



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

TEMPERATURE AND HUMIDITY EFFECT ON CORROSION AND MECHANICAL PROPERTIES OF FENCES AND GATES

This report is submitted in accordance with requirement of the UniversitiTeknikal
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ABSTRAK

Pengaratan ialah masalah yang sedia maklum boleh menyebabkan kerosakan terhadap struktur dan juga bahan malah akan menyumbang kepada pelbagai bentuk kegagalan. Berdasarkan sejarah, salutan pelindung salah satu pendekatan yang berkesan jika digunakan pada permukaan bahan yang terdedah kepada keadaan alamsekitar yang tidak boleh dijangka. Dalam bidang kejuruteraan, bahan atau struktur yang perlu diselenggara adalah bertujuan untuk mengelakkan kegagalan dalam masa yang sama supaya dapat mengurangkan kos yang diperlukan sepanjang proses selenggara. Keperluan kajian terhadap kebolehan saduran melindungi bahan dan cadangan penggunaan saduran yang meluas dalam pelbagai keadaan pasti akan menjadi kriteria penting dalam strategi penyelenggaraan. Dengan adanya keperluan ini, beberapa jenis salutan digunakan terhadap permukaan sampel dalam kajian ini. Sampel-sampel ini didedahkan dengan pelbagai keadaan persekitaran sepanjang kawasan yang dipilih. Keputusan yang diperolehi daripada ujian mekanikal selepas pendedahan menunjukkan, setiap salutan mempunyai kebolehan tersendiri sebagai salutan pelindung dan ianya bergantung kepada jenis persekitaran dimana salutan ini digunakan. Salutan daripada jenama Heavyguard menunjukkan ianya sesuai digunakan pada permukaan sampel Lokasi 1 dan Lokasi 2 untuk keputusan sifat mekanikal yang elok. Manakala pada Lokasi 3, salutan dari jenama Unilux menunjukkan ianya paling sesuai digunakan untuk mendapatkan sifat mekanikal yang elok pada sampel. Dengan berbezanya suhu dan kelembapan pada setiap lokasi, saduran-saduran ini menunjukkan sifat perlindungan yang tersendiri dan pemilihan salutan manakah yang paling sesuai bergantung pada suhu dan kelembapan keadaan lokasi ianya digunakan.

ABSTRACT

Corrosion is well known problem that can caused degradation to structure and materials thus contribute to various losses. Historically, protective coating is an effective approach to be used on corroded surfaces of materials which exposed unpredicted environmental condition. In engineering,, material or structure need to be maintained are mainly to prevent failure at the same time to reduced cost spend along maintenance process. The need of study on coating capabilities and recommendation of their wide used for protection on materials in variety condition surely will be important criteria in maintenance strategy. Through this requirement, some coating type was applied on representing sample surface in this sduty. These samples were exposed to variety environmental condition along selected location. The result obtained from mechanical test after exposure show that each coating has its significant capabilities as a surface protection which is depends on what kind of environment they were applied to sample. Coating from Heavyguard brand shows it is suitable to be applied for sample at Location1 and 2 for good mechanical properties result. Meanwhile at Location 3 coating from Unilux brand result most suitable coating to be applied for sample surfaces to obtain good mechanical properties of sample. With different of temperature and humidity at for each location, these coatings show its own protective characteristics and the selection which is most suitable depends on the temperature and humidity at location they were used.

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
CO ₂	-	Carbon Dioxide
GHE	-	Green House Effect
GDP	-	Gross Domestic Product
NACE	-	National Association of Corrosion Engineer
RH	-	Relative Humidity
Zn	-	Zinc

CHAPTER 1

INTRODUCTION

1.0 Introduction

Corrosion is a well-known problem which can cause degradation to materials and this type of problem can contribute to costly damage to infrastructures. The term corrosion in engineering also refers to the degradation of plastics, concrete and wood, and not only refers to metals element. Corrosion also one of the usual factors caused by the reaction of metallic materials with their nature (Fathoni, Zakaria, & Rohayu, 2013). The consequences of corrosion are many and varied. Their effects to the operation of equipment or structures sometimes can be very serious than the simple losses of a mass of metal. Variety of failures also can occur and replacements need to be done are unpredictable even though the amount of metal destroyed is quite small. Maintaining the outer layer of the equipment and structure can be very important when involves with natures phenomenon. This is because it can be costly when comes to damages at the structural components which can cause lot of money to be spend for maintenance. Coatings and materials selection is the most important factors to building a perimeter structures which always exposed to unpredicted environmental factors. By applying suitable protection on the surfaces of the structures usually can give long term lifespan for these components itself (Sakairi, Otani, & Sasaki, 2014).

1.1 Background of the Project

Corrosion is the process results from the chemical reaction of metallic materials with the environment. If temperature are below the dew point, the surface become moist and it can caused some type of deterioration occur to the materials or structures (Kim & Kim, 2016). This study is focusing on temperature and humidity effect which are the two common factors that can make the corrosion rate increase to the exposed metal and structures. This is because the condition of moistures is very associated with relative humidity and also temperature level in process of absorption for exposed parts. The wetness or moisture of surface also not depends only at relative moistness but can also with different parameters, which includes deposition of salt, radiation of daylight, and also wind (Fathoni et al., 2013).

The exposed fences and gates along the perimeter of Technology Campus which is located in the middle of industrial estate are suspected to have continuous corrosion effect due to its environment. Along the campus perimeter, there are different stages of corrosion on the surfaces of fences and gates. The corrosion stages seems vary and the protective coating that already applied on these structures degraded differently from one placed to another. This study is done to see how the temperature and relative humidity at these different placed affecting the corrosion stages and which coating is suitable to be applied based on their adjacent environment.

The experiment was done involves preparing the new sample of same metal that were used for fences and gates along this campus perimeter. New sample of mild steel was prepared with dimensions 150mm in length, 24mm wide and 2.6mm thickness for representing the fences and gates structure. Moreover, for suggestion selection of coating, three different types of paint were used in this experiment. All samples involved were coated with three types of paint which are Seamaster, Heavy Guard and UniLux before being left for exposure.

Along the exposure period, the temperature and humidity data at three different locations were recorded from time to time. After two month, these samples

then were take out from the experiment site and were tested in laboratory using suitable testing for their mechanical properties data. The comparison of mechanical properties for samples were done involved comparing the percentage of difference sample without exposure and sample with exposure. The result from mechanical properties testing was analyzed to select which coatings are suitable to be applied on the sample surfaces based on their location. This is because temperature and humidity level at certain location can result in different stage of corrosion.

The outcome of this experiment is about making a suggestion to the wide selection of coating by comparing the mechanical properties of sample due to corrosion-environmental factor, which are temperature and relative humidity. Thus, it believes from this experiment a suggestion on wide selection of coating for the fences and gates can be made at the same time can suggest the maintenance team to make a strategy for cost-effective in future maintenance.

1.2 Problem Statement

A large group of the researchers nowadays agree that the change of our environmental is because of Green House Effect (GHE). This phenomenon comes from human daily activities which is mostly because of the discharge happen specifically CO₂ gases release by ignition and burning materials (Mamalis, Spentzas, & Mamali, 2013). Due to human exercise, worldwide temperature also increase due to collection of green-house gasses in the environment and at the same time it can affect the biological system characteristic (Pandey, Gosain, Paul, & Khare, 2016). Due to Green House Effect (GHE), atmosphere which is not constant in term of its unusual climate then causes unusual precipitations to environment.

Precipitation and climate change are some of the hazards which will contribute the corrosion to occur at the surfaces of materials because temperature and humidity also will be different with changes of climate (Pandey et al., 2016). From this phenomenon's, climate changes around the Technology Campus are believed caused the fences and gates continuously exposed to corrosion. It is a concern to

suggest a wide selection of coatings to these perimeter structures based on their adjacent environment in order to provide information for future maintenance and cost effective strategy regarding these perimeter structure problems.

A proper maintenance approach and good design of fencing can reduce the failure problem of perimeter structures. This is because, protections or perimeter for human property are very important to make sure belonging are in a safe and ready state. Moreover, it is to make sure our property of facilities inside these perimeter safe while at the same time for security and protection (Noor Rosly Hanif, Wan Nor Azriyanti Wan Abd Aziz, Peter Aning Tedong, Peel, D. & Lloyd, 2013).

In numerous experiments in Africa and Malaysia, the experiment shows that fencings which used in this experiment are quite effective to protect their belonging. In that experiment it shows that, the most failures come are from faulty design of the structures and while improper maintenance also can cause the failures of that structure easily to occur (Sukumar, 1999). In early history Oil & gas industry it was identified that it has been suffering due to corrosion which cause significant cost for repair and maintain the infrastructures at the same times caused unplanned shutdowns (Mansoori, Mirzaee, Esmaeilzadeh, Vojood, & Soltan, 2017).

Moreover, corrosion also a problem that can leads to economic losses annually. In the US, the annual direct cost of corrosion that was been estimated are approximately \$276 billion or 3.1% of the gross domestic product (GDP) (Bai, Zhao, Zheng, & Chen, 2015) and NACE also state that it is the total costs which associated to all types of corrosion (Mansoori et al., 2017). This is because, the impact of corrosion are influenced by different various geographic regions. In Malaysia, there are different of geographic region for every state and even thought there are not yet specific estimation for gross domestic product (GDP) and annual direct cost of corrosion but the corrosion issues still cannot be avoid indirectly.

Apart from corrosion problem, the cost of corrosion still can be reduced if using application of various corrosion technologies. Nowadays, surface coating technology is a successful method in facing corrosion problem. This also included

proper method used to control corrosion problem such as the use of coating on surfaces of structure (B.W. Allcock & Lavin, 2003). This is because, most metals are surely cannot be avoid to corrosion, and corrosion can be reduced by using corrosion-resistant or a surface finish. Applying suitable and proper method of paint on fences and gates can ensure the maintenance cost can be reduced effectively. Moreover, selecting suitable metal also can be important things to deal with corrosion problem. This is because selection of metal such as metal that have a high melting points and corrosion resistance also can be great corrosion resistance applications to protect basic materials from unstable conditions (Kumar & Rao, 2017).

1.3 Objectives

1. To compare the mechanical properties of affected fences and gates due to corrosion-environmental factor, which are temperature and humidity.
2. To suggest a wide selection of coatings for future maintenance.

1.3 Project Scope

1. To define the types of corrosion and its environment.
2. To observe and analyze the corroded sample due to temperature and humidity factor.
3. To test the corroded sample for their mechanical properties.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter will discuss about the literature review of corrosion, the parameters involves in corrosion, types and characteristic of material, features of surfaces coating, type of machines used for testing process and theory of testing.

2.1 Effect of Corrosion

Corrosion problems is a dangerous issue, this is because it also can be costly when comes to damages at the structural components which can cause lot of money to be spend on the maintenance. The researcher found that the main critical report by Uhlig in 1949 is that the cost of corrosion to countries is to surely hard to be predicted. It is because corrosion is universal problems which require good understanding to handle them (Roberge, 2008). The effect from corrosion problems sometimes are pitting or grooving over localize nor big spot at the structures. Corrosion that happened on large areas can result a degradation of the plate thickness. In unstressed metal it is less occur sudden failure if compare to stress metal (Ellenberger et al. 2004). More important is their effect which can reduce the cross-section of the component, thus increase mechanical stress and could lead to the mechanical failure (Hattangadi, 2004). Not only in metal component, the corrosion effect also can occurs to concrete structure which also deteriorate when exposed to elevated temperature (Yuan & Li, 2015).

2.2 Class of Metal

2.2.1 Ferrous Metal

Ferrous metal is a metal which there are iron contains in them. The very widely known ferrous metal is the steel. The different between amongst iron and steel is content of carbon they have.

Table 2.1: Composition and Properties of Ferrous Metals (Source: educastur.com)

Name	Composition	Properties
Cast Iron	alloy of iron and 2-5% carbon, 1-3% silicon and traces of magnesium, sulphur and phosphorus	Hard skin, softer underneath, but brittle. It corrodes by rusting.
Mild Steel	alloy of iron and 0.15-0.3% carbon	Tough, ductile and malleable. Good tensile strength
Medium Carbon Steel	alloy of iron and 0.35-0.7% carbon	Strong, hard and tough, with a high tensile strength
High Carbon Steel	alloy of iron and 0.7-1.5% carbon	Even harder than medium carbon steel, and more brittle.
Stainless Steel	alloy of iron and carbon 16-26% chromium, 8-22% nickel and 8% magnesium	Hard and tough, resists wear and corrosion
High Speed Steel	alloy of iron and 0.35-0.7% carbon (medium carbon steel) with tungsten, chromium, vanadium, and sometimes cobalt	Very hard, high abrasion and heat resistance