KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (KNUST)

COLLEGE OF ENGINEERING

ENGINEERING IN SOCIETY REPORT

IMPROVING THE ENGINEERING MATERIALS OF A BRIDGE IN PANKRONO ESTATE

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INDEX NUMBER: 3684718

DEPARTMENT: MATERIALS ENGINEERING

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ACKNOWLEDGEMENT

It is said that successful people never reach their goals alone and I cannot therefore say I achieved this feat single handedly.

For this reason, I say thank you to the creator and sustainer of life -eternity will not be long enough for me to express my love and gratitude to you.

And to Engineer Marcus, Engineer Ebo Quansah, Chief Engineer Afukaar, Miss Ashley Aggrey, Richard Turkson, Miss Victoria Amegashti, Miss Nana Obeng Blay and the others, for the time and insightful contributions they invested in my work. I pray for more years of friendship with you all.

Lastly, I say a very big thank you to my family, especially to my parents for their unending support in writing this report. “Ayeekoo!” is all I can say for now.

DEDICATION

I dedicate this report to my God, the one who granted me wisdom to embark on this research.

I again dedicate this book to any upcoming engineer, researcher or scientist in the family who needs to access this report.

I also dedicate to the College of Engineering in Kwame Nkrumah University of Science and Technology, especially materials engineering department for any research which my report proves useful to.

I finally dedicate this report to the fruits of my womb.

ABSTRACT

This study was carried out to tackle safety of a bridge in Pankrono Estate using knowledge obtained in materials engineering.

The report acknowledges the works earlier done by some researchers in relation to bridge materials, construction and maintenance.

Major materials such as wood, stones and concrete used in the construction of bridges worldwide have also been discussed.

The main methods for data acquisition were the use of questionnaires and photographs, prepared maps of the community under study and the internet to obtain relevant information but there were limitations to the study.

The problems observed at the bridge site have been discussed and the proposed solution is to adopt the construction of an ideal bridge found on the “Mecca road” in Kwame Nkrumah University of Science and Technology (KNUST).

The recommended solution for the community is to reconstruct the bridge using a technology called reinforced concrete which is comparatively cost effective.

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CHAPTER 1: INTRODUCTION

1.1: DESCRIPTION OF CENG 291

The engineering in society course has been running for the past few years with the overall aim of inculcating in the students an appreciation of the fact that the purpose of engineering is to solve societal problems.

The course is aimed at encouraging students early in their programs of study to draw a link between their chosen field of engineering and the application of this field to issues that confront the daily lives of people.

Thus students identify problems in their communities pertaining to their programs and attempt an engineering solution to these problems.

1.2 BRIEF DESCRIPTION OF THE PROBLEM

Water is very essential to life but becomes a societal challenge when it hinders the movement of people.

Thus, once upon a time, a bridge was constructed in Pankrono Estate to solve this river crossing problem in the community. Children, market women and others used this to get to their destinations faster but as years passed the railings of the bridge corroded and parts of it broke off. Deep erosion set in the surroundings of the bridge making the inhabitants use wood as a means to cross the river to get to their destinations. The current state of the bridge poses a threat to all who use it, hence the need for a solution to the problem.

1.3 AIMS AND OBJECTIVES

The main aim of this report is to eradicate the unsafe nature a bridge in Pankrono Estate.

This report was made to achieve the following objectives;

- Discuss the problem identification method.
- Discuss materials engineering and its classes.
- Discuss the solution to the problem.

CHAPTER 2: LITERATURE REVIEW

2.1 ACKNOWLEDGING FEW RESEARCHES MADE ON BRIDGES;

- Imam, B and Chrysanthopoulos, MK (2010). A review of metallic bridge failure statistics IABMAS 2010, 2010-07-11 to 2010-07-15, Philadelphia, USA. This paper presents a review of bridge failure statistics based on literature survey and web based search, focusing on metallic bridges.
- Proposed engineering method could help make buildings and bridges safe from Kanazawa University in January 17, 2019. Researchers discovered that the distance between the dislocation in nanolayer interfaces of pearlite can determine how much the material can stretch or contract without breaking (ductility).
- Evaluation and repair of existing bridges in extreme environments and changing climates in November 1, 2016. Aging or deterioration of the nation's infrastructure is a significant issue that requires attention, especially for bridges subject to extreme environments and changing climates.
- Existing metallic bridges in Egypt: current conditions and problems in October, 2017. Several metallic bridges are present in Egypt and form an important part of the transportation network.
- Smart materials improve earthquake-resistant bridge design by Misha Raffiee at California Institute of Technology.

2.2 DEFINITION AND HISTORY OF BRIDGES

According to the *Cambridge Dictionary*, a bridge is a structure that is built over a river, road or railway to allow people and vehicles to cross from one side to the other.

The history of bridges can be traced to the age when man fell trees to help them cross rivers and other water bodies. With time, man begun to build bridges with stones, the materials used for bridges have undergone evolution ever since.

Artificial materials such as steel, concrete, etc. are now used in the construction of bridges and the construction of such bridges is termed the second period of bridge engineering.

2.3 WOOD AS A CONSTRUCTION MATERIAL FOR BRIDGES

Wood is one of the composite materials found in nature hence environmentally friendly. Although in the 20th century concrete and steel replaced wood as the major materials for bridge construction, wood is still used for short and medium span bridges. The low density nature of wood makes it gain high specific strength.

But wood also has some disadvantages such as, it is;

- Highly anisotropic in nature
- Susceptible to termite attacks, infestations and woodworm
- Highly combustible
- Not usable in high temperatures

Figure 4.2: The Mathematical Bridge, Cambridge

2.4 STONE AS A CONSTRUCTION MATERIAL FOR BRIDGES

For a long time in history, stone has been used mainly in the form of arches this is because it possesses higher compressive strength. The use of stones gave the engineers ease of constructing bridges that are aesthetically pleasing and high in durability. But stone has low tensile strength.

Figure 2.4: The Zhuzhou Bridge, China

2.5 METALS AS A CONSTRUCTION MATERIAL FOR BRIDGES

The metal mostly used in building bridges is iron which has been modified to steel. Steel has a higher tensile strength when compared with any other material. This makes it suitable for the construction of bridges with a longer span. Steel is a combination of iron and other elements such as carbon. Based on the amount and variation of the elements, the properties could be altered accordingly. The properties of high tensile strength, ductility and hardness are influenced by change in the constitution.

Figure 2.5: The Hachimanbashi Bridge

2.6 CONCRETE AS A CONSTRUCTION MATERIAL FOR BRIDGES

Concrete is a composite material made by man. Concrete is the widely used construction material for bridges. When cement, aggregate and water are mixed together a chemical reaction called hydration takes place which causes the mixture to harden. The hardened mass is called concrete.

Advantages

- Has high compressive strength
- Concrete is inexpensive compared to steel
- Concrete can practically be made into any shape

Disadvantages

- Concrete is a brittle material and can crack or break with little warning.
- Concrete is very weak when a tension force is applied to it.

- Because a certain amount of time is needed for hydration to completely occur, concrete members do not gain their full strength until much time has passed.

Concrete has no strength in resisting tension in a material but steel is good at resisting tension. Thus, a technology has been made for building bridges where steel is often embedded within the concrete at locations where tension forces are known to exist, making reinforced concrete.

Figure 2.6: Reinforced Concrete Bridge

CHAPTER 3: METHODOLOGY

3.1 PROBLEM IDENTIFICATION

The community is hit with numerous challenges such as poor drainage systems, robbery attacks, untarred roads and the unsafe nature of the bridge. As a member of the community, I knew these problems since they were the daily complaints of the community members. Thus, I visited a few houses and enquired of them of the problem they would want to be eradicated soon. Upon the statistics I had, most of them wanted the robbery attacks in the community to be reduced. But since I would not be able to solve the problem with materials engineering, I settled on solving the bridge problem in Pankrono Estate. The bridge identified has a location address of GH-AK-151-8356 using the GPS Digital Address System.

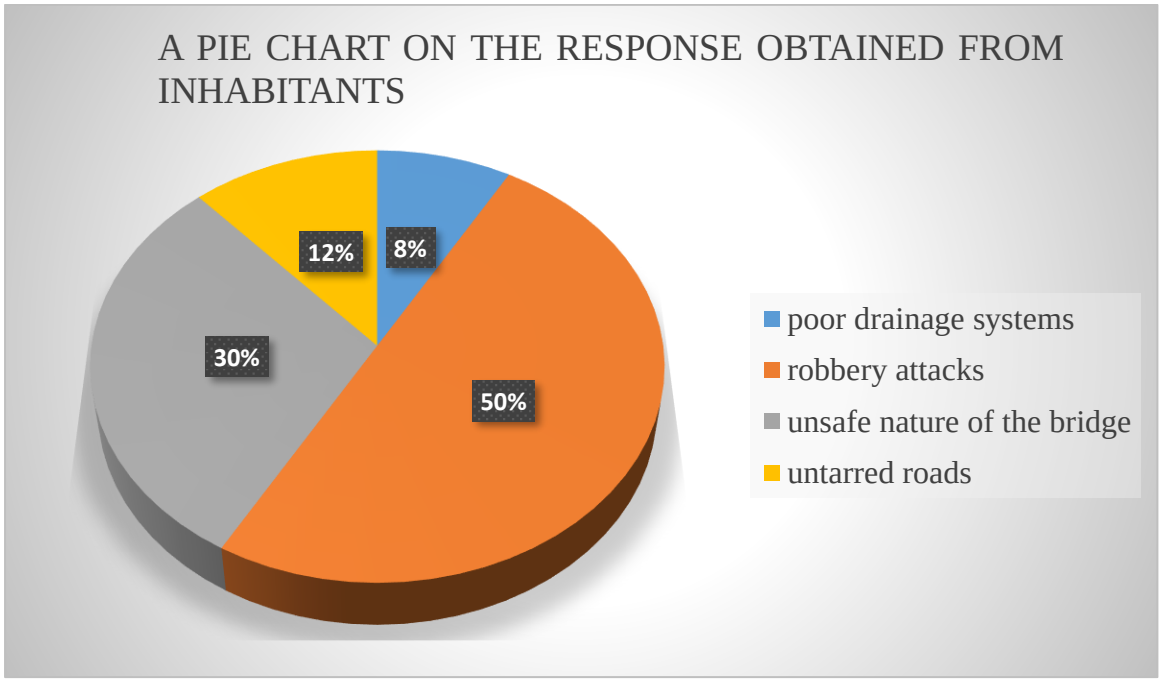

Figure 3.1: Needs assessment of inhabitants

The sample size for this survey was fifty-five (55) inhabitants.

3.2 DATA ACQUISITION PROCESS

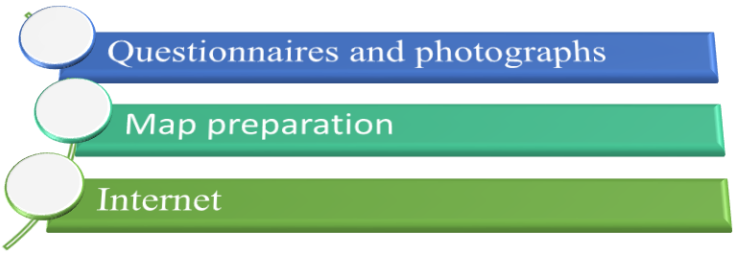

Figure 3.2: The materials and methods used

Questionnaires and Photographs

Questionnaires were prepared to obtain relevant data from the people walking on the bridge and to ensure consistency of the data. Photographs of the bridge were taken with a mobile phone to support facts in the report.

Map preparation

The acquisition of maps from Google, getamap.net and satellite was quite difficult since Pankrono Estate is a small community on the Tafo land. But a prominent landmark in the community was found on Google map, that is, Pankrono Estate Seventh Day Adventist Church.

Internet

Other sources of information especially the preparation of the map was obtained via the net using a mobile phone.

3.3 LIMITATIONS OF METHODOLOGY USED

- Had few challenges of assisting those who could not answer the questionnaires due to illiteracy on their part.
- Conducted the exercise with a few people who were using the bridge out of the whole population.
- Few people were not cooperative in the process.

Chapter 4: DISCUSSION OF THE PROBLEM

4.1 DESCRIPTION OF THE COMMUNITY UNDER STUDY

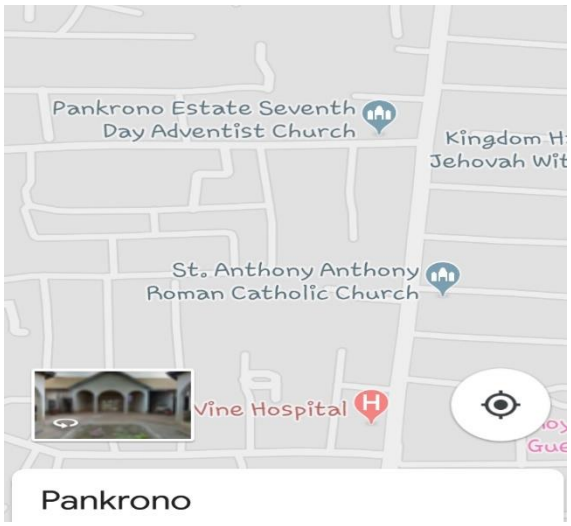

Figure 4.1.1: Map of Pankrono Estate

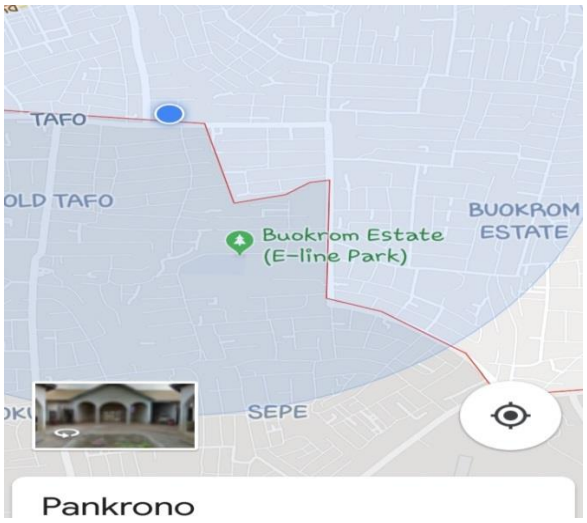

Figure 4.1.2: Map of Pankrono Estate 2

Pankrono Estate is a populated place in the Tafo Municipality in the Ashanti Region with the Region. It is located after Buokrom and at an elevation of two hundred and eighty-two (282) metres above sea level having a population of two thousand, four hundred and fifty (2450). The main language of the inhabitants of the community is 'Asante Twi'.

Pankrono Estate is also known as Tafo Estate. The community prides itself with landmarks such as schools, churches and parks. The inhabitants of Pankrono Estate are mostly middle income earners and their buildings make this evident.

However, the community is faced with problems such as poor drainage systems, untarred roads, criminal attacks, soil erosions, poor infrastructural facilities and a few others.

4.2 DESCRIPTION AND NATURE OF THE PROBLEM

Almost 70% of the inhabitants of Pankrono Estate use this bridge to get to the other community, Buokrom faster. Upon a quick survey, it was found out that the bridge is a footbridge busily used in the mornings and afternoons by market women, school children, etc. It was noticed that the footbridge had excessive vibration problems under specific loading (body masses ranging from 18.9 to 35.5), making crossing uncomfortable and scary.

Figure 4.2.1: Wooden bridge

Figure 4.2.2: Trainee engineer on the metallic bridge

It is believed that other factors such as improper maintenance of the bridge, impropriety in selection of construction materials and the regular flooding of the bridge have all contributed their quota to the dilapidated bridge. Suffice it to say that, the bridge was made with concrete, metal and wood. And these materials are much affected whenever the river overflows its banks.

A survey was conducted on based on the ages of people who use the bridge from 6.30am to 9.00 am. Thus, I counted the number adult males, adult females, young females and young males. The sample size I had for this survey was two hundred and thirty seven (237) people who crossed the river during that duration.

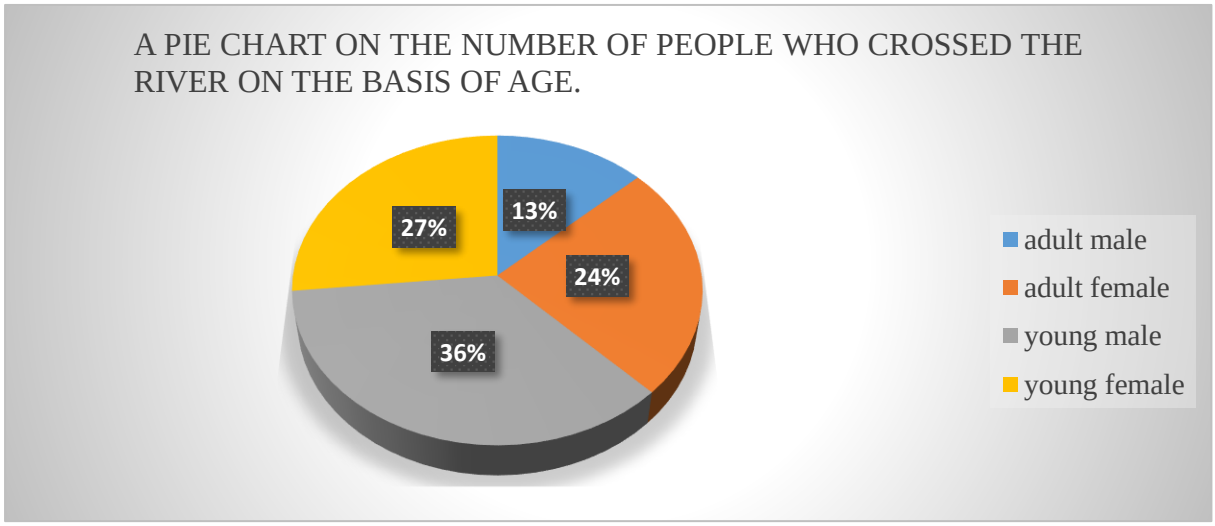

Figure 4.2.3: Kind of people who walk on the bridge

4.2.1 RUSTING OF THE BRIDGE RAILINGS

Rust is a redox reaction of iron in the presence of oxygen and water to form a red oxide which is visible. Bridge railings built along the bridge deck overhang act to prevent departure from the bridge.

The railings of a bridge in Pankrono Estate has become rusty, thus a reddish brown colour has been formed on it. Also, due to its exposure to rust, the railings have become weak and parts have broken off endangering the lives of people who walk on it.

Figure 4.2.4: Broken bridge railings

Figure 4.2.5: Metallic bridge and railings

4.2.2 WOODEN STRUCTURE

The inhabitants of Pankrono Estate placed a wood (plywood) over a deep hole created by erosion in order to access the rest of the bridge. Also, the sewage of the nearby houses passes under the wooden structure and drains into the river.

Figure 4.2.6: Student crossing wooden bridge

Figure 4.2.7: Trainee engineer on the wooden bridge

4.3 MATERIALS ENGINEERING AND ITS CLASSES

Before I explain materials engineering, let us define the keyword engineering. Encyclopedia defines engineering as the discipline of applying technical and scientific knowledge and physical resources to design and produce materials, structures, machines, devices, systems and processes that meet desired objective under specified criteria. Engineering encompasses a range of specialized sub disciplines with a specific area of emphasis and related to a particular area of technology. Examples include: materials engineering, petroleum engineering chemical engineering and so forth.

Now, materials engineering can be defined as the discipline of designing the structure of a material to produce a predetermined set of properties based on established structure-property correlation.

The classes of materials are ceramics, polymers and metals. A chemical combination of any of the two classes gives a composite. With this knowledge, let us draw the link between materials engineering and my project topic that is, “Improving the engineering materials of a bridge in Pankrono Estate”.

To improve something means the quality of the thing in question is low hence making the quality or results better than before. This bridge serves as a challenge to the inhabitants of the community hence as a trainee material engineers, I am solving the problem by improving the materials be it to ceramics, polymer or metals.

Table 4.3: Classes of materials

CLASS	EXAMPLES
1. Metals	Gold, aluminum, copper, alloys, nickel, manganese
2. Ceramics	Porcelain, glass, silicon nitride
3. Polymers	Polyurethane, polyvinyl chloride, nylon, polyester
4. Composites	Wood, bone, concrete, fiberglass

CHAPTER 5: PROPOSED SOLUTIONS AND RECOMMENDATIONS

PROPOSED SOLUTION

As the days went by, I found a problem in Pankrono Estate and attempted to solve it using materials engineering principles. Meanwhile, I saw a similar bridge on "Mecca Road" in the Kwame Nkrumah University of science and Technology (KNUST); I found the bridge as an ideal solution to the problem of my community.

Figure 5.1: Side view of KNUST bridge

Figure 5.2: The ideal bridge in KNUST

- The bridge was constructed at a height the river cannot overflow the footbridge when the banks are full.
- The railings of the bridge are strong and it was coated with oil to check rusting.
- The bridge is made of reinforced concrete and mild steel chequered plate which has been placed in the middle of the bridge. The chequered plate reduces the slipperiness of the steel, since it is a rough finish.
- The mild steel chequered plate is made of eighty four percent (84%) steel, fifteen percent (15%) aluminum and one percent (1%) stainless steel. The chequered plate is characterized with excellent corrosion resistance and weld ability, together with high strength. It is also rich in impact resistance as well as load resistance and thus used in the construction of bridges.
- I would suggest a suitable drainage system to channel the sewage under the wooden structure.

This solution was proposed because the cost of materials is comparatively cheaper and would last long since almost ninety seven percent (97%) of the university's population have walked on this bridge and its current condition is still safe.

RECOMMENDATIONS

Although the proposed solution would solve the problem of the community to the barest minimum, I would also recommend for the authorities of the community to reconstruct the bridge with a different material; reinforced concrete which is comparatively cost effective.

However, there should be periodic inspection of the failure points of the bridge and proper maintenance of the bridge should in general be carried out.

CHAPTER 6: CONCLUSION

This report discussed how the problem was identified in the community and how the principles of materials engineering was used in solving the problem. The objectives of this study have thus been achieved.

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- www.getamap.net

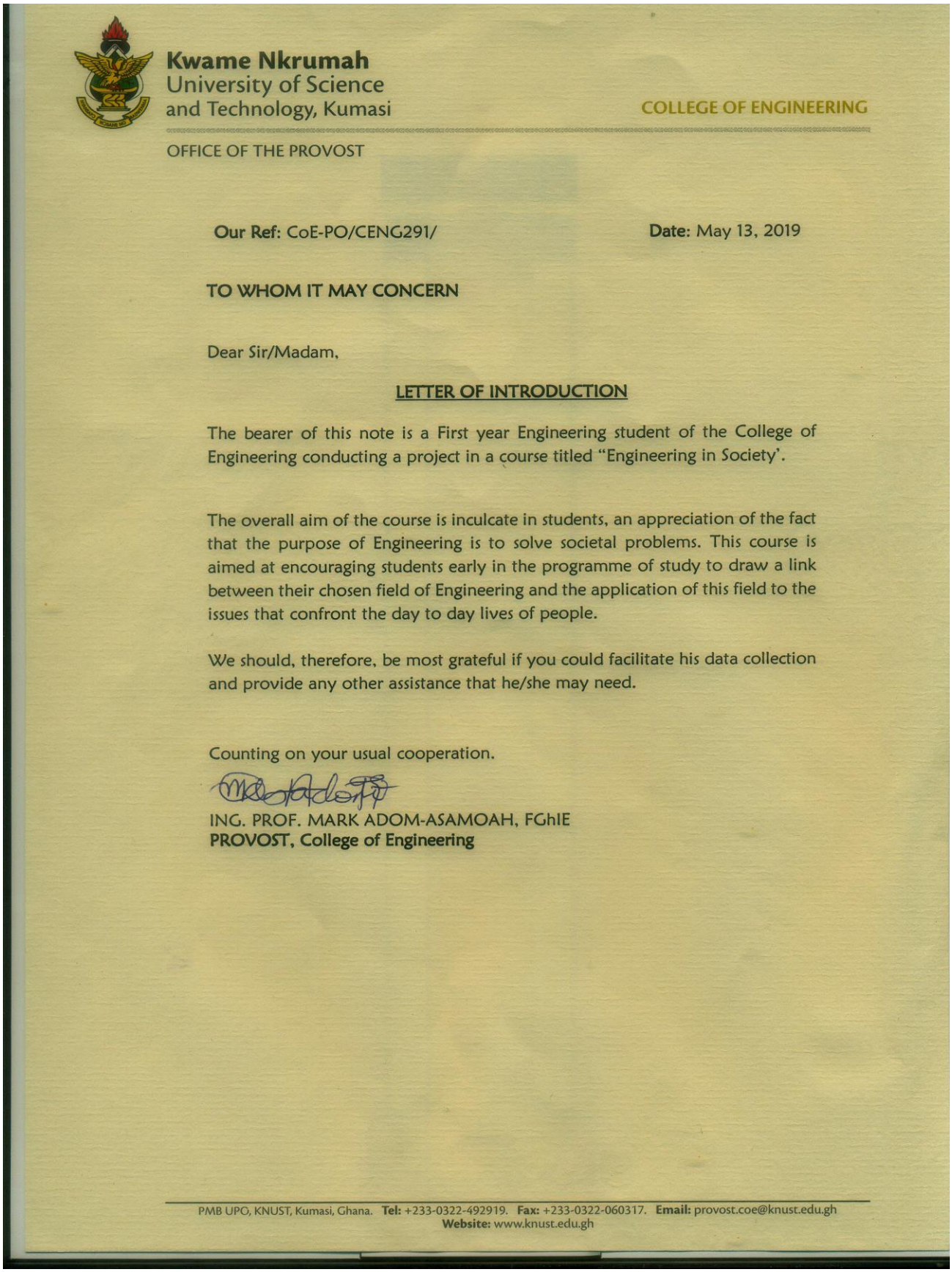
APPENDICES

QUESTIONNAIRES

Questionnaires made on the topic improving the engineering materials of a bridge in Pankrono Estate.

1. How often do you use this bridge?
    a. Daily
    b. Weekly
    c. Monthly
    d. Occasionally
2. In terms of percentage, how safe is the bridge to you?
    ---
3. If there was an alternative way and the bridge, which would you prefer?
    ---
4. What can you say about the bridge when it rains?
    a. Slippery
    b. Not slippery
5. Have you fallen on the bridge before?
    a. Yes
    b. No
6. What can you say about the wooden part of the bridge?
    a. Dangerous
    b. Not dangerous
7. What can you say about the bridge railings?
    a. Harmful
    b. Not harmful

COPY OF THE LETTER OF INTRODUCTION



Kwame Nkrumah
University of Science
and Technology, Kumasi

COLLEGE OF ENGINEERING

OFFICE OF THE PROVOST

Our Ref: CoE-PO/CENG291/ **Date:** May 13, 2019

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 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 the programme 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/she may need.

Counting on your usual cooperation.

ING. PROF. MARK ADOM-ASAMOAH, FGhIE
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