"COST EFFECTIVE ALTERNATIVE METHODS FOR STEEL BRIDGE PAINT SYSTEM MAINTENANCE"

CONTRACT NO. DTFH61-97-C-00026

Report III:

ABRASIVE INJECTED WATER BLASTING FOR THE REMOVAL OF LEAD-BASED PAINT

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TECHNOLOGY INTRODUCTION

The Abrasive Injected Water Blasting (AIWB) process involves introducing an abrasive into a high pressure water stream where it is delivered to the surface to be blasted. The abrasive is introduced into the stream immediately prior to the exit-nozzle of the gun. This combination of high-pressure water and abrasive prepare the substrate while minimizing the airborne particulate matter. AIWB will impart a profile on the substrate and is capable of cleaning to an SSPC-SP-5, though flash rusting may occur. The depth of the profile is dependent on the type and size of abrasive used. This equipment is useful in spot repair requirements for highway structures where localized corrosion and/or damaged paint areas require repair. While performing the spot repair requirements, AIWB is also capable of feathering transition areas of intact paint, which surround areas prepared to bare metal. In addition, the surrounding areas of intact paint are sweep-blast to remove delaminated coating. AIWB is an effective tool for removing weakly adherent coatings and surface rust, though hand tools and power tools are often used to increase productivity while clean areas of heavy packed, rust and scale.

PROJECT APPROACH

During the months of March through May 1998 Corrpro Companies, Inc. observed and documented production information for the spot preparation of three highway structures in northern Virginia utilizing abrasive injected water blasting (AIWB). The observed structures were part of a multiple bridge maintenance painting contract for Virginia Department of Transportation's Northern Virginia District. All three structures were overpass bridges, in high traffic areas and were coated with a lead-based, alkyd primer applied over mill scale. Megaco, Inc. of Lorton, VA performed all AIWB surface preparation, coating application, traffic control operations, and containment rigging for this contract.

The type of equipment used for this the AIWB work was the Aqua Miser D-44, manufactured by Carolina Equipment & Supply. The Aqua Miser D-44 consumed 3.2 gallons per minute of water when operated at its maximum output pressure of 15,000 psi. The abrasive used for injection during the spot preparation portion of this contract was Starblast® by DuPont. Starblast® is the iron aluminum silicate mineral, staurolite.

The contractor prepared the areas of corrosion and rust bleed-through down to bare metal with AIWB. Intact paint immediately surrounding bare metal areas was feathered-in using the AIWB equipment to allow a smooth transition from bare metal to the intact coating. All other areas of intact paint received a sweep-blast using the AIWB unit. Areas where the paint delaminated during this sweep-blast were taken to bare metal and feathered-in to intact paint.

Prior to coating application, the structures were pressure-washed with a minimum of 3000 psi fresh potable water, using commercially available power washing equipment to rinse away remaining abrasive and paint-residue. Bare metal areas were spot primed with a zinc-rich moisture cure urethane (MCU). Areas that were spot primed received spot applications of a micaceous iron oxide MCU intermediate and a MCU topcoat. All fascia beams, bottom flanges, and areas five feet out on either side of shoes and/or expansion joints received full overcoat applications of the midcoat and topcoat in addition to spot applications of the zinc-rich MCU applied to bare metal.

Liquid waste was pumped, collected and stored in dedicated 55 gallon drums. Large paint chips and spent abrasive were filtered from the wastewater and placed into 55 gallon drums designated for solid waste.

RESULTS

Productivity Data:

During the three months that these structures were undergoing spot repair, engineers observed various production runs using the AIWB equipment. Due to the nature of this repair work, (i.e. spot prepare corroded areas, and overcoat), production rates during a given shift were dependant upon the amount of old coating that was removed. Therefore, man-hours from individual shifts were compiled and averaged in order to provide an overall production rate, which could be compared with production rates of other AIWB spot repair structures.

In addition to production rates, the percent of the total bridge surface area that was prepared down to bare metal was calculated. Knowing the percentage of surface area that was prepared down to bare metal is helpful when comparing the spot and sweep production rates of two different structures. Table 1.1 summarizes the productivity data.

Table 1.1: Productivity Data

Structure	Ave. Production Rate (ft^2/man-hr)	Bare Metal (ft^2)	Total Area (ft^2)	% Deterioration
1	106	8,960	44,800	20.0%
2	149	1,911	17,820	10.7%
3	349	477	8,550	5.6%

With respect to the three structures, the overall production rates increased as the deteriorated coating area decreased. This is expected since preparing a corroded area down to bare metal is more time consuming than sweep blasting an intact coating system. The above listed production rates also incorporate time spent on power tool pre-cleaning areas of heavy corrosion scale prior to AIWB and the final fresh water pressure wash necessary to remove residual abrasive and coating debris residue after AIWB. The hand tool/power tool cleaning utilized in the heavily corroded areas caused the spot cleaning production rates to be lower.

The water consumed per square foot was also dependent on the amount of coating deterioration on the structure, shown in Table 1.2. As the percent deterioration of the structure decreased, the amount of water consumed per square foot decreased. The decrease in time spent preparing areas to bare metal resulted in less water being consumed.

Table 1.2: Water Consumption

Structure	% Deterioration	Water Consumed (gallons)	Water Consumption Rate (gal/ft^2)
1	20.0%	6,860	0.153
2	10.7%	2,180	0.122
3	5.6%	800	0.094

Surface profile measurements were taken to document the anchor pattern that AIWB imparted to the areas of the substrate blasted to white metal. Profile measurements were 1.9 mils, 2.5 mils, 2.7 mils, and 3.5 mils. The average profile measured was 2.7 mils.

Environmental Data:

Air monitoring was performed during an abrasive-injected water blasting demonstration. This demonstration was performed on a structure separate from the three specifically observed for spot AIWB. However, this demonstration structure was included in the contractor's multiple structure contract and contained similar coating systems to those found on the observed structures. During this eight hour demonstration shift the contractor utilized two Carolina Equipment & Supply Aqua Miser D-44 AIWB units with one blaster per unit to remove all coatings down to bare metal. Personal air monitoring pumps were placed on the two blasters for the duration of the shift as well as one laborer whose function was to refill the Aqua Miser units with abrasive and seal up visual mist emission leaks from the containment. Results of the air monitoring are summarized in Table 1.3 below.[1]

Table 1.3: Lead in Air Monitoring Results

Description	Lead in Air ($\mu g/m^3$)
Abrasive Injection Water Blaster 1	34.40
Abrasive Injection Water Blaster 2	19.17
Laborer	14.38

None of the air sample results exceeded the Occupational Safety and Health Administration's (OSHA) Permissible Exposure Limit (PEL) of 50 $\mu g/m^3$ for an eight hour time weighted average (TWA), but one sample did exceed OSHA's action level for lead which is 30 $\mu g/m^3$. Detection of lead in the laborer's air sample is evidence that particles of lead can become suspended and travel with the mist emissions from abrasive injected-water blasting operations. This laborer was never inside of the containment. Repairs of the containment to prevent visible mist emissions were made from outside of the containment.

The wastewater from one of the structures was tested for lead content. The total lead concentration of the wastewater exceeded the Fairfax County limit, 5.63 ppm, for disposal in its wastewater treatment plant. This indicated that special processing was needed for the wastewater. The results of the testing are as follows:[2]

Table 1.4: Lead in Water Sampling Results

Description	Total Lead Concentration (ppm) in wastewater
Drum 1	60.25
Drum 2	41.45

[1,2] Monitoring performed by DynCorp

ECONOMIC DISCUSSION

Many factors must be considered when determining the economic impact of a technology on a bridge maintenance painting project. The cost for a maintenance painting project can be broken down into four main areas:

I. Mobilization/Demobilization

II. Coating removal

- Productivity
- Equipment Cost
- Worker and Environment Protection
- Waste Disposal

III. Painting

IV. Staging/Containment

In order to validate a technology one must first compare it to the current state-of-practice for a spot repair scenario. A spot repair scenario is defined as preparing areas of corrosion and deteriorated paint to bare substrate while feathering the edges of the transition point from bare area to intact paint. The current state-of-practice for a spot repair scenario is hand-tool/power-tool cleaning. However, in order to make a comparison of AIWB technology to the current state-of-practice for a spot repair scenario, consideration must be given to the extent of coating deterioration. The percent of coating deterioration for a structure will determine a technology's particular production rate for that structure.

A cost model, which accounts for percent deterioration in spot repair, was developed for this FHWA study. This model estimates the entire itemized project cost taking into consideration, among other issues, mobilization, profit and insurance. Since production rates are dependent upon the amount of deterioration, costs are also dependent upon extent of deterioration. This was accounted for in the model by directly relating production rates as a function of coating deterioration.

For example, the cost model assumes that a structure which exhibits 15% coating deterioration can be hand-tool/power-tool spot prepared in accordance with SSPC SP-2/SP-3 at a production rate of ~ 60 ft^2/hr/man, while providing appropriate containment, PPE for workers and disposal of all hazardous waste. The assumed production rate may seem to be somewhat high because it refers to the paintable area of the bridge, not only the deteriorated area. Abrasive-injected water blasting (while spot preparing corroded and damaged areas and sweep blasting all other surfaces) is assumed to have a production rate ~ 125 ft^2/hr/gun, while providing appropriate containment, PPE for workers and hazardous disposal of all waste.

This cost model calculated cost for maintenance painting of structures with varying extents of coating deterioration for a comparison between abrasive injected water blasting and hand/power tool cleaning surface preparation methods. The results are summarized in Table 1.5.

Table 1.5: Cost Comparison of AIWB versus Hand / Tool Power Tool Cleaning for a Spot Prepare Spot Paint Scenario.

Structure Size	Percent Area Deteriorated	Hand Tool Cost per ft^2	AIWB Cost per ft^2	Structure Size	Percent Area Deteriorated	Hand Tool Cost per ft^2	AIWB Cost per ft^2
5,000 ft^2	10%	$8.35	$8.55	**50,000 ft^2**	10%	$3.37	$2.73
	20%	$12.18	$9.38		20%	$5.38	$3.78
	30%	$13.81	$12.42		30%	$7.56	$4.75
7,500 ft^2	10%	$6.17	$6.13	**100,000 ft^2**	10%	$3.11	$2.48
	20%	$9.27	$8.43		20%	$5.21	$3.50
	30%	$10.68	$8.99		30%	$7.18	$4.49
10,000 ft^2	10%	$6.35	$5.09	**200,000 ft^2**	10%	$2.92	$2.20
	20%	$7.79	$7.02		20%	$4.95	$3.26
	30%	$10.55	$7.65		30%	$6.98	$4.27

As the data shows, AIWB is close in price to hand/power tool cleaning when deterioration is minimal, but becomes the more economically viable option when deterioration increases. This data is also shown graphically in Figure 1 of Appendix A. Another useful piece of data in determining the economic viability of AIWB is the critical deterioration point. The critical deterioration point is defined as the percent deterioration for which the cost of abrasive injected water blasting approximately equals the cost for hand/tool power tool cleaning. This point occurs at different levels of deterioration depending on the size of the structure. Table 1.6 summarizes these critical points.

Table 1.6: Critical Deterioration Points

Structure Size	**5,000 ft^2**	**7,500 ft^2**	**10,000 ft^2**	**50,000 ft^2**	**100,000 ft^2**	**200,000 ft^2**
Critical Point	~14%	~10%	~7%	<5%	<5%	<5%

It can be seen that as the structure size increases, the critical deterioration point decreases. One can then infer that AIWB becomes more viable as the structure size increases.

It is also worth mentioning that the initial cost breakeven point for conducting spot repair using AIWB, when compared to full removal with once through grit, is 48% deterioration for large structures (>50,000 ft^2) and 38% deterioration for smaller structures (<50,000 ft^2) according to this model. When structures exhibit coating deterioration larger than 48% and 38% respectively, it is more cost effective to conduct a full removal of the old coating system. When comparing hand/power tool cleaning for spot removal to full coating removal with once through grit, the initial breakeven point is 25% deterioration.

CONCLUSIONS

1. Production rates on the three structures varied depending on the deteriorated condition of the coating system. The percentage of the total structure blasted to bare metal was directly related to the deterioration of the coating system. As the percentage of the structure prepared down to bare metal increased, the production rate for the spot and sweep method of abrasive injected water blasting decreased.

2. While there are lead particles suspended in the mist resulting from abrasive injected water blasting, the concentrations are below the permissible exposure limit established by OSHA (50 $\mu g/m^3$). The lead in air concentrations observed (19.17 – 34.40 $\mu g/m^3$) from abrasive-injected water blasting are hundreds of times less than that typically seen for dry abrasive blasting of lead containing coatings (>2,500 $\mu g/m^3$).[3]

3. While lowering the amount of dust produced in much the same way as water jetting, abrasive-injected water blasting creates a surface profile, which water jetting does not do. The depth of this profile depends on the type of abrasive used. This profile will assist in long term coating performance.

4. Costs for hand/power tool cleaning were similar to that of AIWB for minimal deterioration, but became considerably more at higher percent deterioration. This was especially true for the larger structures where the cost increased by as much as 57% for hand/power tool cleaning.

[3] SSPC Supervisor/Competent Person Training for Deleading of Industrial Structures (SSPC-96 V3-T), Course Curriculum

Appendix A

Graphs

Figure 1. Graphical Representation of % Deterioration vs. Cost per square foot ($/SF)