Strength and Durability Properties on Fiber Reinforced Concrete by Replacing Fine Aggregate with Stone Powder

Naga Prathyusha S, A.H.L. Swaroop

Abstract:-The goal for taking up this exploration is because of the at that now a days the natural sand affirming to Indian standards is becoming scarcer and costlier because of non-accessibility in time for the reason that law of land, unlawful digging by sand mafia etc… For this reason a motivation has been done to identify a new source of aggregates. The objective of this study is to verify the appropriateness, feasibility & forthcoming utilization of Stone powder for future years. Stone powder is a loss from the quarry preparing units. It accounts 30% of the residue from the quarry industry. Use of stone powder as a replacement of Natural sand reduces cost of construction but also it helps to reduce the wastage of material so it can be give a good impact to the environment. Hence in the current study an attempt has been made on concrete mix of grade M40 by experimenting the strength properties & durability of concrete by replacing Stone powder by 25%, 50%, 75% & 100% to Natural sand and expand the project the addition of steel fibers of 0.5%, 0.75% and 1% have done and also the effect of curing of 3% of H₂SO₄, HCl and Sea water on these concrete mixes are determined by immersing these cubes for 28 days, 90 days in above solutions and respective changes in compressive strength, tensile strength & weight reduction observed and it has been found that the compressive, split tensile strength of concrete made of stone powder increases nearly 17% and 60% with addition of steel fibers. The durability studies show a decrease of nearly 17% in compressive strength.

Key words: Stone powder (SP), Strength & Durability, Steel Fibers

I. INTRODUCTION

Concrete is one of the daily utilized composite materials in our construction activities. It has a total production of some billion tones every year. Its key ingredients are cement, fine aggregate, coarse aggregate, water and admixtures etc… Generally Aggregates occupy 60 to 80% of the volume of concrete and also greatly influence on hardened concrete properties, mix proportions and economy. The main important property for good quality aggregate should satisfy the resistance to abrasion, resistance to freeze/thaw, wear & tear action etc… And also it must have to maintain to give good workable concrete as early as possible. For this purpose the best suitable material is SP. It is the residue or waste material after the extraction and processing of rocks to form particles like coarse aggregates. The aggregates which are less than 6mm is termed as Stone Powder. It can be used for various different activities in construction like building materials, road development materials, bricks & tiles etc…

II. TESTING OF CONSTITUENT MATERIALS

Stone powderis obtained from the crushing units. It is the dust formed from rock particles at the time of grading of coarse aggregates. So, the properties of stone dust are same as that of coarse aggregate. But it is the best suitable for replacing fine aggregate, because the bulking capacity and fineness modulus are same as fine aggregate which is used in concrete. As a part of normal production processes in quarries, a certain portion of rock is reduced to fine material to withstand significant loading. As a result it has an increased extensibility and tensile strength to hold the matrix together. Durability is the ability of the material to withstand significant deterioration in concrete. The durable properties of concrete are to measure the lifespan and ability of concrete to withstand severe weathering condition. It is an important factor in identifying how sustainable the structure will ultimately be durable concrete in relatively impermeable as long as it remains un-cracked.

| Material                        | Properties                           |
|---------------------------------|--------------------------------------|
| Ordinary Portland Cement (53 grade, Ultratech) | Specific Gravity : 3.12 |
|                                 | Normal consistency : 32%             |
|                                 | Fineness : 0.5%                      |
|                                 | Residue 90 µm sieve : 45 min         |
|                                 | Final setting time : 480 min         |
| Fine Aggregate (River Sand)     | Locally Available Sand               |
|                                 | Specific Gravity : 2.6               |
|                                 | Fineness Modulus : 2.81              |
|                                 | Percentage Bulking : 43.75%          |
| Stone Powder                    | From G.Kondur – Particle size < 4.75mm |
|                                 | Specific Gravity : 2.7               |
|                                 | Fineness Modulus : 3.04              |

Revised Manuscript Received on July 06, 2019.
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III. EXPERIMENTAL PROGRAM

The present work investigates the effect of using SP as a partial replacement for sand on the compressive strength and split tensile strength for M40 grade concrete. It identifies the trend in variation of these strengths with increasing replacement. The optimum replacement for which strength is maximized is found and the addition of Steel fibers had done with various percentages of 0.5, 0.75 & 1% by volume of concrete. Then the durability study (Acid resistant & Sulphate resistant) is done for the concrete.

IV. MIX DESIGN

The mix design is done in accordance with IS:10262-2009 for different trails and fixed this proportion i.e., 1:1.61:2.89

| Materials          | Quantity        |
|--------------------|-----------------|
| Cement             | 430kg/m³        |
| Water              | 163 liters      |
| Fine aggregate     | 692kg/m³        |
| Coarse aggregate   | 1245.56kg/m³    |
| w/c ratio          | 0.38            |
| Super Plasticizer  | 0.62% of weight of cement |

Table 2 Mix Proportion Details

The mix proportion is checked by replacing of 50% stone powder with aggregates to know the water/cement ratio and then the replacement of stone powder and addition of fibers to the optimum strength has been done.

V. MIXING PROCESS

As the mixing process affects the properties of concrete, a uniform mix is adopted for preparing the mixes. Ordinary Portland cement and aggregate were first dry mixed for two minutes. 70% of total mixing water were added to the dry mix and mixing is done for 1 minute and then Chemical additives (Super plasticizer) was added to the remaining 30% of the water. The water is then poured into the mixed material & mixing is done for 2 minutes and cubes were casted. The cubes are of size 150 x 150 x 150mm were used.

VI. DIFFERENT MIXES OF CONCRETE WHICH HAD DONE

| S.No | Mix Name                              | Mix Designation |
|------|---------------------------------------|-----------------|
| 1    | Conventional Concrete                 | M0              |
| 2    | Fine aggregate is replaced with SP by 25% in concrete | M1              |
| 3    | Fine aggregate is replaced with SP by 50% in concrete | M2              |

Table 3 Mix Designation

VII. RESULTS & DISCUSSIONS

A. STRENGTH RESULTS

1. Compressive Strength

![Fig 1 Graph for Compressive Strength Results](image)

Compressive Strength was determined at different replacement levels of stone powder and also by adding of steel fibers at 28 days & 90 days. Table 4 represents the compressive strength values. It shows that on increment of SP in concrete the compressive strength increases from 49.43MPa to 56.43MPa at 28 days and 50.98MPa to 58.01MPa at 90 days for the replacement of 50% SP. The optimum replacement for which strength is maximized is found and the addition of steel fibers is done. Due to addition of fibers the strength is increased up to 56.43MPa to 59.36MPa at 28 days and 58.01MPa to 60.98MPa.

![Table 3 Mix Proportion Details](image)

4. Fine aggregate is replaced with SP by 75% in concrete | M3              |
5. Fine aggregate is replaced with SP by 100% in concrete | M4              |
6. Fine aggregate is replaced with SP 50% and addition of 0.5% steel fibers | M5              |
7. Fine aggregate is replaced with SP 50% and addition of 0.75% steel fibers | M6              |
8. Fine aggregate is replaced with 50% and addition of 1% steel fibers | M7              |
2. Split Tensile Strength

ii. Split Tensile Results

| S.No | Mix Designation | Tensile Strength (MPa) |
|------|----------------|-----------------------|
|      |                | 28 Days | 90 Days |
| 1    | M0             | 4.30    | 4.93    |
| 2    | M1             | 4.45    | 5.07    |
| 3    | M2             | 5.56    | 6.23    |
| 4    | M3             | 4.54    | 5.18    |
| 5    | M4             | 3.55    | 4.35    |
| 6    | M5             | 9.63    | 10.09   |
| 7    | M6             | 11.42   | 11.89   |
| 8    | M7             | 10.95   | 11.32   |

Fig 2 Graph for Split Tensile Strength results

Split Tensile strength was determined at different replacement levels of SP and also by adding of steel fibers at 28 days & 90 days. Table 5 represents the compressive Strength values. It shows that on increment of SP in concrete the Tensile Strength increases from 4.30Mpa to 5.56Mpa at 28 days and 4.93Mpa to 6.23Mpa at 90 days for the replacement of 50% SP. The optimum replacement for which strength is maximized is found and the addition of steel fibers is done. Due to the addition of fibers the strength is increased p to 5.56Mpa to 11.42Mpa at 28 days and 6.23Mpa to 11.89Mpa.

B. DURABILITY

The behavior of acids on the hardened concrete is the exchange of compounds into the salts of acid. Due to the exchange of ions there will be a loss in weight along with the compressive strength. Each and every concrete specimen gets affected by acid.

1. Chloride Attack

iii. Percentage weight loss & Compressive strength by chloride Attack

| S. No | Mix Designation | Average weight before Immersion in Acid (Kg) | Average weight after Immersion in Acid (Kg) | % weight loss (%) | Specimens cured under 3% HCL solution |
|-------|----------------|---------------------------------------------|---------------------------------------------|-------------------|--------------------------------------|
| 1     | M0             | 8.75                                        | 8.37                                        | 4.32              | 46.34                                |
| 2     | M5             | 9.11                                        | 8.98                                        | 1.48              | 52.91                                |
| 3     | M6             | 9.24                                        | 9.02                                        | 1.65              | 54.69                                |
| 4     | M7             | 9.30                                        | 9.16                                        | 1.5               | 53.34                                |

Fig 3 Tensile Strength Setup

Fig 4 Graph for Percentage weight loss by Chloride Attack

Fig 5 Graph for Compressive Strength by Chloride Attack

The table 6 represents the % weight loss & compressive strength to the specimens due to curing by hydrochloric acid. The effect of curing is done for 3% Hcl. The outer portion of the cubes gets consumed by the acid and there is a maximum reduction of 2mm at all sides for all the concrete specimens. So, the weight of each cube gets decreased. The decreased weight is up to 4.32% for conventional concrete and 1.65% and strength decreased p to 8Mpa i.e., 60Mpa to 52.41Mpa to fiber reinforced stone powder concrete.
2. Sulphate Attack

iv. Percentage weight loss & Compressive strength by Sulphate Attack

| S. No | Mix Designation | Average weight before immersion in Acid (Kg) | Average weight after immersion in Acid (Kg) | % weight loss (%) | Specimens cured under 3% H_2SO_4 Compressive Strength (MPa) |
|-------|-----------------|---------------------------------------------|--------------------------------------------|-------------------|-------------------------------------------------------------|
|       |                 |                                             |                                            |                   | 28 Days 90 Days                                              |
| 1     | M0              | 8.54                                       | 8.01                                       | 6.21              | 46.13 43.23                                                 |
| 2     | M5              | 9.36                                       | 9.14                                       | 2.43              | 52.63 49.70                                                 |
| 3     | M6              | 9.2                                        | 8.98                                       | 2.39              | 54.39 51.28                                                 |
| 4     | M7              | 9.30                                       | 9.08                                       | 2.34              | 52.88 50.22                                                 |

![Fig 6 Graph for Percentage weight loss by Sulphate Attack](image)

![Fig 7 Graph for Compressive Strength by Sulphate Attack](image)

The table 7 represents the % weight loss & compressive strength to the specimen due to sulphuric Acid. The effect of curing is done for 3% of H_2SO_4. The outer portion of the cubes gets effected by the acid and it indicates a more attack than compared to curing by hydrochloric acid for all the concrete specimens. The weight of cube get decreased up to 6.21% for conventional concrete and 2.34% and strength decreased up to 9Mpa i.e., 60.98Mpa to 51.28Mpa to fiber reinforced concrete.

3. Sea water attack

v. Percentage weight loss & Compressive strength by sea water attack

| S. No | Mix Designation | Average weight before Immersion in Acid | Average weight after Immersion in Acid | % weight loss (%) | Specimens cured under Sea water Compressive Strength (MPa) |
|-------|-----------------|----------------------------------------|----------------------------------------|-------------------|-------------------------------------------------------------|
|       |                 |                                        |                                        |                   | 28 Days 90 Days                                              |
| 1     | M0              |                                        |                                        |                   |                                                             |
| 2     | M5              |                                        |                                        |                   |                                                             |
| 3     | M6              |                                        |                                        |                   |                                                             |
| 4     | M7              |                                        |                                        |                   |                                                             |

![Fig 8 Graph for Percentage weight loss by Sea water Attack](image)

![Fig 9 Graph for Compressive strength by Sea water Attack](image)

The table 8 represents the % weight loss & compressive strength to the specimen which is cured under sea water. The outer portion of the cubes gets effected by the salts present in the sea water and there is a formation of layer around the cubes of containing salts on all sides for all the concrete specimens so the weight of each cube gets decreased up to 3.04% for conventional concrete and 1.19% and strength decreased up to 7Mpa i.e., 60.98 to 53.36Mpa to fiber reinforced stone powdered concrete.

![Fig 10 Cubes in Sea water](image)

VIII. CONCLUSIONS

Based on the experimental results in SFRC with partial replacement of fine aggregate with S, the following conclusions are observed:
At 50% replacement of fine aggregate by stone powder, the optimum compressive & split tensile strength is obtained at 0.62% of super plasticizer.

There is an increase in compressive strength, for partial replacement of fine aggregate with SP & addition of steel fibers is up to 16.4% for 90 days.

There is an increase in split tensile strength, for partial replacement of fine aggregate with SP & addition of steel fibers is up to 58.53% for 90 days.

Durability test results show reduction in compressive strength by 15.91%, tested against 3% H₂SO₄.

Durability test results show reduction in compressive strength by 14.05%, tested against 3% HCl.

Durability test results show reduction in compressive strength by 14.05%, tested against sea water.

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