EPOXY GROUP
Epoxy Interest Group of CRSI

ANTI-CORROSION TIMES

VOLUME 24, NO. 1 WINTER 2009

REPORTING ON INDUSTRY NEWS, NOTEWORTHY APPLICATIONS & NEW DEVELOPMENTS ON FUSION BONDED EPOXY COATINGS FOR CORROSION PROTECTION OF REINFORCING STEEL

In this issue

Anti-Corrosion Times
is a publication of the Epoxy Interest Group of CRSI, Concrete Reinforcing Steel Institute, a not-for-profit trade association providing valuable resources for the design and construction of quality cast-in- place reinforced concrete. Published biannually, the *Anti-Corrosion Times* is produced to help specifiers, engineers, architects, fabricators and end-users receive the most recent information about how and where epoxy-coated reinforcing steel is used, recent technical changes and information resources.

EPOXY INTEREST GROUP OF CRSI
Concrete Reinforcing Steel Institute
933 N. Plum Grove Rd.
Schaumburg, IL 60173
847-517-1200
www.epoxycoatedrebar.com

Epoxy Coaters present a new name and logo, along with a strong marketing focus

With more interest in epoxy-coated reinforcing steel by more DOTs and specifiers, the epoxy coaters within CRSI chose to amplify their goals for the industry while focusing and concentrating marketing efforts under a stronger Epoxy Interest Group name and identifying logo.

The illustration above graphically displays this new name and image along with a tag line that will help identify their precise intent.

From March 2008 on, the group will promote epoxy-coated reinforcing steel using this identity.

All in the group remain members the Concrete Reinforcing Steel Institute (CRSI) and are still operating within their charter. This type of interest group is being formed more frequently within not-for-profit trade groups like CRSI.

The Epoxy Interest Group (EIG) is operated by CRSI members that are epoxy coaters. Bob Anderes, Chairman of the group notes, "the epoxy-coaters have come a long way since joining CRSI back in 1983. Our strong research, excellent quality programs and years of experience have combined significantly to a point where we must really go forward and let the

(continued on next page)

(continued from page 1)

industry know about the finest corrosion protection product for the concrete construction industry".

DOTs, specifiers, contractors and other application users

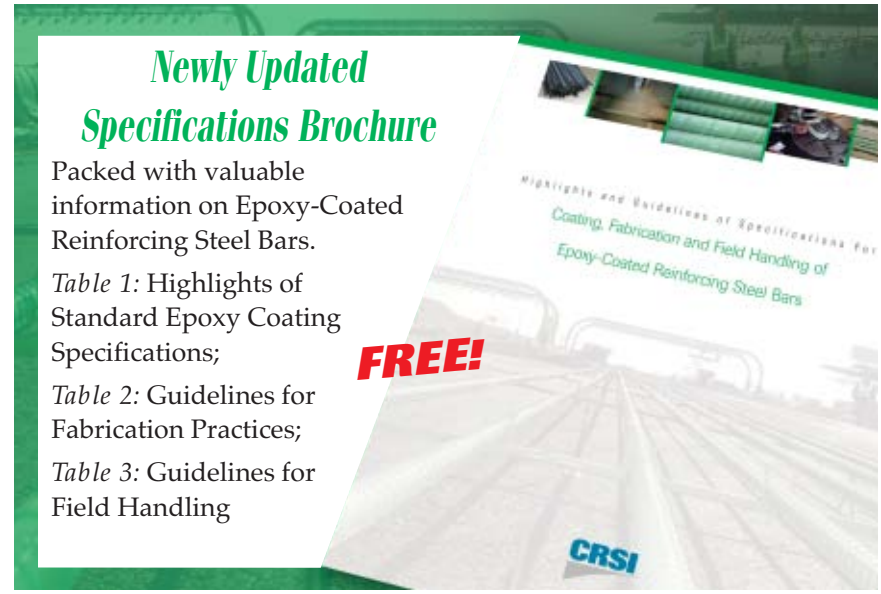
The CRSI epoxy coaters receive a certified designation by a third party certification group to produce, control and deliver quality epoxy-coated reinforcing steel specified today by many DOTs. The stringent certification process ensures the DOTs that specify and contractors that install epoxy-coated reinforcing steel bars receive materials from an applicator plant with the ability to consistently produce epoxy-coated reinforcing bars that meet or exceed ASTM standard specifications. Research studies have shown that epoxy-coated reinforcing bars produced to meet ASTM specifications can greatly increase the useful life expectancy for these concrete structures including but not limited to: bridges, roads, salt water structures, parking garages and other areas where corrosion can occur due to corrosive environments and salts.

A certified plant and its employees are trained, equipped, and capable of producing high quality epoxy-coated reinforcing bars. The plants are randomly inspected, a minimum of once per year, by an independent third party. The purpose of CRSI's plant certification program is to:

- Help plants produce and deliver high quality material
- Improve plant operations
- Recognize excellence.

The certification program is based on meeting ASTM standard specifications for epoxy-coated reinforcing bar. The certification program also stringently evaluates:

- Quality control policies and procedures
- Handling and storage practices
- Surface preparation
- Curing
- Holiday testing
- Thickness measurement
- Adhesion testing.



For your free copy, visit the web site at www.epoxycoatedrebar.com.

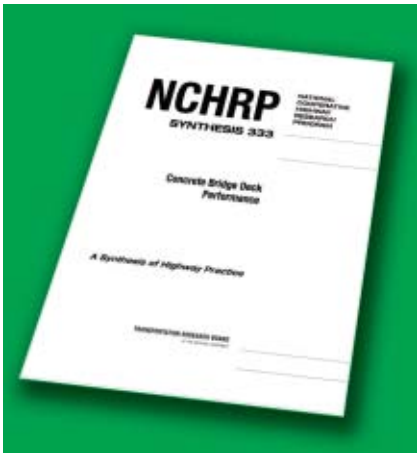
New full color advertisements, the Anti-Corrosion Times newsletter and a new web site are just some of the new materials to be used in the 2008 marketing campaign

Marketing

During the 2008 calendar year, the new logo identity will appear on more full color ads, mailings, brochures, aids and a new web site to promote the Epoxy Interest Group members and to further create awareness and interest in epoxy-coated reinforcing steel and its important benefits for DOTs, engineering specifiers and contractors.

Highway administrators, engineers and researchers

Bridge research study aims to improve the performance of bridge decks . . . NCHRP Synthesis 333 — Concrete Bridge Deck performance by Transportation Research Board



This compact synthesis report covers 111 pages and provides information on previous and current design and construction practices used to improve the performance of bridge decks. The document is immediately useful as it records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. The primary focus is on North American practice for cast-in-place (full depth and partial depth), reinforced concrete bridge decks on steel beams, concrete I- and T-beams or concrete box beams. The focus of this article will be on the performance of epoxy-coated steel reinforcing bars.

Until the 1960s, reinforced concrete bridges performed reasonably well, with delaminations and spalling caused by corrosion limited to structures exposed to salt in coastal areas. With the increased use of deicing salts in the 1960s, the amount of corrosion began to increase. By the 1970s, it was recognized that spalling was caused by corrosion of the reinforcing steel from the ingress of chloride ions from deicing salts.

Strategies to prevent or slow down the penetration of chlorides to the reinforcement include the use of increased concrete cover, low-slump dense concrete overlays, latex-modified concrete overlays, interlayer membranes, asphaltic concrete systems and epoxy-coated reinforcement.

Studies of epoxy-coated steel reinforcing bars in bridge decks cover thirty years of use

The first installation of epoxy-coated bars in a bridge deck was in 1973 on a bridge near Philadelphia, Pennsylvania (Kilareski 1997). The main difficulties at that time included damage to the coating during transportation and handling plus cracking of the coating as a result of inadequate preparation of the bar or bending of the bar after coating (*NCHRP Synthesis of Highway Practice 57;* 1979). New methods such as bending the bars before coating, increasing the number of supports during shipping, padding the bar bundles and using nylon slings for loading-unloading were developed in an attempt to overcome these problems (Virmani and Clemena; 1998). Most specifications for the use of epoxy-coated bars required that all damage or exposed areas be patched with an approved liquid epoxy repair material before concreting. Reference Guides that cover these methods include *Field Handling Techniques for Epoxy-Coated Rebar at the Job Site* and *Fabrication of Epoxy-Coated Rebar* and are available from the Epoxy Interest Group at www.epoxycoatedrebar.com.

Recently reconstructed I-40 bridge in Oklahoma. Completed in 65 days using 235 tons of epoxy-coated rebar in both decks following a barge collision that collapsed the original bridge.

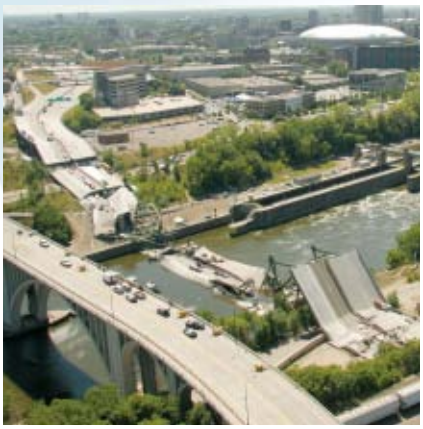
In 1987, Babaie and Hawkins reported that 41 state DOTs were using epoxy-coated reinforcement

This free research report is available from the Epoxy Interest Group on the internet

(continued on page 7)

The I-35 bridge collapsed on August 1, 2007 during the Minneapolis-St.Paul rush hour

This tragic bridge collapse has been dissected every which way since last August. The incorrect thickness of certain gusset plates was the focal point of the collapse.



I-35 Bridge after collapse, August 2, 2007

Cause of the bridge collapse

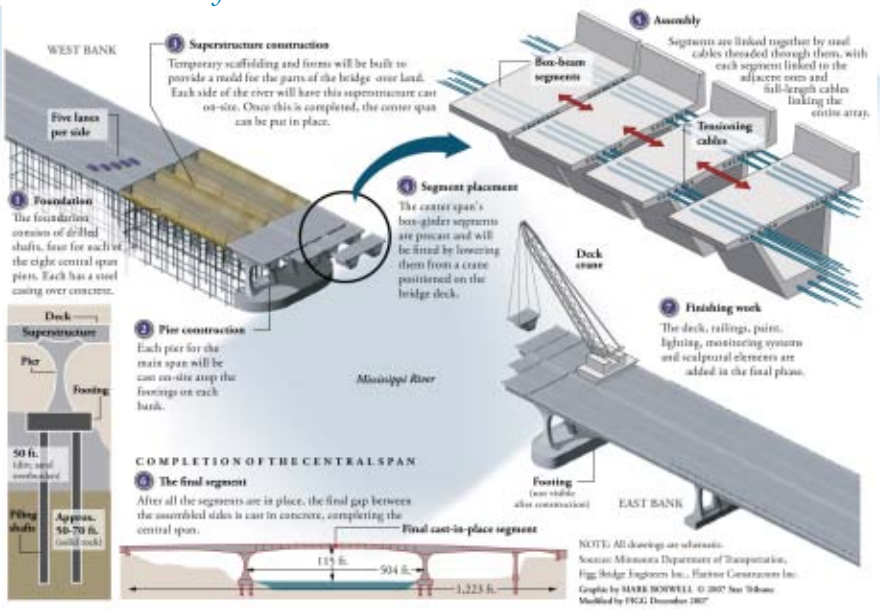
NTSB officials in January 2008 announced serious design flaws in the size of several gusset plates used in the main truss of the 40-year-old bridge and was said by one official to be "a critical part" of the failure.

Undersized plates were found at eight of the 112 joints on the main truss of the bridge. The 16 plates, two at each joint, were about half the required thickness and too thin to provide the margin of safety expected in a properly designed bridge. It was confirmed that the plates were the cause of the collapse.

NTSB investigators found that the bridge collapse was unavoidable once U-10 steel gusset plates failed at the U-10 connections, in a main truss near the center of the bridge.

Epoxy-coated reinforcing steel bars used extensively throughout the new I-35 bridge structure over the Mississippi River

The new bridge was scheduled to be completed in 14.5 months using a design-build process for a unique reinforced concrete design which is earmarked to last 100 plus years. Actual traffic opening occurred at 11 months 18 days.



New I-35 Bridge design plan

Original Design-Build Schedule for completion in 14.5 months

Design/Site Preparation
October 2007 - March 2008

Foundation Construction
December 2007 - February 2008

Pier Construction
February 2007 - March 2008

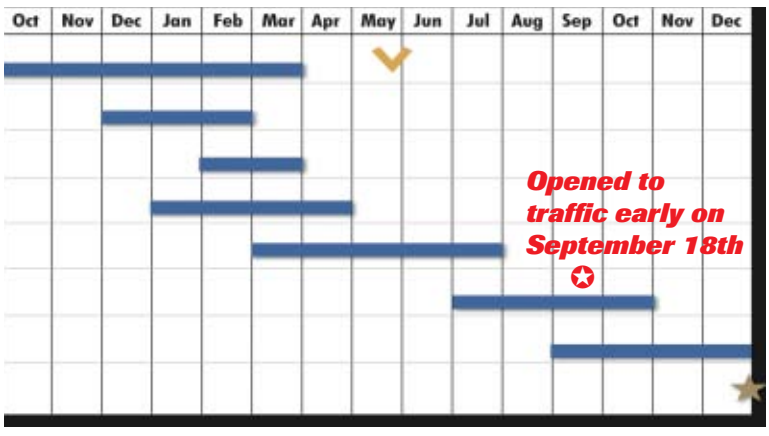
Segment Casting
January 2008 - April 2008

Superstructure Construction
March 2008 - July 2008

Segment Erection (Center Span)
July 2008 - October 2008

Finishing Work
October 2008 - December 2008

GRAND OPENING
December 24, 2008



Artist rendering of new I-35 Bridge

Using a design-build process to accelerate the original completion schedule was originally estimated at 14.5 months, the new St. Anthony Falls (I-35) Bridge design over the Mississippi River utilized concrete as the material of choice. The high strength concrete specified provides superior durability and contributes to the multiple levels of structural redundancy. The aesthetic design selected is a functional sculptural bridge reflecting a series of modern arch forms. Reinforced cast-in-place concrete construction easily accommodates this unique design concept. Concrete also has lower maintenance costs than other materials, which will add up over the bridge's expected lifespan of 100 plus years.

Four concrete segments of this new bridge required a total of more than 10,000,000 pounds of epoxy-coated reinforcing steel bars. The segments include the footings, the two superstructure box girders, arch form piers and the bridge deck. Epoxy-coated reinforcing steel bars have proven to greatly extend the life cycle of bridges, as well as roads, by providing superior corrosion protection in corrosive environments. Both epoxy-coated reinforcing steel bars and concrete are also readily available for accelerated construction schedules.

The results of this design-build process were exceptional. The bridge was opened to traffic ahead of schedule after 11 months, 18 days, from design/ site prep to traffic, shaving more than three months off of the original project-ed completion schedule. ■

Epoxy-coated reinforcing steel bars inside a footing at the beginning of the concrete pour

Epoxy-coated reinforcing bars (approx 5,000 tons) are in the footings, box girders, arch piers & deck

Piers for the new I-35 Bridge

Building the superstructure of the box girder

Bridge deck pour

Photos and illustrations from MnDOT

Dulles International Airport Constructing Main AeroTrain Station with Epoxy-Coated Reinforcing Steel Bars

The new station is being constructed 60 feet below the surface adjacent to the airside of the main terminal. The station will span the east-west direction of the terminal, a distance of around 1,600 ft. There will be four levels: departures (49,600 ft), arrival (49,600 ft), security mezzainine (121,700 ft) and the platform (54,500 ft). The station will use skylights to allow as much natural light to filter into the station as possible. The desginer is Skidmore, Owings, Merrill and the construction firm is Turner Construction.

Dulles construction of Main AeroTrain Station

Certified Coaters' Epoxy Coating Process

Material Description of Epoxy-Coated Reinforcing Steel Bars

To effectively protect reinforcing steel against corrosion, a coating must provide a continuous film that will:

~ resist penetration by salt ions
~ resist the action of osmosis
~ adhere to and expand/ contract with the steel substrate
~ resist a breakdown from weathering and exposure
~ be flexible and durable enough for handling.

Fusion-bonded epoxy coating satisfies all of these requirements very well. It is a thermoset material, meaning that once it is cured, the coating will stay solid even at higher temperatures. It achieves its beneficial properties as a result of a heat catalyzed chemical reaction. Epoxy coating starts out as a dry powder. The powder is produced by combining organic epoxy resins with appropriate curing agents, fillers and pigments flow control agents. When heated, the powder melts and its constituents react to form complex cross-linked polymers.

Unlike many paints, fusion-bonded epoxy coatings used for steel reinforcement do not contain appreciable solvents or other environmentally hazardous substances.

Manufacturing Process

In most North American coating plants, rebar is first coated in straight lengths and then fabricated (i.e., cut to length and bent to shape). The application of fusion-bonded epoxy coating to steel reinforcement involves four major process steps: surface preparation, heating, powder application and curing.

Surface Preparation—is to assure that maximum adhesion will develop at the interface between the steel and the coating. Rebars are blast-cleaned to a near white metal finish using abrasive grit. This cleans the steel of contaminants, mill scale and rust. It also roughens the surface to give it a textured anchor profile. The surface roughness "keys" the coating to the steel and provides mechanical anchorage. Texturing the surface also facilitates adhesion by increasing the exposed surface area of the steel and providing more opportunity for chemical bonding of the coating.

Heating—after blast-cleaning, the bars are heated to approximately 450ºF. This is usually accomplished using electrical induction heaters. Gas-fired heating is used in some cases.

Powder Applications—the heated steel is then passed through a powder spray booth where the dry epoxy powder is emitted from spray nozzles. As the powder leaves the nozzles, electrically charged particles are attracted to the grounded steel surface providing even coating coverage. When the dry powder hits the hot steel, it melts and flows into the anchor profile (i.e., the microscopic peaks and the valleys on the surface) and conforms to the ribs and deformations of the bar. The heat also initiates a chemical reaction that causes the powder molecules to form complex cross-linked polymers that give the material its beneficial properties.

Curing—the coating is allowed to cure a short period (approx. 30 seconds) during which time it hardens to a solid. Although not a requirement of the process, the curing period is often followed by an air or water quench that quickly reduces the bar temperature to facilitate handling.

(continued from page 3)

for reinforced concrete decks built without overlays. They also reported that using epoxy-coated bars for the top layer of reinforcement, combined with a limit of 0.45 for the water–cement ratio and 2.5 inches of cover over the reinforcement promised to provide 50 years of corrosion-free life even in severe chloride environments.

More recently, responses to a Michigan DOT survey in 2002 indicated that 84% of the states responding used epoxy-coated reinforcement as their most common type of reinforcement in bridge decks (Aktan and Fu; 2003). Responses to the questionnaire conducted for this synthesis also identified that 84% of the respondents use epoxy-coated reinforcement as a strategy to prevent corrosion of reinforcement. 71% of respondents specified epoxy-coated reinforcement for the top and bottom mat layers of reinforcement. 42% of respondents specified epoxy-coated reinforcement for the areas that project from the girder into the deck.

In the 1970s, epoxy-coated bars were only used in the top layer of reinforcement (Virmani and Clemena; 1998, Kepler et al.; 2000). More recent data from field investigations have indicated that better corrosion performance is obtained when epoxy-coated reinforcement is used in both layers of reinforcement than when it is used in the top layer only (Smith and Virmani; 1998). Most states now recognize the importance of using epoxy-coated reinforcement in both layers of deck reinforcement.

Smith and Virmani (1996) reported on the performance of epoxy-coated reinforcement used on 92 bridge decks and 3 barrier walls in 11 states and 3 Canadian provinces. The epoxy-coated reinforcement had been in service for up to 20 years. Corrosion was worse in locations with cracking, less cover, high-permeability concrete, and/or high chloride concentrations.

81% of epoxy-coated reinforcement samples (202) exhibited no signs of corrosion, even with chloride concentrations at the bar level above the corrosion threshold.

Conclusion about the effectiveness of epoxy-coated reinforcing steel bars to enhance bridge deck performance

Epoxy-coated reinforcement continues to be the most effective reinforcement used to reduce the potential for deterioration of concrete bridge decks from reinforcement corrosion. The use of epoxy-coated reinforcement in both layers of deck reinforcement provides better corrosion performance than when it is used in the top layer only. However, epoxy-coated reinforcement cannot be relied on to never corrode in a wet or chloride environment. Other reinforcement materials offer the potential as alternative reinforcement materials; however, none of these have been extensively used in practice to develop any general conclusions about their performance in actual bridges.

Several design practices can be beneficial to improve concrete bridge deck performance, including minimizing restraints to shrinkage of the deck, using epoxy-coated reinforcement in both layers of deck reinforcement, minimum practical transverse reinforcing bar size and closer spacing and providing adequate cover. ■

Epoxy-coated reinforcement before the deck pour.

Numerous examples of research available within this research synthesis are available at Epoxy Interest Group of CRSI. Download the study at www.crsi.org/epoxy/act.fall08 or ask for a CD-ROM with this research and many more reports on the performance of epoxy-coated reinforcing steel.

FREE!

Just updated . . . Field Handling and Fabrication Practice Field Cards for Epoxy-Coated Reinforcing Steel Bars

These field cards are laminated and prepunched for easy tagging of the epoxy bars. They hold a wealth of information in a small space while succinctly instructing the reader about onsite placement directions or fabrication practices and the correct patching technique of bars that have been damaged. Ask for quantities of one or both of the cards you need today. Contact CRSI or visit the web site at www.epoxycoatedrebar.com. ■

Colorado & Kentucky DOTs require certified plants

Colorado & Kentucky recently became the 19th and 20th states along with 2 provinces in Canada to require certified plants to produce epoxy-coated reinforcing steel bars in reinforced concrete highway and bridge construction. At this time, three plants are certified to supply epoxy-coated reinforcing bars and dowel bars through June 2009 for DOT projects in Colorado. Two additional plants may also qualify if reinstated after June 2008.

Colorado DOT specifications are still being established but will eventually appear in the CDOT Field Materials Manual under CP11, Part II, Subpart 2.

EPOXY COATING PLANT CERTIFICATION™
CONCRETE REINFORCING STEEL INSTITUTE

CERTIFIED PLANT

Certified Plants as of August 2008

Alberta
Harris Rebar, Inc., Leduc, 780-986-7055
California
American Highway Technology, Riverbank, 209-869-1201
Colorado
CMC Coating of Colorado
Brighton, 303-654-0098
Commercial Resins, Henderson, 303-288-3914
Illinois
ABC Coating Company of Illinois, Peotone, 708-258-9633
Dayton Superior, Kankakee, 888-745-3751
B.L. Downey Company LLC, Broadview, 708-345-8000
CMC Toltec Steel, Kankakee, 815-928-9600
Indiana
Block Heavy and Highway Products Co.
Valparaiso, 219-476-4106
Midwest Pipe Coating, Inc., Schererville, 219-322-4564
Gerdau Ameristeel, Muncie, 765-286-5454
Iowa
Sioux City Foundry Co., Sioux City, 712-252-4181
Wady Industries, Inc., Maquoketa, 563-652-5136
Kansas
Dayton Superior, Parsons, 800-745-3709
Michigan
ABC Coating Company of Michigan, Inc.
Wyoming, 616-245-4626
Minnesota
ABC Coating Company of Minnesota, Inc.
Minneapolis, 612-378-1855
Simcote, Inc., St. Paul, 651-735-9660
Missouri
Gerdau Ameristeel -
Kansas City Reinforcing Steel & Coating Plant
Kansas City, 816-231-3110
Mississippi
Steel Specialties of Mississippi, Pearl, 601-939-2702
New Jersey
Gerdau Ameristeel, Sayreville, 732-721-6600
New York
Corrosion Control Inc., Auburn, 315-252-1800
North Carolina
ABC Coating Company of North Carolina, Inc.
Gastonia, 704-865-9171
Ohio
Simcote, Inc., Marion, 740-382-5000
Oklahoma
ABC Coating Company of Oklahoma, Inc.
Tulsa, 918-585-2587
Gerdau Ameristeel, Muskogee, 918-682-2600
Ontario
Harris Rebar, Stoney Creek, 905-662-5700
Teme, Inc., Stony Creek, 905-643-0045
Pennsylvania
Harris Rebar Atlantic, Inc., Bethlehem, 610-882-1401
Lane Enterprises, Inc., Carlisle, 717-249-8342
Titusville Fabricators, Inc., Franklin, 814-432-2551
Tennessee
Gerdau Ameristeel, Knoxville, 865-546-0102
Texas
CMC Coating of Texas
Waxahachie, 972-937-9841
Utah
Western Coating, Inc., Ogden, 800-835-3039
Washington
Western Coating, Inc., Auburn, 800-835-0576

A current list of certified plants is always available on the web site at www.epoxycoatedrebar.com. Information on updates for the Colorado DOT specifications can be accessed on their web site www.dot.state.co.us. ■