HORSEHEAD CORP.

ZINC CORPORATION OF AMERICA

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Report For: Young Galvanizing, Inc.
P.O. Box 334 – Route 551
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Subject: Evaluation of Galvanized Rebar

Background

Young Galvanizing submitted to our lab two small sections of galvanized rebar, as shown in Figure 1, and a section of concrete for analysis. The samples were removed from a bridge deck located on Route 66, south of Kittanning, Pennsylvania. The bridge, which was built around 1973, is undergoing an extensive renovation to replace the medial barrier. The original bridge deck will remain in place.

We were asked to evaluate the rebar and concrete in order to determine its current condition. Our evaluation included chemical analysis of the concrete and metallographic examination of the galvanized rebar.

Chemical Analysis of Concrete

The concrete was analyzed (without the aggregate) with the results listed below. The chloride content of the concrete was then calculated in pounds per cubic yard using the analytical value.

Ca	14.3 %
Al	1.60
Cu	<0.01
Fe	1.74
Mg	0.58
Mn	0.03
Na	0.27
Si	9.80

Zn	0.72
Cl	0.12
S	1.00

Calculated Chloride Content 4.8 lbs/yd^3

The chloride content of concrete has a significant effect on the service life of galvanized rebar. The normal source of the chloride is the deicing salts used during the winter months. 'Black' rebar (i.e. uncoated) will begin to corrode when the chloride content of the concrete exceeds 1.1 pounds per cubic yard (lbs/yd^3). At this point the rust that forms on the rebar will build up pressure causing the concrete to spall. However, galvanized products require a chloride content more than five times (>5.5 lbs/yd^3) that of black rebar before corrosion begins. As seen above, this concrete far exceeds the chloride threshold needed for black bar corrosion, but has not yet reached the threshold needed before galvanized *begins* to corrode.

Metallographic Examination

The rebar samples were randomly labeled #1 and #2, and prepared for metallographic examination .of the coating cross section. Figures 2 and 3 show the coating cross sections for Samples #1 and #2, respectively. Both samples show a similar coating structure consisting of a thick delta next to the steel substrate and a columnar growth of zeta crystals. A layer of pure zinc covers these iron-zinc alloy layers. These samples show a good metallurgical bond to the underlying steel and no visible signs of corrosion.

The same samples that were used for the metallographic examination were also used for the coating thickness measurements. A series of seven to ten thickness readings were taken around the circumference of the rebars using a calibrated eyepiece on an optical microscope at high magnification. These readings were then averaged with the results shown below. The average coating thickness remaining on these bars exceeds the minimum requirement for ***new*** Class II rebar (6.0 mils) per ASTM A767.

Average Coating Thickness

Sample #1	10.6 mils
Sample #2	9.7 mils

Conclusions

- After 30 years of service, these rebars are in excellent condition with no evidence of corrosion. This was confirmed by metallographic examination of the coating cross section.

- The chloride content of the concrete is well beyond the threshold needed for corrosion of 'black' bar. The chloride content has not yet reached the threshold needed for the corrosion of galvanized rebar.

- After 30 years of service, the zinc coating on these rebars still exceeds the thickness required for new Class II bars.

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Reference: ZCA Project ZM04-02
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Figure 2. Cross section of galvanized coating on Sample #1.
Magnification: 100X

Figure 3. Cross section of galvanized coating on Sample #2.
Magnification: 100X