

NATURAL FIBRES AND POLYMERS SELECTION WITH A COMBINATION OF ASPHALT MIXTURE BASED ON MECHANICAL AND PHYSICAL PROPERTIES



BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY WITH HONOURS

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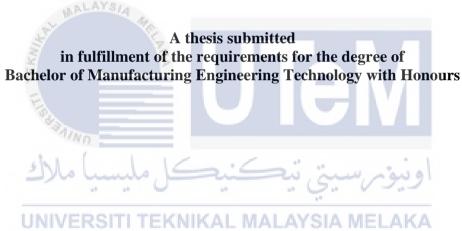
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Bachelor of Manufacturing Engineering Technology with Honours

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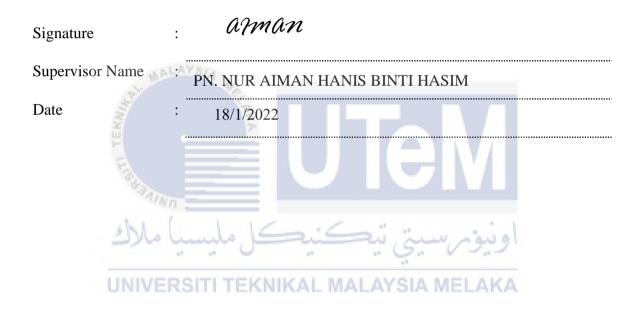
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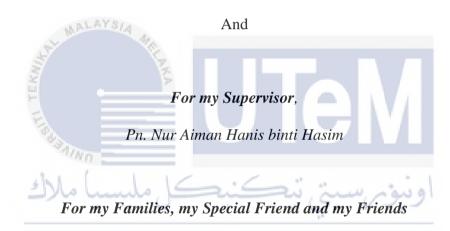


DEDICATION

To my beloved parents who are always supported me:

Muhammad Sabri bin Othman

Norlela binti Hasim



who provide a loving, caring, encouringing, and supportive atmosphere. These are characteristics that contribute to the environment that is always needed to achieve the

goals a heads.

ABSTRACT

Road was designed and built for people to go to work, travel, and vacation. However, even roads can reach their limits and be damaged. Potholes, in general, are bowl-shaped holes in the surface of asphalt road pavement and their presence will bring dangerous situation to users, drivers or riders. Potholes are repaired by filling the damaged area with an asphalt mixture. However, the fix is temporary, and they are prone to damage. This is due to the quality of asphalt pavement. There have been a few studies about on how to increase the performance of potholes repair where researchers and experts have state that combining natural fibres and polymers with asphalt mixture can improve their performance. Thus, there are a lot of natural fibres and polymers that can be used to be mix in the asphalt mixture. The list of natural fibres and polymers to be evaluated are coconut, jute, hemp, sisal fibres and Polypropylene (PP), High-Density Polyethylene (HDPE), Polystyrene (PS), Polyethylene Terephthalate (PET) respectively. Therefore, this paper is to provide a case study on the material selection of natural fibres and polymers based on design requirements by focusing on the physical and mechanical properties of natural fibres, polymers and asphalt mixtures. Then, to compare the results of natural fibres and polymers by using two different methods which are Pugh Decision Matrix and Grey Relational Analysis (GRA). The results shows the highest ranking score for natural fibre and polymer are jute fibre and Polyethylene Terephthalate (PET) from Pugh Decision Matrix analysis. From the Grey Relational Analysis (GRA), the highest ranking score for natural fibre and polymer are hemp fibre and Polyethylene Terephthalate (PET). Based on these two method analysis which are Pugh Decision Matrix and Grey Relational Analysis (GRA), jute fibre, hemp fibre and Polyethylene Terephthalate (PET) are selected as the best natural fibre and polymer to . O. V combine with asphalt mixture. 0 1.0 and you

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ABSTRAK

Jalan dirancang dan dibangun bagi orang - orang untuk pergi bekerja, bepergian, dan berlibur. Walau bagaimanapun, walaupun jalan raya boleh mencapai had mereka dan rosak. Lubang, secara umum, adalah lubang berbentuk mangkuk di permukaan turapan jalan asfalt dan kehadiran mereka akan membawa keadaan berbahaya kepada pengguna, pemandu atau penunggang. Lubang dibaiki dengan mengisi kawasan yang rosak dengan campuran asfalt. Walau bagaimanapun, pembaikan adalah sementara, dan mereka terdedah kepada kerosakan. Ini disebabkan oleh kualiti turapan asfalt. Terdapat beberapa kajian tentang bagaimana untuk meningkatkan prestasi pembaikan lubang di mana penyelidik dan pakar telah menyatakan bahawa menggabungkan gentian semulajadi dan polimer dengan campuran asfalt dapat meningkatkan prestasi mereka. Oleh itu, terdapat banyak gentian semulajadi dan polimer yang boleh digunakan untuk dicampur dalam campuran asfalt. Senarai gentian asli dan polimer yang akan dinilai ialah kelapa, jute, hem, gentian sisal dan Polipropilena (PP), Polietilena Ketumpatan Tinggi (HDPE), Polistirena (PS), Polyethylene Terephthalate (PET). Oleh itu, kertas ini adalah untuk menyediakan kajian kes mengenai pemilihan bahan gentian semulajadi dan polimer berdasarkan keperluan reka bentuk dengan memberi tumpuan kepada sifat fizikal dan mekanikal gentian semulajadi, polimer dan campuran asfalt. Kemudian, untuk membandingkan hasil gentian semulajadi dan polimer dengan menggunakan dua kaedah yang berbeza iaitu Matriks Keputusan Pugh dan Analisis Hubungan Kelabu (GRA). Keputusan menunjukkan skor kedudukan tertinggi untuk gentian semulajadi dan polimer adalah serat jute dan Polyethylene Terephthalate (PET) dari analisis Matriks Keputusan Pugh. Dari Analisis Hubungan Kelabu (GRA), skor kedudukan tertinggi untuk serat semula jadi dan polimer adalah serat hem dan Polyethylene Terephthalate (PET). Berdasarkan dua analisis kaedah ini iaitu Pugh Decision Matrix dan Grey Relational Analysis (GRA), jute fibre, hem fibre dan Polyethylene Terephthalate (PET) dipilih sebagai gentian semulajadi dan polimer terbaik untuk digabungkan dengan campuran asfalt..

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LIST OF SYMBOLS AND ABBREVIATIONS

NFRPCS	- Natural Fibre Reinforced Polymer Composites
GRA	- Grey Relational Analysis
QFD	- Quality Function Deployment
QFDE	- Quality Environmental Function Deployment
VOC	- Voice of Customers
VOE	- Voice of Environment
ARB	- Automotive Roll Bar
MCDM	- Multi-criteria decision-making
MODM	- Multi-objective decision-making
MCDA	- Multi-criteria decision analysis
PVC	- Polyvinyl Chloride
PP	- Polypropylene
HDPE	- High-Density Polyethylene
PS	- Polystyrene
PET	Polyethylene Terephthalate
HMA	- Hot-mix asphalt
MPa	UNIVERSITATEKNIKAL MALAYSIA MELAKA
GPa	- Gigapascal
Kg/m ³	- Kilogram per meter cube
kJ/m ²	- KiloJoule per meter square
Rf	- Rating factor
Wf	- Weighted factor
Df	- Decision Factor
%	- Percentage
GRC	- Grey Relational Coefficient
GRG	- Grey Relational Grade

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CHAPTER 1

INTRODUCTION

1.1 Background

Potholes and road pavement are basically made from asphalt, which consist of hydrocarbons and can leak into the environment, polluting it. Every year, potholes cause damage to automobile wheels, tyres, and suspensions, as well as accidents that result in deaths and injuries. Potholes, in general, are bowl-shaped holes in the surface of asphalt road pavement and their presence will bring dangerous situation to users, drivers or riders (Han et al., 2019). Potholes are normally formed because of the heavy traffic loads by vehicles, terrible and unstable weather especially during rainy seasons or hot season in Malaysia. In an article news from Rojak Daily in January 2021, according to Universiti Putra Malaysia Department of Civil Engineering lecturer Prof Dr Ratnasamy Muniandy, there are some factors that causes potholes which are road design, material design and environmental factors, moisture and unstable temperature. Potholes form when there are cracks on the roads, which, over time, will cause the road materials to damage. Other than that, water also the critical factor in forming potholes as it can absorb and diffuse into internal road pavement and the foundation of road can become soft hollow and apparently this is where the potholes and road damage can formed. Besides, low temperatures and water can decrease the quality of potholes repair and patching process of road pavement. So, a lot of time and a good quality repair are required to prevent the potholes from happening again. Most common problem of potholes are shoving, dishing, bleeding, edge disintegration, stripping and alligator cracking.

Pothole repairs remain a major maintenance item in the budgets of many highway agencies and the annual appearance of potholes each spring is a major public relations concern for these agencies. This is especially true when repairs are temporaries and the same areas are repaired over and over. Despite significant advances in pavement materials and pavement mechanics, pothole repair remains a relatively undeveloped area (Ghosh et al., 2018). There is clearly a need for long-lasting, low-cost materials and construction technologies for repairing potholes.

There are numerous reports and news stories in Malaysia about potholes. Repairing potholes entails filling the damaged area with an asphalt mixture. Even if the potholes have been repaired, the repair does not last long and they are easily damaged again. A few studies have been conducted on how to improve the performance of pothole repair, and Fu *et al.* (2017) state that combining natural fibre reinforced polymer composites (NFRPCs) with asphalt mixture can improve their performance.

1.2 Problem Statement

Natural Fibres and Polymers are the main focus in this case study which is to combined with asphalt mixture for patching potholes application based on mechanical and physical properties. NFRPCs is the composite that consist the mixture of natural fibre and polymer matrix. NFRPCs is important to study because when the design of NFRPCs combined with asphalt mixture indirectly can improve the mechanical performance of asphalt mixture. This can be proven by studies in Bhosale *et al.* (2019) article, they state that natural fibre availability, low cost, and ease of manufacturing have drawn researchers' attention to the possibility of combining natural fibre and polymer to improve mechanical properties and study the extent to which they satisfy the required specifications of good reinforced polymer composite for industrial and structural applications.

Eventhough, there are studies in this area, there are still several unanswered questions. Firstly, there is no investigation about the relationship between material selection criteria for natural fibre and polymer combined with asphalt based on design requirement by focusing on mechanical and physical properties. According to Milad, Ali and Yusoff, (2020) article, they have review a brief discussion of the asphalt mixtures modified with waste material, and the recycled materials used as a modifier in the asphalt mixture. So, there is research gap that needs to be studied which is material selection criteria for natural fibre and polymer that can use to combine with asphalt mixture based on mechanical and physical properties.

Secondly, the problem is most of the studies and research do not states the rank for best natural fibres and polymers that can be used in the asphalt mixture. Thus, further studies need to be done for material selection criteria. This can be done to determine and compare the ranking score by using decision making method analysis.

The focus on this case study are to study and determine the material selection criteria for natural fibres and polymers based on mechanical and physical properties and to give rank to the material selection by using two different methods which are Pugh Decision Matrix and Grey Relational Analysis (GRA). Then, to explain the comparison of result obtained from Pugh Decision Matrix and Grey Relational Analysis (GRA) for natural fibres and polymers to combine with asphalt mixture.

1.3 Research Objective

Specifically, the objectives are as follows:

- 1) To study and determine the material selection criteria for natural fibres and polymers based on mechanical and physical properties.
- 2) To explain and compare the result obtained from Pugh decision matrix and

Grey Relational Analysis (GRA) for natural fibres and polymers.

1.4 Scope of Research

The scope of this research are as follows:

- To study the mechanical and physical criteria of natural fibres and polymers that can satisfy the design requirement of asphalt mixture.
- To determine a ranking score of selected natural fibres and polymers properties by using Pugh Decision Matrix and Grey Relational Analysis (GRA).
- 3) To explain and choose the best natural fibre and polymer to mix into the asphalt mixture based on their ranking score based on mechanical and physical properties.



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter contains the literature review of this study which relates to the scope of this study. The research also being conduct based on the journal, thesis, case study, technical document, books, reports and also electronic- media sources. Each source was chosen based on how well it suited with the scope of the study. All of these sources must be relevant to customer satisfaction and were chosen for their similarity with the scope of the study.

Natural Fibre Reinforced Polymer Composites (NFRPCs) are attracting many industries, academicians and researchers all around the world as their compatibility and utilization on the mixture of natural fibre and polymer matrix need a lot of studies, research and experiment (Mohammed et al., 2015). The objective of this article review is to study and determine the usage and application of natural fibre reinforced polymer composites (NFRPCs) as mixture in the asphalt for the potholes repair or road pavement and to study and determine the material selection criteria for natural fibres and polymers based on mechanical and physical properties.