Global Scientific JOURNALS

GSJ: Volume 8, Issue 3, March 2020, Online: ISSN 2320-9186

www.globalscientificjournal.com

PRODUCTION OF HIGH STRENGTH CONCRETE USING CRUSHED STONE SAND AND SILICA FUME

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Abstract:

The paper describes the use of Crushed Stone Sand (CSS) and Silica Fume (SF) in the concrete towards the production of High strength concrete. Sand taken from river sources are expensive due to transportation expenses. Also depletion of these natural sources causes environmental problem. As environmental, transportation and other constraints make the availability and use of river sand less attractive, a substitute or replacement product for concrete needs to be found. Based on these reasons we used CSS as a replacement of river sand in the project. Concrete with targeted strength of 10,000 psi, incorporating 5%, 10%, and 15% of silica fume (SF) with complete replacement of CSS were examined in fresh and hardened state. Experimental investigation showed that crushed stone sand (CSS) has significantly higher water absorption. The compressive and flexural strength was seen to increase with an increase of silica fume. Workability of the concrete was found to be decrease as the percentage of SF increased in the mix. In this particular research work 10% replacement of silica fume (SF) with a complete replacement of CSS as a fine aggregate in concrete mix was recorded to be optimum value. Where, concrete was able to achieve only 4477psi of compressive high strength value at 28 days which is way lesser than that of the targeted high strength of 10,000 psi.

KEY TO SYMBOLS AND ABBREVIATIONS

CSS	=	Crushed stone sand
SF	=	Silica fume
HRWR	=	High range water reducer
OPC	=	Ordinary Portland cement
SSD	=	Saturated surface dry
FM	=	Fineness modulus
C+P	=	Cement + pozzolanic
ASTM	=	American society for testing and materials
ACI	=	American concrete institute

Introduction:

Concrete is widely used all over the world. It is man-made material which is made of coarse aggregate, fine aggregate, binding material and water. Admixtures are also used when it is required. The mixture, when formed and cured for a certain period of time, it hardens into rock like mass known as concrete.

Sand is a main constituent of concrete and occupies a volume of 35 % of concrete. Sand is obtained mainly from river beds and contains high percentage of inorganic materials such as chlorides, sulphates, silt and clay which affects adversely the strength and durability of concrete. Digging sand from bed sources in excess quantity is hazardous to environment. The deep pits in the river bed ground water table and also there is a chance of erosion of nearby land due to excess lifting of sand. So there must be an alternative for fine aggregates which is CSS which is used as a alternative to sand which is beneficial and it is common in the world. CSS is manufactured by crushing large stone of quarry to size of sand. It size, shape and texture depend on type of stone and its source. Use of CSS is becoming a good alternative for sand keeping in view the technical, commercial and environmental requirements [1].

The commercial availability of high strength concrete has provided an economical alternative to bulky columns of conventional concrete for the lower floors of high rise buildings. The rapid increase in available concrete strength is principally due to the development of superplasticizers and application of mineral admixtures, especially silica fume. The use of superplasticizer allow significant reduction in water to cement ratio and hence the production of high strength concrete. The use of silica fume (SF) results in formation of highly dense and impermeable matrix of concrete.

Literature Review:

Over the years different researchers utilized one or two of the above materials in their researches and contributed development in concrete technology.). The CSS is a material of high quality. The fine particles and irregular shape of the CSS has harsh effects on the workability and finish ability of concrete. These harsh effects have given CSS a poor reputation in the construction industry. However, recent studies have shown that this CSS can be used to produce concrete with higher compressive and flexural strengths. To achieve high strength concrete a mineral admixture known as SF is added in concrete mix. The use of SF in concrete increase flexural strength, compressive strength, it also enhances freeze and thaw durability absorption resistance, bond strength in steel bar, chemical attack resistance, corrosion resistance of reinforcement steel and it decrease creep rate thermal conductivity, bleeding, density and workability [2]. It is also seen that to make the concrete workable HRWR commonly referred to as super plasticizers, are chemical admixtures that can be added to ready-mix concrete to improve its plastic and hardened properties [3]. HRWR are capable of reducing the water requirement for a given slump by about 30%, thus producing quality concrete having higher strength and lower permeability [4].

Problem statement:

Common river sand is expensive due to excessive cost of transportation from natural sources. Also large-scale depletion of these sources creates environmental problems. As environmental, transportation and other constraints make the availability and use of river sand less attractive, therefore CSS can be used as a natural sand replacer in concrete.

GSJ: Volume 8, Issue 3, March 2020
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Aim and Objectives:

The aim of this research is to achieve high strength concrete while using the following factors:

- To study the effect of CSS when used as a complete replacement (100%) of fine aggregate in concrete mix.
- To study the combine effect of CSS and SF. When CSS is used as a complete replacement of fine aggregate and SF is used as a partial replacement of various percentages of cement (5%, 10% and 15%) on properties of concrete in fresh and hardened state.

In order to achieve the above aim, the following are the objectives.

- Carry out testing on various ingredient of concrete to determine their physical property.
- Prepare concrete mix design consisting controlled and various percentages of SF and test the cylinder at 7, 28, and 90 days and beams at 28 and 56 days of concrete age.
- Determining the properties of above designed concrete mixes in fresh state.
- Determining the compressive strength, flexural strength of above mixes of controlled and various percentages of SF and note the effect while varying its inclusion by weight

Methodology:

Mix Design and Experimental work:

To investigate the effect of crushed stone sand (CSS) with partial replacement of silica fume (SF) on some of the fresh and hardened properties of high strength concrete, a detailed experimental program was prepared and tests carried out in accordance with the relevant ASTM standards and results formulated. All the ingredients were physically tested before incorporating them in the mix design. Mix design for the concrete was prepared according to the provisions of ACI code.

Casting of Specimens:

For casting of cylinders and beams, standard cast iron mold cylinders of 4” x 8” size, and beams of 4” x 4” x 24” size and 4” x 4” x 20” size were used. The molds were cleaned and made free from the dust by coating the oil insides of them. it helps in de-molding after 24 hours of casting. Concrete was filled in to molds in three layers and each layer was temped 25 times by the temping rod. Extra concrete was removed with the help of trowel and the top surface was finished with trowel to make it smooth. After finishing the top of molds, the concrete was left over night to allow the fresh concrete to set / harden, after which these were transferred to curing tank.

Curing of Specimens:

Curing is a process of maintaining satisfactory moisture content and favorable temperature in concrete during the hydration of cement and may continue until the desired properties developed to a sufficient degree to meet the requirement at service. After casting the molded specimens were placed in the laboratory at a room temperature for 24 hours. After this period, the specimens removed from the molds immediately submerged in clean and fresh water. The specimens were cured in curing tank till testing age was achieved.

Test on Hardened Concrete:

Compressive Strength:

The compressive strength of the concrete was determined in accordance with ASTM C 39. To find compressive strength 11 cylinders having size of 4” x 8” for each four mixes. The cylinder specimens were tested under compression testing machine at 7, 28 and 90 days of concrete age. In order to obtain an average value of compressive strength three specimens were tested at the same age of concrete.

Flexural Strength

The flexural strength of the concrete was determined in accordance with ASTM C 78. To find flexural strength 8 beam having size of 4” x 4” x 24” and 4” x 4” x 20” for each four mixes. The beam specimens were tested under flexural testing machine at 7, 28 and 90 days of concrete age. In order to obtain an average value of flexural strength three specimens were tested at the same age of concrete.

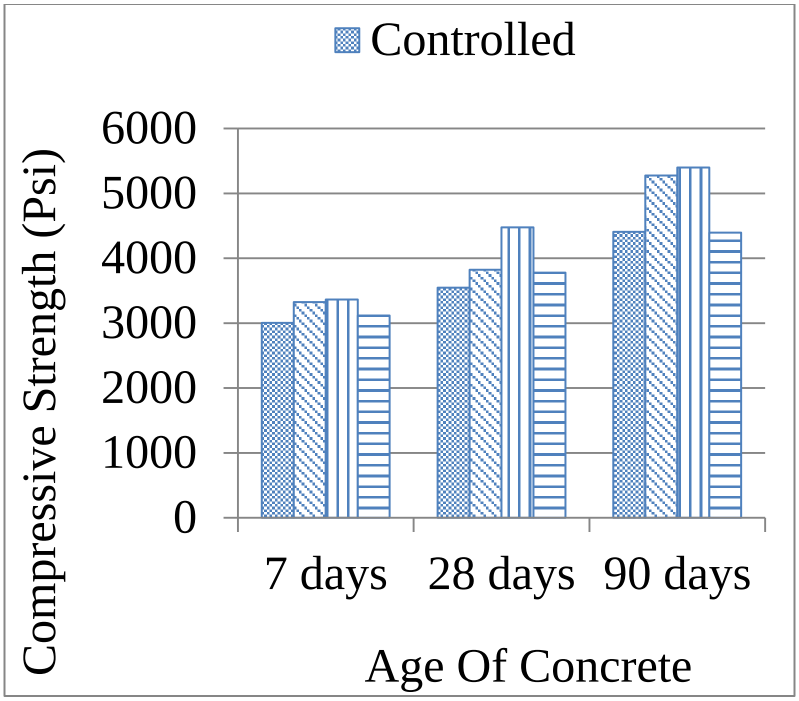
Results and Discussions

This chapter presenting the detail results performed on hardened state of concrete. The results and discussion on results are the following.

Compressive Strength Results:

Compressive Strength (psi)			
Sample	7 days	28 days	90 days
Controlled	3005	3546	4408
5% Silica Fume	3325	3824	5277
10% Silica Fume	3364	4477	5399
15% Silica Fume	3117	3779	4396

GSJ: Volume 8, Issue 3, March 2020
ISSN 2320-9186

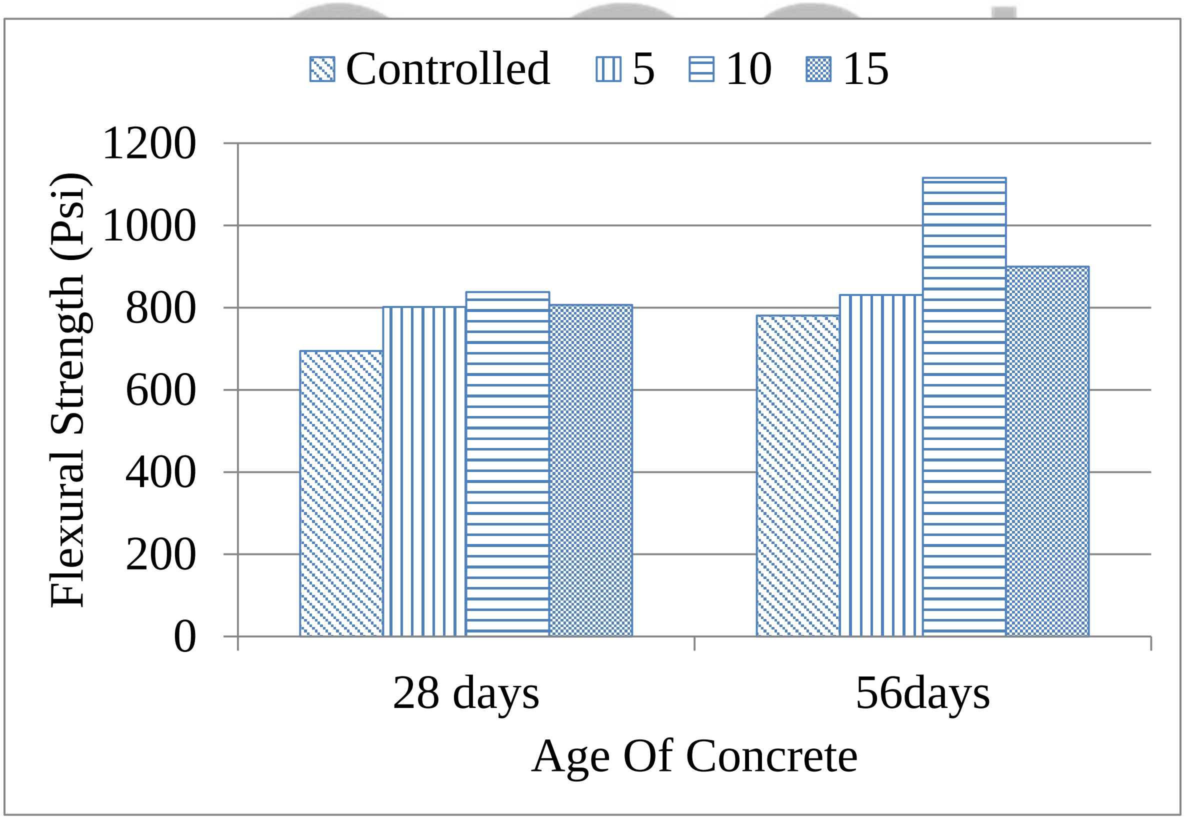


Compressive Strength

- Strength increases u10% replacement of SF.
- Strength decreases beyond 10% replacement of SF.

Flexural Strength Results:

Flexural Strength (psi)		
Sample	**28 days**	**56days**
Controlled	**695**	**781**
5% SF	**802**	**831**
10% SF	**838**	**1116**
15% SF	**807**	**900**



Conclusions and Future Recommendations:

Based on the experimental results and the subsequent discussion on the results, following Conclusion and Future Recommendations are produced.

Conclusions:

- Concrete produced with CSS has various benefits such as better economy of concrete and environment friendly.
- In compressive as well as flexural strength tests, 10% replacement of SF with cement and complete replacement of CSS as a fine aggregate came out to be the optimum value.
- Workability of fresh concrete was noted to decrease as the percentage of SF replacement with cement was increased.
- Water absorption of CSS was found that to be significantly higher than that of normal sand.
- Loss of strength occurs beyond 10% of SF replacement with cement in concrete mix which is also significant.

Future Recommendations:

- Literature review shows that Concrete produced by using up to 60% of CSS as a replacement of fine aggregate yields optimum value. Therefore, one may keep this %age of CSS fixed and produce concrete with the variation of Silica Fume %ages.
- Further study on various percentages of silica fume (SF) should be done for their effect on fresh and hardened concrete.
- CSS may be used as a fine aggregate in production of light weight concrete, such as foam concrete and light weight aggregate concrete etc.
- Additional test on strength of concrete having CSS may be evaluated. Such as split tensile test, static modules of elasticity of concrete, abrasion resistance test, permeability test and PH test.

- Keep the optimum value of silica fume and may varying different percentages of CSS.
- Detailed study showed be carried out using SCM for the case particularly described in this paper.

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