CORROSION RESISTANCE OF STEEL IN HISTORIC KALURGHAT BRIDGE

BUET – JIDPUS O Md Hachnayen Ahmed, Member
BUET Prof Dr. A.F.M. Saiful Amin

1. INTRODUCTION

Steel's corrosion resistance is an indispensable factor for archaic steel bridges regarding safety and serviceability. This study represents an expansive corrosion-resistant analysis on archaic Kalurghat Bridge. For assessing different corrosion behavior of the elements, the process combines advanced analytical techniques, laboratory trials, and field inspections. In 2001, the Bangladesh Railway declared that Kalurghat Bridge was vulnerable due to many weak sports in different parts. The 1930s-constructed Kalurghat Bridge is currently perilous for transportation and degradation.

2. HISTORICAL AND STRUCTURAL OVERVIEW

The Kalurghat Bridge combines Chattogram's northern and southern portions. Before the Shah Amanat Bridge went into operation in 1989, the 93-year-old bridge became the only vital connection in the southern region. Previously, a 700-yard steel rail bridge that linked the railway stations of Janalihut and Gomdandi. Then, the deck was reconstructed for motor vehicles amid the Burma Front Conflicts later in World War II. The deck was removed after country's 1947 partition. The bridge's existing structure evolved later in 1962 when it became suitable for any type of vehicle. 19 distinct span types were used in the building process of the bridge: a single 47.55m steel girder, twelve under-slung spans estimating 31.85m, five pieces estimating 26.00m, one 13.00m deck-type span, and twelve 4.88m joists.

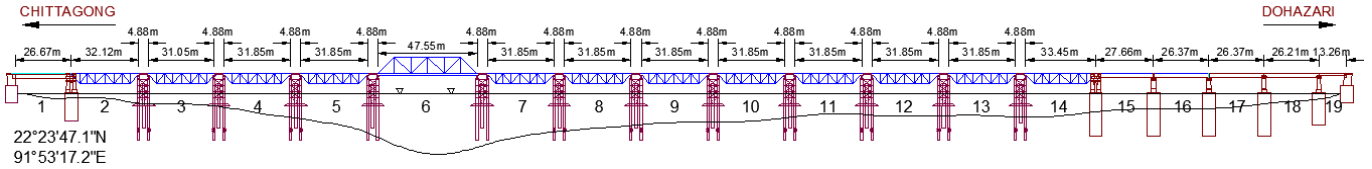

Fig. 1: Profile of Kalurghat Bridge

3. LABORATORY EXPERIMENTS AND CORROSION TESTING

To illustrate the diverse range of steel compositions observed in the construction, six samples were meticulously selected from distinct locations on the Kalurghat Steel Bridge (Fig 2). This appropriately computed corrosion resistance index precisely reflects the bridge's entirety corrosion resistance. Sample details are provided in Table 1.



Fig. 2: Test Samples taken from site

ID	Part Name	Span	Year of Construction/ Reconstruction
1	Parts of C Channel	4	1931
2	Branching Angle	3	1931
3	Gusset Plate	8	1986
4	Gusset Plate	18	2004
5	Packing Plate	6	2004
6	Top Plate	12	2004

4. CORROSION ANALYSIS AND RESULTS

4.1 Visual Assessment

As part of a thorough corrosion evaluation, visual inspections, and pictures were made at multiple locations to detect different types of corrosion, degree of damage, and structural hazards. This steel bridge had close to each of the following types of corrosion.

General Corrosion: This specific type of corrosion showed signs of a consistent attack on the steel's surface. According to Fig. 3(a), this type is innocuous and is identified by a consistent rust layer which is effortless to detect. The base of the cords, pillars, truss members, and other bridge deck areas indicate uniform corrosion. Crevice Corrosion: Crevice corrosion was observed in areas where the steel surface was exposed to a small gap or crevice, such as between the steel plates or under corrosion products. Two types of Crevice corrosion to be found in steel bridges.

i) Underfilm corrosion was observed in many parts of the bridge including deck joist connection plates and the upper portion of the deck surface as shown Fig in 4(b). ii) Deposit attack occurs due to a build-up of debris deposits that carry moisture on steel components within the bridge as shown in Fig 4(c). Pitting corrosion is a form of localized corrosion that results in deep penetrations into the surface of the base metal, as indicated in Fig. 3. (d).



(a) Uniform Corrosion at Piller



(b) Underfilm Corrosion between bracing connection



(c) Defects attacks at main girder connections



(d) Pitting corrosion at the cord of the main truss

Fig. 3: Different forms of corrosion observed

4.2 Critical areas susceptible to corrosion

The trials revealed numerous important places on the Bridge that were especially prone to corrosion. It was discovered that the existence of residual stresses and microstructural differences in the weld zone made the welded joints more prone to corrosion. Higher rates of corrosion were seen in the steel specimens with damaged coatings, underscoring the significance of preserving the integrity of protective coatings. More severe corrosion was observed in steel specimens exposed to corrosive fluid splashes and drips, demonstrating the necessity of adequate drainage and protection of these parts.

4.3 Corrosion Index

Exposure tests were performed at multiple locations to assess the extent to which environmental conditions impact the corrosion of weathering steel (Amin et al., 2020). But in our case based on real sample from existing steel bridge, we have calculated atmospheric corrosion index (I) from chemical composition to determine the corrosion susceptibility of steel the bridge. Chemical analysis was performed for six samples using Optical Emission Spectrometer (Model Foundry Master Pro, Oxford Instrument, Germany). The atmospheric corrosion resistance index (I) was calculated using the Larrabee-Coburn method, which is a predictive method outlined in ASTM G101-04. (See Table 2). This process considers the chemical composition of the steel, specifically the concentrations of key elements such as copper, nickel, chromium, and phosphorus. These elements influence the formation of protective oxide layers on the steel surface, thus influencing corrosion resistance. However, it was required to examine the bridge's present condition to strengthen axle load capacities and nurture it from further damage.

Table 2: Chemical composition and atmospheric corrosion resistance index (I) of the six steel samples.

Sample Identification	Chemical Composition, wt.%								I
	C	Si	Mn	P	S	Cr	Ni	Cu	
1	0.1	0.05	0.51	0.046	0.029	0.02	0.041	0.11	3.5
2	0.21	0.01	0.64	0.018	0.017	0.039	0.045	0.018	1.0
3	0.09	0.03	0.32	0.013	0.002	0.029	0.007	0.003	0.4
4	0.1	0.03	0.33	0.014	0.002	0.029	0.007	0.002	0.4
5	0.19	0.04	0.69	0.015	0.016	0.018	0.026	0.012	0.7
6	0.08	0.21	1.2	0.012	0.002	0.022	0.015	0.014	1.0

C: Carbon, Si: Silicon, Mn: Manganese, P: Phosphorus, S: Sulfur, Cr: Chromium, Ni: Nickel, Cu: Copper, I: Corrosion Index

5. CONCLUSION

This methodology provides a robust and standardized approach to evaluate the corrosion resistance of the Kalurghat Steel Bridge. The calculated corrosion resistance index, coupled with the chemical composition data, offers valuable insights into the bridge's current state and helps inform future maintenance and repair strategies.

6. REFERENCES

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