EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF CONCRETE BY USING CERAMIC WASTE & QUARRY DUST AS PARTIAL REPLACEMENT OF COARSE AND FINE AGGREGATES

K RAJA 1*, E.BALA KOTESWARARAO 2*, DR.V.ANJANEYA PRASAD 3*

1. M.Tech- Student , Dept of CIVIL, Chintalapudi Engineering College,JNTUK,AP,INDIA.
2. Asst.Prof, Dept of CIVIL, Chintalapudi Engineering College,JNTUK,AP,INDIA.
3. Prof, Head - Dept of CIVIL, Chintalapudi Engineering College,JNTUK,AP,INDIA.

ABSTRACT

Leaving waste materials into environment directly can cause environmental problems. Quarry dust a waste from the quarry processing units accounts and the ceramic waste from the ceramic industries accounts 30% as waste by product. Therefore this waste can be used to produce new products or can be used as admixtures so that the natural resources are used efficiently and hence environmental wastes can be reduced. Here quarry dust is used for partial replacement of cement and ceramic waste is used for the partial replacement coarse aggregates in concrete for study of physical and mechanical properties of concrete. Quarry dust and ceramic waste is obtained from the industries during the quarrying and manufacturing process of ceramic tiles and marble something. Hence the reuse of waste material has been emphasized. Waste can be used to produce from waste deposits. Therefore scientific study should be made towards reuse both at an experimental phase and in practical applications.

This paper deals with the utilization of quarry dust in partial replacement of fine aggregate (sand), and ceramic waste in partial replacement of coarse aggregates in conventional concrete. The material properties of concrete that is compressive strength, split tensile strength and flexural strength are studied as per IS: 516. For experimental studies, 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% of partial replacement of ceramic waste in concrete were tested and found that 40% of ceramic waste gives optimum values. The percentage of ceramic waste is kept constant at 40% and quarry dust of 15%, 30%, 45%, 60%, 75% and 90% were used as partial replacement of fine aggregate and found that 30% of quarry dust gives optimum values.

INTRODUCTION

General

From the past concrete was considered as a widely used construction material. We use concrete structures with interest of development of urban and industrial areas, aggressive marine environments, harmful sub-soil water areas and many other hostile conditions where other materials of construction are found to be uneconomical and durable. Since the use of concrete in recent years have spread to highly harsh and hostile conditions, the
earlier impression that concrete is a very durable material is being threatened, particularly on account of premature failures of number of structures.

In the past only strength of concrete was considered in the concrete mix design procedure assuming strength of concrete in all pervading factor for all other desirable properties of concrete including durability. In the recent revision of IS 456: 2000, one of the points discussed, deliberated and revised is the durability aspects of concrete, in line with codes of practice of other countries, which have better experiences in dealing with durability of concrete structures. One of the main reasons for deterioration of concrete in the past is that too much emphasis is placed on concrete compressive strength. As a matter of fact advancement in concrete technology has been generally on the strength of concrete. It is now recognized that strength of concrete alone is not sufficient. The degree of harshness of the environment condition to which concrete is exposed over its entire life is equally important. Therefore, both strength and durability has to be considered explicitly at the design state. It is interesting to consider yet another viewpoint regarding strength and durability relationship.

The daily production in ceramic industry 30% goes to waste. This waste is not recycled in any form at present. However, the ceramic waste is durable, hard and highly resistant to biological, chemical and physical degradation forces. As the ceramic waste is piling up every day. Use of inorganic industrial residual products in making concrete will need to sustainable concrete design and greener environment.

And Quarry Dust is also a waste product obtained during the process of quarrying. In general a quarry dust is used a filler materials attempt was made in partial replacement of fine aggregate (sand). In addition to this, an alternative source for the potential replacement of natural aggregates in concrete has gained good attention. As a result reasonable studies have been conducted to find the suitability of granite quarry dust in conventional concrete.

**Ordinary Portland cement:**

Portland cement is the most commonly used type of cement in the world today. Portland cement can be found in both concrete and mortar, not to mention other construction mediums such as stucco and some types of grout, where it acts as a binding agent. On a chemical level, Portland cement is a fine powder comprised of a minimum of 66% calcium silicate, with the remainder largely being a mix of aluminum, and iron. Portland cement is a hydraulic material, which requires the addition of water in order to form exothermic bonds, and is not soluble in water.

Originally designed as a cement which would set slowly, allowing enough time for it to be properly laid, and a water resistant cement which could be used in construction applications where water would come in contact with the cement, Portland cement was first patented in 1824 by an English man, Joseph Aspdin, but the mix which became truly successful, and which is still used today, was designed by his son, William Aspdin in around 1843.

**Portland Cement Applications:**
Portland cement is most often used in concrete and mortar. Concrete is made by combining water, sand, gravel, and cement, whereas mortars are made by combining cement with water and sand only. Concrete is much stronger than mortar, and is used in most modern buildings as a durable and strong construction material capable of bearing great loads. Mortar is used to bind other substances together, such as the bricks in a house.

**Portland Cement Strength** : Portland cement usually takes several hours to set, and will harden in a matter of weeks. Cement is a somewhat curious material in that it continues to harden over time as long as there is water available for the components of the cement to form bonds with. One week old Portland cement has strength of around 23 MPa, whereas three month old cement has strength of 41 MPa. These numbers apply to standard Portland cement which has not had any additives added to it. Various treatments and additives can make cement set and harden at different rates, and various types of Portland cement also posses’s different properties which affect the rate of setting and hardening.

**Physical properties**

The following physical properties should be checked before selecting a Portland cement for the civil engineering works. IS 269–1967 specifies the method of testing and prescribes the limits:

(a) Fineness

(b) Setting time

(c) Soundness

(d) Crushing strength

a) Fineness: It is measured in terms of percentage of weight retained after sieving the cement through 90 micron sieve or by surface area of cement in square centimeters per gram me of cement. According to IS code specification weight retained on the sieve should not be more than 10 percent. In terms of specific surface should not be less than 2250 cm2/gm.

b) Setting time: A period of 30 minutes as minimum setting time for initial setting and a maximum period of 600 minutes as maximum setting time is specified by IS code, provided the tests are conducted as per the procedure prescribed by IS 269-1967.

c) Soundness: Once the concrete has hardened it is necessary to ensure that no volumetric changes take place. The cement is said to be unsound, if it exhibits volumetric instability after hardening. IS code recommends test with Le chattier mould for testing this property at the end of the test, the indicator of Le chattier mould should not expand by more than 10 mm.

d) Crushing strength: For this mortar cubes are made with standard sand and tested in compression testing machine as per the specification of IS code. The minimum strength specified is 16 N/mm2 after 3 days and 22 N/mm2 after 7 days of curing.

**Ceramic waste:**

Ceramic waste is a recycled aggregate is coming in to the ceramic industry. Ceramic waste is generated as a waste during the process of cutting, and marking. In this study an attempt has been made to find the suitability of the
ceramic industrial wastes as a possible replacement for conventional coarse aggregate. Mainly this type of recycled aggregate is used for the developments of concrete with non-conventional aggregates to improve the properties of concrete and reduce the cost.

Quarry Dust:

Quarry Dust a waste product obtained during the process of quarrying. In general a quarry dust is used a filler materials attempt was made in partial replacement of fine aggregate (sand). In addition to this, an alternative source for the potential replacement of natural aggregates in concrete has gained good attention. As a result reasonable studies have been conducted to find the suitability of granite quarry dust in conventional concrete.

MATERIAL PROPERTIES

GENERAL

The experimental program proposed for this research project is carried out using the materials like Cement, Sand, Quarry Dust, Coarse Aggregates(CA), recycled coarse aggregate(ceramic waste), and water. The description of each of the material is described in the following sections. The objective of this study is to evaluate the effect of the quality of ceramic waste and Quarry Dust on the strength of concrete. To meet this objective, cement, CA, Manufactured sand and water are evaluated. The materials used in this study are tested to obtain their properties as per the relevant IS codes.

CEMENT:

Although all materials that go into concrete mix are essential, cement is very often the most important because it is usually the delicate link in the chain. The function of cement is first of all to bind the sand and stone together and second to fill up the voids in between sand and stone particles to form a compact mass. It constitutes only about 20 percent of the total volume of concrete mix; it is the active portion of binding medium and is the only scientifically controlled ingredient of concrete. Any variation in its quantity affects the compressive strength of the concrete mix. Portland cement referred as (Ordinary Portland Cement) is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. The OPC is classified into three grades, namely 33 Grade, 43 Grade, 53 Grade depending upon the strength of 28 days. It has been possible to upgrade the qualities of cement by using high quality limestone, modern equipments, maintaining better particle size distribution, finer grinding and better packing. Generally use of high grade cement offers many advantages for making stronger concrete. Although they are little costlier than low grade cement, they offer 10-20% saving in cement consumption and also they offer many hidden benefits. One of the most important benefits is the faster rate of development of strength.

Ordinary Portland Cement (OPC) is the cement best suited to general concreting purposes. OPC 53 grade confirming with IS: 12269 is used. The cement is kept in an airtight container and stored in the humidity controlled room to prevent cement from being exposed to Moisture. The physical properties of cement.
Vicat apparatus conforming to IS: 5513-1996, balance, whose permissible variation at a load of 1000g should be +1.0g, gauging trowel conforming to 12269 are used to find setting time of cement and normal consistency. The surface area of powder can be determined by measuring the pressure drop of fluid flow through a packed powder bed. The most frequently used apparatus is the Blaine, which is a standard test method. The test is carried out as per IS: 4031(Part-2) 1999 for characterizing the fineness of cement by air permeability. The specific surface of cement is 413m2/kg. The soundness of cement is estimated using ‘Le chattier’ method. Expansion of cement is found to be 0.2 mm. The chemical Properties of OPC are shown in Table 3.2 Compressive strength of cement is estimated using IS: 4031(part-6) 1999 is followed and the results obtained are as shown in Table 3.3. All the values obtained are within the limits given by IS 12269.

Aggregates:

Aggregates are the major ingredients of concrete. They constitute 70-75% of the total volume; provide a rigid skeleton structure for concrete, and act as economical space fillers. The aggregates form the main matrix of the concrete. The aggregate particles are glued together by the cement and water paste. With cement and water the entire matrix binds together into a solid mass called concrete. Aggregates influence the properties of concrete such as water requirement, cohesiveness and workability of the concrete in plastic stage, while they influence strength, density, and durability, surface finish and colour in hardened stage. It is therefore significantly important to investigate the various properties of aggregates.

Aggregates are generally inert and broadly divided into two categories, i.e. fine and coarse, depending on their size. Aggregates with grain size below 4.75mm are termed fine aggregates and above 4.75mm are termed as coarse aggregates. I.S: 383-1963 defines the requirement of aggregates.

Gradation of Aggregates:

Gradation refers to the particle size distribution of aggregates. Grading is a very important property of aggregate used for making concrete, in view of its packing of particles, resulting in the reduction of voids. This in turn influences the water demand and cement content of concrete. Grading is described in terms of the cumulative percentages of weights passing a particular IS sieve. IS 383 specifies four ranges or zones for fine aggregate grading. Table 3.4 gives the range of percentage passing for each zone.

Grading limits for fine aggregate as per IS: 383

Zone I sand is the coarsest and Zone IV is the finest whereas sand in Zone II and Zone III are moderate. It is recommended that fine aggregates conforming to grading zone II or Zone III can be used in reinforced concrete.

Specific Gravity:

Specific gravity refers to the relative (as compared to water) density of a unit volume of aggregate. Specific gravity of the aggregate generally is indication of its quality. A low specific gravity may indicate high porosity and therefore poor durability.
and low strength. The range of specific gravity for aggregates is generally between 2.4 and 2.9.

Specific gravity of sand \( (G) = \frac{(W_2-W_1)}{((W_2-W_1)-(W_3-W_4))} \)

Where,
W1 - weight of empty pycnometer in gms
W2 - weight of pycnometer + dry sand in gms
W3 - weight of pycnometer + sand + water in gms
W4 - weight of pycnometer + water in gms

The values of specific gravity determined are given in Table 3.5

River sand 2.63

**Sand:** The sand used in this research for preparation of normal concrete is natural river sand conforming to grading zone-II as per IS: 383-1970 with specific gravity 2.6 and having fineness modulus as 3.42. The amount of fines less than 0.125 mm is to be considered as powder and is very important for the theology of the SCC. This material is dried at room temperature for 24 hours to control the water content in the concrete. The maximum size of FA is taken to be 4.75 mm. The testing of sand is done as per IS: 2386 – 1963. The sieve analysis results.

Quarry dust was collected from local processing units of Chowdavaram. It was initially dry in condition when collected and was sieved by IS: 90 micron sieve before mixing in concrete.

The basic tests on quarry dust were conducted as per IS: 387 and its specific gravity were around 2.1. Dry sieving of quarry dust through 90 micron sieve was found to be 85-95% done before mixing in concrete and the corresponding bulking value of quarry dust was 33.2%.

**Water:**

Generally, water that is suitable for drinking is satisfactory for use in concrete. Water from lakes and streams that contain marine life also usually is suitable. When water is obtained from sources mentioned above, no sampling is necessary. When it is suspected that water may contain sewage, mine water or wastes from industrial plants or canneries, it should not be used in concrete unless tests indicate that it is satisfactory. Water from such sources should be avoided since the quality of the water could change due to low water or by intermittent tap water is used for casting. The potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly potable water was used for making concrete available in Material Testing.
laboratory. This was free from any detrimental contaminants and was good potable water.

**Coarse Aggregates:**

The aggregate which is retained over IS Sieve 4.75 mm is termed as coarse aggregate. The coarse aggregates may be of following types:-

Crushed graves or stone obtained by crushing of gravel or hard stone. Uncrushed gravel or stone resulting from the natural disintegration of rocks. Partially crushed gravel obtained as product of blending of above two types.

The normal maximum size is gradually 10-20 mm; however particle sizes up to 40 mm or more have been used in Self Compacting Concrete. Gap graded aggregates are frequently better than those continuously graded, which might expensive grader internal friction and give reduced flow. Regarding the characteristics of different types of aggregate, crushed aggregates tend to improve the strength because of interlocking of angular particles, while rounded aggregates improved the flow because of lower internal friction. Locally available coarse aggregate having the maximum size of 20 mm was used in this work. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested as per IS: 383-1970. Specific gravity and other properties of coarse aggregates.

**Ceramic waste:**

The properties of ceramic waste coarse aggregate are well within the range of the values of concrete making aggregates. The properties of ceramic waste coarse aggregate concrete are not significantly different from those of conventional concrete. The use of ceramic waste coarse aggregate concrete has increased because it has various advantages over other cementitious materials.

**SIGNIFICANCE AND OBJECTIVES:**
The objectives of the present investigation are to get the thoroughness with the existing mix design procedures for concrete by varying the percentage replacement of coarse aggregate by ceramic waste (0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%).

Then after the further investigation will going to carried out with the optimized coarse aggregate(ceramic waste) by conventional coarse and fine aggregate(sand) replaced by quarry dust with various percentages 0%, 15%, 30%, 45%, 60%, 75% & 90%.

Investigations were carried out on OPC mixes for M30 grade concrete using 20mm maximum size of aggregates of both ceramic and conventional coarse aggregate to ascertain the mechanical properties of the designed mixes and to find the optimum coarse & fine replacement by ceramic waste & Quarry Dust.

Hence in the present investigation more emphasis is given to study the ceramic waste using coarse aggregate & sand using quarry dust so as to achieve better concrete composites and also to encourage the increased use of recycled aggregate to maintain ecology.

Results and Graphs for split tensile Strength:

The Comparison Of 7 Days split tensile Strength Result Of cylinders With Replacement Of 40% Ceramic Waste & various % of Quarry Dust strength with 0% Quarry Dust strength

The Comparison Of 28 Days split tensile Strength Result Of cylinders With Replacement Of 40% Ceramic Waste & various % of Quarry Dust strength with 0% Quarry Dust strength.

CONCLUSION

The w/c ratio was kept constant for all the replacement levels of fine aggregate with quarry dust and coarse aggregate with ceramic waste.

The assumption of consideration of constant w/c ratio helps for understanding the effect of strength parameters due to the change of natural aggregates.

1. From the experiments conducted, replacement of ceramic waste as coarse aggregate in concrete can be optimized.

2. At 10%, 20%, 30% & 40% replacement of coarse aggregates with ceramic waste the strength properties were decreased linearly were compared with conventional concrete.
3. And at 50%, 60%, 70% & 80% replacement of coarse aggregates with ceramic waste the strength properties were marginally decreased and at 90% and 100% replacement level strength properties were highly decreased when compared with conventional cement concrete.

4. And there is no highly difference of 7 days and 28 days strength properties of compressive strength and split tensile strengths.

5. From the results at the 40% of replacement of coarse aggregates with ceramic waste the strength properties showed the maximum strength than the remaining percentages 10%, 20%, 30%, 50%, 60%, 70%, 80%, 90% & 100%. So the 40% of ceramic waste were adopted to the further study.

6. So In the further investigation 40% replacement of ceramic waste as coarse aggregate and quarry dust as fine aggregate (sand) by conventional aggregates content in concrete can be optimized.

7. In the further investigation the combined effect of 40% replacement of coarse aggregates with ceramic waste and 15%, 30%, and 45% replacement of quarry dust with sand the strength properties were decreased linearly were observed.

8. And the combined effect of 40% replacement of coarse aggregates with ceramic waste and 60%, and 75% replacement of fine aggregates with quarry dust the strength properties were marginally decreased and at 90% replacement of fine aggregate the strength properties were highly decreased when compared with conventional cement concrete. And in the combined effect of replacement of natural aggregates by recycled aggregates there is a small difference of 7 days and 28 days strength properties of compressive strength and split tensile strengths.

The material properties of concrete i.e. compressive strength, Split tensile strength and Flexural strength are studied as per IS: 516.

In the further study the ceramic waste can be used as additive partial replacement of coarse aggregates and fine aggregate with quarry dust as additive partial replacement to sand.

From the results it can be concluded that the replacements of ceramic waste of 40% and Quarry dust of 45% gives maximum strength than the remaining percentages (0%, 15%, 30%, 60%, 75%, and 90%). At 40% replacement of coarse aggregates with ceramic waste and with 45% replacement of sand with quarry dust the observed compressive strengths for M30 grade concrete is 41.07 MPa. And the observed flexural strengths for M30 grade concrete is 4.07 MPa. And the observed split tensile strengths for M30 grade concrete is 2.70 MPa.

REFERENCES

1) R M Senthamarai & P.Devadas Manoharan. Have studied use of hazardous industrial waste in concrete making will lead to greener environment.

2) C. Medina a, M.I. Sanchez de, Rojas b, M. Fries b. Have studied to investigated the reuse of ceramic waste as coarse aggregate in co-efficient concretes.
3) Benito Mas. Have focuses on the use of mixed recycled aggregates (MRAs) as coarse aggregate or fine fraction in concrete and the influence of the cement used.

4) Hanifi Binici. Have studied the Durability of concrete made with granite and marble as recycle aggregates.

5) Maria Chiara Bignozzi, Andrea. Sacconitioan (ASR) have studied Ceramic waste as aggregate and supplementary cementing material: A combined action to contrast alkali silica reaction (ASR).

6) Ilker Bekir Topcu, Selim Sengel. Has studied the properties of concretes produced with waste concrete aggregate.


8) Felix F. Udoeyo. studied properties of sawdust as partial replacement of cement. Before application in concrete, the ash was ground and sieved through a number 425 micron BS sieve.

9) Noor-ul Amin. Explained the use of bagasse ash in concrete and its impact on the strength and chloride resistivity.

10) Roz-Ud-Din Nassar. Examined the strength of recycled aggregate concrete containing milled glass as partial replacement for cement.


14) Noor-ul Amin. Studied the use of bagasse ash in concrete and its impact on the strength and chloride resistivity.


18) Muhd fadhil. Studied Workability and Compressive strength of ductile self compacting concrete (DSCC) with various cement replacement materials


21) H.A.F. Dehwah. Studied the Mechanical properties of self-compacting concrete incorporating quarry dust powder, silica fume or fly ash.


