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# Experimental Investigation on Concrete by use of Manufactured Crushed Sand as a Fine Aggregate

**Pratibha C. Borkar[1], Dr. Tushar G. Shende[2]**

*Civil Engineering Department, G.H. Raisoni Institute of Engineering and Technology, Nagpur (M.S.)*

**Abstract –** *Sand is a natural granular material consisting of finely divided mineral particles depending on the local sources and conditions of the rocks. The sand must be well classified, dry, hard, strong, clean and free of clay, dirt, organic matter and adhesion. It must not contain harmful impurities, such as iron, coal, bones, shells, mica, alkalis, or other minerals in such a form or in such quantities as to affect the curing, strength and durability of the concrete. BIS Guidelines IS: 383-2016 for selection and testing of Coarse and Fine aggregates are available. Generally, Sand is classified as Zone I, Zone II, Zone III and Zone IV (i.e. Coarser to Finer).*

*Generally, river sand is used as fine aggregate in concrete. But, due to administrative reasons, sand mining is restricted and scarcity of sand arises, which affects the construction project sites and financial aspects. The heavy demands in construction activities force to find suitable substitutes which are cheap and easy way of getting substitute for natural sand. Environmental concerns are also being raised against uncontrolled extraction of natural sand. The arguments are mostly in regards to protecting riverbeds against erosion and the importance of having natural sand as a filter for ground water. The above concerns, combined with issues of preserving areas of beauty, recreational value and biodiversity, are an integral part of the process of most local government agencies granting permission to aggregate producers across the world.*

*This paper presents comparative study based upon experimental investigation work on important properties of concrete. The compressive strength of concrete with approximately 40%,60%,80% replacement of natural sand by manufactured crushed sand to reveal higher strength as compared to reference mix is attempted. To get better strength and higher water cement ratio for better workability, crushed sand to provide alternative to natural sand maintaining the environment as well as economical balance is attempted. Crushed sand can be suitable substitute for river sand at reasonable cost. The manufactured crushed sand is expected to have good gradation and nice finish .The purpose is to study behaviour of strength of concrete in percentage variation of fine aggregate (natural sand and manufactured crushed sand) with percentage variation in cement and fly ash.*

## I- INTRODUCTION

Non-availability of natural sand at reasonable cost, forces to search for alternative material. Manufactured sand qualifies itself as suitable substitute for river sand at reasonable cost. The manufactured sand has good gradation and nice finish, which was lacking in natural sand. Due to the irregular particle shape of the manufactured sand, in addition to the reduced amount of water cement ratio, manufactured sand is more important for high strength concrete mixes. Manufactured sand offers important economic advantages in regions where the availability of natural sand is scarce or in cities where transportation cost is high. The use of manufactured crushed sand in the construction industry helps to prevent unnecessary damages to the environment and provide optimum exploitation of the resources. Manufactured sand offers a viable alternative to the natural sand, if the problems associated with the workability of the concrete mix can be resolved by using

super plasticizer. The addition of super plasticizer to a concrete mix with manufactured sand allows the mix to have a better workability. Environment friendly approach is most important aspect and is touched due to understanding of earth life balance along with pollution free society [1, 14]. The strength and durability related tests have demonstrated superior strength and durability characteristics of HPC mixes containing silica fume and M-Sand. The dwindling sources of natural sand, and its high cost could encourage the adoption of M-sand.

The environmental friendly high performance concrete with M-sand and silica fume can be effectively used in the construction industry to minimize the environmental pollution. The industrial by products silica fume and manufactured sand can be advantageously used in producing high performance concrete. Manufactured sand can be suitably used in making structural grade concrete by replaced 100% with natural sand [2, 4, 10]. The 50% of cement can be replaced with GGBS which result in resistance to penetration of water as proved by rapid chloride penetration test and water absorption test, is increased with increasing proportion of M-Sand Concrete. The durability of M-sand concrete under acid and sulphate attack is higher inferior to that of conventional concrete [5,7]. The usage of M-sand for high strength high performance concrete provides stronger and durable concrete structures which will be economical as well as environment friendly by preserving natural resources such as river sand. At the time of concrete used in crushed sand, it always used admixture for workability and strength improvement of concrete [6,11]. The split tensile strength T 28 days of M25, M30, M40 grade of concretes was the optimum mix for achieving higher tensile strength is 50 % natural sand 50 % manufactured sand. The required workability can be achieved by using water reducing admixture. The river sand can be fully replaced with manufactured sand. Compressive strength of concrete is increasing when the river sand is replaced by MS [12,13]. Durability test was conducted to analyse the cracking effect of MS. The MS mortar cubes has similar property and gives same workability and strength while plastering.

Use of crushed sand has to control with adequate and balanced weight batching [15, 16]. The compressive strength of concrete has been increased up to 6% when sand is replaced by crushed sand in totality and subsequently slump value also increases. The value of slump is increased after addition of 1% of admixture for all proportions of sand replacement and maximum slump value is obtained at 50% replacement of natural sand with artificial sand [17, 18]. Concrete by partial replacement of sand by crushed sand and cement fly ash mortar mixtures with sand gradation is obtained. After 90 days, there is a decrease in the absorption capacity of all mortar mixtures [20].

| Properties | 20 mm Aggregate | 10 mm Aggregate |
|---|---|---|
| Combine Flakiness & Elongation Index-% | 26.72 | 37.03 |
| Impact value-% | 13.17 | 14.64 |
| Water Absorption-% | 0.890 | 1.310 |
| Specific Gravity | 2.873 | 2.829 |
| Loose Bulk Density kg/ltr | 1.530 | 1.475 |
| % passing 75 Micron-% | 0.48 | 0.58 |

## II-METHODOLOGY

Cement, Ordinary Portland cement of 43Grade was used. Course aggregate includes both 20mm and 10mm aggregate. Fine aggregate includes both Natural sand (River sand from Wainganga River) and Crushed sand (Manufactured crushed sand from K.S.Metals crusher plant).Fly ash was obtained from power plant located near Nagpur. Technoplast S-300(Asian Paints) was used as Chemical Admixture in mix. Drinking water was used for preparation of concrete mix from source at plant site free from impurities. Material collected from various sources for preparation of concrete as per type and source given below. Cement, Fly ash, Admixture, Course aggregate (20mm, 10mm), fine aggregate (Natural/Crushed sand) sample was initially tested for quality check.

### Testing of Material

Various tests are done on collected material as per IS specification. (IS: 383-2016 and IS 2386 part I, II, III, IV).Test result of material used for preparation Mix design of M25 grade of concrete is as given in tabular form. Table A to F shows below test result of materials used for concrete mix preparation.

Table 1: Test report of Fine aggregate (Crushed sand and Natural sand)

| Properties | Crushed sand | Natural sand |
|---|---|---|
| Fineness modulus of sand | 3.38 | 2.79 |
| Water absorption-%(IS 2386 part III) | 2.20 | 1.20 |
| Specific Gravity-(IS 2386 part III) | 2.74 | 2.64 |
| Loose Bulk Density kg/Ltr-%(IS 2386 part III) | 1.693 | 1.455 |

| Sieve Analysis (IS 2386 Part-1) | Test Results of Manufactured crushed sand | Test Results of Natural River sand | Requirement as per IS:383-2016(Zone II) |
|---|---|---|---|
| Sieve size ,mm | %Passing | %Passing | |
| 10 | 100.00 | 98.92 | 100 |
| 4.75 | 77.00 | 95.08 | 90-100 |
| 2.36 | 65.46 | 93.42 | 75-100 |
| 1.18 | 47.46 | 84.10 | 55-90 |
| 0.6 | 33.40 | 46.10 | 35-59 |
| 0.3 | 22.54 | 2.38 | 8-30 |
| 0.15 | 15.58 | 0.76 | 0-10 |

Table 2: Test report of Course aggregate (20mm and 10mm Aggregate sample) Sieve Analysis test result below satisfy the Requirement as per IS: 2386(Part I, III, IV)

| Test Result of 20mm aggregate | | Test Result of 10mm aggregate | | Requirement as per IS:383-2016 (Zone II) |
|---|---|---|---|---|
| Sieve size mm | % passing | Sieve size mm | % passing | |
| 40 | 100.00 | 12.50 | 100.00 | 100 |
| 20 | 95.49 | 10 | 59.86 | 85-100 |
| 10 | 0.10 | 4.75 | 0.26 | 0-20 |
| 4.75 | 0.00 | 2.36 | 0.00 | 0-5 |

Table 3: Test on Cement-Ultratech OPC43 Grade

| | |
|---|---|
| Consistency | 28.5 % |
| Specific Gravity | 3.10 |
| Initial Setting time | 185 min |
| Final Setting time | 260 min |
| Soundness by Le'chattelier Expansion | 1.0 min |
| Specific surface by Blain's Air | 390 sq.m/kg |
| 3 days compressive strength | 380 Mpa |
| 7 days compressive strength | 49.0 Mpa |
| 28 days compressive strength | 64.0 Mpa |

Table 4: Test on Fly ash

| | |
|---|---|
| Specific Gravity of Fly ash | 2.09 |
| Specific surface by Blain's Air of Fly ash | 339 sq.m/kg |

As per above test results, it shows material fulfilled the requirement as per IS code. Mix design of M25 grade concrete is prepared with %variation in Natural and crushed sand along with %variation in cement and flyash. Concrete cube prepared with different condition of variation in materials at site.

After curing period of concrete cube 7days, 21days, 28days, tests are done for compressive strength of concrete.

## III - EXPERIMENTAL WORK DONE

Compressive strength of concrete cube with variation in material contents as shows below.

Table 5: T-(1) Compressive strength of concrete with 100% N.S. and %variation in Fly ash

| Sr. No. | Concrete cube Age in days | Compressive Strength of concrete Cube (Mpa) | | |
|---|---|---|---|---|
| | | Condition I: M25 OPC+100% N.S. +10%Flyash | Condition II: M25 OPC+100%N.S.+ 20%Flyash | Condition III: M25 OPC+100%N.S.+ 30%Flyash |
| 1 | 7 | 22.09 | 23.73 | 20.93 |
| 2 | 7 | 23.64 | 22.67 | 18.89 |
| 3 | 7 | 22.84 | 24 | 19.24 |
| 4 | 7 | 22.89 | 23.20 | 18.58 |
| 5 | 7 | 23.87 | 24.76 | 19.51 |
| 6 | 7 | 21.42 | 24.18 | 22.71 |
| 7 | 21 | 29.11 | 30.62 | 26.04 |
| 8 | 21 | 30.18 | 30.27 | 23.96 |
| 9 | 21 | 30.58 | 29.56 | 25.38 |
| 10 | 21 | 30.44 | 28.89 | 25.87 |
| 11 | 21 | 29.96 | 27.51 | 27.02 |
| 12 | 21 | 31.64 | 28.36 | 23.96 |
| 13 | 28 | 35.07 | 33.60 | 32.27 |
| 14 | 28 | 37.96 | 34.84 | 29.96 |
| 15 | 28 | 36.18 | 33.07 | 29.24 |
| 16 | 28 | 37.42 | 32.00 | 30.58 |
| 17 | 28 | 36.49 | 33.29 | 29.29 |
| 18 | 28 | 35.38 | 32.13 | 30.22 |

Table 6: T-(2) Compressive strength of concrete with %Variation in Natural /Crushed sand

| Sr. No. | Concrete cube Age in days | Compressive Strength of concrete Cube (Mpa) | | |
|---|---|---|---|---|
| | | Condition I: M25 OPC+60%N.S .+40%C.S. | Condition II: M25 OPC++40%N. S.+60%C.S. | Condition III: M25 OPC+20%N.S .+80%C.S. |
| 1 | 7 | 23.73 | 24.49 | 23.56 |
| 2 | 7 | 24.71 | 22.76 | 21.82 |
| 3 | 7 | 24.00 | 23.82 | 24.27 |
| 4 | 7 | 23.51 | 22.13 | 22.84 |
| 5 | 7 | 25.24 | 24.98 | 21.56 |
| 6 | 7 | 24.67 | 23.87 | 19.42 |
| 7 | 21 | 30.62 | 32.22 | 29.78 |
| 8 | 21 | 31.96 | 33.11 | 31.56 |
| 9 | 21 | 32.93 | 31.60 | 30.49 |
| 10 | 21 | 31.64 | 31.33 | 27.91 |
| 11 | 21 | 30.84 | 32.98 | 29.96 |
| 12 | 21 | 32.40 | 31.78 | 29.11 |
| 13 | 28 | 36.62 | 37.42 | 33.73 |
| 14 | 28 | 37.60 | 37.29 | 35.47 |
| 15 | 28 | 35.07 | 37.69 | 34.71 |
| 16 | 28 | 37.21 | 35.07 | 32.23 |
| 17 | 28 | 35.02 | 34.13 | 30.62 |
| 18 | 28 | 36.13 | 35.38 | 31.47 |

Table 7: T-(3) Compressive strength of concrete with fixed 60% N.S. ,40%C.S. and %variation in Fly ash content

| Sr. No. | Concrete cube Age in days | Compressive Strength of concrete Cube (Mpa) | | |
|---|---|---|---|---|
| | | Condition I: M25 OPC+60%N.S. +40%C.S.+ 10%FlyAsh. | Condition II: M25 OPC+60%N.S .+40%C.S.+20 0%FlyAsh | Condition III: M25 OPC+60%N.S .+40%C.S.+30 0%FlyAsh |
| 1 | 7 | 21.11 | 22.76 | 20.21 |
| 2 | 7 | 23.38 | 23.60 | 21.51 |
| 3 | 7 | 24.36 | 21.82 | 20.53 |
| 4 | 7 | 25.51 | 22.0 | 18.98 |
| 5 | 7 | 24.49 | 23.64 | 20.27 |
| 6 | 7 | 23.47 | 25.11 | 21.29 |
| 7 | 21 | 31.64 | 31.33 | 30.40 |
| 8 | 21 | 31.29 | 32.80 | 28.93 |
| 9 | 21 | 32.93 | 31.60 | 32.09 |
| 10 | 21 | 31.78 | 33.24 | 29.47 |
| 11 | 21 | 32.98 | 32.27 | 28.84 |
| 12 | 21 | 32.67 | 33.51 | 31.51 |
| 13 | 28 | 33.29 | 33.29 | 32.09 |
| 14 | 28 | 34.13 | 34.84 | 30.62 |
| 15 | 28 | 34.76 | 34.18 | 28.62 |
| 16 | 28 | 35.73 | 34.44 | 32.44 |
| 17 | 28 | 34.58 | 33.29 | 31.33 |
| 18 | 28 | 35.33 | 34.18 | 30.58 |

Table 8: T-(4) compressive strength of concrete with fixed 40% N.S. , 60%C.S. and %variation in Fly ash content

| Sr. No. | Concrete cube Age in days | Compressive Strength of concrete Cube (Mpa) | | |
|---|---|---|---|---|
| | | Condition I: M 25 OPC+40%N.S.+ 60%C.S.+ 10%FlyAsh. | Condition II: M25 OPC+40%N.S .+60%C.S.+20 %FlyAsh | Condition III: M25 OPC+40%N.S .+60%C.S.+30 %FlyAsh |
| 1 | 7 | 25.96 | 25.11 | 20.67 |
| 2 | 7 | 25.29 | 23.60 | 22.76 |
| 3 | 7 | 24.22 | 22.76 | 22.09 |
| 4 | 7 | 23.20 | 22.04 | 20.31 |
| 5 | 7 | 24.98 | 24.53 | 18.76 |
| 6 | 7 | 24.09 | 23.60 | 21.91 |
| 7 | 21 | 31.73 | 30.89 | 27.20 |
| 8 | 21 | 32.40 | 31.78 | 26.13 |
| 9 | 21 | 34.40 | 29.96 | 28.53 |
| 10 | 21 | 32.04 | 31.73 | 22.73 |
| 11 | 21 | 33.16 | 29.64 | 26.58 |
| 12 | 21 | 33.07 | 28.80 | 28.36 |
| 13 | 28 | 35.73 | 32.40 | 30.44 |
| 14 | 28 | 35.20 | 33.16 | 29.73 |
| 15 | 28 | 37.56 | 33.24 | 31.20 |
| 16 | 28 | 35.02 | 34.40 | 31.29 |
| 17 | 28 | 36.71 | 32.31 | 32.09 |
| 18 | 28 | 35.73 | 33.26 | 30.13 |

Table 9: T-(5) Compressive strength of concrete with fixed 20 % N.S. ,80%C.S. and %variation in Fly ash content

| Sr. No. | Concrete cube Age in days | Compressive Strength of concrete Cube (Mpa) | | |
|---|---|---|---|---|
| | | Condition I: M25 OPC+20%N .S.+80%C.S. + 10%FlyAsh. | Condition II: M25 OPC+20%N.S .+80%C.S.+2 0%FlyAsh | Condition III: M25 OPC+20%N.S. +80%C.S.+30% FlyAsh |
| 1 | 7 | 21.73 | 20.18 | 20.36 |
| 2 | 7 | 23.38 | 19.16 | 22.04 |
| 3 | 7 | 25.07 | 16.31 | 23.38 |
| 4 | 7 | 20.40 | 17.29 | 21.24 |
| 5 | 7 | 22.80 | 18.89 | 23.02 |
| 6 | 7 | 21.20 | 20.27 | 21.02 |
| 7 | 21 | 30.09 | 23.47 | 28.22 |
| 8 | 21 | 31.51 | 25.16 | 26.04 |
| 9 | 21 | 30.49 | 25.64 | 27.20 |
| 10 | 21 | 28.53 | 28.96 | 28.18 |
| 11 | 21 | 28.36 | 27.24 | 30.40 |
| 12 | 21 | 29.36 | 24.62 | 26.13 |
| 13 | 28 | 32.36 | 29.69 | 29.69 |
| 14 | 28 | 34.84 | 31.29 | 31.78 |
| 15 | 28 | 34.27 | 31.47 | 32.40 |
| 16 | 28 | 33.38 | 30.62 | 30.93 |
| 17 | 28 | 32.62 | 31.78 | 32.98 |
| 18 | 28 | 34.93 | 32.18 | 33.56 |

## IV - RESULT AND DISCUSSION

**T-(1) Compressive strength of concrete with 100% N.S. and %variation in Fly ash**

The average compressive strength of M25 grade of concrete at 7 days ,21days and 28 days with 100% Natural sand and 10%, 20%, 30%variation in Fly ash by reducing cement content shows below,

| Compressive strength of concrete | 7 Days (Mpa) | 21Days (Mpa) | 28Days (Mpa) |
|---|---|---|---|
| Condition I : M25 OPC+100%N.S.+10%Flyash | 22.795 | 30.32 | 36.415 |
| Condition II : M25 OPC+100%N.S.+20%Flyash | 23.755 | 29.20 | 33.155 |
| Condition III III : M25 OPC+100%N.S.+30%Flyash | 19.98 | 26.93 | 31.25 |

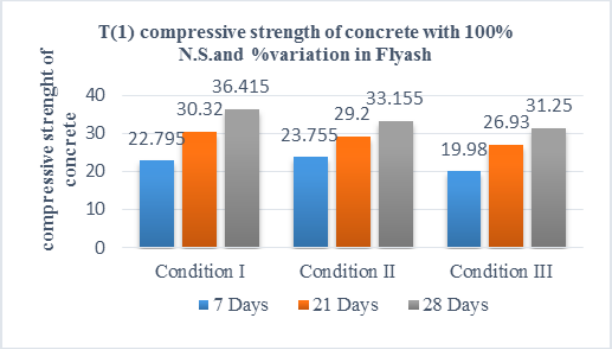


Fig.1- T (1) compressive strength of concrete with 100% N.S. and %variation in Fly ash

From above test result of concrete cube is shows that the targeted compressive strength of concrete is achieved after 28 days of curing in all condition I, II, III of mix. Compressive strength of concrete increased from 7 days to 28 days gradually in above condition of mix. Due to increased content of fly ash from 10%,20%,30% with respect to reducing cement content in mix resulted in lowering of compressive strength of concrete from 36.415 N/mm $^2$ , 33.155 N/mm $^2$ , 31.25 N/mm $^2$ respectively. Recommended for not to increase fly ash contend in mix more than 30%.

**T-(2) Compressive strength of concrete with % Variation in Natural /Crushed sand**

The average compressive strength of M25 grade of concrete at 7 days ,21days and 28 days with % variation in Natural sand and manufactured crushed sand shows below,

| Compressive strength of concrete | 7 Days (Mpa) | 21Days (Mpa) | 28 Days (Mpa) |
|---|---|---|---|
| Condition I : M25 OPC+60%N.S. +40% C.S. | 24.31 | 31.735 | 36.28 |
| Condition II II : M25 OPC+40%N.S. +60% C.S. | 23.675 | 32.17 | 36.165 |
| Condition III : M25 OPC+20%N.S. +80% C.S. | 22.24 | 29.80 | 33.04 |

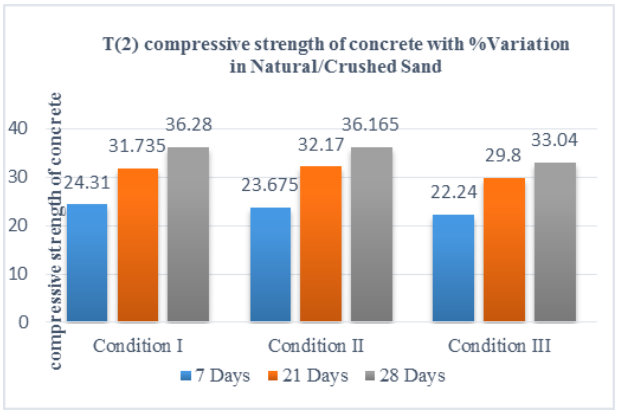


Fig.2- T (2) compressive strength of concrete with % Variation in N.S. /C.S.

From above test result of concrete cube, it shows that the targeted compressive strength of concrete is achieved after 28 days of curing in all condition I, II, III of mix. Compressive strength of concrete increased from 7 days to 28 days gradually in above condition of mix. Due to increased content of crushed sand from 40%,60%,80% with respect to reducing Natural sand content in mix compressive strength of concrete is 36.28 N/mm $^2$ , 36.165 N/mm $^2$ , 33.04 N/mm $^2$ respectively found to be more than targeted compressive strength of M25 grade of concrete. Hence, recommended for to increase crushed sand contend in mix more than 80% wrt to natural sand.

**T-(3) Compressive strength of concrete with fixed % of N.S. /C.S. and %variation in Fly ash**

The average compressive strength of M25 grade of concrete at 7 days ,21days and 28 days with 60% Natural sand and 40% crushed sand with increased 10%, 20%, 30% Fly ash content by reducing cement content shows below,.

| Compressive strength of concrete | 7Days (Mpa) | 21 Days (Mpa) | 28 Days (Mpa) |
|---|---|---|---|
| Condition I : M25 OPC+60%N.S. +40%C.S. +10%Flyash | 23.72 | 32.215 | 34.635 |
| Condition II : M25 OPC+60%N.S. +40% C.S. +20%Flyash | 23.16 | 32.46 | 34.035 |
| Condition III : M25 OPC+60%N.S. +40%C.S. +30%Flyash | 20.485 | 29.775 | 30.945 |

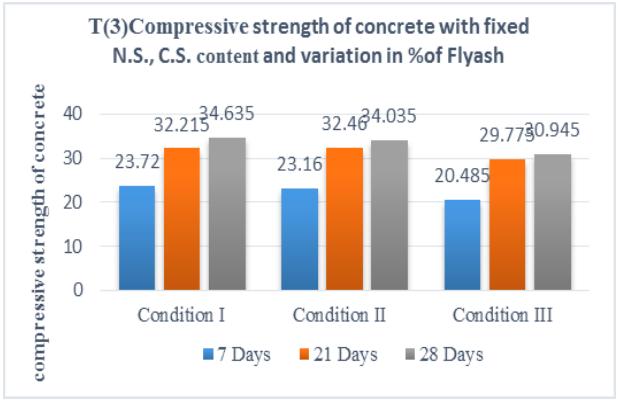


Fig.3- T (3) compressive strength of concrete with fixed % of N.S. /C.S. and %variation in Fly ash

From above test result of concrete cube is shows that the targeted compressive strength of concrete is achieved after 28 days of curing in all condition I, II, III of mix. Compressive strength of concrete increased from 7 days to 28 days gradually in above condition of mix. Due to increased content of fly ash from 10%,20%,30% with respect to reducing cement content in mix resulted in lowering of compressive strength of concrete from 34.635 N/mm $^2$ , 34.035 N/mm $^2$ , 30.945 N/mm $^2$ respectively. Recommended for not to increase fly ash contend in mix more than 30%.

**T-(4) Compressive strength of concrete with fixed % N.S. /C.S. and %variation in Fly ash content**

The average compressive strength of M25 grade of concrete at 7 days ,21days and 28 days with 40% Natural sand and 60% crushed sand with increased 10%, 20%, 30% Fly ash content by reducing cement content shows below,

| Compressive strength of concrete | 7 Days (Mpa) | 21 Days (Mpa) | 28 Days (Mpa) |
|---|---|---|---|
| Condition I : M25 OPC+40% N.S. +60%C.S. +10%Flyash | 24.625 | 32.80 | 35.99 |
| Condition II : M25 OPC+40% N.S. +60%C.S. +20%Flyash | 23.605 | 30.465 | 33.125 |
| Condition III : M25 OPC+ 40%N.S. +60%C.S. +30%Flyash | 21.085 | 27.425 | 30.815 |

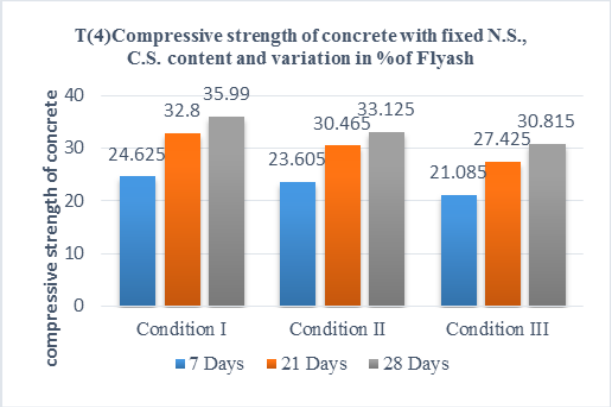


Fig .4-T (4) compressive strength of concrete with fixed % N.S. /C.S. and %variation in Fly ash

From above test result of concrete cube is shows that the targeted compressive strength of concrete is achieved after 28 days of curing in all condition I, II, III of mix. Compressive strength of concrete increased from 7 days to 28 days gradually in above condition of mix. Due to increased content of fly ash from 10%,20%,30% with respect to reducing cement content in mix resulted in lowering of compressive strength of concrete from 35.99 N/mm $^2$ , 33.125 N/mm $^2$ , 30.815 N/mm $^2$ respectively. Recommended for not to increase fly ash contend in mix more than 30%.

**T-(5) Compressive strength of concrete with fixed % N.S. /C.S. and %variation in Fly ash content**

The average compressive strength of M25 grade of concrete at 7 days ,21days and 28 days with 20% Natural sand and 80% crushed sand with increased 10%, 20%, 30% Fly ash content by reducing cement content shows below.

| Compressive strength of concrete | 7 Days (Mpa) | 21 Days (Mpa) | 28 Days (Mpa) |
|---|---|---|---|
| Condition I : M25 OPC+20% N.S. +80%C.S. +10%Flyash | 22.43 | 29.73 | 33.73 |
| Condition II : M25 OPC+20% N.S. + 80%C.S. +20%Flyash | 18.68 | 25.35 | 31.17 |
| Condition III : M25 OPC+20% N.S. +80% C.S. +30%Flyash | 21.845 | 27.7 | 31.89 |

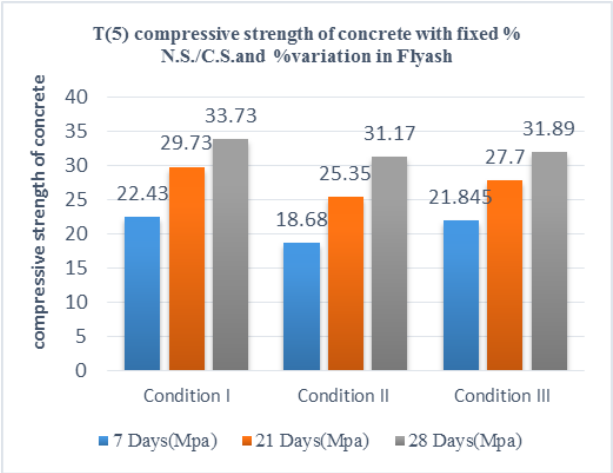


Fig .5 -T (5) compressive strength of concrete with fixed % N.S./C.S.and %variation in Fly ash

From above test result of concrete cube,it is shows that the targeted compressive strength of concrete is achieved after 28 days of curing in all condition I, II, III of mix. Compressive strength of concrete increased from 7 days to 28 days gradually in above condition of mix. Due to increased content of fly ash from 10%,20%,30% with respect to reducing cement content in mix resulted in lowering of compressive strength of concrete from 33.73 N/mm $^2$ , 31.17 N/mm $^2$ , 31.89 N/mm $^2$ respectively. Recommended for not to increase fly ash contend in mix more than 30%.

## V- CONCLUSIONS

Based on the experimental investigations carried out on M25 grade concrete mixes the following conclusions are drawn.

1. The compressive strength of M25 grade of concrete at 28 days with 100% Natural sand and 10%,20%,30%variation in Fly ash by reducing %

cement content is 36.415 Mpa,33.155Mpa,31.25Mpa respectively. The compressive strength of M25 grade of concrete at 28 days with 60%.40% 20%Natural sand and 40%,60%,80%manufactured crushed sand is 36.28 Mpa,36.165 Mpa,33.04 Mpa respectively. The compressive strength of M25 grade of concrete at 28 days with 60%.Natural sand and 40% manufactured crushed sand and 10%,20%,30%increse in fly ash by reducing %cement content is 34.635 Mpa,34.035 Mpa,30.945 Mpa respectively. The compressive strength of M25 grade of concrete at 28 days with 40%.Natural sand and 60% manufactured crushed sand and 10%,20%,30% increse in fly ash by reducing % cement content is 35.99 Mpa, 33.125 Mpa, and 30.815 Mpa respectively. The compressive strength of M25 grade of concrete at 28 days with 20%.Natural sand and 80% manufactured crushed sand and 10%,20%,30% increse in fly ash by reducing % cement content is 33.73 Mpa,31.17 Mpa,31.89 Mpa respectively.

2. From above all test results, it is found that from 40% ,60%, 80% replacement of natural sand with manufactured crushed sand and increase in 10%,20%,30% of fly ash with reducing OPC cement content have achieved permissible compressive strength of concrete at 7 days ,21days and 28days.

3. It recommended to use more than 80% of manufactured crushed sand by replacing natural sand in high grade of concrete. But not to increase fly ash content more than 30% with respect to cement content.

4. From all observations, it is necessary to maintain water cement ratio in concrete with manufactured crushed sand always used admixture for workability and strength improvement of concrete.

5. Due to the irregular particle shape, fines content, without impurities of the manufactured sand, in addition to the reduced amount of water cement ratio, manufactured sand is more suitable for high strength concrete mixes.

6. Crushed sand have potential to provide alternative to natural sand maintaining the environment as well as economical balance. Crushed sand is suitable substitute for river sand at reasonable cost. The manufactured crushed sand have good gradation and nice finish.

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