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STUDY THE RE-USE OF CONSTRUCTION AND DEMOLITION WASTE FOR FRIENDLIER ENVIRONMENT: WASTE CONCRETE AND WASTE GRANITE AGGREGATES

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Abstract

Waste aggregate concrete is the most common project in the world of construction. The waste materials are causing environmental pollution and hurting nature, the use of wastes give more clean nature and so that the use of wastes in concrete can solve these problems. This study aims to investigate the use of waste granite as coarse aggregate in concrete, studying also the use of waste concrete from old buildings as coarse aggregate, and then comparing between them. The study shows that waste black granite aggregate gives best results in compression and tensile strength, compressive strength increased from 33.6 to 43.9 MPa, Using waste concrete as coarse aggregate increased also compressive strength from 33.6 MPa for reference mix to 36.9 MPa with 100% replacement.

Keywords:

Concrete;
Waste aggregate;
Granite;
Compressive strength;
Tensile strength.

1 Introduction

The remains of construction and demolition (C&D) denotes to any material that is generated by a project from activity that includes construction, demolition, renovations/remodel, tenant improvement, and/or grading/excavation. This material contains concrete, mortar, bricks and tiles, ceramics, stone, gypsum, aerated concrete blocks, metal, wood, glass, paper, cloth and plastic etc. After a series of processing such as screening, sorting, crushing, and light material separation, these solid wastes can be reused or recycled so as to conserve the environment and make it friendlier [1]. The transform of C&D wastes into aggregate can be considered as economic tool to minimize the solid waste in the environment, this process also opens many work opportunities [2].

For more clean environment, waste materials are used widely to achieve several benefits such as low cost concrete, sometimes lightweight concrete achieved by using plastic wastes [3, 4] or waste wood as fiber in concrete [5] and that give less weight or dead loads if it is used as blocks in partitions of concrete buildings, the mechanical properties of waste aggregate concrete can also be improved by modify it with non-slip sand and micro steel fiber [6]. A lot of researchers used wide range of wastes in their studies , Ameer ,G [7] studied the effect of waste ceramic on concrete and found that compressive strength give 17% increment by using waste white ceramic compared with ordinary aggregate concrete , waste glass also used in concrete and gives an increment in some mechanical properties of concrete [8,9] , waste slag from iron and metals factories can also be used in concrete as coarse and fine aggregates, 25% increment in compressive strength achieved by using waste slag iron as fine aggregate in concrete [10, 11].

The waste granite is also used in concrete as coarse aggregate to improve the mechanical properties and reduce the cost of concrete production [12, 13], where many researchers studied the use of waste aggregate from construction and demolition waste such as waste bricks, waste glass, and

waste minerals to reduce the environmental pollution and to produce the least cost of concrete [14 – 17], waste tiles is also recycled as aggregate in concrete to achieve advantages of concrete properties and develop the environmental impact [18]. Jaafar et al [19] studied the effects of using recycled wastes such as tiles, concrete, and bricks as aggregate in concrete, they found increasing in compressive strength using waste clay bricks with increment of about 2.6% and 4.2% increment by using waste concrete. Ubi et al [20] obtained concrete with 30.8 MPa by using waste granite as coarse aggregate in concrete while for reference mix of M25 (mix with 25 MPa) and the increment was about 23 %, this study shows increment in compressive strength from 33 to 43 MPa with increment near 31%. Tran et al [21] evaluated the properties of recycled concrete aggregate for medium quality of structural concrete, beside the effect of using waste concrete as aggregate in concrete, they found a reduction 5 – 9 % in compressive strength.

This research aims to improve the mechanical properties of ordinary concrete by using two types of waste materials that including waste concrete from old structures and waste granite as coarse aggregate to reduce cost and more clean environment.

2 Experimental work

2.1 Preparing the materials

In this research, the C&D waste is prepared so as to get the accepted and standard type of aggregate. The materials firstly includes screening and sorting these remains into sizes greater and less than 150mm, secondly the mulk less than 15mm is also screened out from both of these two sizes. After that, the wood, plastic and light materials are removed and the left is also processed by air separator to get rid of the impurities. Finally, the inorganic aggregates would be collected to be ready for using in this study (Fig. 1).

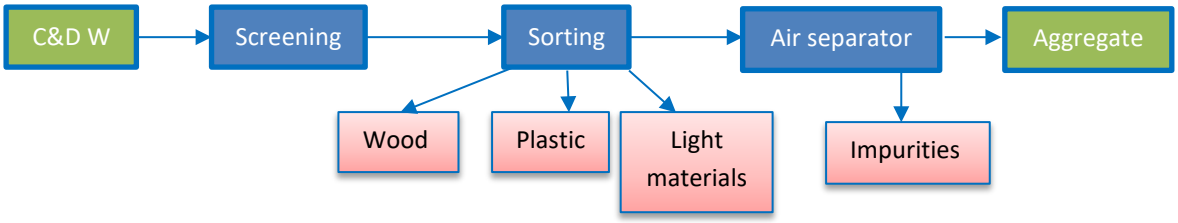

Fig. 1: Stages of transforming construction and demolition waste into aggregate.

2.2 Mixing the materials

Control mix ordinary concrete is used with mix proportions as 1:1.5:2.2 (cement: fine aggregate :coarse aggregate) with super-plasticizer (0.6 liter for each 100 kg cement) , the waste aggregate concrete is used in two types as replacement from coarse aggregate , the first type of waste aggregate is black granite aggregate that results from uses in buildings flooring, and grinding waste pieces of granite to make it as coarse aggregate as shown in Fig. 2, the black granite properties is shown in Table 1, while its chemical composition is shown in Table 2, the waste granite is used as coarse aggregate with replacement this type of waste aggregate with ordinary aggregate using different percentages of 20%, 40%, 60%,80% and 100% (total replacement).The second type of waste aggregate is waste concrete aggregate, it was used in this work instead of ordinary aggregate with the same percentages. Fig. 2 shows both waste concrete aggregate and waste granite aggregate that are used in this study. The sieve analysis of coarse and fine aggregates which are shown in tables 3 and 4, are confirmed to Indian standards 383 [22], which are a global standards used in different studies around the world.

2.3 Testing the materials

In this work, compressive strength, tensile strength, absorption and density of concrete are calculated, the compressive strength is done by using 100*100*100 mm cubic molds and tested the

concrete in 28 days after casting them as shown in Fig. 3 for reference mix, Fig.4 shows concrete contains waste concrete aggregate during compression test, Fig.5 shows waste granite with 100% replacement aggregate concrete specimen under test for compressive strength also. Tensile strength test is done by using 100*200 mm cylinders and tested them by using splitting tensile test as shown in Fig.6.

Table 1: Some properties of black granite used as coarse aggregate.

Color	Compressive strength, [MPa]	Tensile strength, [MPa]	Hardness (Moh's scale	Density [kg/m^3]
Black	301	28	6 – 7	2989

Table 2: chemical composition weight percentages of black granite.

SiO^2	FeO, Fe_2O_3	Al_2O_3	K_2O	Na_2O	CaO	Others
72	2.9	14.4	4.1	3.7	1.8	1

Table 3: Grading of fine aggregate confirmed with Indian Standards-383.

Sieve size	% pass by weight	Limits of Indian standards 383 ZONE 2
10*	100	100
4.75*	94.1	90 – 100
2.36*	78.3	75 – 100
1.18*	63.2	55 – 90
600**	47.9	35 – 59
300**	13.4	8 – 30
150**	2.8	0 – 10

* = mm, ** = micron

Table 4: Grading of coarse aggregate confirmed with Indian Standards-383.

Sieve dimension –mm	% pass by weight	20 MM ,Indian standards 383
40	100	100
20	96.1	95 - 100
10	28.9	25 - 55
4.75	3.1	0 - 10

Fig. 2: Illustrative picture for waste concrete aggregate and waste black granite used in the study.

Fig. 3: Reference mix concrete during test for compressive strength.

Fig. 4: Concrete contain waste concrete aggregate during the test.

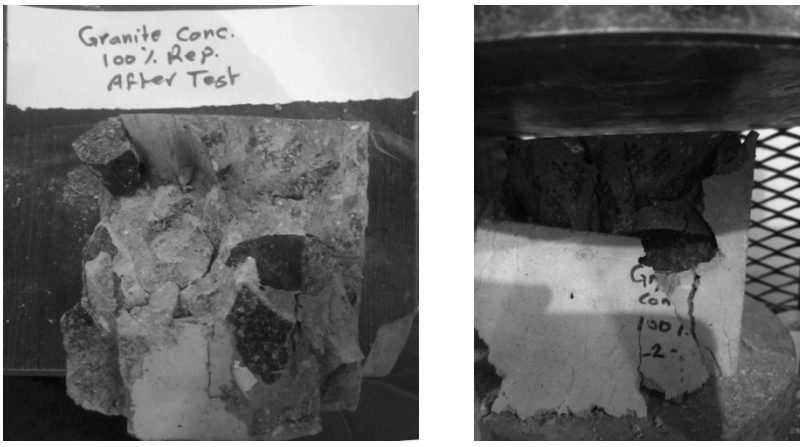

Fig. 5: Concrete with 100% waste granite aggregate under the compression test.

Fig. 6: Waste granite aggregate concrete under the tensile test.

3 Results and discussion

Table 5 shows the properties of waste concrete aggregate as coarse aggregate, it illustrates that a reference mix gives 33.65 MPa strength in compression while it gives 36.9 MPa by using 100% replacement of waste concrete as aggregates and that may be attributed to rough texture of crushed waste concrete, tensile strength also increased from 1.7 to about 2.8 MPa by using waste concrete aggregate. The absorption slightly increased from 1.9% to 2.3 % by using waste concrete and density decreases from 2487 to 2384 Kg/m^3. Table 6 shows properties of concrete using waste granite as coarse aggregate, the density of concrete is highly increased from 2487 to 2708 kg/m3 by using 100% replacement of waste granite and that because of high density of granite itself (2990 kg/m^3). The compressive strength increased from 33.65 to 43.97 MPa and that is much higher value than the value obtained from waste concrete which was 36.9 MPa, this may be attributed to the excellent mechanical properties of the used granite, which have compressive strength greater than 300 MPa. The tensile strength also increased from 1.7 for reference mix to 3.57 MPa and this may also be indicated to the high tensile strength of granite in addition to the good bond with cement paste. The absorption deceases from 1.9% to 1.5% by using waste granite.

Fig. 7 illustrates the relation between the percentages of waste concrete aggregates and compressive strength of concrete, Fig. 8 clarifies the relation between the percentages of waste granite aggregates and compressive strength of concrete, while figures 9 and 10 show the development of tensile strength for both concretes. The density changes for both two new types of waste concrete aggregate changed with different styles, waste concrete causing slightly lower changing in density when it used as coarse aggregates as shown in Fig. 11, however the waste granite aggregate caused higher increment in density when it is used as coarse aggregate as shown in Fig. 12, both concretes show higher increment in compressive strength and tensile strength compared with ordinary concrete. Less absorption achieved by using waste granite as a coarse aggregate and that can give higher durability for concrete.

4 Conclusions

It can be concluded from this study that the waste materials can be used in concrete with multiple benefits such as using waste concrete from old buildings and waste granite that results from construction works. The density changed for the both new types of waste aggregates concrete in this study, waste concrete caused slightly changing (give lower values) in density when it is re-used as coarse aggregates, while waste granite aggregate caused higher increment in density when it is used as coarse aggregate, from other side the both concretes show higher increment in compressive strength and tensile strength comparing with ordinary concrete. The use of the two waste materials give very

satisfying results in compressive and tensile strength and also less absorption achieved by using waste granite as coarse aggregate.

Table 5: The properties of waste concrete aggregate (concrete contain waste concrete).

Mix type	Compressive [MPa]	Tensile [MPa]	Density [kg/m^3]	Absorption [%]
Reference mix of waste concrete as aggregate in concrete	33.65	1.74	2487	1.96
20% rep	34.11	1.78	2472	2.02
40% rep	34.76	1.87	2459	2.11
60% rep	35.42	2.08	2434	2.23
80% rep	36.81	2.45	2406	2.29
100% rep	36.90	2.79	2384	2.32

Table 6: The properties of waste granite concrete aggregate.

Mix type	Compressive [MPa]	Tensile [MPa]	Density [kg/m^3]	Absorption [%]
Reference mix of waste granite concrete	33.65	1.74	2487	1.96
20% rep	35.90	2.20	2543	1.93
40% rep	37.84	2.69	2587	1.85
60% rep	40.05	3.13	2642	1.79
80% rep	42.18	3.40	2673	1.68
100% rep	43.97	3.57	2708	1.54

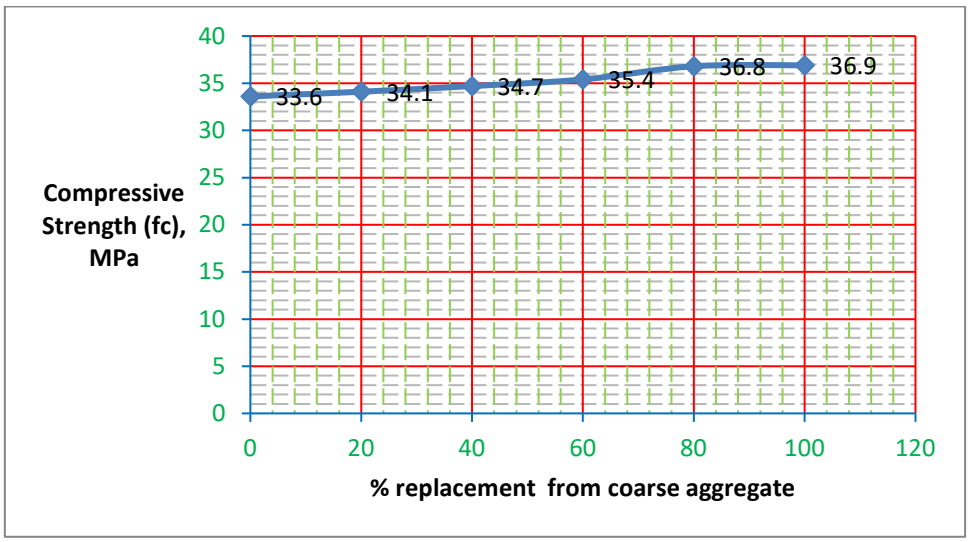

Fig. 7: Compression development using different waste concrete percentages.

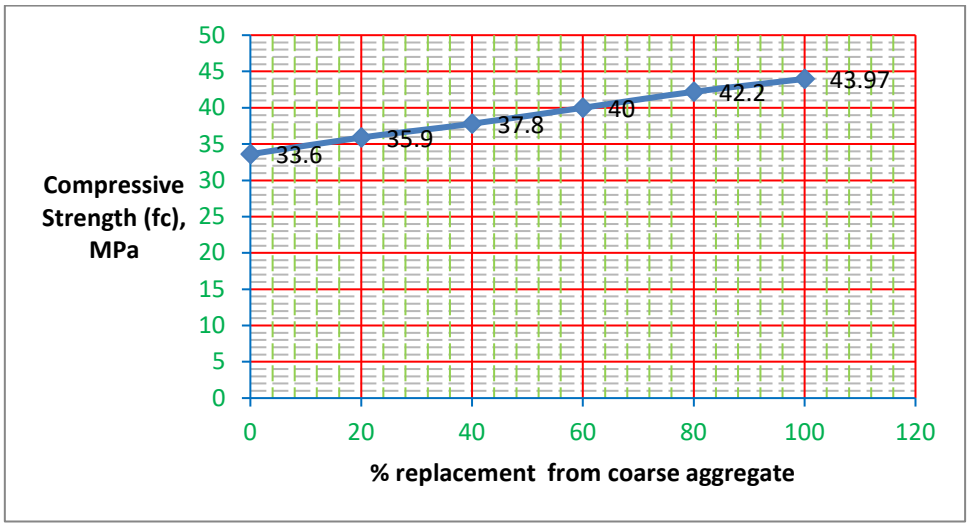

Fig. 8: Compression development using different waste granite percentages.

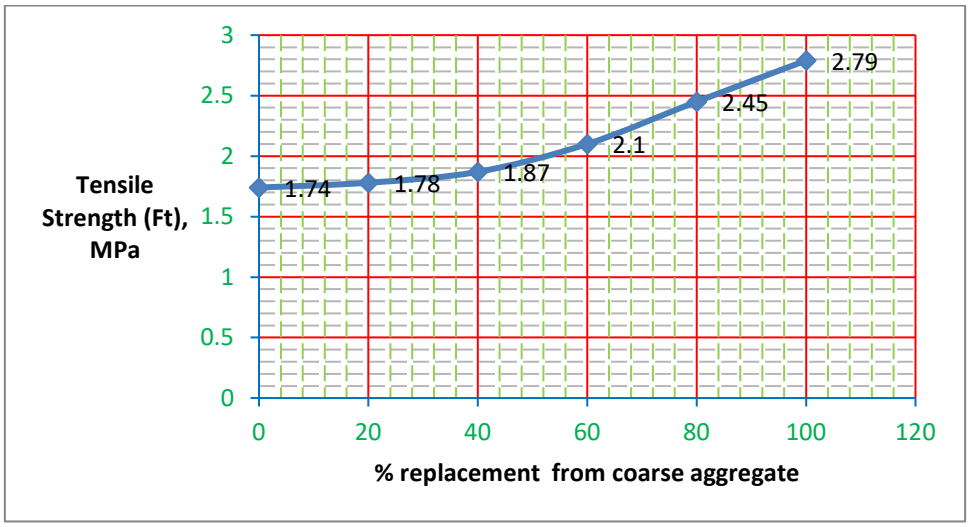

Fig. 9: Tensile strength (Ft) development using different waste concrete percentages.

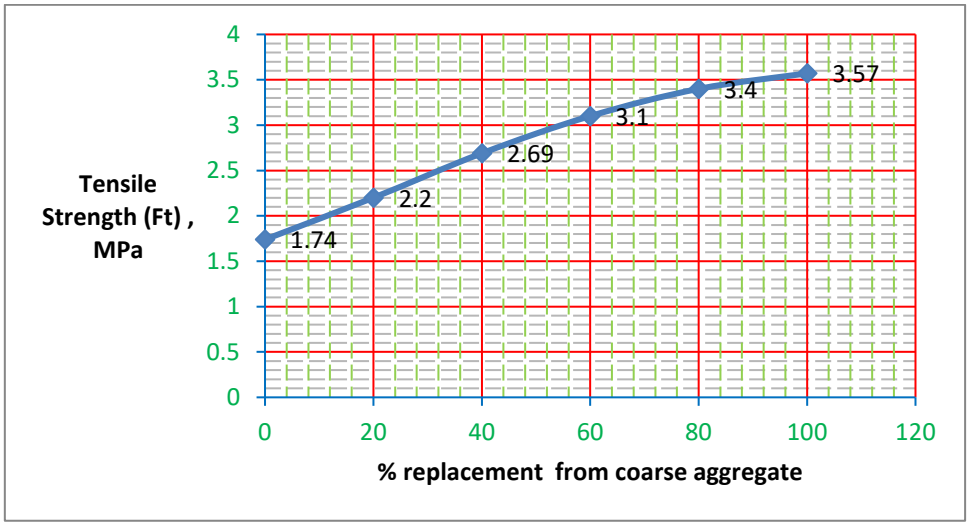

Fig. 10: Tensile strength (Ft) development using different waste granite percentages.

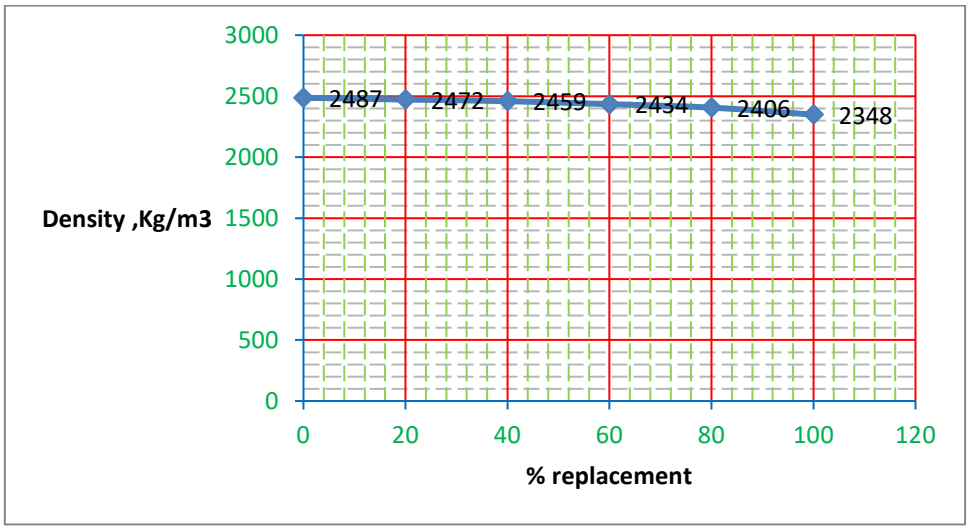

Fig. 11: The change of density of concrete with different waste concrete aggregate.

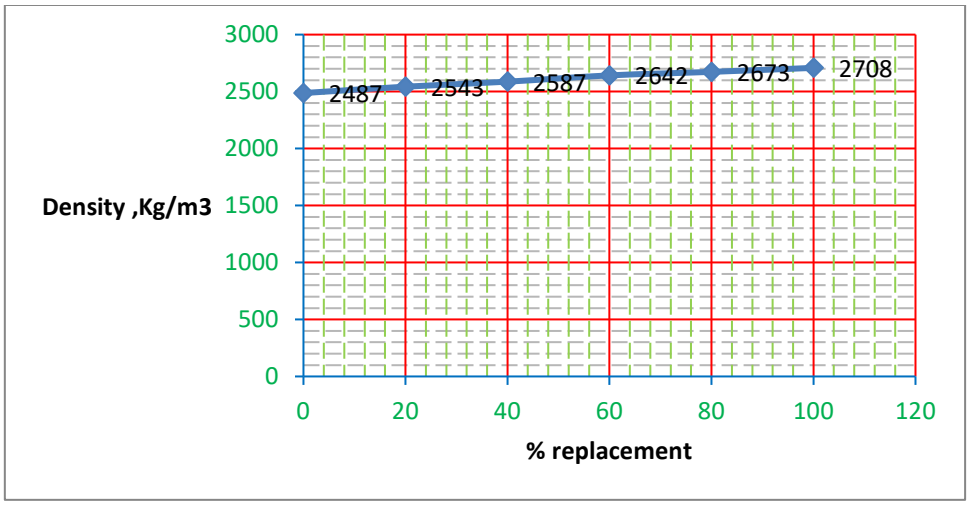

Fig. 12: The change of density for concrete with different waste granite aggregate.

References

[1] ELSHABOURY, N. - AL-SAKKAF, A. - ABDELKADER, E. M. - ALFALAH, G.: Construction and Demolition Waste Management Research: A Science Mapping Analysis, International Journal of Environmental Research and Public Health, 2022, 19(8), 4469, https:doi.org/10.3390/ijerph19084496.

[2] LOPEZ, D – BONOLI, A. – MARTIN-MORALIS, M. – ZAMORANO, M.: Analysis of the Scientific Evolution of the Circular Economy Applied to Construction and Demolition Waste, Sustainability, 2021, 13(16), 9416; https://doi.org/10.3390/su13169416.

[3] KHAJURIA, A., SHARMA, P.: Use of Plastic Aggregates in Concrete, International J of Innovative Technology and Exploring, 2019, vol. 9, issue 1, pp: 4406-4412, DOI: 10.35940/ijitee.A5088.119119.

[4] ISLAM, S., KHAN, H.: Application of Recycled Plastics Waste as Coarse Aggregate in Concrete, 7th International Conf. on Solid Waste Management in South Asian Countries, 2021, pp: 3-8.

[5] XU, R., HE, T., DA, Y, LIU, Y., LI, J, CHEN, C.: Utilizing Wood Fiber Produced with Wood Waste to Reinforce Autoclaved Aerated Concrete, Construction and Building Materials, 2019, vol. 208, pp-242-249, https://doi.org/10.1016/j.conbuildmat.2019.03.030.

[6] AL-KATIB, A.A.A. - AL-BAHRANI, H.S. - AL-KATIB, H.A.A.: Engineering Assessment of Waste Aggregate Concrete Modified with Non-Slip Sand and Micro Steel Fibers, IOP Conference series: Materials Science and Engineering, 2018, doi: 10.1088/1757-899X/454/1/012026.

[7] TALIB, A. G., JABAL, Q., AL-BAGHDADI, W.H.: White Clay Ceramic Tableware Wastes as Coarse Aggregate in Concrete – Some Mechanical Properties and Durability Against Fire and Sulfate Attack, Key Engineering Materials journal, 2021, vol. 893, pp.: 121-129, doi.org/10.4028/www.scientific.net/KEM.895.121.
[8] JABAL, Q., AL-BAGHDADI, W.H., AL-HUSSAINI, O. M.: Mechanical Properties and Durability for Concrete Using Waste Heat Resistance Glass (Pyrex Type) as Coarse Aggregate, 3rd Int. Scientific Conf. of Engineering Science and Advances Technologies, Journal of Physics Conference Series, 2021, vol. 1973, pp.: 1-9, DOI 10.1088/1742-6596/1973/1/012171.
[9] QAIDI, S., NAJM, H., ABED, S., ONURALP, Y., ALDUGHAISHI, H., ALOSTA, M., SABRI, N., ALKHATIB, F., MILAD, A.: Concrete Containing Waste Glass as an Environmentally Friendly Aggregate, Materials Journal, MDPI, 2022, vol. 15, pp.: 1-16, doi.org/10.3390/ma15186222.
[10] KARIM, M.: Applicability of Iron Slag as Coarse Aggregate in Concrete Production, Conference Paper, 2023, pp: 964-971.
[11] SAJJAD, H.: Utilization of Waste Iron Slag as the Fine Aggregate Material in Concrete Block for Low Cost Applications, 3rd International Conference on Structural Engineering Research ,Australia ,2022, November , pp:164-170.
[12] EMEGHAI J., ORIE, O.: Mechanical Properties of Concrete with Agriculture Waste as a Partial Substitute for Granite as Coarse Aggregate, Pakistan Journal of Engineering and Technology, 2021, vol.4, no. 2, pp.: 5 – 12, DOI: 10.51846/vol4iss2pp5-12.
[13] AL-FATLAWI, R. A.: Mechanical Properties of Gabbro Aggregate Concrete, International Journal of Civil Engineering and Technology (IJCIET), 2018, vol.9, Issue 10, pp. 176 – 181, http://iaeme.com/Home/issue/IJCIET?Volume=9&Issue=10.
[14] MOHAMMED, T., HASNAT, A., AWAL, M. A., BOSUNIA, S.: Recycling for Brick Aggregate Concrete as Coarse Aggregate, Journal of Materials in Civil Engineering, 2014, vol.27, No.7, DOI: 10.1061/(ASCE)MT.1943-5533.0001043.
[15] SRIVASTAVA, V., GAUTAM, S. P., AGARWAL, V.C., MEHTA, P.K.: Glass Wastes as Coarse Aggregate in Concrete, Journal of Environmental Nanotechnology, 2014, vol.3, no.1, pp. 67 – 71, DOI: 10.13074/jent.2013.12.132059.
[16] NAFISA, T.: Use of waste Glass as Aggregate and Cement Replacement in Concrete, Ph.D. Thesis, West Cook University, Australia, 2020, doi.org/10.25903/nft4%2D8q67.
[17] SHUBHI, D.: Utilization of Iron and Steel Slag in Building Construction, AIP Conference, 2019, pp. 1-7.
[18] DANIYAL, M.D., AHMED, S.: Application of Waste Ceramic Tile Aggregate in Concrete, International Journal of Innovative Research in Science, 2015, vol.4, Issue 12, DOI:10.15680/IJIRSET.2015.0412128.
[19] JAAFAR, A.S, ABBAS, Z.K., ALLAWI, A.A.: Investigating the Ability of Producing Sustainable Blocks Using Recycled Waste, Engineering, Technology & Applied Science Research Journal, 2023, vol.13, Issue 6, pp. 12006 – 12011, doi.org/10.48084/etasr.6357.
[20] UBI, S.E, NKRA, P.O., AGBOR, R.B., EWA, D.E., NUCHAL, M: Efficacy of Basalt and Granite as Coarse Aggregate in Concrete Mixture, Int. Jorrnal of Engineering Technologies and Management Research, 2020, vol.7, issue: 0, p.p.: 1-9, DOI: https://doi.org/10.29121/ijetmr.v7.i9.2020.769.
[21] TRAN, D.V.P, ALLAWI, A, ALBAYATI, A, CAO, T.N, EL-ZOHAIRY, A, NGUYEN Y.T.H.: Recycled Concrete Aggregate for Medium-Quality Structural Concrete, Materials Jor., MDPI, 2021, vol. 14, issue: 16, doi.org/10.3390/ma14164612.
[22] INDIAN STANDARDS 383: Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete, 2002, India.