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Replacement of stone Dust and Ceramic scrap as Aggregate in Concrete

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Natural coarse aggregate in concrete can be replace with ceramic waste aggregate as its properties are well within the range of specifications. Strength of ceramic concrete decreases due to many reasons such as higher flakiness, improper bonding of the aggregate with cement paste due to porcelain surface and higher water absorption of the ceramic waste aggregate. Observing the results, strength aspects of ceramic waste aggregate concrete is well within the permissible limits and ideal replacement level of ceramic waste is 20% and 40%.Water absorption of ceramic waste aggregate was 0.18% higher than that of natural aggregate (0.10%), due to the opening of pore structure during crushing and chiselling. Even after crushing and chiselling, few cracks were observed on surface of ceramic waste. For these reasons water absorption was little more than that of the natural aggregate. Both compressive and split tensile strengths decrease as the quantity of ceramic waste aggregate increases. Compressive strength of concrete made using 05 % ceramic waste aggregate and 05 % stone dust as replacement of coarse aggregate and fine aggregate respectively, is about 20% more than that of referral concrete at 28 days. However, compressive strength at 05% recycled aggregate and 05% stone dust is marginally than that of conventional concrete. The compressive strength of 05% stone dust and ceramic waste sample is in close proximity of the referral concrete. Thus, it can be concluded that stone dust up to 05% with 05% ceramic waste aggregate is satisfactory for use. Results show that with partial replacement of stone dust with 05% and 05% Ceramic waste coarse aggregate, flexural strength increased by 20, 48 and 40% at the age of 28 days as compared to referral concrete. The compressive strengths of concrete using natural sand and quarry dust were measured in the laboratory. Compressive strength was found to increase with ages for normal concrete.

1.1 INTRODUCTION

Concrete is vital component used for all types of structures,to mitigate the construction cost.Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space among the aggregate particles and glues them together. The usage of concrete, worldwide, is twice as much as steel, wood, plastics, and aluminium combined. Concrete's use in the modern world is only exceeded by the usage of naturally occurring water. The economy, efficiency, durability, moldability and rigidity of reinforced concrete make it an attractive material for a wide range of structural applications.

Concrete is widely used for making architectural structures, foundations, brick/block walls, pavements, bridges/overpasses, motorways/roads, runways, parking structures, dams, pools or reservoirs, pipes, footings for gates, fences and poles and even boats. Combining water with a cementations material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely. A conventional concrete is becoming costlier owing to the non-availability of the fine aggregate in the vicinity of the site of construction. Hence an investigation is carried out on alternative building material.

Conservation of natural resources and preservation of environment is the essence of any development. The problem arising from continuous technological and industrial development is the disposal of waste material. If some of the waste materials are foundsuitable in concrete making, not only cost of construction can be cut down, but also safedisposal of waste materials can be achieved.Concrete is vital component used for all types of structuresto mitigate the construction cost and quantity of building materials we have to go for alternate materials.

Aggregate is one of the important constituents which has effect in strength development in the theory that the gaps of coarse aggregate is filled by the fine aggregate and the gaps of fine aggregate is filled by the binding materials. In addition the strength of concrete mainly depends on water/cement ratio, aggregate gradation, and aggregate size and shape, cement quality, mixing time, mixing ratios, curing etc. Concrete must be both strong and workable, a careful balance of the cement to water ratio is required when making concrete. Fine aggregate are basically sands won from the land or the marine environment.

Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve. For concrete sand fineness modulus range is 2.3-3.1. Among these ingredients river sand is commonly used as fine aggregate in concrete which is becoming scarce and hence expensive due to excessive cost of transportation from natural sources. The large scale depletion of these sources creates serious environmental problems. So Governments are restricting the collection of river sand from river bed. In such a situation the crusher dust can be an economical alternative to river sand. Crusher dust is a byproduct generated from quarrying activities involved in the production of crushed coarse aggregate. The residue from stone crusher is further washed with water to remove the excess fines so that the fraction confirming to the IS 383 – 1970 specifications can be extracted.

1.2 Need of stone dust as a fine aggregate

Availability of good quality Natural River sand due to depletion of resources and restriction due to environmental consideration has made concrete manufactures to look for suitable alternative fine aggregate. One such alternative is "stone dust".Fine aggregate is often obtained from river beds. This became very scarce as the Government of Tamil Nadu has imposed ban on the mining of the same due to the environmental hazards. The quality of the river sand normally depends on its source and most of the time it varies quite a lot. As the use of fine aggregate in concrete is more than 30% of the composite, its mechanical properties affect the quality of concrete.

The alternative material should be waste materials in the aspects of reduction in environmental load and waste management cost, reduction of production cost as well as augmenting the quality of concrete. Hence crushed sand has been identified as a substitute for river sand thereby solving the issue of mining of sand from river beds and improving the quality of fine aggregate. Quarry dust has been used for different activities in the construction industry such as road construction, and manufacture of building materials such as light weight aggregates, bricks and tiles.

1.3 Stone dust

Crushed rock aggregate quarrying generates considerable volumes of quarry fines, often termed "quarry dust". The finer fraction is usually smaller than according to Chaturanga et al., [25] is desirable because of the benefits such as useful disposal of a by-product, reduction of river sand consumption and increase instrength. Quarry dust has rough, sharp and angularparticles, and as such causes a gain in strength due to better interlocking. Quarry dust has been identified as possible replacement for sharp sand in concrete works. Jayawardena and Dissanayake [5, 6] in their paper "Use ofquarry dust instead of river sand for future constructions inhornblende and hypersthenes as the major minerals Sri Lanka" identified quartz, feldspar, biotitic mica, presentin fresh rock which shows mica percentages between 5%and 20%. They added that mica percentages in charnockticgneiss and granitic gneiss are always less than 5%, similar to sand and therefore suitable for use in civil engineering construction.

1.4 Natural Sand v/s Stone dust

The sand from river due to natural process of attrition tends to possess smoother surface texture and better shape. It also carries moisture that is trapped in between the particles. These characters make concrete workability better. However, silt and clay carried by river sand can be harmful to the concrete. Another issue associated with river sand is that of obtaining required grading with a fineness modulus of 2.4 to 3.1.

It has been verified and found, at various locations across south India, that it has become increasingly difficult to get river sand of consistent quality in terms of grading requirements and limited silt / clay content. With well-designed screening system the required grading (Zone II) and fineness modulus (2.4 to 3.1) can also be achieved consistently in the case of stone dust. Processed stone dust can improve both compressive strength and flexural strength through better bond compared to river sand.

Advantages of Stone dust

1. Have no impurities like silt, clay and pebbles.
2. Possess less curing time.
3. Have no wastage, no additional labour cost for sieving and saves 15% to 20% on cost.
4. Provides 40% additional durable and strength compared to other sand (6).
5. Is supplied throughout the year in all monsoon season.
6. Is natural rock cursed stone sand.
7. Can be used as by product for producing eco-friendly blocks, pavers and fly ash bricks.

Table 1.1 Physical properties of quarry rock dust and natural sand.

Property	Quarry rock dust	Natural sand	Test method
Specific gravity	2.54-2.60	2.60	IS 2386 (Part III) 1963
Bulk relative density (kg/m^3)	1720-1810	1460	IS 2386 (Part III) 1963

Absorption (%)	1.20-1.50	Nil	IS 2386 (Part III) 1963
Moisture content (%)	Nil	1.50	IS 2386 (Part III) 1963
Fine particles less than 0.075mm (%)	12-15	06	IS 2386 (Part I) 1963
Sieve analysis	Zone II	Zone II	IS 383 - 1970

Table 1.2 Chemical compositions of quarry rock dust and natural sand.

Constituent	Quarry rock dust (%)	Natural sand (%)	Test method
SiO_2	62.48	80.78	[10]IS: 4032-1968
Al_2O_3	18.72	10.52	
Fe_2O_3	06.54	01.75	
CaO	04.83	03.21	
MgO	02.56	00.77	
Na_2O	Nil	01.37	
K_2O	03.18	01.23	
TiO_2	01.21	Nil	
Loss of ignition	00.48	00.37	

1.5 Need of Ceramic scrap

Now a day's disposal of solid waste is the major problem in the world wide, because of land for disposal of this waste is .Recycled aggregates can be defined as the result of waste treatment and management where, following a process of crushing to reduce size, sieving and laboratory analysis, the waste complies with technical specifications for use in the construction sector and civil engineering.

According to Ignacio (2007) it is not possible to carry out an exhaustive characterization of all kinds of recycled aggregates. Therefore, this topic will be discussed in more general terms by looking at concrete aggregates, asphalt agglomerate aggregates and other recycled aggregates which incorporate aggregates from clean ceramic material waste and aggregates from mixtures. As mentioned previously, one of the objectives of the new waste reuse and recycling policies in the construction and industrial sectors is to use recycled aggregates as a substitute for conventional natural aggregates, with the aim of reducing both use of natural resources and environmental impact caused by dumping.

1.6 Ceramic Waste

As a result, recent years have witnessed rising social concern about the problem of waste management in general, and industrial waste and waste from the construction industry in particular. This problem is becoming increasingly acute due to the growing quantity of industrial, construction and demolition waste generated despite the measures which have been taken in recent years at European Community, national and regional levels aimed at controlling and regulating waste management, in accordance with sustainable development policies and the Kyoto Protocol.

The need to manage these wastes has become one of the most pressing issues of our times, requiring specific actions aimed at preventing waste generation such as promotion of resource recovery systems (reuse, recycling and waste-to energy systems) as a means of exploiting the resources contained within waste, which would otherwise be lost, thus reducing environmental impact. In addition to helping protect the environment, use of such waste offers a series of advantages such as a reduction in the use of other raw materials, contributing to an economy of natural resources. Moreover, reuse also offers benefits in terms of energy, primarily when the waste is from kiln industries (the ceramics industry) where highly endothermic decomposition reactions have already taken place, thus recovering the energy previously incorporated during production. Ceramic waste may come from two sources.

The first source is the ceramics industry, and this waste is classified as non-hazardous industrial waste (NHIW). According to the Integrated National Plan on Waste 2008-2015, NHIW is all waste generated by industrial 198 Ceramic Materials activity which is not classified as hazardous in Order MAM/304/2002, of the 8th February, in accordance with the European List of Waste (ELW) and identified according to the following codes:

- 10 Waste from thermal processes.
- 10 12 Waste from the manufacture of ceramic products, bricks, roof tiles and construction materials.
- 10 12 08 Ceramic, brick, roof tile and construction materials waste (fired).

The second source of ceramic waste is associated with construction and demolition activity, and constitutes a significant fraction of construction and demolition waste

(CDW), as will bead dressed in more detail below. This kind of waste is classified by the ELW according to the following codes:

- 17 Construction and demolition waste
- 17 01 Concrete, bricks, roof tiles and ceramic materials
- 17 01 03 Roof tiles and ceramic materials

Globally, the ceramics industry sector is unusual in that it is primarily found in regional concentrations where the majority of agents or industries involved in the system whereby the end ceramic product attains value are located.

The development of these ceramic“clusters”, with companies in the same or related sectors located in geographical proximity, has enabled the sector globally to attain a state-of-the-art level of progress and technological innovation. The main ceramic “clusters” are located in Brazil, with one in Santa Catarina and two in the state of Sao Paulo; in Portugal, in the Aveiro region; in Castellón, Spain; andin the province of Emilia Romagna, Italy. The ceramics industry in China has also begun to take on greater prominence, representing 35% of global production in recent years. The ceramics industry is comprised of the following subsectors: wall and floor tiles, sanitary ware, bricks and roof tiles, refractory materials, technical ceramics and ceramic materials for domestic and ornamental use.

Advantages of Ceramic Waste

- High Electrical and thermal insulating property.
- Chemically stable and high melting temperature.
- Brittle and virtually no ductility.
- High temperature stability.
- More resistance to fire hazarder.

1.7 Objectives

The following are the objectives of ceramic waste and stone dust are

- The effective utilization of solid waste such as ceramic scrap waste as a coarse aggregate.
- The effective utilization of rock waste such as stone dust used as a fine aggregate.
- The alternative usage of stone dust and ceramic waste should reduces some considerable amount of cost
- In order to improve the solid waste disposal
- Minimization of cost of construction materials

2. EXPERMENTAL STUDY

Materials

2.1 General:

It is quite obvious that the strength of concrete depends upon the strength of its constituents. Therefore it is very necessary to know the characteristics of the materials used in any concrete. The materials used in the study includes ordinary Portland cement (53grade), fine aggregate (Natural sand and stone dust), Ceramic scrap, Portable water for mixing and curing.

The properties of these materials are represented in the following section.

2.2 Cement

Cement is a fine powder, which when mixed with water and allowed to set and harden can join different components or members together to give a mechanically strong structure. Cement can be used as a binding material with water for binding solid particles of different sizes like bricks, stones or aggregates to form a monolith.

There are two different requirements that any cement must meet:

- It must develop the appropriate strength and
- It must exhibit appropriate rheological behaviour among the chemical constituents of cement.

The predominant type of cement used in modern concrete is Portland cement, other types of cement available include; Blended cement, which is similar to Portland cement but may contain materials such as fly ash slag or silica fume; High early strength cements, which as the name suggests gains strength a lot quicker then Portland or blended cements; Low heat cements, used when limits are placed on the heat of hydration of the concrete; Shrinkage limited cements; Sulphate resisting cements, Coloured cements; Masonry cement.

The cement used in all mixtures of the study was an ordinary Portland cement of 53 grade. The physical and chemical properties of the cement used are listed in table. All the results meet the requirement of ASTMC150 specification [37] and IS: 12269, 1987.The Table 3.1 shows the physical characteristics of the cement used.

Table 3.1 Physical Properties of OPC of 53 grades

Sl. No.	Details	Results	As per IS 12269-1987
1.	Fineness (%)	3.0	Should not be > 10%
2.	Normal Consistency (%)	30	_
3.	Specific Gravity	3.10	_
4.	Setting Time(in minutes) Initial Setting Time Final Setting Time	 28 min 538 min	Should not be less than 30min < 600min

2.3 Compressive Strength of Cement

The result obtained on test the cubes of cement mortar, after three days and seven days were 17.36N/mm^2 and 24.6 N/mm^2 respectively. Corresponding results of IS code are 115 and 175 N/mm^2 respectively which confirms that quality of cement used in investigation was good. Properties of Portland cement as per IS specifications.

2.4 Fine Aggregate

The fine aggregate used in mixtures are natural sand and stone dust. Locally available river sand which is the natural sand and stone dust from the quarry passing through 4.75 mm sieve and retained on 75 micron sieve is used. The gradation of both sand confirm to Zone II, of IS 383-1970. Sieve analysis and properties of fine aggregate is shown in the table 3.2

Table 3.2 Sieve Analysis of Fine Aggregates

Sieve Size (in mm)	**N-Sand**	**Stone dust**	**Zone II Gradation Specification**
4.75	98.63	99.40	90 – 100
2.36	92.91	98.425	75 – 100
1.18	57.38	69.605	55 – 90
0.60	28.45	41.855	35 – 59
0.30	7.43	12.835	8 – 30
0.15	1.144	1.560	0 – 10
0.075	0.254	0.935	0-5
Remarks	**coarse**	**coarse**	**Coarse**

2.5 Coarse Aggregates

2.5.1 Conventional Coarse Aggregate:

Machine crushed granite obtained from a local Quarry was used as coarse aggregate.

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. The aggregates occupy 70 to 80 % of volume of concrete. The aggregates between 4.75 mm to 50 mm are classified as coarse aggregate, except for the mass concrete which may contain up to 150 mm size aggregate. The properties of the aggregate affect the water demand, workability and cohesion of concrete in plastic state and strength, density, durability and porosity of hardened concrete.

Table 3.3 Properties of Coarse Aggregate

Property	Crushed aggregate
Specific gravity	2.47
Water absorption %	0.10
Impact value %	26.67
Crushing value %	32.67
Abrasion value %	14.25

2.5.2 Ceramic Scrap:

The ceramic scrap was obtained from a local ceramic insulator industry. The ceramic insulators are initially broken into pieces with hammer in to required size.

Table 3.4 Properties of Ceramic waste Aggregate

Property	Ceramic waste aggregate
Specific gravity	2.42
Water absorption %	0.18
Impact value %	21.0
Crushing value %	25.0
Abrasion value %	10.25

3. TEST ON SPECIMENS

3.1 Introduction

The compressive strength of concrete is done of the most important and useful properties of concrete. In most structural applications concrete is employed primarily to resist the compressive stresses .In those cases where strength in tension or in shear is of primary importance, the compressive strength is frequently used as a measure of those properties. Therefore, the concrete making properties of various ingredients of mix are usually measured in terms of the compressive strength. For compressive strength, specimens of dimensions 150 x 150 x 150 mm were cast. For flexural strength, specimens of dimensions 100 x 100 x 500 mm were cast. For impact strength, specimens of diameter 152 mm and thickness 63.5 mm were casted; all the tests are conducted after the 28 days of curing.

35.2 Compressive Strength Test

The compression test is quite resourceful since most of the desirable characteristic properties of porous concrete are qualitatively related to its compressive strength. The compression test is carried out on the specimens of cubical or cylindrical shapes. For the present investigation cubical specimen is preferred. The compression test was conducted on cubes at 3 days, 7 days and 28 days of curing according with IS 521-1959 using the formula.

$$\mathbf{F_c = P / A}$$

Where F_c - compressive strength of concrete

P - Maximum load applied to the specimen

A - Cross-sectional area of the specimen

Fig 5.1 Experimental set of cube specimen

Fig 5.2 Failure of cube specimen

Table 5.1 compressive strength of stone dust and ceramic scrap concrete

Sl No	Percentage of replacement		Average 3 days compressive strength N/mm^2
	Stone dust	Ceramic scrap	
1	0	0	18.75
2	**5**	**5**	**24.57**
3	10	10	21.42
4	15	15	20.35
5	20	20	18.88

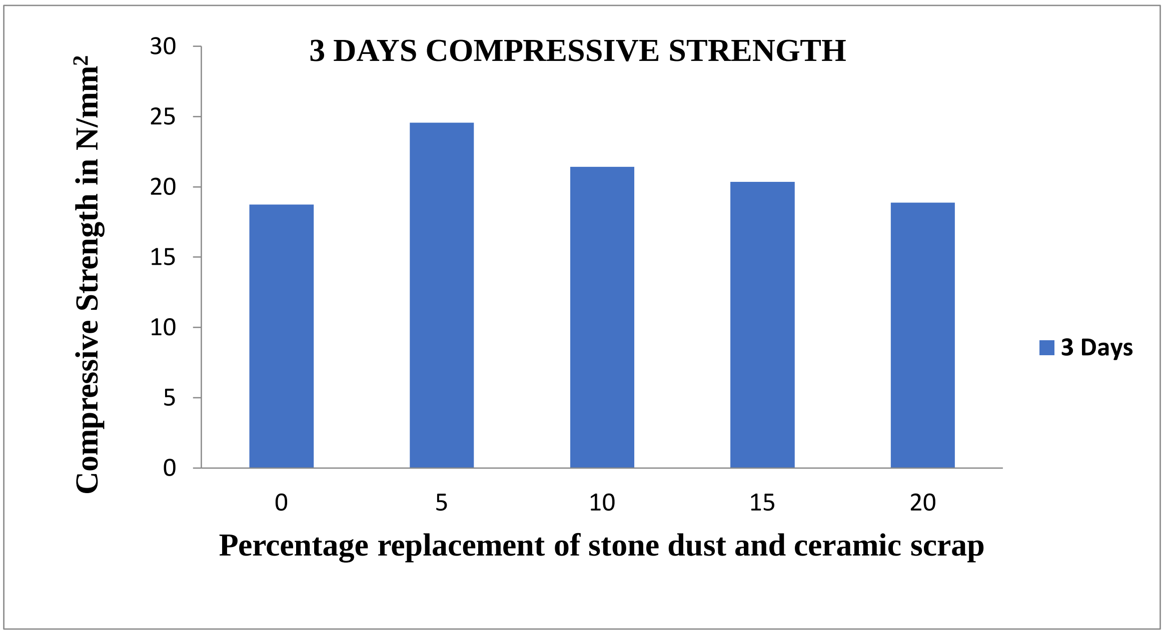

Fig 5.3 Variation of 3 days Compressive strength

From the experimental analysis, it is evident that at age of 3days the Compression Strength increases as a percentage of stone dust and ceramic waste (as replacement material for fine and coarse aggregate respectively) increase up to 5%. For further increase in the percentage of stone dust and ceramic waste the compressive strength decreases.

Table 5.2 compressive strength of stone dust and ceramic scrap concrete

Sl No	Percentage of replacement		Average 7 days compressive strength N/mm²
	Stone dust	Ceramic scrap	
1	0	0	23.70
2	**5**	**5**	**31.85**
3	10	10	28.66
4	15	15	24.88
5	20	20	24.15

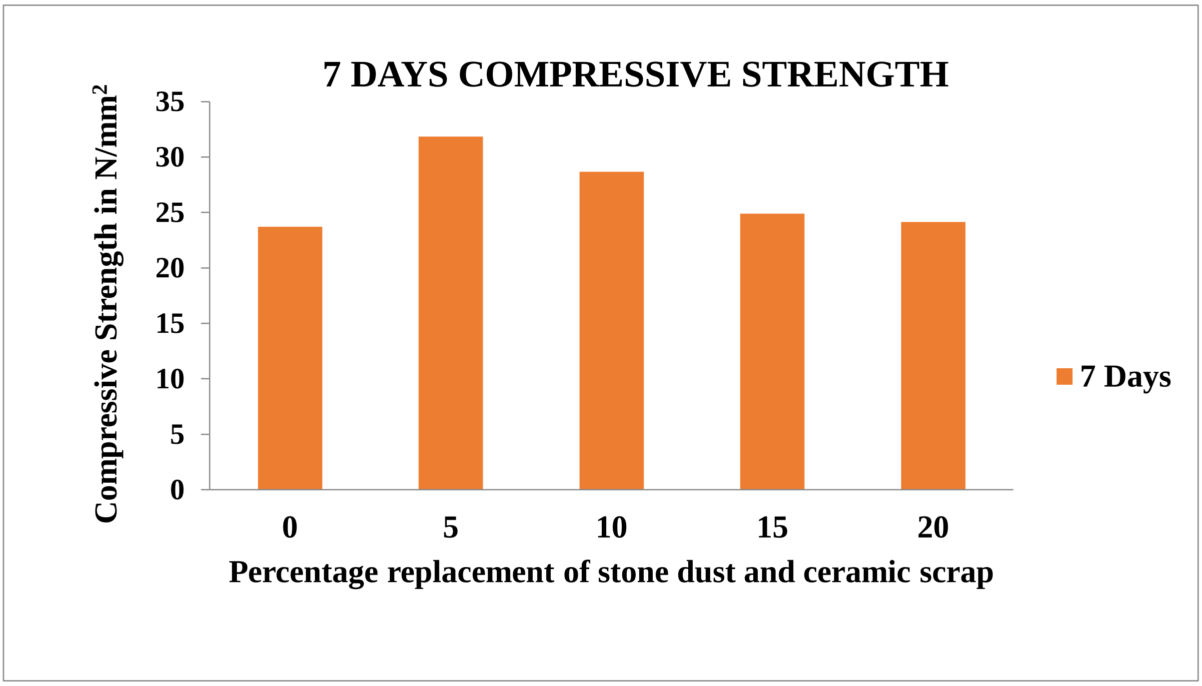

Fig 5.4 Variation of 7 days Compressive strength

From the experimental analysis, it is evident that at age of 7days the Compression Strength increases as a percentage of stone dust and ceramic waste (as replacement material for fine and coarse aggregate respectively) increase up to 5%. For further increase in the percentage of stone dust and ceramic waste the compressive strength decreases.

Table 5.3 compressive strength of stone dust and ceramic scrap concrete

Sl No	Percentage of replacement		Average 28 days compressive strength N/mm²
	Stone dust	Ceramic scrap	
1	0	0	36.14
2	**5**	**5**	**43.33**
3	10	10	38.81
4	15	15	33.63
5	20	20	32.00

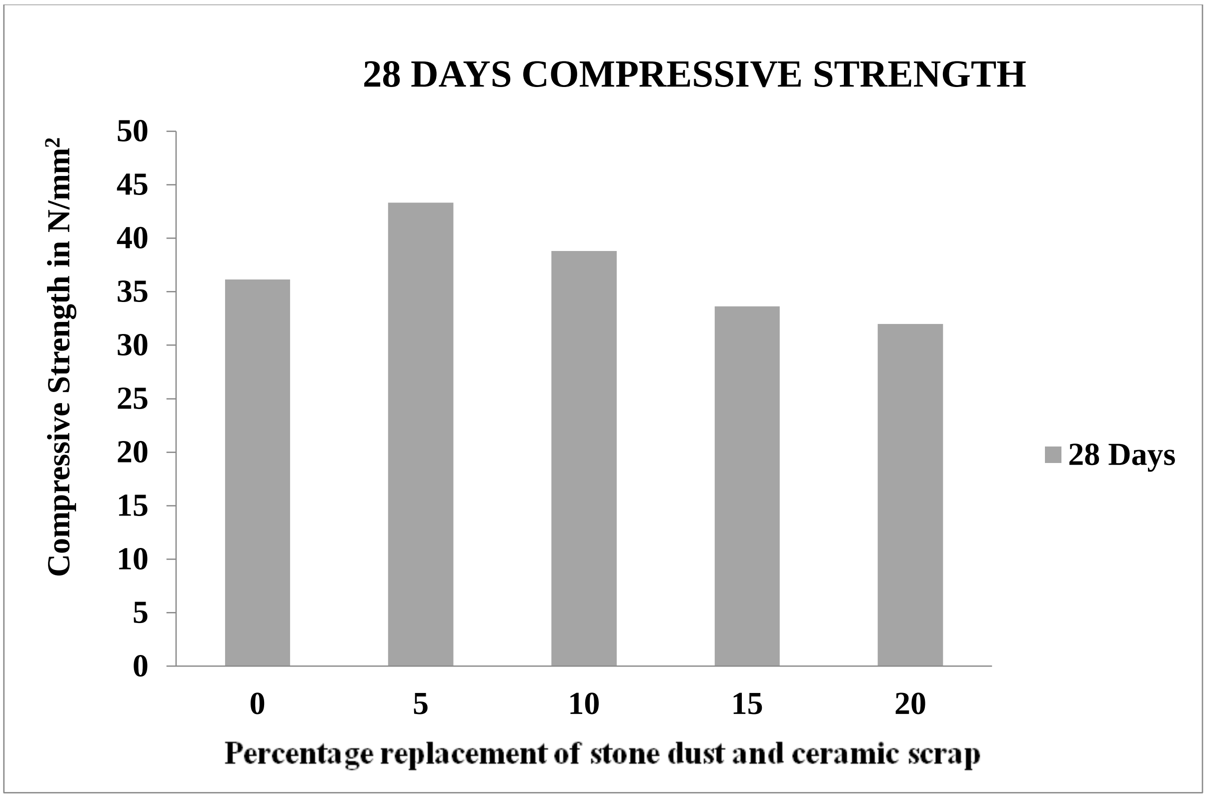

Fig 5.5 Variation of 28 days Compressive strength

From the experimental analysis, it is evident that at age of 28days the Compression Strength increases as a percentage of stone dust and ceramic waste (as replacement material for fine and coarse aggregate respectively) increase up to 5%. For further increase in the percentage of stone dust and ceramic waste the compressive strength decreases.

Table 5.4 compressive strength of stone dust and ceramic scrap concrete

Sl No	Percentage of replacement		Average 3 days compressive strength N/mm²	Average 7 days compressive strength N/mm²	Average 28 days compressive strength N/mm²
	Stone dust	Ceramic scrap			
1	0	0	18.75	23.70	36.14
2	**5**	**5**	**24.57**	**31.85**	**43.33**
3	10	10	21.42	28.66	38.81
4	15	15	20.35	24.88	33.63
5	20	20	18.88	24.15	32.00

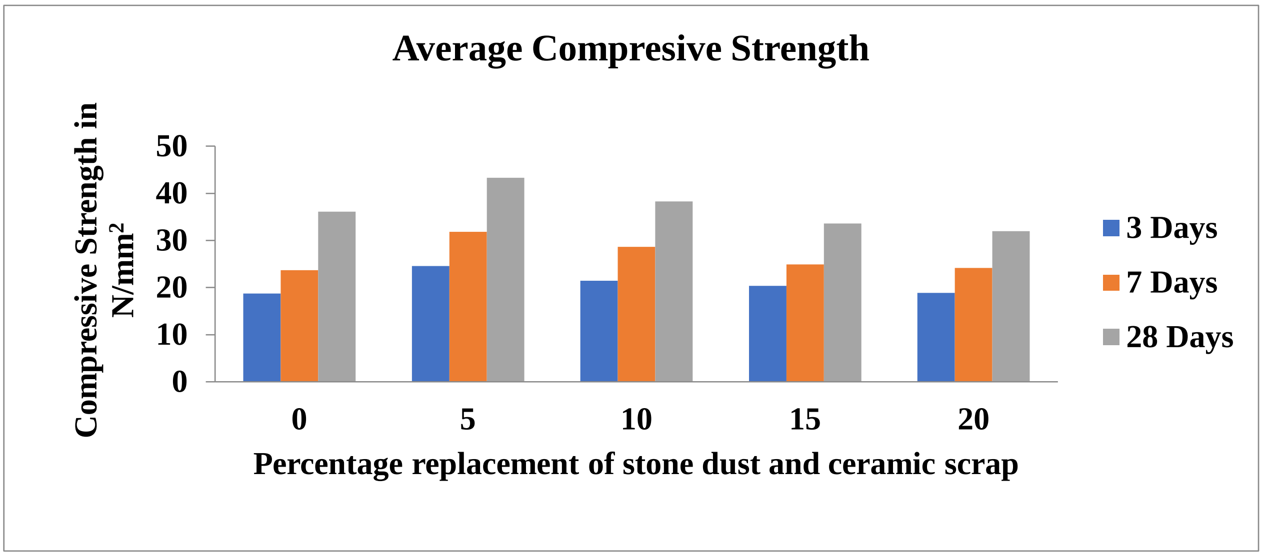

Fig 5.6 Variation of 3, 7& 28days Compressive strength

From the experimental analysis, it is evident that at age of 3, 7 and 28days the Compression Strength increases as a percentage of stone dust and ceramic waste (as replacement material for fine and coarse aggregate respectively) increase up to 5%. For further increase in the percentage of stone dust and ceramic waste the compressive strength decreases.

3.3 Flexural Strength Test

Flexural strength also termed as modulus of rupture is a measure of its ability to resist bending. The specimens casted for flexural strength test were of dimensions 100 x 100 x 500 mm. The effective span was 400 mm and the specimens were subjected to two points loading, the distance between the loads was 133 mm. The test procedure was carried out in accordance with IS 516-1959.

The flexural strength of the specimen shall be expressed as the modulus of rupture and shall be calculated using the formula

$F_{cf}=3F(L-L_1)/2bd^2$ N/mm²

Where, F_{cf} – flexural strength
F – Maximum load applied to the specimen
L – c/c distance between the two supports
L_1-Distance b/w two loading support

b – Width of the specimen
d – Depth of the specimen

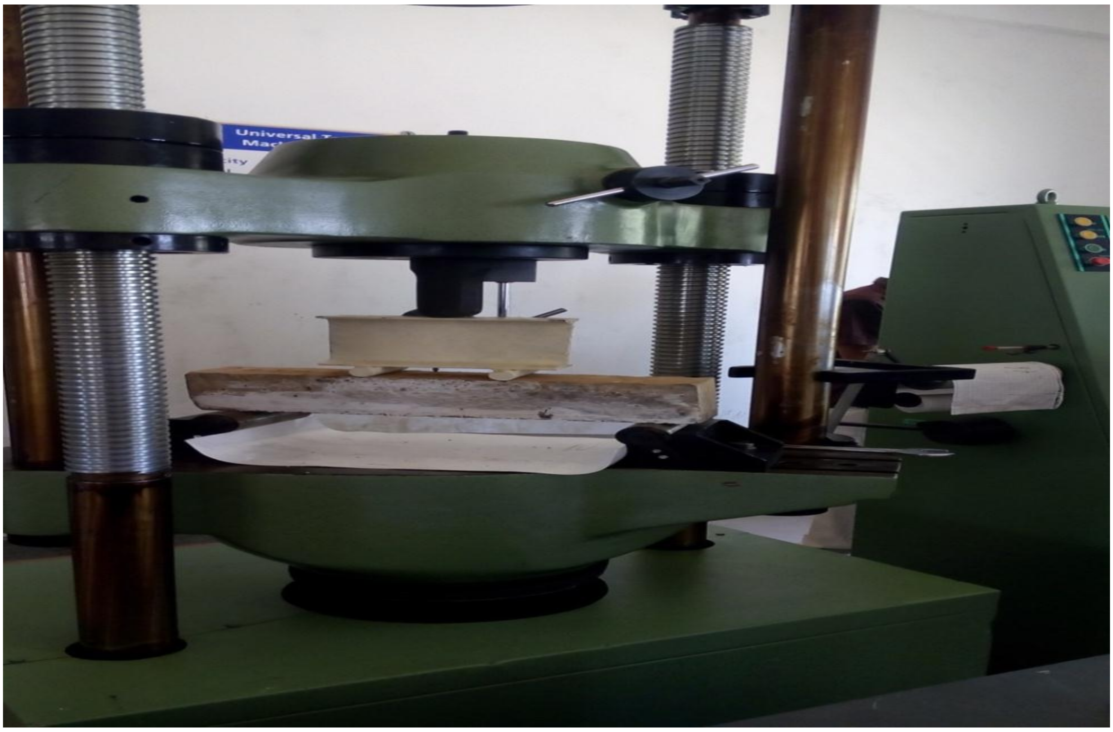

Fig 5.7 Experimental set of beam specimen

Fig 5.8 Failure of beam specimen

Table 5.5 Flexural strength of stone dust and ceramic scrap concrete

Sl No	Percentage of replacement		Average 3 days Flexural strength N/mm²
	Stone dust	Ceramic scrap	
1	0	0	2.32
2	**5**	**5**	**4.27**
3	10	10	3.23
4	15	15	3.00
5	20	20	2.85

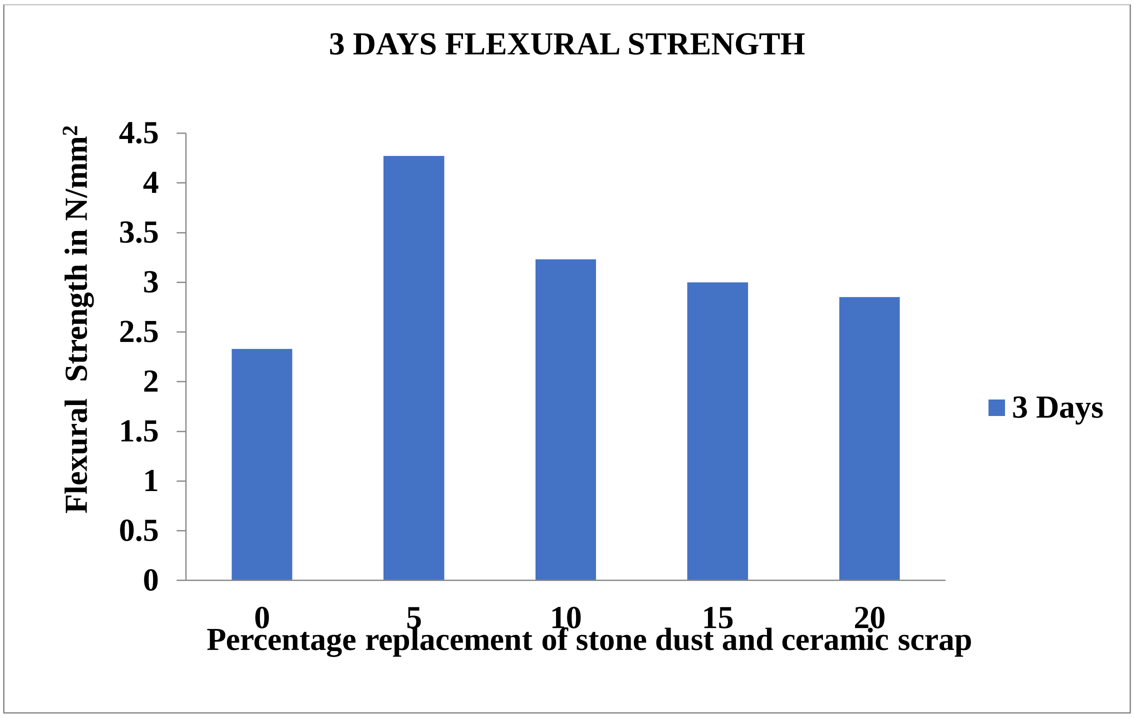

Fig 5.9 Variation of 3 days Flexural strength

From the experimental analysis, it is evident that at age of 3days the Flexural Strength increases as a percentage of stone dust and ceramic waste (as replacement material for fine and coarse aggregate respectively) increase up to 5%. For further increase in the percentage of stone dust and ceramic waste the Flexural strength decreases.

Table 5.6 Flexural strength of stone dust and ceramic scrap concrete

Sl No	**Percentage of replacement**		**Average 7 days Flexural strength N/mm^2**
	Stone dust	**Ceramic scrap**	
1	0	0	3.07
2	**5**	**5**	**3.90**
3	10	10	3.30
4	15	15	3.10
5	20	20	2.82

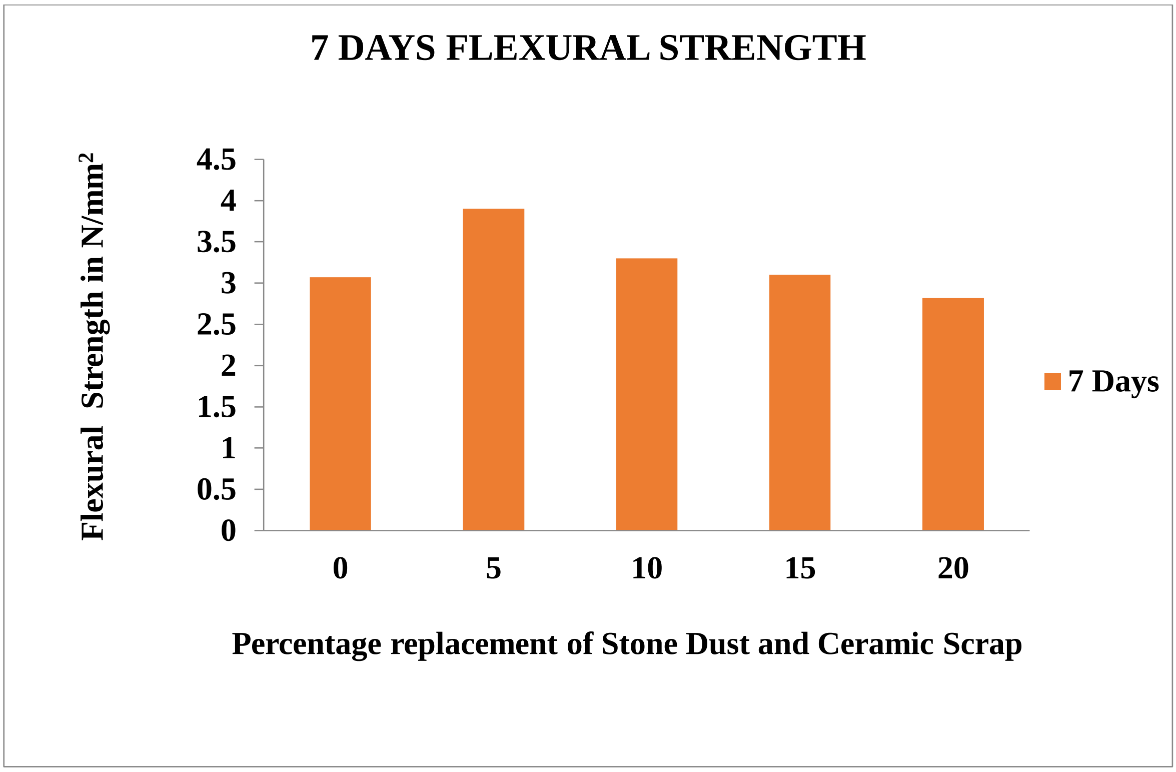

Fig 5.10Variation of 7 days Flexural strength

From the experimental analysis, it is evident that at age of 7days the Flexural Strength increases as a percentage of stone dust and ceramic waste (as replacement material for fine and coarse aggregate respectively) increase up to 5%. For further increase in the percentage of stone dust and ceramic waste the Flexural strength decreases.

Table 5.7 Flexural strength of stone dust and ceramic scrap concrete

Sl No	Percentage of replacement		Average 28 days Flexural strength N/mm^2
	Stone dust	Ceramic scrap	
1	0	0	3.37
2	**5**	**5**	**4.96**
3	10	10	4.50
4	15	15	4.27
5	20	20	3.30

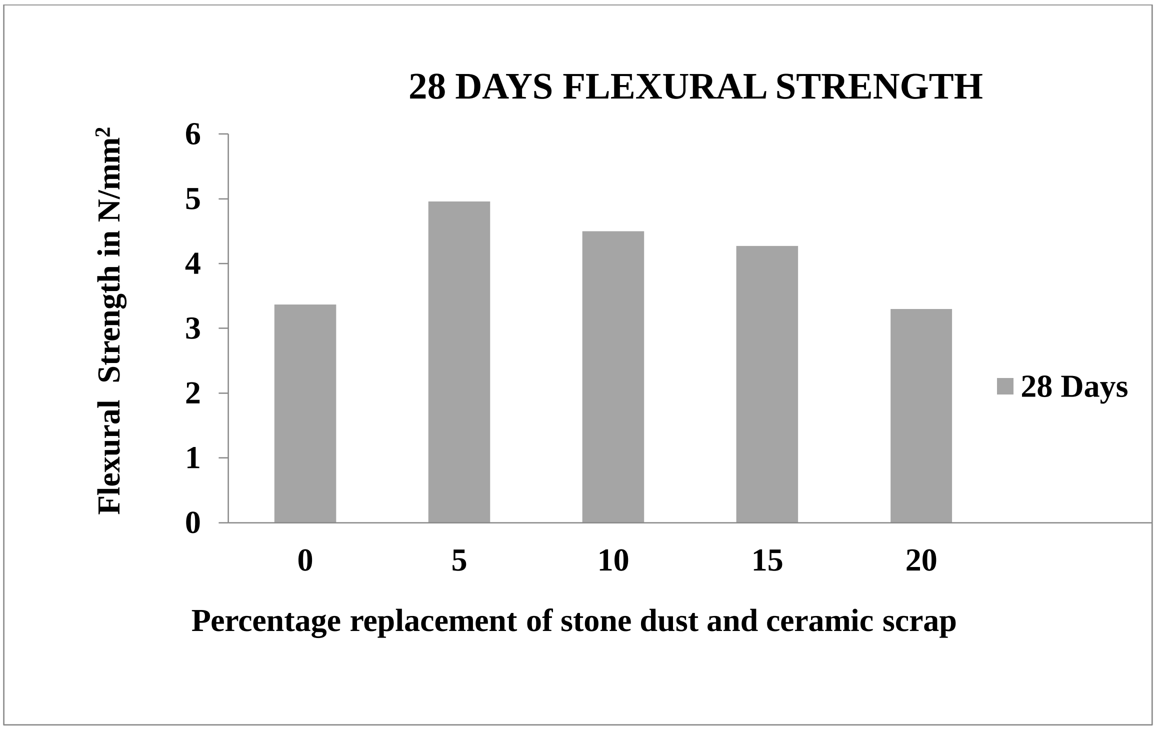

Fig 5.11Variation of 28 days Flexural strength

From the experimental analysis, it is evident that at age of 28days the Flexural Strength increases as a percentage of stone dust and ceramic waste (as replacement material for fine and coarse aggregate respectively) increase up to 5%. For further increase in the percentage of stone dust and ceramic waste the Flexural strength decreases.

Table 5.8 Flexural strength of stone dust and ceramic scrap concrete

Sl No	Percentage of replacement		Average 3 days Flexural strength N/mm²	Average 7 days Flexural strength N/mm²	Average 28 days Flexural strength N/mm²
	Stone dust	Ceramic scrap			
1	0	0	2.32	3.07	3.37
2	**5**	**5**	**4.27**	**3.90**	**4.96**
3	10	10	3.23	3.30	4.50
4	15	15	3.00	3.10	4.27
5	20	20	2.85	2.82	3.30

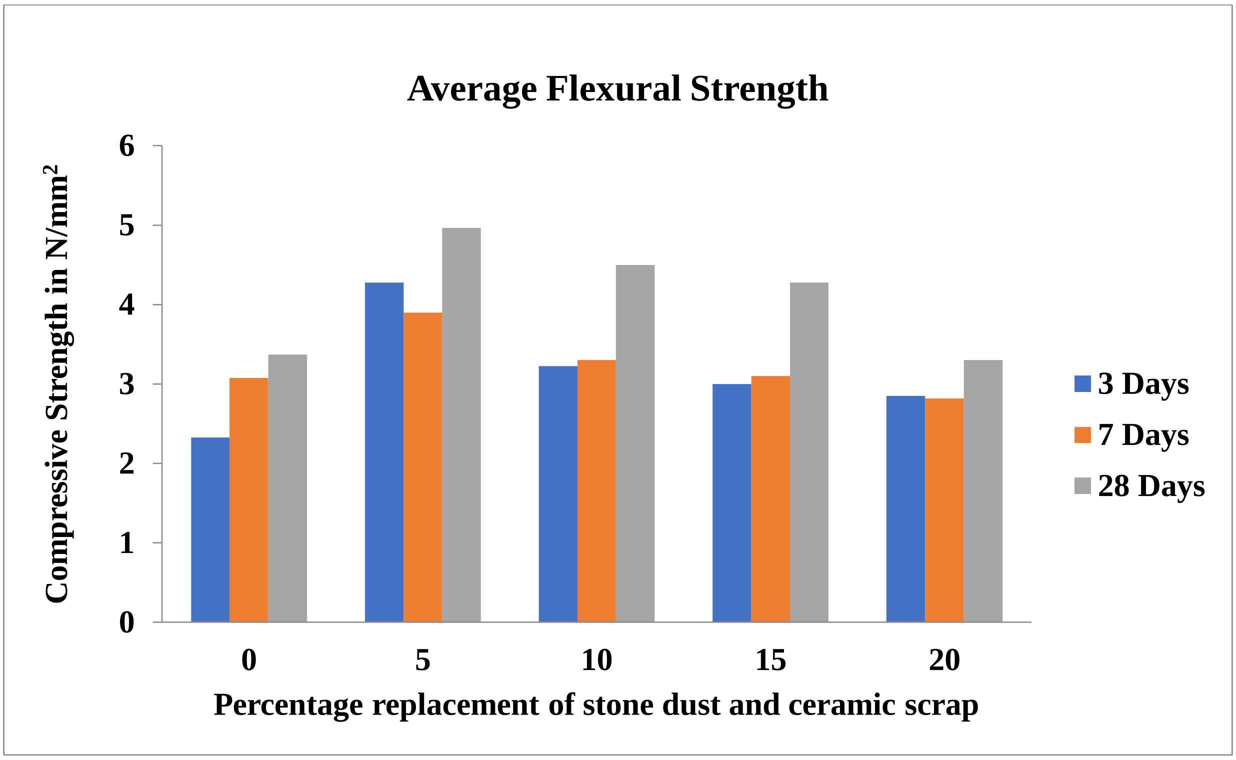

Fig 5.12 Variation of 3, 7 & 28 day's Flexural strength

From the experimental analysis, it is evident that at age of 3, 7 and 28days the Flexural Strength increases as a percentage of stone dust and ceramic waste (as replacement material for fine and coarse aggregate respectively) increase up to 5%. For further increase in the percentage of stone dust and ceramic waste the Flexural strength decreases.

3.4 Split Tensile strength

Six cylindrical specimens for each replacement percentage were cast according to the design mix. The cylindrical specimens are of 150mm diameter and 300mm height. Specimens were de moulded after 24 hrs and cured into pond @ temp of 27 ±2° for a period of 28 days. Split tensile strength is measured by testing cylinder under diametric compression.

Based on the load at which the cylinder splits, the split tensile strength is computed. The Split tensile strength of concrete of standard 150mm Dia and 300mm height cylindrical mould is calculated using the formula;

$$SP = P \times 9.81/(10 \times L \times D)\ N/mm^2$$

Where **SP =** Split tensile strength of concrete in N/mm^2

P = Ultimate load resisted by concrete in Newton’s

D=Diameter of cylindrical specimen in mm

L = Height of cylindrical specimen in mm

Fig 5.13 Experimental set of Cylinderspecimen

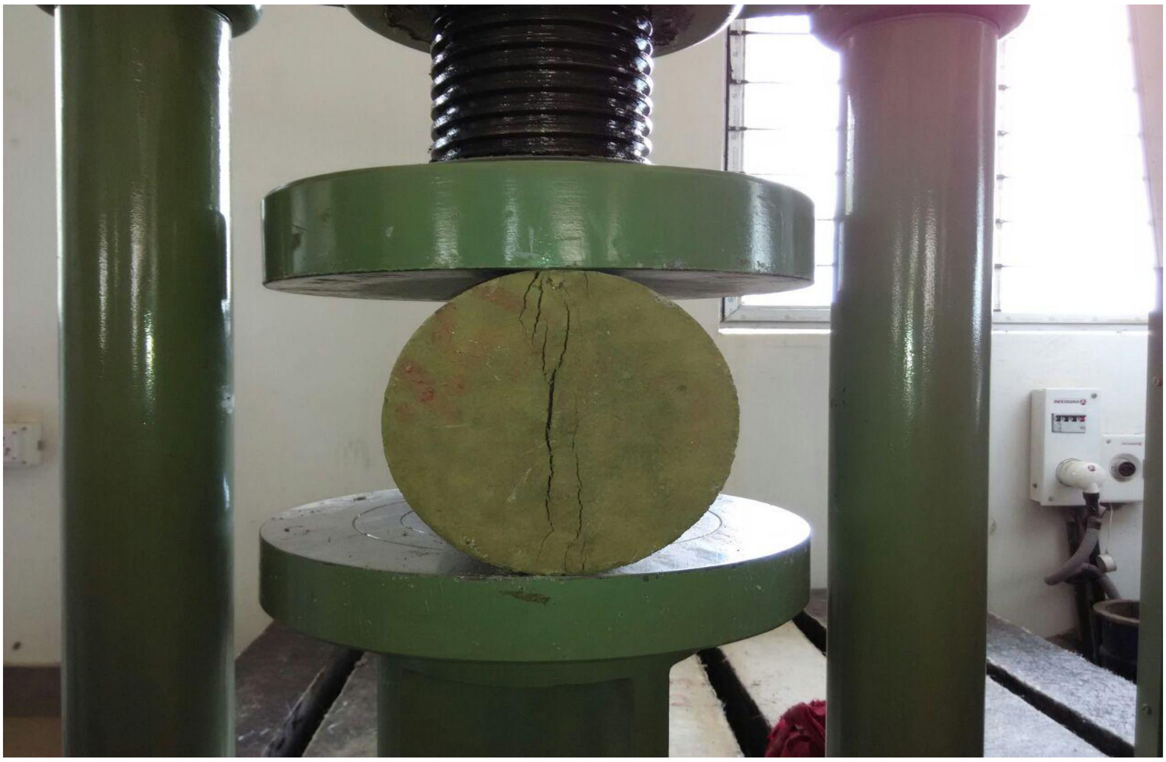

Fig 5.14 Failure of cylinder specimen

Fig 5.15 Failure of Cylinder specimen after testing

Table 5.9 Split tensile strength of stone dust and ceramic scrap concrete

Sl No	Percentage of replacement		Average 28 days split tensile strength N/mm²
	Stone dust	Ceramic scrap	
1	0	0	3.55
2	**5**	**5**	**4.94**
3	10	10	4.47
4	15	15	4.36
5	20	20	4.19

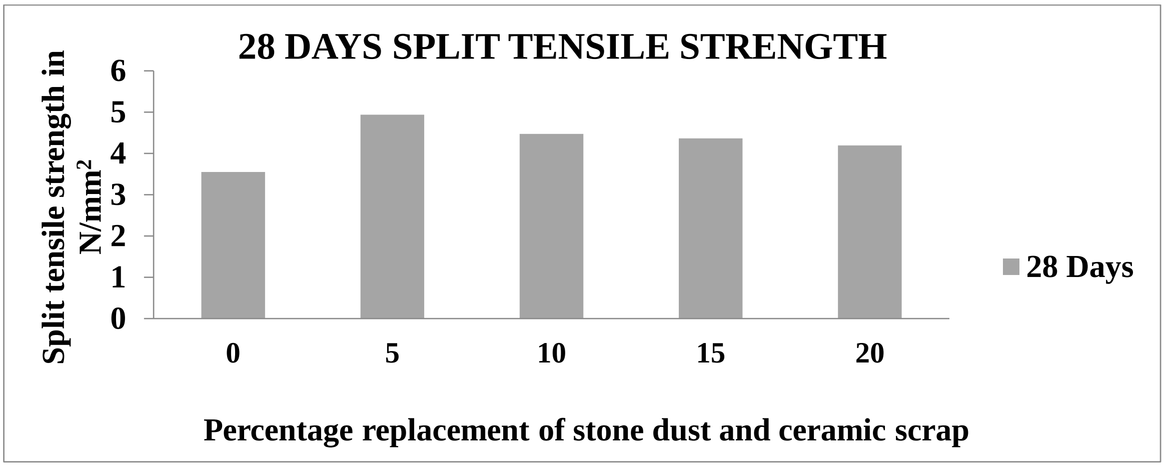

Fig 5.16Variation of 28 days split tensile strength

From the experimental analysis, it is evident that at age of 28 days the Split tensile Strength increases as a percentage of stone dust and ceramic waste (as replacement material for fine and coarse aggregate respectively) increase up to 5%. For further increase in the percentage of stone dust and ceramic waste the Split tensile strength decreases.

4. RESULTS AND DISCUSSIONS

Compressive strength:

The result of compressive strength with replacement of stone dust and Ceramic scrap for 3, 7 and 28 days are presented in Table 6 and its graphical representation as shown in Fig. 1. From the results, compressive strength of concrete with 5% replacement of stone dust as a fine aggregate and Ceramic scrap as a coarse aggregate have the highest 3, 7 and 28 days strength which reaches24.57 N/mm² 31.85 N/mm² and 43.33 N/mm²respectively.Results shows that with 5% replacement of fine aggregate with stone dust and 5% replacement of coarse aggregate with Ceramic waste as a coarse aggregate, the compressive strength of concrete increased by 20%at the age of 28 days compared to referral concrete. It can be seen that compressive strength is increased with replacement of stone dust and Ceramic scrap up to the 5% and further more replacement of these materials, the corresponding compressive strength was decreased.

Flexural strength:

The flexural strength of specimen was determined 4.280, 3.90 and 4.970 N/mm^2 at 3, 7 and 28 days respectively (Table 7). The variation of flexural strength with replacement level is shown in Fig. 2. It was observed that the flexural strength increases with 5% replacement of stone dust and ceramic scrap and further more % replacement these materials, the strength was decreased at 3,7 and 28 days compared with referral concrete mix. Results shows that with 5% replacement of fine aggregate with stone dust and 5% replacement of coarse aggregate with Ceramic waste aggregate, the flexural strength of concrete increased by 48% at the age of 28 days compared to referral concrete mix.

Split Tensile strength:

From the experimental analysis, it is evident that at age of 28days the Split tensile strength increases with 5% replacement of stone dust and ceramic waste as a fine and coarse aggregate. For further increase in the percentage of stone dust and ceramic waste, the split tensile strength was decreases. The results were absorbed that with 5% replacement of fine aggregate with stone dust and 5% replacement of coarse aggregate with Ceramic waste aggregate, the split tensile strength of concrete increased by 40% at the age of 28 days compared to referral concrete mix.

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