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Comparative Studies on Sustainable Alternative Materials for Aggregates in Concrete

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A B S T R A C T

Concrete industry is one of the largest consumers of natural resources due to which sustainability of concrete industry is under threat. Preventing the exhaustion of natural resources and enhancing the usage of waste materials has now became a significant problem in this modern world. In the present study, an attempt has been made to investigate the strength parameters of concrete made with partial replacement of coarse aggregate with 10%, 20% and 30% of shabath stone waste, coconut shell and partial replacement of fine aggregate with 10%, 20% and 30% of crushed cullet glass, quartz.

The main parameter investigated in this study is the replacement of M30 grade concrete with partial replacement of coarse aggregate with 10%, 20% and 30% of shabath stone waste, coconut shell and partial replacement of fine aggregate with 10%, 20% and 30% of crushed cullet glass, quartz. This project presents a detailed experimental study on compressive strength, split tensile strength at age of 3, 7 and 28 days.

In this project, out of various percentage of replacement of fine aggregate by crushed glass, quartz and coarse aggregate by shabath stone waste, coconut shell of among 16 mixes. The mix 3 has resulted highest compressive and tensile strength when compared with conventional cube. Among 16 mixes precisely mix 14, 15 & 16 clearly states that target mean strength can be achieved by replacing natural fine and coarse aggregate with sustainable aggregates

Keywords: stone waste, aggregates, sustainable, , coconut shell.

INTRODUCTION

Due to the high consumption of raw material by the construction sector results in chronic shortage of building materials. Construction Industry has been conducting various researches on utilization of waste products obtained from domestic & Industrial activities in order to reduce the utilization of precious natural resources. India is pioneer in exploration of commercial rock deposits. Of the 300 varieties of stone being traded in world market nearly half of them are from India. India possesses a wide spectrum of dimensional stones that include granite, marble, kotastone, sandstone, limestone, sate, and quartzite spread out all over the country. In India 0.9% of total urban waste comprises of glass. Glass is an ideal material for recycling as it is non biodegradable.

Crushed bottle glass if properly sized show properties similar to that of sand due to its high silica content. The potential of using agricultural wastes in civil engineering and building construction works have been investigated by various researchers in a study, compared concrete made with coconut and palm kernel shells as replacement for coarse aggregates and concluded that coconut shells performed better than palm kernel shells as replacement for conventional aggregates in the concrete. Some mineral species and groups are much more abundant than others; these are termed the rock-forming minerals. The major examples of these are quartz, the feldspars, the micas the amphiboles the pyroxenes, the olivines, and calcite except the last one, all of the minerals are silicates. Overall, around 150 minerals are considered particularly important, whether in terms of their abundance or

Grades of concrete

Concrete is known by its grade which is designated as M15, M20 etc. in which letter M refers to concrete mix and number 15, 20 denotes the specified compressive strength (f_{ck}) of 150mm cube at 28 days, expressed in N/mm^2.

Thus, concrete is known by its compressive strength. M20 and M25 are the most common grades of concrete, and higher grades of concrete should be used for severe, very severe and extreme environments.

2. Compressive strength of concrete

Like load, the strength of the concrete is also a quality which varies considerably for the same concrete mix. Therefore, a single representative value, known as characteristic strength is used.

Coconut Shell :

Properties of concrete with coconut shells (CS) as aggregate replacement were studied. Control concrete with normal aggregate and CS concrete with 10-20-30% coarse aggregate replacement with CS were made. Properties like compressive strength, split tensile strength, water absorption and moisture migration were investigated in the laboratory. The results showed that, density of the concretes decreases with increase in CS percent. Workability decreased with increase in CS replacement. Compressive and split tensile strengths of CS concretes were lower than control concrete. Permeable voids, absorption and sorption were higher for CS replaced concretes than control concrete.

Quartz is the most common oxide mineral. It has many uses, glass, optics, sand for **construction** and building, part of cement and plaster, is used as a building stone, pottery, flux in metallurgical applications, has abrasive uses and is the key ingredient in computer chips (silicon is extracted from **quartz**).

Quartz is a naturally occurring substance that is solid and inorganic representable by a chemical formula, usually abiogenic, and has an ordered atomic structure. It is different from a rock on grounding it finely which can be an fine aggregate.

LITERATURE REVIEW

IQBAL MIRZA.M
IOSR Journal of Engineering (IOSRJEN) e-ISSN: 2250-3021, p-ISSN: 2278-8719 Vol. 3, Issue 7 (July. 2013), ||V6 || PP 08-13
Addressed by the use of waste glass as partial replacement of fine aggregates in concrete. Fine aggregates were replaced by waste glass powder as 10%, 20%, 30% and 40% by weight for M-25 mix. The concrete specimens were tested for compressive strength, splitting tensile strength, durability (water absorption) and density at 28 days of age and the results obtained were compared with those of normal concrete. The results concluded the permissibility of using waste glass powder as partial replacement of fine aggregates up to 30% by weight for particle size of range 0-1.18mm.

VEDIVELLI.B
The Open Civil Engineering Journal, 2010, 4, 65-71
This paper examines the possibility of using SGP as a replacement in fine aggregate for a new concrete. Naturalsand was partially replaced (10%, 20%, 30%, 40% and 50%) with SGP. Compressive strength, Tensile strength (cubesand cylinders) and Flexural strength up to 180 days of age were compared with those of concrete made with natural fine aggregates. Fineness modulus, specific gravity, moisture content, water absorption, bulk density, %voids, % porosity(loose and compact) state for sand (S) and SDA were also studied.

HAIDER.K.AMMASH
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Investigation was carried out to study the possibility of using waste glass of size up to 5mm as a fine aggregate in concrete and mortar. The waste glass was used as a partial weight replacement of sand with percentages of 10, 20, 30 and 40 %. The results have indicated that increasing the fractions of sand replacement by waste glass leads to reduce the compressive and tensile strength for both mortar and concrete. Up to 20 % replacement, the 28 days compressive strength of concrete and mortar is about 92 and 95 percent from the reference strengths,respectively. Also, it was found that the expansion of mortar specimens increase with increasing the waste glass content in the mix.

(precisely cut and shaped like a tuning fork) oscillate (vibrate) 32768 times per second. The first quartz oscillator was built in 1920.

Foundry Material: Quartz has a higher melting point than most metals which makes it ideal for the molds and cores of common foundry work. Refractory bricks are often made of quartz sand because of its high heat resistance. Quartz sand is also used as a flux in the smelting of metals.

Construction: Sandstone is a common building material used by the ancient Egyptians and in modern high rise office buildings as strong blocks and decorative tiles. Quartz sand is an integral component in cement. It is also used for traction on roadways and railroads. It is a filler used in the manufacturing of paints, rubber and putty.

GENERAL

Concrete is an artificial material, which is made up of cement, fine aggregate, coarse aggregate and water. In this study cement was replaced with 10%, 20% and 30% of Class F fly ash and fine aggregate was replaced with 10%, 20% and 30% of crushed cullet glass aggregate in various combinations to arrive at the most suitable mix. The properties of materials used for preparing the different Mixes of concrete M30 will be described in the following sections.

gravity of cement used is 3.1.
Cement, in general, adhesive substances of all kinds, but, in a narrower sense, the binding materials used in building and civil engineeringconstruction. Cements of this kind are finely ground powders that, when mixed with water, set to a hard mass. Setting and hardening result from hydration, which is a chemical combination of the cement compoundswith water that yields submicroscopic crystals or a gel-like material with a high surface area. Because of their hydrating properties, constructional cements, which will even set and harden under water, are often called hydraulic cements. The most important of these is portland cement.

Classification of Aggregates Based on Shape:

We know that aggregate is derived from naturally occurring rocks by blasting or crushing etc., so, it is difficult to attain required shape of aggregate. But, the shape of aggregate will affect the workability of concrete. So, we should take care about the shape of aggregate. This care is not only applicable to parent rock but also to the crushing machine used.

Aggregates are classified according to shape into the following types

- Rounded aggregates
- Irregular or partly rounded aggregates
- Angular aggregates
- Flaky aggregates
- Elongated aggregates
- Flaky and elongated aggregates

Fine Aggregate

Sand that is available in nearby locality has been used as fine aggregate. Other foreign matter present in the sand has been separated before use. The specific gravity of sand used in this investigation is 2.52

The tested physical **properties** of the both **fine** and **coarse aggregates** were specific gravity and density. Fineness modulus was determined for both **river sand**and quarry dust, whereas **aggregate** impact and Los Angeles abrasion of the crushed granite were tested. Concrete mix ratio was batched by weight.

Typically, coarse aggregate sizes are larger than **4.75 mm** (5 mm in British code), while fine aggregates form the portion below **4.75 mm**. A maximum size up to 40 mm is used for coarse aggregate in most structural applications, while for mass concreting purposes such as dams, sizes up to 150 mm may be used

Lightweight Concrete Using Coconut Shells as Aggregate:-

Aggregates provide volume at low cost, comprising 66 percent to 78 percent of the concrete. With increasing concern over the excessive exploitation of natural and quality aggregates, the aggregate produced from industrial wastes and agriculture wastes being viable new source for building material. This study was carried out to determine the possibilities of using coconut shell as aggregate in concrete. Utilising coconut shell as aggregate in concrete production not only solves the problem of disposing this solid waste but also helps conserve natural resources. In this paper, the physical properties of crushed coconut shell aggregate were presented. The fresh concrete properties such as density and slump and 28-day compressive strength of a lightweight concrete made with coconut shell as coarse aggregate also presented. The findings indicated that water absorption of the coconut shell aggregate was high about 24 % but the crushing value and impact value was comparable to that of other lightweight aggregates. The average fresh concrete density and 28-day cube compressive strength of the concrete using coconut shell aggregate were 1975 kg/m^3 and 19.1 N/mm^2 respectively. It is concluded that crushed coconut shells are suitable when it is used as substitute for conventional aggregates in lightweight concrete production.

Quartz

The silica polymorph that is most stable at the Earth's surface is αquartz. Its counterpart, β-quartz, is present only at high temperatures andpressures. These two polymorphs differ by a "kinking" of bonds this change in structure gives β-quartz greater symmetry than α-quartz, and they are thus also called high quartz (β) and low quartz (α).

Super Plasticizers

Plasticizers or **water reducers**, and superplasticizers or **high** range **water reducers**, are chemical **admixtures** that can be added to **concrete mixtures** to improve workability. Unless the mix is "starved" of **water**, the strength of **concrete** is inversely proportional to the amount of **water** added or **water-cement** (w/c) ratio

Superplasticizers, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. ... The

Casting

A pan type concrete mixer was used for the preparation of concrete mix. The mixing operation of concrete ingredients is shown in the Fig. 2.6.1. The Micro silica is added slowly and mixed thoroughly to avoid balling and slurry in the concrete. The specimens are cast in five batches, each batch consisting of six cubes for compressive strength, two prisms for flexural trength, two cylinders for split tensile strength, one cylinder for rapid chloride penetration test and sorptivity.

Curing:

Curing is the process of controlling the rate and extent of moisture loss from concrete during cement hydration. It may be either after it has been placed in position (or during the manufacture of concrete products), thereby providing time for the hydration of the cement to occur. Since the hydration of cement does take time – days, and even weeks rather than hours – curing must be undertaken for a reasonable period of time if the concrete is to achieve its potential strength and durability. Curing may also encompass the control of temperature since this affects the rate at which cement hydrates.

TESTING PROCEDURE

The testing of cubes and cylinders have been done after 3, 7 & 28 days. The following tests were performed in the present research work:

1. Compression test on concrete cubes
2. Split tensile test on cylinders

3. Rapid chloride penetration test on cylinders

Compressive Strength Test

Compressive strength measurements are primarily concerned in testing the strength of concrete. Cube specimens were tested using the 2000 kN capacity Compression Testing Machine. This machine fulfills the entire requirement for compression testing as per IS: 516- 1959.

Split Tensile Strength Test

This test method covers the determination of the splitting tensile strength of cylindrical concrete specimens, such as molded cylinders and drilled cores. The values stated in inch-pound units are to be regarded as the standard. This standard does not purport to address all of the safety concerns, if any associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determines the applicability of regulatory limitations period to use.

COMPRESSIVE TEST ON CUBES

According to IS 516:1959, compression test was carried out on a standard 150x150x150mm cubic specimens. All the cubes were tested in surface dried condition for each mix combination, three cubes were tested at the age of 3, 7 and 28 days using compression testing machine of 2000 ton capacity. The loading was continued till the specimen reaches its ultimate load. The ultimate load divided by the cross sectional area of the specimen is equal to the ultimate compressive strength.

MIX.NO.	3 DAYS COMPRESSIVE STRENGTH			7 DAYS COMPRESSIVE STRENGTH			28 DAYS COMPRESSIVE STRENGTH
1	13.3 Mpa	11 Mpa	13.8 Mpa	25 Mpa	25 Mpa	22 Mpa	38 Mpa
2	15.2 Mpa	15.9 Mpa	14 Mpa	28.3 Mpa	28.5 Mpa	25.2 Mpa	41.6 Mpa
3	15.6 Mpa	16.7 Mpa	15.6 Mpa	29 Mpa	31 Mpa	29.3 Mpa	46 Mpa
4	16.3 Mpa	16.2 Mpa	15.4 Mpa	27 Mpa	28.7 Mpa	28 Mpa	44 Mpa
5	14 Mpa	15.2 Mpa	14.9 Mpa	24 Mpa	26 Mpa	23 Mpa	39.5 Mpa
6	14.6 Mpa	14.9 Mpa	14.7 Mpa	24 Mpa	24.9 Mpa	23 Mpa	37 Mpa
7	14.3 Mpa	14.9 Mpa	14.7 Mpa	24.5 Mpa	25.6 Mpa	23 Mpa	36.5 Mpa
8	13 Mpa	13.5 Mpa	13.6 Mpa	21.5 Mpa	23.7 Mpa	23 Mpa	36 Mpa
9	12.7 Mpa	13 Mpa	12.9 Mpa	20 Mpa	22 Mpa	21 Mpa	34 Mpa
10	12 Mpa	12.4 Mpa	11 Mpa	27.6 Mpa	28 MPa	27 Mpa	35 Mpa
11	12.8 Mpa	13.9 Mpa	12.6 Mpa	21 Mpa	22 Mpa	19 Mpa	36 Mpa
12	13 MPa	13.6 Mpa	12 Mpa	20 Mpa	23 Mpa	21 Mpa	33 Mpa
13	10.9 Mpa	11.3 Mpa	11 Mpa	19.6 Mpa	20.3 Mpa	19 Mpa	34 Mpa
14	13 Mpa	13.6 Mpa	14.2 MPa	22 Mpa	21 Mpa	23 Mpa	37.6 Mpa
15	13.1 Mpa	12.6 Mpa	13.3 Mpa	23.6 Mpa	24 MPa	23 Mpa	37.2 Mpa
16	12.6 Mpa	12.9 Mpa	13.1 Mpa	22 Mpa	21 Mpa	22.6 Mpa	36.5 Mpa

SPLIT TENSILE STRENGTH

This test method covers the determination of the splitting tensile strength of cylindrical concrete specimens, such as molded cylinders and drilled cores. The values stated in inch-pound units are to be regarded as the standard. This standard does not purport to address all of the safety concerns, if any associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determines the applicability of regulatory limitations period to use.

MIX .NO.	3 DAYS	7 DAYS	28 DAYS
1	2.3	3.71	4.2
2	2.6	4.05	4.58
3	2.8	4.2	4.89
4	2.89	4.3	4.95
5	2.25	3.55	4.15
6	2.43	3.89	4.3
7	2.7	4.00	4.7
8	1.9	3.23	3.76
9	2.1.	3.56	3.9
10	2.4	3.73	4.2
11	2.89	4.3	4.75
12	3	4.26	4.89
13	3.15	4.35	4.9
14	2.2	3.6	3.9

15	2.1	3.5	3.8
16	1.95	3.23	3.6

CONCLUSIONS

Based on the experimental results, the following conclusions are drawn

1. In this project, out of various percentage of replacement of fine aggregate by crushed glass, quartz and coarse aggregate by shabath stone waste, coconut shell of among 16 mixes. The mix 3 has resulted in highest compressive strength as well as tensile too when compared to conventional cube.
2. Among 16 mixes precisely mix 14,15&16 clearly states that target mean strength can be achieved on replacing natural fine and coarse aggregate with sustainable aggregate.
4. The cost analysis has clearly stated that compared to conventional concrete the replaced aggregate concrete can be produced with lesser cost, the analysis report also states that replaced aggregate concrete can be produced with 50% of cost of production of conventional concrete.

5. Water absorbtion test states that the replaced aggregate concrete cube is of lesser weight when compared to convention concrete cube here by we can claim that the aggregate replaced concrete is an light weight concrete.

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