Durability Studies on Concrete by Replacing Natural Sand with M-Sand – A Review

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Abstract— Concrete is extensively used around the globe and its consumption rate is more than the water. Due to infrastructure development, the natural resources depleting day by day. The use of M-Sand in concrete has desirable benefits such as increase in the strength for various percentage of replacement of natural sand and reduce mining of sand from the river bed. The various researchers has conducted research work to study only the mechanical properties of concrete with M-sand. The durability of concrete is the ability to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties. Need of hour is to focus more on durability properties of concrete with M-sand for severe exposure conditions to study the behavior and residual strength properties.

Keywords—Compressive strength, Split tensile strength, Flexural strength, M-sand, Workability, Durability.

I. INTRODUCTION

Concrete is one of the most widely used construction material by construction industries, it is usually associated with Portland cement and Fine aggregate as the main component for making concrete. Due to restriction imposed on sand quarrying by government, resulted scarcity of natural river sand. The cost of river sand automatically increased due to huge material demand and infrastructure development in India. Most of the construction industries use river sand only as fine aggregate. Investigations are going on due to increase in demand and depletion of river sand, along with restrictions imposed on the exploitation of the river sand. The alternative materials for river sand include manufactured sand, industrial by products (some forms of slag, bottom ash), recycled aggregates, etc. Among the above materials, manufactured sand is relatively receiving significant attention as a replacement for river sand. The M-sand is produced by impact crushing rock deposits to obtain a well graded fine aggregate. Generally, M-sand contains high fines, whereas lesser amount of clay and silt. Rock dust is the major component of these fines.

The effects of particle texture and shape of fine aggregates are more predominant than effects of coarse aggregates in concrete. Better interlocking of particles can be achieved by using angular shape of fine aggregates, which could lead to improvement in strength of cement concrete. M-sand possesses high angularity and when used in cement concrete produces less workability due to increased surface area.

Increasing extraction of natural sand from river beds causing many problems, loosing water retaining sand strata, deepening of the river courses and causing bank slides, loss of vegetation on the bank of rivers, exposing the intake well of water supply schemes, disturbs the aquatic life as well as affecting agriculture due to lowering the underground water table etc. are few examples. Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete and cement mortar. The most commonly used fine aggregate is natural river or pit sand. Fine and coarse aggregate constitute about 75% of total volume. It is therefore, important to obtain right type and good quality aggregate at site, because the aggregate forms the main matrix of concrete or mortar.

II. COMpressive STRENGTH

The M-Sand can be used as partial replacement for the natural sand in concrete, it is observed that compressive and flexure strengths are increased as the percentage of M-Sand is increased up to optimum level of 50%. The percentage of increase in the compressive strength is 18.88% and the flexure strength is 13.2% at the age of 28 days by replacing 50% of natural sand with M-Sand and 5% of cement by silica fume. From the experimental investigation, it has been observed that increase in the compressive strength of M20 and M30 grade of concrete for the replacement of natural sand by manufactured sand in the proportions of 0%, 20%, 40%, 60%, 80%, 100% is of order 0%, 4.7%, 14.43%, 19.73%, 17.13%, 15.69% and 0%, 5.8%, 12.8%, 19.8%, 17.1%, 13.2%.
After treating the specimens with hydrochloric acid for 28 days period, it was observed that the decrease in the compressive strength of M20 grade concrete for replacement of natural sand by manufactured sand in proportions of 0%, 20%, 40%, 60%, 80%, 100% is of order 11.7%, 10.18%, 9.92%, 7.12%, 9.13%, 9.65%[2]. It was observed that the compressive strength and weight loss of M35 grade of self compacting concrete decreases by immersion of cubes in sodium chloride solution and increases as exposure day increases [3]. By various durability tests, it was observed that the penetration of water into concrete decreases by increasing proportions of M-sand in concrete [4]. By investigation, it reveals higher compressive strength of cement mortar with 50% replacement of natural sand by manufactured sand when compared to reference mix [5]. According to laboratory investigation, the 28days compressive strength of self compacting concrete increases as the proportion of M-sand increases from 0% to 50% in M30 and M40 grade concrete, that is 29.6N/mm² to 31.6N/mm² and 41.8N/mm² to 44N/mm², after that compressive strength decreases if percentage of M-sand increases beyond 50%[6]. It was analyzed and observed that compressive strength of concrete mix with 100% Robosand at 28 days was 17.98% more that of 100% River sand. At 28 days of curing, compressive strength of concrete mix with combination of Robosand and GGBS (25% & 50%) was found to relatively higher than that of conventional mix. But combination of Robosand and 70% GGBS resulted in little lower compressive strength than that of conventional mix [7]. It has been observed from the investigation that the workability of mortar increases with partial replacements up to 80% and reduces upon complete replacement. The strength of M-sand mortar is high when compared to natural sand cement mortar at all replacement levels [8]. According to authors, it was observed that the compressive strength of concrete specimens made with 50% replacement of river sand by Robosand gives higher strength of 12% to 15% and with 100% replacement gives a higher strength of 3% to 4% as compare to reference mix [9]. It has been investigated that the increase in compressive strength for Fly ash and M-Sand replacement in the range of 25% by 25%, for M35 grade of cement with control mix for 28 days and 56 days curing period [10].

III. FLEXURAL STRENGTH

It is observed that the flexure strength of concrete can be improved by partial replacement of Silica fume for cement and M-sand for fine aggregate and the increase in flexure strength is 13.2% at the age of 28 days by replacing 50% of natural sand with M-Sand and 5% of cement by silica fume[11]. The increase in the flexural strength of M20 and M30 grade of concrete for the replacement of natural sand by manufactured sand in the proportions of 0%, 20%, 40%, 60%, 80%, 100% is of order 0%, 5.6%, 14.5%, 22.48%, 16.47%, 14.9% for flexural strength respectively and 0%, 5.65%, 14.5%, 22.48%, 16.47%, 14.9% for flexural strength respectively. After treatment with HCL solution for 28 days, the flexural strength of M20 and M30 grade concrete for replacement of natural sand by manufactured sand in proportions of 0%, 20%, 40%, 60%, 80%, 100% is of order 12.76%, 11.31%, 11.11%, 10.29%, 11.08%, 11.74% and 11.24%, 10.83%, 9.13%, 8.28%, 9.27% for flexural strength respectively[2]. According to laboratory investigation, the 28days flexural strength of self compacting concrete increases as the proportion of M-sand increases from 0% to 50% in M30 and M40 grade concrete, that is 3.06N/mm² to 6.2N/mm² and 3.21N/mm² to 7.44N/mm², after that flexural strength decreases if percentage of M-sand increases beyond 50%[6]. From experimental results, it was observed that flexural strength of beam at 28 days for conventional mix 100% Robosand was 18.07% higher than that in conventional mix. Increased percentage of flexural strength of 25% GGBS mix, 50% GGBS mix and 70 % mix were 1.03%, 9.65%, and decreased by 3.26% respectively, when compared with 100% Robosand mix. But compared to conventional mix, flexural strength in presence of GGBS was increased 17.21% for 25% GGBS, 10.15% for 50% GGBS and 20.74% for 70% GGBS. It was clearly noted that, at 28 days, there was gradual increment in flexural strength as slag content increased [7]. According to the authors, it was observed that the flexural strength of concrete specimens made with 50% replacement of river sand by Robosand gives higher strength of 20% to 22% and with 100% replacement gives a higher strength of 5% to 8% as compare to reference mix [9].
IV. SPLIT TENSILE STRENGTH

The increase in the split tensile strength of M20 and M30 grade of concrete for the replacement of natural sand by manufactured sand in the proportions of 0%, 20%, 40%, 60%, 80%, 100% is of order 0%, 6.19%, 14.8%, 18.2%, 16.9%, 12.2% and 0%, 7.4%, 14.8%, 19.1%, 15.8%, 12.6% for split tensile strength respectively. From durability test after treated with HCL solution for 28days, it has been observed that, the decrease in split tensile strength of M20 and M30 grade of concrete for replacement of natural sand by manufactured sand in proportions of 0%, 20%, 40%, 60%, 80%, 100% is of order 9.91%, 9.33%, 8.63%, 7.38%, 7.79%, 8.60%, and 8.75%, 8.16%, 6.71% 5.73% 6.25 % 6.95% for split tensile strength respectively.[2]. According to laboratory investigation, the 28days split tensile strength of self compacting concrete increases as the proportion of M-sand increases from 0% to 50% in M30 and M40 grade concrete, that is 3.1N/mm² to 3.91N/mm² and 3.47N/mm² to 4.3N/mm², after that split tensile strength decreases if percentage of M-sand increases beyond 50%[6]. It was observed that the split tensile strength of cylinder at 28 days for mix with 100% Robosand was 29.29% higher than that in conventional mix. Decreased percentage of split tensile strength of 25% GGBS mix, 50% GGBS mix and 70 % mix were 11.24%, 13.79%, and 31.12% respectively, when compared with 100% Robosand mix. But compared to conventional mix, split tensile strength in presence of GGBS was increased 21.35% for 25% GGBS, 19.54% for 50% GGBS and 7.28% for 70% GGBS [7]. According to the authors, it was observed that the split tensile strength of concrete specimens made with 50% replacement of river sand by Robosand gives higher strength of 7%to 9% and with 100% replacement gives a higher strength of 3%to 4% as compare to reference mix [9].

V. DISCUSSIONS

From the literature review, it has been observed that the authors has carried out experiments to study only the mechanical properties of concrete for various percentage replacement of fine aggregates by manufactured sands. Limited information and data will be available on durability studies on concrete with M-sand. Manufactured sand is been used extensively due to the non-availability of natural fine aggregates. The literature review does not provide sufficient information on durability studies on concrete structures with M-sand for severe exposure environmental condition.

Hence, much research work is necessary to study the durability properties of concrete with M-sand and to investigate the performance of M-sand when the concrete subjected to severe environmental exposure condition.

VI. CONCLUSIONS

Based on the literature review, the following conclusion can be drawn:

1. The percentage of increase in the compressive strength is 18.88% and the flexure strength is 13.2% at the age of 28 days by replacing 50% of natural sand with M-Sand and 5% of cement by silica fume.
2. After treating the specimens with hydrochloric acid for 28days period, it was observed that the decrease in the compressive strength of M20 grade concrete for replacement of natural sand by manufactured sand in proportions of 0%, 20%, 40%, 60%, 80%, 100% is of order 11.7%, 10.18%, 9.82%, 7.12%, 9.13%, 9.659%.
3. By various durability tests, the penetration of water into concrete decreases by increasing proportions of M-sand in concrete.
4. The split tensile strength of concrete specimens made with 50% replacement of river sand by Robosand gives higher strength of 7%to 9% and with 100% replacement gives a higher strength of 3% to 4% as compare to reference mix.
5. After treated with HCL solution for 28days, the decrease in split tensile strength of M20 and M30 grade of concrete for replacement of natural sand by M-sand in proportions of 0%, 20%, 40%, 60%, 80%, 100% is of order 9.91%, 9.33%, 8.63%, 7.38%, 7.79%, 8.60%, and 8.75%, 8.16%, 6.71% 6.95% for split tensile strength respectively.

REFERENCES


