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MANUFACTURE OF CONCRETE PAVER BLOCK USING WASTE MATERIALS AND BY-PRODUCTS: A REVIEW

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ABSTRACT: Flexible surface treatment for exterior pavement applications and the particular requirement to be specific pedestrian walkway design and parking areas are the fundamental feature of paver block identification. The use of conventional materials such as cement, aggregate, and sand is no longer such a priority. Under those circumstances, the production of research-based pavers block has been done to ensure the sustainability and usability of new building materials is expanded. Henceforth, this research is conducted to study and investigate the potential of using waste materials as a partial substitute for aggregate in producing concrete paving block (CPB). In essence, the application of waste materials in concrete paver blocks is highly potential. The innovations in recycling technologies expanded the usage of waste materials to produce paver block products. On the whole, in the manufacturing of concrete, the paper improves and enhances the usability of waste materials. The application of various waste materials such as plastic, steel slag, and crumb rubber is excellent. Compressive strength of paver blocks with different rates of waste steel aggregates and utilizing elastic cushions shows paver blocks give up to 50% more strength quality than customary paver blocks. In terms of the use of industrial waste materials, as a substitute material by reducing the percentage amount of the weight of the cement with the composition ratio varies based on the comparative volume category of the paving block aggregate such as 0%, 5%, 10%, 15%, 20%, and 25% are more applicable.

Keywords: Concrete, Paver, Block, Waste Material, Crumb Rubber

1. INTRODUCTION

In whatever form or categorization solid, liquid, or poisonous, Wastes have become a significant consequence of modernization and economic growth, according to events in the twentieth and early twenty-first centuries and compendia of waste investigations. Global waste generation rates are increasing at a faster rate than it has ever been, approximated at around 1.3 billion tonnes per year in 2015 and expected to rise to roughly 2.2 billion tonnes per year by 2025, with 15-year projected per capita waste generation rates ranging from 1.2 to 1.42 kilograms per person per day [1]. As a result, experts have warned that growth will continue unless society changes how they utilize and reuse natural resources.

Malaysia is said to generate a massive quantity of municipal solid waste, estimated to be approximately 33,000 t/d, or 1.17 kg per person each day. Fig.1 shows the order of waste management hierarchy from most to least favored. The hierarchy explained waste prevention options as a guideline in managing generating, sorting, and processing of waste materials. Reduction in early-stage as a preventive action by reducing the amount of generated waste. Followed by reuse, recycling, and recovery option. Safe disposal is put as the last option. Malaysia now produces about 23,000 tons of waste per day. However, by 2022, this Fig.1 is anticipated to grow to 30,000 tonnes. Due to the rising population and industrialization, the quantity of waste produced is rising, yet only around 5% of it is recycled [2].

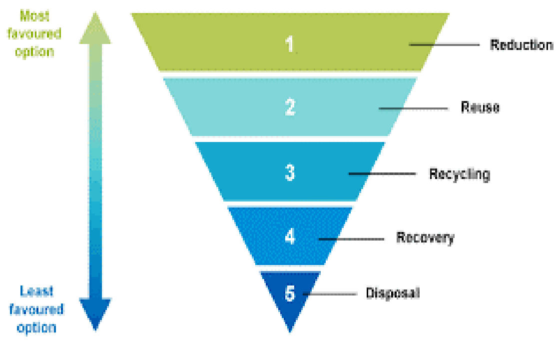

Fig.1 Waste minimization hierarchy

As a result, waste management is an important aspect of a country's economic condition and population's lifestyle. Solid waste management is a discipline concerned with the regulation of solid waste creation, storing, gathering, transporting, treatment, and disposal [3].

Industrial by-products or wastes are quickly becoming important components for aggregate substitution in concrete, for both environmental and economic reasons. For sustainability reasons, it became a growing demand in finding ways to recycle or reuse waste materials from the construction sector. Using industrial by-products and solid wastes in roadway constructions is one approach. Waste management has become an essential concern in several Asia such as Hong Kong, Japan, and Thailand, as the urbanization process and economic growth accelerate, resulting in increasing volumes of waste materials requiring effective treatment. Waste reduction, reuse, material recycling, and also energy recovery are encouraged rather than landfill disposal.

2. RESEARCH SIGNIFICANCE

The study focused on explaining the usage of recyclable materials including many kinds of glass, crumb rubber, and various materials to develop paver block. The finding of this study will redound to the benefit of society considering that recycled material plays an important role environment today. The production of specially designed paver products with a mixture of waste is believed to further brighten the potential of product generation. Specifically, the development of recycling technology can be considered as a sustainable method for the development of paver products with practical production technology. It is larger and seen to be able to generate better potential in line with the objectives of this study as a comparison and accumulator of knowledge assets for the development of technology for the production of paper from waste. The greater demands for paver blocks with renewable and recycled material justify the need for more effective, life-cycle waste managing approaches. Thus, this study reviews various approaches derived in the forms of available waste and methods of constructing paver blocks from previous works. Production of paver block will be guided on what should be emphasized by focusing material composition in paver block design.

3. PAVER BLOCK TYPE

A series of research studies were undertaken in these nations in the field of employing industrial by-products or solid wastes in Concrete Paving Block (CPBk) manufacturing. There have been several types of research on the use of construction and demolition wastes as fine and coarse aggregates, demonstrating the feasibility of using large volumes of construction and demolition in concrete. The utilization of recycled aggregates in CPB manufacturing has been proven to work and is increasing in acceptance [4].

The decrease of solid waste disposal in landfills reduces the environmental impact, and the usage of such solid waste also improves the quality-of-life natural elements that would otherwise be utilized in concrete production. In recent years, the quantity of coal ash generated by power stations in Japan has risen to over 27,000 tonnes per day [5]. As a by-product produced from milling waste, fly ash is classified as manufacturing waste and claimed to be reused and utilized as a fine aggregate substitute in the manufacture of CPB.

However, the use of fly ash is only acceptable if it achieves the production aim value with a 25 percent fly ash replacement ratio. Aside from construction and demolition waste, other types of waste might contribute to sustainability, such as plastic waste [5]. Plastic waste was also looked at as a possible aggregate or cement substitution to create a concrete block with additional value.

Recycled plastic may be incorporated into concrete without affecting its characteristics or weakening it significantly. Although waste materials can be usefully included in concrete, either as part of the cementitious binder phase or as aggregates, not all waste materials are appropriate for this application. As a result, civil engineers must research suitable materials that can completely or partially replace traditional concrete constituents.

As an alternative to aggregates, a variety of waste materials can be utilized in the production of concrete. Block paver is a form of concrete brick that is used for exterior flooring and road work instead of being utilized in walls. Although some paving blocks have reversible surfaces, most concrete paver blocks have one smooth and one rough face where both sides can be used.

Paving blocks' long-lasting performance makes them ideal for heavy-duty applications since they can sustain large weights and resist shearing and braking pressures.

Block of pavers, also known as interlocking paver blocks, have been widely used for a long time in a range of international as a specialized problem-solving strategy for offering pavement in locations at which classical paving systems might be less sturdy due to a variety of technical and environmental limitations. A concrete paver block was originally used to substitute paver bricks [6], which had grown popular at the time due to its wide application potential. Paver blocks are rectangular and have a size that is similar to that of bricks. The paver block and block form have progressively changed over the last five decades, from non-interlocking to partially interlocking to completely interlocking to multiple interlocking designs. Concrete paving is made up of small, solid, unreinforced pre-cast concrete paver blocks that are laid on a thin, compacted bedding material that is built over a properly designed base course and secured with edge restraints/curbstones.

By using a suitable fine material, the space or gap between the paver block is then filled by it. When used in places where conventional systems have a shorter service life due to geological, traffic, environmental, and operational restrictions, a well-planned and manufactured interlocking paver block provides outstanding performance. Light, medium, heavy, and extremely heavy traffic conditions have all been used in different ways across the country. This research paper only included the use of paver blocks for non-traffic areas.

Walkways, Shopping centers, Pedestrian Plazas, Landscapes, Monuments Premises, Premises, Public Gardens/Parks, Commercial Centres, Bus Stations Parking Areas, and Railway Platforms are all examples of this sort of block. Over the last 30 years, small element paving has progressed from its initial usage as a surface for footpaths and roads to become a structural component of heavy-duty pavements. Numerous geometric components, such as the ‘X', ‘L', and ‘Y' forms [6] as shown in Fig.2, have been introduced to the basic rectangular shape during this time. These different forms were designed to improve the mechanical laying capacity of pavers by increasing the ‘interlock' between them [6].

The respective advantages of rectangular and shaped pavers have been the subject of much discussion and scientific study, but neither side has been able to establish definitively that one is preferable to the other. The innovative paver concept presented in this study is designed to address many of the recognized issues with small element paving [7]. Paver blocks can be used for different categories of traffic such as Non-Traffic, Light-Traffic, MediumTraffic, Heavy-Traffic, and Very Heavy-Traffic [8].

Fig.2 Shapes and Classification of Paver Blocks

The four forms of paver blocks correspond to four generic forms of paver blocks:

3.1 Type A

Paver blocks with straight vertical sides which do not interlock when laid down in any arrangement. This shape provides access to the underground utilities and prevents the shape from damage due to any works carried out on it.

3.2 Type B

When tiled in any design, paver blocks with alternating plain and curved/corrugated vertical faces lock into each other across the curve/corrugated faces.

3.3 Type C

When paved in any design, paver blocks with all curved or corrugated faces slot into each other as well as all vertical faces.

3.4 Type D

When paved in any design, 'L' and 'X' shaped paver stones with all faces curved or corrugated lock into each other as well as all vertical faces and provide slip-resistant and skid resistance.

4.0 PAVER MATERIALS COMPONENT

The sorted suitable waste materials used in the production of the paving blocks were collected from the municipality's nearby garbage collection sites. These used plastics, for example, were cut apart, cleaned to eliminate any contaminants, then dried in the open air until no moisture remained. The processed materials (polythene bags, sachet water bags, wrappers, etc.) were packaged and delivered to the lab for testing [8]. The thermoplastic characteristics of the repeated plastic working (RPW) employed imply that it may be molded and remolded recursively when heated. It also has many side chains, which increase the distance between the major CC chains, as well as tight packing and intermolecular interaction, since it is a very flexible material. Its density ranges between 0.91 and 0.94 g/cm^3.

Aside from plastic waste, there have been recent studies that have employed rubber crumb, especially from old tires, as a coarse aggregate substitute. Ordinary Portland cement (OPC), natural aggregate, water, superplasticizer, crumb rubber as shown in Fig.3, and SBR latex were utilized in the research study to produce crumb rubber CPB [9][10][11].

Continuous grading, according to the Cement & Concrete Institute, helps compaction. As a result, paving blocks manufactured from semi-dry mixes with chunky particle shapes will compress faster.

Fig.3 Re-cycled crumb rubber material

4.1 Development of Paver Block Containing Recycled Plastic

For CPB projects, local mining silica sand as fine aggregate and quarry dust with specific gravities of 2.64 and 2.68 are utilized. For each test, the quarry dust samples were oven-dried for one week before being quantified to get the appropriate proportions. The ensuing laboratory experiments employed quarry dust particles of 0/4.75 mm via BS (British Standard) sieve size.

As a result, if the material is insufficiently graded for its intended application, excellent grading can be accomplished by mixing two or more components. Ghacem Super Rapid class CEM II /B-L PLC 32.5R is an OPC with a specific gravity of 3.15 and meets the requirements of BS EN 197-1.

The primary oxide compositions in this type of cement are CaO, SiO2, Al2O3, Fe2O3, with minor oxides of MgO, Na2O, K2O, MnO, TiO2, P2O5, and SO3 [12][13]. Molding of the specimens that adhered to BS EN 1008 for the study was done with clean and pure stand tap pipe water.

By using a weight or volume batching method, the mix proportions of Cement, Sand, Quarry Dust, and RPW components were determined. Individual components needed for paving block preparation were weighed until the appropriate masses were reached [14].

However, nowadays, there is a lot of innovations that already have been introduced to give an environment-friendly purpose. Hence, there are a few examples of innovation for the paving block. Plastic is one of the most widely used materials in almost every community on the planet. Plastic manufacturing is expanding daily as it becomes more widely utilized. Polyethylene terephthalate (PET) bottles, containers, and grocery bags are all made of the same plastic. Considering plastic is a major component of municipal solid waste (MSW), efforts to recycle it have resulted in extensive research projects, such as concrete blocks. Plastic waste was studied for potential use as an aggregate or cement substitute in the production of a concrete block with value-added performance, in addition to improving sustainability.

Recycled plastic can be incorporated into concrete without affecting its characteristics or weakening its strength significantly. Although waste materials can be usefully included in concrete, either as part of the cementitious binder phase or as aggregates, it is important to note that not all waste materials are appropriate for this application. As an alternative to aggregates, several forms of waste plastics can be utilized in the production of concrete. Researchers have employed expanded polystyrene (EPS) waste, high-density polyethylene (HDPE), PET waste bottles, polypropylene fibers, and polyethylene bags in various forms in concrete.

Several sorts of studies on creating paver blocks made from recycled plastics have been conducted in recent years. LDPE-bonded sand block by combining Low-density polyethylene (LDPE) water sachets with sand, which is now utilized in Ghana to make paving blocks for hard standing areas and pavements. In comparison to cast in situ concrete, a concrete paver block constructed in a rural setting provides an excellent aesthetic view [15]. Recycled plastic may be utilized to improve the abrasion, skid, and freeze-thaw resistance of concrete paving blocks [16]. In terms of compressive strength, the usage of plastic trash has decreased significantly, but it is still appropriate for use as a pedestrian paver block in parks, footpaths, and yards.

4.2 Pavement Derived from Palm Oil Eco Processed Pozzolan (EPP) Material as Partial Cement Replacement

To reduce environmental impact, a siliceous and aluminous substance known as pozzolan has been proposed as a partial alternative for cement. Pozzolan is a finely powdered pumice or flies ash that, in the presence of moisture, chemically interacts with calcium hydroxide to create silicate or aluminate compounds having cementitious characteristics [17]. Due to its pozzolanic characteristics, fly ash has been shown to offer several advantages when used as a cement replacement in concrete, including better workability, decreased permeability, and higher compressive strength [18].

However, in the palm oil business, spent bleaching earth (SBE) is generated as solid waste and is generally disposed of in landfills [19]. SBE is further extracted and refined before being calcined by heat treatment, resulting in calcined compounds known as EPP.

The use of EPP as a cement substitute in the manufacture of paving blocks can help to lessen the manufacturing industry's reliance on cement. It will cut CO2 emissions and fossil fuel use in the long run. The EPP paving block's longevity can also help to decrease the amount of maintenance required. Because EPP produces a thick cement paste, chloride ions are limited in their penetration, and steel reinforcements are less rusted. It will also improve the surface quality of the paving stones and minimize the number of pores.

Furthermore, since EPP allows for a better yield in the concrete mix, it requires less EPP than various cement alternatives. EPP's pozzolanic characteristics and high silica content make it an excellent choice for precast concrete and construction materials. A silica-rich material is converted to a calcium silicate with excellent cementing properties by the pozzolanic reaction.

When calcium hydroxide (Ca (OH)2) reacts with silica, calcium silica hydrate (C-S-H) paste is formed, which acts as a binding glue to strengthen any cement-based materials. The C-S-H paste will also aid in the reduction of pores and the enhancement of paving block strength and durability.

4.3 Reusing of Steel Slag Aggregate in Eco-Friendly Interlocking Concrete Paving Blocks Production

Slag recycling lowers costs and improves material conservation, decreasing pollution from non-biodegradable slag wastes [20]. As been mentioned in a previous study [21], highlighted some of the many forms of steel slags and their physicochemical properties. Further mentioned that slag can serve as an excellent substitute for natural aggregates, conserving the environment and natural resources [22]. Much research has been published on the advantages of using slag as a concrete aggregate. These studies discovered that slag-based concrete possesses compressive, splitting tensile, and flexural strengths, as well as a modulus of elasticity, that is equivalent to or slightly greater than concrete made with conventional aggregates.

Also, a previous study investigated the use of blast furnace slag as a coarse aggregate substitute in concrete production, finding that compressive strength improved by 61 percent after 7 days and 78 percent after 28 days [23].

In addition, a study [24] found that employing steel slag aggregates in concrete is a concept that gets results that have a greater influence on concrete strength than natural aggregate. It was also noted that compressive strength increased until it reached 50% replacement, after which it began to decline while claiming that using slag in high-strength concrete improves the building sector by ensuring higher safety and attaining long-term infrastructure.

Steel slag may be utilized as a green material in the manufacturing of paver units [25]. Steel slag pavers have better abrasion resistance, according to the study. Steel slag aggregates will react and create a strong link with the hardened cement paste under high temperature curing conditions [26], leading the concrete to have greater compressive strengths.

Also, according to [27], on the impact of steel slag types on the shrinkage property of concrete, slag may be utilized to improve concrete performance by minimizing cracking caused by early age shrinkage of the concrete mix. When the amount of steel slag in the concrete mixture is increased, the dry shrinkage of the concrete rises [28].

A study of the long-term performance of alkali, activated concrete mixes comprising steel slag as coarse particles, finding no evidence of strength reversal after one year of testing [29][30]. However, as compared to ordinary concrete, alkali-activated concrete with steel slag aggregate has a high-water absorption rate.

4.4 Crumb Rubber Concrete Paving Blocks with Styrene-Butadiene Rubber (SBR) Latex

An ideal concrete paving block should have great tensile strength and toughness, according to experts. As a result, concrete with great strength and hardness must be designed. For typical concrete, it has been discovered that the higher the strength, the lesser the toughness. So, developing high strength and high toughness concrete without innovation is challenging.

Because of the great toughness of waste tires, it is predicted that adding crumb rubber to a concrete mix will significantly enhance the toughness of the concrete [31][32][33]. Previous laboratory studies have shown that adding waste tire rubber to concrete can improve toughness, impact resistance, and plastic deformation [34][35][36].

This means that it has a lot of potential for use in sound barriers, retaining structures, and pavement structures. Because of the poor bonding between the paste and aggregates, the strength of paving blocks with crumb rubber is assumed to be lower than those without crumb rubber. Polymers like styrene-butadiene rubber (SBR) latex, on the other hand, might increase the strength, hardness, and bondability of the cement matrices [37].

Compressive strength is one of the most important criteria in paver block that have to take seriously to give a better paver block. Compressive strength is the maximal compressive stress that a solid material can withstand without cracking under a continuously applied force.

A compressive strength test is a method to see how the paver block's compressive strength shifted over time at 0, 7, 14, and 28 days. Specimens were cured for 28 days by spraying water on them every day. The compressive strength test should be conducted following MS 76:1972 [38]. There are a few example studies of compressive strength tests for paver blocks that have been innovated.

5.0 COMPRESSIVE STRENGTH OF PAVER BLOCK

The weight of batching technique yielded 1:2:3 (mixture A) and 1:1:2 (mixture B) mix proportions of cement, sand, and soil in the compression method. Recycled Plastic (RP) was used to replace sand at a percentage of 0%, 5%, 10%, 15%, 20%, 25% and 30% by weight sand. So, there are two results of compressive strength which are for mixture A and mixture B respectively in Fig.4.

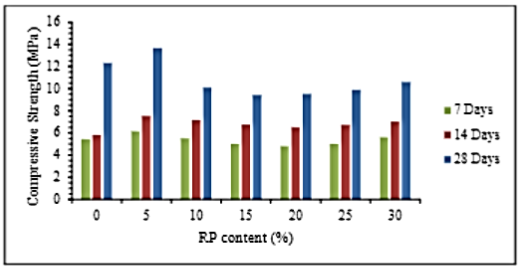

Fig.4 Compressive strength for mixture A

The greatest compressive strength obtained was 13.67 MPa which is a sample of 28 days with 5% RP as shown in Fig.5, according to the compressive test findings in Fig.1. The previous study has linked the use of RP in paving concrete blocks to a reduction in compression strength [39][40]. The loss in compressive strength is related to the smooth surface of plastics, which weakens the adhesion between the RP fine particle and cement paste [41]. The minimum strength required for pedestrian walkways is 15 N/mm2 [42].

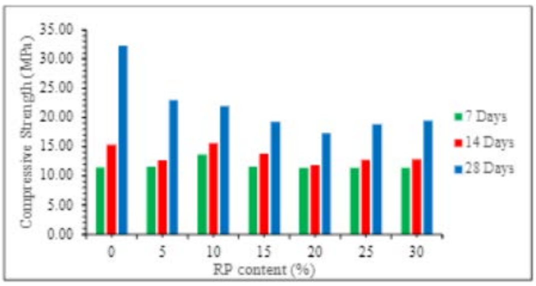

Fig.5 Compressive strength for mixture B

The inclusion of RP lowers the compressive strength, as seen in Fig.6. All specimens' compressive strength at 28 days is higher than mixture A's. At 25 % and 30 % RP, there is a small improvement in compressive strength. At 0% replacement, the greatest strength was 32.29 MPa, followed by 22.98 MPa at 5% replacement. The minimum strength criterion for the usage of pedestrian walkways (15 N/mm^2) was met by all specimens. This suggests that the improved ratio improves the adherence of paver block materials.

5.1 Compressive Strength of Pavement Derived from Palm Oil Eco Processed Pozzolan (EPP) Material as Partial Cement Replacement

The maximum compressive strength achieved from the pavement block without EPP showed that the tricalcium silicate (Ca3SiO5) composition in OPC cement has a role in the pavement block's strength. Cement is made up of 50% tricalcium silicate, which gives the pavement its strength. Another 25% comes from dicalcium silicate (Ca2SiO4), which also contributes to the pavement's strength.

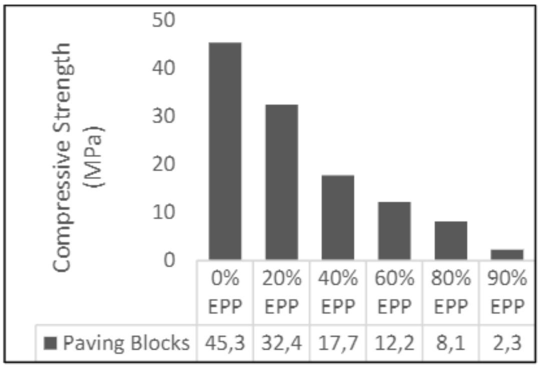

Fig.6 Compressive strength of paving blocks at different EPP percentage

The amount of tricalcium silicate in the pavement may be lowered as a result of the cement reduction, which might have a major impact on the pavement's strength. According to this research, the highest amount of EPP which might be used as a cement alternative in this pavement composition is 20%. Given that the minimum compressive strength for pavement is 30 MPa [44], paving blocks with 20% EPP are suitable for use with a specified compressive strength of 32.4 MPa. The compressive strength of paving blocks increased from 40 % EPP to 90 % EPP, they are classified as weak for paving block application. This is because when a little load is given to a material with a compressive strength of less than 30 MPa, it can quickly break.

5.2 Compressive Strength of Reusing of Steel Slag Aggregate in Eco-Friendly Interlocking Concrete Paving Blocks Production

The compressive strength increased when sand was replaced with WSF by 20% and 40%, respectively, as seen in the diagram. However, as the quantity of WSF content in the interlocking concrete paver units exceeds 40% replacement, a decrease in the characteristic compressive strength of the interlocking concrete paver units was recorded. As a result, regardless of the combination refraction, growing WSF concentration results in a substantial loss of strength. at 7, 14, and 28 days after curing, the interlocking concrete pavers' compressive strength was reduced by 60%, 80%, and 100% replacement, respectively.

Furthermore, while the interlocking concrete pavers have considerable mean compressive strength values for 60 %, 80 %, and 100 % WSF content, the values are below the predicted strength. At 20 % and 40 % WSF, the compressive strength of the concrete mixes rose by 4.76 % and 14.57 %, respectively, whereas the compressive strength of the mixtures (60, 80, and 100 %) decreased by 6.24 %, 22.62 %, and 25.57 % as shown in Fig.9, respectively. The data show that adding WSF to the mixes improved the toughness of the interlocking concrete pavers when less than 40% of the sand was replaced with WSF. This is due to the strong bond between the slag aggregate and the cement paste.

A study has been conducted in producing paver block by using ash. The result showed in Fig.7. In effect, the highest compressive strength value is obtained on the use of 15% Sinabung ash with curing [46]. The mixture was designed in the range of 5%, 10%, 15%, 20%, and 25%.

Referred to the normal concrete (with curing) without the addition of sinabung ash and lime has a compressive strength value which is equal to 35.96 Mpa. The increase of paving block quality is caused by the use of Sinabung and Lime ash. which is known as Sinabung ash has a Silica content of 73.4% and Lime has CaO content equal to 51.8%.

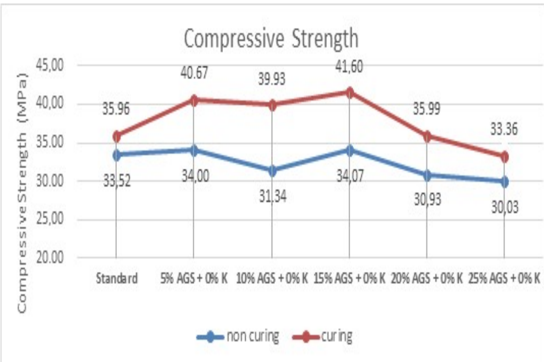

Fig.7 Compressive Strength Test with Sinabung Ash

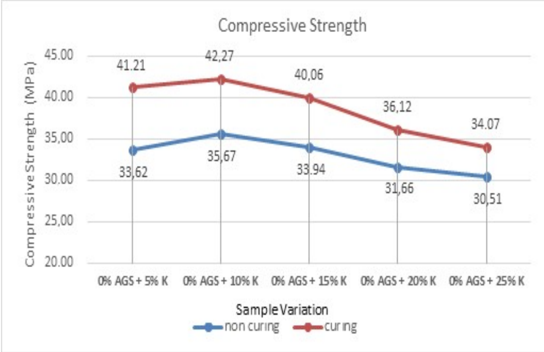

Fig.8 Compressive Strength Test with lime

Silica gives the effect as a filler on the manufactured paver block [47]. This shows that the particle size of waste material has played an important role in developing paver block strength. Compared to the waste marble study, waste marble is well usable instead of the usual aggregate in the concrete paving block production [48]. A study on the lime as filler material [49] showed in Fig.8, the compressive

strength value of a mixture of 10% lime with curing of time 28 days is 42.27 Mpa. On the whole, the use of Sinabung ash and lime as a cement substitution material can increase the compressive strength of the paving block. Overall, waste material with the specific treatment and use of certain methods is seen to be able to technically produce paver blocks compulsively

Table 1 shows the Tabulation of the previous study on the development of paver block. In a recent study [50], pet bottles were used to develop a paver called Hatthe block and have an equal ratio of plastic waste and quarry dust.

This technique developed by melting the plastics to the highest point at 140 oC and has increased the compressive strength. LDPE and Bakelite waste used by [58] and [49], the usage of these materials as a replacement to the cement and create an achievable characteristic of paver that required as high strength gained, less wastage and invented recycles product. Researchers [49] [50] and [50] have demonstrated cement replacement techniques with various usage of waste materials from HDPE and Polyethylene (PE), Crusher dust, and waste from glass.

Provided that, these results obtained show a significant characteristic which is desirable design for paver block. From compressive strength characteristics to the features of the paver, these materials relatively responded to the mixes and produces paver with their characteristic. In general, the recommended cast-off materials can be used and mixed with paper products. The consistencies of mixture measured and compared in compressive strength [56].

Table 1 Tabulation of the previous study on the development of paver block

Researcher	Description	Outcomes
Kaviya *et. al.*, 2017 [50]	The main objective of this investigation is to recycle plastic waste into pavers and to analyze its characteristics based on the recent developments in industrial needs. The material used is pet bottles.	hatthe block having an equal ratio of plastic waste and quarry dust possess high compressive strength than that of other mixtures and all the test blocks melt again at a temperature greater than 140 ^{O}C. Since these blocks have low compressive strength, they can be used in walking pavements where there is no action of heavy load.
Koli, 2016 [51]	Evaluating the influence of coarse aggregate on the mechanical and physical properties of paving blocks made using melted Low-Density Polyethylene (LDPE).	The compressive strength of paving blocks made with LDPE plastic and aggregate approaches the compressive strength of an ordinary C20 concrete paving block. LDPE plastic waste paving blocks present a better resistance against the aggressive effect of water than concrete paving blocks.
Anusha *et al.* 2021 [52]	This study helps to develop a waste Bakelite for fine and coarse aggregate to minimize the disposal of plastics which creates a waste management problem (waste Bakelite).	The 20% replacement was considered to be an appropriate mix proportion to have higher compressive strength than a conventional one. But waste bakelite mortar is less preferred for plastering work in the construction field rather it can be used as bricks, pavers, blocks, etc.
Poonam and Ramesh, 2016 [53]	Utilized the waste plastic in the manufacturing of paver block by using High–density polyethylene (HDPE) and Polyethylene (PE) bags at various percentages with sand and aggregate. Materials used are waste plastics, sand, fly ash and red oxide, etc., with a mixed proportion of 1:2, 1:3, 1:4, 1:5, 1:6 representing plastic and river sand respectively.	The compressive strength of mix ratio 1:4 has proven to be more strength and increases its fire resistance property compared to conventional block. Moreover, the water absorption rate decreases with an increase in waste plastic content.
Hastuty and Sembiringand, 2018 [54]	Manufacturing paving blocks with crusher dust is studied. Paving blocks are replaced with crusher dust by various percentages and its properties have also been studied. (Crusher dust)	The results show that replacing sand with crusher dust has a minimal reduction in weight and also leads to the economy. Since the availability of sand is reducing nowadays using crusher dust will reduce polluting the environment since it is being dumped in many places.
Osman *et al.*, 2021 [55]	The feasibility of waste glass inclusion as partial FA replacement systems. Properties of concrete incorporating waste glass as a partial substitution for FA amounts of 15%, 30%, and 45% were investigated. The waste glass material used was obtained from waste collectors (Glass waste)	The results obtained show clearly that glass enhances the compressive strength properties of the final concrete product. The study indicated that waste glass can effectively be used as a fine aggregate replacement (up to 45%) without substantial change in strength.

6. CONCLUSION

Ultimately, paver blocks are used for exterior pavement applications with various esthetical functions. This study was carried out to investigate the available material and method in the implementation of paver products that are available developed from waste material. Specifically, paving blocks classified as

precast solid products made out of cement-based. The products are available in various sizes, shapes, colors, textures, and patterns as per the requirement with interlocking key design. Based on the available method and materials currently, the application of waste products turned to paver block is greatly acceptable. The production met certain

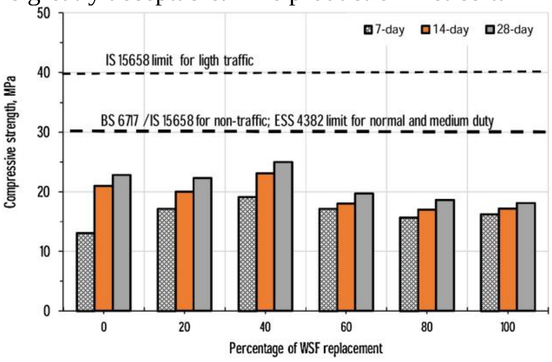

Fig.9 Compressive Strength of Interlocking Concrete Paver Units at Different Crushed Waste Furnace Slag (WSF) Percentage

criteria and characteristics such as compressive strength, itself. The amount of waste material mixed with cement or by-products showed a significant and advantageous pattern. The major findings of the literature survey are as follows:

1. The compressive strength is achievable and can be concluded placed in the required category between 7 N/mm^2.
2. The waste material gradually and relatively contributes to the main characteristic of paver and waste material can be a parent material in producing paver. The composition and ratios are different from each waste material that depends on the origin of produced plastic or by-products component with the significant element.
3. Technically, paving open surfaces to facilitate easy movement and for convenience in walking adds to the beautification of the area.
4. Block paving manufacturing methods are now allowing the use of recycled materials such as glass, old building rubble, stone ash, plastic waste, Fly ash, Copper slug, and marble waste.
5. The mixture design and cement ratio of mix proportions will determine the compressive strength of the paver block itself.
6. Paver block made up from plastic in concrete mix reducing the weight of block up to 15%.
7. Silica gives the effect as a filler on the manufactured paver block. The smaller particle gives the effect as filler material that contributes to the development of compressive strength.
8. The use of Sinabung ash and lime as a cement substitution material can increase the compressive strength of the paving block.
9. Steel slag aggregates in concrete is a concept that gets results that have a greater influence on concrete strength than natural aggregate.
10. Eco-Processed Pozzolan (EPP) allows for a better yield in the concrete mix, it requires less EPP than various cement alternatives and has the potential to be used in producing paver block.

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