UTILIZATION OF STONE CUTTING WASTE IN CONCRETE AS REPLACEMENT OF FINE AGGREGATE

Vinay Agrawal[1], Vikram Gupta[1], Rajesh Gupta[1], Sanjay Mundra[1]

1. Malaviya National Institute of Technology Jaipur, India

ABSTRACT. River Sand is expensive due to excessive cost of transportation from natural sources. Also large scale depletion of these sources creates environmental problems. As environment, transportation and other constraints make the availability and use of river sand less attractive, a substitute or replacement product for concrete industry needs to be found. River sand used as fine aggregates in production of concrete poses the problem of acute shortage in all parts of country.

The continuous use of this has started posing serious problem with respect to its availability, cost and environmental impact.

In such a situation crushed stone sand (CSS) may be a suitable alternative to river sand. CSS can be defined as residue, tailing or other non-valuable waste after the extraction and processing of rocks to form fine particles less than 4.75 mm. Use of CSS in concrete is drawing attention to researchers and investigators.

In this research, various mix designs have been developed for different water-cement ratios using standard design codes for both conventional concrete and CSS concrete.

Tests are conducted on cubes and beams to study the strength of concrete made of CSS concrete and results are compared with Natural sand concrete. An attempt has also been made to durability studies on CSS concrete when compared with Natural sand concrete. It is found that compressive strength, flexural strength and durability studies of concrete made of CSS concrete is better than conventional concrete upto 15% replacement of natural river sand by CSS.

Keywords: Crushes stone sand; Environmental impact; Conventional concrete; Mechanical property; Stone cutting waste

Vinay Agrawal is Associate Professor at Malaviya National Institute of Technology Jaipur

Rajesh Gupta is Associate Professor at Malaviya National Institute of Technology Jaipur

Vikram Gupta is M.Tech Student at Malaviya National Institute of Technology Jaipur

Sanjay Mundra is Research Scholar at Malaviya National Institute of Technology Jaipur

INTRODUCTION

Concrete is one of the most widely utilized material globally with total production of about 25 billion tonnes per annum. Its key ingredients are cement, fine aggregate, coarse aggregate, water and admixtures etc. with rapid surge in the growth rate of globalization and urbanization comes into industrial demand for the raw materials in the concrete industry. The exponential demand for the fine aggregate i.e. natural sand exerts tremendous stress on the natural reserves of sand i.e. river beds.

Researchers have assessed and tried to establish the feasibility of a wide range of industrial waste products such as slag, rubber tyre, recycled glass, pond ash, waste foundry sand, plastic waste, stone waste etc. as a substitute or partial replacement for fine aggregate in the concrete production. In 2012 the world's total production of dimension stones came out to be 125 million tons.

Materials

The materials for the study comprised of cement, fine aggregates, crushed stone sand, coarse aggregates, admixture and water. Portland Pozzolana cement was used in most of concrete design mixes. The fine aggregates included Natural River sand from River Banas and crushed stone sand from Gunavata and Chandwaji region in the State of Rajasthan. The coarse aggregates selected for study comprised of 20 mm and 12.5 mm-sized aggregates. High range water reducer admixtures were incorporated to reach the desired workability.

Experimental Program

The experimental program was divided into two parts. The first part was dedicated to examine the effect of fine aggregates type, grading and blend ratio on the fresh and hardened properties of concrete. The second part of the program focused on the optimization of the selected design mix.

In this research work, we were replacing of sand by crushed stone sand. We were taking replacement of fine aggregate is 15%, 25%, 50%, 75% and 100% by crushed stone fines for both two series of w/c of 0.40 and 0.45.

The samples were tested for slump, compressive strength and flexural strength. The effects on each of these properties were examined by changing the percentage replacement of Natural River sand (NS) with crushed rock sand (CRS). An optimization study was performed to study the effect on the properties of concrete.

Table 1 Design Mix for W/C – 0.40

REPLACEMENT	CEMENT (kg/m^3)	STONE FINES (kg/m^3)	SAND (kg/m^3)	10 mm (kg/m^3)	20 mm (kg/m^3)	WATER (kg/m^3)	ADMIXTURE (in % of cement)	COMPACTION FACTOR
0%	370	0	765.3	465.6	700.1	148	0.8	0.95
15%	370	114.8	650.5	465.6	700.1	148	0.85	0.93
25%	370	191.3	574	465.6	700.1	148	0.90	0.94
50%	370	382.6	382.6	465.6	700.1	148	0.95	0.93
75%	370	574	191.3	465.6	700.1	148	1.0	0.93
100	370	765.3	0	465.6	700.1	148	1.1	0.93

Table 2 Design Mix for W/C – 0.45

REPLACEMENT	CEMENT (kg/m^3)	STONE FINES (kg/m^3)	SAND (kg/m^3)	10 mm (kg/m^3)	20 mm (kg/m^3)	WATER (kg/m^3)	ADMIXTURE (in % of cement)	COMPACTION FACTOR
0%	330	0	780.4	475.6	712.5	148.5	0.75	0.95
15%	330	117.0	663.3	475.6	712.5	148.5	0.8	0.94
25%	330	195.1	585.3	475.6	712.5	148.5	0.84	0.93
50%	330	390.2	390.2	475.6	712.5	148.5	0.91	0.92
75%	330	585.3	195.1	475.6	712.5	148.5	0.95	0.94
100	330	780.4	0	475.6	712.5	148.5	1.00	0.89

RESULTS AND DISCUSSION

Workability

Workability of concrete maintained at a constant level by varying the dose of superplasticizer. If the Crushed Stone Sand is added without increasing the superplasticizer, then the workability decreased.

The results of workability (regarding compaction factor) for various replacement series are as shown in the table below-

Table 3 Compaction Factor Results

S. NO.	REPLACEMENT	COMPACTION FACTOR (W/C – 0.40)	COMPACTION FACTOR (W/C – 0.45)
1.	0%	0.95	0.95
2.	15%	0.93	0.94
3.	25%	0.94	0.93
4.	50%	0.93	0.92
5.	75%	0.93	0.94
6.	100%	0.93	0.93

Density of fresh and Hardened Concrete

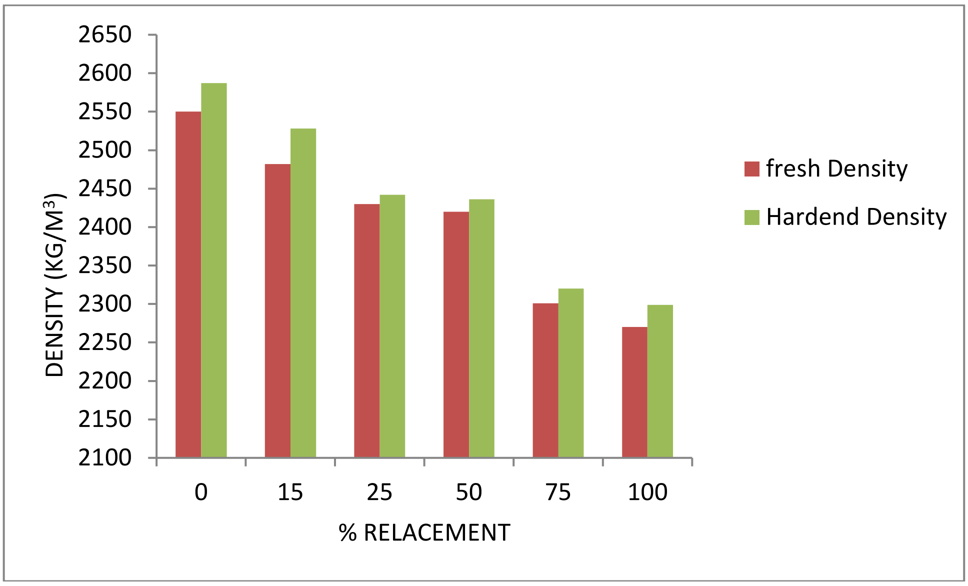

Figure 1 Density of Fresh and Hardened Concrete (W/C – 0.40)

Figure 2 Density of Fresh and Hardened Concrete (W/C – 0.45)

Compressive Strength of Concrete

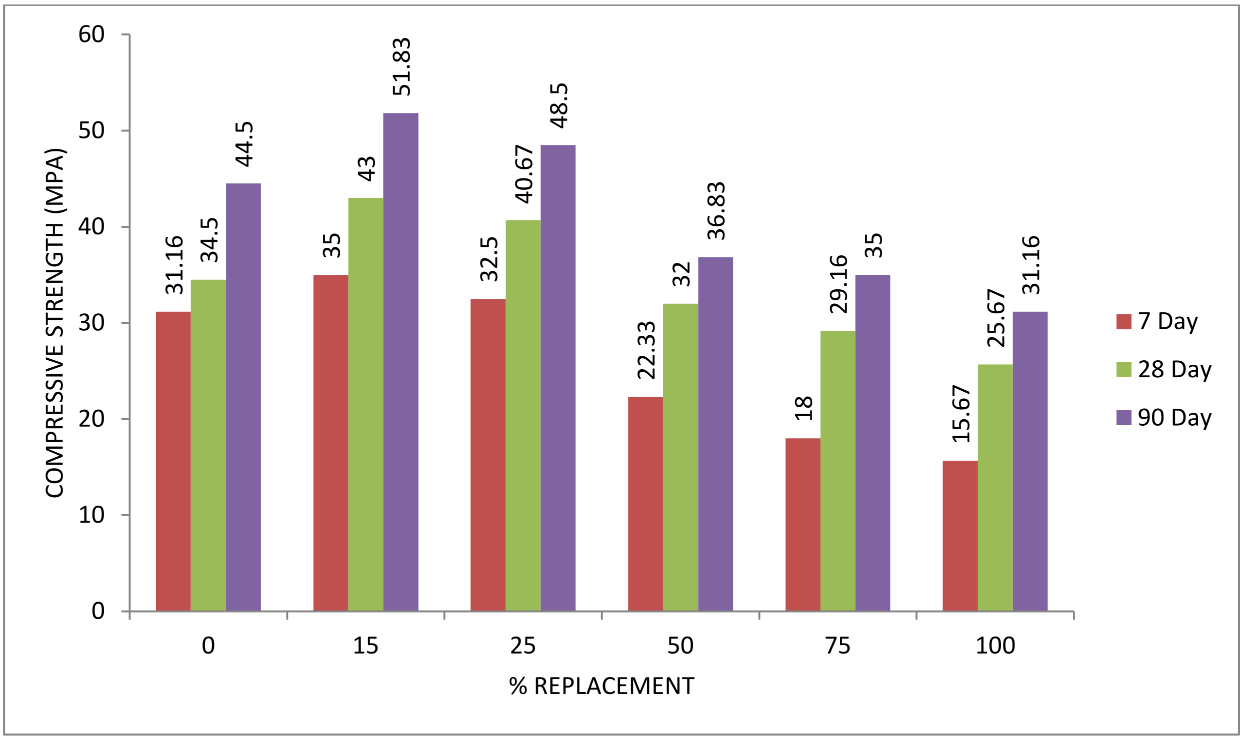

Figure 3 Compressive strength of concrete at varies CSS replacement (W/C – 0.40)

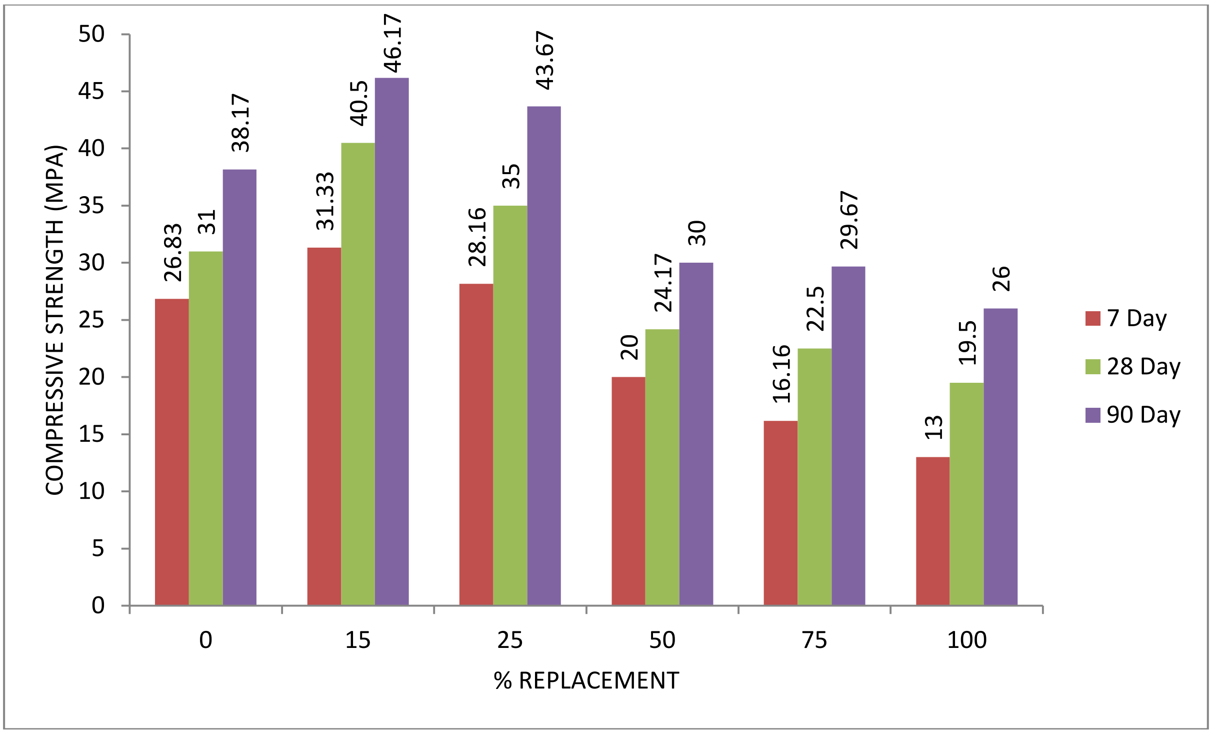

Figure 4 Compressive strength of concrete at varies CSS replacement (W/C – 0.45)

Flexure Strength of concrete

The results of flexural strength up to a period of 90- days are taken. As compressive strength, the flexural strength of concrete exhibit similar pattern.

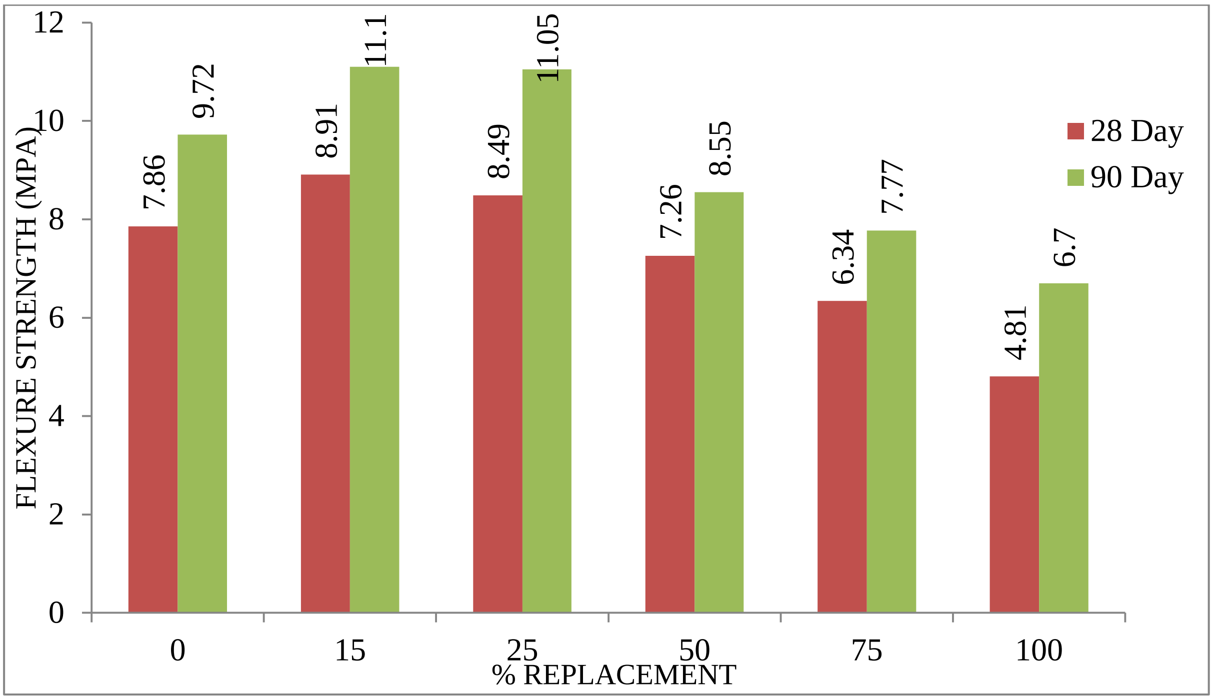

Figure 5 Flexural strength of concrete at different CSS replacement (W/C – 0.40)

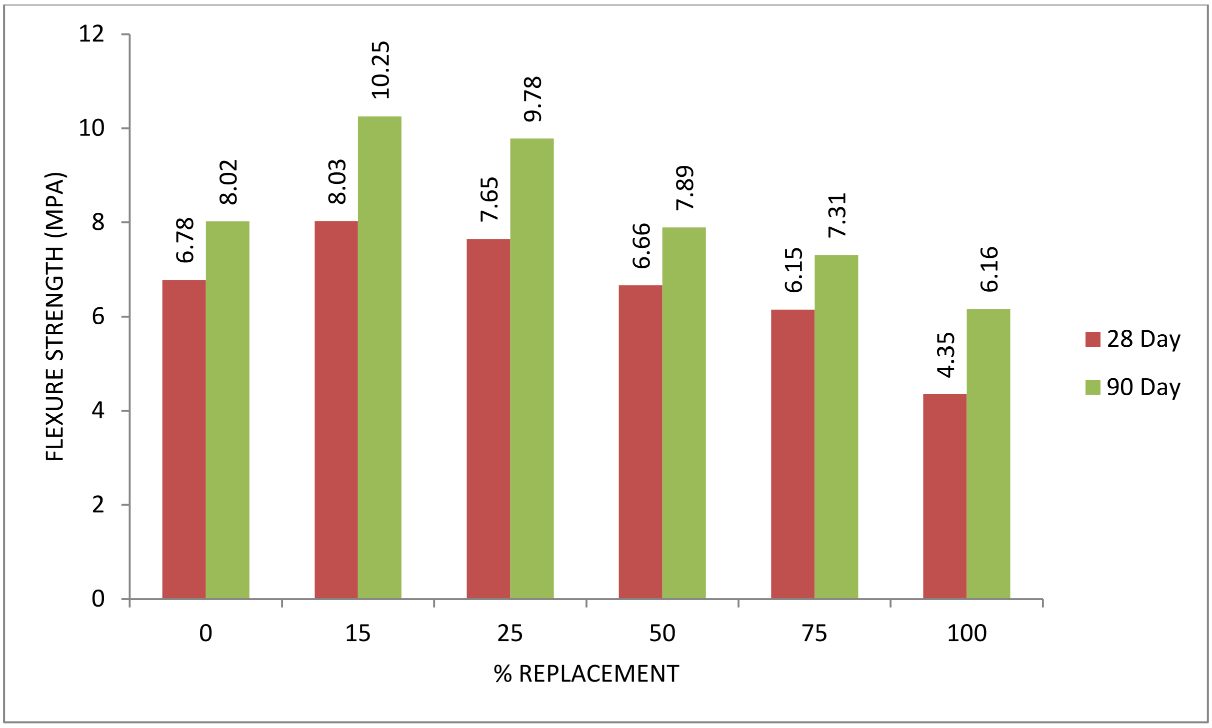

Figure 6 Flexural strength of concrete at different CSS replacement (W/C – 0.45)

Split Tensile Strength

The results of split tensile strength up to a period of 90- days are taken. As compressive strength, the split tensile strength of concrete exhibit similar pattern.

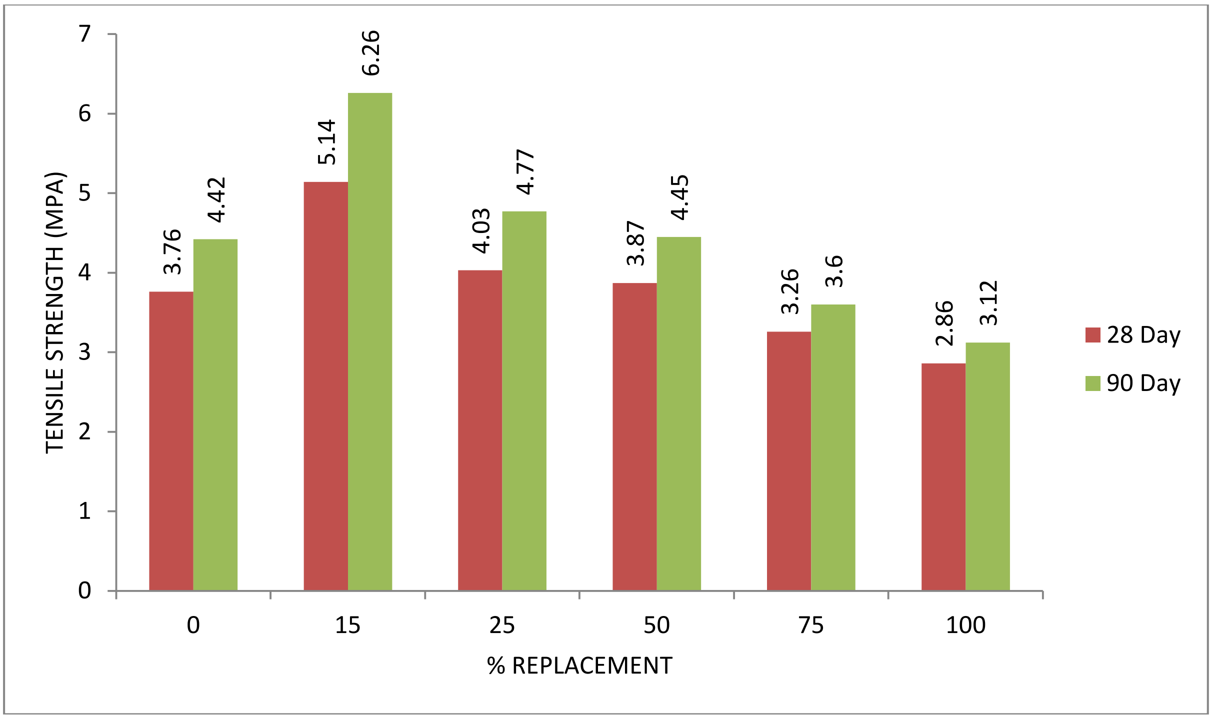

Figure 7 Split Tensile Strength of concrete at different CSS replacement (W/C – 0.40)

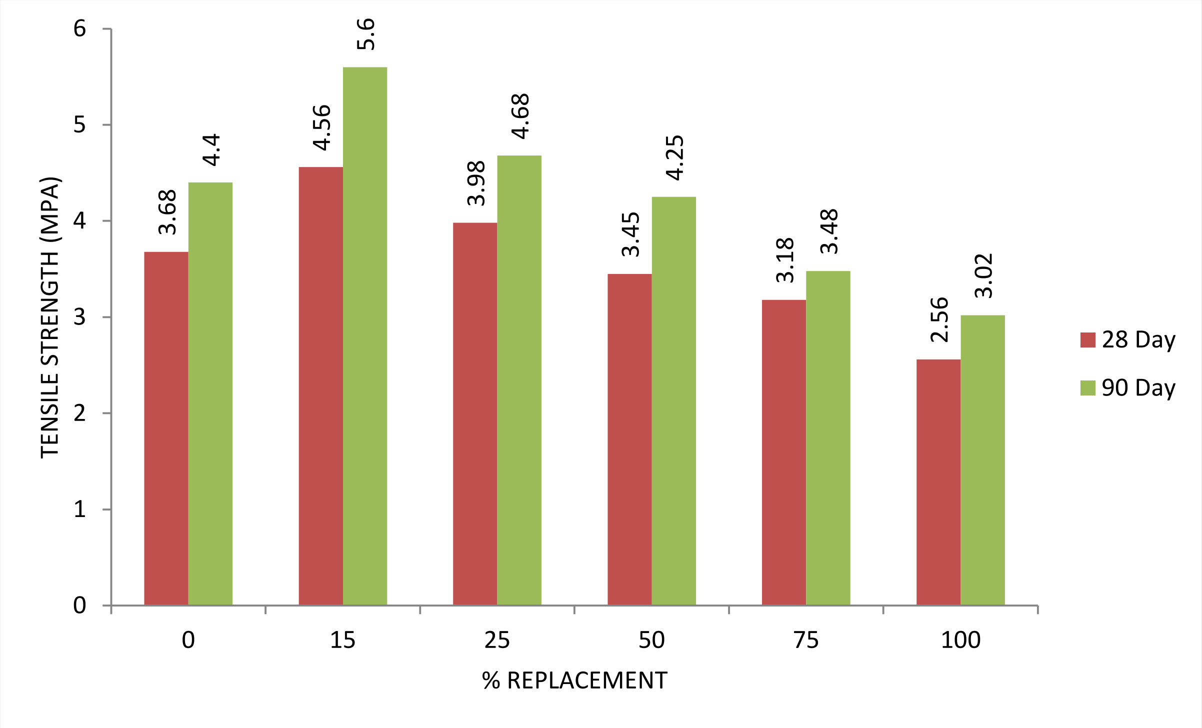

Figure 8 Split Tensile Strength of concrete at different CSS replacement (W/C – 0.45)

Abrasion Test

CSS is derived from the sedimentary rock which hardness is less, and the abrasion property of concrete is the function of surface texture and hardness. Therefore, depth of wear is increased as the replacement level of CSS increases.

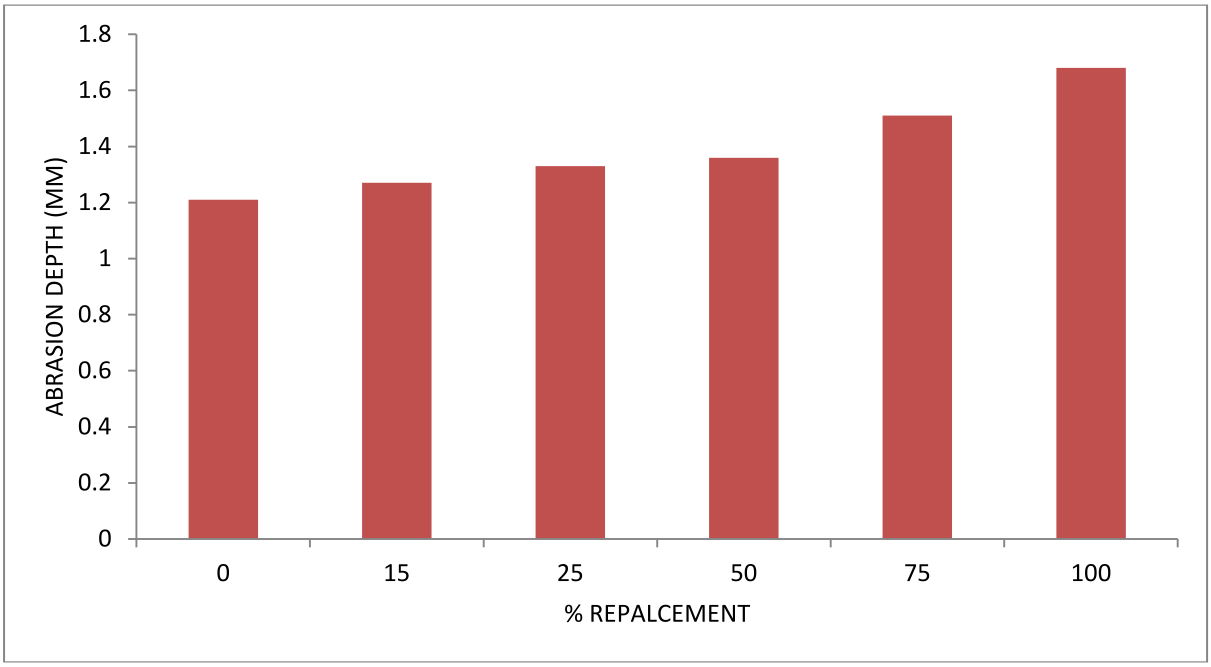

Figure 9 Thickness loss versus CSS replacement (W/C – 0.40)

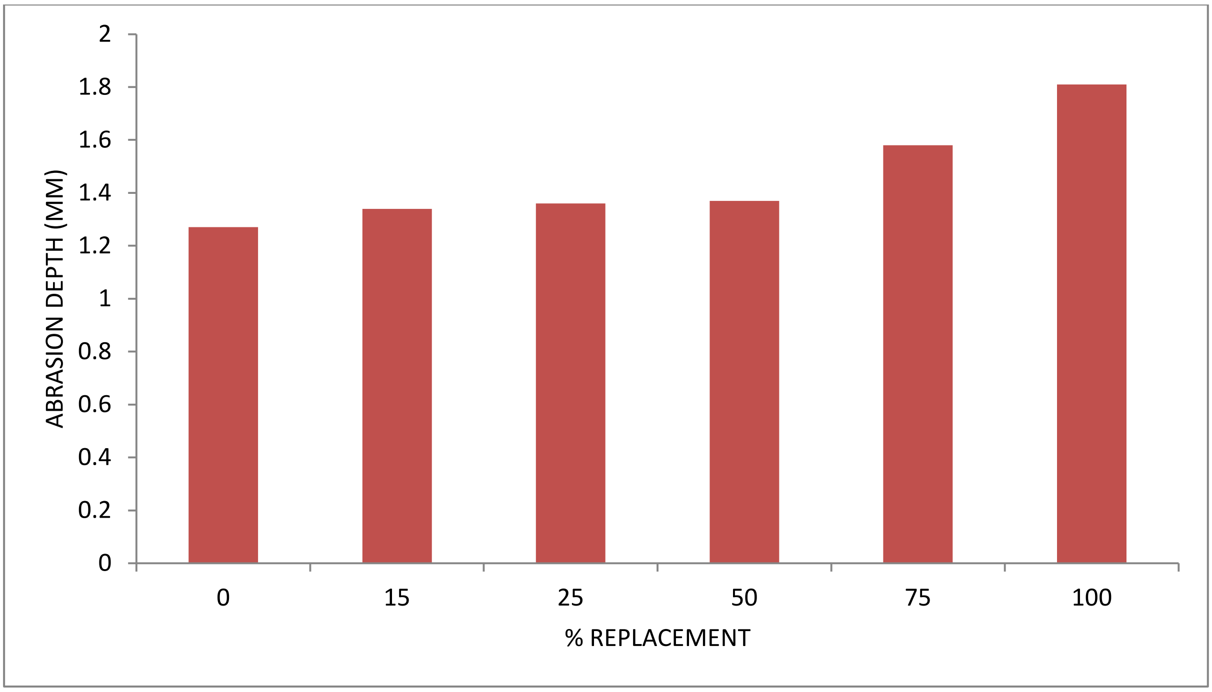

Figure 10 Thickness loss versus CSS replacement (W/C – 0.45)

DIN Permeability Test

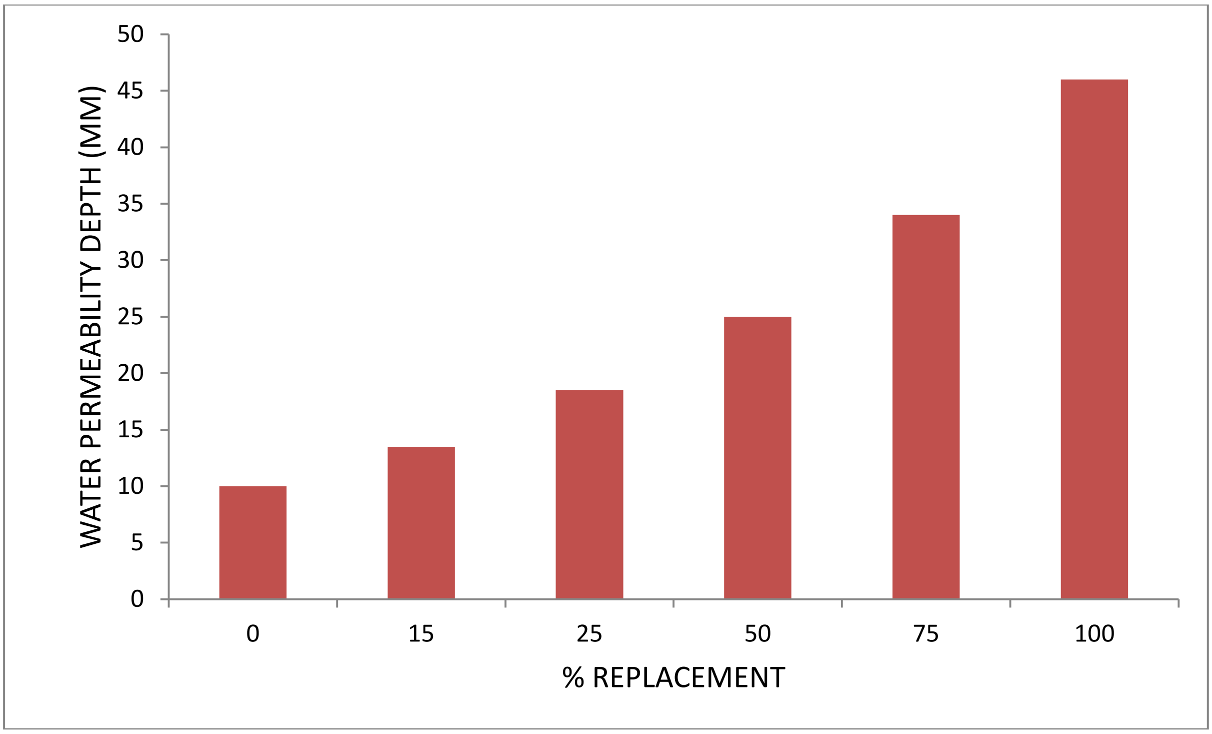

Figure 11 Water permeability at various replacement level (W/C – 0.40)

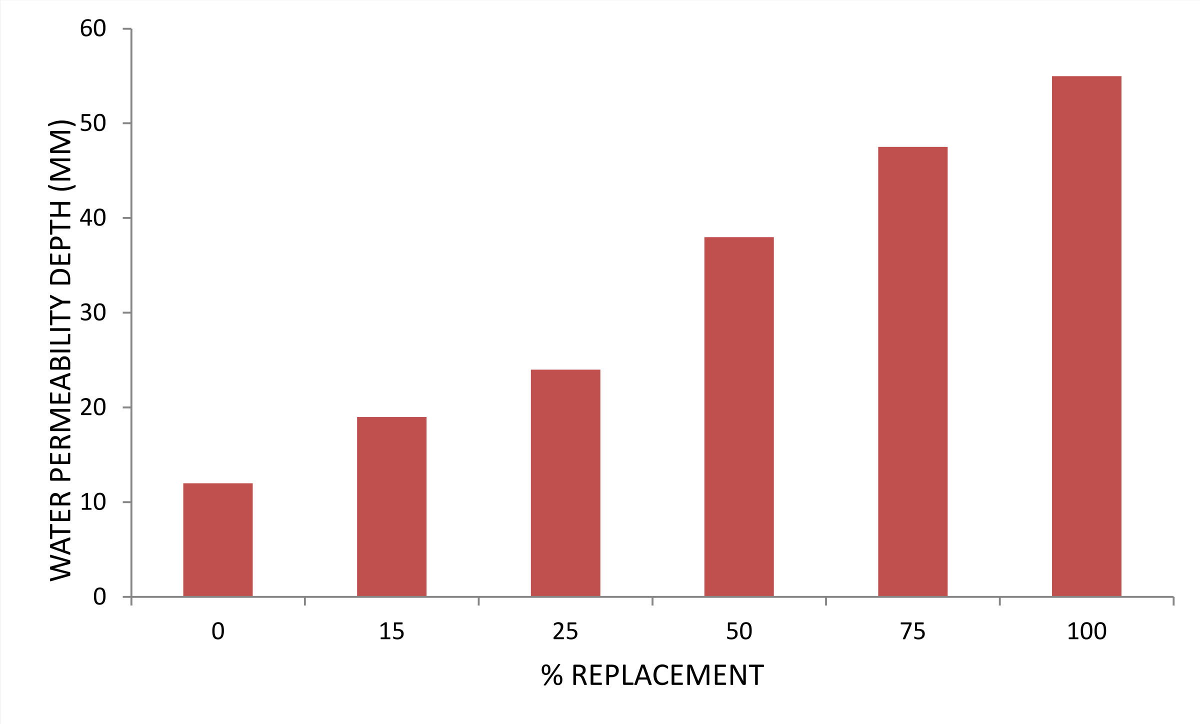

Figure 12 Water permeability at various replacement level (W/C – 0.45)

CONCLUSION

The workability of the CSS substituted concrete was lesser than the control concrete and it was observed that the workability decreased with increase in the percentage replacement for both the w/c ratio. The loss of workability can be easily recovered with the application of new generation super-plasticizers.

Upto a certain optimum percentage replacement of the CSS substituted concrete enhanced the compressive strength of the concrete as compared to the control concrete. The compressive strength started decreasing for substitution beyond this optimum replacement attaining even lesser value than the control concrete at very higher percentage replacement.

The optimum percentage replacement for all w/c was found to be 15%. A significant decrement was observed in the value of compressive strength beyond 15% for both w/c.

The same trend was observed for all the compressive strength measurements at 7d, 28d and 90d.

The flexure strength and split tensile strength results followed the same trend as the compressive strength.

Abrasion of concrete containing sandstone is more because abrasion mainly depends upon hardness and as we know that sandstone is derived from the sedimentary rock which hardness is comparatively less therefore the abrasion value is more. However, the abrasion values are still within the desired limits.

From the DIN-Permeability result it is observed that the depth of penetration increases with increase in CSS replacement.

So from the above study it can be concluded that up to a 15% replacement the use of crushed stone sand as a partial replacement of fine aggregate can be beneficial in cement concrete without sacrificing the desired strength. However beyond 15 % replacement the Concrete mix can be utilized for non-structural purposes.

REFERENCES

1. BRAVARD, J., GOICHOT, M., GAILLOT, S., Geography of Sand and Gravel Mining in the Lower Mekong River First Survey and Impact Assessment. EchoGeo, 2013. p. 26
2. CORINALDESI, V., MORICONI, G., NAIK, T.R., Characterization of marble powder for its use in mortar and concrete. Constr. Build. Mater. 2010. 24 (1), 113-117.
3. DIVAKAR, Y., MANJUNATH, S., ASWATH, M.U., Experimental investigation on behaviour of concrete with the use of granite fines. IJAERS, 2012.1 (4), 84-87.
4. ERGÜN, A., Effects of the usage of diatomite and waste marble powder as partial replacement of cement on the mechanical properties of concrete. Constr. Build. Mater. 2011. 25 (2), 806-812.
5. E. VERSTRYNGE, L. SCHUEREMANS, D. VAN GEMERT, and Creep and failure prediction of diestian ferruginous sandstone: modelling and repair options, Constr. Build. Mater. 29, 2012, 149–157
6. FELIX KALA, T., Effect of granite powder on strength properties of concrete. Int. J.Eng. Sci. 2013. 2 (12), 36-50.
7. FELIXKALA, T., SETHURAMAN, V.S., Shrinkage properties of HPC using granite powder as fine aggregate. IJEAT, 2013.2 (3), 637-643.
8. F. GAMEIRO, J. BRITO, C. D. SILVA, Durability performance of structural concrete containing fine aggregates from waste generated by marble quarrying industry, Engineering Structures, 59 , 2014, 654–662.
9. GARAS, G.L., ALLAM, M.E., BAKHOUM, E.S., Studies undertaken to incorporate marble and granite wastes in green concrete production. ARPN J. Eng. Appl. Sci. 2014. 9 (9), 1559-1564.
10. GAO, J.M., QIAN, C.X., LIU, H.F., WANG, B., LI, L., ITZ microstructure of concrete containing GGBS. Cement Concrete. Res. 2005., 35 (7), 1299-1304.
11. GENCEL, O., OZEL, C., KOKSAL, F., ERDOGMUS, E., MARTÍNEZ-BARRERA, G., BROSTOW, W., Properties of concrete paving blocks made with waste marble. J. Clean. Prod. 2012. 21(1), 62- 70.
12. HAMZA, K.K. AIZBOON, Effect of using granite slurry in concrete. Constr. Build.Mater. 2013. 10, 1014-1020.
13. HAMEED, M.S., SEKAR, A.S.S., Properties of green concrete containing quarry rock dust and marble sludge powder as fine aggregate. ARPN J. Eng. Appl. Sci. 4(4). 2009.
14. ADIGUN, E.M.A., Cost effectiveness of replacing sand with crushed granite fine in the mixed design of concrete. IOSR J. Mech. Civ. Eng. 2013. 10 (1), 1-6.
15. ALIABDO, A.A., ELMOATY, M.A., AUDA, E.M., Re-use of waste marble dust in the production of cement and concrete. Constr. Build. Mater. 2014. 50, 28-41.IS: 8112-1989, 43 grade ordinary Portland cement specification, Bureau of Indian Standards, New Delhi, India.
16. AL-HAMAIEDEH, H.D., KHUSHEFATI, W.H., Granite sludge reuse in mortar and Concrete.J. Appl. Sci. 2013. 13, 444-450.
17. AL-ZBOON, K. & TAHAT, M. Recycling of stone cutting waste in floor tiles production. International Journal of Theoretical & Applied Sciences, 2009. 1(1): 64-71
18. ALMEIDA N., BRANCO F., & SANTOS J. R.. Recycling of stone slurry in industrial activities: Application to concrete mixture. Building and environment – The International Journal of Building Science and Its Applications, 2007, 810-819
19. ANDRE, A., DE BRITO, J., ROSA, A., PEDRO, D., Durability performance of concrete incorporating coarse aggregates from marble industry waste. J. Clean. Prod. 2014. 65,389-396.

20. ARIVUMANGAI, A., FELIXKALA, T., Strength and durability properties of granite powder concrete. J. Civ. Eng. Res. 2014. 4 (2A), 1-6.
21. ARULRAJ, G.P., ADIN, A., KANNAN, T.S.,. Granite powder concrete. ESTIJ 2013, 3 (1), 193- 198.
22. ARUNTAS¸, H.Y., GÜRÜ, M., DAYI, M., TEKIN, _ I., Utilization of waste marble dust as an additive in cement production. Mater. Des. 2010. 31 (8), 4039-4042.
23. ASTM C 1585-04, Standard test method for measurement of rate of absorption of water by hydraulic cement concretes.
24. BACARJI E, TOLEDO FILHO RD, KOENDERS EAB, FIGUEIREDO EP, LOPES JL. Sustainability perspective of marble and granite residues as concrete fillers. Construction Building Material 2013; 45(1):10.
25. BAHAR DEMIREL. The effect of the using waste marble dust as fine sand on the mechanical properties of the concrete. Int J Phys Sci 2010; 5(9):1372–80.