A Rational Approach for Planning Steel Bridge Repainting Projects

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Introduction

The objective of a good bridge preservation program is to maximize service life while minimizing cost. This document is intended to help guide engineers to achieve this goal using a rational decision process and cost estimation calculation. A cost comparison spreadsheet, and process map (flow chart) have been developed as a part of this report. By using these tools an engineer can input project specific parameters and evenly compare the cost of all three alternative painting schemes. These schemes are: remove and replace the existing coating system, overcoat the existing coating system, or spot paint specific areas on the structure where the existing coating system needs restoration. By utilizing time-value of money calculations, the cost of these three schemes can be compared, allowing a cost effective engineering decision to be made and implemented with regard to restoration and preservation of existing steel bridges.

The estimation of cost requires that parameters such as estimated service life, cost for maintenance of traffic, user costs and other project and geographic specific variables be entered by the user. A definition of the input parameters is provided below:

1) **Painting cost per square foot** of structure (with and without lead). This has to be evaluated per structure, since labor costs, location (over land or water, etc.), and structure type (truss, built up girders, rolled girders, box girders, etc.) play a big role in the cost to paint a structure.
2) **Expected service life**. Unknowns such as whether the structure is in a coastal location or inland and the existing condition of the structure will affect the expected service life of the newly applied coating and must be taken into account.
3) **Maintenance of traffic duration**. How long will maintenance of traffic be required? This will depend on the size of the structure, accessibility and the number of hours per day the contractor can work, and therefore has to be determined on a project by project basis.
4) **Cost per day for Maintenance of Traffic**. This will change relative to the extent of traffic control needed on a daily basis. For example, is the structure has 6 lanes in an urban area or 2 lanes in a rural area?
5) **User Costs** represent an overall cost bourn by the travelling public associated with travel costs due to traffic delays and detours. Some of the economic variables that affect User Costs are: increased travel time, compensation/wage rates, average daily traffic (ADT), average daily truck traffic (ADTT), vehicle operation costs, vehicle crash costs, etc.
6) **What is the surface area of the structure?**
7) **Heavy metals present?**
8) **Percent corrosion?** What is the amount of corrosion present on the structure that will need to be addressed prior to painting?
9) **The current interest rate.**
10) **Average Motorist Delay** is the additional time measured in minutes that a motorist spends in traffic to reach his or her destination due to delay resulting from Maintenance of Traffic operations.
11) AADT (Average Annual Daily Traffic).
12) Average Hourly Wage for Truck Driver salaries is used to estimate lost revenue due to delay resulting from Maintenance of Traffic operations.
13) Passenger Vehicle Pay Factor compared to Truck Driver salaries is a way to estimate the average cost to people driving passenger vehicles for lost time due to delay resulting Maintenance of Traffic operations.

By entering this information the spreadsheet will calculate the cost of the three coating schemes, which can be utilized in conjunction with the flow chart to determine the most economical long term decision.

The user cost calculated by this spread sheet is an approximate method to an analysis that can be very complex. If the user has site specific data or a preferred method for estimating user costs, the user is free to alter the spread sheet accordingly.
Bridge Coating Assessment

Is Corrosion >20%?

Is Corrosion >10%?

N

Continue monitoring

N

Overcoating meet SSPC TU3*?

Calculate cost to remove and replace (Srr)

Calculate cost to overcoat (Soc)

Remove and Replace

Calculate cost to spot

Aesthetic issue?

$rr < $soc?

$rr < $sp

Soc < $sp

Overcoat

Spot Paint

*SSPC TU3 - Society of Protective Coatings Technology Update 3. This update is utilized to assess whether the risk of overcoating an existing coating is warranted. Risk is assessed on adhesion and existing coating thickness. These parameters are usually quantified during an on-site condition assessment per ASTM standards.
### 20 year Casting Maintenance Combinations

<table>
<thead>
<tr>
<th>Remove and Replace</th>
<th>Overcoat</th>
<th>Spot Paint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

#### Example Conditions

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance of Traffic Cost ($)/day</td>
<td>650</td>
</tr>
<tr>
<td>Area of Steel (sq ft)</td>
<td>150,000</td>
</tr>
<tr>
<td>PH Percent</td>
<td>63</td>
</tr>
<tr>
<td>Corrosion</td>
<td>10%</td>
</tr>
<tr>
<td>Friction rate</td>
<td>0.5</td>
</tr>
<tr>
<td>Average Additional Delay (min)</td>
<td>5</td>
</tr>
<tr>
<td>AADT (Total)</td>
<td>20,000</td>
</tr>
<tr>
<td>% AADT that is trucks</td>
<td>61</td>
</tr>
<tr>
<td>Passenger vehicle day factor</td>
<td>0.75</td>
</tr>
<tr>
<td>Average hourly wage ($/hr)</td>
<td>18</td>
</tr>
</tbody>
</table>

### 20 year analysis

#### Remove and Replace

- Total Future Value Cost to Remove and Replace: $58,749,224
- Future Value of User Delay Cost: $21,384,222
- Future Value of MOT at yr 20: $51,214,975
- Present Value Cost to Paint without MOT: $5,200,000
- Present Value Cost to Paint with MOT: $51,206,000
- Present Value User Delay Cost to remove and replace: $51,287,999

#### 2 overcoats and 1 spot paint (5% progressive corrosion)

- Total Future Value Cost at yr 20: $56,558,846
- Total Future Value of User Delay Cost at Year 20: $3,510,971
- Future Value of MOT at yr 20: $51,047,773
- Future Value of Initial Overcoat at yr 20: $1,305,996
- Future Value of Second Overcoat at yr 20: $1,012,703
- Future Value of Spot paint at yr 20: $461,864
- Total Present Value Cost to Paint: $5,001,979
- Present Value User Delay Cost to Overcoat: $761,075
- Present Value User Delay Cost to Spot Paint: $281,259

#### 1 Overcoat and 3 spot paints (5% progressive corrosion)

- Total Future Value Cost at yr 20: $50,482,135
- Total Future Value of User Delay Cost at Year 20: $2,377,063
- Future Value of MOT at yr 20: $49,105,072
- Future Value of Initial Overcoat at yr 20: $1,305,996
- Future Value of First Spot Paint at yr 20: $500,242
- Future Value of Second Spot Paint at yr 20: $428,032
- Future Value of Third Spot Paint at yr 20: $341,496
- Total Present Value Cost: $5,502,135
- Present Value Cost to Overcoat: $767,559
- Present Value User Delay Cost to Overcoat: $767,559
- Present Value User Delay Cost to Spot Paint: $281,259

#### 3 spot paints (5% progressive corrosion)

- Total Future Value Cost at yr 20: $53,089,533
- Future Value of MOT at yr 20: $51,347,072
- Future Value of Initial Spot Paint at yr 20: $1,305,996
- Future Value of 2nd Spot Paint at yr 20: $727,793
- Future Value of 3rd Spot Paint at yr 20: $624,932
- Future Value of 4th Spot Paint at yr 20: $501,059
- Future Value of 5th Spot Paint at yr 20: $421,179
- Present Value Cost: $5,035,712
- Present Value Cost to Spot Paint: $281,259
- Present Value User Delay Cost to Spot Paint: $281,259

Then the User Cost would be:

\[(\text{Days of MOT}) \times (\text{Delay Time in Hours}) \times (\text{ADT} \times (100 - \text{AADT})) / 100 \times \text{Passenger Vehicle Factor} \times \text{AADT} \times \text{Hourly Wage Rate} \]

For example if the ADT was 100,000 with AADT being 10% and the Days of MOT = 100 and the average delay was 0.25 hours then

\[100 \times 0.25 \times (100 - 10) = 25 \times (100,000 - 10,000) / 100 \times 0.5 \times 10,000 = 2500 \times \text{Hourly Wage Rate} \]
Suggested Guidelines to achieve Quality Steel Bridge Repainting Projects

There are many alternatives and inputs associated with this decision process. It is difficult to execute this scheme without a fundamental structural and coatings knowledge base. In order to assist the responsible party, the following references and insight are provided:

- Like any other contracted project, in order to obtain representative bids that can be compared fairly, a well defined scope of work is critical.
- A specification or contract must be developed that clearly articulates the required levels of surface preparation and coating application. This contract should include quality control inspection frequencies and methodologies for verification of contract requirements.
- A strong quality assurance program should be implemented to verify that contractor quality control is effective. Quality assurance should incorporate hold-point-inspections to verify work is compliant with the contract. A hold-point is defined in the contract as a stoppage of work until quality assurance testing and compliance evaluation up to the present time is complete. Hold-point-inspections typically include:
  - Surface contamination assessment prior to abrasive blasting.
    - SSPC AB1/AB2/AB3: Standards for the cleanliness of abrasives used to blast clean steel.
    - SSPC SP1: Solvent Cleaning.
    - SSPC SP6: Commercial Blast Cleaning.
    - SSPC SP10: Near White Blast Cleaning.
    - SSPC Vis 1: Guide and Reference photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.
  - Prime, intermediate and finish coatings application including stripe coating.
    - SSPC PA1: Shop, Field and Maintenance Painting of Steel.
    - Coating Manufacturer’s Product Data Sheet.
    - Department of the Navy Tech Data Sheet 82-08: Paint Failures – Causes and Remedies.
- In addition to those above, the following technical updates, guides and standards are available and are often incorporated into contract documents:
  - ASTM D-610 Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces.
  - SSPC Technology Update No. 3 Overcoating.
The theoretical design life of a bridge has until recently been 50 years, but with the evolution of new
design guidelines and construction materials the anticipated service life for newly constructed
bridges is 75 years or greater. The anticipation of a longer service life for coated steel bridges can
only be achieved in an economical fashion if bridge practitioners take advantage of the tools at their
disposal, and base repainting decisions on well thought out economic evaluations. It is also
essential to have properly qualified (NACE Certified) contractor and inspection personnel, a good
quality control plan and practices, quality assurance inspections to ensure that the plan is being
followed, and the Institutional courage to hold Contractors to their contractual obligations.