Section: Research Paper

DEVELOPMENT OF MODIFIED CONCRETE INCORPORATING RECYCLED AGGREGATE AND BAGASSE ASH: A SUSTAINABLE APPROACH

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ABSTRACT:
The construction industry cannot operate without the utilization of concrete. The manufacturing of materials like cement and aggregates has been considered to cause the most pollution in the construction industry. The construction industry is compelled to identify an alternate material for concrete matrix because of material scarcity, a supply-demand imbalance, and environmental contamination. Reviewing previous and current research on the use of substitute materials in concrete production and its uses in the construction sector is the main goal of this study. The researchers' interest in using these materials as an alternative source for cement and aggregate materials was stoked by the widespread availability of recyclable waste materials including Construction and Demolition Wastes (C and DW) and industrial byproduct like bagasse ash. In the present study the compressive strength of the modified concrete of grade M20 is taken into consideration. For modification of concrete and to make the concrete economical, waste materials like recycled aggregates and bagasse ash are used. The natural coarse aggregates are completely replaced by recycled aggregates and the cement is partially replaced (by weight) by bagasse ash.This study might support encouraging users to use more alternative materials for producing concrete for significantly large construction projects.
Key words: M20 Concrete mix, Construction and Demolition Wastes (C and DW), bagasse ash.

1. INTRODUCTION:

As global average temperatures rise and the Earth's climate changes, the need to minimize CO_2emissions becomes more pressing. In order to accomplish this, creative techniques to mitigating the impacts of CO_2 emissions are required. One such method is to use alternative materials instead of cement and natural aggregates in the manufacturing of concrete. Since the manufacturing of cement and the extraction of natural aggregates emits a lot of CO_2, this approach might be a feasible alternative for minimizing CO_2 emissions.

The annual CO_2 emissions from the manufacture of concrete are about 8% of the total. The construction industry began adopting substitute materials in concrete to meet demand and protect the environment [1]. Construction and demolition waste recycling A sustainable way to deal with trash and the depletion of natural resources is to use construction debris as an alternative to aggregates in concrete. The environmental issue brought on by the disposal of industrial waste is considerably reduced when using industrial byproducts as a substitute for cement. The use of alternative materials like Construction & Demolition Waste and bagasse ash in concrete applications was critically examined in this paper. Various replacement percentages of Natural Aggregates (NA) with Recycled Coarse Aggregate were tested by numerous researchers [2]. Additionally, research was done to see how well bagasse ash would work as a partial cement replacement. The present investigation was conducted after taking into account previous research on the strength performances following the replacement of cement with bagasse ash and coarse aggregate with recycled cement. However, recycled coarse aggregate was used to substitute cement to variable degrees and bagasse ash to a greater extent, making the concrete more cost-effective and durable. This research aims to study the effect of bagasse ash (BA) on the durability of recycled aggregate concrete. . In order to partially replace Portland cement, BA were utilised at various percentages of 10%, 20%, 30%, and 40% by weight of cement. Recycled aggregate concrete was produced by using recycled aggregate to completely replace coarse aggregate in the mix proportion of conventional concrete. Investigated was the obtained concrete's compressive strength.

The impact of ground fly ash (GFA) and ground bagasse ash (GBA) on the resilience of recycled aggregate concrete was examined by RattaponSomna et al. [3]. In the mix percentage of conventional concrete (CON), recycled aggregate was utilised to completely replace crushed limestone, while GFA and GBA were used to partially replace Portland cement type I at rates of 20%, 35%, and 50% by weight of binder. On concretes, we looked at compressive strength, water permeability, chloride penetration depth, and expansion by sulphate attack. According to the findings, recycled aggregate concrete's durability was significantly increased when GFA and GBA were used to partially replace cement. GFA or GBA should be replaced with 20% by weight of binder in recycled aggregate concrete in order to provide the desired compressive strength, low water permeability, high chloride penetration resistance, and high sulphate resistance.

A. Bahurudeen et al. [4] included several tests in their investigation, including oxygen permeability, fast chloride penetration, chloride conductivity, water sorptivity, DIN water permeability, and Torrent air permeability. According to the study's findings, adding sugarcane bagasse ash to concrete significantly improves its performance. In comparison to control concrete, bagasse ash blended concrete had a lower heat of hydration, increased strength from pozzolanic reaction, a considerable decrease in permeability due to pore refinement, and identical drying shrinkage behaviour.

From all the existing traditional methods of mix design, N K Bairagi et al [5] research found the best appropriate way for RAC. It is possible to change an affecting parameter by using an empirical relationship that has been identified. By obtaining these mix design parameters, RAC is able to get the intended and designed goal strength without having to use any trial mixes. However, the suggested adjusted technique calls for 10% extra cement, which is thought to be quite realistic and acceptable given the worse quality of recycled material.

Somayeh Lotfi et al. [6] recycled end-of-life (EOL) concrete on an industrial site. After recycling, the resulting recycled aggregate's (RA) qualities were examined, and the findings are reported. A comparison of the mechanical and durability characteristics of manufactured Recycled Aggregate Concrete (RAC) and Natural Aggregate Concrete was done experimentally (NAC). The design of the concrete mix and the type of cement have a significant impact on the characteristics of RAC, according to the results. On the other hand, the performance of

RAC is only slightly and controllably impacted by the substitution of RA, even at a high % replacement level. By adjusting the mix design and employing the right kind of cement, this result provides a strong hint as to the viability of using RA in structural concrete.

There have been numerous studies on recycled aggregate concrete and bagasse ash in addition to the studies mentioned above. Similar studies on the performance of concrete utilising recycled aggregate and bagasse ash are shown in references [7, 8, 9, 10, 11, 12, 13, 14, and 15].The utilisation of waste materials in concrete, such as recovered aggregate and bagasse ash, has come a long way. However, these components have not been replaced all at once to produce more affordable and environmentally friendly concrete. According to a survey of the literature on the subject, while some writers have investigated the potential of employing these recycled materials in the lab, there aren't many research based on actual applications of RA from CDW and bagasse ash. The purpose of this article is to examine the combined impact of waste materials when conventional concrete's natural coarse aggregate is partially replaced with recycled aggregate and 100% replaced with recycled aggregates.

As per Amendment 5 to IS-456:2000 concrete cube testing is done to ensure that following minimum strength is to be achieved:

3 days	:	45 percent of specified strength
7 days	:	60 percent of specified strength
14 days	:	85 percent of specified strength

2. EXPERIMENTAL PROGRAM

For the M20 grade of concrete, there were six trials (3 trials for the 7th day of testing and 3 trials for the 28th day of testing), each consisting of three cube specimens. 90 M20 grade concrete cubes in total were casted, and their compression strength was evaluated. 45 of the 90 concrete cubes were examined on day 7, and the remaining 45 were tested on day 28. The cubes were all 150x150x150 mm in dimension. All the specimens were mixed and cured in a laboratory.

Figure 1: Compressive test of the Specimen

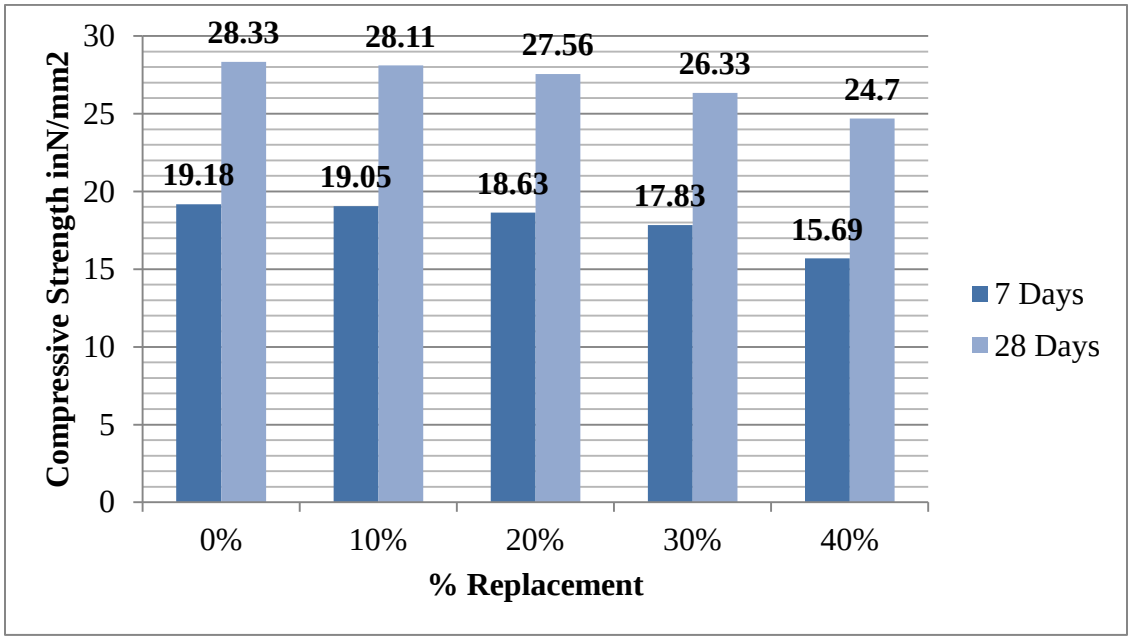
3. TEST RESULTS

% Replacement	Compressive Strength N/mm^2	Compressive strength at 7 days as per Amendment 5 to IS-456:2000	Actual Percentage Gain
0%	19.18	60 % of specified strength (Target Mean Strength = 26.6 N/mm^2)	120.17%
10%	19.05		119.36%
20%	18.63		116.73%
30%	17.83		111.72%
40%	15.69		98.31%

Table 1:7 days comparative compressive strength of M20 grade concrete.

% Replacement	Compressive Strength N/mm^2	Target Mean Strength	Percentage Variation
0%	28.33	As per 10262:2019 the Target Mean Strength for M20 grade of Concrete is 26.6 N/mm^2	6.5% increase
10%	28.11		5.68% increase
20%	27.56		3.61% increase
30%	26.33		1.01% decrease
40%	24.70		7.14% decrease

Table 2:28 days comparative compressive strength of M20 grade concrete



Graph 1: Comparative Compressive strength of M20 grade concrete.

4. VALIDATION

For the purpose of validation of the results extracted after the experimental investigations two precursory research articles were considered. The first article entitled as 'Recycled construction and demolition concrete waste as aggregate for structural concrete' was considered whose authors Ashraf M. WagihEt al. [2] investigated over the use of recycled construction aggregate usage in newly formed concrete mixes. The study was made on 50 different mix designs comprising of different percentages of recycled aggregates used ranging between 0% to 100%. Hence this paper was considered to be a validatory reference.

Compressive Strength in MPa Experimental Results		**Compressive Strength in MPa Validatory Results (Extrapolated)**		**Percentage Variation Expected**	**Percentage Variation Actual**
0% Recycled Aggregates	28.33	0% Recycled Aggregates	26.13	05%-15%	7.762 %
20% Recycled Aggregates	27.56	25% Recycled Aggregates	25.2	05%-15%	8.554%
40% Recycled Aggregates	24.70	50% Recycled Aggregates	23.06	05%-15%	6.639 %

Table 3: Validation of the results

From table 3, the validatory data is found to be within the expected mean variation range, hence it can be concluded that the results extracted from the experimental investigations are found to be validated.

5. CONCLUSION

In this study, the natural coarse aggregate in concrete was completely replaced with recycled coarse aggregates and cement by weight was partially replaced with bagasse ash in varying percentages of 10%, 20%, 30% and 40%.This study highlights on the possibility of employing alternative of cement and natural aggregate materials in the manufacturing of concrete. According to the study, using bagasse ash in lieu of cement and recycled aggregate in place of natural aggregates might successfully cut CO2 emissions in a wide range of ways. It was determined, in particular, that the findings obtained for the modified concrete were within the standard range when compared to the conventional concrete.

The specimens were tested for compression and the experimental findings can be summarized as follows:

- As per the mix design for the controlled concrete of grade M20 the target strength should be 26.6 N/mm^2.
- At 0% replacement of cement and 100% natural aggregate (controlled model) the 28 days compressive strength achieved was 106.5% as compared to target strength.

- At 10% replacement of cement and 100% replacement of natural aggregate the 28 days compressive strength achieved was 105.7% as compared to target strength.

- At 20% replacement of cement and 100% replacement of natural aggregate the 28 days compressive strength achieved was 103.6% as compared to target strength.

- At 30% replacement of cement and 100% replacement of natural aggregate the 28 days compressive strength achieved was 98.98% as compared to target strength.

- At 40% replacement of cement and 100% replacement of natural aggregate the 28 days compressive strength achieved was 92.86% as compared to target strength.

From the above observations its can be seen that the compressive strength achieved for 20% replacement of cement with bagasse ash is 103.6% that of target strength but for 30% replacement of cement with bagasse ash the Compressive strength achieved is less than the target strength i.e. 98.98%.
Thus, the above values suggest when natural aggregates are 100% replaced by recycled coarse aggregates that the optimum percentage replacement of cement with bagasse ash that should be replaced to gain target compressive strength lies between 20% and 30%.

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