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Protective Coating: A Strategy for Prevention of Corrosion of Buildings in Universities in Anambra State

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ABSTRACT

The study examined protective coating as a strategy for the prevention of corrosion of buildings in universities in Anambra state. The study adopted a descriptive survey research design One research question and one hypothesis guided the study. The population for the study was 66 respondents; comprising 45 building lecturers and 21 instructors from the building department of two universities in Anambra State. The study was census as the entire population was studied. The instrument for data collection was a structured questionnaire which was subjected to face and content validity by three experts from the Department of Building, Nnamdi Azikiwe University, Awka, Anambra State. The internal consistency of the instrument was determined by using Cronbach's Alpha reliability coefficient method and the instrument had an internal consistency of .74. Copies of the questionnaire were administered to the respondents. The data gathered for the study was analyzed using mean and standard deviation to answer the research question and determine the closeness responses respectively, and t-test in testing the hypotheses at 0.05 level of significance. The findings of the study reviewed that the respondents agreed that protective coating is an effective strategy for the prevention of corrosion of buildings in universities in Anambra State. The study therefore recommended that protective coating methods should be adopted by contractors when building or renovating buildings in universities in Anambra State.

KEYWORDS

corrosion; building; protective coating; university; strategy

INTRODUCTION

The provision, promotion, and sustenance of quality education which is the bedrock of national growth and development is the core mandate of tertiary institutions and more especially the university. The university is a seat of higher learning that houses administrative, academic, and living quarters. It is the body of faculties and departments created to educate people for life, for a profession, and to grant degrees (Abimaje & Baba, 2014). In achieving this lofty responsibility, the university as a center for higher education needs critical assistance such as good road networks and buildings.

Buildings are structures that serve as shelters for man, his properties, and activities. Buildings are properly planned, designed, and constructed to obtain desired satisfaction from the environment. Iyagba (2010) stated that a building is a structure used especially for a dwelling, factory, store, shop, or warehouse. Buildings exist to meet a primary physical need of shelter for man, his goods, his animals, and all the mechanical and electrical equipment he requires for his present-day existence. In addition to meeting this physical need, buildings and well-related groups of buildings may also satisfy man's desire for mental and spiritual satisfaction from his environment.

To achieve these, buildings must be well designed as well as efficiently constructed. A building is essentially a space that is selected from the natural environment and is constructed for a specific use (Aginam et al., 2014). Structures are part of a building and cannot be conceived in isolation but must be conceived as part of the whole architectural design and structural services. Olusola (2012) opined that the structure of the building is that which gives the construction sufficient strength to withstand the loads to which the whole building is subjected. A building structure does this by carrying the load imposed on it and transferring it safely to the foundation. Every university has buildings consisting of classrooms, workshops, laboratories, offices, recreational centers, staff quarters, and business centers. These buildings often experience corrosion a few years after their construction or renovation (Amandeep, 2016).

The word corrosion is derived from the Latin word corrosions; which means eaten away or consumed by degrees; an unpleasant word for an unpleasant process. Corrosion is the degradation of materials‟ properties due to interactions with environments, and corrosion of metals (and many materials for that matter) is inevitable. The fundamental cause or driving force for all corrosion is the lowering of a system's Gibbs energy (Albert, 2014). The corrosion process can be categorized as follows:

(1) Chemical corrosion: This occurs when a metal reacts with dry air or oxygen.
(2) Electrochemical corrosion: This occurs in the presence of an electrolyte.

Considering the mechanism of corrosion, corrosion reaction takes place by two simultaneous reactions: the oxidation of a metal at an anode (a corroded end releasing electron) and the reduction of a substance at the cathode (a protected end receiving electron).

In order for the reaction to occur, the following conditions must exist:

(1) A chemical potential difference must exist between adjacent sites on a metal surface (or between alloys of a different composition),
(2) An electrolyte must be present to provide solution conductivity and as a source of material to be released at the cathode, and
(3) An electrical path through the metal or between metals must be available to permit electron flow.

An electrochemical corrosion of iron in contact with water is an example that can be used to describe the electrochemical reactions. In a nearly neutral or slightly acid environment, the water is dissociated into hydrogen ions (H+) and hydroxyl ions (OH-) as;

$$H2O \rightarrow H+ + OH-$$

When metal is placed in contact with a liquid, surface ionization occurs because of the electric charge difference at the solid-liquid interface. For example, ion dissolves in water in the form of positively charged ferrous ions (Fe2+) where

$$Fe \rightarrow Fe2+ + 2e- \quad (2.2)$$

Electrochemically, a chemical substance is oxidized when it loses electrons to a second substance. The electrode at which oxidation takes place is called anode. The electrode at which reduction takes place is called the cathode. Hence, the oxidation reaction results in the formation of positive charge ferrous ions at the anode. Ferrous ions moving away from the metal surface are further oxidized to ferric ions (Fe3+) as follows:

$$Fe2+ \rightarrow Fe3+ + e- \quad (2.3)$$

The positively charged ferric ions are attracted to the negatively charged hydroxyl ions to form a corrosion product, Fe (OH)3.

$$Fe3+ + 3(OH)- \rightarrow Fe(OH)3$$

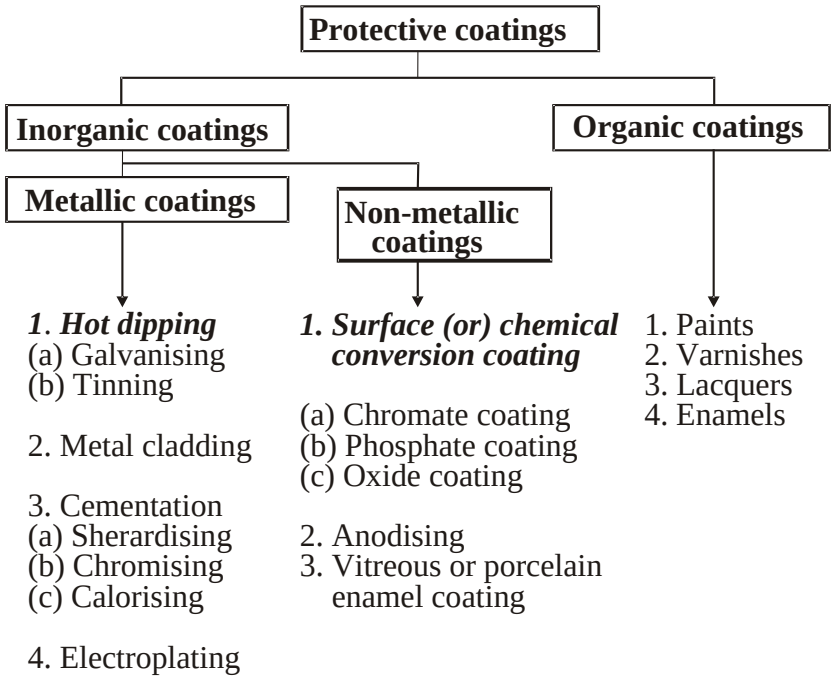
Apart from the presence of moisture and acid, the basic reason for metallic corrosion is that metals have the tendency to revert back to their thermodynamically stable state (Dara, 2000).

Generally, there are different types of corrosion, depending on the metal reactions, geometry, and physical environments. Corrosion occurs in several widely different forms (Trethewey & Chamberlain, 2015; Green & Perry, 2018; Uppal & Bhatia, 2019; Aggarwal, 2020). According to Trethewey and Chamberlain, any corrosion that occurs at preferred sites of metal is described as a selective attack and it includes grain boundary corrosion, intergranular corrosion, microbiologically induced corrosion (MIC), and selective leaching.

The prevention of those forms of corrosion on buildings requires effective construction strategies such as protective coatings.

Protective coatings are a unique method of corrosion control. They are a simple way to reduce corrosion, by limiting the exposure of the metal to a corrosive environment (Prathibha et al., 2012). Protective coatings are used to give buildings long-term protection under a broad range of corrosive conditions, extending from atmospheric exposures to frill immersion in strongly corrosive solutions. Protective solution provides little or no structural (building) strength, yet they provide other materials so that the strength and integrity of a structure can be maintained. Paint is a very common protective coating, but tar, pitch, bitumen, and plastics are also used (Simpeh, 2013). Applying protective coatings, such as paints, sealants, or corrosion-inhibiting coatings, can provide a barrier between the metal surface and the corrosive environment (Yuce & Kardas, 2016). These coatings help prevent direct contact between the metal and corrosive agents, effectively reducing the risk of corrosion with galvanizing methods

Protective coatings are used to protect the metals from corrosion. Protective coatings act as a physical barrier between the coated metal surface and the environment. However, they are also used for decorative purposes. In addition to corrosion protection and decoration, they import some special properties such as hardness, electrical properties, oxidation-resistance, and thermal insulating properties to the protected surface.



Coatings like paints, varnishes, lacquers, and enamels are called organic coatings. They are applied on metallic surfaces for both corrosion resistance and decoration (Adams, 2021).

The base metal surface is usually contaminated with rust, scale, oil, and grease among others. If they are present at the time of coating, it will give porous and discontinuous coatings. Therefore, to get uniform and smooth protective coatings, these substances should be removed by proper pretreatment methods. This is called as pre-treatment of metal surface and they include the following:

(i) Mechanical Method

These methods are useful to remove loose scales and oxides. The various methods are hammering, scraping, wire-brushing sandblasting, etc. Sandblasting is done when a slightly roughened surface is desired. It is the process in which sand or abrasives along with air steam under pressure of 25-100 atm is concentrated on the metal surface.

(ii) Chemical Method

These methods are mainly used for removing oils, grease, and rust among others. The method consists of:

a) *Solvent Cleaning*
Solvents such as alcohols, xylene, toluene, chlorinated hydrocarbons, etc., are generally used in solvent cleaning. This is followed by cleaning with steam and hot water containing wetting agents.

b) *Alkali Cleaning*
In alkali cleaning chemicals like sodium hydroxide tri-sodiumphosphate, sodium silicate, soda ash etc., are used. This is useful in removing oil paints. This cleaning is followed by washing with 1% chromic acid solution.

c) *Acid Pickling*
Acids like H_2SO_4, HCl, HF, H_3PO_4, and HNO_3 in dilute solutions are used for ferrous metals. For non-ferrous metals, HNO_3 with other acids is mainly used. The metals are dipped inside the solution at a higher temperature.

(iii) Electrochemical method

This method according to Admasu (2015). is used where the oxide scales cannot be removed by the other methods. The metal whose surface has to be cleaned is made either anode (Cathode pickling) or cathode (Anode pickling). The electrolyte is usually in an acid solution or an alkali solution on passing a direct current, the dissolution of the oxide scales at anode or cathode takes place.

(iv) Paints

Paints are stable mechanical mixtures of one (or) more pigments. Paint is a dispersion of pigments into the drying oil. the vehicle or drying oil is a film-forming material, to which other ingredients are added in varying amounts. The requisites or characteristics of a good paint are:

1) It should spread easily on the metal surface.
2) It should have high covering power.
3) It should not crack on drying.
4) It should adhere well to the surface.
5) The color of the paint should be stable.
6) It should be corrosion and water-resistant.
7) It should give a smooth and pleasing appearance.
8) It should dry quickly.

One of the important aspects of paint is the pigment volume concentration. Pigment Volume Concentration (P.V.C) of a paint is an important criterion or a guide for the paint manufacturer to prepare paints with desired properties.
Generally, the characteristics of paints depend on the nature and quantities of pigments, extenders, and particles present in the paint (Agus et al., 2019).

Apart from being used for protection from corrosive atmospheres, for decoration, for reflecting away heat, etc., paints have been formulated for special purposes (or) uses are called special paints. Some of the important special paints are as follows;

(i) Fire Retardant Paints

1) These paints contain ingredients like calcium ammonium phosphate, magnesium ammonium phosphate, calcium carbonate, etc.,
2) Under intense heat, they decompose to give CO_2, NH_3, and H_2O for these gases (non-inflammable gases) cover the flame quickly and extinguish the fire. This is mainly used in wooden houses.

(ii) Temperature Indicating Paints

1) This paint contains ingredients like amine salts of copper, iron, manganese, cobalt, and nickel.
2) These substances undergo color changes and indicate a particular temperature.

Owning to the important role buildings play in the universities, it is imperative to adopt a strategy that will prevent it from corrosion.

STATEMENT OF THE PROBLEM

The structural integrity, safety, and maintenance expenses of buildings at universities in Anambra State are seriously threatened by corrosion. The environmental conditions, such as high humidity, coastal proximity, and industrial activities, contribute to the accelerated deterioration of building materials, infrastructure, and equipment due to corrosion (Ghulamullah, et al., 2015). Without a clear understanding of the prevailing corrosion issues and the efficacy of existing prevention methods, these institutions are at risk of incurring increased maintenance costs, compromised structural integrity, and potential safety hazards the long-term economic and operational implications of unchecked corrosion in university buildings are expensive and potentially diverting financial resources from critical educational and research investments. It is therefore important to examine the protecting coating as a strategy for the prevention of corrosion in buildings in universities in Anambra State, hence the study.

Purpose of the study

Specifically, the study sought to examine the use of protective coating as a strategy for the prevention of corrosion in buildings in universities in Anambra State.

Research Question

1. What are the protective coating strategies for the prevention of corrosion of buildings in universities in Anambra State?

Hypothesis

HO_1: There is no significant difference between the mean response of building lecturers and instructors on the use of protective coating as a strategy for the prevention of corrosion of buildings in universities in Anambra State

METHOD

The study adopted a descriptive survey design. The population for the study was 66; which comprised 45 building lecturers and 21 instructors from the two public universities in Anambra State; namely Chukwuemeka Odumegwu Ojukwu University and Nnamdi Azikiwe University. The study was census as the entire population was used for the study. The instrument for data collection was a structured questionnaire titled "Protective Coating and Corrosion Prevention of Building in Universities" (PCCPBU) was used for data collection. The questionnaire was subdivided into two (2) sections, namely A and B. Section A requested information for bio data of the respondents while Section B comprised 10 items to determine the Coating methods used for preventing corrosion. The instrument was structured on five (5) point Likert scale such as Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D) Strongly Disagree (SD) with the corresponding numerical values of 5, 4, 3, 2, and 1 respectively. The instrument of this study was subjected to face and content validity by three experts from the Department of Building, Nnamdi Azikiwe University, Awka, Anambra State.

The reliability of the instrument was established by using the Cronbach Alpha reliability method. Twenty (20) copies of the instrument were administered to lecturers and instructors at Delta State University, which is outside the area of the study but possessed similar characteristics Their responses were used to analyze the research questions using Statistical Package for Social Science version 23.10 (SPSS) to determine the reliability of the instrument; which yielded .74 coefficient index. The researcher through the help of research assistants visited the various institutions and administered questionnaires face-to-face to the respondents. In the end, the researcher along with the research assistants collected the filled questionnaires which indicated the responses of the respondents. The data obtained from the respondents were analyzed using mean, standard deviation, and t-test statistical tools. The mean and standard deviation were used to answer the research question and examine the closeness of responses and t-test statistics were used to test the null hypothesis at the .05 level of significance. To determine the level of decision of each item in relation to the research questions, mean responses up to 3.50 and above were regarded as agree while mean responses below 3.50 were regarded as disagree. Standard deviation value close or wide apart was used to determine homogeneity and heterogeneity in the perception of the respondents. The decision for null hypotheses was as follows: if the calculated value of the (t- cal) was less than the critical value of (t-crit), accept the null hypothesis but if the calculated value of the (t- cal) was greater than or equal to the critical value of (t-crit) at .05 level of significance, then reject the null hypothesis. The computation of the mean, standard deviation, and t-test was carried out with Statistical Package for Social Science version 23.10 (SPSS).

RESULTS

Research Question 1: What are the protective coating strategies for the prevention of corrosion of buildings in universities in Anambra State?

TABLE 1: Mean Responses of building lecturers and instructors on the Protective Coating for preventing corrosion in buildings.

S/N	Items	Building lecturers			Instructors		
		$\bar{x}$	SD	RMK	$\bar{x}$	SD	RMK
1	Powder coating	4.17	76	Agree	3.85	.78	Agree
2	Painting the exterior walls	3.97	.85	Agree	4.13	88	Agree
3	Painting the surfaces of a building	4.61	.70	Agree	4.79	.41	Agree
4	Epoxy coatings	4.77	.42	Agree	4.75	.43	Agree
5	Fire-retardant coatings,	4.53	.86	Agree	4.37	.99	Agree
6	Ceramic coatings.	4.64	.71	Agree	4.47	.80	Agree
7	Anti-graffiti coatings	4.20	90	Agree	4.16	.89	Agree
8	Waterproofing membranes	4.65	48	Agree	4.64	.48	Agree
9	Rust converters	4.76	.43	Agree	4.63	.49	Agree
10	Anti-condensation coatings	4.04	1.01	Agree	4.03	1.00	Agree
	Grand Mean	**4.43**	**0.71**	**Agree**	**4.38**	**0.72**	**Agree**

Table 1 is the result of the mean responses of building lecturers and Instructors on Protective Coating methods used for preventing corrosion in buildings in universities in Anambra states. The table revealed that the respondents agreed on all the items in the table. The mean responses of the building lecturers ranged from 3.97 to 4.77 while the mean responses of the instructors ranged from 3.85 to 4.95. The grand mean of building lecturers and Instructors was 4.43 and 4.38 respectively this exceeded the criterion mean of 3.50; thus, the respondents agreed that the protective coating will be effective for the prevention of corrosion of buildings in universities in the Anambra States. The grand standard deviations of lecturers and instructors which were 0.71 and 0.72 respectively showed that they were homogenous in their responses.

HO_1: There is no significant difference between the mean response of building lecturers and instructors on the use of protective coating as a strategy for the prevention of corrosion of buildings in universities in Anambra State.

TABLE 2: t-test analysis on the Mean Response of Mean Responses of building lecturers and instructors on the Protective Coating methods used for preventing corrosion in buildings.

Respondents	N	$\bar{X}$	SD	Df	T	Sig	P	Decision
Building lecturers	45	4.43	0.71	64	1.55	.122	.05	Accept
Instructors	21	4.38	0.72					

Table 2 is the result of an independent sample t-test comparing the mean responses between the mean response of building lecturers and Instructors on the use of protective coating as a strategy for the prevention of corrosion of buildings in universities in Anambra State. The data revealed that the mean of building lecturers was 4.43 and a standard deviation of .71. For Instructors, the mean of 4.38 and a standard deviation of .72 was obtained. Since the significant value (2-tailed) of .122 exceeded .05 (P>.05) the null hypothesis was accepted. Thus, there is no significant difference between the mean response of building lecturers and instructors on the use of protective coating as a strategy for the prevention of corrosion of buildings in universities in Anambra State.

DISCUSSION OF FINDINGS

The answer to the research question revealed that both lecturers and instructors agreed that protective coating will be effective for the prevention of corrosion of buildings in universities in Anambra State. The finding of the study also revealed that there is no significant difference between the mean responses of building lecturers and instructors on the use of protective coating as a strategy for the prevention of corrosion of buildings in universities in Anambra State. The findings of the study are in harmony with Refat and Ishaq (2013), who stated that cathodic protection is a method to reduce corrosion by minimizing the difference in potential between anode and cathode. This is achieved by applying a current to the structure to be protected (such as a pipeline) from some outside source.

CONCLUSION

Based on the findings of the study. It was concluded that university buildings of any structure suitable for use as classrooms, laboratories, libraries, workshops, and offices among others should be prevented from corrosion through the use of protected coating.

RECOMMENDATIONS

Based on the findings of the study and the conclusion reached, the following recommendations were made

(1) That protective coating method should be adopted by contractors during the construction of buildings in universities.
(2) Protective coating methods should be adopted by contractors when renovating buildings in universities.

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