

A STUDY ON PROPERTIES OF CONCRETE USING INDUSTRIAL WASTE SAND AS PARTIAL REPLACEMENT OF FINE AGGREGATE: A CRITICAL REVIEW

Dr. K.V. Maheshwari¹, Asst. Prof. Dipesh Pindoriya², Hetal Gorasiya³

¹ Principal, HJD- Institute, Kutch, Gujarat, India

² Assistant Professor, civil department, HJD- Institute, Kutch, Gujarat, India

³ PG students, Masters of Structural Engineering, HJD- Institute, Kutch, Gujarat, India

Abstract: *This paper is based on the study on utilization of industrial waste sand in concrete. Waste sand requires large area for the disposal by open dumping. In this paper, we are going to replace natural sand with industrial waste sand in different percentage like, 0% , 10%, 20%, 30%, 40%, 50% & 60%. We will conduct workability tests- slump test & compaction factor test for M30, M45 & M60 grade of concrete. We will check harden properties of concrete with different tests like compression test, split tensile test & flexural test. Also the durability of concrete will be tested with acid attack, sulphate attack, water absorption test. The main aim of this study is to find optimum percentage of utilization of industrial waste sand in concrete.*

Key words: *Industrial Waste Sand; Literature review; etc....*

I. Introduction

Waste material deposited in huge quantity by open dumping on valuable land. If we start use this waste sand by utilising this sand in concrete, the problem can be solved. This paper is about the use of waste Sand as partial replacement of fine aggregate in concrete. Now a day, sustainable infrastructural growth demands the alternative material that should satisfy technical requirements of natural aggregate. The waste material also should be available large quantity. The cheapest and the easiest way of getting substitute for natural aggregates is use of industrial waste materials which has somehow similar properties with desired size and grade.

II. Literature Review

“Engineering properties of concrete with partial utilization of used foundry sand”, Thiruvankitam Manoharan, Dhamothiran Laksmanan, Kaliyannan Mylsamy [1]

In this paper river sand was partially replaced by UFS. The percentage replacements were 0, 5, 10, 15, 20 and 25 % respectively. Experimental investigations were carried out to evaluate the mechanical, durability and micro structural properties of M20 concrete at the age of 7, 28 and 91 day. XRD (X-ray Diffraction), EDX(Energy Dispersive X-ray) and optical-microscopic imaging analysis were performed to identify the presence of various compounds and micro cracks in the concrete with UFS. Comparative studies on control mix against trial mix were carried out.

“Utilization of recycled crumb rubber as fine aggregates in concrete mix design”, Camille A. Issa, George Salem [2]

In this paper they had studied about use of recycled materials such as crumb rubber from tires in construction. The basic building materials in concrete construction are primarily aggregate and cement. The two main reasons for not utilizing are claimed material are (1) addition of material is a detriment to performance, and (2) excessive cost. In his study, the performance of recycled materials crumb rubber as valuable substitute for fine aggregates ranging from 0% to 100% in replacement of sand in concrete mixes was investigated.

“Evaluation of iron ore tailings as replacement for fine aggregate in concrete”, Ali Umara Shettima, Mohd Warid Hussin , Yusof Ahmad, Jahangir Mirza [3]

In this research main objective was to evaluate IOT as replacement for river sand in concrete and compare with the result of conventional concrete. Concrete mixtures containing 25%, 50%, 75% and 100% IOT as river sand replacement were prepared with 0.5 water-to-cement ratio (W/C). Compressive and splitting tensile strengths, modulus of elasticity and durability tests (drying-shrinkage, water absorption, and chloride penetration and carbonation effects) were conducted on concrete containing IOT.

“Utilization of Bagasse Ash as a Partial Replacement of Fine Aggregate in Concrete”, Prashant O Modani, M R Vyawahya [4]

This paper studies the effect of Sugar-cane bagasse in concrete. Bagasse ash mainly contains aluminium ion and silica. In this paper, untreated bagasse ash has been partially replaced in the ratio of 0%, 10%, 20%, 30% and 40% by volume of fine aggregate in concrete. Fresh concrete tests like compaction factor test and slump cone test were undertaken along with hardened concrete tests like compressive strength, split tensile strength and sorptivity.

“Properties of concrete incorporating fine recycled aggregates from crushed concrete wastes”, Cheng-Chih Fan, Ran Huang, Howard Hwang, Sao-Jeng Chao [5]

In this paper fine recycled aggregate produced by crushing concrete wastes was used as a replacement for fine natural aggregates for manufacturing concrete. Two methods were adopted for production of fine recycled aggregates from crushed concrete wastes. First produces coarse as well as fine aggregates (R1) second, produces only fine aggregate (R2).

“Utilization of fine recycled aggregates in concrete with fly ash and steelslag”, E. Anastasiou, K. Georgiadis Filikas, M. Stefanidou [6]

In this research they had studied the possibility of producing concrete incorporating large volumes of industrial by-products and secondary materials. The alternative materials tested were fly ash as binder for cement replacement, recycled fine aggregate originating from mixed construction and demolition waste and steel slag as coarse aggregate. Several mortar and concrete mixtures were prepared using different aggregate and binder combinations in order to identify the feasibility of producing concrete with maximum use of alternative materials. The different mixtures were tested for mechanical strength at different ages, while durability measurements such as chloride ion penetration and freeze–thaw resistance were also carried out.

“Novel lightweight concrete containing manufactured plastic aggregate”, Fahad K. Alqahtani, Gurmel Ghataora, M. Iqbal Khan, Samir Dirar [7]

In this research they had studied on investigation of a manufactured plastic aggregate as a replacement for volcanic lightweight aggregate and Lytag aggregate in concrete is presented. The influence of replacement level on the fresh, hardened and microstructure properties of concrete was investigated. The slump, compressive Strength, flexural strength, splitting tensile strength and elastic modulus decreased with the increase in replacement level.

“Use of fine recycled aggregates from ceramic waste in masonry mortar manufacturing”, J.R. Jiménez, J. Ayuso, M. Lopez, J.M. Fernandez, J. de Briton [8]

In this paper they had studied performance of fresh and hardened masonry mortar manufactured using fine recycled aggregate from ceramic partition wall rubble. Five mortars were prepared replacing 0%, 5%, 10%, 20%, and 40% of the natural sand by fine recycled aggregate.

“Effect of copper slag, iron slag and recycled concrete aggregate on the mechanical properties of concrete”, J. Vijayaraghavan, A. Belin Jude, J. Thivya [9] In this research investigates the effect of using alternatives for both fine and course aggregates with copper slag (30%, 40% and 50%), iron slag (30%, 40% and 50%) and recycled concrete aggregate (20%, 25% and 30%) with various proportions of mix by the partial replacement of sand and gravel respectively. The mechanical properties were concluded and compared among conventional concrete with proposed mix under the timeline of 28 curing days.

“Blasted copper slag as fine aggregate in Portland cement concrete” M.A.G. dos Anjos, A.T.C. Sales, N. Andrade [10]

This work aims to study Concrete mixtures were produced, with high aggregate replacement ratios, varying from 0% to 100%. Axial compressive strength, diametrical compressive strength, elastic modulus, physical indexes and durability were evaluated. Assays showed a significant improvement in workability, with the increase in substitution of fine aggregate. With 80% of replacement, the concrete presented lower levels of water absorption capacity. Axial compressive strength and diametrical compressive strength decreased, with the increase of residue replacement content.

“Mechanical properties of structural concrete containing very fine aggregates from marble cutting sludge”, R. Rodrigues, J. de Brito, M. Sardinha [11]

The aim of this research is to evaluate the mechanical performance of concrete with various incorporation ratios of sludge from the marble extraction industry as cement replacement (0%, 5%, 10% and 20% of the total volume of cement), as well as with plasticizers. Workability and bulk density tests were carried out on fresh concrete, while compressive strength, splitting tensile strength, modulus of elasticity, ultrasonic pulse velocity and abrasion resistance tests were performed to evaluate the relevant properties of concrete in the hardened state.

“Performance of mortar and concrete made with fine aggregate of desert sand”, Guoxue Zhanga, Jianxia Song, Jiansen Yang, Xiyuan Liu [12]

In this paper they had done research on utilization desert sand in mortar and concrete in civil engineering, mortar and concrete made of Tenggeli desert sand and Maowusu sandy land sand have been tested in order to clarify their engineering characteristics. Based on the determined chemical composition and the physical characteristics of desert sand, the mechanical properties of mortar and concrete made of two types of desert sand as fine aggregate were investigated. The results of the tests indicate that desert sand can be used as a fine aggregate in mortar and concrete for general civil engineering.

“Rheological and mechanical properties of concrete containing crushed granite fine aggregate” Guilherme Chagas Cordeiro, Laura Monteiro Soares Crespo de Alvarenga [13]

This research paper study the influence of crushed granite fine aggregate (CGA) on the rheological and mechanical properties of concrete is reported in this work. Concretes were produced with 10, 30, and 50% (in volume of fine aggregates) of CGA, with respect to a reference mixture, which contained a regular siliceous river sand. The reference was designed for a 28-day compressive strength of 50 MPa and a slump ranging from 200 to 220 mm. All concrete mixtures had 20% of rice husk ash as the volume of cementitious materials from the rheological (Brookfield viscometer), and 28-day compressive strength tests of cement-based pastes

“Recycling of PET bottles as fine aggregate in concrete” Mariaenrica Frigione [14]

In this paper they had studied substitution of concrete the 5% by weight of fine aggregate (natural sand) with an equal weight of PET aggregates manufactured from the waste un-washed PET bottles (WPET), is presented. The WPET particles possessed a granulometry similar to that of the substituted sand. Specimens with different cement content and water/cement ratio were manufactured. Rheological characterization on fresh concrete and mechanical tests at the ages of 28 and 365 days were performed on the WPET/concretes as well as on reference concretes containing only natural fine aggregate in order to investigate the influence of the substitution of WPET to the fine aggregate in concrete.

“Durability performance of concrete made with fine recycled concrete aggregates” L. Evangelista, J. de Brito [15]

This paper presents the Fine recycled aggregates that are seen as the last choice in recycling for concrete production. Many references quote their detrimental influence on the most important characteristics of concrete: compressive and tensile strength; modulus of elasticity; water absorption; shrinkage; carbonation and chloride penetration. These two last characteristics are fundamental in terms of the long-term durability of reinforced or prestressed concrete. In the experimental research carried out at IST, part of which has already been published, different concrete mixes (with increasing rates of substitution of fine natural aggregates –sand – with fine recycled aggregates from crushed concrete) were prepared and tested. The results were then compared with those for a reference concrete with exactly the same composition and grading curve, but with no recycled aggregates.

“The effect of Colloidal Nano-silica on workability, mechanical and durability properties of High Performance Concrete with Copper slag as partial fine aggregate” S. Chithra , S.R.R. Senthil Kumar , K. Chinnaraju [16]

This study investigates the effect of colloidal Nano silica on the properties of High Performance Concrete with copper slag as fine aggregate at a constant replacement level of 40%. Cement mortars and concrete mixes were produced by replacing Portland cement by colloidal Nano silica at 0.5%, 1%, 1.5%, 2%, 2.5% and 3%. Tests on workability, compressive strength, splitting tensile strength, flexural strength, rapid chloride penetration, and water absorption, and sorptivity and abrasion resistance were conducted on concrete mixes.

“The use of coarse and fine crushed bricks as aggregate in concrete” Farid Debieb, Said Kenai [17]

This paper examines the possibility of using crushed brick as coarse and fine aggregate for a new concrete. Either natural sand, coarse aggregates or both were partially replaced (25, 50, 75 and 100%) with crushed brick aggregates. Compressive and flexural strengths up to 90 days of age were compared with those of concrete made with natural aggregates. Porosity, water absorption, water permeability and shrinkage were also measured.

“Use of Silica sand as Fine Material in Concrete” J.V Kerai, S.R. Vaniya [18]

Concrete making from silica sand as partial additional of fine aggregate they had studied for workability, compressive strength, and tensile strength. They use silica sand as partial of fine aggregate by different percentage for making concrete of grade M-20. The fraction additional was 0%, 10%, 20%, 30%, 40%, 50%, 60%, & 70%. “They had prepare cubes, cylinders, beams and finally slump test, compressive strength test, splitting tensile strength test and flexural strength test was conducted to obtain the necessary results”.

III. Conclusion

- [1] Concrete mixes having UFS above 20 % showed higher durability, effective utilization of river sand in concrete.
- [2] Lower density to lower weight. Enhanced ductility of concrete. Enhanced insulation properties, as proved by the conductivity test.
- [3] Consistently higher compressive strength, higher splitting tensile strength, Water absorption rate and chloride penetration of the concrete increase as the IOT substitution rate by sand was increased.
- [4] The compressive strength of the mixes with 10% and 20% bagasse ash increases at later days. Purest form the bagasse ash can prove to be a potential ingredient of concrete.
- [5] Crushing process can significantly influence the quality of the resulting FRA. The RA replacement ratio is an important factor affecting the physical, mechanical and durability of resulting concrete. This indicates that the quality of concrete specimens containing R2 is better than the quality of concrete specimens containing same amount of R1.
- [6] Increased water absorption. Improves the concrete microstructure by providing good aggregate-binder bonding.
- [7] The slump of the RP2F1C decreased, by 11–23% (25–50 mm) compared to LWC, with the increase in replacement of 25 to 100%. The compressive strength, flexural strength, splitting tensile strength and elastic modulus of the RP2F1C decreased by 15–62%, 27–44%, 12–31% and 11–54%, respectively, with the increase in replacement of 25–100%.
- [8] The bulk density of fresh mortar decreased with the increase in the replacement ratio. The replacement ratio of natural sand with fine recycled aggregate up to 40% by volume didn't affect the properties of mortar.
- [9] 40% of copper slag, 40% of iron slag and 25% of RCA is the optimized replacement mix of fine and course aggregate respectively, which highly enhances the mechanical properties of concrete compare to conventional concrete.
- [10] Above 20% replacement of the natural aggregate, there was no need to add super plasticizer admixture in concretes to achieve the desired consistency. Mixtures with replacements of over 40% presented the highest decreases in compressive strength and tensile strength.
- [11] The compressive strength decreases as the replacement ratio increases. But this decrease is not significant up to replacement ratios of 10%. The splitting tensile strength parameter decreases with the increase of the replacement ratio.
- [12] The workability of mortar was extremely poor when the cement/sand ratio is smaller than 0.5. It is suggested that desert sand should not be used as masonry mortar. The concrete with Tenggeli desert sand showed better workability than the concrete with Maowusu sandy land sand.
- [13] The mixture containing CGA required more super plasticizer to maintain the same workability of the reference concrete. The compressive strength was not negatively affected by the natural sand replacement up to 50% of CGA, after the specific dosages of super plasticizer. water absorption was reduced when 30 and 50% of the natural sand were replaced by CGA.
- [14] The compressive strength and splitting tensile strength of WPET concrete are of 0.4–1.9% lower but with a slightly higher ductility. The advantage of recycling PET in concrete is that this plastic material does not have to be purified, nor is the removal of colors required.
- [15] Water absorption increases with the replacement ratio, up to a max. 46% for concrete made with FRA, compared with a reference concrete using only FNA. The non-steady-state chloride migration coefficient increases linearly with the replacement ratio increases. For smaller replacement ratios up to 30%, the use of FRA for structural concrete production is feasible.
- [16] As the content of colloidal nano silica was increased up to 3%, the consistency was increased. The use of Nano silica in cement mortars with 40% copper slag as fine aggregate replacement increased the compressive strength. Reduction in slump values with increase in the colloidal Nano silica content.

- [17] Recycled brick aggregates present relatively lower bulk density and higher water absorption. The decrease in compressive strength at 28 days was about 35, 30 and 40% when coarse, fine or both fine and coarse aggregates are respectively, substituted. The decrease of flexural strength was about 15%, reaching up to 40% when coarse and fine recycled aggregates concrete were used. The ratio of compressive/flexural strength varies between 8.1 and 11.8. Reduction in modulus of elasticity and compressive strength.
- [18] Up to 50% replacement of fine aggregate with silica sand has not much reduction in compressive strength of concrete. With the replacement of silica sand in concrete, flexural strength was decreases from 0% to 30% and then increases in 40% & 50% compared to 30%, then after decrease the flexural strength in 60% & 70% replacement. Flexural strength decreases from 2.54% to 16.57%. Split tensile strength was decreases from 0% to 30% and then increases in 40% & 50% compared to 30%, then after decrease in the split tensile strength at 60% & 70% replacement. The Replacement of silica sand in concrete rises from 10% to 70%, the acid cured cube strength was decreases from 4.54% to 20% for mix1. The Replacement of silica sand in concrete increases from 10% to 70%, the sulphate cured cube strength was decreases from 3.62% to 28.03% for mix1.

References:

- [1] Thiruvengadam Manoharan, Dhamothiran Laksmanan, Kaliyannan Mysamy—Elsevier 2017, Engineering properties of concrete with partial utilization of used foundry sand.
- [2] Camille A. Issa, George Salem—Elsevier 2013, Utilization of recycled crumb rubber as fine aggregates in concrete mix design.
- [3] Ali Umara Shettima, Mohd Warid Hussin, Yusof Ahmad, Jahangir Mirza—Elsevier 2016, Evaluation of iron ore tailings as replacement for fine aggregate in concrete.
- [4] Prashant O Modani, M R Vyawahra – Elsevier 2013, Utilization of Bagasse Ash as a Partial Replacement of Fine Aggregate in Concrete.
- [5] Cheng-Chih Fan, Ran Huang, Howard Hwang, Sao-Jeng Chao —Elsevier 2016, Properties of concrete incorporating fine recycled aggregates from crushed concrete wastes.
- [6] E. Anastasiou, K. Georgiadis Filikas, M. Stefanidou —Elsevier 2014, Utilization of fine recycled aggregates in concrete with fly ash and steel slag.
- [7] Fahad K. Alqahtani, Gurmel Ghataora, M. Iqbal Khan, Samir Dirar—Elsevier 2017, Novel lightweight concrete containing manufactured plastic aggregate.
- [8] J.R. Jiménez, J. Ayuso, M. Lopez, J.M. Fernandez, J. de Brito – Elsevier 2013, Use of fine recycled aggregates from ceramic waste in masonry mortar manufacturing.
- [9] J. Vijayaraghavan, A. Belin Jude, J. Thivya—Elsevier 2017, Effect of copper slag, iron slag and recycled concrete aggregate on the mechanical properties of concrete.
- [10] M.A.G. dos Anjos, A.T.C. Sales, N. Andrade —Elsevier 2017, Blasted copper slag as fine aggregate in Portland cement concrete.
- [11] R. Rodrigues, J. de Brito, M. Sardinha —Elsevier 2015, Mechanical properties of structural concrete containing very fine aggregates from marble cutting sludge.
- [12] Guoxue Zhanga, Jianxia Song, Jiansen Yang, Xiyuan Liu —Elsevier 2006, Performance of mortar and concrete made with fine aggregate of desert sand.
- [13] Guilherme Chagas Cordeiro, Laura Monteiro Soares Crespo de Alvarenga —Elsevier 2016, Rheological and mechanical properties of concrete containing crushed granite fine aggregate.
- [14] Mariaenrica Frigione —Elsevier 2010, Recycling of PET bottles as fine aggregate in concrete.
- [15] L. Evangelista, J. de Brito, Elsevier—2010, Durability performance of concrete made with fine recycled concrete aggregates.
- [16] S. Chithra, S.R.R. Senthil Kumar, K. Chinnaraju — Elsevier –2016, The effect of Colloidal Nano-silica on workability, mechanical and durability properties of High Performance Concrete with Copper slag as partial fine aggregate.
- [17] S. Chithra, S.R.R. Senthil Kumar, K. Chinnaraju — Elsevier –2016, The effect of Colloidal Nano-silica on workability, mechanical and durability properties of High Performance Concrete with Copper slag as partial fine aggregate.
- [18] J.V Kerai, S.R. Vaniya --ISJRD 2015, Use of Silica sand as Fine Material in Concrete.