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Classification on Corrosivity Class in Coastal Region, Myanmar

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Abstract:- – **Steel is used widely in structures due to its low cost and good mechanical strength. The main problem is destruction of materials caused by the chemical or electrochemical action of the surrounding environment which is known as corrosion. The environmental parameters such as time of wetness, temperature, relative humidity, and rainfall are the main parameters that cause the atmospheric corrosion. These parameters are measured according to ISO 9225. Chloride deposition rate is studied as pollutant. In study area, the corrosivity class is C3-C4 according to ISO 9223.**

Keywords: **Atmospheric corrosion, coastal region, corrosivity class, environmental parameters, pollutant**

I. INTRODUCTION

Steel is the most employed metallic material in open-air structures and is used to make a wide range of equipment and metallic structures due to its low cost and good mechanical strength. Mild steel is a type of carbon steel with the low amount of carbon.

Myanmar is the north-western-most country on the mainland of Southeast Asia. It is strategically located near major Indian Ocean shipping lanes. It is a developing country and due to the increasing of industry at the main cities, such as Yangon, Mandalay, and so on, the pollution level is also arising. There is an increasing use of structural steel, especially in the fabrication of structures, such as steel buildings

Corrosion is defined as the destruction of materials caused by the chemical or electrochemical action of the surrounding environment. Corrosion process can be conveniently classified into Chemical Corrosion and Electrochemical Corrosion. The reaction of metals with dry air or oxygen is considered a chemical corrosion. Electrochemical Corrosion occurs in the presence of the electrolyte.

Atmospheric corrosion refers to the corrosive action that occurs on the surface of a metal in contact with an atmospheric environment. It is a complex process involving a large number of interacting and constantly varying factors, such as meteorological factors (including temperature, wind speed, rainfall, and relative humidity), air pollutants, metallurgical factors (including metal type, microstructure, and morphology), distance from the sea etc. The combined effect of these factors may result in significant variations in corrosion rates.

The corrosivity class is classified based on meteorological parameter and pollutant based on one year period from October 2017 to September 2018. The meteorological parameter is measured by using Data Logger and chloride pollutant is measured according to Gauze Method (JIS Z 2382). The To determine the mass loss of specimen due to corrosion, the removal of corrosion products from corrosion test specimens will be first done according to ISO 8407.

II. FIELD TEST ON METEOROLOGICAL AND POLLUTANT PARAMETERS

A. Exposure Test Site

The selection of the exposure test site should meet adequate security, observations of the test specimens and recording of the environmental factors according to ISO 8565. [1]

Fig. 1 Exposure site location

Refer to the above factors, Government Technological High School (Letkokkon) is selected for test location. Moreover, it is 800m far from the North of Andaman Sea Coastline. Therefore, it is selected as exposure test site because of coastal region. It is situated on the latitude 14.4376⁰ N and longitude 95.9938⁰ E and slightly far from the road with low traffic.

B. Measurement of Meteorological Parameters

Meteorological data, such as temperature, rainfall, and relative humidity, are recorded by data logger in the observation system. This system is located on the roof of Government Technological High School (Letkokkon). In this study, the following meteorological data are collected from October 2017 to September 2018. [3]

Temperature: The relationship between temperature and atmospheric corrosion rate is quite complex in nature. An increase in temperature tends to stimulate corrosive attack by increasing the rate of electrochemical reactions and diffusion process and leads to a higher corrosion rate. However, raising the temperature leads to a decrease in relative humidity which reduces the time of wetness. By reducing the time of wetness, the overall corrosion rate tends to diminish. Fig. 2 shows recorded temperature for one year exposure time. There is a fluctuation in temperature over one year period. In May, temperature reaches to a peak of over 35ºC and the lowest temperature of below 15ºC is in January.

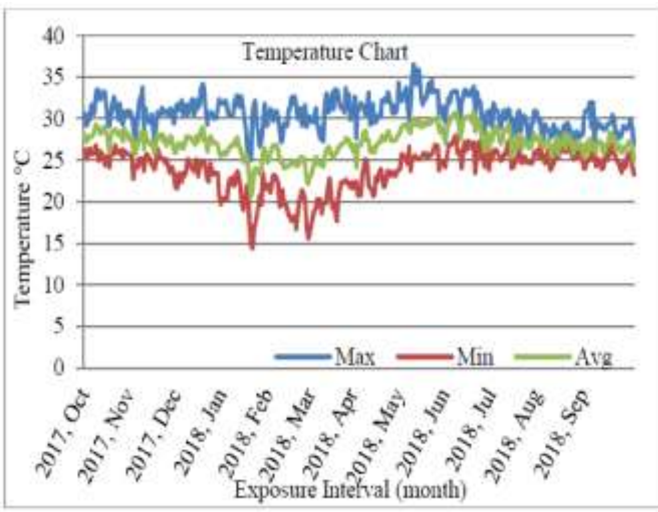

Fig. 2 Temperature (ºC) in Letkokkon

Relative Humidity: Relative humidity, RH, is closely relative to the rate of atmospheric corrosion. There is a critical threshold of RH, below which corrosion will not happen on a metal because there is insufficient moisture to create an electrolyte layer in the surface. At about 60% RH rusting commences at a very slow rate, but the corrosion rate increases sharply at 75-80% RH. At nearly 90% RH, the tertiary increase in corrosion rate is observed. Fig. 3 shows maximum, minimum and average relative humidity over one year interval. Relative humidity is much variation from October 2017 to September 2018. There is maximum relative humidity in rainy seasons such as July, August, September, and October and minimum in dry seasons such as February, March, and April.

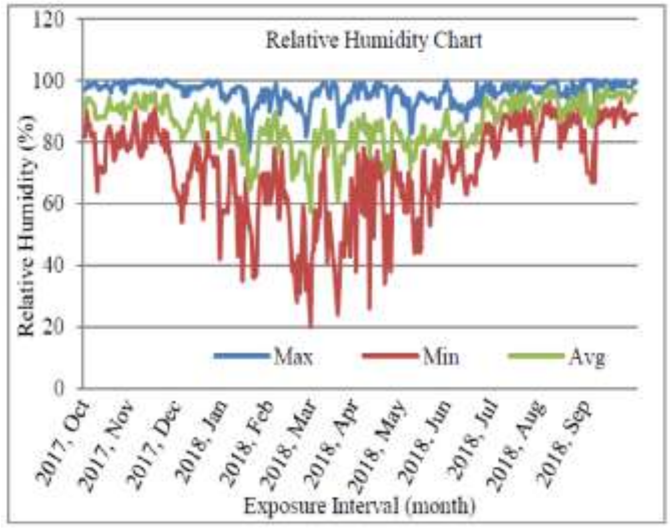

Fig. 3 Relative Humidity (%) in Letkokkon

Rainfall: Precipitation in the form of rain effects corrosion by giving rise to a phase layer of moisture on the material surface which promotes corrosion. On the other hand, rain washes away pollutants deposited on the surface which decreases corrosion. Fig. 4 is the amount of rainfall in millimetres over exposure time. There is no rainfall in four months over one year period. On the other hand, rainfall increases to a peak of 620mm in September. August and November have second heaviest rainfall about 600mm.

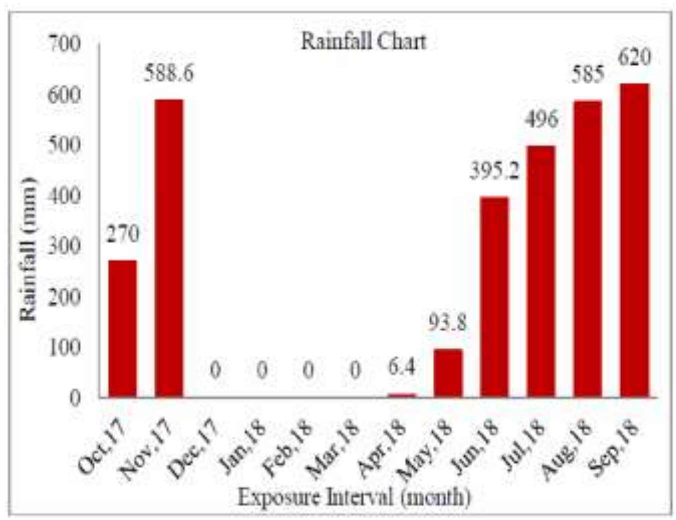

Fig. 4 Rainfall (mm) in Letkokkon

Time of Wetness: It is the length of time when the relative humidity is greater than 80% at a temperature greater than 0°C. Fig. 5 mentions monthly time of wetness for one year exposure time. There is 6563 hrs time of wetness from October 2017 to September 2018.

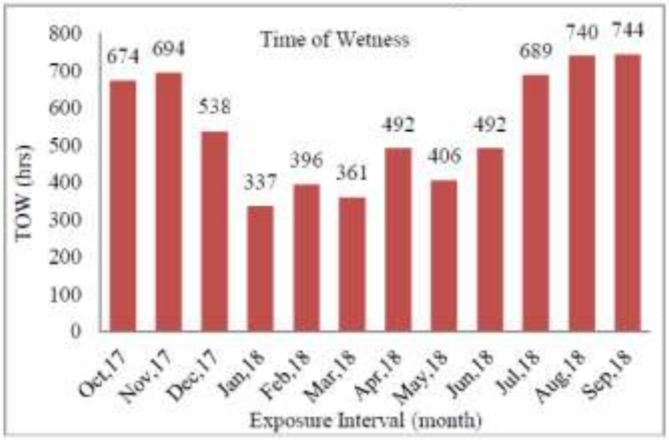

Fig. 5 Time of wetness (hrs) in Letkokkon

C. Collection of Pollutant

In pollutant atmospheres, chlorides and sulphur dioxide are the common pollutants influencing metallic corrosion.

The collection of chloride deposition rate is done as per Japanese Industrial Standard, JIS-Z-2382 [7] and these tests are collected near the specimen exposure test. In Fig. 6, the trend shows monthly chloride deposition rate in $mg/m^2/d$. The chloride deposition rate is very low in first three months and sharply increases up to $8mg/m^2/d$ in January and February. There is a drop in March and recovers in April and May. In June, chloride deposition rate rockets to $15mg/m^2/d$ and reaches to a peak of $16mg/m^2/d$ in August.

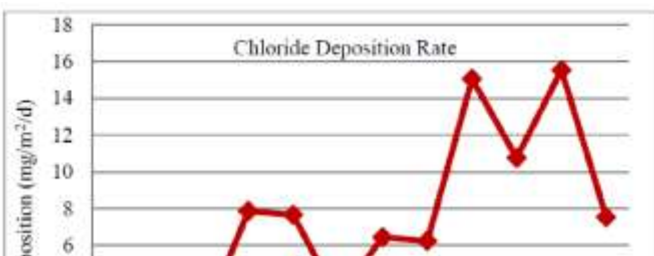

Fig. 6 Chloride deposition ($mg/m^2/d$)) in Letkokkon [4]

Sulphur dioxide is the gaseous product of the combustion of fuels that contain sulphur such as coal, diesel fuel, gasoline, and natural gas. The concentration of sulphur dioxide plays an important role in urban and industrial atmospheres. However, in this study, the deposition rate of sulphur dioxide is not taken into account because Letkokkon is not an industrial area and has low traffic. Therefore, category of deposition rate of sulphur dioxide is assumed as P0. [5]

III. Classification On Corrosivity

A. Classification on Time of Wetness

The classification on time of wetness for atmosphere is given in Table I according to ISO 9223. The classified values are based on the long-term characteristics of macroclimatic zones for typical conditions of the location categories. [2]

TABLE I Classification Of Time Of Wetness

Category	**TOW (h/a)**	**TOW (%)**
τ1	$\tau \leq 10$	$\tau \leq 0.1$
τ2	$10 < \tau \leq 250$	$0.1 < \tau \leq 3$
τ3	$250 < \tau \leq 2500$	$3 < \tau \leq 30$
τ4	$2500 < \tau \leq 5500$	$30 < \tau \leq 60$
τ5	$5500 < \tau$	$60 < \tau$

τ_1, almost no condensation is expected. For τ_2, the probability of liquid forming on the metallic surface is low. τ_3 to τ_5 include periods of condensation and precipitation.

B. Classification on Chloride Deposition

A Gauze method specified by Japanese Industrial Standard (JIS Z 2382) is used to measure the salinity concentration. Table II shows the classification of pollution by airborne salinity according to ISO 9223.

TABLE II

CLASSIFICATION OF POLLUTION BY AIRBORNE SALINITY REPRESENTED BY CHLORIDE [2]

Deposition Rate of Chloride $mg/(m^2.d)$	**Category**
$S \leq 3$	S0
$3 < S \leq 60$	S1
$60 < S \leq 300$	S2
$300 < S \leq 1500$	S3

C. Classification on Corrosivity Class

Table III shows corrosion rates for the different corrosivity categories based on ISO 9223. [2]

TABLE III

CORROSION RATES FOR THE DIFFERENT CORROSIVITY CATEGORIES

Corrosivity Category	Unit	Carbon Steel
C1	μm/a	$r_{corr} \leq 1.3$
C2	μm/a	$1.3 < r_{corr} \leq 25$
C3	μm/a	$25 < r_{corr} \leq 50$
C4	μm/a	$50 < r_{corr} \leq 80$
C5	μm/a	$80 < r_{corr} \leq 200$
C6	μm/a	$200 < r_{corr} \leq 700$

Table IV shows time of wetness and chloride deposition rate for one year exposure period in Letkokkon.

TABLE IV

TIME OF WETNESS, AND CHLORIDE DEPOSITION RATE OF THE STUDY AREA (LATKKOKHONE)

Time	TOW (hrs)	Cl^- ($mg/m^2/d$)
Oct, 2017	674	2
Nov, 2017	694	2.88
Dec, 2017	538	1.98
Jan, 2017	337	7.88
Feb, 2018	396	7.67
Mar, 2018	361	3.09
Apr, 2018	492	6.45
May, 2018	406	6.25
Jun, 2018	492	15.06
Jul, 2018	689	10.77
Aug, 2018	740	15.55
Sep, 2018	744	7.55
	6563 (Total hours per year)	7.26 (average value of one year)

The pollution categories and time of wetness categories are used for the determination of the corrosivity category. The estimated corrosivity categories of the atmosphere are mentioned in Table V based on ISO 9223. [2]

TABLE V

ESTIMATED CORROSIVITY CATEGORIES OF THE ATMOSPHERE

Unalloyed Carbon Steel	**τ1**		
	S0-S1	**S2**	**S3**
P0-P1	1	1	1 or 2
P2	1	1	1 or 2
P3	1 or 2	1 or 2	2
Unalloyed Carbon Steel	**τ2**		
	S0-S1	**S2**	**S3**
P0-P1	1	2	3 or 4
P2	1 or 2	2 or 3	3 or 4
P3	2	3	4
Unalloyed Carbon Steel	**τ3**		
	S0-S1	**S2**	**S3**
P0-P1	2 or 3	3 or 4	4
P2	3 or 4	3 or 4	4 or 5
P3	4	4 or 5	5
Unalloyed Carbon Steel	**τ4**		
	S0-S1	**S2**	**S3**
P0-P1	3	4	5
P2	4	4	5
P3	5	5	5
Unalloyed Carbon Steel	**τ5**		
	S0-S1	**S2**	**S3**
P0-P1	3 or 4	5	5
P2	4 or 5	5	5
P3	5	5	5

The atmospheric corrosivity category based on environmental parameters is described in Table VI.

TABLE VI

CORROSIVITY CLASS FOR STUDY AREA

Time of Wetness	TOW (h/a)	6563
	Category	τ5
Sulphur	SO2 [$mg/(m^2\text{-}d)$]	-
	Category	P0
Airborne Salinity	Cl^- [$mg/(m^2\text{-}d)$]	7.26
	Category	S1
Atmospheric Corrosivity Category		C 3-C4 (26-80µm/a)

IV. Discussion And Conclusion

In atmospheric corrosion, the meteorological parameters (temperature, rainfall, relative humidity, time of wetness), pollutant parameters and distance from the sea are the main factors to cause corrosion. The field exposure test is conducted about 800m far from the North of Andaman Sea Coastline.

The meteorological data is collected from October 2017 to September 2018 by using Data Logger which is installed on the roof of Government Technological High School (Letkokkon) to classify the corrosivity class. Myanmar has a tropical monsoon climate under the Koeppen climate classification system. The Country features a length rainy season from May through October, where a substantial amount of rainfall is received; and a dry season from November through April, where little rainfall is seen. It is primary due to the heavy precipitation received during the rainy season. In study area, there is maximum rainfall about 620mm in September. The maximum temperature is 36.5°C in May and minimum temperature is 14.4°C in January. During the course of the year, average temperatures show little variance, with average highs ranging from 25 to 36°C and average lows ranging from 14.4 to 26.8°C.

. The chloride deposition is calculated by using Gauze Method according to JIS Z 2382 and TOW is calculated the length of time when the relative humidity is greater than 80% at a temperature greater than 0°C. In study period, TOW is 6563 hrs for one year period and the average chloride deposition rate is 7.26 $mg/m^2/d$. The sulphur dioxide deposition is not considered as this area is rural coastal area and there is low traffic.

According to ISO 9223, the corrosivity class is C3-C4 (26-80µm/a) in study area which is located 800m from costal line.

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