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The Review of Potential Application of Recycled Glass Powder as Partial Replacement of Sand in Concrete

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Abstract: The growth production and manufactured sector in Malaysia had led to increase in the industrial by-product waste especially glass. Every year, millions of tonnes of waste glass are produced around the world. Glass is disposing of as waste in landfills, which is unsustainable because it does not disintegrate in the environment. These growing problems of glass waste can be reduced if new disposal method is utilized other than disposed it to the landfill. This study is focused on the utilization of glass waste with sand replacement. The main objectives of this study are to determine the characteristics of glass waste and to conduct physical and mechanical properties test towards the concrete with different percentages of glass as example. Concrete mixing ratios necessitate sand, and the quantity of sand is diminishing as a result of increased economic consumption, and sand dredging can be hazardous to the environment.

Keywords: Glass Waste, Sand Replacement, Concrete.

1. Introduction

Glass waste is a severe environmental issue in our area and around the world. Glass garbage takes up a lot of room in landfills because it is non-biodegradable. It also pollutes the air, water, and soil because it is not biodegradable. Because of the high demand for glass in building, as well as the low quality and variety of construction sites and products, the construction industry is one of the most appealing ways to reduce global glass waste pollution. [1]. In highly populated cities around the world, a lack of landfill area is also a problem. As a result, the landfill's size expands and becomes unmanageable. One of the most effective strategies to reduce the amount of glass waste that enters our environment is to reuse it. Glass waste recycling and reuse helps to conserve natural resources, minimise landfill space, and save energy while also offering a source of income and saving money in development.

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Sand is the most commonly utilised resource in concrete mixtures in all forms of construction around us, and it necessitates sand digging in places like beaches and rivers. The demand for concrete mix components, such as sand, has risen considerably as a result of fast growth in nations such as China, India, the Middle East, and North Africa. [2]If not adequately handled, this can have a negative impact on the ecosystem and even lead to tragedy. As there is a heavy emphasis on enhancing sustainability and environmental preservation, this is something that should be taken into account when helping to enhance construction procedures. By repurposing glass pieces that would otherwise be discarded.[3].

The most prevalent kind of glass recycling, which includes expenses are incorporated into each stage of the process, including gathering, sorting, transporting, beneficiating, and remaking glass into bottles. Glass can be found in a variety glass can come in a different type of variety shapes and sizes, glass produce also including, flat glass, packaging or container glass, bulb glass, and cathode ray tube glass.[4]. Glass may theoretically be recycled endlessly without losing any chemical or physical qualities. Recycling is challenging and expensive because fragmented and the mixed colour waste glass can substitute in the chemical composition in the recycled glass. [1].

The world's population grows at a rapid rate, unpredictable quantities of waste material emerge. When waste glass is not properly disposed of, it causes environmental issues. Sustainable building techniques refer to the design and responsible to management of a healthy in the built environment that takes into account resource efficiency and ecological. The building industry is currently facing a number of challenges, including rising fuel and energy costs, the need to reduce massive amounts of greenhouse gas emissions, particularly CO2 emissions, the high cost of raw materials, as well as the lack of appropriate quantities and quality of these raw resources. With the growth in annual cement output, these difficulties are projected to become more difficult. [1], [2], [5]

2. Methodology

Research methodology is the process through which researchers put their findings into action. The approach used in this study is critical for gathering information and meeting all of the study's objectives. Methodology is a portion of the research process that includes methodologies for forming and planning the study, data gathering activities, constraint determination, framework, and analytical methods. This research will look into the possibility of using glass powder as a recycled sand replacement in concrete for industrial applications. This chapter also discusses the many stages of research, which should include the researcher selection procedure, data gathering, and data analysis. Finally, this research was carried out by evaluating and comparing previous data from journals and publications that investigated the usage of recycled glass powder as a sand substitute in concrete mixes in our country's development. Various journals and related papers were used to discover the potential of glass powder in the replacement of sand in concrete mixes in order to gain more effective data to achieve the goals and objectives of this research. The goal of this study is to figure out how many appropriate percentages to use and how long the combination will last in the field of building construction.

2.1 Methodology Framework

When doing this research, the research technique is critical since it has an impact on the research study's success rate. Data will be obtained first through a literature study, which will aid in the creation of critical data on the facts and concerns surrounding the use of glass powder instead of sand in concrete mixes. In addition, this research will compare data with that of other researchers in order to bolster the conclusions of the research that has been conducted. Following that, more research will be looked at to see whether it meets the research objectives, and in the final discussion of this study report, the general statement will be completed, and some ideas for improvement will be made. The methodology procedures are simplified as the following flow chart as shown in Figure 1.

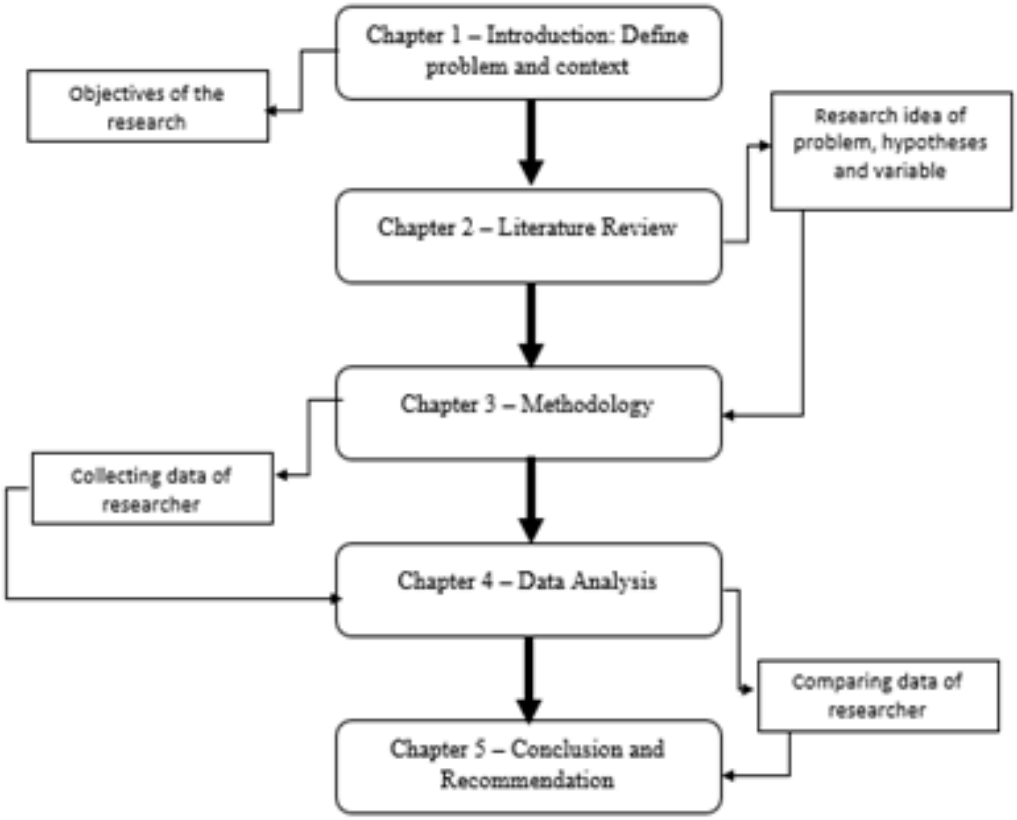

Figure 1 : Flowchart of design framework

2.2 Methods

The information needed will be filtered and tabulated into a table from journal articles collected from various sources for a better understanding of data and analysis. The resources were organised according to the year they were published, the title of the research, and the different properties of glass powder that were relevant to the study's goal. Properties test towards to physical properties, mechanical properties, characteristics of glass waste and chemical properties were used to filter the data. All of the properties of glass powder were reviewed in research, and the relevant data was highlighted. The cement will be replaced by waste glass powder in the range of 0%, 10%, 20% and 30% by weight for M-25 grade concrete. These tests will be carried out to evaluate the mechanical properties at 2, 7, 28 and 90 days

2.3 Research Instrument

In this section, the research instrument compares the data collected by previous researchers. Physical properties of glass, chemical properties, mechanical properties, and the percentage of waste glass replacement are all investigated in this study.

3. Results and Discussion

The results and discussion section presents data and analysis of the study. This section can be organized based on the stated objectives, the chronological timeline, different case groupings, different experimental configurations, or any logical order as deemed appropriate.

3.1 Results of Comparison Slump test

Table 1: Comparison of slump test [3], [5]–[8]

Replacement ratio sand by glass	Slump value (mm) Researcher 1	Slump value (mm) Researcher 2	Slump value (mm) Researcher 3	Slump value (mm) Researcher 4
0%	20	100	35	6
5%	-	-	-	6.5
10%	-	89	36	7
20%	24	81	37	7.5
25%	-	-	-	8
30%	-	72	35	9
35%	-	-	-	10
40%	29	68	-	11
50%	-	57	-	-
60%	32		-	-
80%	35		-	-
100%	37		-	-

Whenever the percentage value of the sand-to-glass replacement ratio increases. The height of the slump value test pattern has largely increased. This demonstrates that because glass powder is durable, it can be used to replace it in concrete. In comparison to the other researchers, the probability of the size of the powder glass was little for the second researcher. The slump value is reduced as a result of this. When the glass powder is too fine, it is easier to fall than when the glass powder is coarser.

3.2 Results of Comparison Compressive Strength

Table 2: Comparison of Compressive Strength test age 28 days [3], [5]–[8]

Replacement ratio sand by glass	Compressive strength (MPa) (average)	Compressive strength test result (coarse glass powder)	Compressive strength test result (fine glass powder)	Compressive strength test result (mixed glass powder)	Compressive strength at 28 days cube designation
0%	20.82	20.82	20.82	20.82	29.66
10%	16.19	13.08	15.97	19.53	29.33
15%	20.1	22.8	17.7	19.7	-
20%	14.43	10.9	16.2	16.9	30.00
30%	18.90	15.34	20.44	21.12	29.66
40%	-	-	-	-	29.33
50%	-	-	-	-	24.33

Continued Table 2: Comparison of Compressive Strength test age 28 days

Replacement ratio sand by glass	Compressive strength of concrete with sand by glass powder	Compressive Strength for 28 days (average)	Compressive strength (N/mm2)	Compressive strength development over time for the control and glass concrete mixes.
0%	48.62	50.8	32.88	33
5%	50.42	-	25.14	-
8%	-	-	32.7	-
10%	57.14	40.6	37.68	31
15%	61.30	-	-	-
20%	67.63	50.4	24.38	31
25%	68.50	-	-	-
30%	69.25	58.6	21.68	32
40%		-	21.37	-

Table 3: Comparison of Compressive Strength test age 7 days [3]–[5], [7], [8]

Replacement ratio sand by glass	Compressive strength N/mm2 d.m. patil	Compressive strength of concrete with sand by glass powder	Variation of compressive strength development in concrete with age	Compressive Strength for 7 days (average)	Compressive strength test results for 7 days	Compressive strength development over time for the control and glass concrete mixes.
0%	13.33	38.83	38	31	22.83	22
5%	-	35.65	35	-	19.50	-
8%	-	-	-	-	24.41	-
10%	20.66	43.50	40	29.4	22.57	16
15%	-	44.55	42	-	-	-
20%	17.33	51.75	50	40.8	15.6	22
25%	-	57.45	56	-	-	-
30%	16.33	58.30	58	51.8	14.95	23
40%	16.33	-	-	-	14.50	
50%	20.33	-	-	-		

On 28 days, Compressive Strength for Strength Test at ten percent and twenty percent exhibited a drop in value. On 7 days, the graph pattern revealed an increase with each glass powder replacement ratio of sand replacement. As the value of glass powder decreases with the addition of concrete ageing, this proves that its replacement should be considered. A more proper research on the use of glass powder

instead of sand in building for safety reasons is needed. Because of the chemical in the glass, the glass's strength may change as a result of the chemical's reaction.

3.3 Results of Split test result

Table 4: Comparison of Split tensile test age 28 days [6], [9], [10]

Replacement ratio sand by glass	Split tensile test results of various mixes (N/mm2)	Splitting strength of concretes with and without glass	Tensile strength
0%	3.5	3.0	2.36
5%	2.1	-	2.45
8%	3.5	-	-
10%	4.09	2.8	2.75
15%	-	-	3.33
20%	2.62	2.6	3.14
25%	2.72	-	2.94
30%	-	2.8	2.84
40%	2.47	-	2.75

3.4 Mixing and Casting of Concrete

Table 5: Mixing proportion of concrete days [3], [5]

Type of Concrete Mix	Amount of glass powder (g)	Mix proportions for 1 m^3 of concrete with a w/c = 0.48 (natural fine aggregate) (kg)	Mix proportions for 1 m^3 of concrete with a w/c = 0.48 crushed recycled waste glass (fine aggregate)	Waste glass kg/m^3
0%	0	731	0	0
5%	-	-	-	30.6
10%	-	658	73	61.2
15%	-	-	-	91.8
20%	-	585	146	122.4
25%	-	-	-	153
30%	1500	512	219	183.6
35%	-	-	-	214.2
40%	-	-	-	244.8
50%	2500	-	-	-
70%	3500	-	-	-

The value is increased following the percentage of the concrete mix to examine the influence of waste glass content on tensile and compressive strength.

3.5 Discussions

The comparison of data and objectives is discussed based on the findings of the research to provide the study's conclusions, discussion, and recommendations for using recycled glass powder as a partial cement replacement in concrete. Determine whether the glass material has the ability to replace sand.The main focus of this research is on the reviews of tests and laboratories that have been conducted from various perspectives by different percentages that may be utilized to substitute sand in concrete.In the discussion and conclusions, the data and concepts from the preceding study, as well as the opinions offered in Glass waste replacement of sand in concrete, have been linked. In this research, some of the proposed product evaluation concepts are provided as value added from the study's findings. As a result, the potential application of glass powder replacement in the field of product will aid in waste reduction and environmental contamination.

4. Conclusion

This evaluation will contribute in the reduction of glass waste. It will help in the reduction of current pollutants. The findings of this study can be applied in the construction field to reduce sand dredging and developer costs in the construction field. Glass powder replacement of sand in construction can contribute in the recycling of existing glass, such as windows, bottles, automobile mirrors, and building mirrors without just dumping it out to disposal area.

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