Material Selection Of Natural Fibre Reinforced Polymer Composites (NFRPCs) Potholes Based On Design Requirements

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ABSTRACT: Road has been the important part of human life. It has been design and build for people for their daily life. However, road can reach their limits and will be damaged. Heavy traffic loads and change of weather are main factor that distributes to road damaged and potholes. Potholes are repaired by filling the damaged area with an asphalt mixture. However, the fix do not last long and they are prone to damage. This is due to the quality of asphalt pavement. Researchers and experts have state that combining natural fibres reinforced polymer composites (NFRPCs) with asphalt mixture can improve their perfomance. Yet, there are a lot of natural fibres and polymers that can be used to be mix in the asphalt mixture. Thus, this paper is to provide a case study on the material selection of natural fiber reinforced polymer composites pothole by focusing on the design requirement and thermal properties of natural fibres, polymers and asphalt mixtures.

Keywords: *NRFPCs, Potholes, asphalt mixture*

INTRODUCTION

Road has been the important part of human life. It has been design and build for people to go to work, travel, transport and to connect with each other. Without the road, it is really hard to move from one place to another place. It is very important to design and build the safe, smooth and durable road. However, even road can reach their limits and will be damaged. Heavy traffic loads by vehicles and sudden change of weather during rainy and hot seasons are two main factors that causes potholes [8]. There are some factors that causes potholes which are road design, material design and environmental factors, moisture and unstable temperature.

A significant advances in pavement materials and pavement mechanics, pothole repair remains a relatively undeveloped area [4]. There is clearly a need for long-lasting, low-cost materials and construction technologies for repairing potholes.

According to [3] combining natural fibres reinforced polymer composites (NFRPCs) with asphalt mixture can improve their perfomance. However, there are many natural fibres and polymers that can be used to mix with the asphalt, thus this studies and research are to study the criteria of the material selection of NFRPCs and choose the best NFRPCs to be combine with asphalt mixture. In [1] research paper, they state that a new types materials of natural fibres such as hemp, coconut coir, jute, flax and sisal are compatible and suitable to mix in the asphalt.

METHODOLOGY

NFRPCs combined with asphalt mixture indirectly can improve the mechanical performance of asphalt mixture. This can be proven by studies in [2], natural fibre availability, low cost, and ease of manufacturing have drawn researchers' attention to the possibility of reinforcing natural fibre 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.

According to [6] 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 NFRPCs that can use to combine with asphalt mixture for patching potholes based on design requirement.

In [5] stated that they have used pugh decision matrix for selection of a thermoplastic matrix for the natural fibre composite for an automotive anti-roll bar.

2.1 Data Collection of Mechanical Properties of Asphalt Mixture, Natural Fibres and Polymer Matrix.

Researchers had done some data collection based on previous study in order to investigate and identify the best mechanical properties on natural fibers, asphalt mixture, and the polymer matrix used.

2.2 Decision Matrix Method

Pugh selection method is an important tool in design for manufacturing and concurrent engineering field, which has been recognised. In fact, the total design model was also recognised as the tool to support concurrent engineering, and not only Pugh selection method is recognised [7].

ANALYSIS AND FINDING

Table 1 shows a typical decision matrix is then constructed, in which a set of tensile strength(MPa), young modulus(GPa), elongation at break (%) and density(kg/m3) are listed in the first row of the decision matrix. A rating system of 1–5 will be used in this study, with 1 being the worst and 5 the best, to assign a rating factor (Rf) to each material under individual criteria. Individual rating factors are assigned by referring to the properties in Table 2 and scaling them roughly proportionally. A weighting scale is usually assigned to account for this variation. Individual design criteria are assigned weighting factors 1–5, with tensile strength being 5, young modulus being 3, elongation at break being 4, and density being 2 as shown in Table 3.

Table 1 The mechanical properties of Natural Fibre and Polymer Matrix.

Natural Fibre and Polymer Matrix	Tensile Strength(MPa)	Young Modulus(GPa)	Elongation at break(%)	Density(kg/m3)
Coconut	175	4-6	30	1200
Sisal	400-700	9-12	5-14	1450
Jute	400-800	10-30	1.5-1.8	1460
Hemp	550-900	70	1.6-4	1480
Polypropylene(PP)	41.4	1.8	43-73.2	920
High-Density Polyethylene(HDPE)	38	1.5	1120-1290	970

Table 2 Decision Matrix for material selection of Natural Fibre and Polymer Matrix.

Natural Fibre and Polymer Matrix	Tensile Strength(MPa)	Young Modulus(GPa)	Elongation at break(%)	Density(kg/m3)	Score
Coconut	3	2	3	3	11
Sisal	4	2	2	4	12
Jute	4	3	1	4	12
Hemp	5	5	1	4	15
Polypropylene(PP)	1	1	3	2	7
High-Density Polyethylene(HDPE)	1	1	5	2	9

Table 3 Decision Matrix with Weighting Factors.

Natural Fibre and Polymer Matrix	Tensile Strength(MPa)	Young Modulus(GPa)	Elongation at break(%)	Density(kg/m3)	Score
Weighting Factor	(5)	(3)	(4)	(2)	
Coconut	3	2	3	3	39
Sisal	4	2	2	4	42
Jute	4	3	1	4	41
Hemp	5	5	1	4	52
Polypropylene(PP)	1	1	3	2	24
High-Density Polyethylene(HDPE)	1	1	5	2	32

CONCLUSION

According to the pugh decision matrix, the most suitable natural fibres and polymers that can be used and mixed into the asphalt mixture are hemp fibre and HDPE respectively. Based on its physical and mechanical properties that are compatible with the design requirements of an asphalt mixture.

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