Hardened Properties of Concrete Containing Copper Slag, Rock Dust and Polypropylene Fiber

Keshav Krishna Molugu Venugopal, Venu Malagevelli, J.S.R. Prasad

Abstract*: The concrete is the material that is obtained from concrete forming materials. These raw materials are mixed in particular proportions, these proportions are based on different concrete grades. These concrete grades defines the strength of the concrete. Construction of structures are based upon concrete, the construction process is growing day by day at a huge scale, hence there is more demand for the raw materials. In order to maintain the demand, excessive extractions of raw materials are done, which makes environment more harmful. In order to limit the extraction of natural raw materials that are used for producing concrete mix, alternative supplementary materials are replaced with fine aggregates. This study involves using of alternative supplementary materials as partial replacement of fine aggregate by copper slag and rock dust, copper slag and rock dust are used at various proportions. The various proportions of rock dust and copper slag are 0% to 50% replacement at an increment of 5% interval. Polypropylene fiber is the material that is added as supplementary material to the concrete mix, it is added at constant volume of 1.5% volume of concrete, it is mixed in concrete to improve toughness and reduce shrinkage of concrete. Super plasticizer admixture that is used is Conplast SP430DIS which contains sulphonated naphthalene formaldehyde is added to cement based on site trails which increases the early concrete strength. Combining copper slag, rock dust, polypropylene fiber and super plasticizer admixture in modified concrete gave best results when compared to conventional concrete due to content of silica in copper slag. Hence this combination can be used for further investigation.

***Keywords*: Copper Slag, Rock Dust, Super Plasticizers Admixture and Polypropylene Fiber.**

I. INTRODUCTION

The concrete is the main material that is used for construction process, without concrete there is no construction process. Hence concrete production and construction process is directly proportional. As we know that concrete is produced with concrete forming materials. Modified concrete is produced by supplementary materials which can be used in place of raw materials. The cement that is used for producing concrete mix should be Ordinary Portland Cement (O.P.C), there are many grades of OPC that can be used, various grades of OPC gives various strength. The cement that is used should be according to Indian Standards. The coarse aggregate that is used for producing concrete mix is obtained from crushing of rocks at quarries, the coarse aggregate that is used should be according to Indian Standards and should be of particular size. The fine aggregate that is used for producing concrete mix is obtained from natural sources like river sand. Due to excessive extraction of river sand from river bed, the river bed is getting damaged, the fine aggregate that is used should be according to Indian Standards and should be of particular size. In order to reduce the damage of river bed, few alternative materials that can be used in place of fine aggregate. The alternative fine aggregate that are used are copper slag and rock dust. Copper slag is an industrial waste and rock dust is the by-products that is obtained after crushing of rocks at quarries. This study involves addition of various percentages of fine aggregate replacement by rock dust and copper slag like 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50% and rest 50% of fine aggregate is river sand. Polypropylene fiber is incorporated in dry state of mix, it is mixed to concrete in order to improves toughness of concrete and reduce the shrinkage cracks that is obtained. Super plasticizer admixture is mixed with water and added to concrete in its wet state, it is added after wetting 80% of concrete mix. Super plasticizer admixture gives early strength to concrete and gives more workability at low water cement ratio also. It should be added at controlled dosage. The water that is used for producing concrete mix should be potable water, it should be added to dry mix at controlled proportion or else the required strength will not be obtained. The water content depends on w/c ratio.

II. LITERATURE REVIEW

The following literature review is organized with respect to supplementary materials for concrete and identifying the evidences on the strength variation like split tensile strength, compressive strength and flexural strength by using copper slag, rock dust, polypropylene fiber and super plasticizer admixture. [1] Addition of copper slag to concrete had increased the self-weight of the concrete.

Revised Manuscript Received on October 10, 2019

***** Correspondence Author

Keshav Krishna Molugu Venugopal, Postgraduation Student, Department of Civil Engineering, Institute of Aeronautical Engineering, Dundigal, Hyderabad, Telangana, India. Email: keshavmolugu26@gmail.com

Venu Malagevelli, Professor, Department of Civil Engineering, Institute of Aeronautical Engineering, Dundigal, Hyderabad, Telangana, India. Email: venu.bits@gmail.com

JSR Prasad, Professor, Department of Civil Engineering, Institute of Aeronautical Engineering, Dundigal, Hyderabad, Telangana, India. Email: jsrpddeq@gmail.com

The compressive strength was increased by 32.3%, the flexural strength test on beams shown that the ultimate load carrying capacity of the beam was increased by 30% for at 38% replacement of copper slag. Copper slag as a partial replacement of sand has imparted strength up to 50% replacement. [2] Micro-structural analysis of industrial waste based concrete are compared with normal concrete, replacing copper slag as 40% for sand substitution had improved the strength and durability characteristics at same workability and decreased surface water absorption, ultra-high performance concrete can be produced with the help of copper slag. [3] Compressive strength has been increased up to 17%, split tensile strength has been increased up to 22%, flexural strength has been increased up to 24 % and modulus of elasticity is increased by 11% when polypropylene fiber is added at 1.5% to volume of concrete when compared to conventional concrete, 1.5% fiber in concrete yielded maximum strength. [4] Adding polypropylene fibers (PPF) and copper slag gave the better workability. Segregation, bleeding, surface cracking and free water content of copper slag are compensated by addition of PP fibers and super plasticizer, higher PP fibers content reduces the workability and lowers the compressive strength. Copper slag admixed with PP fibers exhibits a high 7-day strength amounting to 90% of target mean strength. [5] Water absorption is decreased by 1%-3% and porosity is reduced up to 43.25% for copper slag. Addition of polypropylene fiber reduces spalling of concrete and does not create any crack on the surface even after failure, polypropylene fiber absorbs excess water delivered by copper slag and avoids segregation and bleeding. [6] The compressive strength, split tensile strength of concrete samples are studied with different amounts of fiber varying from 0%, 0.5%, 1%,1.5% and 2.0%, but sample with 1.5% polypropylene fiber gave better results when compared to other percentages of fibers, compressive strength was increased by 34%, split tensile strength was increased by 40%. [7] The compressive strength of the cube is increased when sand is replaced at 40% of copper slag and starts decreasing. The compressive strength was increased by 12.55%, split tensile strength was increased by 9.97% and flexural strength was increased by 12.76% for 28 days. [8] Polypropylene fiber concrete has high mechanical strength, stiffness and durability, polypropylene fiber usage reduces the cost and various properties of concrete are reduced, few properties of concrete are increased. Higher workability is achieved with the addition of High Range Water Reducers (HRWR) admixtures with w/c 0.3. [9] Copper slag is used at various percentages as 0%,10%,20%,30%,40%,50% and 60% with mix proportion of 1:1.60:2.96, w/c ratio is 0.45. Compressive strength was increased up to 17%, flexural strength was increased up to 49.15% and split tensile strength was increased up to 27.35% with 40% copper slag when compared to plain concrete and the water absorption of copper slag is 0.16%. Copper slag replacement for fine aggregate is more effective than cement replacement. [10] The experimental results shows that 25% replacement of fine aggregate by rock dust. The strength and durability can be improved with addition of rock dust and fibers to the concrete. [11] Strength characteristics of concrete are studied using crushed stone dust is partially or fully replaced with sand for M25 and M30 grades of concrete and compared with basic properties of conventional mix, the various properties have been increased. [12] Compressive strength of concrete was increased when sand is replaced with quarry dust, workability of concrete is decreased due to absorption of water by quarry dust, the workability of concrete is decreased with increasing percentage of quarry dust, the workability is very less at standard water cement ratio and requires more water to make zero slump. 50% replacement of quarry dust shown that w/c ratio is increased to 1.6. The ideal percentage of the replacement of sand with quarry dust for compressive strength was 55% to 75%. [13] For mortar, crushed rock powder is replaced from 20% to 100% at 20% incremental interval. Basic strength properties of concrete are investigated by replacing natural sand by rock dust at 20%, 30% and 40%, the natural sand can be replaced up to 40% by crushed rock powder for cement mortar purpose. [14] Effect of super plasticizer admixture on properties of concrete are investigated, different percentage dosage of admixture like 0.6%, 0.8%, 1% and 1.2% are mixed in concrete. At 28 days, the compressive strength of concrete with 1% of admixture is more than the conventional concrete without admixture, the compressive strength of concrete is reduced if the dosage of admixture is beyond 1%, over dosing of super plasticizers admixture causes bleeding and segregation. [15] Properties of artificial sand in the concrete are studied, fine aggregate is replaced with artificial sand with 0% to 100% with an increment of 20% and natural sand can be replaced with 60% to 80% of artificial sand. [16] Studies are conducted on the usage of quarry dust as 100% substitutes for fine aggregate, different mix design methods like Indian Standards (IS), American Concrete Institute (ACI), United States Bureau of Reclamations (USBR) are done for both conventional concrete and quarry dust concrete. Tests are conducted on cubes and beams to study the compressive strength, flexural strength and durability of concrete using quarry dust and are nearly 10% more than the conventional concrete. [17] Usage of fiber reinforced concrete (FRC) is increasing due to its various advantages. Samples were prepared by using various fiber contents starting from 0 to 6% of with an increment of 0.5% to find compressive strength, split tensile strength and flexural strengths of concretes and the strength of the concrete is increasing as the fiber content is increased up to some extent. [18] Concrete is a basic material for the construction. Metakaolin has been used in the concrete as supplementary material. Concrete with 35 MPa is used and all the material properties are compared with conventional concrete and modified concrete.

III. MATERIAL PROPERTIES

The concrete mix is obtained from concrete forming materials and should be according to Indian Standards. The additional supplementary materials that are added along the concrete forming materials are copper slag, rock dust, polypropylene fiber and super plasticizer admixture.

The concrete that is formed with only cement, fine aggregate, coarse aggregate and water is known as conventional concrete, if any other extra material that is added apart from these four materials, then it is known as modified concrete. The following section discusses about all the materials and their properties that are used in this study.

A. Cement

The role of cement in concrete production is that, it acts like a binding material which binds all the materials that are used for obtaining concrete when water is added. The cement shows best result when the water is according to w/c ratio. 0.45 is the w/c ratio chosen. Only Ordinary Portland Cement (OPC) of any grade can be used, OPC 53 grade which is manufactured from Cement Corporation of India (CCI) has been used. The cement that is used should be according to American Society for Testing Materials (ASTM) and according to Indian Standard (IS 12269:1987), the cement that is used falls under Type 1. The cement should be sieved from 90µ IS sieve. Few properties of CCI OPC 53 grade is shown below table.

Table-I: Physical Properties of Ordinary Portland Cement

S.No	Physical Properties	As per CCI Guidelines
1.	Fineness-Minimum Specific Surface (cm^2/gm)	225
2.	Initial Setting Time	Not less than 60 minutes
3.	Final Setting Time	Not less than 600 minutes
4.	Soundness-Expansion by Le-Chatelier (mm) 10 (max)	5 (max)
5.	Soundness-Expansion by Autoclave (%)	0.8 (max)
6.	Minimum Compressive Strength for 3 days (kg/cm^2)	27
7.	Minimum Compressive Strength for 7 days (kg/cm^2)	37
8.	Minimum Compressive Strength for 28 days (kg/cm^2)	53

B. Fine Aggregate

Fine aggregate is the small size filler material, it fills the gap that is formed when cement and coarse aggregate are mixed in dry state, the fine aggregate that is used is sieved from IS 4.75 mm sieve, and according to IS 383:1970. Mostly used fine aggregate material is river sand. Other supplementary material can also be used as a partial replacement of fine aggregate are rock dust and copper slag. There is no sieving process done for supplementary material. The river sand that is used for study purpose is obtained locally in Telangana State.

C. Copper Slag

Copper slag is the material that is obtained after the smelting process of copper, it comes under the category of industrial waste as shown in fig.1. It is used in concrete production as replacement of cement and sand due to silica content in it, hence in this study it is used as partial replacement of fine aggregate. Replacement of fine aggregate by 40% of copper slag gave best result, the different proportions of copper slag that are used are from 0% to 50% replacement with an interval of 5% increment. Across the world around 33 tons of copper slag is generated. The copper slag that is used for project purpose is obtained from Chennai. Copper Slag has chemical properties, these chemical properties are tested by Lucid Laboratories. The following table shows the chemical properties that are obtained after testing dry copper slag specimen.

Table-II: Chemical Composition of Copper Slag

S.No.	Parameters	Results (% by mass)
1.	Silica (SiO_2)	32.24
2.	Iron (Fe_2O_3)	58.46
3.	Alumina (Al_2O_3)	3.59
4.	Titanium (TiO_2)	0.24
5.	Calcium (CaO)	2.63
6.	Magnesium (MgO)	0.66
7.	Potassium (K_2O)	0.05
8.	Sodium (Na_2O)	0.10
9.	Manganese (MnO)	0.04
10.	Phosphorous (P_2O_5)	0.14
11.	Vanadium as (V_2O_5)	0.01
12.	Copper as (CuO)	0.12
13.	Loss on Ignition	1.63

Fig.1. Copper Slag

D. Rock Dust

Rock dust is the material that is obtained after crushing rocks, it comes under the category of by-products as shown in fig.2. It can be added to concrete mix as partial replacement of fine aggregate and cannot be used as full replacement of river sand because it is the end product and does not have enough strength. The various proportions of rock dust that are used for study purpose is 0% to 50% at 5% increment. The rock dust is obtained locally.

Fig.2. Rock Dust

The various proportions of rock dust and copper slag that are used for this particular study are discussed in section IV.

E. Coarse Aggregate

Coarse aggregate is the material that are larger size filler materials, it is used as part of concrete mix is it acts as inert filler material for concrete, the material that is used is crushed granite rocks. The coarse aggregate should be sieved from IS 20 mm sieve and retain on 4.75 mm sieve from IS Sieve and according to IS 383:1970.

F. Water

Water is an integral part of concrete production the quality of water should be maintained in order to get best performance of concrete. Water that is used should be potable and according to IS 456:2000. It plays a major role in hydration of concrete and overall properties of concrete, it is used for obtaining concrete mix and it is also used for curing of concrete samples. The water is added to dry concrete mix as per particular water cement ratio. Water cement ratio changes when weight of cement changes. The water is collected from borewell of Institute of Aeronautical Engineering (IARE).

G. Polypropylene Fiber

The additional supplementary material that is used a part of concrete producing materials are fibers. The type of fiber that is used is "Recron 3S Virgin Polypropylene Fiber", as shown in fig.3 it is procured from Reliance Industries. The concrete in which fibers are mixed is known as fiber reinforced concrete. This type of fiber is added to concrete mix to improves the toughness of the concrete specimen and reduce shrinkage cracks. The polypropylene fiber that is used is a virgin polyester and polypropylene monofilament fiber. Various studies are done on adding of polypropylene fiber to concrete mix and concluded that fiber can be added up to 1.5% volume of concrete. If the fiber content is beyond 1.5% volume of concrete, then the concrete mix becomes fibrous and strength of the concrete gets reduced. Hence the fiber content is chosen as 1.5% volume of concrete. The cracks are merely visible on the concrete specimen even after failure of the specimen when polypropylene fiber is added as shown in fig. 11, various studies that are mentioned in literature contains addition of polypropylene fiber to copper slag. But for this study, the polypropylene fiber is added along rock dust and copper slag combination.

Fig.3. Polypropylene Fiber

H. Super Plasticizer Admixture

The super plasticizer admixture that is used for project study is "Conplast SP430DIS", it is a chloride free and it is based on selected sulphonated naphthalene formaldehyde, it is a brown solution which instantly disperses in water as shown in fig.4. The super plasticizer that is used complies with IS:9103, BS:5075 and ASTM-C-44944 Type 'A' and Type 'G' depending on the dosage. It is has been specially formulated to give high water reductions without loss of workability. It provides excellent acceleration of strength gain at early ages and major increase in strength at all ages by significantly reducing water demand in a concrete mix. It improves the workability of concrete, durability of concrete by increasing ultimate strength and reducing concrete permeability. It is used to produce high workability requiring little or no vibration during placing. The properties of super plasticizer admixture are shown below which are mentioned in company guidelines.

Specific gravity is 1.2±0.02, chloride content is nil (as per BS 5075 part I), air content is as per IS 9103. It is compactible and it is used with all types of cement expect high alumina cement, it is compacted with other types of admixtures when added separately to the mix. Site trails should be carried out to optimum dosages. It is used to produce flowing concrete that requires no compaction and some minor adjustments may be done to produce high workable mix without segregation, cohesion is improved due to dispersion of cement particles which minimizes segregation and improving surface finish. It gives large increase in workability without significant changes in compressive strength, it may be used to produce substantial water reduction resulting in a considerable increase in compressive strength, reduction in w/c ratio enables increase in density and impermeability thus enhancing durability of concrete.

The optimum dosage is determined by site trails with concrete mix which enables the effects of workability, strength gain or cement reduction is measured. Site trails should be compared with mix containing no admixture. As a guide, the rate of addition is generally in the range of 0.5-2 kg/100 kg of cement. From various studies it is concluded that super plasticizers admixture is added up to 1%, but for this study, the amount of super plasticizer admixture added to cement is 1 kg/100 kg of cement is used which gave the best result in compressive strength of conventional concrete. Below table shows the dosage of super plasticizers admixture to cement paste. This process is done with the help of marsh cone test apparatus. Different percentages of dosages of super plasticizers admixture (0.2%, 0.4%, 0.6%, 0.8% and 1%) is mixed with cement paste and the time of flow from marsh cone test apparatus fig.5 is recorded which shown in below table.

Table-III: Dosage of Addition of Super Plasticizing Admixture to Cement Paste

S.No	Dosage of Addition of Super Plasticizers Admixture	Time of Flow from Marsh Cone Apparatus
1.	0.2% (4 ml)	1.55 sec
2.	0.4% (8 ml)	2.54 sec
3.	0.6% (12 ml)	2.13 sec
4.	0.8% (16 ml)	1.42 sec
5.	1% (20 ml)	1.25 sec

Fig.4. Super Plasticizers Admixture

Fig.5. Marsh Cone Test Apparatus

IV. EXPERIMENTAL PROCEDURE

The experimental procedure involves testing of cube specimen for conventional concrete and modified concrete, testing of cylinder specimen for conventional concrete and modified concrete and testing of prismatic beams specimen for conventional concrete and modified concrete specimen. This experimental procedure involves mix design of M30 grade concrete that is used for project purpose.

A. Compressive Strength of Conventional Concrete and Modified Concrete

The compressive strength testing machine of 2000kN capacity is used to determine the compressive strength as shown in fig.6. Compressive strength test of the concrete specimen is done on the hardened state of concrete to know the characteristic compressive strength of the concrete. This type of test is conducted on standard cast iron cube moulds of size 150mmx150mmx150mm and according to IS 516:1959. The compressive strength is done for conventional concrete and modified concrete. Total number of cube specimens that are casted are 72 (Copper Slag Rock Dust Polypropylene Fiber) CSRDPPF samples which includes conventional concrete and modified concrete as shown in fig.9 and fig.10. Total number of studies that are conducted are 12, in each study six cubes are casted. First three cubes are tested after 7 days of curing and the average value is noted, this value is known as compressive strength of concrete for 7 days and rest three cubes are tested after 28 days of curing and the average value is noted, this value is known as compressive strength of concrete for 28 days. This compressive strength of concrete determines the strength of the concrete and grade of the concrete mix. Modified concrete samples involves different proportions of copper slag and rock dust and polypropylene fiber at constant percentage. The compressive strength of the concrete is [Load/Area] N/mm^2

Fig.6. Compressive Strength Testing Machine

B. Split Tensile Strength for Conventional Concrete and Modified Concrete

The split tensile strength testing machine of 2000kN capacity which is used to determine the split tensile strength is shown in fig.7. The split tensile strength test is done on hardened state of concrete of cylinder specimens. The cylinder specimen that is used for testing is made up of standard cast iron cylinder mould of size 150mmx300mm and as per IS 516:1959. The split tensile strength is done for conventional concrete and modified concrete samples as per IS 5816:1999. Total number of samples that are studied are 24 CSRDPPF samples which involves conventional concrete and modified concrete. Total number of studies that are conducted are 12, in each case study two cylinders are casted in which one cylinder is tested after 7 days and curing and one cylinder is tested after 28 days curing, the tensile strength of concrete is obtained from this test procedure.

The tensile strength of concrete is [2x load/Aπ] N/mm^2. Modified concrete specimen includes different proportion of copper slag and rock dust, polypropylene fiber at constant volume percentage. The sample cylinder after breaking is shown in fig.11 and the CSRDPPF cylinders are shown in fig.9 and fig.10.

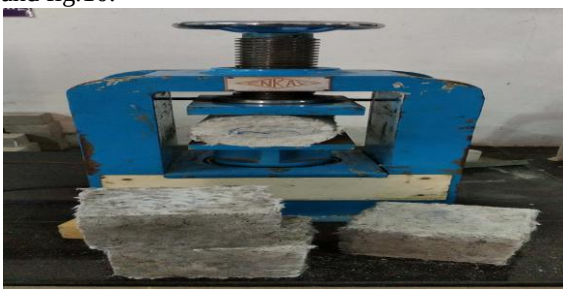

Fig.7. Splite Tensile Strength Tetsing Machine

C. Flexural Strength for Conventional Concrete and Modified Concrete

The flexural strength testing machine is of 100 kN capacity that is used to determine flexural strength is shown in fig.8. The flexural strength test is done on hardened concrete prismatic beams. The prismatic beam that is used for testing is made up of standard cast iron prismatic beams of size 150mmx150mm75mm as per IS 516:1959. The flexural strength is conducted for conventional concrete specimens and modified cocrete specimen. Total number of samples that are studied are 12 CSRDPPF samples which involves conventional concrete and moddified concrete as shown in fig.9 and fig.11. Flexural strength of concrete is done after 28 days of curing. Modified concrete specimen includes various proportions of copper slag, rock dust and polypropylene fiber at constant percentage. The flexural strength of concrete is [3pa/bd^2] N/mm^2

Fig.8. Split Tensile Strength Testing Machine

D. Mix Design

Mix design is the process of selecting suitable materials of the concrete and determining their proportions for producing concrete mix of maximum strength, the concrete mix is designed as per IS 10262:2009, IS 456:2000 and SP23. The target mean strength for M30 grade concrete as per IS code book is 38.25 N/mm^2. The mix proportions that are followed in this study is shown below table.

Table-IV: Mix Proportion of M30 Grade Concrete

S.No	Materials	Weight (kg/m^3)
1.	Cement	394
2.	Water	197
3.	Fine Aggregate	732
4.	Coarse Aggregate	1139
5.	Water Cement Ratio	0.45
6.	Super Plasticizer Admixture	1 kg/100 kg of cement
7.	Polypropylene Fiber	1.5% Volume of Concrete

The fine aggregate weight contains different proportions of copper slag, rock dust and constant proportion of sand. As discussed in above sections regarding 12 case studies have been done for this study are shown below

CSRDPPF 1: Conventional Concrete.

CSRDPPF 2: 50% replacement of sand by rock dust, 0% replacement of sand by copper slag and 1.5% volume of fiber.

CSRDPPF 3: 45% replacement of sand by rock dust, 5% replacement of sand by copper slag and 1.5% volume of fiber.

CSRDPPF 4: 40% replacement of sand by rock dust, 10% replacement of sand by copper slag and 1.5% volume of fiber.

CSRDPPF 5: 35% replacement of sand by rock dust, 15% replacement of sand by copper slag and 1.5% volume of fiber.

CSRDPPF 6: 30% replacement of sand by rock dust, 20% replacement of sand by copper slag and 1.5% volume of fiber.

CSRDPPF 7: 25% replacement of sand by rock dust, 25% replacement of sand by copper slag and 1.5% volume of fiber.

CSRDPPF 8: 20% replacement of sand by rock dust, 30% replacement of sand by copper slag and 1.5% volume of fiber.

CSRDPPF 9: 15% replacement of sand by rock dust, 35% replacement of sand by copper slag and 1.5% volume of fiber.

CSRDPPF 10: 10% replacement of sand by rock dust, 40% replacement of sand by copper slag and 1.5% volume of fiber.

CSRDPPF 11: 5% replacement of sand by rock dust, 45% replacement of sand by copper slag and 1.5% volume of fiber.

CSRDPPF 12: 0% replacement of sand by rock dust, 50% replacement of sand by copper slag and 1.5% volume of fiber.

Fig.9. CSRDPPF Samples in curing tank

Fig.10. CSRDPPF Cube specimens and CSRDPPF cylinder specimen before testing

Fig.11. CSRDPPF Cylinder Specimen after testing

Fig.12. CSRDPPF Beam Specimen after testing

V. RESULTS AND DISCUSSIONS

The results involves test results of compressive strength for conventional concrete and modified concrete for 7 days and 28 days of curing, split tensile strength test for conventional concrete and modified concrete for 7 days and 28 days of curing and flexural strength test for conventional concrete and modified concrete for 28 days of curing are shown in form of graphical representation.

A. Compressive Strength for Conventional Concrete and Modified Concrete

Compressive strength test results values for conventional concrete and modified concrete for 7 days and 28 days of curing are shown in below graph Fig.13

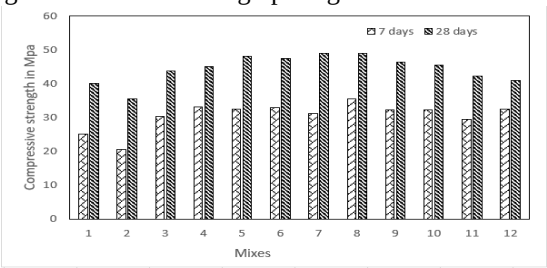

Fig.13. Compressive Strength for 7 days and 28 days of curing for conventional concrete and modified concrete

The compressive strength of conventional M30 grade concrete at 28 days was 40 N/mm^2, but actual target mean strength for M30 grade concrete at 28 days according to IS 10262:2009, was 38.25 N/mm^2, the reason of obtaining more compressive strength are adding of super plasticizers admixture at a controlled dosage, the type of super plasticizer admixture that contains sulphonated naphthalene formaldehyde. This type of admixture is used to get early strength to concrete, to produce high workable concrete and to get more strength after 28 days of curing The sample with 20% rock dust, 30% copper slag and 1.5% fiber gave the best result when compared to sample with 0% copper slag, 50% rock dust and 1.5% fiber, because of silica content mixed in copper slag, silica plays a major role in strength of concrete. The sample with 20% sand replacement by rock dust, 30% sand replacement by copper slag and 1.5% fiber gave 27.7% more strength than sample with 0%sand replacement by copper slag, 50% sand replacement by rock dust and 1.5% fiber and it is 22.6% more than strength of conventional concrete. Hence copper slag and rock dust at 30:20 can be replaced up to 50% for sand replacement and polypropylene fiber content at 1.5% can be used to get best results in modified concrete category.

B. Split Tensile Strength for Conventional Concrete and Modified Concrete

Split tensile strength test results values for conventional concrete and modified concrete for 7 days and 28 days of curing are shown in below fig. 14

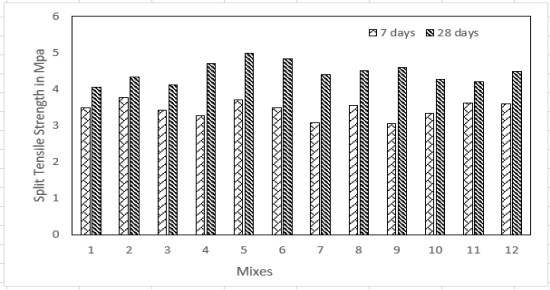

Fig.14. Split Tensile Strength for 7 days and 28 days of curing for conventional concrete and modified concrete

The split tensile strength of conventional M30 grade concrete at 28 days was 4.05 N/mm^2, the split tensile strength value of concrete is very low because the concrete is very weak in tensile strength. The sample with 35% rock dust, 15% copper slag and 1.5% fiber gave the best result when compared to the sample with 45% rock dust, 5% copper slag and 1.5% fiber. The sample with 35% sand replacement by rock dust, 15% sand replacement by copper slag and 1.5% fiber gave 17.27% more strength than the sample with 45% sand replacement by rock dust, 5% sand replacement by copper slag and 1.5% fiber and it is 18.68% more strength than conventional concrete.

C. Flexural Strength for Conventional Concrete and Modified Concrete

Flexural strength test values for conventional concrete and modified concrete for 28 days of curing are shown in below fig. 15

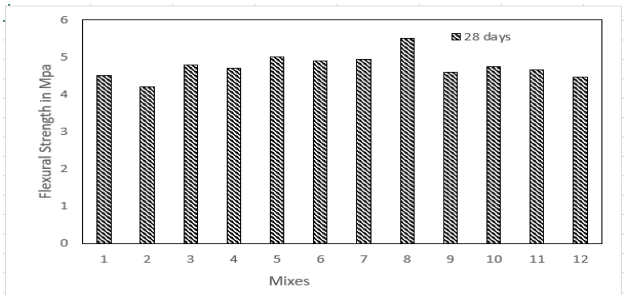

Fig.15. Flexural Strength for 28 days of curing for conventional concrete and modified concrete

The flexural strength of conventional M30 grade concrete at 28 days was 4.5 N/mm^2. The sample with 30%copper slag, 20% rock dust and 1.5% fiber gave the best results when compared to sample 50% rock dust, 0% copper slag and 1.5% fiber. The sample with 30% sand replacement by copper slag, 20% sand replacement by rock dust and 1.5% fiber is 23.64% more than sample with 50% sand replacement by rock dust, 0% sand replacement by copper slag and 1.5% fiber and 18.19% more than conventional concrete.

VI. CONCLUSIONS

The following conclusions were drawn from the study.

1. The compressive strength of concrete was found for conventional concrete and modified concrete for 7 days and 28 days of curing. The compressive strength of modified concrete gave best performance when compared to conventional concrete.
2. The split tensile strength of concrete was found for conventional concrete and modified concrete for 7 days and 28 days of curing, the values that are obtained are very low because concrete is weak in tensile force. The split tensile strength of modified concrete is more than split tensile strength of conventional concrete.
3. The flexural strength of concrete was found for conventional concrete and modified concrete for 28 days of curing. The flexural strength of modified concrete gave better performance than compressive strength.
4. The reason of getting more compressive strength, more tensile strength and more flexural strength of modified concrete when compared to conventional concrete is due to additional supplementary materials that are added as partial replacement of sand.
5. Copper slag contained silica up to 32.24% to the total weight of copper slag that was used for the project study, role of silica in concrete is that it develops the strength of the concrete and cement also contains silica content.
6. Polypropylene fiber is used in concrete mix in order to improve the toughness of the concrete, which lead to formation of top surface crack even after failure of specimen.
7. Rock dust can be used as partial replacement of fine aggregate up to 30-35%, the reason why it is replaced at small amount is that it is a end product after crushing rocks and doesn't contain much strength.

REFERENCES

1. Blessen Skariah Thomas, Anoop, Sathish Kumar "Utilization of Solid Waste Particles as Aggregates in Concrete" Conference Title, Sci Verse Science Direct, Procedia Engineering 38 (2012), pp.3789-3796.
2. Manoj Kumar Dash, Sanjaya Kumar Patro, Ashoke Kumar Rath "Sustainable Use of Industrial-Waste as Partial Replacement of Fine Aggregate for Preparation of Concrete-A Review, International Journal of Sustainable Built Environment 5 (2016), pp.484-516
3. Divya Dharan, Aswathy Lal "Study the Effect of Polypropylene Fiber in Concrete" International Research Journal of Engineering and Technology (2016) Vol. 3(6), pp.616-619.
4. Vijayaprabha Chakrawarthi, Brindha Darmar, Ashok Kumar Elangovan "Copper Slag Concrete Admixed with Polypropylene Fibers" Gradevinar 68 (2016) 2, pp.95-104.
5. Vijayaprabha, Brindha, Siva "Durability Performance of Copper Slag Concrete Admixed with Polypropylene Fiber" Journal of Structural Engineering (2017) Vol. 43(6), pp.598-606.
6. Kolli. Ramujee "Strength Properties of Polypropylene Fiber Reinforced Concrete" International Journal of Innovative Research in Science, Engineering and Technology (2013) Vol. 2(8), pp.3409-3413.
7. Vimarsh, Basavana Gowda, Ramesh "Study on Strength Properties of Fiber Reinforced Concrete by Partial Replacement of Sand by Copper Slag" International Journal of Civil and Structural Engineering Research (2014), Vol. 2(1) pp.104-110.
8. Madhavi, Swamy Raju, Deepak Mathur "Polypropylene Fiber Reinforced Concrete-A Review" International Journal of Emerging Technology and Advanced Engineering (2014) Vol. 4(4), pp.114-119.
9. Manoj Singal, Sumesh Jain "An Experimental Investigation of Concrete Properties M30 due to Addition of Copper Slag" International Journal for Technology Research in Engineering (2017), Vol. 5(4), pp. 3073-3078.
10. Malagavelli Venu "Development of Cement Concrete with Non-Biodegradable Waste Products and Supplementary Materials" (2014).
11. Lakhan Nagpal, Arvind D, Sumit Kumar "Evaluation of Strength Characteristics of Concrete using Crushed Stone Dust as Fine Aggregate" International Journal of Innovative and Exploring Engineering (2013), Vol. 2(6), pp.102-104.
12. Chandana Sukesh, Katakam Balakrishna, Sri Lakshmi Sai Teja, Kanakambara Rao "Partial Replacement of Sand with Quarry Dust in Concrete", International Journal of Innovative and Exploring Engineering (2013), Vol. 2(6), pp.254-258.
13. Nagabhushana and Sharada Bai H "Use of Crushed Rock Powder as Replacement of Fine Aggregatein Mortar and Concrete", Indian Journal of Science and Technology Vol. 4(8), pp.917-922.
14. Salahaldein Alsadey "Effect of Super Plasticizing Admixture on Properties of Concrete", Proceedings of International Conference on Transport, Environment and Civil Engineering (ICTECE 2012) August 25-26, 2016 Kuala Lumpur (Malaysia), pp.132-134.
15. Rajendra. P, Mogre, DhanajayK.Parbat and Sudhir P. Bajaj "Feasibility of Artifical Sand in Concrete", International Journal of Engineering Research & Technology, (2012) Vol.2(7), pp.1606-1610.
16. Ilangovana. R, Mahendrana. N and Nagamani. K "Strength and Durability properties of Concrete Containing Quarry Rock Dust as Fine Aggregate", ARPN Journal of Engineering and Applied Sciences, (2008) Vol. 3(5), pp.20-26.
17. Venu Malagavelli, Neelakanteswara Rao Paturu "Polyester Fibers in the Concrete an Experimental Investigation", Advanced Materials Research, Trans Tech Publications (2011) Vol.261, pp.125-129.
18. Venu Malagavelli, S. Angadi, JSR Prasad, S. Joshi "Influence of Metakaolin in Concrete as Partial Replacement of Cement", International Journal of Civil Engineering and Technology(2018) Vol.9(7), pp.105-111.
19. IS 12269:1987 Specification for OPC 53 Grade.
20. ASTM: American Society of Testing Material.
21. IS 383:1970, Specification for Coarse and Fine Aggregate from Natural Source for Concrete.
22. IS 460:1962, Specification for Test Sieves.
23. IS 456:2000, Plain and Reinforced Concrete-Code of Practice.
24. IS 9103:1999, Specification for Concrete Admixture.
25. BS 5075-3:1985, Concrete Admixtures Specification for Super Plasticizing Admixture.
26. IS 516:1959, Method of Tests for Strength of Concrete.
27. IS 5816:1999, method of test Splitting tensile Strength of Concrete.
28. IS 10262:2009, Concrete Mix Proportioning.
29. SP 23, Handbook on Concrete Mixes: Bureau of Indian Standards

AUTHORS PROFILE

Keshav Krishna Molugu Venugopal, Pursuing M.tech in Structural Engineering in Department of Civil Engineering, Institute of Aeronautical Engineering, Dundigal, Hyderabad. B.tech in Civil Engineering in Department of Civil Engineering from St. Martins Engineering College, Dhulapally, Kompally, Hyderabad.

Venu Malagavelli, working as Professor in the Department of Civil Engineering, Institute of Aeronautical Engineering, Dundigal, Hyderabad. He obtained PhD and ME from Bits Pilani and B.Tech from JNTUCEH, Hyderabad. He published more than 30 papers in International and National Journals and conferences. His area of research is development of new concrete using industrial waste materials. He is a life member of IEI, ICI, IIBE, ISTE etc. He received travel grants from DST and CICS.

Dr. J S R Prasad, is a professor in the Department of Civil Engineering, Institute of Aeronautical Engineering, Hyderabad and has 15 years of experience in industry, research and academics. He obtained B.Tech from Andhra University, Vishakapatnam, M.tech from Indian Institute of Technology, Roorkee and was conferred doctorate by Indian Institute of technology, Roorkee in 2009. He has published 15 research papers in national and international journals. He is a **FELLOW** of the Institute of Engineers (India), Life member of Indian Society of Earthquake Technology (ISET), Indian Concrete Institute (ICI) and Indian Society of technical Education.