Michigan Department of Transportation - M•DOT

Mates

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MICHIGAN'S BRIDGE COATING SYSTEM

Michigan's highway environment is recognized as very corrosive due to the use of deicing salt and our prolonged wet seasons. This environment takes a serious toll on steel bridge members. In the early 1980s, MDOT adopted zinc-rich coating systems for painting our bridges. Zinc-rich paints are referred to as 'galvanic protective coatings' since the zinc in the coating will oxidize before the steel it is in contact with, thus protecting the steel from corrosion. Through extensive laboratory testing, and shop and field painting experience, we have adopted the following system for all bridge painting.

Background

In 1984, MDOT initiated a research project to evaluate the field performance of its organic zinc-rich coating system. The system consisted of an organic zinc-rich epoxy primer, a polyamide epoxy intermediate coat, and an aliphatic polyurethane topcoat. This system had been developed through accelerated laboratory testing to provide a remedial coating system for pitted, chloride-contaminated unpainted weathering ('rusty steel') steel bridges. Michigan has in excess of 600 unpainted weathering steel bridges and in our wet, chloride-laden environment they have not provided the resistance to corrosion that was anticipated.

Due to the problems experienced with chloride-contaminated weathering steel, several alternate coating systems were studied. The coating system we were seeking would arrest corrosion and prevent further section loss or pitting, especially at critical locations. Chlorides trapped in pits in the steel surface would need a barrier from moisture to stop their corrosive action. With these criteria in mind, our current coating system was developed. Environmentally exposed weathering steel surfaces, or severely corroded previously painted surfaces, typically have areas where heavy pitting of the steel is present. Because of the known problem of trapping chlorides in the pits, a 'white blast' clean condition was originally specified. With a white blast, the pits in the steel would theoretically be chloride free. It proved to be impossible to achieve this condition in the field, however, and a 'near white' blast condition was achievable and considered acceptable, even though small pin-hole sized rust blooms would exist at the bottom of the pits. Because of the existence of these small rust blooms, an inorganic zinc-rich primer with a vinyl topcoat was not adequate to stop the pit-based corrosion in the contaminated steel. Because of the dispersed rust blooms in the pits, and the chloride concentration, an organic zinc-rich epoxy primer coat was selected for field evaluation. It is generally recognized that organic zinc-rich primers are the most tolerant of these less-than-ideal blast cleaned conditions, and our accelerated laboratory testing confirmed this.

In the early 1980s, several organic zinc-rich systems were tested in the laboratory. The first was a two-coat system, an organic zinc-rich primer with a polyamide epoxy topcoat. This system was originally applied in the field on weathering steel bridge beam surfaces 5 ft on either side of leaking expansion joints where the corrosion rate and damage were significant.

The second type of coating system tested, which is our current system, was an organic zinc-rich epoxy primer with a polyamide epoxy intermediate coat and an aliphatic polyurethane topcoat. The organic zinc-rich primer proved to be successful in arresting the pit-based corrosion characteristics of chloride-contaminated weathering steel. This system added the extra benefit of a high gloss, low chalking topcoat that is resistant to dirt pickup and aesthetically pleasing to the traveling public.

Coating System Evaluation

The Department conducts yearly evaluations of manufacturers submitting products for the current organic zinc-rich, three-coat system (See **MATES** Issue No. 42). The evaluation procedure includes the following steps:

1) Submission of materials by the manufacturer (complete system),

2) Application of the material to test panels in the laboratory,

3) Laboratory testing and evaluation of paint test panels,

4) Quality assurance for field application of the accepted materials.

Each year an application package of literature outlining our specific requirements is sent to interested paint manufacturers across the U.S. and Canada, inviting them to submit paint for our structural paint evaluation program. Each coating system submitted is then subjected to a set of six performance tests. Five of the six tests involve accelerated laboratory testing. The current evaluation system results in a final overall rating, based on the application characteristics and performance ratings.

Advantages of Organic Zinc-Rich Primers

Organic zinc-rich epoxy primers are hard, tough, and solvent-resistant as well as highly adherent. Tolerance for less-than-ideal surface preparation is better than for inorganic zinc-rich primers. The zinc provides a mechanism which sacrifices itself, delaying the corrosion of the base steel.

Another advantage of organic zinc-rich coatings is their ease of application. Spraying the primer is considerably easier than spraying the inorganic zinc-rich paints using the standard airless spray equipment. Sprayability ratings are made based on spray pattern, atomization, ease of controlling the film build, and amount of plugging of the spray gun per gallon of paint used. For field application these criteria are very important. A good control of the film build and the ease of spraying of the primer can improve productivity and cut the cost of paint and labor.

Recoatability is another major advantage of organic zinc-rich primers over inorganic zinc-rich primers. Because the curing mechanism is solvent evaporation and a chemical reaction, the amount of cure of the coating can be determined fairly easily. The humidity conditions are less critical for organic coatings which depend on moisture to cure. Once the coating is cured the epoxy intermediate coat can be applied. Normally, no gassing or pinholes occur in the intermediate coat or in the polyurethane topcoat, a common problem with inorganic zinc-rich primers. This is due to the less porous nature of the organic primer coat.

Because the curing time is predetermined by temperature, dry spray of the primer will not be a problem as it is with

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inorganic coatings sprayed in very warm temperatures. Also, mudcracking of thick primer coating applications does not occur.

Field Experience

MDOT began total field painting using the three-coat, organic zinc-rich system in 1984. The first jobs using this system were on severely corroded, unpainted weathering steel structures. Six of the initially painted structures were selected for an evaluative study starting in 1984. The structures are examined periodically to determine if any rust, adhesion problems, blistering, appearance problems (fading, uneven color), or mechanical damage have occurred. The latest inspections (1991) revealed that the coating systems remain in excellent condition. Only minor application and surface preparation problems were noted which were the sole sources of the minor trace rusting on the structures.

Since the first complete organic zinc-rich painted structure in 1984, more than 400 bridges have been painted with the current coating system. Over 65 of these structures were originally unpainted weathering steel structures. To date, the coating system has performed very well.

In 1986, the Department changed from an inorganic zinc-rich system to our current organic zinc-rich specification in the bridge fabricating shops for total coating of new bridge steel as well. This requirement unified the shop painting and field repair of the newly painted structures and also offered the application advantages of the organic primer in the shop and its superior performance in the field.

Conclusions

Although the organic zinc-rich epoxy primer, polyamide epoxy intermediate coat, and the aliphatic urethane topcoat have been exposed to a variety of environmental conditions for a fairly limited time (about 7 years), their condition is excellent and in line with the projected 30 to 40 year life of the system. With the field evidence collected over the past several years, we expect the coating system to continue to perform satisfactorily with minor maintenance repairs, and it remains the system of choice for both field maintenance painting and shop coating new steel structures.

-Eileen Phifer

RUTTING RESEARCH STUDY

Rutting, a permanent deformation of bituminous mixtures in the wheel path, is present on many Michigan highways, including both flexible (bituminous) and composite (concrete with bituminous overlay) pavements. Most pavement engineers agree that the principal cause of rutting is repetitive mixture densification (reduction of air voids) and shear (plastic flow) deformation under heavy traffic loading. The amount of rutting that occurs is determined by several key contributors; the magnitudes of vehicle loading and pressures of tires, the volume of traffic, temperature changes in the pavement, and the various properties of the mixture being placed, and sometimes the base support conditions. Mixture properties include aggregate characteristics, amount and stiffness of the asphalt cement, and the quality of compaction (in-place air voids) during construction.

Rutting is associated with three primary variables; materials, environment, and wheel loadings. The interaction of these factors and their individual contributions to the problem need to be understood prior to designing a new, rut-resistant pavement or overlay.

In April 1991, the Michigan Department of Transportation established a contract with Michigan State University (MSU) to conduct a research project that will determine the relative effects of these factors on rutting on Michigan highways. The objective of the study was to recommend necessary changes in our current construction procedures, mix designs, and pavement design procedures as follows:

1) Document current construction and quality assurance measures that increase or decrease the likelihood of rutting occurring.

2) Isolate the effects of traffic loading on the potential for rutting to occur.

3) Evaluate the rutting potential of the mixtures currently specified as compared to mixtures used historically. Establish a guide for a rut-resistant mixture.

4) Identify the most economical aggregate materials to use, considering production, sources, type, gradation, and angularity.

5) Evaluate the varying environmental factors (temperature and moisture) on typical structural designs and mixtures.

6) Develop a mechanistic model where the potential rut depth of a particular structural design or bituminous mixture can be predicted.

7) Enhance the software design program, MICH-PAVE, so that deflection data can be directly entered into the program for the calculation of layer moduli to more easily evaluate the structural characteristics of a pavement.

A technical advisory committee was formed to coordinate the project between MSU and MDOT. Its function is to advise on where test sites will be located, provide guidance on Department procedures, identify potential users in MDOT of the study's results, and develop an implementation plan.

The project has been divided into several tasks: collection of field data, laboratory study, pavement design analysis, software program development, formation of an analytical rut prediction model, development of a new mix design guide, revisions to construction procedures, and, finally, implementations of the results. The entire study is expected to take three years to complete. This may appear to be a very long time to wait for answers, but many of these tasks overlap and much helpful information should result as data are analyzed.

The collection of field data is now underway. About 200 pavement sections were evaluated by the committee before 63 were selected for detailed analysis as test sites. The pavements being studied fall into three types: 1) flexible with no overlay, 2) flexible with overlay(s), and 3) rigid pavement with overlay(s). The recent stone mastic asphalt (SMA) demonstration project on M 52 near Webberville will also be included as a test site.

The potential sites were prioritized using several factors: traffic, asphalt layer thickness, number of layers, subgrade soil type (sand or clay), pavement age (an indicator of mix design), and distress characteristics (rutting and fatigue cracking). A database for this information has been established by MSU.

Presently, deflection data are being collected, and pavement cores taken, at each site to confirm layer type, thickness, and material properties. Deflection data will continue to be collected on a seasonal basis (spring/summer/fall) to evaluate the environmental effects on the load carrying capability of the pavement.

In the coming months laboratory testing and computer program analysis using MICH-PAVE will commence. One of the more interesting aspects of this study will be the development of a rutting model. The model will include all the variables identified that affect rutting in flexible pavements and overlays. The model program will be PC-compatible and be able to answer the "What if I do ... ?" questions. The results from the MSU project should give the designer the capability to determine the most effective, rut-resistant design considering the mixtures' properties and costs.

-Dave Smiley

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