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Assessment of Existing Coating System and Test Repainting System on Steel Bridge in Myanmar

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Abstract: In Myanmar, corrosion problem of steel bridges due to coating deterioration are much severe. So corrosion protection techniques for repainting system is needed in Myanmar. This paper represents the existing coating deterioration on truss and after that test repainting systems of Min Chaung Bridge, Rakhine State, Myanmar. Min Chaung Bridge was chosen for test repainting system because Rakhine State is high atmospheric corrosivity category (C4). The aim of this study is to assess the preliminary assessment of the bridge truss coating for pilot repainting. It contains assessment for evaluation of measuring coating thickness, surface salinity and surface treatment method. The results of this investigation are that minimum coating thickness is less than MOC (Ministry of Construction) requirement and in some points; thicknesses are larger than 1.5 times - 2.5times.The existing coating thickness is in the range of 140μm - 720μm for all diagonals of truss. For test repainting system, after three months period data are compared. Almost all coating thickness data and gloss retention data decrease for all cases except some points.

Keywords: Coating deterioration, coating thickness, evaluation, repainting, gloss retention.

I. Introduction

Development for transport systems is very important for every country including Myanmar. The use of steel in bridges goes back over 100 years. Steel is used as I-girder, box girder, and truss members in bridge construction material. Especially steel bridges are more suitable than the pre-stressed concrete bridge and Reinforced Concrete Bridge in long-span Bridge. But mild steel cannot be used without protective coating system because it can be corroded when exposed to atmospheric environment.

The most effective way to protect steel truss is to maintain a protective coating system. For steel bridges, coating failure is one of the primary types of deterioration. In addition, environmental conditions are also including in in one of the effective factor in coating deterioration. The bridges located near the coastal areas are more severe corrosion than other areas.

Steel bridges are constantly exposed to the moisture and salts from the sea water and air. Presence of high levels of chloride in the coastal areas causes the deterioration of steel. Durability of corrosion protection is an important fact when designing and detailing steel bridge. In steel bridge coating system, the rates of coating deterioration varies significantly according to number of coating layers, type of coating system, surface preparation methods, coating thickness, exposure conditions and substrates.

Corrosion attack of steel bridges may occur after coating deterioration. By using visual evaluations and physical measurements of coating properties such as adhesion, coating thickness, gloss retention, color and other parameters are assessment of performance that use in nowadays. Depending on this facts, type of maintenance (spot repair, overcoat, full removal and replacement) are determined and then appropriate paint type and surface treatment methods are chosen. Nowadays the coating degradations are intense and the periodic maintenance of the coating degradations is the major concerns for anticorrosion. The purpose of this study is to know the suitable type of paint systems in steel truss bridge with their environments in Myanmar[1].

II. Location of Study Bridge

A. Location

Min Chaung Bridge was opened in the year 2000 and constructed across Min Chaung River. It is about 4.3mile from the coastal area and 16mile from Sittwe, Rakhine State, Myanmar. The type of the truss is Warren Type, main span for steel truss is 683ft and the total length of the bridge is 2003ft. The repainting work for all steel truss are done by Ministry of Construction in 9th March, 2018 and the coating system is ISO 12944 C4 A4_09. The location of Min Chaung Bridge is shown in Fig. 1 [2].

Figure 1. Location of Min Chaung Bridge

In Fig. 2, the red symbol is the investigated coating members and Fig. 3 shows the sketch of the evaluation faces of diagonal and vertical members.

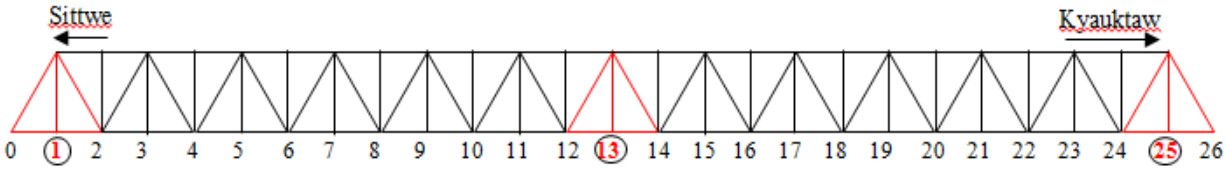

Figure 2. Sketch of upstream side and downstream side truss members

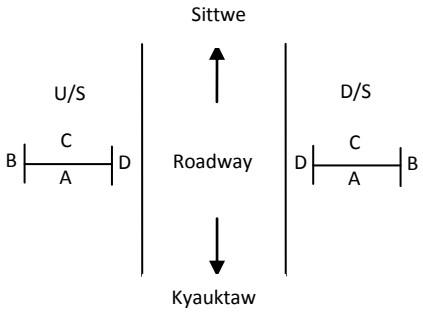

Figure 3. Sketch of faces of diagonal and vertical members

B. Health Condition of Existing Coating

The coating conditions of Min Chaung Bridge were conducted on September, 2018. It was constructed last 19 years ago. MOC tendered for repainting work in March, 2018. The configuration of the paint condition in bridge looks fine. In most of the surface of the vertical members have clear surface; however, diagonal members are relatively dirty with green colour.

Figure 4. Photos of Health Condition on Existing Coating

III. Evaluation on Current Condition

The investigation was carried out on 15th September, 2018 by Prof. Kunitomo SUGIURA (Kyoto University), Mr. Hideki HIBI (Hibi Co. Ltd), Ms. Pyae Phyo Sandar Lin (YTU), Mrs. Khin Moe Moe (MOC), Mrs. Thae Nu Soe (MOC) and Ms. EiMyat Noe Aung (MOC).

A. Existing Coating Thickness on Truss

The existing coating thickness was measured on some vertical and diagonal members in both upstream and downstream sides by coating thickness gauge. The coatingthicknesses were measured 4 sides(2sides on web face and 2sides on flange face) on each member and for 1side; coating thicknesses were measured 5 points on each face. For each face, the outcome results as average are shown in TABLE I.

The recommend paint system is three layers system but there is no adhesion on some existing coatingof truss members by doing cross_cut adhesion test. In addition, coating thicknesses are not uniform and some are over 600µm.

B. Investigation of Existing Coating on Vertical and Diagonal Truss

TABLE I. MEASURING COATING THICKNESS ON TRUSS

	Coating Thickness at U/S Side (µm)								
Face	D 0-1	V1	D 1-2	D 12-13	V13	D 13-14	D 24-25	V25	D 25-26
A	398	559	633	407	407	491	590	669	473
B	437	388	435	361	352	359	349	495	487
C	433	492	502	634	460	323	524	600	650
D	495	440	645	373	296	241	571	721	601

	Coating Thickness at D/S Side (µm)								
Face	D 0-1	V1	D 1-2	D 12-13	V13	D 13-14	D 24-25	V25	D 25-26
A	534	655	656	488	442	273	193	280	165
B	504	510	398	251	271	249	395	190	151
C	646	538	444	355	527	483	183	244	230
D	670	451	259	330	368	407	140	187	248

In these cases, the maximum coating thickness is 721µm. The required thickness for MOC limitation of paint coating system for Min Chaung Bridge is 280µm. It may be that repainting work system is over coating or without removing intermediate or top coat [3].

C. Coating Thickness Comparison for Truss

The comparison of the coating thickness for truss members (D0-1,V1,D1-2, D12-13, V13, D24-25, V25, D25-26) for upstream and downstream are shown in Fig. 5 and Fig. 6.

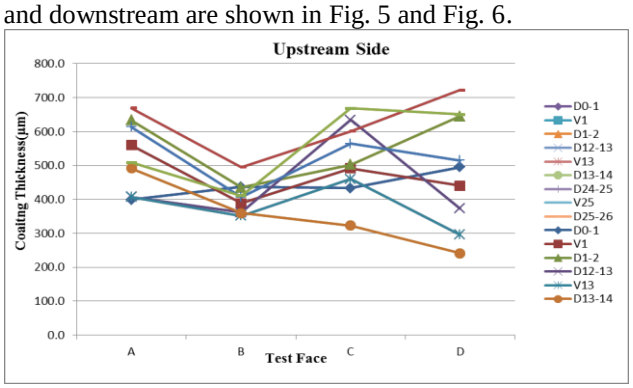

Figure 5. Coating thickness comparison for vertical and diagonal members (upstream side)

For upstream side, the minimum coating thickness is 241µm on face D of D13-14 and the maximum coating thickness is 721µm on face D of V25.

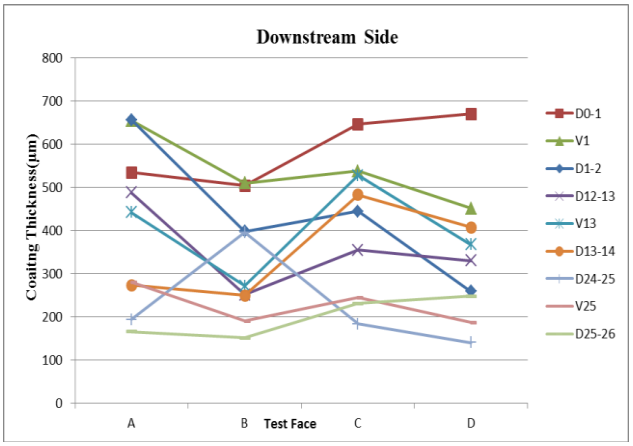

Figure 6. Coating thickness comparison for vertical and diagonal members (downstream side)

For downstream side, the minimum coating thickness is 140µm on face D of D24-25 and the maximum coating thickness is 670µm on face D of D0-1.

D. Surface Salinity

The surface salinity was measured by surface salinity meter SSM-21P at Min Chaung Bridge. The measuring data are as follows.

TABLE II. MEASURING SURFACE SALINITY

	U/S (mg/m^2)		D/S (mg/m^2)	
Face	V3	V5	D3-5	V5
A	-	8.1(34.1°C)	16.9(35.5°C)	-
B	2.7(34.2°C)	10.0(34.4°C)	6.2(35.7°C)	3.6 (35.8°C)
C	-	11.9(33.9°C)	5.9(35.6°C)	-
D	5.5(34.9°C)	12.7(34.8°C)	7.9(35.2°C)	5.9 (35.6°C)

The setting time for measuring data is continuously about 3minutes. The amount of surface salinity is relatively small in Min Chaung Bridge at that time and it is located in EAST_WEST direction and wind direction comes from EAST, a little from the NORTH. This indicates that monsoon season is over and it becomes dry season. In addition, before this day, it is rainy in this bridge.

IV. Repainting on Case Study Bridge

After investigation in August 2018, test repainting is done in December 2018at Min Chaung Bridge.

A. Draft for Test Repainting

Four anti-corrosive paint systems such as Case A-2', Case B-0, Case B-1, Case B-2 are tested in Min Chaung Bridge. The detailed are described in below the TABLE III.

B. Draft for Test Repainting

TABLE III. TEST REPAINTNG SYSTEM

	CaseA-2'	CaseB-0	CaseB-1	CaseB-2
Surface Preparation	Remain Prime Coat	Remove All Layers		
Coating System	**ISO 12944 C4 A3-09**	**ISO 12944 C3 A4-09**	**ISO 12944 C3 A3-11**	**ISO 12944 C4 A4-15**

C. Test Regions for Min Chaung Bridge

Fig.6 shows sketch of upstream side truss members for test repainting at Min Chaung Bridge.

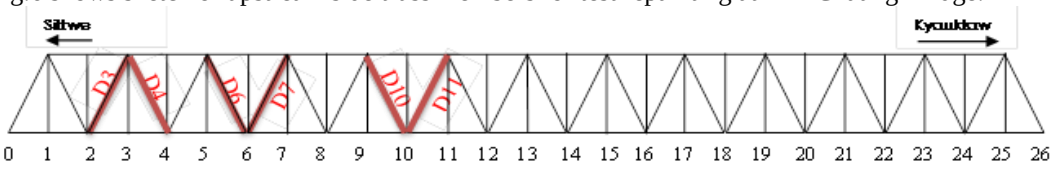

Figure 7. Sketch of upstream side truss members

Case B_1 is painted by three groups. Case B_1 (PWRI) means "tested by Public Works Research Institute, CaseB_1 (J&M) means "J&M Steel Solutions" and CaseB-1 (YTU) means "tested by Yangon Technological University".

D. Comparison of Coating Thickness between December, 2018 and March, 2019 (3 Months Interval)

The test repainting coating thickness measured on December, 2018 is compared with the thickness measured on March, 2019. The comparison of coating thickness between December, 2018 and March, 2019 (3 months interval) are shown in Fig. 8.

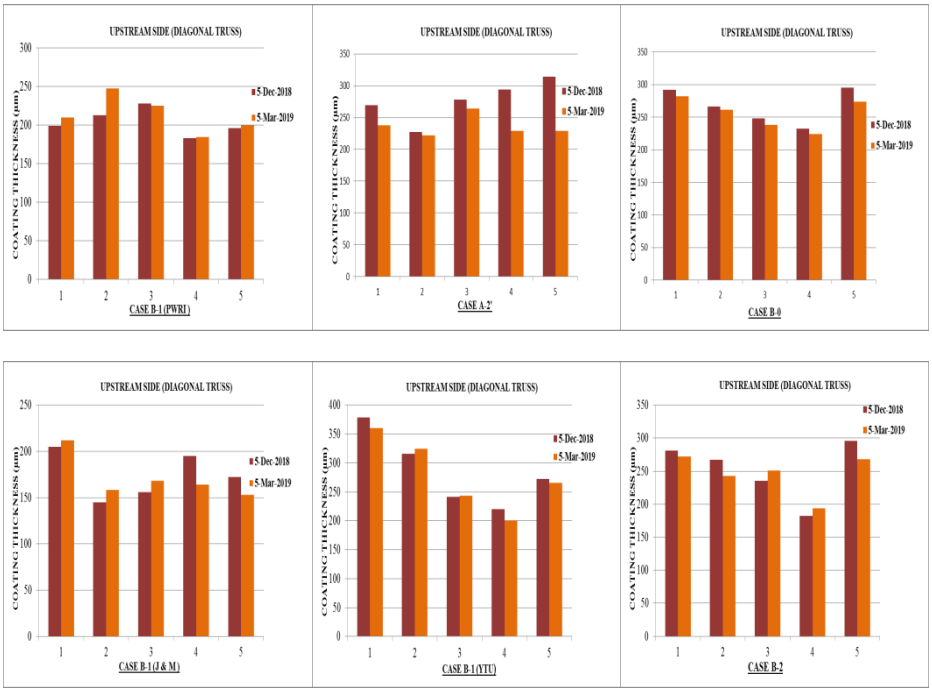

Figure 8. Comparison of coating thickness for Case A-2', Case B-0, Case B-1(PWRI) , Case B-1(J&M), Case B-1(YTU) and Case B-2

The evaluation of measuring coating thickness data normally decrease but for except in Case B-1 and Case B-2, some coating thickness data increase after repainting at 3 months period. This case may be that the amount of moisture content in atmosphere may be higher in these days.

E. Comparison of Gloss Retention (60°and 20°) between December, 2018 and March, 2019 (3 Months Interval)

The comparison of gloss retention 60° between December, 2018 and March, 2019 (3 months interval) are shown in Fig. 9.

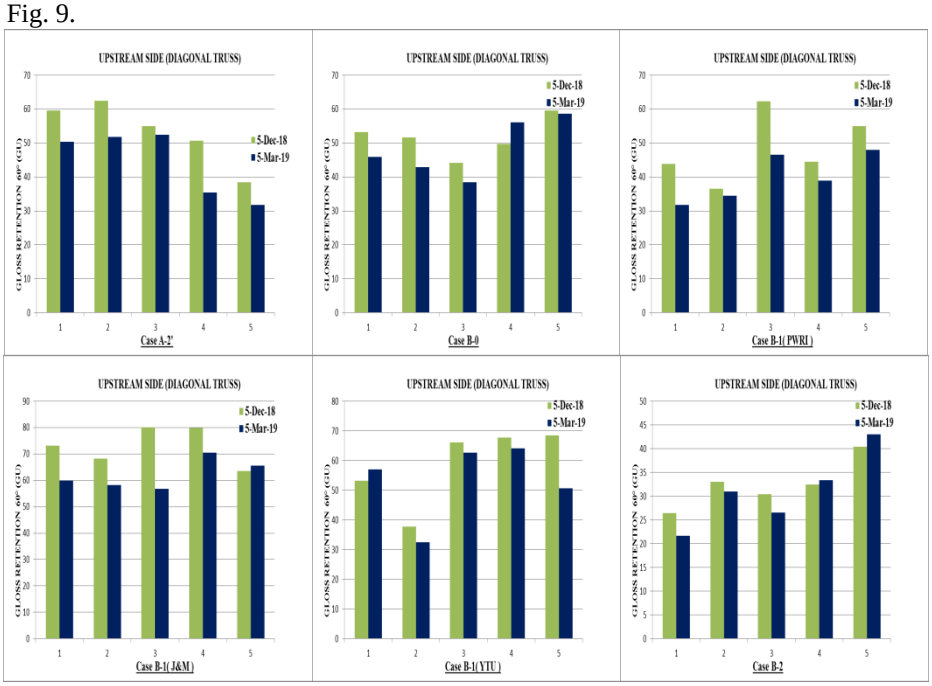

Figure 9. Comparison of gloss retention 60°for Case A-2', Case B-0, Case B-1(PWRI) ,Case B-1(J&M), Case B-1(YTU) and Case B-2

The comparison of gloss retention 20° between December, 2018 and March, 2019 are also described in Fig. 10.

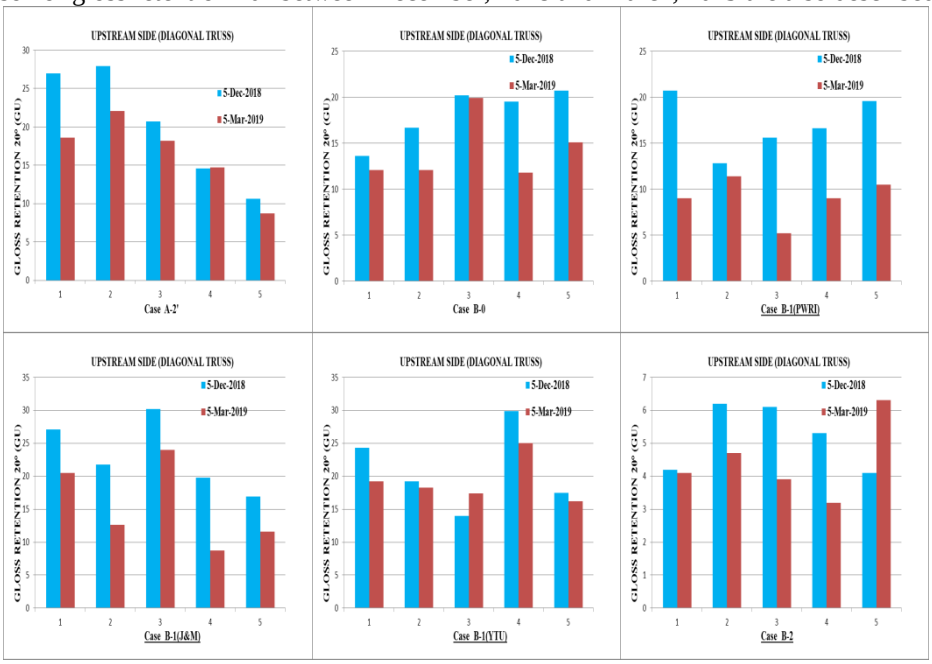

Figure 10. Comparison of gloss retention 20°for Case A-2', Case B-0, Case B-1(PWRI) ,Case B-1(J&M), Case B-1(YTU) and Case B-2

The results data for gloss retention (60°) of all cases also decrease for all Cases but some points in Case B-0, Case B-1 (J&M) and Case B-2 increase after 3 months period.The results data for gloss retention (20°) of all cases also decrease for all Cases but some points in Case B-1 (YTU) and Case B-2 increase after 3 months period. Gloss data decrease after 3 months period because the coating surface degrades.

V. Discussions and Conclusion

A. Discussions and Conclusion on Investigation Results

For repainting by MOC, coating system ISO 12944 C4 A4_09 (280μm) was used because Rakhine State is atmosphericcorrosivity category C4. Prime coat and intermediate coat are Epoxy paints and top coat is Polyurethane paint. The evaluation of coating condition on truss at Min Chaung Bridge is discussed as follows:

- The measuring coating thicknesses on members

for upstream and downstream members of truss at Min Chaung Bridge are not uniform. Minimum thickness is smaller than required thickness and maximum thickness is too greater than limitation.

Coating thicknesses were measured on some vertical and diagonal members and results are discussed as follows:

- By comparing the coating thickness for members, coating thickness on all faces is much different. On upstream side, flange coating thickness (Face D of D13-14) is less than 280μm and other members for Face D are more than 280μm-700μm.
- On downstream side, flange coating thickness (Face D of D1-2, D24-25, V25, and D25-26) is less than 280μm. Other members for Face D are within 280μm-700μm.

In this case, repainting system is over coated (without removing top coat or intermediate coat) over existing coating layer in maintenance operation so that coating thickness is over limitation (280μm). So that, right repainting procedure must be carried out or skill of the workers might be efficient and technical rules were followed when repainting in steel truss bridge. For improving the test repainting system, choose the best coating system on existing condition, surface treatment method, repainting procedure and environmental conditions are important.

B. Discussions and Conclusion on Test Repainting

After investigation work is done, test repainting at Min Chung Bridge is done and four coating systems, ISO 12944 C4 A4_09, ISO 12944 C3 A4_09, ISO 12944 C3 A3_11, and ISO 12944 C4 A4_15 are chosen.

- The evaluation of measuring coating thickness data normally decrease but for except in Case B-1 and Case B-2, some coating thickness data increase after repainting at 3 months period. This case may be that the amount of moisture content in atmosphere may be higher in these days.
- The results data for gloss retention (60°) of all cases also decrease for all Cases but some points in Case B-0, Case B-1 (J&M) and Case B-2 increase after 3 months period.
- The results data for gloss retention (20°) of all cases also decrease for all Cases but some points in Case B-1 (YTU) and Case B-2 increase after 3 months period.

Gloss data decrease after 3 months period because the surface becomes rough when the coating surface degrades. Four coating systems were tested to choose the most suitable anti-corrosive paint system for low life cycle cost for routine maintenance.

VI. ACKNOWLEDGMENT

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