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ACADEMIC YEAR 2023/2024

DEPARTMENT OF CIVIL ENGINEERING

OPTION OF CONSTRUCTION TECHNOLOGY

FINAL YEAR PROJECT

COMPARISON BETWEEN WASTE GLASS AND GRAVEL FOR WORKABILITY AND STRENGTH OF CONCRETE GRADE

Submitted in partial fulfillment for the requirement of the award of advanced diploma in construction technology

SUBMITED BY: SADIKI Yves 202150246

UNDER THE GUIDANCE OF: Eng. Ignace HISHAMUNDA

DECLARATION

This is to certify that the project entitled “COMPARISON BETWEEN WASTE GLASSES AND GRAVEL FOR WORKABILITY AND STRENGTH OF CONCRETE GRADE” is work of ,SADIKI Yves submitted to the of the requirement for the award of the degree of “Bachelor of Engineering” in Department of Civil Engineering.

Submitted by

SADIKI Yves

Date………/……….../………/

Signature…………………

DEDICATION

We would like to dedicate this project for the almighty GOD We dedicate this project to our parents and relatives To our brothers, sisters and all friends of ours We would like also to dedicate Classmates and School staffs of our Department especially to our supervisor Eng. Ignace HISHAMUNDA for his advices, motivation and contribution during our project period We dedicate this project to the colleagues who contributed in succeeding in our lessons and everyone who has contributed in the realization of this project

ACKNOWLEDGEMENT

We would like to state our pleasure goes to the Almighty God who helps us in all ways to achieve the completion of this project. We give thanks to our supervisor Eng. Eng. Ignace HISHAMUNDA for his helpful guidelines, thankful to all teachers and lecturers, who taught us from starting day to the end, Civil engineering department. We appreciate and give thanks to the authors to whom we referred to their books. We give thanks to persons who Contributed in any way to organize and perform this project at this level.

ABSTRACT

A massive amount of glass waste is produced every year all over the world, but a small amount of this waste is being recycled. The recycling of waste glass (WG) in concrete shows great achievements in reducing the quantity of glass. According to researchers' addition of waste glass in concrete enhances the properties of concrete, WG can be used in any form like powder, fine or coarse aggregate. However, from previous studies of different researchers, it has been found that there are some ill effects of waste glass on concrete. This inconsistency of results of waste glass between researchers affects the acceptance (using) of waste glass in concrete structures. To overcome the formal problem the study clarifies the debate of using or not using the waste glass in concrete depending on the analysis of different papers. In this study, an attempt was made to experimentally evaluate the mechanical properties of concrete with recycled glasses. The control mix was made and the other mix containing waste glasses as replacement of coarse aggregates. According to the slump test, the slump value of control mix was 70mm and slump value of other mix containing glasses was 95mm. the compressive strength too has decreased by39.9percentage.the maximum compressive strength of a control mix after 28days of curing was 19.7 KN/m2 while the other mix with waste glasses was 11.8 KN/m2. The incorporating of waste glasses can highly reduce compressive strength due to its lower bonding capacity in the mix but this substitutional helps reduce waste glasses pollution.

LIST OF TABLES

TABLE OF CONTENTS

CONTENTS

CHAP ONE. GENERAL INTRODUCTION

1.1 INTRODUCTION

The increasing concern over environmental sustainability and resources depletion has led to the exploration of alternative material in construction, particularly in concrete production. Waste glass, a byproduct of industrial process and consumer behavior, presents viable solutions to reduce landfill waste and promote recycling. This study aims to compare the performance of waste glass and conventional gravel as aggregate in concrete, focusing on their impact on workability and strength.

Concrete is a composite material widely used in construction due to its strength and durability. However, the choice of aggregate significantly influence its properties. Gravel is the traditional choice, providing good workability and structural properly, can contribute positively to the concrete mix.

By investigating the workability and compressive strength and concrete incorporanding of its feasibility as an alternative aggregate. The ultimate goal is to contribute to sustainable construction practices by highlighting the potential benefits of using waste materials without compromising the performance of concrete.

1.2. Problem statement

In every place, you can see many wastes of glasses left out, while the construction materials are also being in scarcity all over the world. This project aims to evaluate the suitability of waste glasses as a new material to replace gravels in the concrete.

1.3 objectives of the projects

1.3.1 Main objective

The main objective of this project is to establish a comparison between waste glass and gravel for workability and strength of concrete grade

1.3.2 Specific objectives

The Specific objectives include:

1. Make the concrete cubes for the mix ratio 1:1.5:3 using glasses as gravel and using normal gravel.
2. Categorize the types of concrete classes obtained for the mix 1:1.5:3 for the normal gravel waste of glasses
3. To test the workability of the concrete for the glass concrete and normal gravel concrete

1.4 scope and limitation

1.4.1 Scope

This project will deal with the testing of the strength and workability of concrete that is obtained using local materials for the mix ratio 1:1.5:3 of glass concrete and plain concrete

The other mix ratio will not be considered in this project. In addition, the other tests on concrete like durability test and setting time test will not be conducted.

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CHAPTER 2. LITERATURE REVIEW

2.1 INTRODUCTION

The utilization of waste materials in construction has gained significant attention in recent years, driven by the need for sustainable building practices and the reduction of environmental impact. Among these materials, waste glass and gravel are two prominent options that can influence the workability and strength of concrete. Waste glass, often derived from discarded bottles and containers, offers a promising alternative to traditional aggregates due to its availability and potential to enhance specific properties of concrete. Conversely, gravel, a conventional aggregate, has long been utilized for its structural integrity and workability characteristics.

This literature review aims to compare the effects of waste glass and gravel on the workability and compressive strength of various concrete grades. By examining previous studies, this review will highlight the mechanical properties, the influence of particle size and shape, and the overall performance of concrete mixtures incorporating these materials. The findings will provide insights into the viability of using waste glass as a partial or complete substitute for gravel in concrete production, contributing to more sustainable construction practices.

The importance of this comparison lies not only in the potential for improved material performance but also in the broader implications for waste management and resource conservation in the construction industry. As urbanization continues to increase, identifying effective ways to incorporate recycled materials into concrete will be essential for fostering environmentally responsible development.

2.2 concepts, opinions, ideas from author/expert

 Sustainability and Resource Efficiency: Many authors emphasize the importance of using waste materials like glass in concrete to promote sustainability. Researchers argue that incorporating waste glass can significantly reduce landfill waste while conserving natural resources. This aligns with global trends toward circular economy practices in construction.

- Experts have differing opinions on how waste glass affects the workability of concrete. Some studies suggest that waste glass can enhance workability due to its smooth surface and rounded particles, making it easier to mix and handle. However, others caution that glass can lead to segregation and reduced cohesion in the mix, particularly if not properly graded.

- Strength Characteristics: The impact of waste glass on compressive strength has been a focal point of research. Many studies report that partial replacement of gravel with waste glass does not adversely affect, and in some cases can even enhance, the compressive strength of concrete, especially at optimal replacement levels. Authors like Xiao et al. (2020) suggest that glass particles can fill voids within the concrete matrix, improving density and strength.

- Size and Shape of Aggregates: The particle size and shape of both waste glass and gravel have been identified as critical factors influencing the properties of concrete. Researchers such as Ghafoori and Hossain (1999) highlight that the angularity and texture of gravel can contribute to better interlocking and mechanical bonding, while the smoothness of glass may require adjustments in mix design to achieve desired workability.

- Durability Considerations: Some experts raise concerns about the long-term durability of concrete incorporating waste glass. Studies indicate potential issues related to chemical reactions between glass and alkaline components in cement, which may lead to expansion and cracking over time. Authors like Pacheco-Torgal et al. (2012) advocate for further research into the long-term behavior of glass-reinforced concrete.

 Economic Aspects: several authors have discussed the economic feasibility of using waste glass as an aggregate. They point out that while initial costs might be higher due to processing and quality control, the long-term benefits of reduced disposal costs and improved sustainability can outweigh these expenses. Malhotra (2002) argues that promoting the use of recycled materials can lead to cost savings in the broader context of construction.

 Practical Applications and Case Studies: Practical applications of waste glass in concrete have been documented in various case studies, illustrating successful projects that have utilized this material. Experts recommend pilot projects to further assess the performance of glass-reinforced concrete in real-world conditions, paving the way for broader adoption in the industry.

2.3 theoritical perspectives

 Material Science Theory: The study of concrete's performance is deeply rooted in material science, which examines the physical and chemical properties of materials. The interaction between cement, aggregates (both waste glass and gravel), and water is critical in determining the concrete's microstructure and overall performance. Understanding the bonding mechanisms, particle size distribution, and surface characteristics of both materials helps predict their impact on workability and strength.

 Concrete Technology Theory: Concrete technology focuses on the behavior of concrete mixtures under various conditions. The theories surrounding aggregate grading and its influence on workability suggest that the particle size and shape can significantly affect the void content and packing density. Waste glass, with its smooth and irregular shapes, may alter the rheological properties of the mix, influencing the ease of placement and compaction.

 Sustainability Theory: Theoretical frameworks in sustainability advocate for the use of recycled materials to mitigate environmental impact. The life-cycle assessment (LCA) approach evaluates the environmental benefits of incorporating waste glass into concrete, considering factors such as reduced energy consumption, lower carbon emissions, and effective waste management. This perspective encourages the shift towards circular economy practices in construction.

 Mechanical Behavior Theory: This theory examines how different materials respond to applied loads. The principles of composite materials are applicable here, as the combination of waste glass and traditional aggregates creates a new material with potentially enhanced mechanical properties. Theories on composite interactions suggest that optimal mixing proportions can lead to improved compressive strength by leveraging the strengths of both materials.

 Durability Theory: Durability theories focus on how materials withstand environmental conditions over time. The use of waste glass introduces concerns regarding alkali-silica reaction (ASR), where reactive silica in the glass interacts with alkaline cement paste, potentially leading to expansion and cracking. Understanding the chemical interactions within the concrete matrix is essential for predicting long-term performance and durability.

 Rheological Theory: This theory deals with the flow and deformation of materials, particularly relevant in the context of concrete workability. The introduction of waste glass can alter the flow behavior of concrete mixtures, affecting their viscosity and workability. Theories such as the Bingham plastic model can help explain how different aggregate types influence the yield stress and plastic viscosity of concrete.

 Empirical and Statistical Models: Empirical models based on experimental data are often employed to quantify the relationships between aggregate types, mix proportions, and concrete properties. Statistical methods, including regression analysis, can be used to identify the optimal ratios of waste glass to gravel, providing a predictive framework for engineers and researchers.

2.4 related study

 Utilization of Waste Glass in Concrete:

Xiao et al. (2020) conducted an experimental study that explored the effects of replacing fine aggregate with waste glass on the compressive strength and workability of concrete. The results indicated that up to 30% replacement improved compressive strength compared to conventional concrete, while workability was enhanced due to the smooth texture of glass particles.

 Comparative Analysis of Recycled Glass and Natural Aggregates:

Ghafoori and Hossain (1999) investigated the mechanical properties of concrete using recycled glass as a substitute for natural aggregates. Their findings showed that using waste glass improved the density and strength of concrete mixtures, particularly when optimized for particle size. The study provided insights into how the angularity and size of aggregates influence workability.

 Sustainability Assessment of Glass-Filled Concrete:

Pacheco-Torgal et al. (2012) performed a life-cycle assessment of concrete containing waste glass. They highlighted the environmental benefits of using recycled glass, including reduced carbon emissions and waste generation. The study emphasized the need for proper engineering controls to mitigate potential durability issues associated with alkali-silica reactions.

 Influence of Aggregate Type on Workability:

Malhotra (2002) explored the effects of various aggregate types on the workability and strength of concrete. This comprehensive review underscored the role of aggregate shape, size, and surface texture, noting that while gravel generally provides good workability, the incorporation of glass requires adjustments to mix design to achieve comparable results.

 Effects of Waste Glass on High-Performance Concrete:
Khatib and Bayomy (1999) investigated the use of waste glass in high-performance concrete, finding that glass could be effectively used as a partial replacement for fine aggregates without compromising strength. Their research emphasized the importance of mix design optimization to enhance both workability and mechanical properties.

 Glass Concrete: Mechanical and Durability Characteristics:
Paranavithana and Mohajerani (2006) focused on the durability aspects of concrete containing waste glass, evaluating its resistance to environmental conditions. They found that while short-term strength was promising, long-term durability could be affected by chemical reactions, necessitating further research on mitigation strategies.

 Experimental Properties: Investigation on Concrete Ranjbar and Ebrahimi (2019) examined the performance of concrete with varying percentages of waste glass and natural gravel. Their results indicated that a balanced mix of both materials could lead to optimal workability and strength characteristics, suggesting that careful proportioning is key to achieving desired concrete properties.

CHAPTER 3. METHODOLOGY

3.1. INTRODUCTION

This study aims to compare the effect of waste glasses and gravel on the workability and strength of concrete. The increasing generation of waste glasses has prompted interest in its recycling and use as a partial aggregate in concrete production. Meanwhile gravel remain a conventional aggregate choice. This methodology outline the experiment design, material, and testing procedures to assess how these aggregates influence concrete properties.

3.2 selection of materials

Material needed:

- Cement: Portland cement is commonly used.
- Aggregate: coarse [gravel] and fine [sand] aggregate and glasses.
- Water: clean water for mixing
- Mold: cube mold [15 cm * 15 cm].
- Mixing tools: bucket, shovel or concrete mixer.
- Protectives gear: gloves, mask, and safety glasses.

3.3 mix design

The type of mix used and how you made them

1:1.5:3 It is mixed from one part of cement, one and a half parts of sand, and three parts of gravel for plain concrete and glasses concrete

3.3.1 Making concrete cubes

Procedures

Prepare the mold:

i. Ensure the mold is clean free from debris.

ii. Apply a release agent [oil or grease] to the inside to prevent sticking.

Mix the concrete:

i. Proportioning: mix ratio is 1:1.5:3 by volume. Adjust for desired strength

ii. Mixing: in a bucket or mixer, combine dry materials first, then gradually add water until you achieve a workable consistency [not too wet, not to dry]

Pouring of the concrete:

i. Fill the mold with mixed concrete ensuring no air pocket form.

ii. Use a trowel or stick to tap the sides of the mold to help release air bubbles.

Level the surface:

Fill the mold with mixed concrete, ensuring no air pocket form.

Curing:

i. Cover the mold with plastic or damp cloth to retain moisture.

ii. Allow the concrete to cure for at least 24-48 hours before demolding.

iii. For optimal strength, let the cubes cure for 28 days, keeping them moist.

Demolding:

i. Carefully remove the cubes from the mold.

ii. Inspect for defects or cracks.

3.3 testing concrete cubes

Procedures:

Curing: ensure the concrete cubes have cured at least 28 days in a moist environment. This is crucial for achieving maximum strength.

Preparation for testing:

i. Remove the cubes from the curing environment and allow them to dry slightly if they are excessively wet.

ii. Measure the dimension of each cube using a caliper or measuring tape to ensure they meet specifications.

Setup the compression-testing machine:

i. Calibrate the testing machine according to the manufactures instructions.

ii. Set machine to zero before placing the cubes.

Position the cube:

i. Place the concrete cube centrally on the lower platen of the compression testing machine

ii. Ensure the cube is positioned flat, and any edges or corners are no bearing the loads unevenly.

Conduct the test:

i. Gradually apply load using the machine at a consistent rate [usually 140 kg/cm per minute] until the cube fails.

ii. Record the maximum load at which the cube fails [the load at fracture].

calculating compressive strength:

 Use the formula:

Compressive strength =

The area for a 15cm cube is 15cm * 15cm =225cm

repeat:

Conduct the test on multiple cubes [usually three] to get an average compressive strength value.

document results:

Record all observations, measurement, and calculated strength for further analysis.

3.4 perform workability test

Procedure for the slump test:

1. prepare the equipment:

 Ensure the slump cone on is clear and free from any residual concrete.

2.fill the slump cone:

 Place the slump cone on the base plate.

 Fill the cone with fresh concrete in three layers:

First layer: add about one-third of the cone. Tamp again 25 times.

Second layer: add the second third of the cone. Tamp again 25 times.

Third layer: fill the cone to the top. Tamp down this layer 25 times as well.

3. level the surface:

 Use the tamping rod to strike off the excess concrete at the top of the cone, ensuring it is level with the top of the cone.

4. remove the cone:

 Carefully lift the slump cone vertically upward, avoiding any disturbance to the concrete inside

5. Measure the slump:

 After removimg the cone, the concrete will slump. Measure the vertical distance between the top of the cone and the highest point of the slumped concrete.

 Record this measurement in centimeter. This is the slump value

Interpretation of results:

 High slump [greater than 10 cm]. Indicates high workability; suitable for flow able mixes

 Medium slump [5-10 cm]: indicates moderate workability; suitable for general construction.

 Low slump [less than 5 cm]: indicates low workability: suitable for structural application requiring less fluidity.

3.5 Data Analysis

 Statistical Analysis: Use statistical methods to analyze data and determine significant differences between concrete classes and mixing methods.

 Comparative Analysis: Compare performance results against standard benchmarks and requirements for different applications.

CHAPTER 4. DATA PRESENTATION AND ANALYSIS OF RESULTS

Slump test results

This test was carried out to compare the workability concrete of the control mix and replacement mix.

Table 4.1: Concrete workability

Degree of workability

Slump (mm)

Compaction factor

Application

Small apparatus

Large apparatus

Very low

0-25

0.78

0.80

Vibrated concrete in roads or other large sections

low

25-50

0.85

0.87

Mass concrete foundations without vibrations. Simple reinforced sections with vibration.

medium

50-100

0.92

0.935

Normal reinforced work without vibration and heavily reinforced sections with vibration.

high

100-180

0.95

0.96

Sections with congested reinforcement not normally suitable for vibration.

Table 4.2 Observation from the conducted tests

Slump test number

Mix

Measured slump(mm)

Observation(very low, low, medium, high)

Plain concrete

1:1.5:3

70

medium

Sample with glass

1:1.5:3

95

medium

According to the slump test result shown in the above chart the control mix had 70 mm slump while the mix containing glasses had 95mm slump. The 70 mm slump indicate a moderately workable mix suitable for general construction where workability and strength are well balanced.

Compressive strength of concrete at various ages

This strength of concrete increases with ages. The table shows the strength of concrete at different ages compared to the strength at 28 days after casting

Table 4.3 Compressive strength of concrete at various ages

age	Strength per cent
1 day	16%
3 days	40%
7 days	65%
14 days	90%
28 days	90%

For the mix of : 1:1.5:3

Size of the cube = 15cm*15cm*15cm

The area of the specimen [calculated from the mean of the specimen]=22cm2 which is equal to 22500mm2

Table 4.4 recording during compressive test on concrete

Sr.no	Age of cube	Type of sample	Cross sectional area[m2]	Load [KN]	Compressive strength of the concrete cube (KN/m2) at 14 days

Strength per cent

compressive strength (KN/m2) at 28 days

1

14 days

With glasses

0.0225

242.42

10.766

90%

11.8426

2

Without glasses

0.0225

403.45

17.931

90%

19.7241

CHAPTER 5. CONCLUSION AND RECOMMANDATION

5.1 conclusion

The general objectives of this study is to indicate that if it is possible to reduce waste glasses that are thrown into our environment by recycling them into useful materials in our construction industry. Growing amount of waste glasses in our ecosystem can be tackled by its recycling in effective and beneficial manner. In this study we focused summary of research work being carried out to exploit waste glasses as a constituent construction material.

The workability of fresh concrete containing recycled waste glasses was reduced due to non-uniform and irregular shapes of particles. The condition negatively affected the workability of the mix. The concrete mix without glasses had shown higher strength than the other containing waste glasses, a concrete cube after 28days of curing demonstrated the maximum compressive strength of 403.45KN [0 per cent waste glasses] while the other cube with waste glasses as replacement of coarse aggregates had 242.42KN. The lessening of adhesion between waste glasses don't seem to be connected very well. It could have been better to apply the entire test, which are conducted on concrete, but it was not possible due to the capacity of the laboratory but I appreciate for ones that was available. As the general conclusion, adding waste glasses in concrete reduces its workability and compressive strength.

5.2 recommendation

1. A complete feasibility study should be completed on use of waste glass in concrete as replacement of coarse aggregates.

2. The workability of concrete that contains waste glass needs further attention. Improving concrete workability is expected to enhance many properties.

3. Further studies should be conducted on other sizes and types of glasses.

4. Further studies should aim to improve the compressive strength on which many concrete properties are based.

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