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A REVIEW ON UTILIZATION OF CONSTRUCTION AND DEMOLITION WASTE AS RECYCLED AGGREGATES IN CONCRETE

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Abstract
The cost of construction materials are increasing to high rates for a conventional building is a major factor that affects the housing delivery worldwide. This has necessitated research for alternative cost effective materials in construction. There is a large amount of demolished waste generated every year in India and other developing countries. Demolished waste includes concrete blocks which can be recycled into stone aggregates through pre-screening, crushing, screening and separating of aggregate. The natural resources are depleting and construction & demolition wastes are increasing day-by-day. Researchers and governments of many countries trying to find out best solution to deal with this situation. Ceramic waste and granite waste from construction industry needed effective utilization. Many researchers have found its use for making concrete with partially or fully replacement of aggregates. In this study, we found out the optimum level of replacement of such wastes by studying various previous researches and reached to conduct a detailed experimental investigation using Indian Standards. In the proposed experimental investigation, the effect of partial replacement of coarse aggregate by demolished waste on compressive strength and workability of demolished concrete. Sieve analysis will perform for recycled demolished concrete and coarse aggregates. The prepared concrete mix will compare and test in terms of compressive strength and Split tensile strength to conventional concrete. The test will be performed at 7, 14 and 28 days in order to evaluate the strength properties. Finally, comparing the strengths of all concretes and prefer the best strength concrete

Keyword- RCA, marble particle, split tensile strength, Flexural strength, Slump cone test

I. INTRODUCTION

Concrete is versatile its durability, sustainability, and economy have made it the world's most widely used construction material. About four tons of concrete are produced per person per year worldwide. The term concrete refers to a mixture of aggregates, generally sand, and either gravel or crushed stone, held together by a binding material of cementations paste. Understanding the fundamentals of concrete is necessary to produce quality concrete according to design for the construction of durable structure. Essentials of Quality Concrete Workmanship, mix proportions, material characteristics, and adequacy of curing is related to performance of concrete. The production of quality concrete involves a variety of materials and a number of different processes including, the production and testing of raw materials, determining the desired properties of concrete, proportioning of concrete constituents to meet the design requirements, batching, mixing, and handling to achieve consistency, proper placement, finishing, and adequate consolidation to ensure uniformity, proper maintenance of moisture and temperature conditions to promote strength gain and durability, and finally, testing for quality control and evaluation. Many people with different skills come into contact with concrete throughout its production. Ultimately, the quality of the final product depends on their workmanship. It is essential that the workforce be adequately trained for this purpose. When these factors are not carefully controlled, they may adversely affect the performance of the fresh and hardened properties. Concrete becomes hard on drying it is basically a mixture of two components: aggregates and binder paste. The binding paste, comprised of Portland cement and water, binds the aggregates (usually surkhi or sand and crushed stone or gravel) into a rocklike mass as the paste hardens from the chemical reaction between cement and water. Supplement cementations materials and chemical admixtures can also be included in the paste to improve the quality of concrete. The paste may also contain entrapped air or purposely entrained air. The paste constitutes about 25% to 40% of the total volume of concrete. Figure 1shows that the absolute volume of cement is usually between 7% and 15% and the water between 14% and 21%. Air content in concrete ranges from about 4% to 8% of the volume.

Introduction to Construction and Demolition Waste

Balance of the supply of construction and demolition (C&D) wastes and the demand of recycled C&D waste products (Balance Theory) is an effective means of reducing these wastes. The maturity of Balance Theory requires gradual establishment of recycling facilities. These facilities are capable to accept and handle not only inert materials but also other C&D wastes—wood and wood products, cardboard, metal, and plastics. The Balance Theory requires construction workers to adopt the idea of reduction of wastes. They are educated to clean their working places constantly and collect all construction wastes they generated into separate collection spots within the construction site. A site management personnel is required to establish site facilities and set up conditions in employment contracts, and subcontracts for workers, and subcontractors to follow. The culture of separating wastes at sources must be established and widely adopted so that Balance Theory could be realized. Balance Theory advocates the amount of wastes generated from a construction project, and sent for recycling process must be equivalent (or proportional) to the amount of the recycled C&D products imported and used as construction materials for that project. Levels of waste within the construction industry need to be reduced for environmental and economic reasons.

Present Scenario of Demolished Waste used in India

Construction and demolition waste (C&DW) management is gaining attention from policy makers in India. This article estimates C&DW generation from urban building, rural building, and non-building sectors in India and calculates material, energy, and emissions savings from C&DW recycling. The method used in this study is top down up material flow analysis approach. The results indicate that India generated between 112 and 431 million tonnes of C&DW in 2016 depending upon the assumptions, which are orders of magnitude higher than official records indicate. Although per capita waste generation from rural area is less than urban areas, rural areas as a whole generate more waste than urban areas, as rural population is still over two times the urban population in India. Additionally, it was estimated that formal C&DW recycling can save upto 2–8% of natural minerals, such as sand and aggregate in urban areas, energy and emissions savings were negative, implying that recycled C&DW materials are likely to be more resource and environmentally intensive as compared to natural materials. Recycling of concrete debris can make a contribution to reducing the total environmental impact of the building sector. To increase the scope for recycling in the future, aspects of recycling have to be included in the design phase. Besides, aggregate sources near Metro Manila are almost depleted, so aggregates have to be brought from far quarries. Consequently, reclaiming aggregates from concrete debris would lead to environmental and economic benefits.

As we have studied earlier that for any type of civil engineering construction, cement concrete is the chief constituent because it can be made with local available materials, but as large construction is going on presently, and will in future too, new construction technology will be used and for large construction, hence large amount of natural materials will be required which is generally found from nature. Extraction of natural materials fulfills the present requirement of construction, but it degrades the environment in long run, in the form of air pollution, land pollution, water pollution, and rise in temperature due to climate change. We are seeing now a days many old structure are being demolished, and new buildings are constructed. Due to demolition of old structures large amount of construction solid waste are generated. Main Aim of the research are:

1. In our project we are making an effort, and are trying to replace natural coarse aggregate partially and fully by demolished waste concrete.
2. Experiments will be done on fresh as well as hardened concrete, and it will be compared with concrete made with fresh quarried natural coarse aggregates extracted from earth's surface.
3. Also the previous researcher's had replaced some percentage of coarse aggregate with demolished waste in this theis coarse aggregate is fully replaced by demolished waste and then it is being tested .
4. To utilize crushed ceramic (bone China) waste as fine aggregate and recycled course aggregate from demolition waste is used as coarse aggregate in manufacturing of M30 grade of concrete.
5. To partially replace natural sand used as fine aggregates with crushed ceramic (bone China) waste with percentages as 20%. Also to partially replace crushed coarse aggregate with demolition waste with varying percentage as 50% and 70% replacement.
6. To study the combined effect 20% crushed ceramic (bone China) waste and marble particle and 70% demolition waste on varies properties of M30 grade of concrete.
7. If the results are found at par with the results as per IS specifications, a recommendation will be made in future to government agencies, that demolished waste coarse aggregate can be a replacement to natural coarse aggregates and can be used for low cost housing projects.

II. LITRATURE REVIEW

Thakur et al. (2018) given the current scenario, high-quality natural sand is becoming increasingly scarce and expensive due to factors such as limited accessibility to rivers yearround, illegal dredging, and the rapid growth of construction activities. It has become imperative to explore alternative materials for use as natural sand in construction projects. Manufactured Sand (M Sand) stands out as a viable alternative material that can effectively replace natural sand in construction, serving as a partial substitute. This study is designed to assess the suitability and potential of M Sand as a fine aggregate in concrete mixes. An experimental program was devised to cast specimen cubes, varying the replacement of fine aggregate with M Sand in increments of 16 percent. The results demonstrate that natural sand can be effectively replaced with M Sand, with the maximum strength achieved at a 64 percent replacement of natural sand with M Sand, based on compressive strength. This finding underscores the potential and effectiveness of M Sand as a substitute for natural sand in concrete formulations.

Arulmoly et al. (2019) this study explores the use of manufactured sand and offshore sand as full replacements for river sand in cement-sand mortar. Two types of manufactured sand, Hornblende-Gneiss and Charnockite, along with offshore sand, were considered for various replacement levels (0%, 25%, 50%, and 75%). Mortar formulations utilized Portland Limestone Cement with different binder-to-aggregate ratios. The research evaluates the impact on fresh and hardened state properties, comparing them with river sand mortars. Results indicate that a 25% replacement level of manufactured sand with offshore sand provides an economically efficient solution for completely substituting river sand in mortar production.

Dolores Eliche Quesada (2020) examined the effects of grazing hollow beads and recycled ceramics on the mechanical, thermal conductivity, and material characteristics of concrete. The findings demonstrated that the workability and thermal characteristics of the concrete are significantly optimized by the concentration of recycled ceramics and grazed hollow beads. On the other hand, the superabundant concentration may cause the concrete's hydration degree to decrease, which would increase material flaws and suppress the development of C-S-H gel. In conclusion, 10% RCE and 60% GHB are the ideal material system design approaches, taking into account the coordinated development of important variables including mechanical properties, microstructure, and thermal insulation capabilities

Olawale et al. (2021) Plastic items have many residential and industrial uses, which has fueled a global rise in their use. On the other side, the environment is contaminated by the enormous volume of plastic products that are thrown away after usage. Given this, the current study looked into the possibility of using Polyethylene Terephthalate (PET) in place of natural sand while making concrete. While the remaining components of the concrete (cement, granite, water-to-cement ratio, and superplasticizer) were left same, locally acquired river sand was substituted in proportions of 4 to 20% at a step of 4% by the weight of natural sand with PET waste that had been industrially processed. For all concrete mixes, Grade M40 concrete was utilized, with a mix ration of 1:1:2:0.35 (cement, sand, granite, and water to cement). PET-free concrete serves as the control.

Gour et al. (2022) Recycling building materials is essential to preserving natural resources and advancing sustainable human development in a quickly industrializing world. Although incorporating the waste in structural concrete is a cost-effective solution, its use is limited by the material's deteriorating properties, and thus it should be carefully examined. A few studies have utilized bone China waste (BCW), which has pozzolanic qualities, occasionally in concrete. Thus, the workability, compressive, split tensile, and flexure strengths of the fresh and hardened features are initially ascertained in the present study. Natural fine aggregate (sand) was substituted with 0%, 20%, 40%, 60%, 80%, and 100% of BCW. The results of the experiment show that every percentage of BCW substitution produces the required characteristic strength; the combination that produces the maximum strength value is 60% BCW.

Reig et al. (2023) Bricks, wall tiles, roof tiles, sanitary ceramics and other ceramic wastes of many kinds are produced during the manufacturing process as well as during building construction and demolition. Inert ceramic waste takes a long time to biodegrade, so placing it in a landfill has a negative influence on the environment and the surrounding landscape. Conversely, the construction sector uses a lot of energy and natural raw materials; the most widely used materials are Portland cement and concrete. This chapter provides an overview of the numerous studies that have been conducted to value and repurpose various kinds of ceramic waste as recycled aggregate in the production of concrete.

Yang et al. (2024) Freeze casting is a potentially very useful method for preparing porous cement-based materials. Steam curing and freeze-drying, on the other hand, lengthen the preparation time and complicate the procedure. Heat-dry curing was employed in place of steam and freeze-drying during operation to streamline the procedure. The new preparation technique has the advantages of low energy consumption, ease of use, and time savings by combining heat-dry curing and freeze casting. The innovative preparation process can reduce energy consumption by at least 18% and preparation time by at least 16 percent when compared to the conventional method of preparing porous cement-based materials.

Dhanoliya and Tiwari (2023) The garbage from development and demolition is growing daily, and the natural resources are running out. Numerous governments and researchers are attempting to determine the best course of action in this situation. Waste from the construction sector, such as granite and ceramic materials, needed to be used efficiently. Numerous researchers have discovered that it may be used to make concrete where aggregates are replaced entirely or in part. By examining numerous earlier studies, we were able to determine the ideal amount of replacement for these wastes in this study and proceeded to carry out a thorough experimental evaluation utilizing Indian Standards. The proposed experimental investigation will examine the effects of ceramic and granite waste on M40 grade concrete qualities, including compressive, splitting, and flexural strength at 7 and 28 days. The waste materials will be employed as coarse aggregate replacement up to 30%, either separately or in combination.

III. METHODOLOGY

In this Study, work is executed in three stages. Initially, the engineering properties of various materials are determined such as water absorption and specific density of crushed ceramic (bone China) waste, marble particle and crushed recycled coarse aggregate. Further, mix design for M30 grade of concrete with partial replacement of bone China, marble particle and recycled coarse aggregate are investigated. The partial replacement of natural sand used as fine aggregates with crushed ceramic (bone China) waste, marble particle with percentages as 20%. & partial replacement of crushed coarse aggregate with crushed recycled coarse aggregate with varying percentage as 50% and 70%. Properties of M30 grade of concrete is also investigated. Finally, the workability, compressive strength, splitting tensile strength and flexural strength of above-mentioned mixes are determined and also compared with normal concrete (without any replacement).

By studying the literature review, the methodology for the future research work can be formed. The proposed methodology for the experimental work to be conducted has been described in this section. All the ingredients such as fine aggregate (river sand), coarse aggregates, cement, etc., used for making desired concrete mixes will be tested as per specifications of Indian Standards. IS 383: 2016 and IS 2386: 1963 will be used for specifications and testing of aggregates for various physical & mechanical properties to check their suitability as coarse aggregate. IS 4031: 1996 & IS 269: 2015 will be used for specifications and testing of cement for various properties to check suitability as cement. IS 456: 2000 & IS 10262: 2019 will be used for mix design of concrete as per specifications given in them. IS 9103: 1999 will be used for specifications of concrete admixtures and their suitable dosage in concrete. IS 1199: 2018 (Part 2) will be used for consistency determination of fresh concrete. IS 516: 1959 & IS 5816: 1999 will be used for casting, curing, and testing of hardened concrete at suitable age of curing.

In this dissertation work is execute in three stages, initially, the engineering properties of various materials are determined such as water absorption and specific density of crushed ceramic (bone China) waste and crushed recycled coarse aggregate. Further, mix design for M30 grade of concrete with partial replacement of bone China and recycled coarse aggregate are investigated. The partial replacement of natural sand used as fine aggregates with crushed ceramic (bone China) waste with varying percentages as 20%, Also partial replacement of crushed coarse aggregate with crushed recycled coarse aggregate with varying percentage as 0%, 50%, And silica fume 10% constant replacement with cement the combined effect 50% crushed ceramic (bone China) waste and 60% crushed recycled coarse aggregate on varies properties of M30 grade of concrete is also investigated. Finally the workability, compressive strength, splitting tensile strength and flexural strength of above mentioned mixes are determined and also compared with normal concrete (without any replacement).

IV. MATERIALS USED

Cement

The Portland concrete used in the experiment was standard 43-grade Portland concrete. Table 1 lists the concrete's physical characteristics.

Table 1 Physical properties of ordinary Portland cement- 43 grade

Properties	Value
Fineness of cement	6%
Grade of Cement	OPC(43 grade)

Specific gravity of cement	2.90
Initial setting time	112
Final setting time	320
Normal Consistency	34%

Fine Aggregate

As the fine total, locally accessible sand that was confirmed to be in zone II and had an explicit gravity of 2.6 was used. The fineness modulus of the sand that was used was 2.92. The sand that was retained on a 150 micron IS filter and passed 1.18 mm was used. The sifter investigation for fine aggregate is shown in Table 2.

Table 2 Sieve analysis of fine aggregate

IS sieve No.	% passing	Cumulative % retained
4.75	97.31	2.69
2.36	84.82	15.18
1.18	68.51	31.49
600µ	46.89	53.11
300µ	9.27	90.73
150µ	0.87	99.13

Coarse Aggregate

Aggregate forms a major part of concrete structure. Coarse aggregate also plays an important role in the strength of concrete. Hence, all the different properties of coarse aggregate must be properly examined for an ideal mix. There are two types of coarse aggregate used in the design mix that is 10mm and 20 mm. The properties are determined under severe conditions as per IS: 2386-1963 specifications.

Recycled concrete aggregate (RCA)

Recycled concrete aggregate as shown in Fig 1 can be reused as a partial replacement for natural aggregate in new concrete construction. The hardened concrete can be sourced either from the demolition of concrete structures at the end of their serviceability. When concrete structures are demolished, concrete recycling is an increasingly common method of utilizing the concrete waste.

Figure 1: Demolition waste and transportation of demolition waste

Bone China waste

Bone China is a form of porcelain made from kaolin, Feld spathic material, and bone ash. Kaolin is a type of aluminum silicate that contains aluminum oxide and silicon dioxide and is used in concrete production. It is widely used in today life. It can be found in many forms, including Cup plate, Decorative pots, etc. as shown in Fig. 2. The use of bone China as aggregates in concrete has great potential for high-quality concrete development.

Table 3. Physical properties of Born China Waste

Property	River sand	Bone China waste	Acceptance limit for concrete
Specific gravity	2.64	2	2.6-2.8
Fineness modulus	2.54%	3.14%	2.2-3.2
Density (kg/m^3)	1570	1360	-
Water absorption	1.01%	3.20%	0.86-1.16

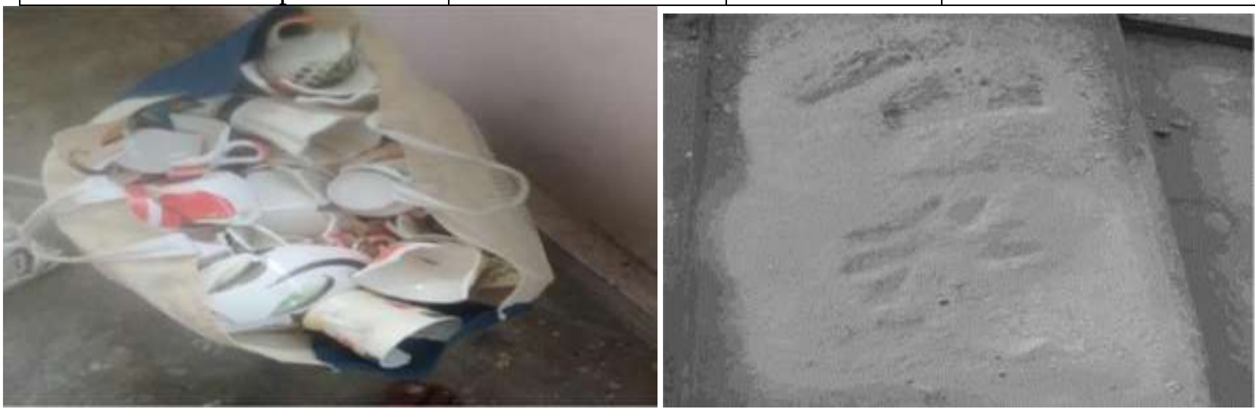

Fig 2: Bone China waste, Bone China powder

Marble Particle

It is therefore a social and legal responsibility of government and industry to solve the problem of marble particle pollution. Thus, new approaches that consider industrial wastes as alternative raw materials become interesting, both technically and economically, for a wide range of applications.

Table 4. Chemical Properties of Marble particle

Oxide compounds	Marble particle (Mass %)
SiO_2	28.35
Al_2O_3	0.42
Fe_20_3	9.70
CaO	40.45
MgO	16.25
Density (g/cm^3)	2.80

Water

Water is most important ingredient for production of concrete and least expensive one also. Purpose of using water is to cause hydration of cement. Quantity of water is to be carefully controlled during manufactured of concrete. Whereas lesser water makes concrete difficult to work with concrete and due to non-uniform mixing the resultant concrete is weaker in strength. Water is additionally utilized for washing aggregate and curing.

The composition of various concrete mixes.

For M30 grade of concrete with coarse aggregate is replaced by Demolition (C&D) Waste and fine aggregate with bone China and marble particle

In this, ordinary Portland cement of grade 43 for M30 grade is used for casting of cubes, beam and cylinder with Demolition (C&D) Waste is replaced in place of coarse aggregate by 50 and 70% without changing the mix design. Table 3.18 shows the quantity of ingredient used when coarse aggregate is replaced by recycled coarse aggregate for casting six cubes and Table 3.18 shows the quantity of ingredient used when coarse aggregate is replaced by recycled coarse aggregate for casting twenty six cubes, nine beam and nine cylinder. The water- cement ratio of design mix is taken as 0.5.

Table 5: Details of Coarse aggregate replacement for mix codes

Mix	Cement (%)	Natural Sand (%)	Bone china Waste/ marble particle (%)	Natural coarse Aggregate (%)	Demolition (C&D) Waste (%)
B0M0D0	100	100	00	100	00
B20D50	100	80	20	50	50
M20D50	100	80	20	50	50
M20D70	100	80	20	30	70
B20D70	100	80	20	30	70

Notation of Mix

1. B0M0D0 - normal concrete, the reference mix (without replacement).
2. B20D50 - in case of combined 20% bone china and 50 % Demolition (C&D) Waste
3. M20D50 - in case of combined 20% marble particles and 50 % Demolition (C&D) Waste
4. M20D70 - in case of combined 20% marble particles and 70 % Demolition (C&D) Waste
5. B20D70 - in case of combined 20% bone china and 70 % Demolition (C&D) Waste

V. CONCLUSION

Based on the above literature review and by studying various researches, it can be concluded that Demolition (C&D) Waste and marble particle wastes are accumulating in huge quantities and there is no proper solution of disposal of such wastes other than land filling. Many researchers have studied their effect on partial or full replacement of such waste as coarse or fine aggregate to obtain their optimum levels. Based on this study, it can also be concluded that the Demolition (C&D) Waste and marble particle can be transformed into useful coarse and fine aggregates to be use in concrete for desired strength Researchers studied Demolition (C&D) Waste and marble particle waste in lower grade of concrete (less than M30) for partially or fully substitution in concrete as coarse and/or fine aggregates and found even more better results as compared to conventional concrete mixes. The literature review suggested that the use of Demolition (C&D) Waste and marble particle waste can be found to be effective for making M30 grade concrete but only up to 70% replacement level.

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