KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF ENGINEERING

DEPARTMENT OF CHEMICAL ENGINEERING

WATER SEEPAGE IN WALLS IN KASOA

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ACKNOWLEDGEMENT

My biggest gratitude goes to God for giving me the strength and ideas to carry on when I felt there was no hope. I would also like to thank my family for their support and encouragement. I am grateful to the Head of Operations of Skidcom Company (the sole distributors of Xypex products in Ghana), Vivian Obuobi, for her immense help. Finally, I would like to thank the staff of Deluxy paint for their assistance.

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ABSTRACT

This project looks at water seepage in walls which is a great concern to the Kasoa community and has been a problem for many years. The root cause was discovered to be the high water table as well as the high salinity of water in the community. Research showed that changes need to be made to the concrete mix used to put up walls and buildings in order for the problem to be solved. Coatings are also made available to be applied to walls and buildings at the footing level to stop the problem in walls and buildings that have already been put up and are facing this problem.

INTRODUCTION

Engineering is the art of making practical application of the knowledge of pure sciences, such as physics or chemistry, as in the construction of engines, bridges, buildings, mines, ships and chemical plants (Word Reference, 2017).

The course, Engineering in Society, CENG 291, helps students appreciate the practical nature of engineering. It aims at educating engineering students on the fact that the course goes beyond classroom work to finding solutions to everyday problems in society. It prepares students to be more aware of problems within their communities and to seize opportunities to solve these problems (Kwame Nkrumah University of Science and Technology, 2011).

There are a number of problems facing my community. The most prominent however, is ***Water Seepage in Walls*** which I have chosen to focus on. It is a problem that has been of great concern to inhabitants of my community.

The word *seepage* as described by the dictionary is the slow escape of a liquid or gas through porous materials or small holes. Water seepage in walls can therefore be defined as the slow escape of water into concrete walls. Water is able to seep into concrete walls because of the pores in the concrete used to put up the buildings. The word slow in the definition is significant as the seepage occurs over a long period of time and when it is finally noticed, much damage is caused to walls and buildings. Indications of seepage may be seen in the peeling off of paint from walls (Fig 4, Fig. 5 & Fig. 6) and damp patches on the walls (Fig. 1, Fig.7, Fig.8 &Fig.9).

AIMS AND OBJECTIVES

This project aims at finding the root cause of water seepage in walls and to develop a workable solution in order to reduce this occurrence to the barest minimum in my community.

MATERIALS AND METHODS

Problem identification

This problem was identified mainly by observation. In the process of looking around and touring my community, I was struck by how old relatively newly painted walls looked. Also, the patches of water that I discovered on almost every building were a very unpleasant sight. Although these are among the reasons why I decided to look into this problem, my main reason is the many different solutions people are desperately trying out which have not been very effective. Instead of finding solutions to the problem, many people have settled for solutions which manage to hide the problem without solving it. A typical example is the cladding of walls (Fig. 2 & Fig. 3). (From research, I concluded that chemical engineers have a big role to play in solving this problem, hence, my decision to look into it.)

Preparation of the map

Preparing the map of my community was made easy with google maps which provided the map I needed.

Collection of data

I obtained in-depth knowledge of the problem with the help of the internet through a number of useful sites.

Verbal interviews were also conducted with a couple of companies in order to affirm information from the internet and gain further insight and practical knowledge.

The problem was captured by taking pictures during fieldwork to provide evidence of the problem for a deeper understanding of it.

RESULTS AND DISCUSSION

Description of my community (Kasoa)

Kasoa is a peri-urban town in the Awutu Senya East Municipal District of the Central region of Ghana.

Kasoa spans three of the territories in the twenty Metropolitan, Municipalities and Districts (MMADs) in the Central Region of Ghana. These are the Awutu Senya district, Awutu Municipal district, and Awutu Senya East Municipal Assembly (ASEMA). It is the second largest town in these districts, second only to Winneba. The town is situated along the Accra-Cape Coast Road, approximately 36 kilometres by road, west of Kotoka International Airport, the International Airport that serves Ghana's capital city of Accra. Kasoa is approximately 28 kilometres by road, west of the central business district of the city of Accra. Kasoa is a fast growing town with a population of about seventy thousand (Nyasulu, 2012).

(Map data, 2017)

Nature and characteristics of the problem

Research has shown that water seepage has three main causes. These are condensation, rain penetration and rising damp. My community happens to be faced with the problem of rising damp. This is as a result of the high water table in the community as well as the high salinity of the water.

Rising damp is the common term for the slow upward movement of water in the lower sections of walls (Fig. 1) and other ground-supported structures by capillary action. Although rising damp of up to 5 metres in height has been observed, the height of rise is typically much lower and is rarely above 1.5m. Rising damp has been a widely observed phenomenon for at least two hundred years. There is also strong evidence to suggest that it was a problem understood by the Romans and Ancient Greeks. To explain further, rising damp occurs when ground water travels upwards through porous building materials such as brick, sandstone, or mortar, much in the same way that oil travels upwards through the wick of a lamp. The effect can easily be seen by simply placing a piece of porous brick, stone, or mortar in a shallow tray of water and observing how the water is absorbed into the porous material and is transported above the water line.

Rising damp can be identified by a characteristic "tide mark" on the lower section of affected walls. This tide mark is caused by soluble salts (particularly nitrates and chlorides) contained in the groundwater. Due to the effects of evaporation these salts accumulate at the "peak" of the rising damp (Trotman, Sanders, & Harrison, 2004).

How rising damp occurs

According to Jurin's law the maximum height of rise is inversely proportional to the capillary radius. Taking a typical pore radius for building materials of 1 μm, Jurin's Law would give a maximum rise of about 15 m, however, due to the effects of evaporation, in practice the rise would be considerably lower (Barozzi & Angeli, 2014; Trotman et al., 2004)

A physical model of rising damp was developed by Christopher Hall and William D Hoff in their paper "Rising damp: capillary rise dynamics in walls". The analysis is based on experimentally well-established properties of porous building materials and the physics of evaporation from building surfaces. Hall and Hoff show that the model can be used to predict the height to which damp will rise in a wall. The height of rise depends on the wall thickness, the sorptivity of the wall structure and the rate of evaporation (Hall & Hoff, 2007). Further work has confirmed experimentally the importance of mortar properties in determining the height to which damp will rise in walls. *BRE Digest* 245 lists several factors that can influence the height of the rise including rate of evaporation from the wall, pore sizes of the masonry, salt content of the materials and the soil, groundwater and degree of saturation, and use of heating within the property. The effect of seasonal variations in evaporation rate on the height of moisture rise have been comprehensively described.

A review of data and publications commissioned by the Property Care Association and carried out by the University of Portsmouth concluded that "Rising damp is an age-old and ubiquitous problem." It also noted that "Records on observation and descriptions on this phenomenon date back to early times. It was identified as a public health issue in the second half of the 19th Century." (Trotman et al., 2004)

Signs and effects of water seepage

Common signs of water seepage include:

- Poor indoor air quality
- Mould growth and mildew
- Rusty appliances
- Bowing, cracking or leaning walls
- Foundation settlement
- Water stains on walls or floors
- Soft spots on walls
- Efflorescence
- Musty or strange odor
- Insect infestation or pest invasion
- Wall crack seepage
- Peeling paint
- Wet, damp walls (Matthews, 2016)

Effects of water seepage are far reaching. Water Seepage tends to cause secondary damage to a building. The unwanted moisture enables the growth of various fungi in wood, causing rot or mould health issues and might eventually lead to sick building syndrome. Plaster and paint deteriorate and wallpaper loosens. Stains, from the water, salts and mould, mar surfaces. The highest airborne mould concentrations are found in buildings where significant mould infestation has occurred, usually as a result of severe water intrusion or flood damage. Moulds can grow on almost any surface and occur where there is a lot of moisture from structural problems such as leaky roofs or high humidity levels. Airborne mould concentrations have the potential to be inhaled and can have health effects. Health concerns around mould include infections, allergenic or immunological illness, and nonallergic illness. Asthma is also triggered by the sensitization of dust mites accruing humid, wet regions of a structure. Another health effect associated with structural dampness is the presence of bacteria in an indoor environment

Externally, mortar may crumble and salt stains may appear on the walls. Steel and iron fasteners rust. It may also cause a poor indoor air quality and respiratory illness in occupants. In extreme cases, mortar or plaster may fall away from the affected wall.

Relation between Problem and Chemical Engineering

This problem must be tackled from the roots instead of waiting till it gets unbearable and then looking for ways to cover it up.

Talking about preventive solutions takes us to the cement and concrete used to build the walls. Chemical Engineers play a major role in the cement industry. The role of a chemical engineer in the cement industry spans the very first units, all the way to packaging.

Unlike most industries, cement manufacturing is completely dominated by mechanical operations with only one partially chemical step. Yet, these mechanical operations fall under the realm of chemical engineering.

The various operations are:

1. Sizing of raw material
2. Mixing of raw material in proper amounts

3. Ensuring homogeneity
4. Meeting size requirements
5. Calcination
6. Separation based on particle size
7. Recycle of undesirably sized particles
8. Storage
9. Control of dust in the air

Each of these operations, except calcination - which is a process can be designed only by a chemical engineer, who knows the mechanics, economics and technology to optimally run all these units. (Kumar, 2011)

Since the problem needs to be attacked from the roots, we must go back to the cement and concrete industries. Chemical engineers are therefore crucial in the development of a solution for water seepage in walls.

Chemical Engineering

Chemical Engineering involves the design and maintenance of chemical plants and the development of chemical processes for converting raw materials or chemicals into valuable forms including those to remove chemicals from waste materials, to enable large-scale manufacture. It combines knowledge of Chemistry and Engineering for the production of chemicals and related by-products.

Chemical engineering is the branch of engineering that deals with chemical production and the manufacture of products through chemical processes. This includes designing equipment, systems and processes for refining raw materials and for mixing, as well as compounding and processing chemicals to make valuable product. Chemical engineers apply the principles of chemistry, biology, physics, mathematics as well as mechanical and electrical engineering to solve problems that involve the production or use of chemicals, fuel, drugs, food and many other products. Some may specialize in a particular field, such as nano materials, or in the development of specific products. Chemical engineering jobs fall into two main groups: industrial applications and development of new products. Chemical engineers may spend time at industrial plants, refineries and other locations, where they monitor or direct operations or solve on-site problems. This branch of engineering is a varied field, covering areas from biotechnology and nanotechnology to mineral processing. It covers various fields of chemical technology in mineral based industries, petrochemical plants, pharmaceuticals, synthetic fibres, petroleum refining plants etc.

Chemical Engineers, the most versatile of all engineers, involve the invention, development, design, operation and management of processes in industries. They combine the work of several fields such as those of chemists, industrial engineers, materials engineers as well as electrical engineers. Chemical engineers are responsible for the availability of modern high-quality materials that are essential for running an industrial economy. They design equipment and operate chemical plants as well as determine the problems and find the best methods of production.

Manufacturing industries that employ chemical engineers include petroleum refining, plastics, paint, batteries, agricultural chemicals (fertilizers, pest control and weed control), explosives, textiles, food processing, consumer products (cleaning, personal care, lawn care) and pharmaceuticals as well as chemical manufacturers that supply products to countless other industries. (Edurena, 2016; Lucas, 2014).

Solution Using Chemical Engineering

The solution to the problem of water seepage in walls will be divided into two parts.

First of all a method used to prevent water seepage in walls that are yet to be built will be looked at, which is a preventive measure.

However, the question that arises is what to do if the walls have already been built and rising damp occurs. Is there is no solution in this case? There is definitely a solution. A curative solution would therefore be developed with respect to the second case.

CASE 1 - Walls that are yet to be put up

At this stage, the concrete should be made waterproof in order to avoid the atrocity of rising damp when this waterproof concrete is used to build walls. In order to make concrete waterproof, chemical admixtures must be added to it during manufacturing in the right proportions so as to prevent water seepage when it is used to build walls. The properties of a concrete mix are very much determined and influenced by the admixtures used, so chemical engineers have a role in the decision making process of the admixtures to be used in a given concrete mix for a given structure.

Chemical admixtures are the ingredients in concrete other than portland cement, water, and aggregate that are added to the mix immediately before or during mixing. Producers use admixtures primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete; to ensure the quality of concrete during mixing, transporting, placing, and curing; and to overcome certain emergencies during concrete operations.

Successful use of admixtures depends on the use of appropriate methods of batching and concreting. Most admixtures are supplied in ready-to-use liquid form and are added to the concrete at the plant or at the jobsite. Certain admixtures, such as pigments, expansive agents, and pumping aids are used only in extremely small amounts and are usually batched by hand from premeasured containers.

The effectiveness of an admixture depends on several factors including: type and amount of cement, water content, mixing time, slump, and temperatures of the concrete and air. Sometimes, effects similar to those achieved through the addition of admixtures can be achieved by altering the concrete mixture-reducing the water-cement ratio, adding additional cement, using a different type of cement, or changing the aggregate and aggregate gradation. (Portland Cement Association, 2017).

Research shows a company, Xypex, which is known for making admixtures (Xypex Admix) to solve the problem of rising damp and wall seepage in general.

Xypex is a unique chemical treatment for the waterproofing, protection and improvement of concrete. XYPEX ADMIX C-1000 is added to the concrete mix at the time of batching. Xypex Admix C-1000 consists of Portland cement, very fine treated silica sand and various active, proprietary chemicals. These active chemicals react with the moisture in fresh concrete and with the by-products of cement hydration to cause a catalytic reaction which generates a non-soluble crystalline formation throughout the pores and capillary tracts of the concrete. Thus the concrete becomes permanently sealed against the penetration of water or liquids from any direction. The concrete is also protected from deterioration due to harsh environmental conditions.

Xypex Admix C-1000 must be added to the concrete at the time of batching. The procedures for addition will vary according to the type of batch plant operation and equipment as follows:

1. Ready mix plant - dry batch operation

   In this procedure, Xypex Admix is added in powder form to the drum of the ready-mix truck, the ready-mix truck is then driven under the batch plant and the balance of the materials added in accordance with standard concrete batching practices. Materials are mixed for a minimum of five minutes to ensure that the Xypex Admix has been thoroughly dispersed throughout the concrete.

2. Ready mix plant - central mix operation

   Xypex Admix is mixed with water to form a very thin slurry.The required amount of material is poured into the drum of the ready-mix truck. The aggregate, cement and water should be batched and mixed in the plant in accordance with standard practices, taking into account the quantity of water that has already been placed in the ready-mix truck. The Admix slurry is poured into the truck and mixed for at least five minutes to ensure even distribution of the Xypex Admix throughout the concrete.

3. Precast batch plant

   Xypex Admix is added to the rock and sand, then mixed thoroughly for 2 - 3 minutes before adding the cement and water. The total concrete mass should be blended using standard practices.

   For all three procedures, it is important to obtain a homogeneous mixture of Xypex Admix with the concrete. Admix powder should not be added directly to wet concrete as this may cause clumping and thorough dispersion will not occur. (Xypex, 1997)

CASE 2 - Already built walls experiencing rising damp

Xypex Crystalline Technology provides a solution to this problem by the development of other products. These products are Xypex Concentrate and Xypex Modified.

Xypex Concentrate is the most chemically active product within the Xypex Crystalline Waterproofing System. When mixed with water, this light grey powder is applied as a cementitious slurry coat to above ground or below ground concrete, either as a single coat or as the first of a two-coat application.

Xypex Modified can be applied as a second coat to reinforce Xypex Concentrate, or applied by itself to damp-proof the exterior of foundation walls. Applied as a second coat, Xypex Modified chemically reinforces Xypex Concentrate where two coats are required and produces a harder finish. Where damp proofing is required, a single coat of Xypex Modified may be used as an alternative to a spray/tar emulsion.

Xypex prevents the penetration of water and other liquids from any direction by causing a catalytic reaction that produces a non-soluble crystalline formation within the pores and capillary tracts of concrete and cement-based materials. (Xypex, 2000b)

The following steps must be followed in the application of Xypex Concentrate:

1. Surface preparation

   Concrete surfaces to be treated must be clean and free of laitance, dirt, film, paint, coating or other foreign matter. Surfaces must also have an open capillary system to provide "tooth and suction" for the Xypex treatment. If surface is too smooth or covered with excess form oil or other foreign matter, the concrete should be lightly sandblasted, water blasted, or etched with muriatic (HCL) acid.

2. Structural repair

   Cracks, faulty construction joints and other structural defects should routed out to a depth of 37 mm and a width of 25 mm. A brush coat of Xypex Concentrate is applied as described in steps 5 & 6 and allowed to dry for 10 minutes. Cavities should be filled by tightly compressing Dry-Pac into the groove with pneumatic packing tool or with hammer and wood block. Dry-Pac is prepared by mixing six parts Xypex Concentrate powder with one part water to a dry, lumpy consistency.

3. Wetting concrete

   Xypex requires a saturated substrate and a damp surface. Concrete surfaces must be thoroughly saturated with clean water prior to the application so as to aid the proper curing of the treatment and to ensure the growth of the crystalline formation deep within the pores of the concrete. Excess surface water must be removed before the application. If concrete surface dries out before application, it must be re-wetted.

4. Mixing for slurry coat

   Xypex powder should be mixed with clean water to a creamy consistency in the following proportions: For brush application 0.65 - 0.8 kg/m^2 5 parts powder to 2 parts water 1.0 kg/m^2 3 parts powder to 1 part water. For spray application 0.65 - 0.8 kg/m^2 5 parts powder to 3 parts water (ratio may vary with equipment type). Do not mix more Xypex material than can be applied in 20 minutes. Do not add water once mix starts to harden. Hands should be protected with rubber gloves.

5. Applying xypex

   Xypex should be applied with a semi-stiff nylon bristle brush, push broom (for large horizontal surfaces) or specialised spray equipment. The coating must be uniformly applied and should be just under 1.25 mm. When a second coat (Xypex Concentrate or Xypex Modified) is required, it should be applied after the first coat has reached an initial set but while it is still “green” (less than 48 hours). Light pre-watering between coats may be required due to drying. The Xypex treatment must not be applied under rainy conditions or when ambient temperature is below 4ºC.

6. Curing

   A misty fog spray of clean water must be used for curing the Xypex treatment. Curing should begin as soon as the Xypex has set to the point where it will not be damaged by a fine spray of water. Under normal conditions, it is sufficient to spray Xypex-treated surfaces three times per day for two to three days. In hot or arid climates, spraying may be required more frequently. During the curing period, the coating must be protected from rainfall, frost, wind, the puddling of water and temperatures below 2ºC for a period of not less than 48 hours after application. If plastic sheeting is used as protection, it must be raised off the Xypex to allow the coating to breathe. Xypex Gamma Cure may be used in lieu of water curing for certain applications. (Xypex, 2000a)

FIGURES

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig.9

CONCLUSION

Water seepage in walls was discovered to be a major problem in Kasoa. It occurs as a result of the high water table and the high salt content of water in the community. This type of seepage is known as rising damp. It results in the peeling of paint and the appearance of damp patches on the wall. To avoid this problem, concrete used to put up walls and buildings should be made waterproof and to solve it sealers and coatings should be used at the footing level of walls and buildings before plastering is done.

RECOMMENDATIONS

The solutions discussed are in use today in a number of countries, including Ghana. However, due to the fact that the products are imported, they are expensive and this may explain why many Ghanaians are not patronizing it.

I therefore recommend that chemical engineers in the country come together to produce similar products locally in order for the problem to be solved at a cheaper cost in the country which will encourage Ghanaians to patronize them. Apart from production, I recommend that chemical engineers should partner with the building industry in order to make them aware and educate them on the importance of these products.

REFERENCES

Barozzi, G. S., & Angeli, D. (2014). A Note on Capillary Rise in Tubes. *Energy Procedia*, *45*, 548–557. https://doi.org/10.1016/j.egypro.2014.01.059

Edurena. (2016). Chemical Engineering: Branch Details, Placements,Best Colleges - EduArena. Retrieved August 13, 2017, from http://www.eduarena.com/chemical-engineering-branch-details-placementsbest-colleges/

Hall, C., & Hoff, W. (2007). Rising damp: capillary rise dynamics in walls. *Of the Royal Society of London A:* …. Retrieved from http://rspa.royalsocietypublishing.org/content/463/2084/1871.short

Kumar, C. (2011). What is the role of an entrepreneur in economic development? Retrieved August 13, 2017, from https://www.quora.com/What-is-the-role-of-Chemical-Engineer-in-cement-industry

Kwame Nkrumah University of Science and Technology. (2011). Course description.

Lucas, J. (2014). What is Chemical Engineering? Retrieved August 13, 2017, from https://www.livescience.com/48134-what-is-chemical-engineering.html

Map data. (2017). Kasoa - Google Maps. Retrieved July 22, 2017, from https://www.google.com.gh/maps/place/Kasoa/@5.5337202,-0.4729278,13z/data=!3m1!4b1!4m5!3m4!1s0xfdfbaedda8d54f7:0xd48e16c6c340829a!8m2!3d5.5300711!4d-0.4408037

Matthews. (2016). Water Seepage Repair -Matthews Wall Anchor & Waterproofing Services. Retrieved July 24, 2017, from https://www.matthewswallanchor.com/water-seepage-repair/

Nyasulu, T. U. (2012). Governance and customary land tenure in per-urban Kasoa in Ghana. Retrieved August 13, 2017, from https://en.wikipedia.org/wiki/Kasoa

Portland Cement Association. (2017). Chemical Admixtures.

https://doi.org/10.2208/jscej.1984.349_140

Trotman, P., Sanders, C., & Harrison, H. (2004). *Understanding Dampness: Effects, causes, diagnosis and remedies*. *BRE*. Retrieved from http://www.brebookshop.com/samples/145268.pdf

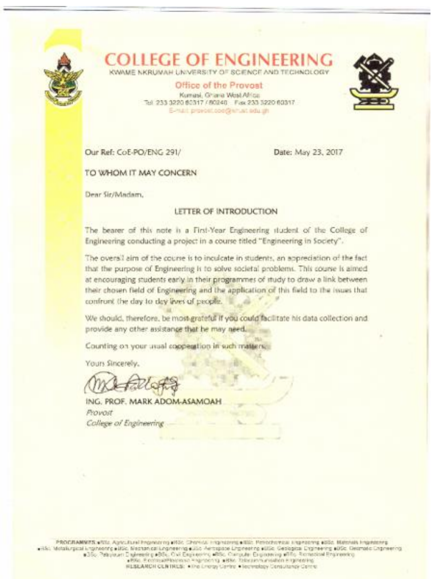
Word Reference. (2017). engineering - WordReference.com Dictionary of English. Retrieved August 13, 2017, from http://www.wordreference.com/definition/engineering

Xypex. (1997). Description Xypex Admix C-Series. Retrieved August 13, 2017, from http://kuert.com/wp-content/uploads/2016/01/Xypex-C-1000-TDS.pdf

Xypex. (2000a). Xypex Concentrate. Retrieved August 6, 2017, from http://www.xypex.com/docs/default-source/product-data-(aus)/(a4-aus)-concentrate.pdf?sfvrsn=14

Xypex. (2000b). Xypex Modified. Retrieved August 6, 2017, from http://www.xypex.com/docs/default-source/product-data-(aus)/(a4-aus)-modified.pdf?sfvrsn=12

APPENDIX



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TO WHOM IT MAY CONCERN

Dear Sir/Madam,

LETTER OF INTRODUCTION

The bearer of this note is a First-Year Engineering student of the College of Engineering conducting a project in a course titled "Engineering in Society".

The overall aim of the course is to inculcate in students, an appreciation of the fact that the purpose of Engineering is to solve societal problems. This course is aimed at encouraging students early in their programmes of study to draw a link between their chosen field of Engineering and the application of this field to the issues that confront the day to day lives of people.

We should, therefore, be most grateful if you could facilitate his data collection and provide any other assistance that he may need.

Counting on your usual cooperation in such matters.

Yours Sincerely,

ING. PROF. MARK ADOM-ASAMOAH
Provost
College of Engineering