EFFECT OF PLASTERING AND CARBON FIBRE REINFORCED POLYMER (CFRP) ON CONCRETE MASONRY PRISM STRENGTH CAPACITY

MOHD ANUAR BIN MOHD YUSOF

SCHOOL OF CIVIL ENGINEERING
UNIVERSITI SAINS MALAYSIA
2017

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By

MOHD ANUAR BIN MOHD YUSOF

This dissertation is submitted to

UNIVERSITI SAINS MALAYSIA

As partial fulfilment of requirement for the degree of

BACHELOR OF ENGINEERING (HONS.)
(CIVIL ENGINEERING)

School of Civil Engineering,
Universiti Sains Malaysia

June 2017

SCHOOL OF CIVIL ENGINEERING
ACADEMIC SESSION 2016/2017

FINAL YEAR PROJECT EAA492/6
DISSERTATION ENDORSEMENT FORM

Title: Effect of Plastering And Carbon Fibre Reinforced Polymer (CFRP) On Concrete Masonry Prism Strength Capacity.

Name of Student: Mohd Anuar Bin Mohd Yusof

I hereby declare that all corrections and comments made by the supervisor(s)and examiner have been taken into consideration and rectified accordingly.

Signature: Approved by:

_____ _____

(Signature of Supervisor)

Date : Name of Supervisor:

Date :

Approved by:

_____

(Signature of Examiner)

Name of Examiner :

Date :

ACKNOWLEDGEMENT

First and foremost, in the name of ALLAH SWT, The Most Merciful and The Most Beneficent, Alhamdulillah, all praises to Allah SWT because of His blessing and His willingness allowed me to be inspired in embarking my final year project to become a reality.

I would like to express my sincere and immense gratitude to my supervisor Dr. Izwan Johari who has supervised me well throughout the entire process of this project. His valuable suggestions, guidance and supports were much appreciated throughout this final year project period. Besides, I am grateful for the guidance and help received from the technical staffs and anyone who contributed whether directly or indirectly throughout this project and in preparing and making this report successful.

ABSTRAK

Batu bata merupakan bahan penting dalam pembinaan khususnya pembinaan bangunan dan ianya digunakan secara meluas di segenap pelusuk dunia sejak beberapa abad yang lalu sehingga ke hari ini. Penggunaan bahan ini berkait rapat dengan beberapa faktor antaranya ialah disebabkan kerana mudah diperolehi, harga yang murah dan pengendalian kerja yang mudah. Namun, terdapat masalah yang timbul, kesan daripada penggunaan batu bata tersebut antaranya ialah keretakan pada dinding bangunan. Bagi tujuan kajian, sejumlah 12 unit spesimen di bina, dengan menggunakan batu batu blok berdimensi 390 mm x 190 mm x 190 mm seunit dan diikat secara menegak sehingga mencapai tinggi 1 meter termasuk ketebalan mortar, terbahagi kepada empat kumpulan yang berbeza, iaitu tanpa lepaan (A), satu belah bahagian di lepa (B), kedua belah bahagian dilepa (C) dan kedua belah bahagian dilekatkan dengan polimer karbon gentian diperkuatkan secara menegak (D), dimana setiap kumpulan berkuantiti 3 unit. Nisbah bancuhan bahan yang digunakan untuk penghasilan mortar adalah berdasarkan ASTM C 1437 bagi setiap spesimen yang dihasilkan. Hasil pemerhatian dan ujian didapati nilai purata bagi beban gagal adalah seperti berikut (A) 180 kN , (B) 175 kN, (C) 209 kN, dan (D) 198 kN. Kesimpulan dapat dibuat kekuatan kumpulan (C) adalah yang tertinggi namun corak keretakkan tidak dapat dikawal berbanding kumpulan (D) dimana corak keretakkan adalah secara pugak serta dapat dijangkakan

ABSTRACT

Brick is an important material in the construction of particular buildings and it is widely used in all parts of the world over the last century until today. The use of these materials is closely related to several factors, among which are easily obtained, cheap and easy job control. There are some effects that arise through the use of brick in building construction. For the purposes of the study, a total of 12 units of bond brick for prism in architecture, using concrete blocks of dimensions 390 mm x 190 mm x 190 mm unit and each specimen that is built has a height of 1 metre, the specimens are classified into controlled specimen without any plaster, one sided plastered, two sided plastered, and specimen strengthened by Carbon Fibre Reinforced Polymer (CFRP) strip in vertical orientation. The mixing ratio of the materials used for the production of mortar for the use of bonding and rendering are the same and tests conducted in accordance with ASTM C 1437 to ensure that the characteristics of the were resulting set is the same and controlled. During the tests performed, the effects of the resulting pressure is observed and recorded. The results of observations and tests found the average value of the failure load is as follows (A) 180 kN, (B) 175 kN, (C) 209 kN, and (D) 198 kN. The conclusion that can be made is strength group (C) is the highest but crack pattern could be controlled compared to the group (D) in which the pattern of cracks is vertical and can be expected.

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LIST OF ABBREVIATIONS

ASTM	**A**merican **S**ociety for **T**esting and **M**aterials
CF	**C**arbon **F**ibre
CFRP	**C**arbon **F**ibre **R**einforced **P**olymer
CMU	**C**oncrete **M**asonry **U**nit
FRP	**F**ibre **R**einforced **P**olymer
GFRP	**G**lass **F**ibre **R**einforced **P**olymer
LVDT	**L**inear **V**ariable **D**isplacement **T**ransducer
OA	**O**rthogonal **A**rrays
URM	**U**nder **R**einforced **M**asonry

CHAPTER 1

INTRODUCTION

1.1 Background

Plastering is one of the most ancient building materials that are widely used for protective and decorative coating of walls and ceilings. There is historical evidence revealing primitive man plastering mud that acts as a protective structure over a framework made of sticks and reeds.

Plasterwork and its decoration were applied more than 4,000 years ago and the most significant proofs are the durable palaces and pyramids of the Pharaohs of Egypt that still exist until today. According to research, the principal tools used during the ancient Egyptian plastering were almost similar to those used nowadays.

A plaster made of calcimine gypsum is the finest plasterwork accomplished by the Egyptians which is nearly identical to the quality of the present plaster of Paris and today's application techniques. Gypsum plaster has progressively replaced lime as the binding agent for sand in plastering mortar with the evolution of modern processing techniques in the early 20th century. One of the influential factors is its controllable rate of setting to allow the plasterer to build up layers or coats of plaster within hours compared to the lime mortar that requires days or even weeks (Granden, 1984).

Today there are some practices in masonry wall plastering which are one-sided plastering and two-sided plastering. Although both of these plastering practices have a similar way of working, the important factor that needs to be identified is the acquired

loading capacity. In this study, different plastering practices are performed on the masonry wall surface.

Nowadays, in constructions industry, the utilization of a composite material known as a Fibre-reinforced Polymer is increasing. It is because of its high tensile strength, light weight, and corrosion resistance. The facileness of its implementation also contributes in making this material suitable for building structures. Furthermore, Fibre-reinforced Polymer is additionally preferred as the solution in bracing the masonry wall. In this study, the effects of Carbon Fibre Reinforced Polymer (CFRP) utilization as a composite material are thoroughly discussed. It is noted that the mechanical properties of this material show useful strength behaviour to satisfy the safe cross-section with FRP materials (Karasin, 2014).

The CFRP reinforcement is applied in strip form, which is more economical compared to wrapping or forming it into a bar shape. Besides, it is also easier since it uses less fibre to achieve excellent performance in terms of higher strength and modulus of elasticity compared to steel. Hence, the flexural and shear strength as well as the deflection of the structural member can be enhanced.

1.2 Problem Statement

Concrete masonry is widely used in the construction of buildings used primarily for load bearing concept. Most load bearing walls are plastered but there are also some that are not patched for aesthetic purposes. However, there is also a case that often occurs in the construction of the residential area where a masonry wall is built and

plastered on one side only especially for those who want to save the construction costs. This condition possesses a potential risk to those who are less fortunate due to the lack of strength of the brick wall. In this situation, many people have a choice whether to plaster on one side or both sides of the wall and also can strengthen it. With plastering, the compressive strength of the wall itself increases. The reason for the strengthening of the wall is able to bear the burden, deterioration, damage or cracking that occurs and to maintain its shape especially for heritage buildings to be preserved. Strengthening by traditional methods such as section enlargement, external plate bonding, external post-tensioning, ferro-cement laminates, and sprayed concrete can increase the cost of skilled labour because of its energy needs, adding a great time, damaging the original value of heritage buildings. So, in this project, different characteristic of specimens have been introduced for comparison. . Those conditions are control specimen without plaster, one sided plaster, two sided plaster and specimens with CFRP applied. By using CFRP as strengthening materials, labour cost and time of work will decreasing.

1.3 Objectives

1) To determine the strength of concrete masonry prism without plastering, with plastering on one sided and two sided.
2) To compare the strength of concrete masonry prism strengthen with CFRP and control specimen.

1.4 Benefit of research

The potential benefits of the proposed research project will help clients, contractors to use this method for strengthening wall. The strength of masonry brick wall can be identified.

1.5 Scope of work

To determine the strength of one-sided and two-sided plastering, three different specimens of concrete masonry prism were prepared which are the control specimen without any plastering, one-sided plastering specimen, and two-sided plastering specimen. One type of specimen is prepared to analyse the influences of using CFRP strip on concrete masonry prism. The sample is attached with CFRP strip in a vertical orientation using adhesive epoxy resins applied to it. The strength and load capacity for each sample are analysed via compressive strength test. The properties of each sample are recorded and compare.

1.6 Dissertation Outline

The five chapters arranged as show below. This section presents brief description of these chapters.

- Chapter 1 (Introduction)

This chapter gives a general background about CFRP, statement problem, goals and objectives of the research, scope of work, and the desired target to be achieved.

- Chapter 2 (Literature Review)

This chapter gives general review of previous research related to CFRP and the effect of the main materials used and application.

- Chapter 3 (Methodology)

This chapter discusses types of laboratory test, standard, adopted procedures, materials properties, and schedules of testing program.

- Chapter 4 (Results and Discussion)

Test results, analysis of the results and discussion are included in this chapter.

- Chapter 5 (Conclusion and Recommendations)

General conclusion and recommendations from this research.

CHAPTER 2

LITERATURE REVIEW

2.1 Masonry

Masonry whether in the form of bricks, blocks or natural stone is one of the most familiar construction materials used with mortar as the binding material. Binding material can be cement, lime, and soil. Masonry wall construction has a number of advantages such as fire protection, thermal and sound insulation, weather protection and security protection. The advantage relates to the durability of the materials which, with appropriate selection, may be expected to remain serviceable for many decades with relatively little maintenance.

Masonry has an economical nature in term of its production does not require very heavy and expensive plant even though it is dependent on skilled mason to deliver a high quality construction. The productivity of masonry works has been maintained by the use of bigger units, enhanced material handling and off-site preparation of mortar.

2.1.1 Load Bearing Masonry Walls

Although the use of structural masonry has been dramatically reduced since the widespread introduction of concrete and steel structures, there is still a large number of existing buildings in use that are structurally composed of load-bearing brick masonry walls (Ernest, 2013). A load bearing masonry wall is built with bricks, stones or concrete blocks. This kind of wall directly transfers the loading from the roof to the

foundation. This wall can either be exterior or interior wall. The thickness of the wall depends on the quantity of load that is carried from the roof and the wall itself has to bear.

2.2 Masonry Units

Masonry wall units are manufactured from three elements which are clay, concrete, and calcium silicate in the form of bricks and blocks. Natural stone masonry is also practiced but its usage is very limited. Although their properties may be dissimilar depending on the raw materials used and the manufacturing methods, their functionalities are majorly the same. Bricks and blocks can be produced in many forms such as solid, perforated and hollow that are typically in the size of 215 x 102 x 65 mm (length x width x height). The conventionally sized blocks are available in lengths of 400-600 mm, heights of 150-300 mm and a wide range of thicknesses between 60 and 250 mm (Hendry, 2001).

2.3 Concrete Masonry Prism

Masonry has been used primarily as gravity load bearing material to resist compression. For example, masonry walls and columns are designed to resist vertical loads. Therefore, the compressive strength of masonry prisms is the most important property required in the design of structural masonry (Kaaki, 2013). It has been established that the compressive strength of the masonry assemblage differs from the compressive strength of the individual components of the prism. Typical compressive strength of masonry units is relatively high but the compressive strength of mortar is low. Figure 2.1 show schematic diagram of hollow prisms and grouted prism.

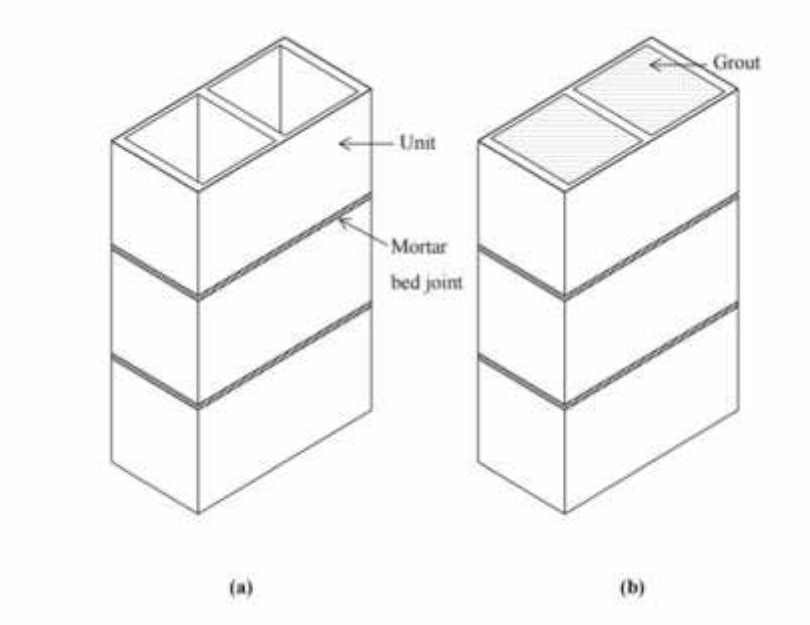

Figure 2.1: Schematic diagram of (a) hollow prisms and (b) grouted prism (Kaaki, 2013)

2.4 The Roles and Importance of Plaster

Plaster has been recognized as the earliest type of finishing material in most of the buildings around the globe that serve important roles in the masonry. The original plaster of ancient buildings stores helpful technological information depending on its roles. One major role of the plaster is to shield the masonry against weathering conditions like wetting and drying cycles, freezing and thawing cycles, salt crystallization cycles due to the changes in ambient temperature, humidity conditions, and wind flow. The plaster exhibits an interesting behaviour on the thermal conductivity and temperature for buildings walls (Mansour, 2013).

2.5 Mortars

The primary function of the mortar is to bind together the individual block units and allow the transfer of compression, shear and tensile stresses between adjacent units (Arya, 2009). Based on that we need a variety of mortars used in building construction works depending on the nature of the application, binding material, density and special purposes that are required in the construction. Mortar is a mixture of water, cement and fine aggregate with the appropriate ratio according to the desired strength.

2.5.1 The flow table test or consistency test

The flow table test or consistency test is widely used to evaluate the fresh properties of mortars. It is simple to perform, employs easy-handling equipment, and allows a guided evaluation of the influence of fine materials addition.

2.5.2 Types of Mortars

- Brick or stone laying mortar

In masonry walls, the structural units such as stones or bricks are linked together using the mortar (The Constructor, 2017). The ingredient proportions in making the mortar for this purpose is decided based on the type of binding material used.

- Finishing mortar

Finishing mortar is applied for the pointing and plastering works. For the general type of plastering, the material of cement or lime mortar is used (The Constructor, 2017). Finishing mortar can also be used to add some architectural effects of building for more aesthetical appearances. The mortar with the properties of great strength, mobility, and resistance against the atmospheric actions such as rain and wind is used for the ornamental finishing.

- Cement Mortar

Cement is used as the binding material while sand is used as a filler (fine aggregate) for this type of mortar where the proportion of cement to sand may vary from 1:2 to 1:6 (The Constructor, 2017). The proportion of cement and sand is determined according to the specified durability and working environments. Cement mortar will provide high strength and resistivity against water.

2.6 Fibre Reinforced Polymer (FRP)

Strengthening solutions based on the external bonding of fibre-reinforced polymer (FRP) composites have become a popular option. Fibre reinforced polymer is a composite made of high-strength fibre and a matrix for binding these fibres to fabricate structural shapes (Balaguru, 2009). FRP materials have high corrosion resistance, good mechanical properties that are almost similar to those of conventional steel along the fibre direction (Cheng, 2006). The fibres used are mostly glass, carbon or aramid whereas the other fibres are usually paper or wood or and sometimes, asbestos. The polymer is usually an epoxy, vinyl ester or polyester thermosetting plastic. However, in certain cases, phenol formaldehyde resins are still in use. FRP is able to furnish a strengthening alternative for unreinforced and under reinforced masonry (URM) due to their preferable properties which are light weight, high tensile strength, corrosion resistance and easy implementation. These properties make FRP a suitable structural element for the strengthening method of masonry wall and reinforced concrete.

2.7 Type of FRP

Nowadays, there are many types of FRP with their very own properties and uniqueness that are available in the market to be used in the construction industry. One of the fibres may be glass, carbon, or aramid, whereas the other fibre may be paper or wood or asbestos. Meanwhile, the type of polymer used may be an epoxy, vinyl ester, polyester thermosetting plastic, or phenol formaldehyde resins. Tan (2012) stated in his project that the most widely used FRP materials in the construction industry are Carbon Fibre Reinforced Polymer (CFRP) and Glass Fibre Reinforced Polymer (GFRP).