World Journal of Advanced Engineering Technology and Sciences
eISSN: 2582-8266
Cross Ref DOI: 10.30574/wjaets
Journal homepage: https://wjaets.com/

(Research Article)

Check for updates

Concrete mixture using natural coarse aggregate (A case study: Ongkak River–Dumoga)

Sudarno, Hendrie J. Palar, Handry Y. Oleysorot, Fery Sondakh, Julius E. Tenda and Tampanatu P. F. Sompie *

Department of Civil Engineering, Manado State Polytechnic. Manado, Indonesia.

World Journal of Advanced Engineering Technology and Sciences, 2023, 08(01), 239–246

Publication history: Received on 14 December 2022; revised on 31 January 2023; accepted on 02 February 2023

Article DOI: https://doi.org/10.30574/wjaets.2023.8.1.0029

Abstract

In current construction, there are still areas that utilize natural materials such as aggregates from rivers as construction materials, one of which is in the Dumoga, Bolaang Mongondow, North Sulawesi. The communities in this area still use natural aggregates from the river in the concrete mixture in the development process. The purpose of this study was to provide information to the public about the material characteristics and quality of concrete using coarse and fine aggregates from the Ongkak River, Dumoga. Therefore, this research aims to compare the results of concrete compressive strength of several mixtures in the field (1: 1.5: 2.5) (1: 2 : 3) (1 : 2.5: 3.5) (1 : 3 : 3) and (1 : 3: 4). Based on the results of the compressive strength, the optimal compressive strength value on average at 28 days is in the specimens with mixed variations (1: 1.5: 2.5) is 24.178 MPa, followed by mix (1: 2.5: 3,5) of 17.094 MPa, mixture (1: 2 : 3) of 15.459 MPa, mix (1 : 3: 4) of 13.737 MPa, and mix (1 : 3 : 3) of 12.250 MPa respectively.

Keywords: Natural Aggregate; Concrete Mixture; Compressive Strength; Ongkak River

1. Introduction

In developments in the current global era, most companies and industries in the construction sector tend to use concrete as a construction material. Developments in today's development are directly proportional to the need for concrete as a building material used. The need for concrete will continue to increase along with the development of the construction industry. In current development, some areas still use natural materials such as aggregates from rivers, one of which is the Dumoga area, Bolaang Mongondow, North Sulawesi. The people in this area still use a lot of natural aggregates from the river as a concrete mixture in development. This study will provide information about the natural aggregate characteristics and compressive strength of the Ongkak River as a concrete mixture material to the public.

Using local materials is very beneficial in construction because of the availability of materials. A large amount of local availability of materials such as laterite in Nigeria, and the test results show that the workability, density, and compressive strength at a constant water-cement ratio increases with the increasing particle size of coarse aggregate and with curing age (Salau, 2015). The people of Alor who live near rivers use river aggregates as concrete material. The compressive strength value of concrete using Takari aggregate is higher than that of Benlelang and Lembur (Mau, 2018). Then, natural sand from Lembang Marinding is suitable for fine aggregate in concrete mixes. (Mabui, 2021). Also, the various local materials available on Madura Island show that these different compressive strength properties are the result of changing the size of the coarse aggregate, thus determining the effect of the size of the coarse aggregate on the concrete. Furthermore, the constitutive model can be used to characterize the effect of particle size on the strength parameters of geopolymer concrete (Pertiwi, 2021). The basis for the application of two types of concrete, pervious cement concrete (PCC) and pervious geopolymer concrete (PGC), both made from sea sand and seawater, can be considered in civil works near the sea such as roads, pavements, car parks (Nguyen-Van, 2022).

*Corresponding author: Tampanatu P.F. Sompie
Department of Civil Engineering, Manado State Polytechnic, Manado, Indonesia.

Copyright © 2023 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution Liscense 4.0.

Using natural coarse aggregate and recycled coarse aggregate made from concrete waste shows that porous concrete made from recycled coarse aggregate has a higher permeability performance and infiltration rate compared to porous concrete made from nature (Cahya, 2021). The supply of natural aggregates on earth is decreasing along with technological advances; therefore, an alternative to natural aggregates such as artificial aggregates using coal combustion waste, namely fly ash. The resulting artificial aggregate is quite suitable for use as a concrete mixture (Adhitya, 2023). The advantage of lightweight concrete is that it reduces loads in the form of dead loads on the structure. Substitution of sand with quicksand as fine aggregate in lightweight concrete affects compressive strength, split tensile strength, and weight. (Gaus, 2022). The use of coral pumice aggregate is in the category of lightweight concrete. The addition of light aggregate as a substitute for coarse aggregate causes workability and compressive strength but does not affect the specific gravity (Pujianto, 2021).

The study of the effect of coarse aggregate size and grading on the workability and compressive strength of concrete show that the workability was similar for all mixes with no apparent relationship pattern to the coarse aggregate size used. There was a significant influence from the coarse aggregate source on the compressive strength of various nominal mixed concrete plans (Prajapati, 2019). The compressive strength increases with increasing coarse aggregate size (Mkpaidem, 2022; Ogundipe, 2018).

The mechanical strength of cement concrete with various types of coarse aggregate depends on the strength and water absorption of the coarse aggregate (Wang, 2021). Experimental data from a complex laboratory study on the effect of complex modified additives (CMA) show that the studied additives form an optimal structure reducing water saturation and increasing the strength properties of concrete. This experiment makes it possible to expect a higher operational property of heavy concrete - frost resistance, increasing its durability (Altynbekova, 2022).

In recent years, significant attention by people to using recycled concrete aggregates (RCA) instead of natural aggregate concrete (NAC) in concrete mixes to reduce the resource demand for natural aggregates and their environmental impact. The research investigates the efficiency of using RCA in concrete mixtures as a substitute for natural coarse aggregate; the results showed that the new property decreased with increasing RCA replacement. The compressive strength of the RCA has been reduced by increasing the replacement of the RCA (Al adday, 2019).

Three treatment methods were used in the study: (1) sulfuric acid (SA), (2) impregnation of silica fume (SF), and (3) a combination of sulfuric acid and silica fume (SASF). Experimental investigations showed an increase in the physical properties of RCA compared to untreated RCA, but statistical tests showed that this improvement was not significant (Tang, 2019). Although RAC may show a compressive strength similar to NAC, its elastic modulus decreases when the RA content increases, whose degree depends on the quality of RA (Chen, 2022).

2. Methodology

This research is an experimental study conducted in the Materials Testing Laboratory of the Civil Engineering Department, Manado State Polytechnic. The implementation of the research starts with the process of making concrete test objects, curing, and concrete testing.

The following is an explanation of the stages of this study which will be described based on the implementation process.

Table 1 Calculation of the Proportion of Mixed Concrete Samples

No	Mix	Cement(Kg)	Sand(Kg)	Gravel(Kg)	Water(Litre)
1	1:1.5:2.5	7.490	13.448	25.434	3.744
2	1: 2 : 3	6.241	14.942	25.434	3.12
3	1: 2.5: 3.5	5.350	16.009	25.432	2.673
4	1 : 3 : 3	5.350	19.211	21.800	2.673
5	1 : 3: 4	4.681	16.810	25.434	2.34

2.1. Concrete Mix Test

In determining the concrete mixture, it conducts a mixing experiment by determining several concrete mix compositions to carry out a compressive strength test to see which combination gives the best compressive strength value. The concrete mix experiment used a comparison with mixed variations (1: 1.5: 2.5), (1: 2: 3), (1: 2.5: 3.5), (1: 3 : 3), (1: 3: 4) using natural aggregates, to get the results of each mixed composition.

Figure 1 Material Weighing And Mixing

Figure 2 Slum Measurement And Making Concrete Samples

Figure 3 Compressive Strength Measurement And Testing Process

3. Results and discussion

3.1. Fine Aggregate Test Results

Inspecting the concrete constituent materials was conducted at the Materials Testing Laboratory of the Department of Civil Engineering, Manado State Polytechnic. In this study, tests on fine aggregate specimens originating from the Ongkak River included testing of specific gravity and absorption, aggregate density, clay content, water content, and sieving analysis (gradation). The results of the aggregate test can be seen in Table 2.

Table 2 Fine Aggregate Test Results

No	Test Type		Unit	Values
1	Specific Gravity	Bulk	gr/cm^3	2.436
		SSD	gr/cm^3	2.554
		APP	gr/cm^3	2.763
2	Absorption		%	4.866
3	Bulk Density	Solid	gr/cm^3	1.417
		Loose	gr/cm^3	1.313
4	Clay Content		%	2.16
5	Water Content		%	5.672
6	Sieve Analysis			Figure 4

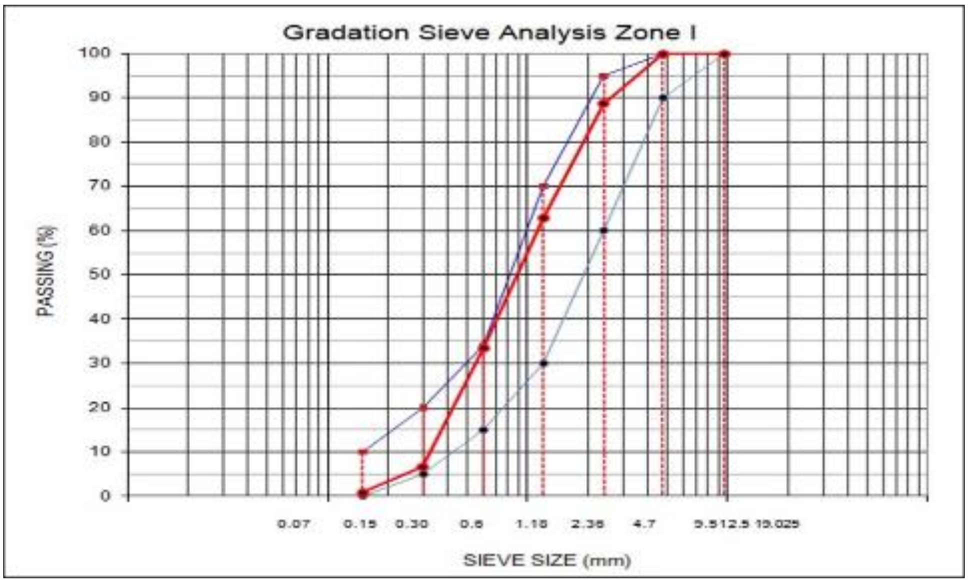

Figure 4 Sieve Analysis of Fine Aggregate

3.2. Coarse Aggregate Test Results

Tests carried out on coarse aggregate from the Ongkak River Dumoga included abrasion testing with a Los Angeles machine, specific gravity and aggregate absorption, aggregate bulk density, clay content, water content and sieve analysis. The test results can be seen in Table 3.

Table 3 Coarse Aggregate Test Results

No	Test Type		Unit	Values
1	Abrasion with Los Angeles		%	30.781
	Specific Gravity	Bulk	gr/cm^3	2.494
		SSD	gr/cm^3	2.586
		APP	gr/cm^3	2.747
3	Absorption		%	3.92

4	Bulk Density	Solid	gr/cm^3	1.607
		Loose	gr/cm^3	1.483
5	Clay Content		%	3.62
6	Water Content		%	1.727
7	Sieve Analysis			Figure 5

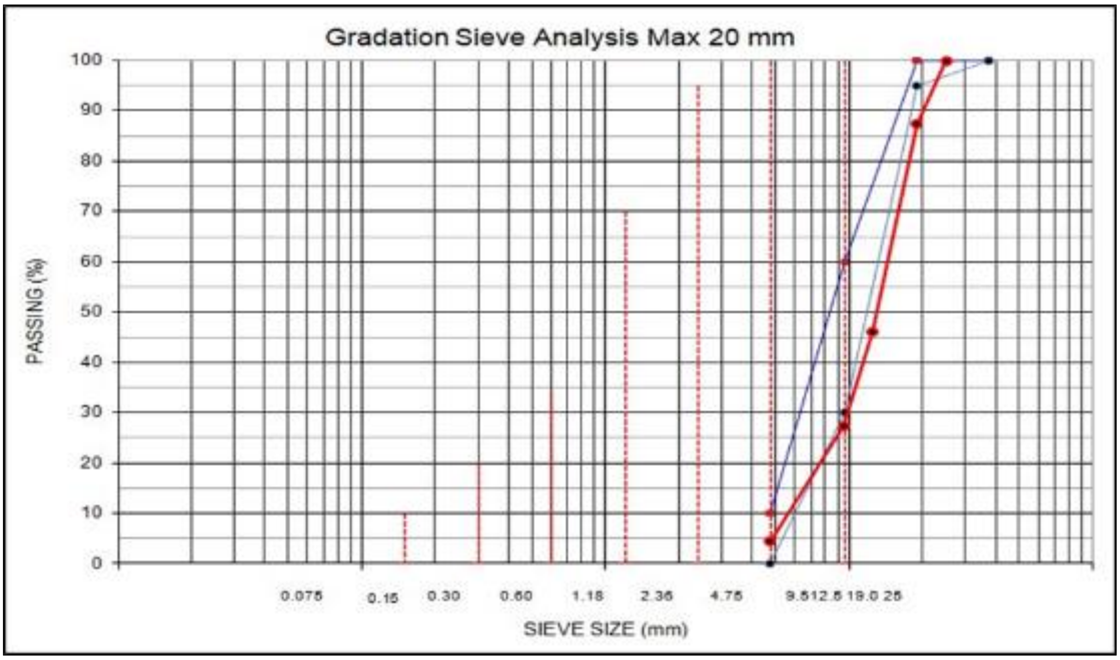

Figure 5 Sieve Analysis of Coarse Aggregate

3.3. Concrete Compressive Strength

The value of the compressive strength of the concrete for each test object is calculated based on the results of the examination of the compressive strength of the concrete test object, obtaining several results from the average for each composition of the concrete mixture in 7, 14 and 28 days as shown in the following table, complete average results for the results of the compressive strength of the test object.

Table 4 Compressive Strength Results for All Mixtures

MIXTURE 1: 1.5: 2.5						
AGE (DAYS)	**COMPRESSIVE STRENGTH**					
	SAMPLE	**WEIGHT (Kg)**	**VALUE (MPa)**	**AVERAGE (MPa)**	**K Kg/cm^2**	**Concrete Classification**
7	1	12.470	21.386	20.030	291	Concrete Class III
	2	12.286	18.673			
14	1	12.205	24.528	22.595		
	2	12.428	20.662			
28	1	12.430	21.394	24.178		
	2	12.114	26.961			
MIXTURE 1: 2 : 3						

AGE (DAYS)	COMPRESSIVE STRENGTH					
	SAMPLE	WEIGHT (Kg)	VALUE (MPa)	AVERAGE (MPa)	K Kg/cm²	Concrete Classification
7	1	11.943	8.845	9.490	186	Concrete Class II
	2	12.135	10.135			
14	1	12.120	12.438	14.073		
	2	12.192	15.707			
28	1	12.073	14.131	15.459		
	2	12.130	16.786			

MIXTURE 1: 2.5: 3.5

AGE (DAYS)	COMPRESSIVE STRENGTH					
	SAMPLE	WEIGHT (Kg)	VALUE (MPa)	AVERAGE (MPa)	K Kg/cm²	Concrete Classification
7	1	12.240	10.898	11.041	205	Concrete Class II
	2	12.470	11.183			
14	1	12.155	12.609	13.618		
	2	12.188	14.627			
28	1	12.185	17.029	17.094		
	2	12.240	17.158			

MIXTURE 1 : 3 : 3

AGE (DAYS)	COMPRESSIVE STRENGTH					
	SAMPLE	WEIGHT (Kg)	VALUE (MPa)	AVERAGE (MPa)	K Kg/cm²	Concrete Classification
7	1	12.203	8.478	8.600	147	Concrete Class II
	2	12.198	8.721			
14	1	12.377	9.282	9.981		
	2	12.530	10.679			
28	1	12.259	14.889	12.250		
	2	12.375	9.610			

MIXTURE 1 : 3: 4

AGE (DAYS)	COMPRESSIVE STRENGTH					
	SAMPLE	WEIGHT (Kg)	VALUE (MPa)	AVERAGE (MPa)	K Kg/cm²	Concrete Classification
7	1	12.210	9.155	8.918	165	Concrete Class II
	2	12.035	8.680			
14	1	12.212	12.800	11.914		
	2	12.124	11.028			
28	1	12.238	14.545	13.737		
	2	11.984	12.928			

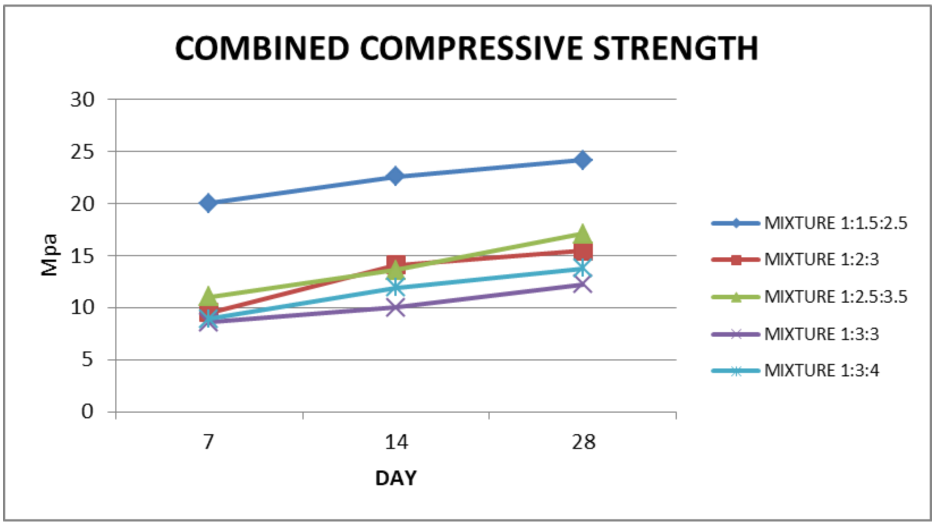

Figure 6 Combined of Field Mix Variation

From the combined compressive strength results in Figure 6, the average compressive strength of mixed variations in concrete, the concrete with the highest compressive strength results in the concrete mixture (1: 1.5: 2.5) with a compressive strength of 24. 17 MPa or K-291 at 28 days and included in class III concrete. Furthermore, mixture (1: 2.5: 3.5) of 17.094 MPa (K-205), mixture (1: 2 : 3) of 15.459 MPa (K-186), mixture (1 : 3: 4) of 13.737 MPa (K-165), and mix (1 : 3 : 3) of 12.250 MPa (K-147); mixtures with compressive strength below that of K-225, including in class II concrete.

4. Conclusion

The average compressive strength of mixed variations in concrete shows that the highest compressive strength results are in a concrete mixture of 1: 1.5: 2.5 with a compressive strength of 24.17 MPa or K-291 at 28 days and included in class III concrete according to the classification of concrete. Moreover, followed by mixing 1: 2.5: 3.5 the compressive strength is 17.094 MPa or K-205 and categorized in class II concrete.

Compliance with ethical standards

Acknowledgments

The authors would like to thank the Head of the Center for Research and Community Service and the Head of the Material Testing Laboratory at Manado State Polytechnic for supporting this research.

Disclosure of conflict of interest

No conflict of interest.

References

[1] Adhitya, B. B., Saggaff, A., Saloma., and Hanafiah. 2023. Manufacture of Geopolymer Artificial Aggregates by Pelletization and Crushing Processes, Civil Engineering and Architecture 11(1): pp. 13–21, DOI: 10.13189/cea.2023.110102

[2] Altynbekova, A., Lukpanov, R., Yenkebayev, S., Tsygulyov, D., and Nurbayeva, M. 2022. Complex Laboratory Studies of Modified Additive Influence on Concrete Physical and Mechanical Properties, International Journal of GEOMATE, Dec, 2022, Vol.23, Issue 100, pp.26-33, DOI: https://doi.org/10.21660/2022.100.3641

[3] Al adday, F, Awad, A., Aleghnimat, R., Bassam, H., and Khater, A. 2019. Fresh and Hardened Properties of Recycled Concrete Aggregate Modified by Irob Powder and Silica, International Journal of GEOMATE, Jan. 2019, Vol.16, Issue 53, pp.222 - 230 Geotec., Const. Mat. & Env., DOI: https://doi.org/10.21660/2019.53.96609

[4] Cahya, E N., Haribowo, R., andArifi, E. 2021. Inclined porous concrete surface impact on infiltration using recycled concrete aggregate. IOP Conf. Series: Earth and Environmental Science 930 (2021) 012100, IOP Publishing, doi:10.1088/1755-1315/930/1/012100

[5] Chen, J., Zhou, Y., and Yin, F. 2022. A Practical Equation for the Elastic Modulus of Recycled Aggregate Concrete. Buildings 2022, 12, 187, https://doi.org/10.3390/ buildings12020187

[6] Gaus, A., Sultan, M. A., Hakim, R., and Rauf, I. 2022. Effects of Using Pumice Sand as A Partial Replacement of Fine Aggregate in Lightweight Concrete Mixtures, IJEBD: (International Journal of Entrepreneurship and Business Development), Volume 05, Number 04, July 2022, pp. 660-666

[7] Mau, M. Y., Hunggurami, E., and Sir, T. M. W. 2018. Compressive Strength of Concrete using Benlelang River Fine Aggregate and Lembur River and Benlelang River Coarse Aggregate, Journal of Civil Engineering, Vol. VII, No. 1, April 2018, pp. 31-36

[8] Mabui, D. S., Tumpu, M., and Rangan, P. R., 2021. Early Age Compressive Strength of Concrete Made With Mountain Sand, River Sand and Portland Composite Cement, Design Engineering, Year 2021 Issue: 9, pp. 10398-10406

[9] Mkpaidem, N. U., Ambrose, E. E., Olutoge, F. A., and Afangideh, C. B. 2022, Effect of Coarse Aggregate Size and Gradation on Workability and Compressive Strength of Plain Concrete, J. Appl. Sci. Environ. Manage, Vol. 26 (4), April 2022, pp. 719-723

[10] Nguyen-Van, D., Nguyen-Tuan, T., and Pham-Thanh, T. 2022. Experimental Study on Pervious Cement and Pervious Geopolymer Concretes Using Sea Sand and Seawater. International Journal of GEOMATE, Nov 2022, Vol.23, Issue 99, pp.63-71, DOI: https://doi.org/10.21660/2022.99.3592

[11] Ogundipe, O. M., Olanike, A. O., Nnochiri, E., S, and Ale, P. O. 2018. Effects of Coarse Aggregate Size on the Compressive Strength of Concrete, Civil Engineering Journal Vol. 4, No. 4, April, 2018, pp. 836-842

[12] Pertiwi, D., Theresia MCA, and Komara, I.2021. The impact of different of coarse aggregate sizes on the strength and performance of concrete using locally available materials, Nat. Volatiles & Essent. Oils, 2021; 8(5): pp. 10332-10340

[13] Pujianto, A and Prayuda, H. 2021. Fresh and Hardened Properties of Lightweight Concrete Made With Pumice as Coarse Aggregate, International Journal of GEOMATE, Nov. 2021, Vol.21, Issue 87, pp.110-117, DOI: https://doi.org/10.21660/2021.87.j2365

[14] Prajapati, J, and Karanjit, S. 2019. Effect of Coarse Aggregate Sources on the Compressive Strength of Various Grades of Nominal Mixed Concrete. Journal of Science and Engineering (JScE), Vol.7, November 2019, pp. 52-60

[15] Salau, M. A and Busari, A. O. 2015. Effect of Different Coarse Aggregate Sizes on the Strength Characteristics of Lateralized Concrete, 2nd International Conference on Innovative Materials, Structures and Technologies IOP Publishing IOP Conf. Series: Materials Science and Engineering 96 (2015) 012079 doi:10.1088/1757-899X/96/1/012079

[16] Tang, A. J, De Jesus, R, and Cunanan, A., 2019. Microstructure and Mechanical Properties of Concrete with Treated Recycled Concrete Aggregates, International Journal of GEOMATE, May 2019, Vol.16, Issue 57, pp.21 - 27 Geotec., Const. Mat. & Env., DOI: https://doi.org/10.21660/2019.57.4537

[17] Wang, L., Yong, H., Lu, J., Shu, C. and Wang, H. 2021. Influence of Coarse Aggregate Type on the Mechanical Strengths and Durability of Cement Concrete. Coatings 2021, 11, 1036. https://doi.org/10.3390/ coatings11091036