ISSN (Print): 0974-6846 ISSN (Online): 0974-5645

Effect on Workability of Concrete due to Partial Replacement of Natural Sand with Gold Mine Tailings

N. Parthasarathi^{1*}, B. M. Ramalinga Reddy² and K. S. Satyanarayanan¹

¹Department of Civil Engineering, SRM University, Chennai - 603203, Tamil Nadu, India; nrnpartha@gmail.com, srm.kssn@gmail.com ²Structural Engineering, SRM University, Chennai - 603203, Tamil Nadu, India; bmreddy@btibangalore.org

Abstract

Objective: Availability of fine aggregates in its natural form is becoming very scarce. It is becoming a challenging task to meet the demand for fine aggregates in its natural form without exploiting the natural resources. To sustain the construction activity, it becomes very essential to explore the possibility of utilizing alternative materials for fine aggregates. Large quantity of inorganic industrial waste is generated annually. Coal mine wastes, blast furnaces lag, iron ore tailings, red mud, zinc tailings, goldmine tailings etc., are some of the inorganic waste products that are generated. **Methods/Statistical Analysis:** In this investigation, an attempt is made to replace partially naturals and with gold mine tailings and study the behavior of concrete in the green state. Mix proportion for M25 concrete was obtained as per IS: 10262 guidelines, for normal concrete and concrete containing gold mine tailings as fine aggregates. **Findings:** Natural fine aggregates were replaced with10%, 20% and 30% goldmine tailings on weight basis. In all five mixes were obtained and workability studies in the form of slump and compaction factor test were carried out. The slump for normal concrete was 84.33 mm and that for concrete containing gold mine tailings was 16.33 mm. The low slump for concrete containing gold mine tailings alone may be attributed to the presence of fine particles. The slump values for 10%, 20% and 30% replacement levels are 63.6 mm, 44.33 mm and 22.6mm respectively. Similar behavior is observed in the case of compaction factor test also. The decrease in the workability of concrete may be attributed to the increase in the fineness of resulting fine aggregates. **Applications/Improvements:** The application of the gold mine tailing in the high scale structures and reduce cement by GMT.

Keywords: Compaction Factor, Concrete Mix, Gold Mine Tailings, Slump

1. Introduction

Large volumes of natural resources are consumed annually to meet the demand of construction industry. It is estimated that consumption of cement will increase by 166% at the end of 2020¹. This leads to large consumption of fine and coarse aggregates. Meeting the demand for fine aggregates in its natural form without exploiting the natural resources is a challenging task. Large quantity of industrial waste is generated annually. Gold mine tailings are one of the industrial wastes generated. In this investigation an attempt is made to replace partially river sand with different percentages of gold mine tailings and study the workability property concrete. Determining the

relative proportions and quantities of material constituents of concrete and making necessary adjustments to the mix design to suit the trial mix design on site. It is also useful in minimizing the cost and optimizing the mean compressive strength of concrete mixes². Nano structural properties of concrete can be studied with considering the variations of the nano silica/Si ratio, the silicate structure, and the contents of Si–OH in the mixture using X-Powder method, AFM (Atomic Force Microscopy) and X- Ray Diffraction (XRD) techniques³. Allometric equations resulting from the relationship between the diameter breast height and stem volume for Cassia siamea Lamk. stand in the coal mining reclamation⁴

^{*}Author for correspondence

Zwoze ze z coming of cost programme									
Sand Type	W/C	% of SP	Mix Proportion	Properties Investigated					
			Troportion	Slump	Compaction factor				
RS	0.45	0.50	1:1.5:2.58	1	V				
GMT	0.60	2.50	1:2.28:3.6	1	√				
RS+GMT(0.9:0.1)	0.45	0.50	1:1.5:2.58	1	√				
RS+GMT(0.8:0.2)	0.45	0.50	1:1.5:2.58	1	√				
RS+GMT(0.7:0.3)	0.45	0.50	1:1.5:2.58	√	√				

Table 1. Details of test programme

RS: River sand; GMT: Gold mine tailings; w/c: Water cement ratio; SP: Superplasticiser

1.1 Scope of the Work and Experimental Programme

The effect of partial replacement of river sand with gold mine tailings on the workability property of concrete is investigated. Mix proportions for M25 concrete was obtained as per IS: 10262⁵ guidelines, for normal concrete and concrete containing different percentages of goldmine tailings. Slump and compaction factor tests were conducted. Details of mix proportions and various tests and mix conducted are given in Table 1.

2. Materials used in the Investigation

2.1 Cement

Ordinary Portland cement conforming to IS: 81126 was used for the preparation of mortar.

2.2 Fine Aggregates

Natural river sand was as fine aggregates in this investigation. The sand grading was altered by replacing certain percentages (10%, 20% and 30%) of river sand by gold mine tailings.

2.3 Coarse Aggregates

Coarse aggregates passing through 20 mm and retained on 4.75 mm sieve were used in this investigation.

2.4 Gold Mine Tailings

Tailings are one of the primary waste products of mining operations. They are made of fine-grained particles of the

parent rock from which the ore is extracted by crushing, grinding and other milling processes. The characteristics of tailings are a result of the composition of the parent rock. Tailings used in this investigation were obtained from Hutti goldmines, Hutti village, Raichur district, Karnataka, India.

3. Testing Procedure

3.1 Blending of Fine Aggregates

The natural sand selected for this investigation conformed to zone-II, as per IS: 383^{7} guidelines. This material was replaced by goldmine tailings on the basis of weight ratios. Three percentages of replacement were adopted namely 10%, 20% and 30%. The grading curves for various sand types are shown in Figure 1.

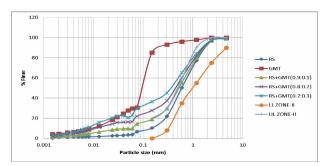


Figure 1. Particle size distribution curves for different sand types.

3.2 Mix Proportioning

Mix proportions for M25 concrete were obtained as per IS: 10262 guidelines, for normal concrete and concrete containing different percentages of gold mine tailings.

Table 2. Gradation results for different sand types

Sand Type	FM	Coarse (4.75- 2.36)	Medium (2.36- 0.425)	Fine (0.425-0.075)	Silt (0.075-0.002)	Clay (<0.002)
RS	2.45	3.33	65.48	24.61	5.52	1.06
GMT	0.28	0	6.16	63.28	25.89	4.67
RS+GMT (0.9:0.1)	2.23	3.00	58.97	23.77	12.3	1.96
RS+GMT (0.8:0.2)	2.01	2.66	52.47	22.94	19.06	2.87
RS+GMT (0.7:0.3)	1.79	2.33	41.96	26.1	25.84	3.77

FM: Fineness modulus

Required quantity of Super plasticizer was used to get a workable mix.

3.3 Determination of Workability of Concrete

Workability is an important property which the concrete has to possess for achieving full compaction. Among the different methods adopted, slump and compaction factor methods are most commonly used in practice. In this investigation, these methods are adopted to find the workability for different sand types.

4. Results and Discussion

4.1 Partial Replacement of River Sand with Gold Mine Tailings

The particle size distribution curves for river sand, gold mine tailings and replaced sand at 10%, 20% and 30%. The changes in the gradation of different sand types due to partial replacement of rivers and with gold mine tailings. The following observations can be drawn from the graphs and results given in Table 2.

- The gold mine tailings are very fine particles with a fineness modulus of 0.28 and contain around 69% of medium and fine sand.
- As result of replacing river sand with gold mine tailings, the quantity of medium and fine sand changes as the replacement level changes.
- The percentage of medium and fine sand in the resulting sand for 10%, 20% and 30% replacement levels are 82%, 75% and 69% respectively.

4.2 Slump and Compaction Factor Test Results

The results of slump and compaction factor tests shown in Figure 2 and the variations of slump and compaction factors for different mix proportions are shown in Figure 3 respectively. The following observations can be made from the results shown in Table 3.

- The slump and compaction factor values for concrete containing gold mine tailings alone are very low inspite of water cement ratio being high when compared to concrete containing rivers and alone. This may be attributed to the presence of very fine sand.
- Concrete containing rivers and alone exhibits good workability with a specific amount of Super plasticizer.
- The workability of concrete reduces as the percentage of gold mine tailings increases in the fine aggregates.
- The degree of workability achieved for concrete with 10% and 20% replacement level is medium

Table 3. Results of slump and compaction factor tests

Sand Type	Mix Proportion	Slump (mm)	Compaction Factor
RS	1:1.5:2.58	84.33	0.91
GMT	1:2.28:3.6	16.33	0.77
RS+GMT (0.9:0.1)	1:1.5:2.58	63.6	0.91
RS+GMT (0.8:0.2)	1:1.5:2.58	44.33	0.85
RS+GMT (0.7:0.3)	1:1.5:2.58	22.6	0.77

- and low respectively as per IS: 4568. The concrete with this workability has applications in mass concrete, lightly reinforced sections in slabs, beams and walls. Also it can be used it can be used for heavily reinforced sections in slabs, beams and walls.
- The degree of workability achieved for concrete with 30% replacement is very low. However, this concrete has applications as blinding concrete, shallow sections and pavements using pavers.

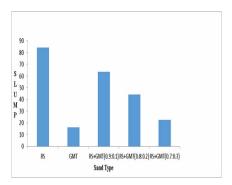


Figure 2. Variation of slump for different concrete mixes.

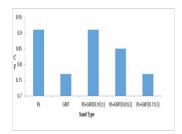


Figure 3. Variation of compaction factor for different concrete mixes.

5. Summary and Conclusions

Influence of the presence of gold mine tailings as a partial substitute for rivers and in concrete on the grading property of fine aggregate and workability of concrete was investigated. The following conclusions can be drawn from the investigation.

- Gold mine tailings constitute very fine sand particles with 69% of fine medium and fine sand. As a result of replacement of river sand with gold mine tailings, the fraction of medium and fine sand slightly decreases when compared to river sand.
- For 30% replacement level, the fraction of medium and fine sand is around 69%, out of which 42% is medium sand.

- The gradation of gold mine tailings and river sand can be altered by reconstitution. The reconstitution can be done by utilizing a particular fraction of manufactured sand and with this the fraction of fine sand and silt can be reduced.
- The work ability of concrete in terms of both slump and compaction factor for concrete containing gold mine tailings alone is very, which can be attributed to the presence very fine sandparticles.
- The slump value decreases by around 24%, 47% and 73% for replacement levels of 10%, 20% and 30% respectively. However, the degree of workability achieved for 10% and 20% replacement levels is medium and low respectively.
- The degree of workability achieved for 30% replacement is very low. A similar trend is observed in case of compaction factor also.

6. References

- Venkatarama RBV. Sustainable building technologies. Current Science. 2004; 87(7): 899–907.
- Adegbola AA, Dada MJ. Development of mathematical equations and programs for the optimization of concrete mix designs. Indian Journal of Science and Technology. 2012 Nov; 5(11):3665–84.
- 3. Amiri B, Bahari A, Nik AS, Movahedi NSS. Use of AFM technique to study the nano-silica effects in concrete mixture. Indian Journal of Science and Technology. 2012 Feb; 5(2):2055–8.
- 4. Sadelillyas. Carbon sequestration and growth of stands of cassia siamea lamk in Coal Mining Reforestation Area, Indian Journal of Science and Technology. 2013 Nov, 6(11), pp. 5405-10.
- IS: 10262-2009, Indian standard code of practice for concrete mix design. New Delhi, India: Bureau of Indian Standards; 2009.
- 6. IS: 8112-1989, Indian standard specification for 43 grade ordinary Portland cement. New Delhi, India: Bureau of Indian Standards; 1989.
- IS: 383, Indian standard code of practice for specification for coarse and fine aggregates. New Delhi, India: Bureau of Indian Standards; 1970.
- 8. IS: 456, Indian standard code of practice for plain and reinforced concrete-Code of Practice [CED 2: Cement and Concreate]. New Delhi, India: Bureau of Indian Standards; 2000.