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An Experimental Study On Strength Characteristics Concrete by Partial Replacement of Coarse Aggregate with Bethamcherala Waste Stone

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Abstract

In the current research work, as per the best knowledge of the authors, for the first time Bethamcherla stones has been used as a partial replacement of coarse aggregate in concrete mix. The scarcity of natural aggregate as well as finding alternative materials that can maintain or enhance the properties of concrete is crucial for sustainable construction practices. Bethamcherla stones (BS), which mainly comprises by limestone can be a potential substitute for coarse aggregate. Limestone is a common material used in concrete production, and its use as an aggregate could offer advantages such as reducing the demand for traditional aggregates and utilizing local resources efficiently. The concrete specimens, casted using BS, were kept for curing for different durations (7, 21, and 28 days), and the mechanical property was assessed using the compressive strength test, a standard procedure for evaluating concrete performance. Compressive strength is a fundamental parameter that reflects the ability of concrete to withstand loads and pressures, making it an essential property to study. It would be interesting to see the results of this study, especially how the compressive strength of the concrete changes with different replacement levels of coarse aggregate with BS aggregates (10%, 20%, 30%, and 40%). This data would provide insights into the effectiveness of using BS as a substitute and help determine the optimal replacement ratio that balances cost and performance considerations. Additionally, while compressive strength is a critical mechanical property, other properties such as flexural strength, durability, and elevated temperature effect also need to be evaluated to understand how the BS aggregates influence the overall behavior of the concrete. If this experimental study proves successful, it could pave the way for more sustainable and cost-effective construction practices in the Kurnool district of Andhra Pradesh and other regions facing similar challenges with traditional aggregate availability. Remember that the success of this research will depend on the accuracy of testing methods, the representativeness of the specimens, and the relevance of the findings to real-world construction applications. Seeing such innovative efforts toward improving construction materials and practices for a more sustainable future is exciting.

Keywords: *Bethamcherla stone; Compressive strength; Kurnool.*

1. Introduction

Concrete is the highly prominent part in the structural construction, it is the most widely used construction material throughout the globe. Concrete is placed at very next position after water. [1] Concrete consisting of cement, fine aggregate, coarse aggregate, water and some admixtures in required proportion for a quick and better results in different conditions. In the construction industry natural aggregate is very essential component of concrete. Natural aggregate is getting expensive due to scarcity. All over the world consumption of natural aggregate as coarse aggregate in concrete production is very high and several developing countries have encouraged some demand in the supply of natural aggregate in order to meet the increasing needs of infrastructural development in recent years.[2] Concrete might be made out of cement, aggregate (generally a coarse aggregate made of gravels or crushed rocks such as limestone, or granite, plus a fine aggregate such as sand), water, and/or admixtures (if required).[3] Among the three quantities, aggregate possesses major part in the concrete mix. So, the aggregate content ought to be in a type of consisting good strength. The aggregate is differentiated as fine aggregate and coarse aggregate. The proportionate amount of every material (i.e. Cement, water and aggregates) Influences the properties of hardened concrete. Based on the purpose and utilize, the properties of concrete can also be changed. [4] The usage of concrete is expanding at a higher rate because of development in infrastructure and construction industry all around the globe. However, there are some negative effects of more creation of concrete like persistent, extensive extraction of aggregate from natural resources will prompt to its exhaustion and ecological imbalance. [5,6] Researchers are looking for replacing coarse aggregate to make concrete more affordable and to lead maintainable development. [7] This environmental reason has generated a lot of concern in the construction world. The utilization of sugarcane, wooden chips, plastic waste, crushed material waste, polyethylene, elastic tyres, vegetable Fibres, paper and pulp industry waste, groundnut shell, waste glass, broken bricks are a few examples of replacing aggregates in concrete. [8- 14] The stone itself, particularly in the forms of overburden, screening residual, stone fragments. Stone wastes are generated as wastes while the process of cutting and polishing. Find a use for all scrap stone and fines Produced. Stone waste can be used in concrete to improve its strength and other durability factors. [15] Stone waste can be utilized as a partial aggregate and as a supplementary addition to accomplish extraordinary properties of concrete. [16] The waste that was produced during stone polishing is not able to use as it is, as coarse aggregate in concrete. So the waste is to be developing as a graded aggregate to use in concrete. To convert the waste into required graded aggregate, it is to be transported to crusher unit. Research was conducted bu replacing BS powder with cement [17-18] and fine aggregate with BS [19-20]. However, there is very less research on the effect of replacement of BS with traditional coarse aggregate. In order to fill the current research gaps in the concrete field, as reviewed in the introduction, experimental program was performed and presented in the present study to investigate the percentage of coarse aggregate required to improve the compressive strength property.

2. Properties of Material Involved

2.1 Cement

Ordinary as a fundamental component of concrete, mortar, stucco, and the majority of non-specialty grout, Portland cement is the type of cement that is most frequently used on a global scale. It evolved from different varieties of hydraulic lime in England in the middle of the 19th century and typically comes from limestone. When materials are heated to create clinker, a fine powder is created. We shall gradually include the additional components after grinding the Clinker. There are several varieties of cements on the market. Comparing various cement grades, the 53 Grade OPC Cement consistently offers stronger strength than the others. According to the Bureau of Indian Standards (BIS), a cement's grade number indicates the minimum compressive strength that the cement is anticipated to reach within 28 days. The minimum compressive strength attained by the cement at the conclusion of the 28th day should not be less than 53Mpa or 530 kg/cm2. The minimum compressive strength attained by the cement at the conclusion of the 28th day should not be less than 53Mpa or 530 kg/cm2. The color of OPC is grey, and by removing ferrous oxide during the cement manufacturing process, we may obtain white cement as well. The experiment employed ordinary Portland Cement of 53 Grade, brand name Ultra Tech Company, accessible in the local market. To avoid the purchase from being impacted by atmospheric conditions, care was taken to ensure that it was prepared from single batching in air tight containers. The cement thus procured was tested for physical requirements in accordance with IS 12269-1987 and for chemical requirement in accordance IS: 4032-1988. The physical properties of the cement are list in the table 1.

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Figure 1 **Cement Used in Research Work**

Table 1 **Cement Properties**

S. No	Properties	Test Results
1.	Normal Consistent	0.32
2.	Time of initial setting	50 min
3.	Time of final setting	320min
4.	Specific gravity	3.15

2.2 Fine aggregate

Natural granular substance called sand is generally made up of tiny stone fragments and mineral particles. Due to its high degree of hardness and chemical inertness, SiO_2 is the most prevalent and weather-resistant mineral. It is usually in the form of quartz. As a result, the experiment's fine aggregate was made of river sand, which was conveniently available in the local markets. According to IS: 2386-1963, tests were conducted on the aggregate's physical properties, including gradation, fineness modulus, and specific gravity. The sand was surface dried before usage. The properties are shown in below Table 2.

Figure 2 **Fine Aggregates Used in Research Work**

Table 2 **Fine Aggregate Properties**

S. No.	Properties	Test results
1.	Specific gravity	2.66
2.	Modulus of fineness	2.51
3.	Bulk density	21.10 %
4.	Sand bulking	27.8
5.	Sand Zone grading	Part-IV

2.3 Coarse Aggregate

Crushed aggregates (smaller than 50 mm in size) collected from neighboring crusher plants, were used in the current research work. The only aggregate that passes through a sieve with a diameter of 50 mm and is kept on a sieve with a diameter of 40 mm is picked. The physical characteristic of aggregate such as fineness modulus, specific gravity, and bulk density were examined according to IS: 2386-1963. The various aggregates were mixed to reach the required combined grade. The properties are listed in the below Table 3.

Figure 3 **Coarse Aggregates Used in Research Work**

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Table 3 Course Aggregate Properties

S.No	Properties	Results of Test
1.	Nominal size	40mm
2.	Particular gravity	2.65
3.	Value of impact	10.50
4.	Absorption Of water	2-3%
5.	Sieve size	40 mm
6.	Aggregate crushing value	20.19 %
7.	Density of bulk for coarse aggregate (density of poured) Density of bulk for coarse aggregate (density of tapped)	1687.31 kg/meter^3 1935.3 kg/meter^3

2.4 BS Aggregate

The waste stone used as the raw material was supplied by the tile companies. When we developed flooring tiles, the industries generated a lot of waste. This trash cannot be utilized in concrete as is due to the size of the stones. As a result, it must be converted into graded aggregate for use in concrete. In order to reduce the stone to the appropriate graded size, we must pass this waste via the crusher machines. Broken stone was collected from Bethamcherla's industry garbage and destroyed structure. The discarded stone was crushed to tiny bits both manually and with the use of a crusher. To use them as a partial substitute for the requisite size of crushed tile aggregate. The physical properties and chemical compositions are mentioned in the following Table 4 and Table 5.

Figure 4 BS Used in Research Work

Table 4 Bethamcherla Waste Stone Aggregate Properties

S. No	Properties	Results Of Test
1.	Specific gravity	3.00
2.	Absorption of water	0.2 percent
3.	Value of Crushing	20.19 percent
4.	Density of bulk	1618 kg/meter 3
5.	Test of attributes impact	16.73

Table 5 Chemical Composition of BS

S. No	Composition Of Attributes	Bs Aggregate
1.	Silicon dioxide	9.80
2.	Aluminum trioxide	1.38
3.	Oxide of iron	1.42
4.	Oxides of Calcium	29.72
5.	Oxides of magnesium	16.32
6.	Magnesium Carbonate	33.82
7.	Calcium Carbonate ($CaCO_3$)	52.87

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3. Concrete mix design with mix proportion

3.1 Specimens Curing

Every one of the examples of Bethamcherla aggregate were casted and restored by setting the examples in relieving tank for term of 7, 21 and 28 days. Standard code used for mix design of concrete IS 456 (2000).

3.2 Mix Proportion

The details of concrete mix proportion used in laboratory are provided below in Table 6

Table 6 Details of Mix Proportion Used in Research Work

Parameters	**Percentage replacement of BS Aggregate in Course Aggregate**				
	Control Mix	MIX (I)10%	MIX(I)20%	MIX (I) 30%	MIX (I) 40%
Water/Cement ratio	0.40	0.40	0.40	0.40	0.40
Water Kg/cubic. Meter	170	170	170	170	170
Cement kg/cu.m	425	425	425	425	425
Fine aggregate kg/cu.m	428	428	428	428	428
Course aggregate kg/cu.m	1422	1280	1137	995	853
BS kg/cu.m	0.00	142	285	427	569

Table 7 Results for 7, 21, And 28 Days of M40 Grade Concrete Compressive Strength

S. No	**Design of mix**	**Percent replacement of (BWS)**	**Strength of Compressive for M40 N/mm^2**		
			07 days	21 days	28 days
1.	M0	0	17.51	18.8	19.74
2.	M1	10	18.53	19.2	20.27
3.	M2	20	18.00	20.6	21.86
4.	M3	30	18.36	20.17	21.52
5.	M4	40	19.2	20.98	22.4

4. Compressive Strength

A total of 15 cubes measuring 150 x 150 x 150 mm were casted for a total of seven days, twenty-one days, and twenty-eight days on each specimen after co nd ucti ng the workability tests like slump and compaction factor. Below is a summary of the findings. Results of the M40 grade concrete compressive strength after 07, 21, and 28 days of use (Table 7).

Figure 5 Compression Testing Machine

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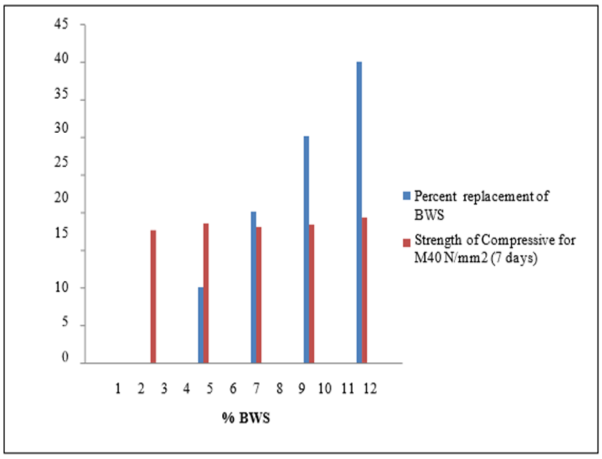

Figure 6 Compressive Strength of M40 at 7 Days for Aggregate Replacement

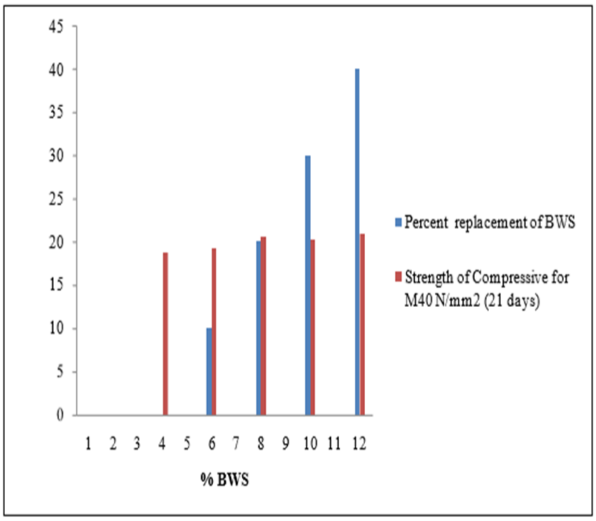

Figure 7 Compressive Strength of M40 at 21 Days for Aggregate Replacement

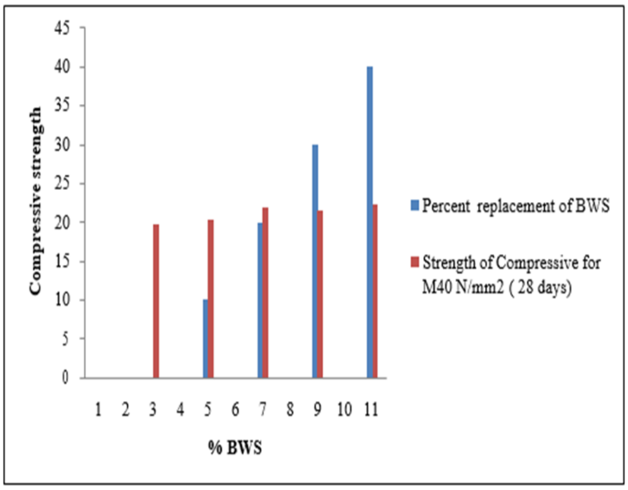

Figure 8 Compressive Strength of M40 at 28 Days for Aggregate Replacement

Conclusion

Based on experimental research on compressive strength and environmental considerations, the findings are Compared to conventional concrete with an increase in BS aggregates up to 40% concrete becomes more workable and also the characteristics of concrete increased linearly. With 40% replacement of BS aggregate there was a increase in compressive strength by compressive strength by 9.6%, 11.59% and 13.47% at 7, 21 and 28 days compared to conventional concrete. However, mixtures including up to 40% BS aggregate are acceptable [21]. Given that granite has mineral and chemical qualities, the coarse aggregate made from BS waste marginally enhances the mechanical properties of concrete.

References

[1]. Behera, M., Bhattacharyya, S.K., Minocha, A.K., Deoliya, R. and Maiti, S., 2014. Recycled aggregate from C&D waste & its use in concrete–A breakthrough towards sustainability in construction sector: A review. Construction and building materials, 68, pp.501-516.

[2]. McGinnis, M.J., Davis, M., de la Rosa, A., Weldon, B.D. and Kurama, Y.C., 2017. Strength and stiffness of concrete with recycled concrete aggregates. Construction and Building Materials, 154, pp.258-269.

[3]. Patel, A.N. and Pitroda, J., 2013. Stone waste in India for concrete with value creation opportunities. International Journal of Latest Trends in Engineering and Technology, 2(2), pp.113-120.

[4]. Ghorpade, V.G., 2013. Effect of recycled coarse aggregate on workability and shear strength of fiber reinforced high strength concrete. International Journal of Innovative Research in Science, Engineering and Technology, 2(8), pp.3377-3383.

[5]. Xiao, J., Li, J. and Zhang, C., 2005. Mechanical properties of recycled aggregate concrete under uniaxial loading. Cement and concrete research,

35(6), pp.1187-1194.

[6]. Gao, C., Huang, L., Yan, L., Jin, R. and Chen, H., 2020. Mechanical properties of recycled aggregate concrete modified by nano-particles. Construction and Building Materials, 241, p.118030.

[7]. Bhat, J.A., 2021. Effect of strength of parent concrete on the mechanical properties of recycled aggregate concrete. Materials Today: Proceedings, 42, pp.1462-1469.

[8]. Habel, K. and Gauvreau, P., 2008. Response of ultra-high performance fiber reinforced concrete (UHPFRC) to impact and static loading. Cement and Concrete Composites, 30(10), pp.938-946.

[9]. Wong, C.M., 2004. Use of short fibres in structural concrete to enhance mechanical properties.

[10]. Tayeh, B.A., Ahmed, S.M. and Hafez, R.D.A., 2023. Sugarcane pulp sand and paper grain sand as partial fine aggregate replacement in environment-friendly concrete bricks. Case Studies in Construction Materials, 18, p.e01612.

[11]. Corinaldesi, V., Mazzoli, A. and Siddique, R., 2016. Characterization of lightweight mortars containing wood processing by-products waste. Construction and Building Materials, 123, pp.281-289.

[12]. Coppola, B., Courard, L., Michel, F., Incarnato, L. and Di Maio, L., 2016. Investigation on the use of foamed plastic waste as natural aggregates replacement in lightweight mortar. Composites Part B: Engineering, 99, pp.75-83.

[13]. Mohammadinia, A., Wong, Y.C., Arulrajah, A. and Horpibulsuk, S., 2019. Strength evaluation of utilizing recycled plastic waste and recycled crushed glass in concrete footpaths. Construction and Building Materials, 197, pp.489-496.

[14]. Binici, H., Shah, T., Aksogan, O. and Kaplan, H., 2008. Durability of concrete made with granite and marble as recycle aggregates. Journal of materials processing technology, 208(1-3), pp.299-308.

[15]. Mohammadinia, A., Wong, Y.C., Arulrajah, A. and Horpibulsuk, S., 2019. Strength evaluation of utilizing recycled plastic waste and recycled crushed glass in concrete footpaths. Construction and Building Materials, 197, pp.489-496.

[16]. Patel, A.N. and Pitroda, J., 2013. Stone waste as a groundbreaking conception for the low cost concrete. International Journal of Engineering Trends and Technology (IJETT)-Volume4Issue4-April.

[17]. Hashim, A.M. and Agarwal, V.C., 2014. Experimental study on strength and durability of concrete with marble and granite powder. International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development, 4, pp.147-156.

[18]. Kaur, E.A. and Bansal, R.S., 2015. Strength and Duriabilty Properties of Concrete with Partial Replacement of Cement with Metakaolin and Marble Dust. vol, 4, pp.1032-1035.

[19]. Verma, A. and Dubey, D.C., 2022. Experimental Investigation in Concrete by Partial Replacement of Sand with Marble Dust: A Review.

[20]. Naresh, C., Ajitha, B., Babu, V.R., Sashidhar, C. and Babu, B.R., 2015. Workability Studies on Fibre Reinforced Concrete Using Bethamcherla Marble Stone as a Replacement of Natural Aggregate. International Research Journal of Engineering and Technology, 2(4).

[21]. Indian standard recommendations for concrete mix design, I.S10261:1982, Bureau of Indian standard, New Delhi.