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AN ASSESMENT OF EFFLORESCENCE AS AN AGENT OF BUILDINGS DESTROYER IN SELECTED BUILDINGS IN OKE OGUN, OYO STATE

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Abstract
Buildings were built with the faith that they will last for a long time. But, the forces of nature and human error conspire to our optimism. This work examined, critically, the overview towards prevention efflorescence as an agent of reducing the strength of building structure and with adequate possible solution. The researcher used Yaro formula to get the number of questionnaires to be distributed to the professionals in the study Area. The study population of the area is 135 and it was collected through their register in various professions. Descriptive and inferential statistic were used, index and ranking method were adopted to find the relationship between the variables obtained. Natural run of water was one of the major factors that causes building efflorescence with 3.17, the respondent rated water table increased in the block presence with 3.15. The impact of efflorescence affect the frequency of building maintenance operation with 3.18 score, the respondents ratio that efflorescence in building reduces the rental value of the building to the tenant because it looks absolute Possible solutions were provided as excavation of trenches to the hard strata, good workmanship. Recommendations made are determined the age of the structure at the time of when efflorescence first appeared, observed the location of efflorescence and examined the condition on the wall e.t.c

Keywords: Efflorescence, Causes, Effects, Prevention, White scum.

Introduction

Background of the Study

The act of growing of salt, crystal on the block wall surface resorted by evaporation of salt-laden water, this is a typical irregularity commonly happens on the surface of block wall, motor and concrete surface.

The water soluble deposited could be alkali sulphates or sodium chloride which generally occurred or appeared after the erection of outward appearance. The salts that are easily brought to this outward resulted to efflorescence. Bower and Winter (2019) opined and deduced the following observations from their research conducted that this irregularity that reduces the strength of block work of any building structure was a recent phenomenon and which appeared on the surface of brickwork in 1980's and which affected the newly erected outward appearance. Secondly, the older outward wall constructed with the similar brickwork did not suffered from the staining. But, this subject matter commonly occurred after a number of years which is contrary to the earlier efflorescence of the soluble substances. The gypsum also affects the outward wall with a high wind-driven rain load but this gypsum observes in both high and low sulphate contents.

In addition, calcium sulphate is the common substances which are present in the building material (Charola, Puhringer and Steiger, 2018). Heritage (2012) observes that gypsum is fairly active with adequate climatic condition changes and does not possibly cause damage with the other chemical substances. It is the major

reasons for inadequate of research activity on gypsum
with the porous materials. Despite the above
observation, gypsum efflorescence has been happening many years back but the physio-chemical procedures at this phenomenon are not well cleared.
Furthermore, efflorescence is a crystalline deposit of chemical substances that is water-soluble salts on block - wall surface. This substance is unavoidable to happen and inconvenience to remove because it is harmful to block – work. It also affects the structural integrity of the wall. Therefore, to allow efflorescence to happen, there are series of vitiating factors that are to be taken into consideration; the aim source of water into the block - wall, soluble substance within the block - wall and early age of a building. Block - wall or cement in mortar could be the source of the efflorescence. In this era of construction, the term efflorescence in known as "building bloom" and it is the major origin in water that is the moisture content during the construction process. The moment the construction is fully completed and moisture content within the building component is totally seasoned or dried off to ambient humidity level there should absence of efflorescence. Therefore, the chemical substance does not affect the wall of any building instantly but the impact would have negative effect on building stability and beautification and structural appearances.
Above all, this chemical substance develops on the facades of porous building materials, which is in form of white scum, fine lose and powdery, with colour impression and appearance varying with severity level (Franke and Graban, 2018).

STATEMENT OF RESEARCH PROBLEM

Most of newly constructed building structures in the study area are seriously affected with the chemical substances and durability of both superstructure and substructure components are weaken and age of building structure are tampered. Therefore, there is need to work on the effects and possible solution to reduce the agent of the building destroyer.

RESEARCH QUESTIONS

This research work provides adequate answers to the following questions:

i. What are the causes of chemical substances in building structure?
ii. What are the effects or impacts of chemical substance in building structure?
iii. what are possible solution to reduce the effects of the chemical substance in building structures?

AIM

The aim of this research paper is to assess the major effects of efflorescence as an agent of building destroyer with view to reduce the chemical substance in building structure. This can be achieved through the following objectives:

i. identify the causes of the chemical substances on building structure?
ii. assess the effects of it on building structure in the study area
iii. Proffer possible solution to arrest the chemical substances in building industry.

CONCEPTUAL LITERATURE REVIEW

The origin of efflorescence – calcium sulphate chemical substance at facades of block - wall requires a source or origin of calcium sulphate in the block wall. The calcium sulphate can be obtained either through ceramic block / sandcrete or concrete block or cement mortar. It can take place in three different mineral forms: hydrated calcium sulphate, bassinette (an evaporate, consisting of calcium sulphate, found at Vesuvius) and anhydrite (an evaporate mineral made of anhydrous-calcium sulphate) which are respectively the hydrates whose solid contains two molecules of water of crystallization per molecule, or per unit cell (dehydrate) CaS04.2H20), hemihydrates CaS04.05H20 and anhydrous (CaS04) forms.
The minerals that consist of hydrated calcium sulphate and anhydrous – calcium sulphate present in block – walls. It is important to differentiate between the two minerals that are formed. In relating to the normal circumstance, gypsum is the most stable calcium sulphate mineral structure, which explains its effectiveness on the chemical substance. The act of converting to anhydrite happens at a measure of cold or heat above 350^0c (Kuntze, 2018).

Sandcrete concrete block is an origin of effloresces. The hydrates of Cas04 calcium sulphate with the ceramic blocks are the origin or source at which the initial calcium sulphate with the clay mixture. The high heat reactions would take place at the time the sandcrete concrete block passes high temperature. At the initial case, the calcium sulphate absorbs the time of firing, in as much the typical sandcrete block burning heat of 950-1055^{0}c are below the calcium sulphate disintegrate or fragment heat of 1200 – 1300^{0}c. Above all, this is structured with the reaction between calcium, bound as carbonate or more francium oxide, plus sulphates, structured by sulphide oxidation (e.g. the common mineral iron disulfide (FeS_2) disintegrate) or directly accomplish within the flue gases. (Vogt &Tatarin, 2013). The no contingent reaction path deals with the last calcium sulphate mineral structure present in the ceramic block is anhydrite that gives the high burning heat.

Mortar: As an origin of $CaS0_4$ calcium sulphate is one of the raw materials or additive agent structured together to produce Portland cement in order to control the setting properties of cement. This chemical substance acts with tracalciumsulphate (C3A). With reference to research work conducted by Heritage 2012, opines that a minor of sulphate can be factorized with the CSH phase.

With the both calcium sulphate and tricalcium aluminate ($CaS0_4$ + C3A) could structured in two series; the ettringite which initially structured can reacts into mono sulphate. Initially, the calcium sulphate added did not carefully think about as an efflorescence that engineer, due to ettringite and mono sulphate that cannot be broken down or dispersed (Mac Gregor & Melander, 2019). The synthetics ettringite does not undergo carbonation when it has been opened to $C0_2$, disintegrating return to gypsum and other minerals. Mono sulphate is more permanent than ettringite, and to disintegrate (Taylor, 2017). The carbonated mortar is more currently unrealized origin of calcium sulphate, an hypothesis originally projected by (Brocken and Nijland, 2018). Therefore, the reality at which the mortar joint carbonation rated is shown between 0.07-1.22mm per year (Pade and Guimaraes, 2007).

CLASSES OF EFFLORESCENCE

The major classes of efflorescence are basically on the period of appearance, primary and secondary efflorescence. The primary efflorescence is usually appeared during the initial age, between 17 to 40 days after the services. Therefore, secondary efflorescence are usually discovered or appeared between 9 months to some years. This could be seen on the walls inform of white scum. This is due to application of water, moisture, rain and dew or drainage dry on the walls. (Allahverdi, 2015). The efflorescence formed on the block - walls through the primary and secondary formation above analysis are weakening the walls. Chin and Petry (2016) opines with the chemical compound / mixture analysis of efflorescence deposited 43 sandcrete block samples gathered from 24 projects in the United State of America. Therefore, the results from data obtained showed that 55% contained soluble sulphate while 48% comprised calcium carbonate. Secondly, another research shows that the efflorescence on the wall contained sulphate salts or calcium carbonates after the thorough experimentation of 22 cases of sandcrete concrete bricks and blocks in Netherlands (Brocken &Nijland, 2018). Above all, the block wall/brick wall and surrounding area can be the origin for this soluble composition that increases the formation of the efflorescence

Table 1.1: Chemical Agents of Efflorescence

Mineral	Chemical Compound
Calcium cabornate	$CaC0_3$
Sodium sulphate	$Na2S0_4$
Potassium sodium sulphate	$K_3Na(S0_4)^2$
Calcium sulphate Dihydrate	$CaS0_4 – 2H_2^0$
Magnesium Sulphate Hydrates	$MgS04 – 6H_2^0$
Potassium Chloride KCL	$MgS0_4 – 7H_2^0$ and
Sodium Chloride Nacl	$MgS0_4 – 4H_2^0$
Sodium Hydrogen Carbonate Hydrate	$Na3H (C0_3)$ 2-$2H_2^0$

Source: Freyer (2018).

It was observed initially that calcium carbonate was the only chemical substance that form efflorescence which begin the leaching of the cement hydration product $Ca(OH)_2$ CH. But, dissolvent of CH was carried together with pure water to the service surface, at the place it reacted simultaneously with $H2C0_3$ (dissolved the $C0_2$) to building the insoluble salt $CaC0_3$ (Aberle, 2019; Allahverdi, 2015). The CH concentration slope or incline/declination of a slope transporting will drive more interior CH to move toward the reaction surface (Moukwa & Vickers, 2019). Though the smallest aggregate of material of CH would eventually used to fire a gum to structure the visible white scum (Kresse, 2009); Allahverdi, 2015). $Ca(0H)_2 + C0_2 + CaC0_3+H_20$

In other words, the reaction occurs only in the presence of liquid water, presented by (Kompatscher, 2007).

OTHER SOLUBLE SALT PLUS SULPHATE

The other soluble salt and sulphate are also based efflorescence in line with calcium carbonate. It was discovered that chloride and nitrate salts produce efflorescence to the surface of wall (Dow and Glasser, 2019). A mixture such as anhydrite, gypsum and hemihydrates are some of the chemicals that are used to manufacture cement and they are the origin of sulphate (Brocken and Nijland, 2018). But, the components of chloride efflorescence can emanate from:

1. Salt or brine that is from sea water which contain chlorine (hydrochloric acid)
2. The accelerant that is anti-freeze compounds in mortar.
3. Sand washed in seawater or ocean – side environment (Groves, 2018)

Above all, deposited salt such as sodium and potassium sulphate are quickly soluble, but it can be washed away by the natural weathering.

RESEARCH METHODOLOGY

The population used in this study work is purely the professionals and also the stakeholders in the building industry. The populations of the study are the Architects, Quantity Surveyors, Builders, Engineers, Consultants, Client and end users of the building.

The sample frame was done to ascertain the construction industry in study Area and sample size formula was used to determine the number of respondents to be selected. The formula was employed using a sampling population of 135 respondents which are randomly selected in the study Area. The sample size for this study was obtained from the register of their various professional bodies. The researcher used Yaro formula to get the number of questionnaires to be distributed to the professionals in the study Area. Therefore, 100 respondents constitute the sample size for the study with the application of the formula below:

$$n = \frac{N}{1 + N(E)^2}$$

Where:

n - Sample size

N - Population of the study

E - Tolerance error

$$n = \frac{N}{1 + N(E)^2}$$

$$n = \frac{135}{1 + 135(0.05)^2}$$

$$n = 100$$

Proportionate sampling technique of ratio 2:3:5 were adopted to allocate the questionnaire to the three senatorial districts Oyo North, Oyo South and Oyo Central due to variation number of the each Local Government within the each senatorial district respectively in Oyo State One Hundred (100) questionnaires were distributed to the three senatorial districts. Data for this study work were retrieved from both the primary and secondary data sources. The information obtained from the survey through the well-structured questionnaires and published information which established conceptual review and modify the research questions. The questionnaires were thoroughly designed in line with the objectives also with the use of Liker scale. With this indications 5 - strongly disagree, 4-disagreed, 3 - none 2 - agree and 1- strongly agree. The questionnaires are of two sections. The section A is based on the socio cultural background of the respondent while section B is based on causes, effects and solution to efflorescence in the building industry in Oyo State.

In looking out relationship between the two variables and the data collected from the respondents descriptive and inferential statistics were adopted to analysis the raw data collected and find out the percentile method, relative index and ranking method.

Percentile Method (%) – $\frac{\sum fx}{\sum F}$

$\sum fx$ = Summation of product of score and frequency

$\sum fx$ = Total frequency

Relative index RII

Where RII = relative index

P_i = respondent rating

N = Sample Size

u_i = number of respondent placing weighting

n = the highest attained score

DATA ANALYSIS AND PRESENTATION

One hundred (100) questionnaires were distributed to the respondents. The researcher recovered 96 questionnaires from the respondents. Therefore, the result analysis obtained for this research work was based on 96 respondent's contributions.

Table 1: Questionnaire Distributed and Retrieved

Profession	Frequency	Percentage
Architect	16	16.6
Builder	28	29.2
Estate Agents	4	14.6
Project Manager	23	24.0
Others	15	15.6
Total	**96**	**100.0**

Source: Field Survey 2024

The following occupations of the respondents were as follows with their frequency distribution and percentage: Architect 16.6 % , builder 29.2%, Estate value 14.6%, project manager 24% , and while the others is 15.6%. The Builder that dominated the study area was due to the fact that tertiary institution dominated the area and this increased the economic growth of the study area.

Table 2: Respondents level of efflorescence recognition

Knowledge on efflorescence	Frequency	Percentage (%)
Yes	90	93.75
No	6	6.25
Total	**96**	**100.0**

Source: Field Survey, 2024.

Table 2 indicates the level at which the respondents have heard the knowledge about the efflorescence, with the table above, this implies that 6.25% have not heard the knowledge on the efflorescence.

Causes of Efflorescence with the Building Structure in the Study Area

Table 3: Shows factors that result to efflorescence in building.

Cause	Architect Index	Builder Index	Estate Index	P. Manager Index	Others Index	Average Index	Rank Index
Natural rum of water	3.24	3.17	3.31	3.27	2.87	3.17	1
Water table increase	2.93	3.13	3.23	3.23	3.15	3.17	2
Moisture presence in sandcrete block	3.17	3.29	3.11	3.29	2.94	3.14	3
Inadequate system of a drainage	3.11	3.27	3.08	3.28	2.89	3.13	4

Watery concrete construction	3.17	3.32	3.06	3.19	2.84	3.12	5
Concrete mix with bad water	3.13	3.14	3.21	3.09	2.99	3.11	6
Poor workmanship	3.10	3.10	3.31	3.19	2.79	3.10	7
Salty water for plastering & rendering	3.07	3.06	3.16	3.14	2.97	3.08	8
Monitor admixture added to concrete	3.09	3.11	3.22	3.16	2.79	3.07	9
Presence of iron oxide on surface	3.09	3.09	3.12	3.16	3.87	3.06	10

Source: Field Survey, 2024.

From the table 3, the raw data collected from the respondents were analyzed; it was revealed that natural run of water was one of the major factors that causes building efflorescence with 3.17, the respondent rated water table increased in the block presence with 3.15 which admixtures added during the concrete productivity was rated third with 3.14. This implies that run of water has negative impacts to the building structure most especially when the surface does not dry within some few minutes.

Impacts Efflorescence in Building Structures

Table 4: Shows the impacts of efflorescence in building

Cause	Architect Index	Builder Index	Estate Index	P. Manager Index	Others Index	Average Index	Rank Index
Maintenance frequency affected	3.20	3.10	3.31	3.29	2.99	3.18	1
Reduces the rental value of the building	3.10	3.20	3.51	3.09	2.89	3.16	2
Affect monetary while of the building	3.17	3.30	3.18	3.19	2.79	3.13	3
Maintenance costs increase	3.10	3.13	3.11	3.09	2.99	3.08	4
Affect aesthetic value of building	3.09	3.11	3.12	3.06	2.99	3.07	5
Causes discolouration	3.09	3.09	3.12	3.06	2.97	3.6	6
Strength of the plastering affected	3.07	3.06	3.11	3.04	2.84	3.03	7

Source: Field Survey, 2024.

In table 4, the responses indicated that the impact of efflorescence affect the frequency of building maintenance operation with 3.18 score, the respondents ratio that efflorescence in building reduces the rental value of the building to the tenant because it looks absolute, while the third impact was rated by the respondent that efflorescence in the building affects the monetary value of building property with mean scores of 3.13.

Remedies to Efflorescence in Buildings

Table 5: This table Shows remedies to efflorescence in building.

Cause	Architect Index	Builder Index	Estate Index	P. Manager Index	Others Index	Average Index	Rank Index
Digging of tremens	3.29	3.25	3.27	3.16	2.78	3.15	1
Fair workmanship and supervision	3.17	3.21	3.16	3.19	2.96	3.13	2

Use of good materials in line with specification	3.15	3.14	3.21	3.09	2.99	3.12	3
Provision of drainage system	3.19	3.09	3.12	3.16	2.87	3.09	4
Accurate feasibility study	3.11	3.12	3.11	3.10	2.94	3.07	5

Source: Field Survey, 2024.

The table 5 above revealed that the trench drying with hard strata layer is the most common tools that can arrest the situation of efflorescence in building with average score of (3.18). In the same direction, good workmanship performance, through supervision and monitoring with average score of (3.13). In addition, the use of good materials and in line with specification is also required while provision of adequate drainage system and feasibility study were ranked 4th and 5th respectively with (3.09) and (3.07)

DISCUSSION ON FINDINGS

Reference to the stated objective above which were fully addressed below are:

i. Identify the causes of efflorescence in building.
ii. Assess the impacts of efflorescence on building structure.
iii. Identity the possible remedies actions to arrest the efflorescence in building from the above findings.

The first objective was achieved as indicated in the table 1.3 and it was revealed that run of water was ranked above other factors. Secondly, increase in water table and presence of moisture in the Sand creates or concrete blocks were respectively ranked as the second factors. If the presence of water on the building were left dried, it would lead to the peeling off the paint also; the wall plastered would be affected by increasing the rate of the efflorescence in the building.

The second objective was to assess the effect of efflorescence on the building structure. The objective was achieved in table 1.4 as the respondents ranked the frequency of maintenance to be the first effect of efflorescence. Reduction in the rental/leasing value of building property was ranked second respectively. Due to schedule plan of work, efflorescence effect of the maintenance works on the building need to be carried out annually.

Thirdly, table 1.5 revealed the tried objectives which identify the remedial actions at which the efflorescence in building structure can be rectified, the following solutions were provided by the respondents. Excavation of trenches to the hard strata was ranked first followed by good workmanship and supervision, using of standard materials and compliance with specification were also ranked respectively by the respondents.

CONCLUSION

The presence of soluble salts and content of moisture requires efflorescence in building. This was achieved through the stated objectives which identified the causes, effect/impact of it in building and proffer the possible solution to minimize or reduce the effect of this efflorescence in building.

Also, information and suggestion provided on the research work were based on the available data provided.

RECOMMENDATIONS

The following recommendations were made based on the results of the data analysis of the research work:

i. Age of the building structure should be determined with the time at which the efflorescence first occurred. If it is new building structure that is less than a year the source of it is the cement in the mortar. But if the building is over a year old, the detail of construction should be fully investigated to understand the possible leakages in the wall.
ii. Location of the efflorescence in the building should be identified to know the exact area at which water is entering to the building which is resulting to efflorescence.
iii. Examine the quality of workmanship based on nature of composition and deterioration of mortar joint both sills and coping should be noted carefully because they can accommodate passage of moisture in construction work.
iv. There should be a periodic maintenance to check both the wall section details, roof to determine the repair of maintenance of the building in order to avoid efflorescence.
v. Ensure that laboratory reports should be made available on construction materials.

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