
# RESEARCH AND DEVELOPMENT OF FIRE RESISTANCE DOOR FROM KENAF CORE AND CEMENT SLURRY

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2022


**Faculty of Mechanical and Manufacturing Engineering Technology**

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# RESEARCH AND DEVELOPMENT OF FIRE RESISTANCE DOOR FROM KENAF CORE AND CEMENT SLURRY

**NUR HAZIRAH IFFAH BINTI HASHIM**

**A thesis submitted**
**in fulfillment of the requirements for the degree of**
**Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours**



**Faculty of Mechanical and Manufacturing Engineering Technology**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2022**

**DECLARATION**

I declare that this Choose an item. entitled " Research and Development of Fire Resistance Door from Kenaf Core and Cement Slurry" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : Nur Hazirah Iffah binti Hashim

Date : 18/01/2022

**APPROVAL**

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours.

Signature : .....

Supervisor Name : Prof. Madya Ir. Ts. Dr. Mohd Yuhazri bin Yaakob

Date : 18 January 2022

**DEDICATION**

Dedicated to

My honourable father, Hashim bin Ali

My precious mother, Nor'Aini binti Giman

My beloved brothers, Muhammad Naquiddin bin Hashim,

Muhammad Naqib Najmi bin Hashim, Muhammad Nasr Nazran bin Hashim

My beloved sisters Nur Husna Izzati binti Hashim, Nur Haziqah Izzah binti Hashim,

Nur Hazimah Ismah binti Hashim, Nur Haqimah Irdina binti Hashim

Thank you so much

## ABSTRACT

In recent years, natural fibres have been one of the most fibres used in many applications due to being available in abundance with lower cost, sustainability, and environmentally friendly compared to synthetic fibres. Thus, this study explored the kenaf core reinforced cement slurry composite for fire resistance door application. The sample of fire resistance doors using kenaf core reinforced cement slurry have been analyzed. The sample size of 360 mm x 250 mm x 40 mm for different sizes of kenaf core 30 mm, 20 mm, 10 mm and 20 mesh (0.84 mm) with varying kenaf core and cement slurry ratios were prepared. The preparation of the composite is by mixing the kenaf core and cement slurry starting with a ratio of 9:1 (cement slurry: kenaf core) and continuously increasing the amount of kenaf core until 7:3 (cement slurry: kenaf core). The composition was poured into a mould with 400 mm x 250 mm x 40 mm. Then, the samples were dried for 7 to 8 hours and proceeded with the curing process to stimulate the cement's maturity strength for 28 days by being immersed in water. All the samples were cut into standard size using an angle grinder by following the ASTM standard for each mechanical testing. The mechanical tests that will be carried out in this study are compression, three-point flexural, and fire resistance. Scanning electron microscope analysis was done to analyze the characterization of the samples. It was found that the best composition sample using kenaf core size 20 mesh had the potential to improve the mechanical performance of the cement and can withstand a long time in resistance to fire. Hence, using kenaf core reinforced cement slurry had proven to have better performance in fire resistance door application.

## *ABSTRAK*

*Kebelakangan ini, penggunaan gentian semulajadi telah menjadi salah satu serat yang banyak digunakan dalam banyak aplikasi kerana boleh didapati dengan kos yang lebih rendah, kemampanan dan mesra alam berbanding dengan serat sintetik. Oleh itu, kajian ini telah meneroka komposit simen yang diperkuatkan dengan teras kenaf untuk aplikasi pintu rintangan api. Sampel pintu rintangan kebakaran menggunakan simen yang diperkukuhkan dengan teras kenaf telah dianalisis. Sampel yang berukuran saiz 360 mm x 250 mm x 40 mm telah disediakan menggunakan teras kenaf yang berbeza saiz iaitu 30 mm, 20 mm, 10 mm dan 20 mesh (0.84 mm) dengan nisbah yang berbeza untuk teras kenaf dan simen. Penyediaan komposit adalah dengan mencampurkan teras kenaf dan simen bermula dengan nisbah 9:1 (simen:kenaf teras) dan jumlah teras kenaf meningkatkan secara berkala sehingga mencapai nisbah 7:3 (simen:kenaf teras). Komposisi dicurah kan ke dalam acuan yang bersaiz 250 mm x 350 mm x 500 mm. Selepas itu, sampel dikeringkan selama 7 hingga 8 jam dan proses pengabaian dilakukan untuk merangsang kekuatan kematangan simen selama 28 hari dalam rendaman air. Semua sampel dipotong menggunakan pemotong sudut dengan mengikuti saiz piawaian ASTM untuk setiap ujian mekanikal. Ujian mekanikal yang dijalankan dalam kajian ini adalah ujian mampatan, lenturan tiga titik dan rintangan api. Pengimbas analisis mikroskop electron telah dijalankan untuk menganalisis ciri-ciri setiap sampel. Hasil kajian mendapati bahawa sampel komposisi terbaik menggunakan saiz teras kenaf 20 mesh berpotensi untuk meningkatkan prestasi mekanikal simen dan dapat bertahan pada jangka masa yang lebih lama dalam ujian rintangan api. Justeru itu, menggunakan simen yang diperkukuhkan dengan teras kenaf telah terbukti mempunyai prestasi lebih baik dalam aplikasi pintu rintangan kebakaran.*

## ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to thank and praise Allah the Almighty, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to extend my appreciation to the Universiti Teknikal Malaysia Melaka for providing the research platform and granting the permission to use the equipment and machines in the laboratory.

My utmost appreciation goes to my main supervisor, Professor Madya Ir. Ts. Dr. Mohd Yuhazri bin Yaakob. I am very thankful for all his support, advice and inspiration. His constant patience for guiding and providing priceless insights will forever be remembered. Also, to my co-supervisor, Dr. Mohd Amirhafizan bin Husin who constantly supported my journey. My special thanks go to both supervisors for all the help and support I received from them.

I would like to give a special thanks to my beloved families for their endless support, love and prayers. I would also like to thank my teammates Muhammad Fikri bin Zulkifli, Meryl Anyie Tomy and Melanie Lye Chuok Xin for the great supports and friendship. Finally, thank you to all the individual(s) who had provided me the assistance, support and inspiration to embark on my study.

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## LIST OF SYMBOLS AND ABBREVIATIONS

| | | |
|---|---|---|
| ASTM | - | American Society for Testing and Material |
| mm | - | millimeter |
| ISO | - | International Organization for Standardization |
| $^{o}C$ | - | Degree Celsius |
| kg | - | kilogram |
| KC | - | kenaf core |
| CS | - | cement slurry |
| SEM | - | Scanning Electron Microscope |
| Φ | - | diameter |

## LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

This chapter will explain and clarify about the background of the study, characteristics and behavior of kenaf core and cement slurry made for fire resistance door. This research is the concept that contains the fundamental theory in previous research, books and journals. Therefore, the information and problem are gathered to identify the development needed for this research.

## 1.1 Background

In recent years, the spread of fire in buildings endangers people's lives. Fire is the result of a chain reaction involving oxygen, fuel and heat (Tola et al., 2018). Most buildings have adequate oxygen and the availability of fuel determines the initial growth of a fire. According to Novak et al. (2018), to prevent the spread of a potential fire and minimize losses, one of the basic requirements, particularly for industrial buildings, is to divide the building into fire zones that are protected by fire structures such as installing the fire doors. The resistance of the doors to fire is critical for the overall fire safety of the building.

The ability of a material or combination of materials to resist the passage of fire from one distinct area to another is referred to as fire resistance. There are many materials that can be used in the manufacturing of fire door structures that give different mechanical properties when react to fire. Guobys et al. (2016) stated some structures use gas and polymer fillers, but these structures are expensive and complicated. Despite its good thermal insulation

properties, wood has a limited fire resistance time due to its high combustion rate (about 2 mm/min). They also stated that the thermal insulation properties of gypsum and stone wool allow them to resist the spread of fire.

To test the fire door when react to fire, fire resistance is used. Because fire resistance tests are very expensive, the number of tests performed on each prototype of the structure is typically limited to one or two (Tabaddor and Jadhav, 2013). The furnace, along with the equipment that allows temperature control and monitoring of gas pressure in the furnace, is the main element in the fire resistance testing lab. According to Sulik and Kimbar (2017), the testing furnace can be powered by liquid or gas fuel. Interestingly, testing furnaces can be built in such a way that horizontal and vertical elements can be tested at the same time.

Over the last decade, natural fibres have been greatly used by human as a reinforcement material in exchange to synthetic fibres in concerning the environment issue. Natural fibre can be classified into plant fibre, animal fibres and mineral fibres. Sreenivas et al. (2020) stated that these fibres are preferrable compared to the synthetic fibres as it is lower in density, stiffness and hardness to the proportion of weight. It also is lighter when combine with other fibres. Based on journal by Ismail et al. (2019), the type of plant, extraction and manufacture process, fibre age or maturity process and the location of the plant's growth will affect the properties of the fibres.

Recently, natural fibres from plant are the most use in composites as the fibres are easily available in the market such as kenaf, jute and hemp. Composite materials are continuously used in many applications due to their flexibility and improved technologies especially from natural fibres that have higher potential than synthetic fibres. According to Hamidon et al. (2019), these natural fibres have received higher attention for the usage in composites as there are easy to be manufacture and give good benefits for the environment. The fibres gain higher demand in the industries such as transportation, building and

construction materials as it can replace synthetic fibre in term of lower cost, eco-friendly and can be recycled (Mustaffa et al., 2018). However, the focus of this study is to use kenaf.

Based on research by Shahar et al. (2019), kenaf markets are rapidly expanding both locally and globally, particularly with the introduction of new technologies and applications that have the potential to improve kenaf fibres's mechanical and chemical properties and replace other materials in the future. Supported by Mahzabin et al. (2018), they stated that kenaf are produced all over the world, including Malaysia, where it contributes to the development of environmentally friendly assets. Kenaf has a high potential for use as an alternative raw material to replace synthetic fibre in the medium density fibre board and particle board manufacturing industries.

Due to the high demand for cement and concrete production around the world, the cement and concrete industries becoming more interested in finding alternative materials to replace the use of these resources with natural fibres (Jiang et al., 2018). There are many research primarily studied the properties of natural fibres that can be used to replace or mix with cement thus can lower the content of cement due to environmental issue. Since there are only few past studies related to kenaf core and cement slurry in fire resistance door, therefore this research will further focus on the study about the development of fire resistance door from kenaf core and cement slurry.



## 1.2 Problem Statement

Over the years, fire has been one of the most common and destructive disasters in the world, destroying lives, properties and businesses when it gets out of control. According to Suresh (2017), there are many fire disasters happened at the construction sites and buildings. In every building, structures such as fire resistance door is necessarily important

to avoid from the spread of fire become larger and to protect the people in the building thus they can escape or evacuate out of the building safely (Guobys et al., 2016). Hence, this fire resistance door is a method of fire safety that highly getting attraction for the people to install in their building so that can reduce the damages. Fire resistance door need to withstand fire and heat at least for 30 to 180 minutes before damages to allow people evacuate safely (Seo et al., 2013). Fire resistance door usually made of cement or concrete as it has great strength compared to other material and easy to handle and manufacture.

According to Kang et al. (2017), although cement-based materials are widely used due to their high compressive strength, they are lack to bending and tensile forces. There are studies being conducted to investigate the mixing of various types of excellent mechanical performance fibre to overcome the shortcomings and improve the mechanical properties of cement- base material. Feng et al. (2019) stated that cement slurry emits a large amount of hydration heat during the cementing process, raising the temperature of the gas hydrate layer and causing gas hydrate decomposition, resulting in leakage. Therefore, to control and reduce the cementing risk and ensuring the cement quality, natural fibre will be added to the mixture.



Furthermore, to protect concrete structures from fire, cementitious fireproof material is widely used. However, there has recently been a surge of interest in developing more environmentally friendly structures with lower cement content, as cement manufacturing has a significant carbon footprint (Won et al., 2012). Other than that, when using cement-based material, weight of the fire door became heavier and not easily to be install. Hence, with the addition of natural fibres, it will reduce the weight of the fire door but still maintaining the performance of the fire door. Therefore, the use of composites based on agricultural residues found in nature is a new trend in material development.

Natural fibres as bio fillers have appealing properties such as low density, low cost, environmental friendliness, reduced tool wear, high specific mechanical performance, renewable and degradable properties (Verma and Shukla, 2018). Hence, many researchers have been gone through research in replacing synthetic fibres in fire resistance door due to environmental issue. The mechanical properties and the behavior of natural fibres will be further test and analysis to develop or improve the fire resistance door. Increasing in the fibre size and fibre percentage will increases the tensile strength of the fibre. However, not many manufacturing of fire resistance door is made from natural fibre. Therefore, this research will be focused on the research and development of fire resistance door from kenaf core and cement slurry.

## 1.3 Objectives

The objective of research are as follows:

a) To fabricate kenaf core reinforced cement slurry in various ratios for fire resistance door application.

b) To investigate the mechanical properties of kenaf core reinforced cement slurry in various ratios.

c) To recommend the best kenaf core reinforced cement slurry ratio for fire resistance door applications.

## 1.4 Scope of Research

The scopes of the research are as follows:

a) To study the potential of kenaf core and cement slurry used to produce fire resistance door.

b) This study will involve process of moulding and curing on kenaf core reinforced cement before proceeding with the testing.

c) This study will determine the best ratio composition of kenaf core reinforced cement slurry to produce fire resistance door.

d) To identify the strength of fire resistance door depending on the various ratios of kenaf core reinforced cement slurry.

e) To observe the performance of fire resistance door in the event of fire.

f) The mechanical properties included resistant to fire, compressive strength, and flexural strength of fire resistance door made from kenaf core reinforced cement slurry is examine and evaluate according to ASTM standard.

## 1.5 Rationale of Research

The rational of research are as follows:

a) Since kenaf plant can be easily grow in tropical climate and getting high demand around the world, therefore farmers can have the opportunity to grow the plant widely but at the same time will increase the social economy in Malaysia.

b) Since kenaf core have great advantages and easily accessible in Malaysia market as it is applicable natural fibres in many applications, therefore this study is conducted to identify the potential of using kenaf core mix with cement slurry in development of fire resistance door.

c) In recent past research, fire resistance door typically made from cement or concrete as this material easy to be produce but the disadvantages of using cement will lead to environmental issue. Thus, to reduce the release of carbon or other

gases comes from cement in production of fire resistance door in the event of fire, kenaf core will be used by mixing with cement.

d) Developing and expose more information about kenaf core in order to produce a fire resistance door that are affordable, lightweight and high resistant to fire.

## 1.6 Thesis of Organization

The purpose of this study is about the research and development of fire resistance door from kenaf core and cement slurry. This report chapter consists of introduction, literature review, methodology, result, and discussion. PSM 1 will cover Chapter 1, Chapter 2, and Chapter 3 while PSM 2 will cover Chapter 4 and Chapter 5. The order sequence from Chapter 1 to Chapter 5 are structured accordingly. Chapter 1 is about the introduction of the research consists of background study, problem statement, objectives, scope of research and the rational of the research. Chapter 2 excites about the literature review of previous studies contains introduction to fire resistance door, testing of fire resistance, and type of material used in fire resistance door continued with kenaf core and its application while end with studies about cement. Then followed by Chapter 3 which describes the methodology in detail about the preparation of the raw materials which are kenaf core and cement slurry to produce fire resistance door. The method used includes preparation process, fabrication process and testing process using standard test such as flexural testing and fire resistance testing. After that, all the data and analysis obtained from the experiment testing will be evaluate in Chapter 4. Finally, all the discussion and findings were concluded in Chapter 5 where the improvement can be developed for further research or study.