Ukarst : Universitas Kadiri Riset Teknik Sipil
Volume 06 Number 01 Year 2022

ISSN (*Online*) 2581-0855
ISSN (*Print*) 2579-4620

Available online at
http://ojs.unik-kediri.ac.id/index.php/ukarst/index

U KaRsT

http://dx.doi.org/10.30737/ukarst.v6i1

Waste Concrete as a Substitute for Coarse Aggregate Materials for Compressive Strength of Concrete Fc' 20,75 MPa

B. Damara[1*], S. D. Hartantyo[2]

[1*,2,] *Departement of Civil Engineering, Faculty of Engineering, Universitas Islam Lamongan*

Email: [1*] bobbydamara@unisla.ac.id [2*] sugeng.dwih@gmail.com

A R T I C L E I N F O

Article History :
Article entry : 10 – 02 – 2022
Article revised : 14 – 03 – 2022
Article received : 13 – 04 – 2022

Keywords **:**
Concrete Stacking Materials, Coarse Aggregate, Concrete Compressive Strenght, Concrete Waste.

IEEE Style in citing this article: ***[1]***
J. Mansoor et al., "Analysis of mechanical properties of self compacted concrete by partial replacement of cement with industrial wastes under elevated temperature," Appl. Sci., 2018, doi: 10.3390/app8030364.

A B S T R A C T

Concrete from construction waste resulting from the construction of new infrastructure replacing old infrastructure can significantly impact the environment. Therefore, there is a need for the proper management of concrete waste. One of the uses of concrete waste is to use it as a coarse aggregate material in the manufacture of Concrete. Using waste concrete is obtaining a material that almost resembles coarse aggregate. This study aimed to determine the optimum content of Concrete with the addition of waste concrete as a substitute for coarse aggregate. This research refers to the standards of SNI and ASTM. The research was conducted by testing the waste concrete to determine whether it is suitable for coarse aggregate material. After that, the compressive strength was tested by curing for 28 days. This research was conducted with 3 samples with 0%, 50%, and 100% of the planned use of concrete waste with concrete compressive strength of Fc' 20,75 MPa. The results showed that the average compressive strength of the 50% concrete waste was 20.59 MPa, and the 100% concrete waste was 13.83 MPa. From these results, it can be seen that the most optimum content of substituted aggregate is a mixture variation of 50%, so the results of this study can be used as a reference in the utilization of recycled concrete waste as a raw material or a substitute for the composition of the concrete mixture.

1. Introduction

Concrete is a construction material produced by mixing sand, crushed stone, cement, and water[1][2]. Usually, several kinds of additives are mixed into the mixture to improve the properties of the Concrete, namely to increase the workability, durability, and hardening of the Concrete [3][4][5]. Concrete can be used to make road pavements, building structures, foundations, bridges, and many others [6][7]. Concrete is widely used in the construction world because it has several advantages, such as being easy to work with, fire resistance, easy to shape according to structural needs, and strong compressive strength [8][9][10].

32 - 42
ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

Concrete also has several disadvantages, such as difficulty changing shape and the work requiring high accuracy [11]. In addition, Concrete from construction waste resulting from the construction of new infrastructure replacing old infrastructure can have a significant impact on the environment [12][13][14]. Therefore, there is a need for the proper management of concrete waste. One of the uses of concrete waste is to use it as a coarse aggregate material in the manufacture of Concrete. The advantage of using waste concrete is obtaining a material that almost resembles coarse aggregate because physically, the concrete test object waste contains coarse and fine aggregate material but does not fully possess properties such as coarse aggregate [15] [16]. In previous studies related to waste Concrete, it was stated that waste concrete was able to replace coarse aggregate and affect compressive strength. However, no research still uses waste concrete as a substitute for coarse aggregate at variations of 0%, 50%, and 100% [17].

This study aimed to determine the optimum content of Concrete with the addition of waste concrete as a substitute for coarse aggregate. This research refers to the standards of SNI and ASTM. This research was conducted with 3 samples with 0%, 50%, and 100% of the planned use of concrete waste with concrete compressive strength of Fc' 20,75 MPa. The research was conducted by testing the waste concrete to determine whether it is suitable for coarse aggregate material. After that, the compressive strength was tested by curing for 28 days. From the results of the compressive strength test, researchers can conclude how much to add recycled Concrete as the optimum coarse aggregate so that the results of this study can be used as a reference in the utilization of recycled concrete waste as a raw material or a substitute for the composition of the concrete mixture[18][19].

2. Research Method

This type of research is experimental research. This research referred to the Indonesian Standard SK SNI and the foreign standard ASTM [20][21]. The research begins by conducting a literature study on the object to be studied, which is recycled Concrete. After that, determine the variation of the addition of recycled Concrete as a substitute for coarse aggregate. Making Concrete is done by testing the material first to determine whether the material is suitable for use. Then proceed with testing the recycled Concrete with several coarse aggregate tests such as the concrete waste sieve analysis test, the waste concrete moisture test, the waste concrete gravity test, the concrete waste infiltration test, and the concrete waste volume weight test. From this test, a result will be obtained whether recycled Concrete is suitable for use as a coarse aggregate material in Concrete. If feasible, then proceed with testing the compressive strength

http://dx.doi.org/10.30737/ukarst.v6i1

Ukarst : Universitas Kadiri Riset Teknik Sipil
Volume 06 Number 01 Year 2022
ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

of Concrete. From the results of these tests, researchers can conclude how much is the addition of recycled Concrete is the optimum coarse aggregate.

2.1 Research Sample

The sample to be tested is hard Concrete with a mixed composition from the results of a standard concrete mix design with a compressive strength of Fc' 20,75 MPa quality concrete, which is then used as concrete waste as a substitute for coarse aggregate [22][23]. The sample used is cylindrical with a diameter of 15 cm and a height of 30 cm.

Table 1. Percentage of Variation Composition in Concrete Mix.

Variation	Coarse Aggregate	Waste Concrete
0%	100%	0%
50%	50%	50%
100%	0%	100%

Source: Author's Calculation (2022).

In this study, 3 variations of concrete waste were used, namely 0%, 50%, and 100%. Each variation amounted to 3 test objects, so the real test objects were 9 test objects.

2.2 Material Research

The materials needed in this study include portland cement, fine aggregate, coarse aggregate, and coarse aggregate substitution material in the form of concrete waste and water [22][24]. The materials used in this research are as follows:

1. Portland Cement

   The cement used in this study was Portland cement Type 1. Cement was obtained from buying through a building shop. The cement used has passed the normal consistency test, cement binding and hardening time, and specific gravity.

Source: Research Documentation.

Figure 1. Portland Cement Type 1.

http://dx.doi.org/10.30737/ukarst.v6i1

ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

2. Fine Aggregate

   The fine aggregate used is the sand that has passed the sand filter analysis test, the water content of sand infiltration, the specific gravity of the sand under SSD conditions, water content, density, and air voids.

Source: Research Documentation.

Figure 2. Fine Aggregate.

3. Water

   The water in this study is clean water that is not contaminated with other substances.

Source: Research Documentation

Figure 3. Water

4. Coarse Aggregate

   Coarse aggregate in this study is crushed stone suitable for use in Concrete by carrying out several tests such as crushed stone sieve analysis, moisture, specific gravity, the water content of infiltration, and volume weight.

Ukarst : Universitas Kadiri Riset Teknik Sipil
Volume 06 Number 01 Year 2022
ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

Source: Research Documentation

Figure 4. Coarse Aggregate

5. Recycle Concrete

   The recycled concrete used in this study uses waste concrete from the Laboratory.

Figure 2. Waste Concrete Test Object

Source: Research Result (2022)

Processing of concrete waste is carried out by mashing or crushing again until the concrete waste is obtained by coarse aggregate sieve analysis of 2.5 mm to 30 mm. After being crushed and obtaining the size used, concrete waste material is soaked in water so that the remaining dust remains or debris that stick loose and in the oven for 24 hours at a temperature of 110 degrees [25][26]. After the completion of the drying process, the concrete waste is weighed so that the specific gravity of the material can be known. It can be used as a concrete mixture as a substitute for coarse aggregate.

2.3 Coarse Aggregate Test

Recycled Concrete that will be used as a substitute for coarse aggregate must meet feasibility through several tests. The coarse aggregate tests carried out on recycled Concrete are the concrete waste sieve analysis test, the waste concrete moisture test, the waste concrete

http://dx.doi.org/10.30737/ukarst.v6i1

ISSN (*Online*) 2581-2157
B. Damara / Ukarst Vol 6 No 1 Year 2022 ISSN (*Print*) 2502-9304
gravity test, the concrete waste infiltration test, and the concrete waste volume weight test. From these tests, a result will be obtained whether recycled Concrete can be used as a substitute for coarse aggregate in Concrete or not.

1. Concrete Waste Sieve Analysis Test

   The reference used in this test is SNI 03-1968-1990.

2. Waste Concrete Moisture Test

   A concrete moisture test is used to determine how much moisture is present - usually to know if flooring can be safely installed without causing issues. Specifications on the coarse aggregate moisture test are 1% to 4% according to ASTM C 566-89 reference.

3. Waste Concrete Gravity Test

   The coarse aggregate specific gravity test is used to calculate the specific gravity of a coarse aggregate sample by determining the ratio of a given volume of aggregate to the weight of an equal volume of water. The reference used is ASTM C 128-78 with a concrete gravity test value of 2,4 until 2,7 gram/dm^3.

4. Concrete Waste Infiltration Test

   The reference used in this infiltration test is ASTM C 127-88-93 with a 1% to 4% specification.

5. Concrete Waste Volume Weight Test

   Inspection of Aggregate Volume Weight is one of the series to determine aggregate characteristics as the main constituent of concrete material. The reference used is SNI 03-1973-1990.

2.4 Making Samples

Test specimens manufacture test specimens by mixing all materials using a mixer with a predetermined amount and variation of the addition of recycled Concrete as coarse aggregate. Pouring the material on the mixer is done sequentially, starting from water, cement, fine aggregate, and coarse aggregate. After mixing evenly, the Concrete is molded into a cylindrical mold. Then a vibrator is used to compact so that the voids in the Concrete are filled. Then leave it for 1 day and continue treating the test object or curing it by soaking it in clean water for 28 days.

2.5 Compressive Strength Test

The compressive strength test is carried out after the Concrete has undergone the test object treatment or curing for 28 days. The compressive strength of the Concrete can be tested

http://dx.doi.org/10.30737/ukarst.v6i1

ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

by operating the test machine with a constant load addition of 2 kg/cm^2 up to 4 Kg/cm^2 per second. This load test continues until the test concrete is crushed.

The compressive strength of the Concrete can then be calculated using the formula

Compresive Strength (K) = $\frac{P}{A}$

In this formula, P is the maximum load in Kg units. In comparison, A is the cross-sectional area of the test object with units of cm^2 [27][28].

The results obtained from the formula are units of Kg/cm^2. Then the conversion to MPa is also carried out using the following formula.

Compressive Strength (MPa) =$\frac{Compresive\ Strength\ (K)}{10,2}\ x\ 0.83$

The number 10.2 is obtained from 1 MPa = 10.2 kg/cm^2. while 0.83 is the conversion value of the compressive strength of Concrete.

3. Results and Discussions

3.1 Coarse Aggregate Substitution Investigation (Concrete Waste)

The results of the coarse aggregate substitution investigation are as follows:

Table 2. The Results of the Coarse Aggregate Substitution Investigation.

No	Test Description	Testing Standard	Specification	Research Result	Information
1	Concrete Waste Sieve Analysis Test	SNI 03-1968-1990	Maks 8 %	FM 4,09 %	Corresponding
2	Waste Concrete Moisture Test	ASTM C 566-89	1 – 4 %	1,10 %	Corresponding
3	Waste Concrete Gravity Test	ASTM C 128-78	2,4 – 2,7 gram/dm^3	2,60 gram/dm^3	Corresponding
4	Concrete Waste Infiltration Test	ASTM C 127-88-93	1 – 4 %	1,27 %	Corresponding
5	Concrete Waste Volume Weight Test	SNI 03-1973-1990	0,4 – 1,9 kg/liter	1,28 kg/liter	Corresponding

Source: Research Result (2022).

From **Table 2.** above, it can be seen that the recycled Concrete meets the standard of eligibility for coarse aggregate.

3.2 Compressive Strength Test of Concrete

The compressive strength of Concrete was tested at the age of 28 days. The results of testing the compressive strength of Concrete are as follows:

http://dx.doi.org/10.30737/ukarst.v6i1

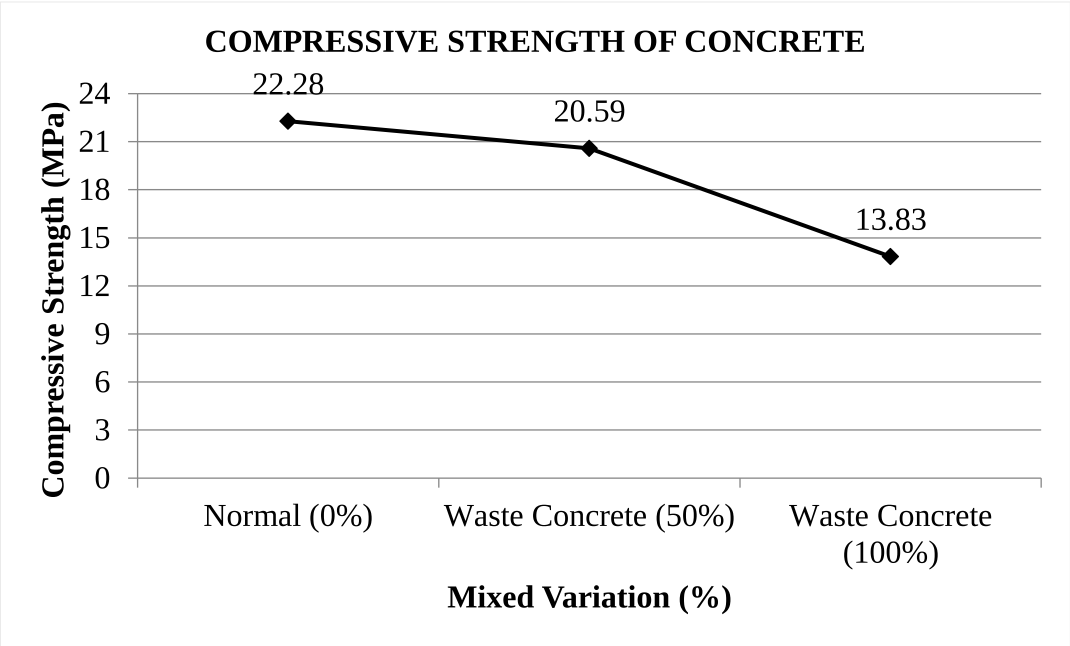
ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

Table 3. The Compressive Strength Test of Concrete at the Age of 28 Days.

Mixed Variation (%)	Compressive Strength (kg/cm²)	Average Compressive Strength (kg/cm²)	Compressive Strength (MPa)	Average Compressive Strength (MPa)
Normal (0%)	283,09		23,05	
	266,10	273,65	21,67	22,28
	271,76		22,13	
Waste Concrete (50%)	271,76		22,13	
	226,47	252,89	18,44	20,59
	260,44		21,21	
Waste Concrete (100%)	175,51		14,29	
	198,16	169,85	16,13	13,83
	135,88		11,06	

Source: Research Result (2022).

From **Table 3.** the average compressive strength (kg/cm^2) in normal concrete (0%) is 273.65 kg/cm^2, waste concrete (50%) is 252.89 kg/cm^2 and waste concrete (100%) is 169.85 kg/cm^2. Meanwhile, if the compressive strength is converted to MPa, then the average compressive strength (MPa) in normal concrete (0%) is 22.28 MPa, concrete waste (50%) is 20.59 MPa and concrete waste (100%) is 13. ,83 MPa.



Source: Research Result (2022).

Figure 4. The Result of the Compressive Strength of Concrete.

http://dx.doi.org/10.30737/ukarst.v6i1

ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

Source: Research Result (2022)

Figure 5. the process of testing the compressive strength of Concrete

From the results of the graph above, it is obtained data that the more mixed concrete waste, the lower the value of the compressive strength of Concrete, in normal Concrete 0% gets a compressive strength value of 22,28 MPa, then in Concrete with a mixture of 50% it decreases with a value of 20,9 MPa and the use of 100% concrete waste is decreasing with a compressive strength value of 13,83 MPa.

4. Conclusion

Based on research and discussion, it can be concluded that the greater the use of waste concrete for coarse aggregate, the greater the decrease in the compressive strength value. The compressive strength decreases with an increasing percentage of mixed concrete waste, with an average compressive strength of 50% concrete waste of 20.59 MPa and 100% concrete waste of 13.83 MPa. The most optimum substitution aggregate content among the planned proportions is the 50% mixture proportion so that the results of this study can be used as a reference in the utilization of recycled concrete waste as a raw material or a substitute for the composition of the concrete mixture.

5. Acknowledgement

The author would like to appreciate and acknowledge the facilities provided by Lamongan Islamic University Civil Engineering Laboratory, which has provided facilities for conducting research and providing materials.

ISSN (*Online*) 2581-2157
B. Damara / Ukarst Vol 6 No 1 Year 2022 ISSN (*Print*) 2502-9304

References

[1] J. Mansoor *et al.*, "Analysis of mechanical properties of self compacted concrete by partial replacement of cement with industrial wastes under elevated temperature," *Appl. Sci.*, 2018, doi: 10.3390/app8030364.

[2] A. S. Ouda and K. L. Abdel-Aal, "Effect of Concrete Waste on Compressive Strength and Microstructure Development of Ceramic Geopolymer Pastes," *Trans. Indian Ceram. Soc.*, 2019, doi: 10.1080/0371750X.2019.1640637.

[3] P. R. Mali and D. Datta, "Experimental evaluation of bamboo reinforced concrete beams," *J. Build. Eng.*, 2020, doi: 10.1016/j.jobe.2019.101071.

[4] D. Bisikirske, D. Blumberga, S. Vasarevicius, and G. Skripkiunas, "Multicriteria analysis of glass waste application," *Environ. Clim. Technol.*, 2019, doi: 10.2478/rtuect-2019-0011.

[5] C. O. Nwankwo, G. O. Bamigboye, I. E. E. Davies, and T. A. Michaels, "High volume Portland cement replacement: A review," *Construction and Building Materials*. 2020, doi: 10.1016/j.conbuildmat.2020.120445.

[6] A. T. Gebremariam, F. Di Maio, A. Vahidi, and P. Rem, "Innovative technologies for recycling End-of-Life concrete waste in the built environment," *Resour. Conserv. Recycle.*, 2020, doi: 10.1016/j.resconrec.2020.104911.

[7] I. Török, A. Puskás, and J. Virág, "Post-tensioned Flat Slabs with Unbonded Tendons for Public Buildings," 2019, doi: 10.1016/j.promfg.2019.02.189.

[8] N. Parthasarathi, M. Prakash, and K. S. Satyanarayanan, "Experimental study on partial replacement of cement with egg shell powder and silica fume," *Rasayan J. Chem.*, 2017, doi: 10.7324/RJC.2017.1021689.

[9] M. F. Akhter, F. Azam, and D. A. Hussain, "Comparative Study on Effect of Fly Ash and Rice Husk Ash on Strength of Concrete," *Int. J. Trend Sci. Res. Dev.*, 2018, doi: 10.31142/ijtsrd18169.

[10] E. Hunggurami, M. E. Bolla, and P. Messakh, “Perbandingan Desain Campuran Beton Normal Menggunakan SNI 03-2834-2000 dan SNI 7656:2012,” *J. Tek. Sipil*, 2017.

[11] O. D. Atoyebi and O. M. Sadiq, "Experimental data on flexural strength of reinforced concrete elements with waste glass particles as partial replacement for fine aggregate," *Data Br.*, 2018, doi: 10.1016/j.dib.2018.03.104.

[12] N. R. Dewi, D. Dermawan, and M. L. Ashari, “Studi Pemanfaatan Limbah B3 Karbit Dan Fly Ash Sebagai Bahan Campuran Beton Siap Pakai (Bsp) (Studi Kasus : Pt. Varia

ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

Usaha Beton)," *J. Presipitasi Media Komun. dan Pengemb. Tek. Lingkung.*, 2016, doi: 10.14710/presipitasi.v13i1.34-43.

[13] S. Jesus, C. M. Pederneiras, C. B. Farinha, J. de Brito, and R. Veiga, "Reduction of the cement content by incorporating fine recycled aggregates from construction and demolition waste in rendering mortars," *Infrastructures,* 2021, doi: 10.3390/infrastructures6010011.

[14] L. Gyura, M. Gáspár, and A. Balogh, "Investigation of Thermal Effects of Flame Straightening on High-Strength Steels," 2021, doi: 10.1007/978-981-15-9529-5_46.

[15] N. Oemiati and A. Junaidi, "Analisa Pengaruh Penambahan Abu Sisa Pembakaran Batu Bata Terhadap Kuat Lentur Beton," *Bear. J. Penelit. dan Kaji. Tek. Sipil*, 2020, doi: 10.32502/jbearing.2828201962.

[16] D. Dermawan and M. L. Ashari, "Studi Komparasi Kelayakan Teknis dan Lingkungan Pemanfaatan Limbah B3 Sandblasting terhadap Limbah B3 Sandblasting dan Fly Ash sebagai Campuran Beton," *J. Presipitasi Media Komun. dan Pengemb. Tek. Lingkung.*, 2018, doi: 10.14710/presipitasi.v15i1.25-30.

[17] F. S. Asrat and T. T. Ghebrab, "Effect of mill-rejected granular cement grains on healing concrete cracks," *Materials (Basel).*, 2020, doi: 10.3390/ma13040840.

[18] M. Mavroulidou and D. Lawrence, "Can waste foundry sand fully replace structural concrete sand?," *J. Mater. Cycles Waste Manag.*, 2019, doi: 10.1007/s10163-018-00821-1.

[19] O. Petruška, J. Zajac, V. Molnár, G. Fedorko, and J. Tkáč, "The effect of the carbon fiber content on the flexural strength of polymer concrete testing samples and the comparison of polymer concrete and U-shaped steel profile damping," *Materials (Basel).*, 2019, doi: 10.3390/ma12121917.

[20] M. U. Hossain, R. Cai, S. T. Ng, D. Xuan, and H. Ye, "Sustainable natural pozzolana concrete – A comparative study on its environmental performance against concretes with other industrial by-products," *Constr. Build. Mater.*, 2021, doi: 10.1016/j.conbuildmat.2020.121429.

[21] R. Žurauskiene and M. Valentukevičiene, "Experimental research on quality parameters of recycled concrete," *Materials (Basel).*, 2020, doi: 10.3390/ma13112538.

[22] C. Irawan, R. Djamaluddin, I. G. P. Raka, Faimun, P. Suprobo, and Gambiro, "The effect of the presence of infilling concrete on flexural performance of spun pile – An experimental study," *J. Teknol.*, 2020, doi: 10.11113/jt.v82.11974.

[23] W. Tjaronge, A. M. Akkas, and A. S. Ulvah, "Experimental study of concrete compressive strength using lightweight concrete debris waste as a substitute for coarse aggregate," *Int. J. Innov. Technol. Explor. Eng.*, 2019.

[24] M. T. Rahman, A. Mohajerani, and F. Giustozzi, "Recycling of waste materials for asphalt concrete and bitumen: A review," *Materials (Basel).*, 2020, doi: 10.3390/ma13071495.

[25] S. Nadhim, P. N. Shree, and G. P. Kumar, "A Comparative Study On Concrete Containing E- Plastic Waste And Fly Ash Concrete With Conventional Concrete," *PARISHODHANA In-house J. Sci. Technol.*, 2018.

[26] I. Martínez-Lage, P. Vázquez-Burgo, and M. Velay-Lizancos, "Sustainability evaluation of concretes with mixed recycled aggregate based on holistic approach: Technical, economic and environmental analysis," *Waste Manag.*, 2020, doi: 10.1016/j.wasman.2019.12.044.

[27] S. Praveenkumar and G. Sankarasubramanian, "Behavior of high performance fibre reinforced concrete composite beams in flexure," *Rev. Rom. Mater. Rom. J. Mater.*, 2019.

[28] Y. Ogawa, P. T. Bui, K. Kawai, and R. Sato, "Effects of porous ceramic roof tile waste aggregate on strength development and carbonation resistance of steam-cured fly ash concrete," *Constr. Build. Mater.*, 2020, doi: 10.1016/j.conbuildmat.2019.117462.