Proposed Pooled Fund Study:

One Coat Paint System for a Lifetime of Corrosion Protection on New Steel Bridges
(Changing the Paradigm of Coatings for Steel Bridges) – Phase II

Background:

Corrosion of steel bridges has been a problem for a very long time. In 1970, after 100 years of oil-based paints using lead pigments, technology changed to the "state of the art" application of a three-coat system consisting of a zinc-rich primer and two additional coating layers. While there are various approaches to the chemical nature of the second and third coating layers, protection of the substrate is rooted in a zinc-rich primer and two additional layers of paint aggregating 8 to 12 mils. These systems are expected to deliver long-term corrosion protection. Coating system life expectation varies, but normally is in the 15 to 30-year range before the first major touch-up will be required. With periodic maintenance, total life expectancy is estimated by some to be as long as 100 years.

The cost of painting steel is thought to be a major deterrent to the use of steel as the preferred material of construction for new bridges. A recent study sponsored by FHWA surveyed costs from 20 fabrication shops nationwide. This survey indicates that the cost of shop applied coating has a significant impact on the delivered cost of a fabricated steel girder. The study indicated that the median cost for application of a shop primer is 7% of the cost of the girder, while the cost of a full ship-applied 3-coat system is 11%. In addition, the same study showed that costs for paint application range widely from 4% up to 20% depending on the complexity of the steel member, logistics of the particular shop, etc. These facts indicate a ripe area for capture of significant cost savings and production efficiencies.

In addition to pure cost impact, the time and space required for proper shop application of a three coat paint system are unattractive to the tightening schedule demands of fabricators and bridge owners. Current practice requires significant shop space for girders to allow for coatings to dry prior to application of the next coat. This dry time requirement (often 24 hours between coats) also requires steel girders to be moved within the shop multiple times. This is not an efficient process. In these times of increased demand for on-time project delivery, shop productivity improvements pay significant dividends.

Under Phase I, 10 candidate one coat primer/topcoat systems were identified. The most promising two of these systems were screened through laboratory testing and one-year field exposure test patches, with the best performers with advantageous properties moving on to field testing and demonstration installation under Phase II.

Strategic Alignment of This Effort

- This effort addresses the issue identified as the number one priority for research as identified by TRB Committee AFH70, Fabrication and Inspection of Metal Structures, for the past two years.
- This effort is also consistent with the strategic goals set forth by the AASHTO TIG for Accelerated Construction by improving the practice in areas of the critical path for bridge construction.
- This effort is consistent with goals of the FHWA R&D effort to define the Bridge of the Future – a more durable, more rapidly constructed bridge.

Research Objectives (Phase II)

To determine the field performance of the most promising one-coat primer/topcoat coating system(s) identified under Phase I of this project. Field exposure will be targeted to different demanding environments: freshwater marine, saltwater marine, inland dry, and control at a known exterior test facility. The experimental coating(s) will be applied to new steel bridges during fabrication.

To optimize the material/application process to provide a quality corrosion protection system that can be easily and consistently installed in shops of various set-up.

Although the field monitoring duration is five years under Phase II, the overall objective is to achieve a lifetime of protection with a single coat of paint.

Benefits of Research

The subject research will document the protective coatings process in the steel fabrication shop in a detailed manner. This study will represent the first effort to obtain quantitative cost and production data within the context of the overall fabrication process. This insight alone will be valuable toward future efforts to optimize this labor and cost intensive process.

The subject research can lead to a halving of the cost of corrosion protection on steel bridges on a first-cost basis. In addition, the use of a high performance, one-coat-for-a-lifetime material will dramatically lower life cycle costs by minimizing and possibly eliminating the need for field touch-up. In concert with identification of new materials, the study will provide insight into the most efficient manner to provide corrosion protection to fabricated steel girders within the shop. An efficiently applied, durable, full shop-applied corrosion protection system will provide improved corrosion durability, improved efficiency to a major common steel shop operation (painting), and reduce congestion by reducing the field work associated with the erection of a new bridge through the elimination of the need for field application of topcoats after erection.

Technical Approach

One possible means to reduce the cost and logistical impact of shop painting would be to make a quantum leap forward in coatings technology. This would involve the development of a coating system that will provide a lifetime of corrosion protection and be applied in one, quick-dry coat at the time of initial fabrication of the bridge in the fabrication shop. A study will be initiated to determine whether the materials currently used as coating binders (epoxy, urethane, acrylic, vinyl, alkyd, etc.) can be adapted to develop such a one-coat primer/topcoat system. If such a material also contained appropriate corrosion inhibitors, the application of the material to new steel bridges during fabrication could achieve a lifetime of protection with a single coat of paint.

It is believed that the same high-tech polymer binders which now last 15 to 30 years can be applied in one coat so that a single application would be all that is needed for the life of the bridge. It is believed that the basic technology likely already exists. A study will be made to identify binder systems which could likely be modified/adapted to this purpose.

After identification, candidate coating materials will be simultaneously exposed to laboratory and field exposure on test panels and on candidate bridges on an accelerated schedule. Using a simultaneous testing approach (i.e., laboratory panel testing and field testing on actual bridges), it might be possible to have a single coat, high performance material identified, tested, and shop applied in a year. If the laboratory and field testing is successful, such a coating could be ready for general field use in less than five years.

Phase I – Proof of Concept – Specific Tasks

1. Develop performance criteria for one-coat coating by conferring with bridge owners, fabricators, paint equipment suppliers, and coatings and resin suppliers. This "wish list" of criteria will be compiled by phone, mail, e-mail, and, as needed, personal visits to certain designated interested parties.

2. Research the performance characteristics and existing data for candidate coating materials by collaborating with resin suppliers, coating manufacturers, pigment suppliers, and others to gather as much existing performance data as possible in order to rank the potential candidate materials.

3. Acquire two candidate coatings with the highest probability of success (based on the research conducted in Tasks 1 and 2) and prepare test panels for laboratory physical and accelerated weathering testing based on the appropriate sections of the protocol set-forth in the AASHTO-NTPEP R31-02 specification. A traditional 3-coat system will also be tested to establish baseline performance data. Concurrently, the same two products (and a traditional 3-coat system) will be applied to bridge members owned by multiple (up to 2) state agencies.

   During each shop application, the tasks required (cleaning, grinding, mixing, coating application, etc.) will be closely monitored, and a benchmark time duration will be developed on a step-by-step optimized basis. This will allow a direct comparison of the cost of the three-coat system versus one-coat operations. This will provide a beta test to refine or confirm the data developed in the current, on-going cost study, "Bridge Painting Costs: Update on FHWA Study," by Bernard R. Appleman, Ph.D.

   The laboratory testing will take approximately 9-10 months to complete, while the field exposure will continue for a full 12 months. Field exposure test patches will be evaluated visually, and for adhesion characteristics after the designated exposure period. Upon completion of Phase 1, a written report will be prepared describing the experimental approach and containing the results of Tasks 1-3.

   PHASE I IS CURRENTLY UNDERWAY. FUNDING WAS PROVIDED BY FHWA AND PROJECT LEADERSHIP IS BEING PROVIDED BY CONNECTICUT DOT WITH THE ASSISTANCE OF REPRESENTATIVES OF SEVERAL OTHER STATE DOTs.

Phase II – Ramp-up Testing for Full Scale Production of New Processes - Specific Tasks

Phase II of this effort will be supported by the subject Pooled Fund. This effort will focus on further definition and implementation of promising candidate coating materials and systems identified in Phase I. Phase II will focus on optimizing the material/application process to provide a quality corrosion protection system that can be easily and consistently installed in shops of various set-up.

Durability testing and verification begun in Phase I will continue in both accelerated testing and actual field exposure of test specimens. In addition, the most promising of the candidates identified in Phase I will be brought to several steel shops in large enough quantities to exercise the logistics and define the cost factors associated with each unique process. It is envisioned that entire bridges or major portions of bridges will be protected using the new materials in a realistic production basis. These data will be compared on a task-by-task basis with data representing the current state of the practice. These comparisons, when coupled with the

durability data, will allow for rational cost/benefit relationships to be drawn for present and new corrosion protection options. Specific savings in cost and time will also be reported.

Candidate structures coated with the new materials will be chosen in a manner allowing for varied and well defined exposure over their service lives. Field performance of the coated steel will be monitored for a period of no less than 5 years – but likely longer in total.

Based on the indications from testing and lessons learned during shop application in Task 3 of phase I, work will continue on providing independent test verification that candidate materials meet the criteria. Testing will involve conducting simultaneous laboratory exposure tests on further-defined candidate systems submitted by vendors whose test data indicate that their material meets the criteria developed in Tasks 1 through 3). Laboratory testing can continue according to existing accelerated test protocols (e.g., AASHTO R31-02). In order to further accelerate the testing and material introduction process, three promising materials will be applied to new bridge steel in each of three different shops. Again, candidate bridges or major parts of bridges will be sought from owners willing to assist in the process of changing the paradigm of steel bridge coatings.

ESTIMATE OF PROJECT FUNDING AND RESEARCH PERIOD

Research Needs

Phase 1 (currently underway and funded by FHWA through Connecticut DOT)

Task 1	100 hours @ $100.00/hour	$10,000.00
Task 2	200 hours @ $100.00/hour	$20,000.00
Task 3 (laboratory)		$20,000.00
Task 3 (field)		$25,000.00
Report Preparation	50 hours @ $100.00/hour	$ 5,000.00
		$80,000.00 ($FHWA funded)

Phase II

Panel Testing	$150,000
• Application and Laboratory Exposure*	
• Application and Field Exposure*	
Bridge Shop Application (lump sum estimate)	$ 100,000
Data collection & Management 350 hours @ $100.00/hr	$ 35,000
Cost & Time Study 450 hours @ $100.00/hr	$ 45,000
Total for Phase II	**$330,000**
Management, oversight & implementation	**$ 25,000**
Sub Total Phase 2	**$355,000**
Total (Phase 1 & Phase 2)	$435,000

*Phase I will identify up to 10 candidate systems. The most promising of these systems will be screened through laboratory testing, with the best performers with advantageous properties moving on to field testing and demonstration installation.. Field exposure will be targeted to four different locations: freshwater marine, saltwater marine, inland dry, and control.

Costs include travel to field test sites for specimen application and periodic grading. Test exposure timeframe is approximately 3 years.

Project Duration

Phase II will require twelve (12) months to identify the bridges and apply coatings, followed by sixty (60) months of monitoring and finally, four (4) months to complete the final report. Therefore the total time for this project is estimated at seventy-six (76) months.

Payoff Potential

It is said that painting costs are an unusually high percentage of new steel bridge construction costs. Estimates as high as 20 to 30% have been claimed at steel bridge conferences. Whatever the actual proven cost is, using one coat instead of three will reduce the cost by at least half, because only surface preparation and one coat application will be needed. Using only one coat will enable and encourage novel in-line painting facilities to increase shop throughput, and further reduce costs. In addition, the application and inspection costs for the second and third two coats will be eliminated. Likewise, field painting cycles in outlying years will be eliminated/minimized.

The research product will be a family of quality paint product-type materials using the same or different resin systems that can be applied in one coat in the shop at the time of fabrication which will last the life of the structure. The one-coat system will result in a specified coating system which will be derived from this report data and recommendations being adopted by a "Single Coat Committee" within SSPC: The Society for Protective Coatings.