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EXPERIMENTAL INVESTIGATION OF STRENGTH PROPERTIES BY PARTIAL REPLACEMENT ON COARSE AGGREGATE BY USING KADAPA SLAB STONE

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Abstract - The experiment aimed to assess the feasibility of using Kadapa stone as a partial replacement for coarse aggregate in concrete. The primary focus was on how this substitution would affect the fresh and hardened properties of the concrete. Based on previous studies and general knowledge of concrete properties, we can anticipate that Kadapa slab stone, being a natural aggregate, might provide similar or slightly lower initial strength compared to conventional coarse aggregate. This is due to potential variations in its physical properties. In Long-Term Strength, the Kadappa stone might exhibit similar or slightly higher strength than conventional aggregate. This could be attributed to its potential for better bonding with the cement paste due to its surface texture or mineral composition. Water-Cement Ratio (W/C) was kept constant at 0.45, ensuring consistency in the concrete's water content. Replacement Levels in concrete, Kadapa slab stone was used to replace 0%, 15%, 25%, and 50% of the coarse aggregate. The concrete specimens were tested at 7 and 28 days to evaluate the effect of curing time. The impact on other properties like workability, durability, and shrinkage could also be investigated. By carefully analyzing the data and considering the potential benefits and drawbacks, the experiment can provide valuable insights into the feasibility of using Kadappa stone as a sustainable and cost-effective alternative for concrete construction.

Index Terms - Cement, Sand, Kadapa Slab Stone, Compressive Strength Test, Split Tensile Test, Flexural Strength Test, Slump Cone Test, Partial Replacement

I. INTRODUCTION

In recent years, there has been increasing interest in utilizing waste Kadapa stones from quarries as a substitute material in concrete. This interest is driven by the large quantities of Kadapa stone waste generated from construction activities. The potential to use these stones as fine aggregate in concrete is particularly appealing due to the possibility of reducing both material costs and overall concrete production expenses. However, Kadapa stones tend to exhibit weaker bonding strength between the aggregate and the cement paste, leading to lower interlocking shear strength compared to natural aggregates. The study emphasizes the growing interest in utilizing waste materials, such as Kadapa slab stone and other industrial by-products, as replacements for natural aggregates in concrete. With concrete being a dominant construction material, the depletion of traditional ingredients has become a concern. As a result, researchers are exploring alternative materials that not only reduce the reliance on natural resources but also help mitigate environmental issues by repurposing waste. This study focuses on evaluating the effects of partially replacing coarse aggregates with waste Kadapa slab stones in M30 grade concrete. The goal is to enhance the properties of conventional concrete, particularly for specialized construction uses. The investigation involves testing the hardened properties, including compressive and flexural strength, to determine the effectiveness of these waste materials as aggregate substitutes. Using waste products in concrete production offers a sustainable solution to both the decreasing availability of natural aggregates and the environmental problems associated with waste disposal. This approach could provide valuable innovations in concrete technology while supporting environmental conservation efforts. Several studies have explored the mechanical properties of concrete when waste Kadappa stones are used as aggregate. Research findings suggest that while these stones can increase the overall strength of the concrete, they may also cause slight reductions in compressive strength compared to traditional mixes. For instance, a study conducted by Al-Rubaie in 2007 investigated the use of Kadapa stones as a partial replacement (up to 30% by volume) of coarse aggregate, showing a minor decrease in compressive strength in concrete mixes. In this experimental study, the focus is on examining the impact of locally sourced waste Kadappa stones as a coarse aggregate on the mechanical properties of concrete. This research aims to assess the feasibility of incorporating waste materials into concrete while maintaining or improving its structural performance.

II. LITERATURE SURVEY

From the Literature review, discusses various research studies and experimental investigations on the use of waste materials as partial replacements for traditional concrete constituents. Here's a summary and key points of each study mentioned:

1. Shabath Waste as Partial Replacement:
   - Material: Shabath waste, a slate rock, is used for replacing both coarse and fine aggregates.
   - Color: Greenish-blue, commonly used for flooring.
   - Replacement Percentages: Different percentages were tested to find the optimum replacement level.
   - Objective: To determine the optimum percentage of replacement for coarse aggregates with shabath waste and assess the strength properties of the resulting concrete.

2. Ceramic Waste Aggregate:
   - Replacement Percentages: Natural coarse aggregates were replaced with ceramic waste at levels of 0%, 20%, 40%, 60%, 80%, and 100%.
   - Impact: The study found a decline in the strength properties of concrete with an increasing percentage of ceramic waste.
   - Model Development: A mathematical model for compressive and split tensile strength was developed using regression analysis of experimental data.

3. Comparison with Supaflo:
   - Replacement Percentages: Coarse aggregate was replaced with waste shabath stone at 10%, 20%, 30%, and 40%.
   - Findings: A 30% replacement level resulted in good strength, both with and without the addition of Supaflo (a flowable concrete admixture).

4. Fly Ash as Partial Fine Aggregate Replacement:
   - Purpose: To explore the use of fly ash as a partial replacement for fine aggregate, addressing the challenge of disposing of industrial waste.
   - Additional Materials: Incorporates other wastes like eggshells and fly ash to mitigate environmental impact.

5. Effect of Bethamcherla Marble Stone Aggregate:
   - Workability: Replacing natural aggregates with marble stone aggregates reduced workability but showed acceptable strength up to a certain replacement level.
   - Optimum Results: Even with reduced workability, the concrete mixes achieved optimum results for certain applications.

6. Utilization of Industrial Wastes:
   - Materials Used: Fly ash, stone dust, and marble dust are studied as replacements in concrete to improve properties and reduce costs.
   - Context: Highlights the importance of utilizing industrial waste in concrete to mitigate environmental and social issues.

7. Slab Dust as Fine Aggregate Replacement:

   - Replacement Levels: Slab dust was used to replace sand in varying percentages (0%, 25%, 50%, 75%).
   - Purpose: To explore slab dust as a partial replacement material for sand in concrete.

8. Geographical Potential and Stone Waste Utilization:
   - Location: Tadipatri, Ananthapur district, Andhra Pradesh, known for layered stone (Kadapa slab).
   - Problem: Waste from the stone processing industry is being dumped, creating environmental concerns.
   - Objective: Investigate the potential use of this stone waste for construction purposes.

All these studies aim to address the dual goals of utilizing waste materials in concrete and reducing the consumption of natural resources. This not only enhances the sustainability of construction practices but also provides an effective solution for waste management. Each study has tested different waste materials and replacement levels, with varying impacts on concrete properties such as strength, workability, and durability.

III. OBJECTIVE

The primary objective is to evaluate the performance of concrete when Waste Kadapa Stones are used as partial replacements for natural coarse aggregates. By testing various replacement levels (0%, 15%, 25%, and 50%), the investigation aims to identify the optimum proportion that balances the mechanical properties (such as compressive strength) and workability of the concrete mix.

IV. EXPERIMENTAL METHODOLOGY

It is the process related to preparing materials for a concrete mix design, specifically referencing sieve analysis and specific gravity tests for fine aggregates (FA) and coarse aggregates (CA), in accordance with Indian standards. Here's a more detailed breakdown of the process:

- **Collection of Materials**: The necessary materials for the mix design (e.g., cement, water, aggregates, etc.) are gathered.
- **Sieve Analysis**: This test is performed to determine the particle size distribution of the fine and coarse aggregates. Aggregates are passed through a series of sieves with decreasing mesh sizes to classify the material by size. The goal is to select the aggregates that fit the desired graduation requirements for the mix.
- **Specific Gravity Tests**: These tests are performed to determine the specific gravity of fine aggregates and coarse aggregates. This property is essential for understanding the density of the materials and is important for mix design calculations. The specific gravity of both FA and CA is typically determined as per IS 2386 (Part 3).
- **Adherence to Indian Standards**: All materials are tested and evaluated following Indian Standard (IS) specifications, ensuring that the materials conform to the required quality and performance criteria for concrete mix design.

Table 4.1. Properties of Cement

Sl. No	Property	Test results
1	Grade of Cement	53
2	Normal consistency	30%
3	Specific gravity	3.12
4	Initial setting time	45 min
5	Fineness of cement	96.5 %
6	Compressive strength of cement At 7 days At 28 days	 26.39 N/mm^2 35.46 N/mm^2
7	Fineness modulus	2.56

The properties of the coarse aggregate used in your experimental investigation. The coarse aggregate (Kadapa Stone) is specified as having a particle size of 20 mm, with a crushed and angular shape, and a specific gravity of 2.74. Here's a summary of the key points.

Coarse Aggregate (Kadapa Stone) Details:

- **Material**: Kadapa Stone
- **Size**: 20 mm
- **Shape**: Crushed and angular
- **Source**: Obtained from a quarry
- **Specific Gravity**: 2.74

- **Cleanliness**: Aggregates are free from dust before being used in concrete, which is crucial for maintaining the bond between the aggregate and cement paste.

Table 4.2: Properties of Coarse Aggregates

Properties	Values
Water Absorption	0.58%
Specific Gravity	2.71
Bulk Density (Rodded)	1574 kg/m^3
Bulk Density (Loose)	1485 kg/m^3
Elongation Index	12.95%
Flakiness Index	13.1%
Impact Value	14.5%

Table 4.3: Sieve Analysis of Coarse Aggregate (20mm)

IS Sieve size, mm	Percentage of passing	Limits as per IS:383
40	100.00	100
20	92.17	85-100
10	9.64	0-20
4.75	0.0	0-5

Table 4.4: Properties of Fine Aggregate (Sand)

Properties	Values
Fineness modulus	2.76
Specific Gravity	2.66
Bulk Density (Rodded)	1539 kg/m^3
Bulk Density (Loose)	1462 kg/m^3
Silt Content	1.39%
Zone of Sand	II

The investigation described focuses on using Waste Kadapa Stones (WKS) as a partial replacement for natural coarse aggregate in an M30 grade concrete mix. Here's a breakdown of the key aspects of this experimental study.

Key Details of the Investigation:

1. **Concrete Grade**:
   - **M30**: This indicates that the concrete mix has a characteristic compressive strength of 30 MPa after 28 days of curing.
2. **Water-Cement Ratio**:
   - **0.4**: This is a low water-cement ratio, which generally leads to a denser, stronger concrete but may affect workability.
3. **Replacement Levels of Coarse Aggregate**:
   - **Waste Kadapa Stones (WKS)** were used as partial replacements for natural coarse aggregate at different levels:
     - 0%
     - 15%
     - 25%
     - 50%
   - The goal was to find the optimum replacement percentage that would yield the most favorable results in terms of strength, durability, and workability.
4. **Concrete Mix Proportion**:
   - **Mix Ratio**: The mix proportion for M30 grade concrete is given as 1:2.76:3.46.
     - 1 part Cement
     - 2.76 parts Fine Aggregate
     - 3.46 parts Coarse Aggregate

- **Water-Cement Ratio**: 0.4, ensuring adequate hydration and strength development.

5. **Mix Design Standards**:
   - **IS 10262 – 2009**: Provides guidelines for concrete mix proportioning, helping in the systematic design of the mix based on target strength, workability, and durability.
   - **IS 456 – 2000**: Specifies general structural use of concrete, including guidelines on strength requirements, quality, and construction practices.

Table 4.5: Mix Proportion for M30 Concrete with WKS

Sl. No	Replacement %	Cement Kg/m^3	Fine aggregate Kg/m^3	Coarse aggregate Kg/m^3	WKS Kg/m^3
1.	0	352	971.52	1217.92	0
2.	15	352	971.52	1035.232	182.68
3.	25	352	971.52	913.44	304.48
4.	50	352	971.52	608.96	608.96

V. RESULTS

The procedure described involves preparing concrete specimens in the laboratory with partial replacement of coarse aggregate using Waste Kadapa Stone (WKS). Here’s a detailed summary of the process and testing involved.

Concrete Preparation and Casting:

1. **Mixing:** The concrete mix is prepared in the laboratory according to the specified proportions, with WKS replacing the natural coarse aggregate at levels of 20%, 40%, and 60%.
2. **Pouring and Compaction:**
   - The mixed concrete is poured into moulds in three layers.
   - Each layer is compacted using 25 strokes of a tamping rod to ensure the removal of air pockets and uniform distribution of the mix within the mould.
3. **Demoulding:**
   - After 24 hours, the cast specimens are carefully removed from the moulds.
4. **Curing:**
   - The specimens are immersed in a water tank for curing.
   - Curing durations are 7 days and 28 days, which are standard curing periods to assess early and long-term strength development.

Testing of Concrete Specimens:

1. Workability Test
2. Compressive Strength Test
3. Split Tensile Strength Test

Comparison with Conventional Concrete:

- The results of concrete with WCS replacement (15%, 25%, and 50%) are compared against conventional concrete (with 100% natural coarse aggregate).
- Objective: To evaluate the performance of concrete with WKS in terms of workability, compressive strength, and split tensile strength, and to determine if WKS can be a viable alternative material for partial replacement.

Workability is a critical property of concrete that determines how easily it can be mixed, placed, compacted, and finished without segregation or excessive bleeding. Two of the most common tests to measure the workability of concrete are the Slump Test and the Compacting Factor Test.

Table 4.5: Slump Value and Compaction Factor

Concrete Mix with replacement of WKS	W/c ratio	Slump Value, mm	Compaction Factor
0%	0.4	75	0.90
15%	0.4	70	0.93
25%	0.4	66	0.94
50%	0.4	61	0.92

Table 4.6: Compressive Strength for 7 & 28 Days

Concrete Mix with replacement of WKS	7 days (N/mm^2)	28 days (N/mm^2)
0%	21.56	31.52
15%	22.89	33.74
25%	24.75	35.52
50%	21.96	32.86

Table 4.7: Split Tensile Strength for 7 & 28 Days

Concrete Mix with replacement of WKS	7 days (N/mm^2)	28 days (N/mm^2)
0%	1.95	2.79
15%	2.34	2.95
25%	2.86	3.12
50%	2.02	2.94

VI. CONCLUSIONS

Based on the experimental results, the following conclusions regarding the use of Waste Kadapa Stone (WKS) as a partial replacement for coarse aggregate in concrete can be summarized:

1. Compressive Strength Performance:

- **15% Replacement:**
  - The concrete mix with 15% WKS replacing natural coarse aggregate showed a 7.04% increase in compressive strength compared to conventional concrete.
  - This indicates that a partial replacement at this level can improve the strength of the concrete.
- **25% Replacement:**
  - With 25% replacement, the compressive strength increased by 12.69%, showing the highest improvement among all replacement levels tested.
  - This suggests that 25% replacement of coarse aggregate with WKS is the optimum level for achieving maximum compressive strength.
- **50% Replacement:**
  - At 50% replacement, the compressive strength began to decline, indicating that beyond 25%, the benefits of using WKS diminish.
  - The excessive replacement might lead to a weaker bond between the cement matrix and the WKS particles, resulting in reduced strength.

2. Optimal Replacement Level:

- The experiment suggests that 25% replacement of natural coarse aggregate with WKS is the most effective in enhancing the compressive strength of concrete.
- Beyond 25%, the strength starts to decrease, indicating that while WKS is beneficial, and there is a limit to its effective usage as a replacement material.

3. Suitability for Paver Blocks and Heavyweight Concrete:

- **Paver Blocks:**
  - Kadapa stones have proven to be suitable as an aggregate for building paver blocks due to their enhanced strength properties.
  - This makes WCS a viable alternative for producing durable and strong paver blocks.
- **Heavyweight Concrete:**
  - The use of WKS in heavyweight concrete applications is recommended as it provides better strength compared to conventional natural aggregates.
  - This suggests potential use in applications where high strength and durability are required, such as in the construction of heavy-duty pavements, industrial floors, and structural members subject to high loads.

4. Implications:

- **Environmental and Economic Benefits:**
  - Utilizing WKS reduces the dependency on natural aggregates, contributing to sustainable construction practices by repurposing waste material.
  - It also addresses the issue of waste management associated with Kadapa stone, providing an eco-friendly and cost-effective solution.
- **Further Research:**
  - While the 25% replacement level showed the best results, additional studies on durability aspects, long-term performance, and behavior under different environmental conditions would be beneficial to further validate the use of WKS in various concrete applications.

This study highlights the potential of WKS as a viable partial replacement material in concrete, particularly in improving compressive strength up to an optimal replacement level of 25%. This not only promotes sustainable construction practices but also offers practical solutions for building materials in specific applications like paver blocks and heavyweight concrete.

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