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Concrete with Manufactured Sand and the Effects on the Property of Durability

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Abstract The concrete is the material generally used in the construction industry. The natural aggregates are the essential materials used in the concrete, but it is observed that there is a shortage of these materials. Therefore, the cost of the material and eventually the construction cost go on increasing across the globe. The manufactured sand i.e. m-sand is a material which can replace the natural fine aggregates if used in proper proportion. Also, the m-sand can be produced in a good amount so that the construction cost is also not affected. In the present work, manufactured sand concrete is studied for the durability properties. Other materials like zinc oxide are also used in the concrete by weight of the cement. The partial replacement of river sand by m-sand is carried out in the percentage varying from 25% to 100%. The tests for the durability which involve water permeability test, acid attack test, sea water test and sulphate attack test have been carried out for the concrete. When the river sand is replaced by m-sand with 50% then the results for the durability obtained hold good results.

Keywords M-Sand, River Sand, Alccofine, Zinc Oxide and Acid Attack Test

1. Introduction

1.1. General

The concrete is the material which is normally used in the construction sector. Nowadays, it is the usual practice of engineers to use the manufactured sand in the concrete as an alternative material. There are different materials available which can be utilized for the natural sand. The metakaolin as well as the Rice husk ash was used so that the cement was replaced in the concrete [1]. The phenomenon related to the freezing and thawing was observed and it was found that the degradation was observed and the concrete was made up with the ground blast furnace slag [2]. When the concrete was mixed with the waste foundry sand then it observed that the concrete compressive and tensile strength get reduced up to a certain extent [3]. Sludge obtained from the treatment of the drinking water has been recycled to obtain the blocks of the concrete having lesser strength and can be used in the construction site [4]. The production of the material with low carbon content and the concrete produced from the composite of Portland as well as the cement with composites have been studied for the durability property [5]. The composite walls usually involve of the concrete filled steel tube columns which are surrounded near to the boundary element. The stirrups are also provided so that the ring is obtained in continuous manner [6]. The deflection in the beam obtained is more than the allowable limit when there is not enough bond exists for the edge of steel and fibre reinforced polymer concrete; the design obtained is also not economical [7].

1.2. Durability

To develop the concrete, different wastes from the industry have been used and the wastes have been utilized efficiently so that the materials required for the construction of buildings are developed. With the use of waste marble powder in the concrete and Ground Granulated Blast Furnace Slag (GGBFS), the foamed concrete with the reinforcement of basalt fibres have been studied [8]. The alternate material for the cement has been studied over the year to reduce the emission of CO_2 and make the concrete environment friendly. When the materials like alumina react with the silica to make the geopolymers, the binding ability is developed in the concrete [9]. The durability of the concrete was studied for the mortar of the cement which was produced with the sand from the desalination sea as well as the mortar with the river sand. The corrosion resistance of the mortar was increased when this mortar was experimentally tested [10].

The durability was studied for the concrete which was exposed to the sea water environment. It was found that the mechanical strength was increased up to 20% for this type of concrete which was made up from the shells of Oyster [11]. The durability was studied for the concrete with the sand having seawater in it, the beams were casted and experiments carried out. The capacity to carry the load was increased up to 27% while consumption of the energy was also increased up to 36.5% [12]. The durability property was studied for the case of the concrete consisting of the geopolymer action and the reinforcement of the fibres like carbon. The diffusion rate for the case of the columns prepared with this concrete augmented up to 58% [13].

The tests were performed on the concrete which include absorption through capillary action, permeability test for the oxygen, resistance of the carbonation and the migration of the chloride. The property of the durability was increased when the waste materials were treated properly [14]. The durability was increased in the concrete when the cement content was reduced up to 50% and the different materials were added to the concrete [15]. The technology of SEM was used for the concrete to understand the analysis of the morphology. Meanwhile, the analysis using the TGA was carried out apart from XRD and the structure related to pores was also studied [16].

The durability property related to the self compacting concrete was studied experimentally. The test of the carbonation resistance was also studied and it found that the carbonation was increased [17]. When the rubber particles used in the concrete then the resistance to the freeze-thaw was observed when the crumb rubber with the 0/1 mm fraction used. If the coarser faction was used in the concrete, then the decreasing effect was observed [18]. When the test of the axial compression studied in the concrete stub column which was produced using seawater sand and tubes made up of GFRP, the different formulae to predict the ultimate strain related to axial behaviour were observed [19].

The lightweight concrete was studied with the experiments for the durability, and the fly ash cenosphere have been used as replacement for the natural sand while the aggregates having sintered fly ash was used for the replacement of the coarse aggregates [20]. The compressive strength of the concrete with the rubber particles as replacement of fine aggregates was studied and it was observed that it increased up to 13% while the flexural strength also increased up to 15.8% [18]. The chloride penetration was observed to be in the zone of permeability with lower values for the days of 180 days as well as 360 days and this is as per code of ASTM C1202 [17]. The durability properties of the concrete were studied for the kind of steel fibres dose varying from 0% to 1.0% while the crumb rubber was also replaced in the ratio ranging from 0% to 20%. The technique of the Diffraction using X-ray was studied for this type of concrete [21].

1.3. M-Sand

The use of m-sand is carried out and it is observed that the properties of the concrete have been improved to some extent. This material is considered to be sand having micronized ability, and the different strengths have been worked out [22]. The alternate material for the natural sand is studied like fly ash sand made from geopolymer action, the solution of the alkaline was made and concrete grade having M25 was experimentally studied. The durability property was improved with such experiments [23]. The granite dust was used in the concrete which was made from the m-sand. These particles were utilized to replace the fly ash. There was improvement in the workability when these materials are used in the concrete [24].

There is an increasing demand to use the substitute material for the natural sand in the concrete and for the different tests to be carried out for the effectiveness of it. The use of products obtained from the industry is also increasing day by day so that the concrete shall have improved properties [25]. The natural aggregates (coarse aggregates) have been replaced using the electronic waste in terms of the aggregates in the concrete. This is considered to be m-sand, the compressive strength found to decrease up to 17.1% while the tensile strength also decreased up to 32.4% [26]. When the self compacted concrete was used for the case m-sand then the workability of the concrete was improved to some extent. The flowability of the segments through which the concrete was to be poured was found to be satisfactory [27]. The ultra high performance concrete with the m-sand was studied through the experiments; it was found that the angular type of aggregates affected the packing of the concrete material. The workability was also affected because of the angular type of m-sand [28].

When the washed glass was used in terms of the sand and treated as m-sand, the workability property decreased as the percentage of m-sand increased after the percentage of 20%. When the higher values of the m-sand used then the cohesive property also get reduced [29]. When the zinc oxide and the alccofine were used in the concrete along with the m-sand, then it was observed that the optimum level percentage replacement was 50% for the replacement of natural sand by m-sand [36].

1.4. Use of Fibres in Concrete

When the fibres of Forta Ferro were used in the concrete, the compressive strength decreased up to 18%. Also, it was found that when the fibres added in the concrete up to 1% then the tensile strength increased up to 49% [30]. The concrete structure was studied for the sand from sea water as well as the reinforced bars made up of the polymer with fibre reinforcement. The mechanism related to the degradation was also studied for the case of the reinforcement bars made up of the polymer fibres [31]. The fibre reinforced bars like basalt fibres, glass fibres and carbon fibres have been studied in the concrete with seawater sand and seawater. The behaviour of the shear in the long term was anticipated with the help of theory related to Arrhenius [32].

2. Materials

The cement used in the present investigation includes the 53 grade cement as per IS 12269, and the physical properties of the cement are shown in Table 1.

The natural sand as well manufactured sand was used in the work and obtained locally. The zone is considered to be Zone-II, the properties were as per IS 383, the properties for the fine aggregates, coarse aggregates and manufactured sand are shown in Table 2.

The properties of the aggregate include fineness modulus of the fine aggregate and it is observed to be 4.96; it is 6.85 for the coarse aggregate while it is observed to be 4.93 for the m-sand. The alccofine 1203 was used in the concrete; the properties of alccofine were almost related to that of the cement. This type of alccofine is considered as material with content of slag and it also includes ultra fineness of the particle. The chemical properties are mentioned in Table 3 while the physical properties are mentioned in Table 1. Apart from the alccofine, the zinc Oxide is also used in the mixture of the concrete.

Table 1. Physical Properties of cement

Sr	Physical Properties	Obtained Values
1	Consistency (%)	29
2	Initial Setting Time (min)	36
3	Final Setting Time (min)	148
4	Specific Gravity	3.15
5	Fineness (%)	5.2
6	Compressive strength - 7days in N/mm^2	38
7	Compressive strength - 28days in N/mm^2	55

Table 2. Properties of Aggregates (Fine, Coarse and M-sand) and Alccofine

Sr	Properties	Aggregates			Alccofine
		Fine	Coarse	M-sand	
1	Water Absorption (%)	0.91	1.04	1.24	--
2	Specific Gravity	2.64	2.83	2.57	2.87
3	Bulk Density (kg/m^3)	1597.54	1660.91	1620.03	828.48

Table 3. Chemical Properties of Alccofine

Properties	Percentage (%)
(Calcium Oxide) CaO	32.20
(Silica) SiO_2	35.30
(Alumina) Al_2O_3	21.40
(Magnesia) MgO	8.20
(Sulphur trioxide) SO_3	0.13
(Iron oxide) Fe_2O_3	1.20

3. Method

The concrete samples were prepared using the different materials and the percentage of the natural sand was replaced using m-sand in the range of 0% to 100%. The percentage of alccofine 1203 was kept as 10% in this mixture of the concrete while the zinc oxide percentage was up to 0.5% by the weight of the cement. The manufactured sand and the river sand used are as per the available in the local market, the grade is as per the zone-II, and the coarse aggregate used has the size with the range of 20 mm. The mix design considered in the present work and the final ratio obtained was 1:1.725:3.235 in terms of the ratio of binder to fine aggregated to the coarse aggregate, and the water to cement ratio was kept as 0.45. The following Table 4 shows the mix proportion used in the concrete. The cement content for M-1 mix was 403 kg/m^3 while M-2 to M-5 mix was 360.56 kg/m^3. The Alccofine 1203 content for M-2 to M-5 mix was 40.3 kg/m^3 and zinc oxide was 2.01 kg/m^3. The procedure used for the case of mix design of concrete is as per the Indian Standard code i.e. IS10262. In this table, M-1 is related to the 0% replacement of natural sand by m-sand, M-2 is for 25% replacement, M-3 is for 50% replacement, M-4 is for 75% replacement and M-5 is for 100% replacement.

Table 4. Mix proportion of the concrete

Mix	M-sand	FA	CA
	kg/m^3	kg/m^3	kg/m^3
M-1	0	660.81	1232.66
M-2	165.21	495.61	1232.66
M-3	330.41	330.41	1232.66
M-4	495.61	165.21	1232.66
M-5	660.81	0	1232.66

4. Results

The cube compressive strength is mentioned in Figure 1; the m-sand percentage varied for the experiments and the results obtained. In the present work, the m-sand was used as partial replacement for the natural sand while the alccofine was used as partial replacement for the cement. The alccofine is responsible for the good strength of the concrete.

From the below graph, it is observed that the compressive strength goes on increasing and it is highest for the M-5 mix of the concrete. The minimum compressive strength was obtained for M-1 mix of the concrete.

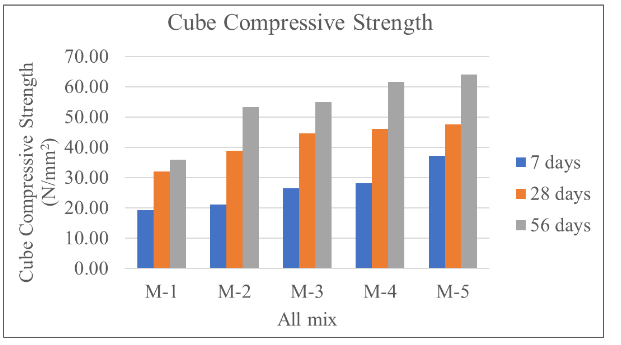

Figure 1. Cube compressive strength of concrete

Figure 2 shows the Split tensile strength of the concrete for the different concrete mixes.

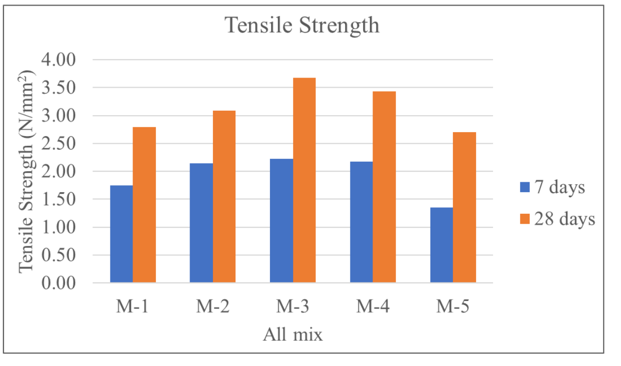

Figure 2. Tensile strength of concrete

From the above graph, it is observed that the tensile strength of the concrete is the maximum for the M3 mix while it is the minimum for the M5 mix of the concrete.

Figure 3 shows the sea water attack test results which are obtained for the alccofine and zinc oxide in the concrete. The loss of weight in Kg is observed for all mixes as follows.

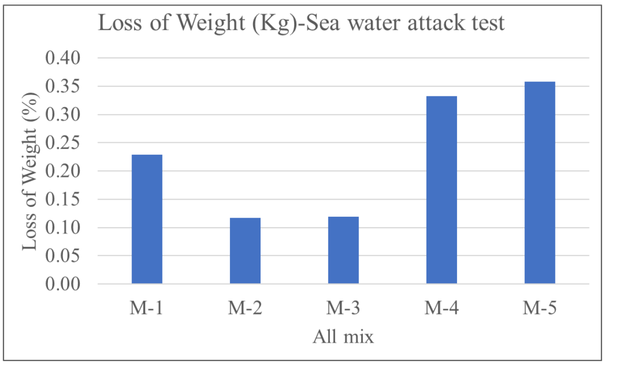

Figure 3. Loss of Weight (kg) in Sea water Attack Test

From the above figure, it is observed that the loss of weight (Kg) is the maximum for the mix-5 while the minimum loss of weight (Kg) is observed for the mix-3.

The following figure 4 shows the loss of strength (N/mm^2) for the Sea water attack test for all mixes.

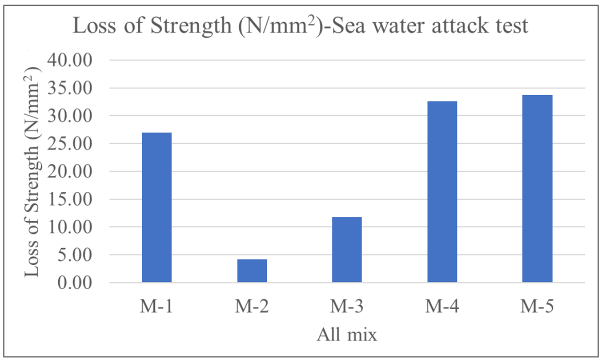

Figure 4. Loss of Strength (N/mm^2) in Sea water Attack Test

The above figure shows the loss of strength when the concrete is tested experimentally for the Sea water attack test. The maximum loss of strength is for the mix-M5 while the minimum is for the mix M-2.

The following figure 5 shows the loss of weight (Kg) for the Sulphate attack test for all the mixes of the concrete.

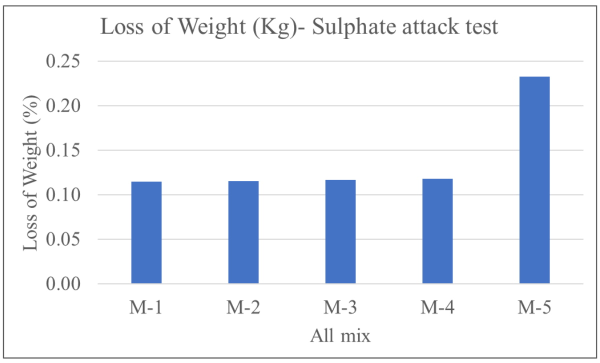

Figure 5. Loss of Weight (kg) in Sulphate Attack Test

The following figure shows the results of the concrete mixes for the sulphate attack test, the maximum loss of weight is found in the mix M-5 while the minimum is found in the mix M-1.

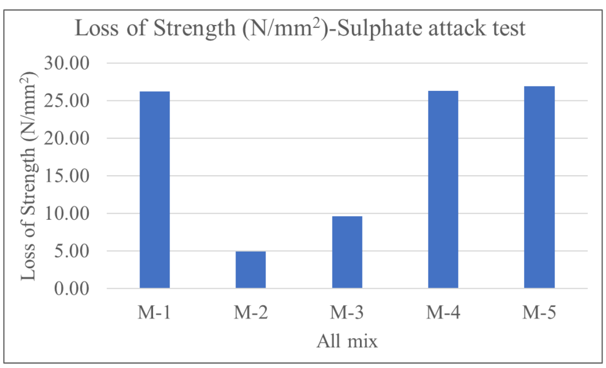

Figure 6. Loss of Strength (N/mm^2) in Sulphate Attack Test

The above figure gives the loss of strength for the sulphate attack test and it is observed that the loss of strength is the maximum for the mix M-5 while the minimum loss of strength is the minimum for the mix M-2.

The following figure 7 gives the loss of weight for the case of water absorption test as follows for all mixes of concrete.

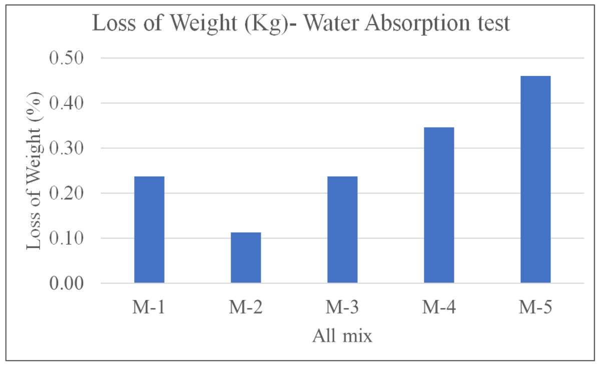

Figure 7. Loss of Weight (kg) in Water Absorption test

The loss of weight is the minimum for the mix-M2 and then it goes on increasing up to mix M-5 for the case of water absorption test.

Figure 8 shows the loss of strength for the water absorption test for the concrete mix.

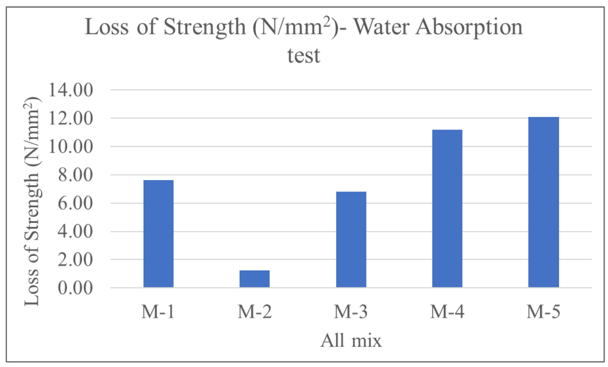

Figure 8. Loss of Strength (N/mm^2) in Water Absorption test

From the above figure, the loss of strength is the minimum for the mix M-2 and the maximum for the mix M-5 when all mixes are compared.

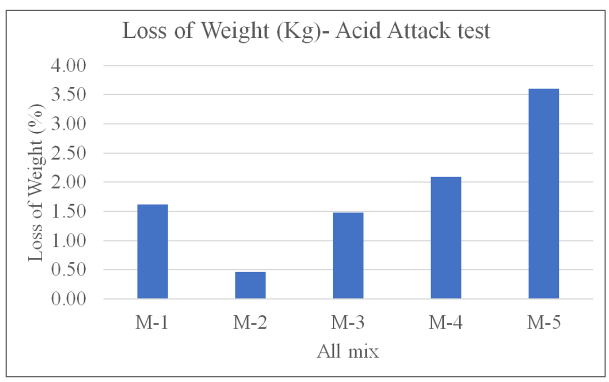

Figure 9. Loss of Weight (kg) in Acid attack test

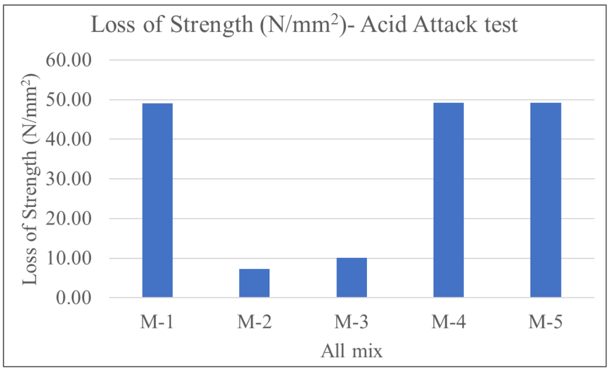

Figure 10. Loss of Strength (N/mm^2) in Acid Attack test

From Figure 9 and 10, it is observed that the loss of weight and loss of strength for the case of acid attack test is the minimum for the mix M-2 while it is the maximum for the mix M-5.

The regression analysis is carried out for the compressive strength and the tensile strength as follows; Figure 11 shows the details of it.

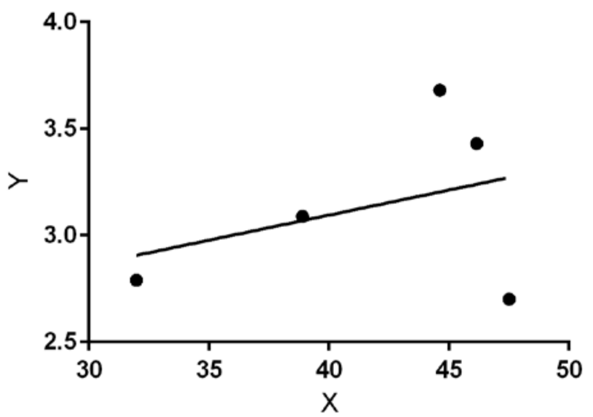

Figure 11. Regression Analysis for the Concrete (X-Axis: Compressive strength, Y-axis: Split Tensile Strength (Y = 0.02349*X + 2.156), R^2=0.137

From the above figure, the regression analysis of the concrete in the case of the compressive strength on the X-axis and the Split tensile strength on the Y-axis is obtained. The relation between the strength holds average values as there is not much effect on the Split tensile strength as compared to the compressive strength. The m-sand was used in the concrete and the effect of alccofine was also restricted for the compressive strength.

4. Conclusions

The present work consists of the concrete mixes preparation using the manufactured sand, alccofine and zinc oxide. The different experimental tests have been performed to test the durability of the concrete. The test of the durability includes the sea water attack test, sulphate attack test, water absorption test and acid attack test. The following conclusions are made from the test conducted on the concrete mixes.

i. The maximum percentage of the manufactured sand in the concrete is observed to be 50% where the test results hold good but after that percentage strength values go on reducing.

ii. The Mix M-3 gave the minimum results in terms of the loss of strength and loss of weight while the mix M-5 was observed to be with highest percentage of the values in terms of the durability.

iii. It is found that the resistivity gets increased at the percentage of the alccofine replaced percentage of 10% while the zinc oxide with 0.5%.

iv. It is observed that the percentage replacement of m-sand more than 50% gives the decreasing weight when compared with the conventional concrete.

REFERENCES

[1] N. Swaminathen, C. V. Kumar, S. R. Ravi and S. Debnath, "Evaluation of strength and durability assessment for the impact of Rice Husk ash and Metakaolin at High Performance Concrete mixes," *Materials Today: Proceedings*, vol. 47, pp. 4584-4591, 2021.

[2] L. M. Nicula, O. Corbu and M. Iliescu, "Influence of Blast Furnace Slag on the Durability Characteristic of Road Concrete Such as Freeze-Thaw Resistance," *Procedia Manufacturing*, vol. 46, pp. 194-201, 2020.

[3] S. M. Mushtaq, R. Siddique, S. Goyal and K. Kaur, "Experimental studies and drying shrinkage prediction model for concrete containing waste foundry sand," *Cleaner Engineering and Technology*, vol. 2, p. 100071, 2021.

[4] Y. Liu, Y. Zhuge, C. W. K. Chow, A. Keegan, P. N. Pham, D. Li, G. Qian and L. Wang, "Recycling drinking water treatment sludge into eco-concrete blocks with CO2 curing: Durability and leachability," *Science of The Total Environment*, vol. 746, p. 141182, 2020.

[5] S. C. Bostanci, M. Limbachiya and H. Kew, "Portland-composite and composite cement concretes made with coarse recycled and recycled glass sand aggregates: Engineering and durability properties," *Construction and Building Materials*, vol. 128, pp. 324-340, 2016.

[6] M. Guan, W. Liu, M. Lai, H. Du, J. Cui and Y. Gan, "Seismic behaviour of innovative composite walls with high-strength manufactured sand concrete," *Engineering Structures*, vol. 195, pp. 182-199, 2019.

[7] S. Han, A. Zhou and J. Ou, "Relationships between interfacial behavior and flexural performance of hybrid steel-FRP composite bars reinforced seawater sea-sand concrete beams," *Composite Structures*, vol. 277, p. 114672, 2021.

[8] Y. Bayraktar, G. Kaplan, O. Gencel, A. Benli and M. Sutcu, "Physico-mechanical, durability and thermal properties of

basalt fiber reinforced foamed concrete containing waste marble powder and slag," *Construction and Building Materials,* vol. 288, p. 123128, 2021.

[9] N. S. A. Júnior, J. S. A. Neto, H. A. Santana, M. S. Cilla and D. V. Ribeiro, "Durability and service life analysis of metakaolin-based geopolymer concretes with respect to chloride penetration using chloride migration test and corrosion potential," *Construction and Building Materials,* vol. 287, p. 122970, 2021.

[10] Feng, J. Liu, J. Wei, Y. Zhang, Y. Chen, L. Wang, Y. Chen and Z. Sun, "Research on properties and durability of desalinated sea sand cement modified with fly ash," *Case Studies in Construction Materials,* vol. 15, p. e00675, 2021.

[11] M. Georges, A. Bourguiba, D. Chateigner, N. Sebaibi and M. Boutouil, "The study of long-term durability and bio-colonization of concrete in marine environment," *Environmental and Sustainability Indicators,* vol. 10, p. 100120, 2021.

[12] Su, X. Wang, L. Ding, Z. Chen, S. Liu and Z. Wu, "Experimental study on the seismic behavior of seawater sea sand concrete beams reinforced with steel-FRP composite bars," *Engineering Structures,* vol. 248, p. 113269, 2021.

[13] S. A. Hadigheh, F. Ke and H. Fatemi, "Durability design criteria for the hybrid carbon fibre reinforced polymer (CFRP)-reinforced geopolymer concrete bridges," *Structures,* vol. 35, pp. 325-339, 2022.

[14] Carriço, S. Real and J. A. Bogas, "Durability performance of thermoactivated recycled cement concrete," *Cement and Concrete Composites,* vol. 124, p. 104270, 2021.

[15] Soldado, A. Antunes, H. Costa, R. do Carmo and E. Júlio, "Durability of mortar matrices of low-cement concrete with specific additions," *Construction and Building Materials,* vol. 309, p. 125060, 2021.

[16] J. Liu, X. Fan, J. Liu, H. Jin, J. Zhu and W. Liu, "Investigation on mechanical and micro properties of concrete incorporating seawater and sea sand in carbonized environment," *Construction and Building Materials,* vol. 307, p. 124986, 2021.

[17] Y. F. Silva and S. Delvasto, "Durability of self-compacting concrete with addition of residue of masonry when exposed to carbonation and chlorides mediums," *Construction and Building Materials,* vol. 297, p. 123817, 2021.

[18] Grinys, A. Augonis, M. Daukšys and D. Pupeikis, "Mechanical properties and durability of rubberized and SBR latex modified rubberized concrete," *Construction and Building Materials,* vol. 248, p. 118584, 2020.

[19] J. Xie, Z. Wang and J.-B. Yan, "Axial compression behaviours of seawater and sea sand concrete-filled GFRP stub tubes at arctic low temperatures," *Thin-Walled Structures,* vol. 170, p. 108566, 2022.

[20] S. K. Patel, R. K. Majhi, H. P. Satpathy and A. N. Nayak, "Durability and microstructural properties of lightweight concrete manufactured with fly ash cenosphere and sintered fly ash aggregate," *Construction and Building Materials,* vol. 226, pp. 579-590, 2019.

[21] S. Dezhampanah, I. Nikbin, S. Charkhtab, F. Fakhimi, S. M. Bazkiaei and R. Mohebbi, "Environmental performance and durability of concrete incorporating waste tire rubber and steel fiber subjected to acid attack," *Journal of Cleaner Production,* vol. 268, p. 122216, 2020.

[22] Y. Zhang, W. Shen, M. Wu, B. Shen, M. Li, G. Xu, B. Zhang, Q. Ding and X. Chen, "Experimental study on the utilization of copper tailing as micronized sand to prepare high performance concrete," *Construction and Building Materials,* vol. 244, p. 118312, 2020.

[23] U. S. Agrawal, S. P. Wanjari and D. N. Naresh, "Impact of replacement of natural river sand with geopolymer fly ash sand on hardened properties of concrete," *Construction and Building Materials,* vol. 209, pp. 499-507, 2019.

[24] H. Li, F. Huang, G. Cheng, Y. Xie, Y. Tan, L. Li and Z. Yi, "Effect of granite dust on mechanical and some durability properties of manufactured sand concrete," *Construction and Building Materials,* vol. 109, pp. 41-46, 2016.

[25] K. G. Santhosh, S. M. Subhani and A. Bahurudeen, "Cleaner production of concrete by using industrial by-products as fine aggregate: A sustainable solution to excessive river sand mining," *Journal of Building Engineering,* vol. 42, p. 102415, 2021.

[26] Z. Ullah, M. I. Qureshi, A. Ahmad, S. U. Khan and M. F. Javaid, "An experimental study on the mechanical and durability properties assessment of E-waste concrete," *Journal of Building Engineering,* vol. 38, p. 102177, 2021.

[27] W.-Q. Hou, J.-J. Yang, Z.-X. Zhang and X.-Q. Yuan, "Experimental study and application of manufactured sand self-compacting concrete in concrete-filled-steel-tube arch bridge: A case study," *Case Studies in Construction Materials,* vol. 15, p. e00718, 2021.

[28] R. Yang, R. Yu, Z. Shui, C. Guo, S. Wu, X. Gao and S. Peng, "The physical and chemical impact of manufactured sand as a partial replacement material in Ultra-High Performance Concrete (UHPC)," *Cement and Concrete Composites,* vol. 99, pp. 203-213, 2019.

[29] M. C. Limbachiya, "Bulk engineering and durability properties of washed glass sand concrete," *Construction and Building Materials,* vol. 23, pp. 1078-1083, 2009.

[30] M. Nematzadeh, A. Maghferat and M. R. Z. Herozi, "Mechanical properties and durability of compressed nylon aggregate concrete reinforced with Forta-Ferro fiber: Experiments and optimization," *Journal of Building Engineering,* vol. 41, p. 102771, 2021.

[31] Z. Wang, X.-L. Zhao, G. Xian, G. Wu, R. K. S. Raman and S. Al-Saadi, "Effect of sustained load and seawater and sea sand concrete environment on durability of basalt- and glass-fibre reinforced polymer (B/GFRP) bars," *Corrosion Science,* vol. 138, pp. 200-218, 2018.

[32] Z. Wang, X.-L. Zhao, G. Xian, G. Wu, R. K. S. Raman and S. Al-Saadi, "Durability study on interlaminar shear behaviour of basalt-, glass- and carbon-fibre reinforced polymer (B/G/CFRP) bars in seawater sea sand concrete environment," *Construction and Building Materials,* vol. 156, pp. 985-1004, 2017.

[33] IS 10262. "Guidelines for concrete mix design proportioning." *Bur. Indian Stand. Delhi* (2009): 1-21.

[34] IS1199. "Methods of sampling and analysis of concrete."*Bur. Indian Stand. Delhi* (1959).

[35] IS516. “Methods of Test for Strength of concrete.” *Bur. Indian Stand. Delhi* (1959).

[36] Thangapandi, K., R. Anuradha, P. O. Awoyera, R. Gobinath, N. Archana, M. Berlin, and Olalusi B. Oladimeji. "Durability phenomenon in manufactured sand concrete: effects of zinc oxide and alcofine on behaviour." *Silicon* 13, no. 4 (2021): 1079-1085.