retaining pins chafe against and enlarge the holes in the cover board and the head of the pin can slip out of the enlarged hole. The cover board can drop on the third rail. Contact shoes slide on top of the third rail and provide power to the traction motors. The shoes break off when they hit the dropped cover board. Traction power is lost and the rail system shuts down. Cover boards are difficult to clean and recoat because of the high voltage and access restrictions.

Metropolitan Atlanta Rapid Transit Authority (MARTA), Miami Dade Transit (MDT), and the San Francisco Bay Area Rapid Transit District (BART), have participated in this project by testing of this system on their facilities. Other rail rapid transit systems, including the Los Angeles County Metropolitan Transit Authority (LACMTA), the Maryland Transit Administration (MTA) in Baltimore, and the Washington Metropolitan Area Transit Authority (WMATA) have also indicated a need for a cover board cleaning and recoating system, and participated in reviewing the work in this project. The cover board cleaning and recoating system can improve the safety and reliability of rail transit systems and can enhance public perception and confidence in the security of rail transit systems.

This report includes information so that other rail rapid transit agencies can consider using such a system for restoring their third rail cover boards. MARTA, MDT in Miami, and BART, have actively participated in this project and tested the coatings on their facilities. This has been very helpful in making the results of this effort useful for transit systems.

Rail rapid transit systems typically use power supplied by an electrified third rail. The third rail is covered by a safety cover board which is typically made of fiberglass reinforced plastic or occasionally of wood, and may have different shapes and dimensions. 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 new wood cover boards be painted periodically using this in place application technology.

Some rail transit systems have more than one type and size of cover board, which makes design of a standard restoration system more difficult. The restoration system may have to be adjustable to accommodate the different sizes, shapes and materials of cover boards

Many rail rapid transit systems routinely replace thousands feet of deteriorated cover board per year at considerable cost. In addition to the high cost, such replacement may require shutting down some rail lines of the rail transit system and cause delays to transit passengers.

In Stage I of this project, bench testing of several alternative mechanical surface cleaning and recoating materials was conducted in cooperation with coating industry firms and transit agencies. It was found that cleaning the cover board with a compressed air jet was sufficient in most cases. For extremely dirty cover boards, washing with high pressure water jets may be necessary. Bench testing showed that spray applied polyurea was the optimum recoating material for cover boards from MARTA, MDT in Miami, and BART.

In Stage II of this project, the surface coating was applied to the boards in place. It was found that it was not necessary to attach a polyurea spray nozzle to an articulated arm on a vehicle that moved on the track. Attaching the nozzle to a fixed arm was found to be adequate to position the nozzle at an appropriate standoff distance (distance between the nozzle and the cover board surface). The recoating system was applied to cover boards and tested with the cooperation of MARTA, MDT in Miami, and BART, in Stage II of this project.

It was determined that compressed air jets was the most appropriate cleaning system and two component polyurea spray was the recommended coating with self adhesive reinforcement mesh as needed.

IDEA Concept and Product

In Stage I of this project, bench tests were conducted to evaluate cleaning with compressed air jets and pressure washing and investigated several surface coating materials and application methods. In Stage II, based on the results of Stage I, a prototype in-place spray applied polyurea restoration system was developed and tested on the tracks of MARTA, MDT in Miami, and BART, and the results were also shown to LACMTA, WMATA, and MTA Baltimore, who also participated in reviewing the work in this project.

Potential Impact on Transit Practice

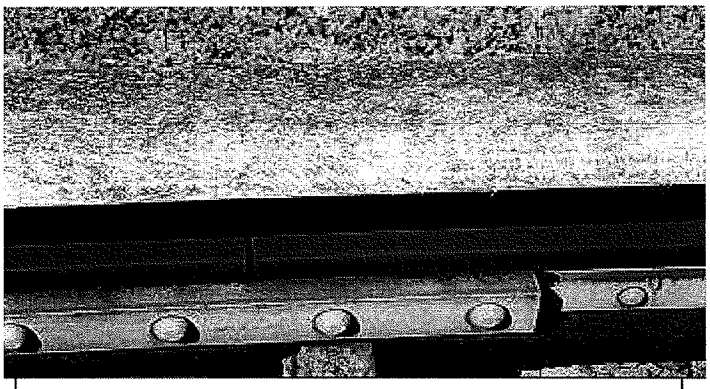

Fig 1. Cover Board with delaminated glass fibers at MDT, Miami

The purpose of this project was to develop a 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 developed a prototype cover board recoating system that was attached to a service vehicle and demonstrated on the tracks of MDT Miami, MARTA and BART, and shown to WMATA, LACMTA and MTA, Baltimore.

There are no automated devices for cleaning and recoating cover boards on rail rapid transit systems. 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 cleaning and 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 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 cleaning and recoating system will improve the safety of rail rapid transit systems. After the recent 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 cleaning and recoating system will enhance the public perception of a safe and secure rail transit system.

Concept and Innovation

Cover board cleaning technologies, such as ultrasonic cleaning, low frequency acoustic vibration, pneumatic polishing, controlled high pressure washing, compressed air jets and powered brushes, were considered. It was found that compressed air jets were adequate for cleaning moderately dirty cover boards and allowed good adhesion of the polyurea spray. For very dirty cover boards, the most appropriate cleaning tool was pressure washing.

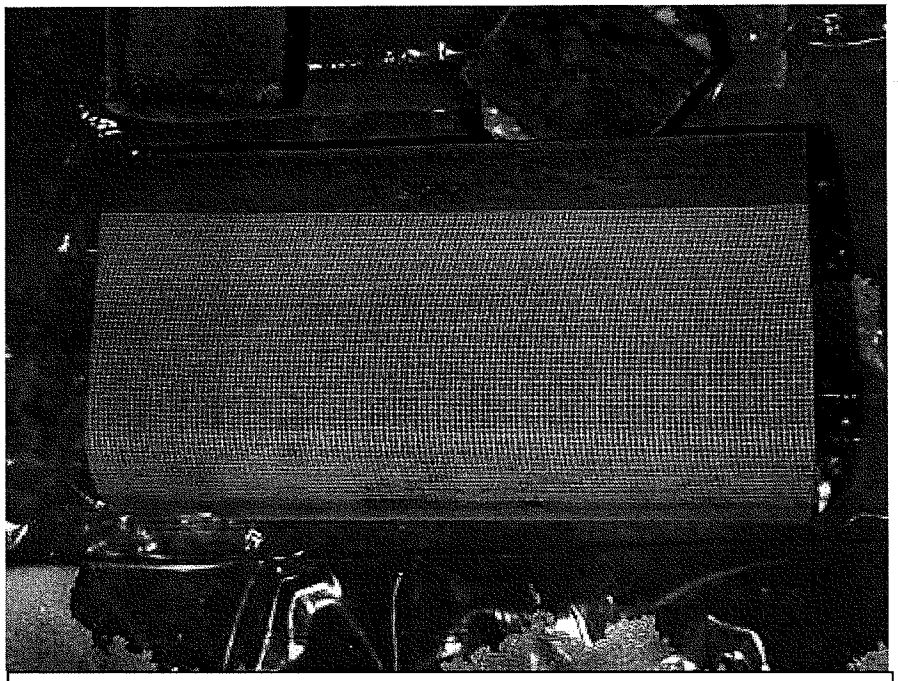

Fig 2. Reinforcement mesh applied to cover board

Coatings considered included two component epoxies, polyurea and polyurea/polyurethane blends. Single component coatings can use roller surface application and included silicones and various paints. Silicones have desirable mechanical strength but the cure time is several hours. During cure, the silicone may get dirt blown on it by the back draft of passing trains and ambient winds. Dirt inclusion will weaken the mechanical strength of the coating. Paints do not have needed mechanical strength properties.

Polyurea and polyurea/polyurethane blend coatings are very hard and tough, adhere well, and dry to the touch in seconds. Full strength is attained in a few days but this should not be a problem. Specialized two component spray equipment is needed for application with the components being mixed in the spray regime. Since the reaction time is almost instantaneous, coating with roller application is not possible. A roller or roller array pressure fed by a static mixer that mixes two components provided by a peristaltic pump from two containers was considered and deemed impractical because of the instantaneous set issue.

Fig 3. Reinforcing mesh and polyurea coating applied to MDT and BART Cover Boards

For severely weakened cover boards, several mesh reinforcement products were applied to the cover board prior to applying the polyurea spray coat. An 8 inch wide, self adhering fiberglass reinforcement mesh applied to the cover board surface prior to applying the polyurea spray coating appeared to provide the best strength benefit to the cover board.

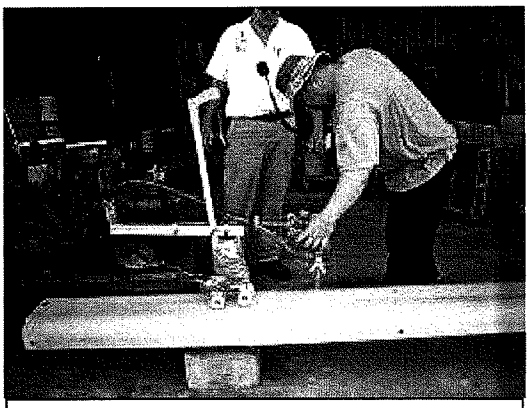

Fig 4. Spray articulated arm prototype development, Miami

Polyurea spray coatings are extremely strong and tough and are used as truck bed liners, and have been considered for force mitigation for blast proofing buildings and army vehicles for physical security.

In Stage II, a prototype system was developed that was suitable for mounting on a service vehicle for in situ cover board restoration. It was found that cleaning the cover board with a compressed air jet was adequate to allow proper adhesion of the coating. Cleaning with pressure washing nozzles was not needed. Also, it was found that a fixed arm was sufficient for coating spray application and a pivoted articulated positioning device was not necessary for the spray nozzle.

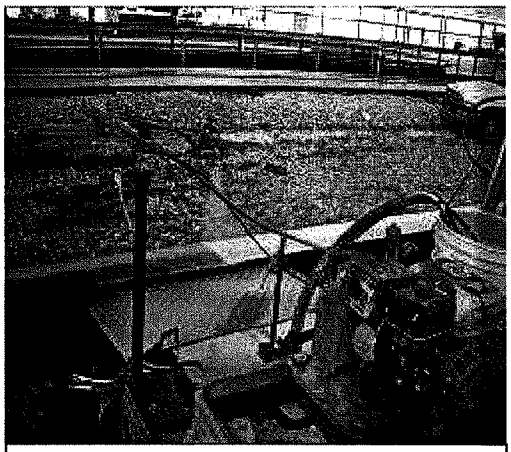

Fig 5. Spray coating cover board at Miami, 1/5/07

Investigation

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.

Ultra Violet 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.

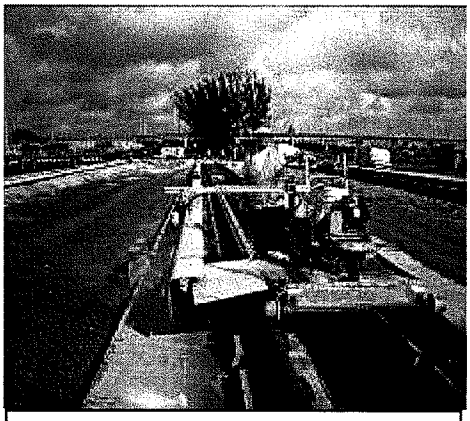

Fig 6. Coating applied to cover board, Miami 1/5/07

Coatings to restore Fiberglass

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

Polyurea is an Aromatic carbon ring compound. The application temperature is about 170 F. The set time is very quick and it dries to the touch in less than 10 seconds. It has reasonable UV protection and color retention and has high strength.

Polyurethane is an Aliphatic long chain compound. The application temp is about 110 F. The set time is longer than polyurea and it has a slower cure. However it has better UV protection.

A blend of polyurea and polyurethane may work better as it embodies some of the best qualities of each product.

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 cover boards.

Evaluation of Cover Board Systems

The MTA Baltimore, WMATA, BART, MARTA, MDT Miami, and LACMTA were visited to determine their cover board restoration needs and show samples of applied coatings to the professional staff and obtain their comments.

This task included holding discussions with the above transit agency staff to solicit their input, and identify requirements that would impact implementation, and address those requirements. Potential issues and solutions were identified. This task accomplished the following:

- A network of technical contacts was developed with whom to collaborate on the project and form an expert review panel.
- Best appropriate cleaning method prior to recoating was determined
- Bench tests of cleaning and recoating were conducted and preliminary prototypes described to show the participating transit agency staff and operating personnel how these systems would work.

After consideration of the research conducted in Stage I, it was determined that cleaning with high compressed air jets and a two component polyurea spray applied coating was the most appropriate cover board restoration system. Field testing was conducted at MARTA, MDT in Miami, and BART.

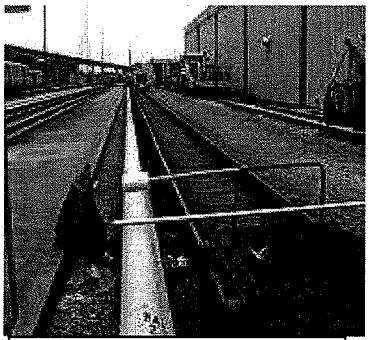

Fig 7. Reinforcing mesh application prior to recoating, MARTA 6/1/07

Fig 8. Recoating application from vehicle moving on the track,

Description of Cover Boards in Transit Systems

(1) Miami Dade Transit, MDT

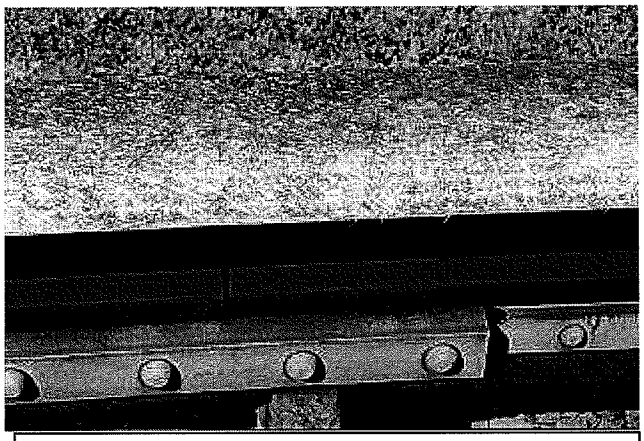

Fig 9. Delaminated glass fibers on cover board after UV damage to Gel coat, Miami, Dec 2003

Fig 10. Weakened Cover board blown off by Hurricane Wilma, Miami, Oct 2005

MDT, Miami has 45.3 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. Overhead, profit and night differential labor cost has to be added to the total cost of replacement. As a result of Hurricane 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 50 miles of cover board including crossovers, pocket track and yards.

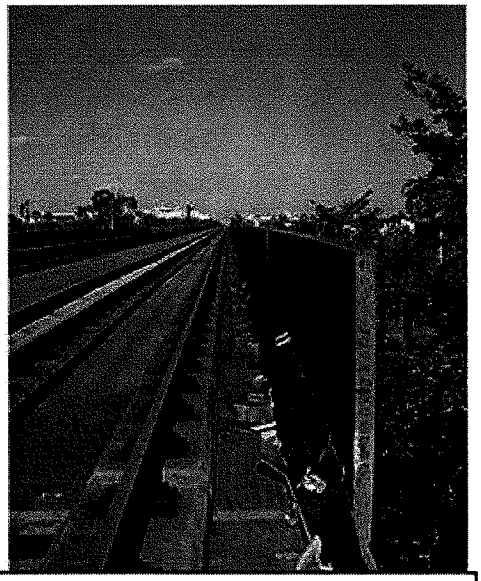

Fig11.Cover Board blown off along with third rail during Hurricane Wilma, Miami, Oct 2005

The cost of spray in place polyurea is about $4 per square foot. This equates to 4 x (14+7)/12 or $7 per lineal foot of cover and side board. Restoration at a cost of $7 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. There are about 4 hours available at night for system maintenance. 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.

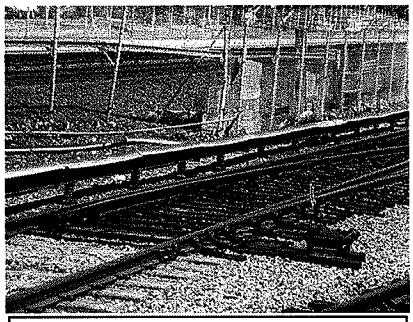

Fig 12. BART Cover Board weakened by sun and wind. 7/21/06

(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. Two hours are available at night, Sunday thru Thursday, 4 hours on Friday night and 7 hours on Saturday night for track maintenance.

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. The system is in use for the remaining hours when no work can be performed.

Fig 13. Restored Cover Board with Polyurea spray & reinforcing mesh, BART

(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.

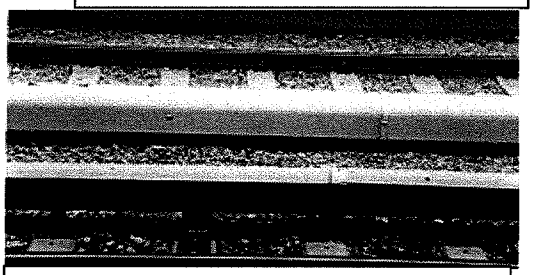

Fig 14. Cover Board MARTA 6/03

(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. NYCT has no siding or parking areas between stations and any improvements would have to be done during a general shut down of track section; or with a high speed recoating system vehicle that can go at the same speed as the trains. Cover boards are made of fiberglass or wood.

(9) MBTA, Boston

MBTA has 108 miles of 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 @ $7/foot *
MDT Miami	44	45		
MARTA	104	98		
NYCT	835	376		
SEPTA	102	63		
BART	268	205		
WMATA	225	106		
MTA, Baltimore	34	34		
LACMTA	34	9		
Total	1646	936	$133,293,600	$34,557,600

* Based on the preliminary unit costs, replacement of cover boards would be expected to cost close to four times as restoration of cover boards.

Plans for Implementation

The results of field testing the prototype cover board cleaning and recoating system conducted at MDT, Miami; BART, and MARTA were shown to MTA Baltimore, and WMATA rail rapid transit systems. The results were presented at the APTA Rail Conference in Toronto in June 2007. 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 and restore weakened fiber glass 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 polyurea spray. For very dirty cover boards, the most appropriate cleaning tool was pressure washing. It was determined that the most appropriate coating was a two component polyurea spray with self adhesive reinforcement mesh as needed.

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 new wood cover boards be painted periodically to protect them and prolong their life using this in place application technology.

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