Effect of Partial Replacement of Construction Industry Waste Materials in Concrete

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Abstract - *Concrete being a versatile material has extended its applications to majority of the sectors of Civil engineering. However, eco-detrimental effects of concrete remain debatable due to its carbon footprints. Recycling of materials reduce the demand on usage of natural materials and in turn reduce the cost of production. Concrete of M-25 grade made with construction industry waste materials (recycled materials) exhibit satisfactory results. Compressive strength of concrete reduces at increased replacement levels of waste materials and also workability is reduced at high replacement levels due to increased water absorption by recycled materials. Reduced mining activity and increased waste utilization makes this concrete eco-friendly. This concrete can be adopted for low-cost construction activities.*

Key Words - *Concrete, Waste Utilization, Demolition dust, Laterite residue, Mangalore tiles.*

1. INTRODUCTION

Construction sector has considered concrete as a versatile material, being adoptive for non- structural and structural parameters. Concrete is a homogeneous mixture of cement, fine and coarse aggregates along with water [1,2]. Cement being a prime content of concrete, liberates about 1 ton of carbon di oxide into atmosphere for production of 1 ton of cement leading to global warming. Usage of virgin aggregates promotes the extensive mining activities which depletes natural sources, which also escalate the budget of construction [2]. Excess mining of river bed leads to deterioration of water bodies and aquatic life along with depletion of water table in vicinity areas [1]. Even though manufactured sand (M-sand) appears to be an alternative to river sand, production process involves blasting, breaking, crushing and transportation of material which is having a long term effects on nature. The quarry pits being the only source of conventional coarse aggregates is contributing in its own way towards exploitation of environment. Meanwhile, cost of conventional construction materials upsurge frequently due to increase in demand and thus inflate the cost of construction.

Many research activities confirm that construction and demolition waste products can be adopted as building material with minimal processing with the name "Recycled construction materials" which makes the concrete sustainable [1]. Even though the quality and long term properties are debatable, concrete with recycled materials are depicting satisfactory mechanical properties in concrete.

With the advent of sustainable engineering concept; reduction of waste, reuse of stable material, and recycling of waste is being effectively adopted in civil engineering now a days. With the advancement in materials and aesthetics of building, lot of renovation and reconstruction activities are leading to production of demolition dust and roof tile waste [3]. Usage of crushed Mangalore tiles increases strength and by galloping a non-biodegradable waste ceramic material, the concrete becomes economic and eco-friendly [4]. Similarly, during dressing and mining of laterite masonry units large quantity of waste is generated which can be used as fine aggregate.

An attempt has been made to replace cement with demolition dust, fine aggregate with laterite residue and coarse aggregates with crushed Mangalore roof tiles in this study. By adopting recycled materials cost of construction can be reduced and the same can also be adopted for low cost housing with locally available construction industry waste as per its properties.

2. MATERIALS AND METHODOLOGY

2.1 Materials

Cement: Ramco 43 grade cement was used for this study and the properties of cement examined and represented in table 1. Cement is replaced with demolition dust which was collected from a demolition site at Bengaluru. Dust is used for studies after sieving in 90micron sieve and its properties are mentioned in table 2.

Table -1: Properties of Cement

Properties	Values
Specific Gravity	3
Normal Consistency (%)	30
Initial setting time (minutes)	45
Final Setting time (minutes)	240
Fineness (%)	98

Table- 2: Properties of Demolition Dust

Properties	Values
Specific Gravity	2.40
Bulk Density (kg/m³)	1563
Fineness (%)	80
Water Absorption (%)	18.24

Fine aggregates: Manufactured – Sand [M-sand] is used as fine aggregate. It is replaced with laterite residue which was obtained from Laterite block mining and cutting site at Mangaluru. The properties of M-sand and Laterite residue are represented in Table 3.

Table -3: Properties of M-Sand and Laterite Residue

Properties	M-Sand	Laterite
Specific Gravity	2.45	2.63
Water Absorption (%)	1.2	11.4
Zone	II	II
Bulk Density (kg/m³)	1412	1211

Laterite is generally found in hot and wet tropical areas across the globe. It is highly weathered stone which is rich in iron oxides exhibiting pinkish to brown colour. Laterite stones are well compacted which can be cut to desired shape and size to suit the requirement of masonry work. Generally, mining of laterite is done in wet condition; as soon as exposed to environment, the block hardens to exhibit sufficient mechanical properties to adopt it as a construction material [5]. These blocks are used in India since ancient days, dressing and cutting of these will create waste material which is comparable to the properties of fine aggregate. Thus, this laterite waste was adopted as replacement material for fine aggregate. The properties of M-sand and laterite were investigated according to IS-383: 1970 [6]. Upto 20% replacement of laterite waste depicts satisfactory results [2].

Coarse aggregates: Conventional coarse aggregates was procured from a Magadi near Bengaluru. Mangalore roof tiles are extensively used in most of the parts of Karnataka and even across country as roofing material. These tiles got name due to its place of origin Mangalore since its inception by German Missionary in 1860. Because of rich iron content in laterite soil of the region, the tile appears in red colour. These materials are reaching the dump site due to the replacement of celling by RCC roofing in the recent days [7]. Disposed Mangalore tiles were collected and crushed. 20mm down size conventional and crushed Mangalore tiles were used as coarse aggregates for this study. The properties of the both the materials are listed in table 4. Being the excellent ceramic material, it remain non-degradable, thus incorporating into concrete would be a better environment friendly solution [7]. Aswathy Mohan et. al., recommends usage of roof tiles up to 25% as the strength reduces for further replacement levels [3]. Mangalore tiles can be replaced up to 20% without compromising in strength, which in turn might reduce the cost of concrete up to 15% [8].

Table- 4:Properties of Conventional Coarse Aggregates and Crushed Mangalore Tiles

Properties	Coarse Aggregate	Mangalore Tiles
Specific Gravity	2.67	2.11
Water Absorption (%)	0.40	6.98
Bulk Density (kg/m³)	1581	1130

Water: Portable water abiding by IS-456:2000 [9] was used for casting and curing of concrete.

2.2. Methodology

M25 grade Concrete was designed as per IS: 10262-2009 [10] and 1:1.48:2.58 proportions of cement, fine and coarse aggregate with 0.43 water cement [w/c] ratio was adopted. The cement was replaced with demolition fines (dust) at 5, 10, 15 and 20%. M-sand was replaced with laterite residue at 10, 20, 30, 40 and 50%. Conventional coarse aggregates were replaced with crushed Mangalore tiles at 15, 30, 45 and 60%. Fresh concrete was measured for workability using slump cone test according to IS 1199-2018 [11]. Concrete was filled to moulds in 3 layers by vibratory compaction method. After 24 hours of casting, specimens were demoulded and subjected to water curing by immersing in curing tank. The cubes specimens were subjected to compression test as per IS:516-1959 [12]. The optimum values were obtained from each replacement and final mix was prepared for optimum values and those specimens were checked for compression, split tensile and flexural strength as per IS:516- 1959 [12].

3. RESULTS AND DISCUSSIONS

The variation in compressive strength with replacement of cement with demolition fines is depicted in figure 1. With the increase in replacement levels, workability reduced which is also represented in fig1. At 5% replacement, due to water absorption by demolition dust particles, w/c ratio available for hydration reduces because of which strength might have increased slightly.

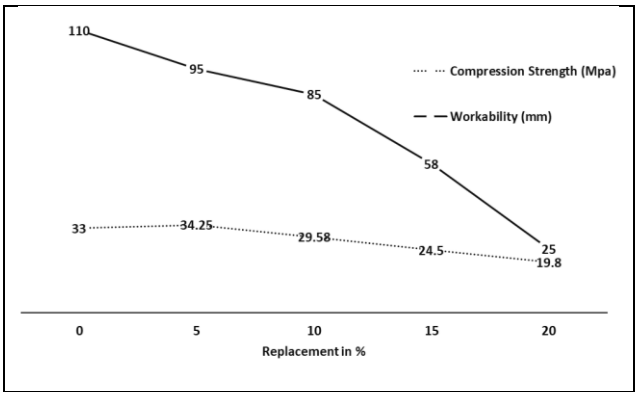

Chart-1: Variation of compressive strength and workability of concrete with replacement of cement with demolition fines

Variation in compressive strength with replacement of M-sand with laterite residue is depicted in fig2. Due to excessive water absorption properties of laterite waste, workability reduced to a greater scale. There was slight improvement in strength at 20% replacement, which may be due to revised w/c because of absorption of excess water by the laterite waste.

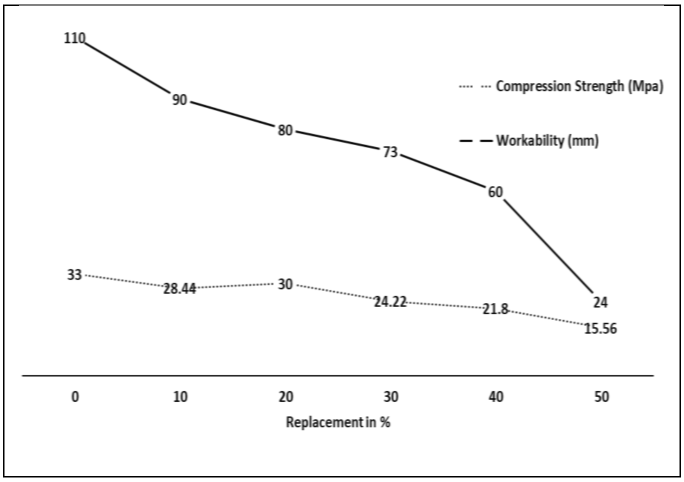

Chart- 2: Variation of compressive strength and workability of concrete with replacement of M-sand with laterite residue

Compressive strength decreased with increase in replacement of conventional coarse aggregates with crushed Mangalore tiles as shown in fig3. Even though water absorption was not rapid, due to large volume of ingredient, water required for lubrication of concrete was reduced resulting in poor workability. At 15% replacement, both workability and strength were satisfactory as represented in fig3.

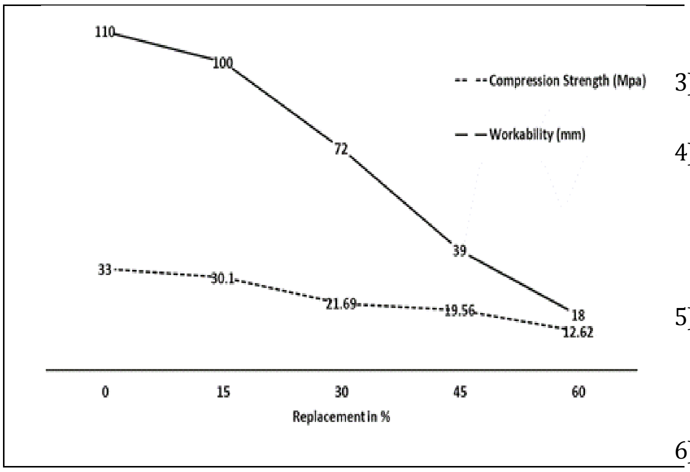

Chart- 3: Variation of compressive strength and workability of concrete with replacement of conventional coarse aggregates with crushed Mangalore tiles

From the fig 1, 2 and 3, it is evident that recycled materials can be replaced for conventional materials in concrete. With reference to these three graphs an optimum mix was attained with 5% of cement replaced with demolition dust, 20% of M-sand was replaced with laterite residue and 15% of conventional aggregates was replaced with crushed Mangalore tiles. This optimum mix was checked for workability, which was 75mm, which is acceptable. Mechanical properties such as compression strength, split tensile strength and flexural strength was investigated for this optimum mix, which is represented in fig4. With 28 days compressive strength of 31.69 Mpa, this concrete satisfies target mean strength. In future, durability properties shall be studied for better understanding.

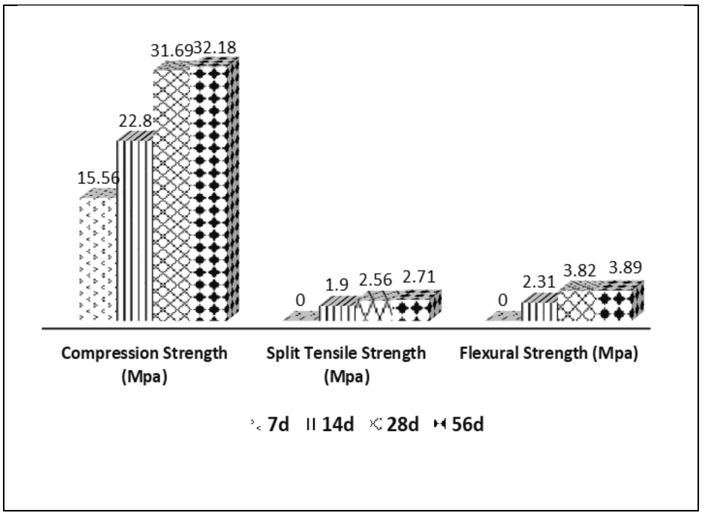

Chart- 4: Mechanical Properties of Optimum Mix Specimens

4. CONCLUSIONS

Following conclusions can be drawn from this research;

1) 5% replacement of cement with demolition dust develops optimum strength.
2) The results of replacement of fine aggregate replaced by laterite waste were similar to the results of G. Shabarish [2], with optimum strength at 20% replacement with M- sand.
3) At 15% replacement of coarse aggregate with Mangalore tiles exhibited optimum results.
4) Concrete made with optimum replacement values; exhibited compressive strength of 31.69Mpa at 28 days and after 28 days of age, improvement in strength was not significant. Split tensile and flexural strength results are proportional to compressive strength.
5) Usage of locally available waste materials reduces the production, transportation cost. By effective utilization of waste materials, pollution nuisance and problems related to landfilling can be avoided.
6) Concrete imbibing demolition dust, laterite waste, crushed Mangalore roof tiles represents eco-friendly and low-cost material for the construction industry.

REFERENCES

1. Otunyo and B. Okechukwu, "Performance of Concrete with Partial Replacement of Fine Aggregates With Crushed Waste Glass", Nigerian Journal of Technology, vol. 36, no. 2, pp. 403 – 410, 2017.

2. G. Sabarish, M. Ratnam, A. Prasad and U. Ranga Raju, "A Study on Strength and Durability Characteristics of Concrete with Partial Replacement of Fine Aggregate by Laterite Sand", International Journal for Innovative Research in Science & Technology, vol. 2, no. 3, pp. 134-141, 2015.
3. Mohan, J. Thomas and N. Joseph, "Use of Clay Tile Chips as Coarse Aggregate in Concrete", IOP Conf. Series: Materials Science and Engineering, 2018.
4. B Pachpute and B. G Bhade, "Effective Use of Mangalore Tiles Waste as a Partial Replacement to Course Aggregate in Concrete", International Journal of Advance Engineering and Research Development, vol. 6, no. 3, pp. 186-189, 2019.
5. K. Brahmaji, B. Ganesh, G. Murthy and K. Chandrika, "An Experimental Analysis on Usage Potential of Lateritic Soil as Part/Full Replacement for Fine Aggregates in Concrete", International Journal of Current Engineering and Scientific Research, vol. 4, no. 2, pp. 11-17, 2017.
6. IS: 383:1970 Indian Standard Code of Coarse and Fine Aggregate from Natural Sources for Concrete, Bureau of Indian Standards, New Delhi.
7. S. Geetha, M. Kavyashree, H. Krupaksha, K. Sthuthi and A. Viksheetha, "Utilization of Bone Aggregate and Mangalore Tiles Waste as a Partial Replacement to Natural Sand and Course Aggregate in Concrete", International Peer Reviewed Open Access Journal, vol. 12, no. 4, pp. 247-251, 2018.
8. D. Siddalingeshwara and B. Sab I, "Replacement of Course and Fine Aggregates in Concrete by using Mangalore Tile Wastage and Iron Ore Slag", International Research Journal of Engineering and Technology, vol. 6, no. 6, pp. 3643-3646, 2019.
9. IS: 456:2000 Indian Standard Code of Plain and Reinforced Concrete - Code of Practice, Bureau of Indian Standards, New Delhi.
10. IS: 1199:2018 Indian Standard Code of Fresh Concrete - Methods of Sampling, Testing and Analysis of Concrete, Bureau of Indian Standards, New Delhi.
11. IS: 516:1959 Indian Standard Code of Methods of Test Concrete, Bureau of Indian Standards, New Delhi.