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Study of Mechanical Properties of Concrete Incorporated with Crushed Stone Sand

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***Abstract*— The paper aims at investigating the behavior of concrete mixed with varying substitutions of crushed stone sand as a partial and complete replacement for sand. Several concrete samples were prepared with 0%, 10%, 20% and 100% replacement levels of crushed stone sand substituted for fine aggregate. All these concrete samples are tested for compressive, flexural and split tensile strength test after curing for 7 days, 14 days, 28 days and 56 days to examine the variation in the mechanical performance of concrete. An optimum mix is obtained for 20% replacement level of crushed stone sand that exhibited the maximum compressive, flexural and split tensile strength.**

Keywords*— Compressive strength, split tensile strength, flexural strength, crushed stone sand

I. INTRODUCTION

There are many types of materials used in the construction. The most commonly used materials are steel, cement, concrete, bricks, stone, clay etc. But concrete is one of the most widely used materials in the construction industry. After water, concrete is most widely using material. Globally 11 billion tons of concrete is consumed each year [1]. Concrete is the most common construction material in the world because it has very good durability, mechanical properties, workability and relative low cost. It is suitable for almost all type of structures and environments like buildings, bridges etc. Since it can be mould into any desired shape which is also a versatile property of concrete.

Concrete is a stone like material obtained by mixing of cement, sand and gravel, or other aggregates with water. It can be poured into any desired shape and dimension of structure through a chemical reaction known as hydration the paste hardens and gain strength to form concrete [2]. As long as the concrete kept cured it continues to gain the strength because the process of hydration continues in the presence of water. Mixed water in concrete can be utilized for hydration, if it is secured by curing. Generally concrete gains most of its strength within first 28 days but a slower process of hydration continues for many years. Concrete is a brittle material and is very strong in compression but weak in tension [3].The characteristic of aggregates play the substantial role in the fresh and hardened properties of concrete as it couples about 50 % to 80 % of total concrete volume. It is commonly accepted that the properties of aggregates use in normal strength concrete (NSC) have great influence on the mechanical properties and durability [4].

In General, the coarse aggregates used in NSC should be hard, dense, non-reactive and durable. The fine aggregates should be free from organic impurities, clay or silt relatively coarser sand. A higher degree of fine and coarse aggregates packing requires less water and thus increasing the concrete quality [5]. In preparation of concrete sand is usually used as fine aggregates. In this study crushed stone sand (CSS) which is locally known as stone dust is used as partial replacement of fine aggregates. After success in result, it is expected that crushed stone sand can be used as alternative of fine aggregates.

II. LITERATURE REVIEW

The purpose of this chapter is to provide a general perspective on the geology of potential sources of crushed stone and how that material is mined and processed to meet the needs of the construction industry.

Bonavetti, V.L. & Irassar, E.F. (1994), "The effect of stone dust content in sand, cement concrete research" presented in his research paper that crushed stone sand is a material of high quality. The fine particle and irregular shape of crushed stone sand has effect on workability and finishing of concrete. However, recent studies have shown that crushed stone sand can be used to produce concrete with higher compressive and flexural strengths [8].

Zain, F.M., Mahmud H.B., (2005), "Influence of quarry dust on the concrete compressive strength development" presented in his research that crushed stone can be used effectively in the replacement of natural sand in concrete and that concrete made with this replacement can attain the same compressive strength. In this case however, replacement of natural sand with crushed stone sand is not only effective, it also causes increase in strength [9].

A.A. Jimoh and S. S. Awe (2007), "A study on the influence of aggregate Size and type on the compressive strength of concrete" presented in his research that the effect of crushed stone sand as fine aggregates causes of flexural strength increase than the concrete with natural sand but the values decreases as percentage of crusher dust increases [10].

Mahzuz et al., and Ahmed AAM, Yusuf MA (2009), "Using of stone powder as an alternative of sand" presented in his research that Boulder stones are crushed in the stone crusher to produce different size of crushed stone which is

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used as aggregates in preparation of concrete for different construction purposes. During this process powder sand is produced as by-product [11].

Mahzuz et al., and Ahmed AAM, Yusuf MA (2009), "Using of stone powder as an alternative of sand" presented in his research that Several research works on the basis of alternative fine aggregate and numerous research works have been carried out by researchers to get a fruitful alternative way of waste utilization and minimization [11].

Mahzuz et al., and Ahmed AAM, Yusuf MA (2009), "Using of stone powder as an alternative of sand" presented in his research that Powder sand is usually considered as waste. Some of those are used in land filling, making bricks, hollow bricks; sanitary rings etc. but a large mass of powder sand are thrown in a stack. These improper disposals of powder sand are seriously threatening to public health, environment, agricultural land and beauty of the areas [11].

Radhikesh P Nanda, Amiy a K. Das (2010), "Stone crusher dust as a fine aggregate in concrete for paving blocks" presented in his research that Replacement fine aggregate by crusher dust up to 50% by weight has a negligible effect on the reduction of any physical and mechanical properties like compressive strength, flexural, strength, and split tensile strength [12].

Lakhan Nagpal, Arvind Dewangan (2013), "Evaluation of Strength Characteristics of Concrete Using Crushed Stone Dust as Fine Aggregate" presented in his research Mixture of stone sand and natural sand can be used for medium grade concrete. If better quality of stone sand can be used, it may give better result in terms of strength. Proper gradation of sand and stone sand can give a better result. Moreover, the economic value of stone sand is almost zero and generally is treated as waste [14].

B.G. Naresh Kumar (2014), "Experimental investigation on the effect of replacement of sand by quarry dust in hollow concrete block for different mix proportions" presented in his research River sand is costly due to transportation, large scale depletion of resources and enforcement regulations. Quarry dust can be used as an alternative to the river sand [13].

III. MATERIALS USED

1. Cement

This is the most commonly used ingredient in concrete as a binder. Mostly hydraulic cement is used in concrete production. The word Hydraulic means that characteristic of cement holding aggregate together is caused by water or other low-viscosity fluids. Portland cement is a carefully proportioned and specially processed chemical combination of lime, silica, iron oxide, and alumina**.** Ordinary Portland cement Type-I conforming to ASTM C 150 [15] was used. In our research DG cement was used having grey color and no lump masses**.**

2. Fine Aggregate

The locally available lawrencepur sand was used as fine aggregates in experimental work. The lawrencepur sand was free from silt, clay and organic impurities that was tested for various properties like specific gravity, bulk density etc. The concrete aggregates (including fine and coarse) should confirm the ASTM C 33 [18].

3. Coarse aggregate

Margalla crush was used as coarse aggregates for the production of concrete. Maximum size of aggregates used was 3/4″ that was free from impurities such as dust, clay particles and organic matter etc. The coarse aggregate was tested for various properties like bulk density, specific gravity etc.

4. Crushed Stone Sand

Crushed stone sand was obtained from Sargodha crushing plant Punjab, Pakistan. It is the product resulting from the artificial crushing of rocks, boulders, or large cobblestones, substantially all faces of which have resulted from the crushing operation. Crushed stone sand consist of about 85% sand size material and 15 % of silt and clay particles [6]. The crushed stone sand is tested for various properties like specific gravity, bulk density etc.

7. Admixture

Superplasticizer "Conplast SP 430" is used for casting of concrete samples. It is made of Sulphonated Naphthalene polymer, specified as per IS: 9103-979 that achieves in reducing the water content by 20%.

8. Water

The locally available potable water used in experimental work. The role of water in concrete production is hydration reaction of cement and for workability of concrete. The water in concrete is to act chemically with cement to form the binding paste. The quantity of water in concrete effects on the workability of fresh concrete and also on the strength of concrete. It enables the concrete mix to flow into formwork.

IV. RESULTS & DISCUSSIONS

TESTS ON FRESH CONCRETE:

Slump Test:

First of all we placed slump test on a flat, moist, non-absorbent, rigid surface like a steel plate. Then we filled the mould to 1/3 full by volume and tamped the bottom layer with 25 evenly spaced strokes the mould to 2/3 full and the second layer with 25 strokes penetrating the top of the bottom layer, filled the concrete on top of the mould and tamped the top layer with 25 strokes penetrating the top of the second layer. Removed the mould carefully in the vertical direction (take about five seconds). We immediately inverted and placed the mould beside the slumped concrete and placed the rod horizontally across the mould and we measured the slump in inches.

Slump Test

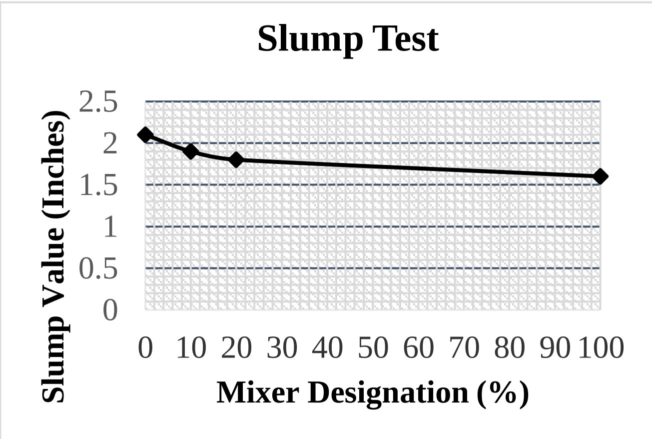

Fig 1. Slump values for varying crushed stone percentages

Compaction factor test:

Place the concrete sample gently in the upper hopper to its brim using the hand scoop. Cover the cylinder and push the concrete sticking, open the trap door of lower hopper and cut of the excess of concrete above the top level of cylinder. Empty the cylinder and then refill it with concrete, level the top surface. Weight the cylinder with fully compacted. Now find the weight of empty cylinder.

Vee-Bee test:

Place the slump cone in the cylindrical container of consistometer. Fill the cone in four layers and tamp each layer with 25 strokes. Move the glass disc attached to the swivel arm. Remove the cone from the concrete immediately by raising it slowly and carefully. Determine the slump by taking the difference between the readings on the graduated rod. Record the time required for complete re-moulding records which measures the workability expressed as number of vee bee seconds.

TESTS ON HARDEN CONCRETE:

Compressive strength resultst:

Compression testing

7 days compressive strength result:

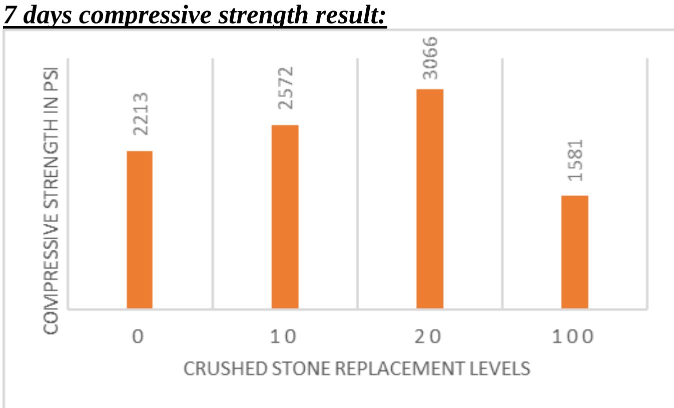

Fig 2: Compressive strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 7 days curing period

14 days Compressive strength result:

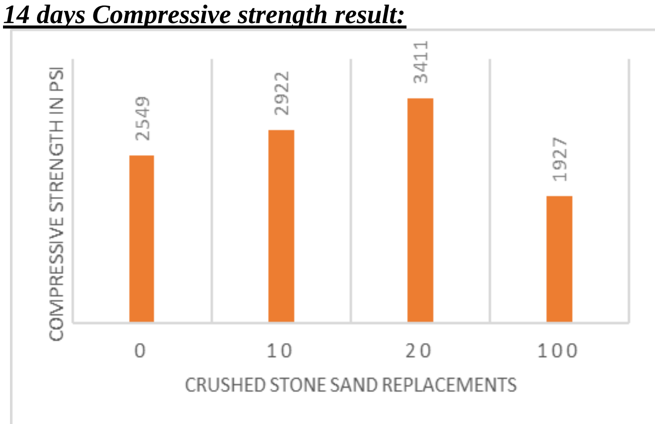

Fig 3: Compressive strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 14 days curing period

28 days Compressive strength results:

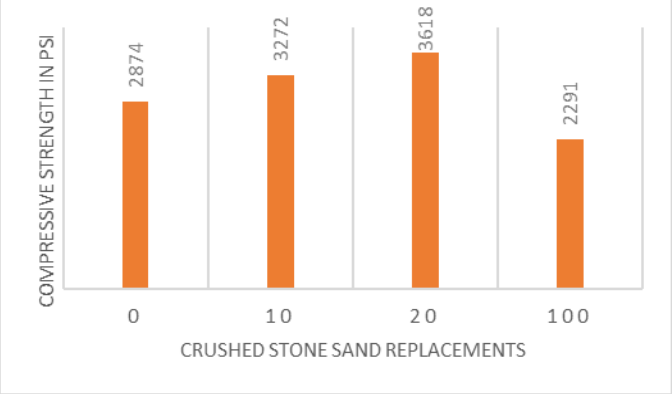

Fig 4: Compressive strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 28 days curing period

56 days Compressive Strength results:

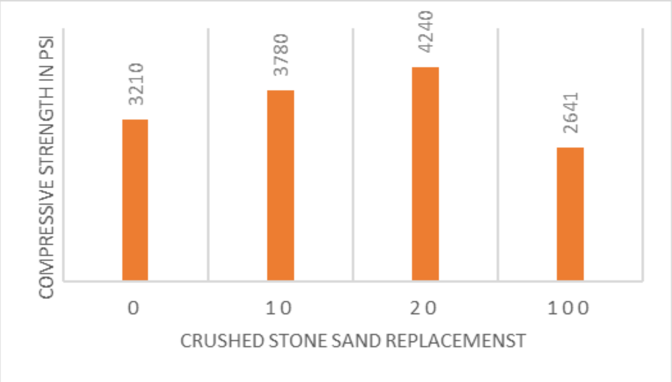

Fig 5: Compressive strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 56 days curing period

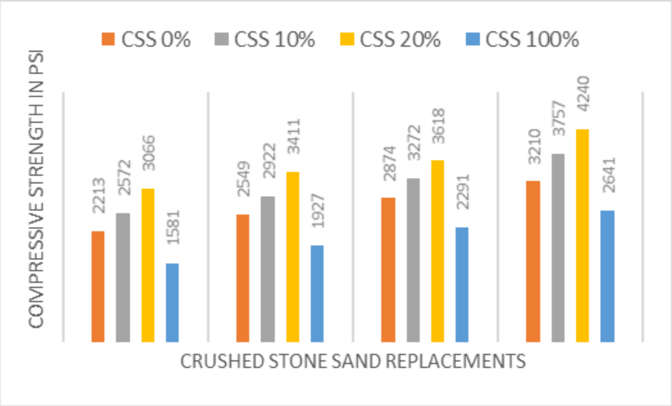

Fig 6: Compressive strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 7, 14, 28 & 56 days

Flexural strength results:

7 days Flexural strength results:

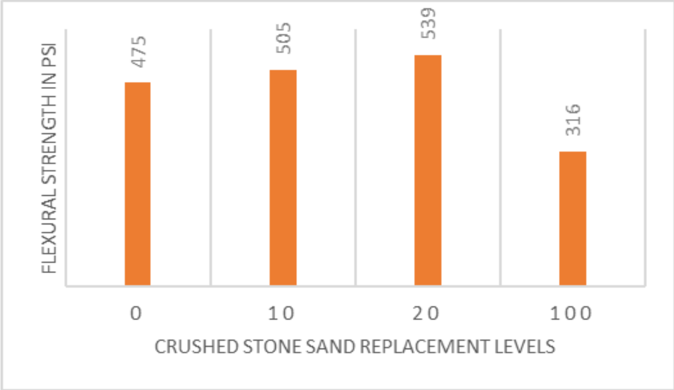

Fig 7: Flexural strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 7 days curing period

14 days Flexural strength results:

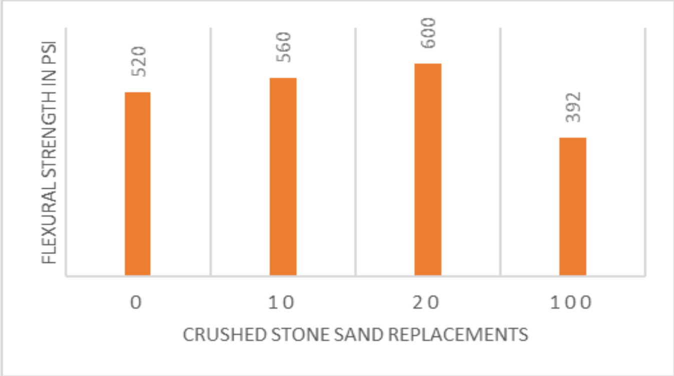

Fig 8: Flexural strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 14 days curing period

28 days Compressive strength results:

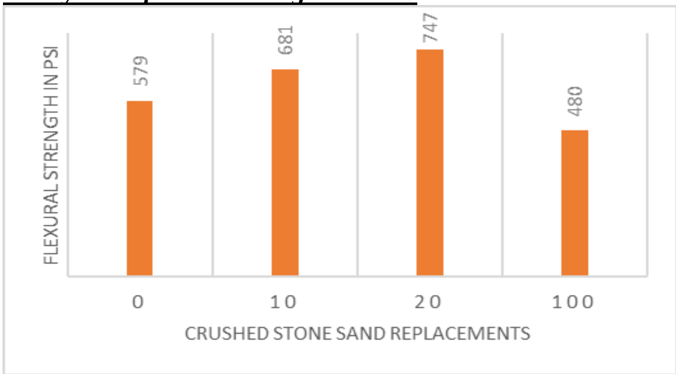

Fig 9: Flexural strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 28 days curing period

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56 days Flexural Strength results:

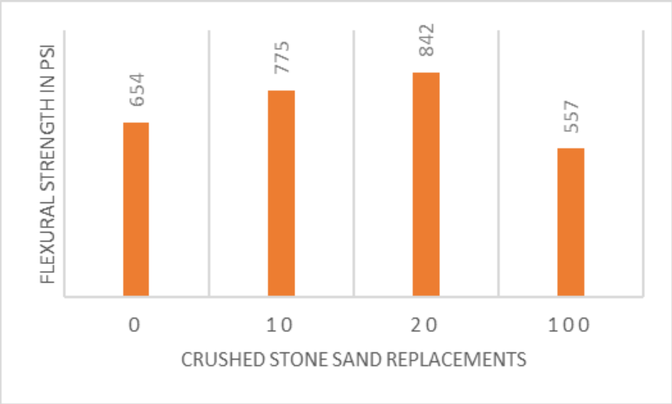

Fig 10: Flexural strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 56 days curing period

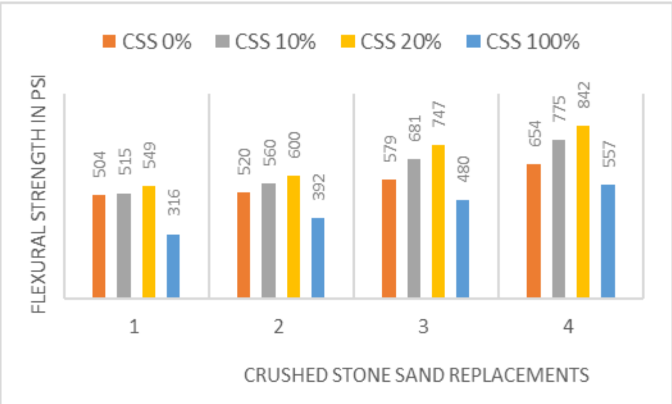

Fig 11: Flexural strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 7, 14, 28 & 56 days curing period

Split Tensile strength results:

7 days Split tensile strength results:

Fig 12: Split tensile strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 7 days curing period

14 days Split tensile strength results:

Fig 13: Split tensile strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 14 days curing period

28 days Split tensile strength results:

Fig 14: Split tensile strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 28 days curing period

56 days Split tensile strength results:

Fig 15: Split tensile strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 56 days curing period

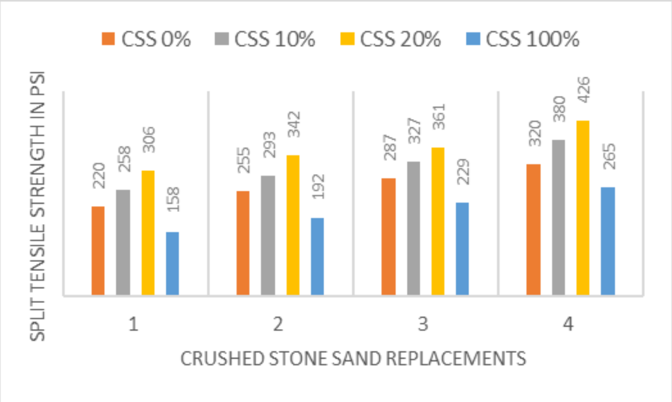

Fig 16: Split tensile strength values of concrete mixes modified with different substitutions of crushed stone sand replacements levels for 7, 14, 28 & 56 days curing period

V. CONCLUSIONS

The most important conclusions drawn from these results are:

- Inclusion of crushed stone sand as a fine aggregates in concrete has positive impact on compressive, flexural and tensile strength.
- CSS is well appropriate for normal strength concrete for better performance in terms of strength and economy over normal sand.
- Workability of concrete reduces as percentage replacement of crushed stone sand increases.
- The results shows that mechanical properties of concrete improves up till 20% replacement of CSS as fine aggregates and reduces at 100% replacement.
- The studies reported that strength of concrete using CSS is comparatively 15-20 percent more than that of control concrete specimens.
- Increase in compressive strength at 10% replacement is 13.84% and at 20% replacement is 25.88%.
- Increase in flexural strength at 10% replacement is 17.61 % and at 20% replacement is 29.01%.
- Increase in split tensile strength at 10% replacement is 13.93% and at 20% replacement is 25.78%.
- It is clear from the study that optimum modifier content (OMC) is 20%.
- The use of CSS in the construction industry helps to prevent unnecessary damages to the environment and provide optimum exploitation of the resources.
- The economic value of CSS is almost zero and generally is treated as waste. If it is used in making of concrete, cost will be minimized as well as waste will be reduced.

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