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ALTERNATIVE MATERIALS FOR SUSTAINABLE ROAD CONSTRUCTION IN SRI LANKA

H.D.D.P. Kodithuwakku[1], T. Ramachandra[2] and P. Kajavathani[3]

ABSTRACT

The current socioeconomic demand requires adequate engineering performance and environmentally friendly materials from the perspective of sustainable development. The scarcity of conventional natural resources and the severe environmental consequences of extraction have prompted research into alternative materials and resources for use in the road industry. Based on the findings of the existing studies, this research aims to explore the suitability of alternative materials for road construction projects towards sustainability in Sri Lanka. A quantitative research strategy was employed in the current study, and the questionnaire was distributed among 44 professionals involved in different types of road projects. The collected data were analysed by using Relative Important Index (RII). 84% of respondents considered alternative sustainable construction materials are highly suitable for the construction of road elements. Bituminous materials, natural soil, crushed rock and cement concrete are mostly commonly traditional materials. Construction and demolition waste (C&D), fly ash, plastic waste, and waste rubber tires were selected as the best materials for base construction, cement kiln dust waste, fly ash, glass waste, and waste rubber for sub-base and C&D waste and glass waste for sub-grade construction. Alternative sustainable materials can solve the waste disposal issue, scarcity of natural materials, and cost savings. Thus, this study presents a collective listing of the most viable alternative materials already in use by the global industry, with the goal of establishing a noble notion for better incorporation of alternative sustainable materials into road construction in Sri Lanka.

Keywords: *Alternative Sustainable Materials; Environmental Sustainability; Recycling; Road Construction; Waste Material.*

1. INTRODUCTION

The road is the legally permissible way for vehicles and other traffic to traverse. Roads include passageways, side drains, culverts, bridges and land needed for upcoming widening. Bamigboye et al. (2021) stated that the construction and maintenance of roads and other transportation amenities continue to be important factors in socio economic progress. Transport contributes 10% to 20% of the Gross Domestic Product (GDP) where road transportation represents between 3% to 5% of the GDP excluding the inputs of

[1] Quantity Surveyor, State Engineering Corporation, Sri Lanka, dinushaqssec@gmail.com
[2] Senior Lecturer, Department of Building Economics, University of Moratuwa, Sri Lanka, thanujar@uom.lk
[3] Lecturer, Department of Building Economics, University of Moratuwa, Sri Lanka, kajavathanip@uom.lk

transport equipment of fuel, and infrastructure. Road infrastructure has benefited societies and economies in a variety of ways (Lee et al., 2019). Further, it improves accessibility in terms of transportation, education, goods, and services, and it can save travel time and costs.

Road construction is always evolving, notably in terms of road paving technology. It is highly reliant on government policies and scientific progress. Possible road pavement technology growth paths must be studied to provide robust information to decision-makers (Radziszewski et al., 2016). The continued growth of the global economy and level of life will almost certainly lead to an increase in raw material consumption worldwide. Over the past two decades, academics have researched how to use environmentally friendly alternative materials in road construction to combat this issue and promote conservation.

In the Sri Lankan context, several researches have been conducted to study different areas of road construction, such as causes for claims in road construction projects, risk management strategies, procurement methods frequently used in road construction projects, integration of sustainability concepts in road construction, and other areas. Modern technologies and new materials have great attention in construction projects to reduce cost and time and to improve the construction quality. Using currently available materials and technology, it is possible to significantly improve the substitution of virgin materials with recycled materials (Gómez-Meijide et al., 2015). Long durability periods are required in terms of social costs; such a solution is attainable (Lee et al., 2019). After a critical review of the existing literature, it is noticed that there is a knowledge gap on the suitability of alternative materials for sustainability in road construction projects in Sri Lanka. Therefore, this study aimed to analyse the alternative materials for sustainable in road construction in Sri Lanka.

2. LITERATURE REVIEW

2.1 OVERVIEW OF ROAD CONSTRUCTION

Sri Lanka has a well-connected 116,000-kilometer road network. Sri Lanka currently has 1.7 kilometres of roads per square kilometre, which is higher than its regional counterparts (Siyambalapitiya, 2018). In Sri Lanka, 753 numbers of class "A," "B," and "E" roads totalling 12,496.337 kilometres in length. The current roadway structure comprises a soil base, base, additional base layer, and coating layers (Halushko et al., 2020). The components of the road pavement structure include the base (broken stone aggregates), subsoil (natural soil compacting), the subgrade (disintegrated rocks like gravel, sand, and clay), and surfacing (bituminous material).

2.2 ALTERNATIVE MATERIALS FOR ROAD CONSTRUCTION

Pavements are broadly classified into two types: flexible pavements and rigid pavements. The classification is based on the structural performance of the materials used (Halushko et al., 2020). Flexible pavements are bituminous roads that have low flexural strength, whereas rigid pavements are concrete roads with great flexural strength. Other novel breakthroughs in changing the qualities of various sorts of pavements have resulted in categories such as pervious pavements, reflecting pavements, interlocking pavements, and composite pavements, among others (Nwakaire et al., 2020). Depending on the binding material, any of them can be classed as either flexible or stiff pavements. The quality of the pavement is directly and mostly determined by the quality of the materials used to construct it. The primary purpose of pavement structural design is to ensure that the pavement stays functional throughout its service life, and material selection is crucial both during the design and construction stages (Nwakaire et al., 2020).

Construction industry generates a larger proportion of solid waste, more attention is being devoted to Construction and demolition (C&D) waste management (Banihashemi et al., 2018). Recycled C&D as an alternative is an environmentally beneficial and sustainable solution to the C&D waste problem (Zhang et al., 2019). C&D waste includes ceramics, concrete, electrical wiring, bricks, tiles, timber, tar and bituminous products, glass, hazardous components plastic, asphalt, metals, soil and dredged soil, combined C&D, insulation materials, and gypsum-based materials (Ghosh et al., 2016). While it is anticipated that road construction activity will remain stable in the near future, the quantity of C&D is constantly rising (Zhang et al., 2019).

Kurpińska et al. (2019) estimated that glass waste account for 10% to 15% of global garbage production. Several strategies have been developed to reduce the environmental impact of glass waste, including using recycled crushed glass as an aggregate for asphalt concrete in the road and civil engineering projects. Plastic is a non-biodegradable polymer-based substance and is one of the most discarded materials on the planet (Rahman et al., 2020). 5 trillion plastic bags are used worldwide yearly, and 1 million plastic bottles are bought every minute. These plastic wastes are being disposed of at an increasing rate, which has negative effects such as visual pollution, flooding, and the extinction of sea life, and it has been found that plastic waste has the potential to be used as a secondary aggregate (Maharaj et al., 2019).

Discarded rubber tires, also known as end-of-life tires or styrene-butadiene-styrene, are non-biodegradable materials and are designed to withstand harsh climatic conditions (Sugiyanto, 2017). Rubber tires have exceptional resistance to acid and water resistance, have a high impact resistance, plastic energy absorption, and provide thermal insulation (Saberian & Li, 2019). End-of-life tyres have been a major issue in a number of countries over the years (Sugiyanto, 2017). The use of waste rubber as a construction material is seen as a viable alternative to waste rubber disposal (Fernandes et al., 2019). Further, the waste rubber is used in embankment construction, aggregate substitution, asphalt modifier, retaining walls, drainage, backfills, and thermal insulation.

Coconut shells and fibres have recently been used in the asphalt paving industry. Ting et al. (2017) investigated the impact of an asphalt mix with coconut shells instead of aggregates. A stone mastic asphalt mix was developed in Brazil using coconut, sisal, cellulose, and polyester fibres (Agunsoye et al., 2014). Cement kiln dust is collected as a waste product of cement manufacturing activities (Seo et al., 2019). Cement kiln dust comprises high-alkaline fine-particulate solids that look like Portland cement and used as an alternative material for cement concrete for road surfaces and building constructions. The cement kiln dust and flyash mix as a binder in stabilising C&D waste aggregates for road construction (Arulrajah et al., 2017). The majority of ceramic waste is generated during building interior construction. These wastes are disposed of in landfills as part of waste management. Recycling this widely generated heavy waste can relieve burden on landfills (Muniandy et al., 2018).

Massive amounts of waste are generated by quarries all over the world. Quarry aggregates have properties and appearances similar to ordinary aggregates (Rahman et al., 2020).

They can be used to construct asphalt pavement for low to medium-traffic situations. Because traditional granite and basalt aggregates are expensive, many countries rely on quarry waste imports for road construction. Mining waste aggregates replaced up to 50% of traditional basalt aggregates in asphalt mix samples (Akbulut & Gurer, 2007). Bio oils, which are derived from biomass adaptation, are a sustainable source of energy that can be used as a modifier in the production of bio asphalt (Raman et al., 2015). Zhang et al. (2019) also investigated the effectiveness of sawdust bio-oil as a rejuvenator for aged asphalt binders. Raman et al. (2015) discovered that bio-asphalts outperform traditional asphalt. Modifiers and substitute aggregates can give leftover materials a second chance at life while assisting in reducing the consumption of natural aggregates (Rahman et al., 2020). The long-term sustainability of the material's environmental impact over of its life cycle is ensured by using alternative binder materials.

2.3 ECONOMIC AND ENVIRONMENTAL ASPECTS

Materials typically account for more than 40% of the total cost of a construction project. Better material management can result in a small reduction in material costs, which can significantly impact the overall project cost (Rahman et al., 2020). According to professionals, using novel materials during the construction of road surfaces and subsequent operations becomes economically viable. Several road pavement life cycle assessment studies have been conducted in recent years (Bamigboye et al., 2021). Modern pavements should be built with materials that reduce traffic noise and improve water drainage (Freitas et al., 2012). Using currently available materials and technology, it is possible to achieve significant improvements in substituting virgin materials with alternative materials (Gomez-Meijide et al., 2015). Both economic and environmental factors influence the growing demand for alternative environmentally friendly materials in asphalt concrete pavements. Therefore, this study focuses on comparative analysis between traditional and alternative materials towards sustainability in road construction project

3. RESEARCH METHODOLOGY

The quantitative questionnaire analysis is a common research method that can provide valuable insights into the attitudes, perceptions, and preferences of individuals. It can be useful to quantify the frequency of specific phenomena or behaviours and to identify patterns or trends (Borrego et al., 2009). It enables researchers to collect quantitative data, which is useful for quantifying the incidence of specific phenomena or behaviours and identifying trends or patterns. Moreover, Zheng et al. (2019) highlight the significance of questionnaire analysis in determining the suitability of alternative sustainable materials for construction. The authors note that questionnaires allow researchers to collect data on the reasons why certain materials are preferred or not preferred as sustainable alternatives, thereby gaining valuable insights for decision-making in road construction projects. In addition, it is emphasised the importance of using questionnaires to collect information on construction materials and sustainability. By quantifying preferences and evaluating various factors such as durability, cost-effectiveness, and environmental impact, questionnaire analysis can help identify the most optimal alternative material for road elements, according to the researchers. Through this method, researchers are able to compare conventional construction materials with sustainable alternatives, allowing for a thorough analysis of their respective benefits and drawbacks.

The sample size for this research study was determined to be 44 due to time constraints. A 4-point Likert scale is used to grade the suitability of alternative sustainable construction materials for various road elements, and a 5-point Likert scale is used to grade the most suitable alternative sustainable material for road elements and to compare it to traditional construction materials. Table 1 and Table 2 present the 4-point and 5-point Likert scales respectively.

Table 2: Four-point Likert scale

Excellent	Good	Average	Poor
1	2	3	4

Table 1: Five-point Likert scale

Very much suitable	Suitable	Neural	Bad	Very Bad
5	4	3	2	1

The Relative Important Index (RII) is a statistical method used to calculate the relative importance of each material and to accurately rank accordingly. On the other hand, MWR technique provides a decision on significance of parameter with related to the received mean values. The following equation (Eq.: 1) is used to determine RII:

$$\boldsymbol{RII = \frac{\sum w}{A \; x \; N}} \qquad \text{..... } Eq. (1)$$

Where: w = Weighting given to each factor; A = Highest weight; N = Total respondents

Importance level is categorised considering RII levels, as shown in Table 3.

Table 3: Recommended ranges for Relative Importance Index (RII)

RII values	**Importance level**
0.8 ≤ RII ≤ 1	High
0.6 ≤ RII ≤ 0.8	High - medium
0.4 ≤ RII ≤ 0.6	Medium
0.2 ≤ RII ≤ 0.4	Medium - low

Source: (Akadiri, 2011)

The collected data were analysed using RII. The obtained results were presented graphically in the form of pie charts, percentage-subdivided bar diagrams, and tables.

4. RESEARCH FINDINGS AND ANALYSIS

The questionnaires were distributed to 50 professionals in the road construction industry. Most professionals had hands-on experience and a comprehensive understanding of sustainable alternative materials. Following the exclusion of incomplete questionnaires, 44 responses were deemed suitable for analysis, resulting in an 88% response rate. The questionnaire mainly analysed the suitable alternative materials for different road elements compared to traditional materials.

4.1 RESPONDENT PROFILES

The questionnaire was distributed among 44 selected civil engineers, quantity surveyors, project managers, design engineers, quality assurance managers, engineering assistants, and technical officer in order to cover different aspects of alternative materials perspectives of different construction professionals. Among selected respondents, 14% have more than 20 years of experience, while 25% have 10 to 20 years. Further, the selected professionals also had experience in different types of road projects, including asphalt roads, and concrete roads. gravel road, highways and Double bituminous surface treatment (DBST) pavement. Table 4 provides the respondent's profiles.

Table 4: Respondent's Profile

Designation	Number of Respondents	Level of Experience	Number of Respondents	Road Type	Number of Respondents
Civil Engineers	15	1-5	17	Asphalt road	19
Quantity Surveyor	14	5-10	10	Concrete road	13
Project Managers	10	10-20	11	Gravel road	6
Other	5	More than 20 years	6	Highway	5
				DBST pavement	1

According to Table 4, the majority of the workers have worked in asphalt and concrete road construction. 19 worked asphalt road construction, while 13 worked in concrete road construction. 6 and 5 of the respondents worked in gravel road and highway construction, respectively. Only 1 respondent had worked on DBST road construction projects.

4.2 TRADITIONAL MATERIALS USED IN ROAD CONSTRUCTION

Initially, the questionnaire focused on capturing the traditional materials used in Sri Lankan road construction apart from the literature findings based on their experience. Figure 1 presents traditional materials used in the road construction industry.

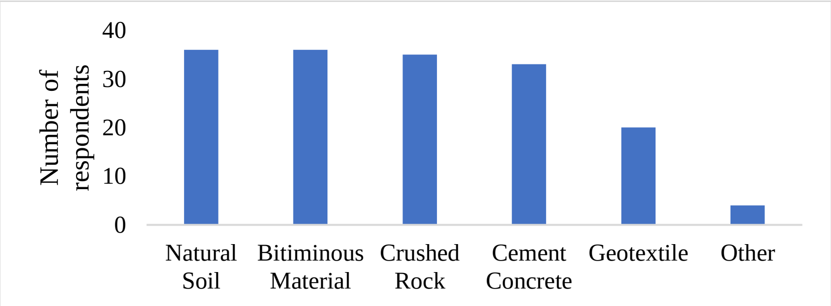

Figure 1: Traditional materials used in the road construction industry.

Figure 1 shows that the industry made extensive use of natural soil, bituminous materials, crushed rock, and cement concrete. Twenty respondents stated that geotextile is a traditional material. Further, respondents added precast concrete, porfido and limestone as other traditional materials for road construction. Out of 44 respondents, 84% of professionals are aware of alternative sustainable materials. Respondents were further inquired about, using sustainable alternative materials for road construction under in Sri

Lankan context to rate as excellent, good, average and poor. 50% of respondents graded the suitability of alternative sustainable construction material as excellent, while 34% graded it as good, yielding 84% of positive responses.

4.3 ALTERNATIVE MATERIALS USED IN ROAD CONSTRUCTION

The applicability of alternative materials identified from the literature to different road elements, including subgrade, subbase, base, surfacing and shoulders, were inquired. This suggests suitable materials for road elements. Figure 2 provides C&D wastes, glass wastes, plastic wastes, waste rubber tires and coconut, sisal, cellulose, and polyestor fiber as alternative sustainable materials in different road construction elements.

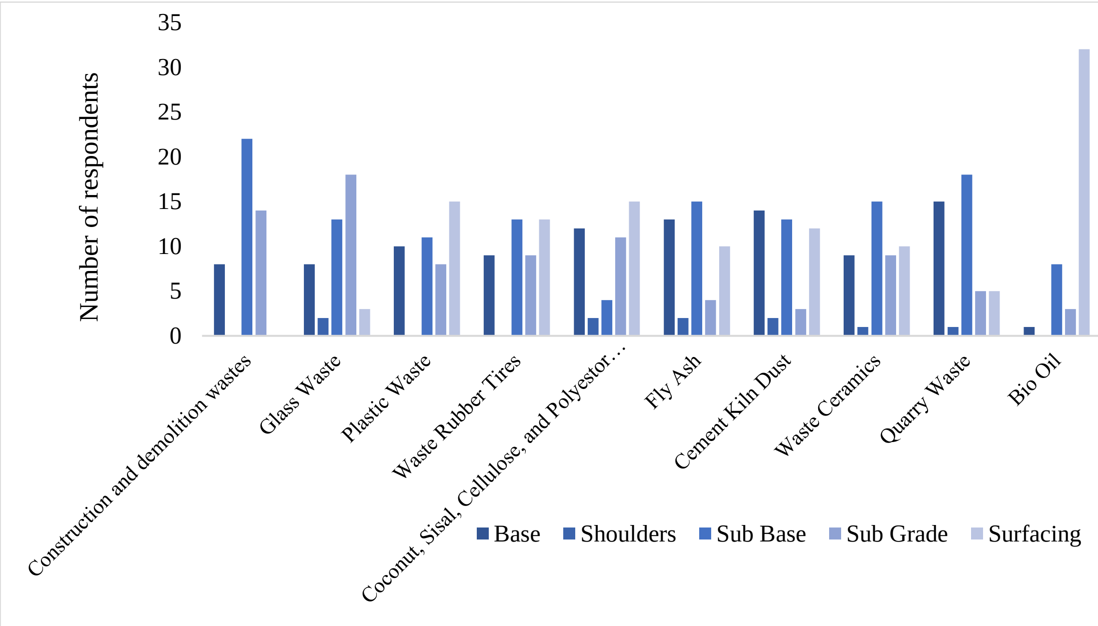

Figure 2: Utilisation of alternative sustainable material

According to Figure 2, 22 respondents stated that C&D wastes could be primarily used as an alternative sustainable material in the sub-base and a significant percentage for subgrade. Most glass waste is used in the subgrade and sub-base. Glass waste can be used moderately as an alternative material in the base. Still, only a few respondents agreed on using glass waste for shoulders and surfacing. Except for shoulder construction, plastic waste and waste rubber tires are commonly used in different road parts. Coconut, sisal, cellulose, and polyestor fiber are utilised mainly in surfacing, base and sub-grade and least in sub-base and shoulders. Fly ash and cement kiln dust can be used moderately for sub-base, base, surfacing, and least in sub-grade and shoulders. Like fly ash and cement kiln dust, waste ceramics and quarry waste are moderately used in sub-base, base and surfacing and least in shoulders. However, compared to fly ash and cement kilns, waste ceramics and quarry waste are preferred for sub-base. Bio oils were primarily used for surfacing, and a few number of professionals marked for sub-grade, Sub-base and base. Compared to all the materials, bio-oil is the least used as an alternative material for different parts of road construction.

4.4 SUITABILITY OF ALTERNATIVE SUSTAINABLE MATERIALS

There are numerous reasons why alternative sustainable materials are preferred, including as a solution to the waste disposal issue and scarcity of natural materials, as a means of cost saving, due to the material properties and performance, durability, and time reduction. On the other hand, it is not preferred due to lack of knowledge on alternative sustainable materials, lack of support for innovators and researchers, apprehensive about taking the risk and lack of government intervention. Respondents were asked to Table 5 summarises the results based on data collected from the respondents.

Table 5: Reasons for suitability of sustainable alternative materials

Reasons	Responses: Agreed	Responses: Not Agreed	% of response: Agreed	% of response: Not Agreed	RII	Importance Level	Overall Rank
Suitability of alternative sustainable materials							
Solution for the waste disposal issue	43	1	98%	2%	0.9818	High	1
Solution for the scarcity of natural materials	42	2	95%	5%	0.9636	High	2
Cost saving	39	5	89%	11%	0.9090	High	3
Material properties and performance	30	14	68%	32%	0.7454	High- medium	4
Durability	26	18	59%	41%	0.6727	High- medium	5
Time reduction	25	19	57%	43%	0.6545	High- medium	6
Non-suitability of alternative sustainable materials							
Lack of knowledge	38	6	86%	14%	0.8909	High	1
Lack of support for innovators and researchers	36	8	82%	18%	0.8545	High	2
Apprehensive about taking the risk	35	9	80%	20%	0.8363	High	3
Lack of government intervention	34	10	77%	23%	0.8181	High	4

The primary justification for using alternative construction materials was that it was a solution to the waste disposal issue and a solution to the scarcity of natural materials, as demonstrated by the RII value of 0.9818 and 0.9636 respectively, indicating a high importance level. Alternative sustainable materials were considered suitable with a high-medium important level of suitability due to cost savings, material properties and performance, durability, and time reduction. Lack of knowledge, lack of support for researchers and innovators, apprehensive about taking the risk and lack of government intervention were demonstrated by RII values greater than 0.8 and were prioritised as highly important reasons for the non - suitability of alternative sustainable materials.

4.5 MOST SUITABLE ALTERNATIVE MATERIAL FOR ROAD ELEMENTS

The respondents were inquired regarding the suitability of available sustainable alternative materials for road components such as base, sub-base, asphalt surfacing, sub-grade and interlocking. Table 6 lists the most suitable alternative material for road elements.

Table 6: Most suitable alternative material for road elements

Element	Alternative Material	RII	Rank
Base	C&D wastes	0.7590	1
	Fly ash	0.7590	1
	Plastic waste	0.7454	2
	Waste rubber tires	0.7318	3
Sub-base	C&D wastes	0.7818	1
	Fly ash	0.7590	2
	Cement kiln dust	0.7590	2
	Waste rubber tires	0.7409	3
Sub-grade	Plastic waste	0.7136	1
Surfacing	Plastic waste	0.7727	1
	Coconut, sisal, cellulose, and polyester fibers	0.7045	2
	Bio-oil	0.7000	3
	Waste Ceramic	0.6863	4
	Quarry waste	0.6681	5
Interlocking	Cement kiln dust	0.7909	1

According to the WMR and RII values, the most suitable alternative sustainable material for the base are C&D waste and fly ash. Following that, plastic waste and waste rubber tyres are ranked. C&D waste is the best sustainable alternative material for the sub-base. After that, fly ash, cement kiln dust, and waste rubber tyres were ranked. Only plastic waste is used as an alternative material for subgrade. Numerous substitute products, including plastic waste, quarry waste, bio-oil, waste ceramic, coconut, sisal, cellulose, and polyester fibres, were listed under the asphalt surfacing materials. Considering RII values, comparatively, all the alternative sustainable materials were assigned a high-medium importance level for different road construction elements.

4.6 COMPARATIVE ANALYSIS BETWEEN TRADITIONAL AND ALTERNATIVE SUSTAINABLE CONSTRUCTION MATERIAL

Compared to traditional construction materials, many alternative sustainable materials are available for different road elements. Table 7 discusses the applicability of traditional construction materials and alternative sustainable materials for the construction of different road elements using MWR and RII.

Table 7: Comparison of traditional construction materials and alternative sustainable materials

Element	Traditional Materials	RII	Rank	Alternative Materials	RII	Rank
Base	Crushed rock	0.7670	1	C&D *waste*	0.7790	1
	Gravel	0.6988	2	*Fly ash*	0.7386	2
				Plastic waste	0.7159	3
Sub Base	Aggregate	0.7954	1	*Cement kiln dust waste*	0.7329	1
	Granular soil	0.7784	2	*Fly ash*	0.7272	2
	Boulders	0.7556	3	*Glass waste*	0.6931	3

Element	Traditional Materials	RII	Rank	Alternative Materials	RII	Rank
	Stabilised soil	0.7386	4	*Waste rubbertires*	0.6802	4
Sub Grade	Gravel	0.8238	1	C& D waste	0.7215	1
	Crushed rock	0.7613	2	Glass waste	0.6988	2
	Crushed concrete	0.7386	3			
	Sand	0.6306	4			
Surfacing	Asphalt concrete	0.8352	1	*Plastic waste*	0.7272	1
	Concrete	0.8068	2	*Bio-oil*	0.7159	2
	Plastic waste	0.7272	1	*Waste rubber tires*	0.7151	3
	Bio-oil	0.7159	2	*Coconut shell*	0.6534	4
	Waste rubber tires	0.7151	3	*Glass waste*	0.6306	5

According to Table 9, crushed rock and gravel were significant traditional building materials for base construction, while C&D waste, fly ash, and plastic waste were significant sustainable alternatives. Compared to crushed rock, C&D waste are considered more important. Similarly, fly ash and plastic waste are considered more important in base construction than gravel. Aggregate, granular soil, boulders, and stabilised soil were more crucial traditional building materials for sub-base construction than alternate sustainable materials. Gravel, crushed rock, and crushed concrete were more crucial traditional building materials for sub-grade construction, whereas C&D waste is a more crucial sustainable alternative material. Comparatively least importance is given to sand and glass waste for sub-grade construction. Regarding surfacing construction, asphalt concrete and concrete were prioritised over alternative sustainable materials such as plastic waste, bio-oil, baste rubber tyres, coconut shell, and glass waste.

5. DISCUSSIONS

The continued growth of the global economy and level of life will almost certainly lead to an increase in raw material consumption worldwide. Modern technologies and new materials have great attention in construction projects to reduce cost and time and to improve construction quality. Using currently available materials and technology, it is possible to significantly improve the substitution of virgin materials with recycled materials. The research has utilised a questionnaire analysis survey mainly based on Engineers, Quantity surveyors and Project Managers providing information on technical and cost-related aspects of the alternative materials further, professionals were considered based on different types of pavements.

The industry highly utilises traditional materials including natural soil, bituminous materials, crushed rock, and cement concrete. 84% of respondents graded the suitability of alternative sustainable construction materials as good. C&D wastes, especially glass, can be used in sub-base and sub-grade. Rubber and plastic tyres are used in road parts. Coconut, sisal, cellulose, and polyestor fibres are used in surfacing, base, and subgrade, with fly ash and cement kiln dust moderately used in shoulders and sub-base. Waste ceramics and quarry waste are moderately used in sub-base, base, and surfacing, but they are preferred for sub-base. Bio oils are mostly used for surfacing, with bio-oil being the least used. C&D waste, fly ash, plastic waste and waste rubber tires are best for the base of the road and plastic waste, bio-oil, waste rubber tires, coconut shells and glass waste, are best for road surfacing. Crushed rock and gravel for the base construction, building and demolition waste, fly ash, and plastic waste are some other sustainable resources for road elements. In the base construction, trash from buildings and demolition is more significant than gravel. For sub-base construction, aggregate, granular soil, boulders, and stabilised soil are particularly important. Concrete and asphalt are preferable for surface construction over substitutes, including plastic, bio-oil, rubber tyres, coconut shells, and glass scrap.

6. CONCLUSIONS AND RECOMMENDATIONS

This study investigates the sustainability of alternative materials for road construction initiatives in Sri Lanka. According to a quantitative survey of 44 professionals, 84% of respondents evaluated alternative sustainable construction materials for road elements. The preferable construction materials were bituminous materials, natural soil, pulverised gravel, and cement concrete. Alternative sustainable materials offer solutions for waste disposal, natural resource scarcity, and cost reductions. This study aims to develop a principle for the improved incorporation of sustainable materials in road construction in Sri Lanka. According to WMR and RII values, fly ash, scrap rubber tyres, and building and demolition debris are the most appropriate sustainable resources for the basis. The greatest environmentally friendly option for the sub-base is C&D debris, which is followed by fly ash, cement kiln dust, and used rubber tyres. For road building components, alternative sustainable materials are given a high-medium relevance rating. Alternative sustainable materials are preferable for many reasons. These include a solution to the waste disposal problem and the depletion of natural resources, a method to reduce costs due to the material's qualities and performance, durability, and labour savings, and a solution to the problem of waste disposal and the depletion of natural resources. On the other side, it is not favoured because people do not comprehend alternative sustainable materials, there is little support for researchers and inventors, people are afraid to take chances, and there is no government action. With a high level of significance, alternative construction materials were predominantly utilised for waste disposal and natural material scarcity. Due to cost savings, material properties, efficacy, durability, and time savings, they were deemed suitable. However, a lack of knowledge, support, risk aversion, and government intervention were cited as major reasons for their unsuitability.

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