

# Study on Physical and Mechanical Properties of Quartzite and Silico-Manganese Slag as Alternative Material for Coarse Aggregate

Ummar Shareef<sup>1</sup> VR Sankar Cheela<sup>2</sup> SSSV Gopala Raju<sup>3</sup>

<sup>1</sup>P.G. Student <sup>2</sup>Assistant Professor <sup>3</sup>Professor

<sup>1,2,3</sup>Department of Civil Engineering

<sup>1,2,3</sup>MVGRCE

**Abstract**—In the present study, utilization of quartzite and Silico Manganese (Si-Mn) slag as an alternative for coarse aggregate was investigated. Studies were conducted on the physical and mechanical properties of the material. Compressive strength property under normal curing condition was studied. M25 grade experimental design was prepared in accordance with Indian standard Code IS: 10292-2000 methods. Cubes with a curing period of 28 days were used. Compressive strength results represent that utilization of quartzite has higher better than Si-Mn Slag. Physical and chemical properties represent that of quartzite had good resistance in crushing and impact tests.

**Key words:** Quartzite, Silico-Manganese Slag, Compressive Strength, Mix Design

## I. INTRODUCTION

Numerous parameters, non-trivial method of analysis, diverse environmental conditions and protracted duration of experimentation formulate study of durability properties an exigent problem. Attack of concrete matrixes and passivation layer by chloride ions, sulphate ions and magnesium ions annihilate concrete structures (Hui Song et al., 2011).

Studies on pore structure, chloride diffusivity, steady and non-steady state migration, stray current migration, water cement ratios and effect of binary and ternary blends with fly ash, silica fume and blast furnace slag were investigated. (Yang 2006; Tong and Gjorv 2001; Bertolini et al., 2007; otsuki et al., 2000; Ahamed et al., 2008). Utilization of waste byproducts such as fly ash, metakaolin, blast furnace slag for the replacement of cement and coarse aggregate enhanced the properties of concrete.

Quartzite and Silico manganese (Si-Mn) slag are end products of the ferro alloy industry (Behera et al). Improper disposal would create havoc to human health and ground water pollution (Bhavana Tripathi et al., 2012). Utilization of these material as replacement of coarse aggregate would reduce stress on both environment and construction industry (Xiaolu Guo et al., 2012; Lizarazo-Mariaga et al., 2011). Mineral composition constitutes crystalline property representing pozzolanic activity close to mineral admixtures like silica fume and fly ash (Moise's Frias et al., 2006). As per Hazardous Wastes (Management and Handling) amendment rules, Si-Mn slag is classified under category of Class B (B.29, Concentration <5000 mg/L) of schedule-II in the hazardous wastes list (MoEF, 2006).

## II. MATERIALS AND METHODS

### A. Cementitious Material

Ordinary Portland cement (OPC) 53 grade conforming to IS 12269: 1987 were used in the current study.

### B. Aggregates

The fine aggregate was locally available river sand conforming to Zone II of IS 383: 2000 [ASTM C33 (ASTM 2011c)] with a specific gravity, water absorption and coarseness modulus. Coarse aggregate was crushed granite rock of maximum size 20mm conforming to IS 383:2000 [ASTM C33 (ASTM 2011c)] with specific gravity, dry rodded unit weight and water absorption. The quartzite and Si-Mn aggregate conforming to IS 383: 2000 [ASTM C33 (ASTM 2011c)] gradation were used for study. The quartzite and Si-Mn slag were produced as byproduct from a local ferro alloy company. The particle size obtained from the industry varied from 75 microns to 20mm. The obtained materials are processed and well graded to have a particle size confirming to IS 383: 2000 [ASTM C33 (ASTM 2011c)]. To obtain the coarseness modulus of coarse aggregate in this study the materials are crushed to the desired size using Los Angles abrasion machine.

Concrete mix proportioning was performed according to the IS 10262:2009 standard volumetric mixture proportioning method. According to ASTM C192-07 (ASTM 2007) mixing of concrete was done using a counter current mixer.

### C. Material Properties

Specific gravity of cement, coarse aggregate, coarse aggregate and quartzite had been found according to Indian standard code IS 2386:1963 part 3 in which three samples had been tested and the average value is reported. Coarseness modulus of coarse aggregate and quartzite had been tested according to Indian standard code IS 2386:1963 part 1 using the standard IS sieves 40mm, 31.5mm, 25mm, 20mm, 16mm, 12.5mm, 10mm, 6.3mm and 4.75mm, graph had been plotted for both of them. Crushing strength of both coarse aggregate and quartzite had been tested according to Indian standard code IS 2386:1963 part 4 in which the samples are chosen from sieving the aggregate by passing 12.5 mm and 10mm retained in which the average value is reported. Impact strength of both coarse aggregate and quartzite had been tested according to Indian standard code IS 2386:1963 part 4 in which the samples are chosen from sieving the aggregate by passing 12.5 mm and 10mm retained in which the average value is reported. Bulk density of coarse aggregate and quartzite had been tested according to Indian standard code IS 2386:1963 part 3 of which average value had been taken from the three samples. Water absorption of coarse aggregate and quartzite had been tested according to Indian standard code IS 2386:1963 part 3 of which average value had been reported from the three samples. Flakiness and elongation index of both coarse aggregate and quartzite had been tested according to Indian standard code IS 2386:1963 part 1 and the values are tabulated.

### III. RESULTS

#### A. Particle Size Analysis

The grain size analysis of the sand and slag used in the present study is represented in figure 1. Slag is following same trend with that of sand, showing it can be replaced with slag. As per IS 383 both are classified as Zone II.

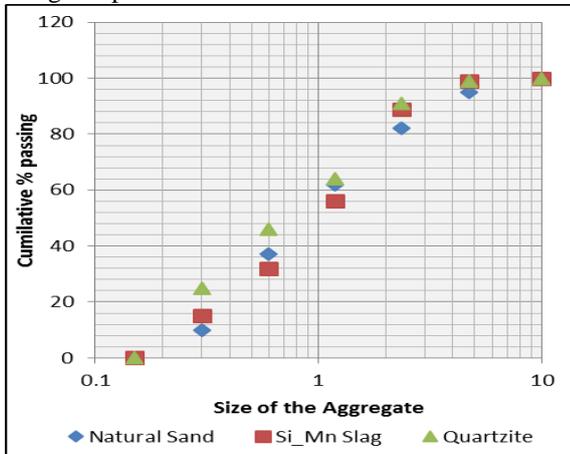


Fig. 1: Particle Size analysis for various aggregates

#### B. Water Absorption and Density of Aggregates

Mansur et.al., (1999) had said that recycled ceramic aggregates show higher water absorption when it was compared to coarse natural aggregates. The values reported are 6.1% and 0.7%, respectively. Regarding the bulk density, they stated that the bulk density is lower for the coarse recycled brick aggregates ( $2.21 \text{ kg/m}^3$ ) than for coarse natural aggregates ( $2.66 \text{ kg/m}^3$ ). De Brito et.al., (2005), coarse recycled ceramic aggregates have high water absorption (12.0%). They reported that this property may cause loss in mechanical strength, workability or durability. They also reported a lower bulk density for recycled brick aggregates ( $1159 \text{ kg/m}^3$ ) than for coarse natural aggregates ( $1542 \text{ kg/m}^3$ ). Medina et al. (2012) said that coarse sanitary ware aggregates has higher water absorption than coarse natural aggregates. The results reported, respectively 0.6% and 0.2%, showed that these properties are very similar for recycled and natural aggregates. They stated that the bulk density is higher for coarse natural aggregates ( $2630 \text{ kg/m}^3$ ) than for coarse recycled ceramic aggregates ( $2390 \text{ kg/m}^3$ ).

According to Indian standard code the water absorption for coarse aggregate ranges from 0% -2% hence we had noticed that the water absorption for quartzite aggregate is 0.55% which satisfies the code results. The bulk density is lower for the coarse quartzite aggregates  $1519 \text{ (kg/m}^3)$  than for coarse natural aggregates  $1722 \text{ (kg/m}^3)$ .

#### C. Specific Gravity

The specific gravity of the palm kernal shells and coconut shells are 1.74 and 1.46. (Olanipekun et.al., . 2006). The specific gravity of recycled coarse aggregate is 2.44 (Claudio et.al., 2011). The specific gravity of scrap-tyre-rubber is 1.3 (Ganjian et al. 2009). The specific gravity of oil palm shell is 1.37(Shafigh et al.2014). These figures fall below the 2.5–3.0 range of specific gravity for normal weight aggregates according to code IS 2386:1963 part 3. The specific gravity of quartzite is 2.68 as correlated with the above materials it can state that quartzite can be beneficially used as coarse aggregate in concrete.

Sample Number	Properties	Natural Aggregate	Quartzite	Si-Mn Slag
1	Specific Gravity	2.72	2.68	2.70
2	Coarseness Modulus	7.87	7.04	7.15
3	Crushing strength	27.6%	36.2%	26.8%
4	Impact Strength	27.5%	34.40%	25.4%
5	Water Absorption	0.5%	0.55%	0.12%
6	Bulk Density	1722	1519	1625

Table 1: Physical Characteristic of Ingredients

#### D. Compressive Strength

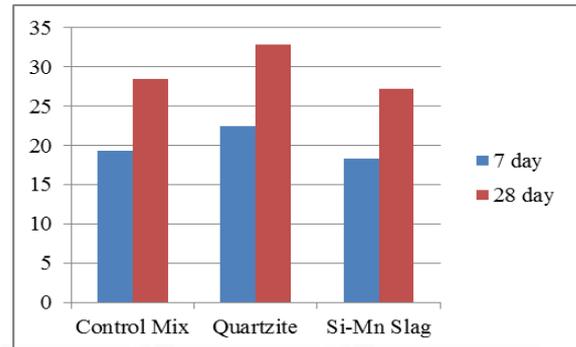


Fig. 2: 28 day's Compressive strength for various aggregates  
Figure 2 represents assessment of compressive strength development over age of concrete between quartzite, Si-Mn slag and Conventional sand mixtures concrete designed for a period of 28 days. The average of three duplicate specimens represents a data point. Figure 2 depict that quartzite has higher compressive strength development in the early stages representing faster setting time. As the hydrated compounds are developed in later stages the bonding developed between hydrated cement pastes may contribute to earlier compressive failure. Surface roughness and moisture absorption provide a scope for better bonding in conventional concrete. The water-cement ratio plays a major role in development of the strength with age. In the present study the concrete cubes are casted at same w/c ratios. The strength of Si-Mn slag concrete gradually decreased as compared to conventional concrete. The fracture toughness is higher for natural sand enabling it resistance to fracture during uniaxial compression (Daphalapurkar et al. 2011; Jared et al.2014)

### IV. CONCLUSIONS

- 1) Quartzite aggregate can be used as alternative material for natural aggregate.
- 2) Quartzite has higher 28 days compressive strength compared to both Si-Mn slag and conventional aggregate.
- 3) Si-Mn slag has low water absorption compared to both quartzite and conventional aggregate.
- 4) The crushing strength for quartzite high and Si-Mn slag is low as compared to conventional aggregate.

#### ACKNOWLEDGEMENT

The authors would like to thank the management and Dr KVL Raju, Principal, MVGR College of Engineering (Autonomous) for providing all the technical, financial support, constant encouragement and suggestions throughout the project.

#### REFERENCES

- [1] Juan Lizarazo-Marriaga, Peter Claisse, Eshmaiel Ganjian, "Effect of Steel Slag and Portland Cement in the Rate of Hydration and Strength of Blast Furnace Slag Pastes", *Journal of Materials in Civil Engineering*, 2011 Vol. 23, No. 2, 153–160.
- [2] Moisés Frias, M. Isabel Sánchez de Rojas, Jesús Santamaría, Cristina Rodríguez, "Recycling of silicomanganese slag as pozzolanic material in Portland cements: Basic and engineering properties", *Cement and Concrete Research* 36 (2006) 487 – 491
- [3] Xiaolu Guo and Huisheng Shi., "Utilization of steel slag powder as a combined admixture with ground granulated blast furnace slag (GGBFS) in cement based materials", *Journal of Materials in Civil Engineering* 2013.
- [4] Yang, C.C., "On the relationship between pore structure and chloride diffusivity from accelerated chloride migration test in cement-based materials", *Cement and Concrete Research*, 2006, 36: 1304–1311.
- [5] Bertolini, L., Carsana, M. and Pedferri, P., "Corrosion behavior of steel in concrete in the presence of stray current", *Corrosion Science*, 2007, 49: 1056-1068.
- [6] Otsuki, N., Miyazato, S.I., Diola, N.B. and Suzuki, H., "Influences of bending crack and water-to-cement ratio on Chloride-induced corrosion of main reinforcing bars and stirrups. Materials", *Journal*, 2000, 97(4): 454-464.
- [7] Ahmed, M.S., Kayali, O. and Anderson, W., "Chloride penetration in binary and ternary blended cement concretes as measured by two different rapid methods", *Cement & Concrete Composites*, 2008, 30: 576-582.
- [8] Tong, L. and Gjörv, O.E., "Chloride diffusivity based on migration testing", *Cement and Concrete Research*, 2001, 31: 973-982.
- [9] Hui, Song. and Jiankang, Chen., "Effect of damage evolution on poisson's ratio of concrete under sulfate attack", *Acta Mechanica Solida Sinica*, 2011, 24: 209-215
- [10] Nabil M. Al-Akhras ., "Durability of metakaolin concrete to sulfate attack", *Cement and Concrete Research*, 2006, 36: 1727–1734
- [11] Mindess, S., Young, J., and Darwin, D. *Concrete*, 2nd Ed., Pearson Education, Upper Saddle River, NJ 2003.
- [12] Neville, A. (1995). *Properties of concrete*, 4th Ed., Pearson Education, Harlow, Essex.
- [13] Jared, R. Wright., Chris, Cartwright., Dan, Fura., and Farshad, Rajabipour., "Fresh and Hardened Properties of Concrete Incorporating Recycled Glass as 100% Sand Replacement", *J. Mater. Civ. Eng.*, 2014 26.1-11.