



EFFICACY OF BASALT AND GRANITE AS COARSE AGGREGATE IN CONCRETE MIXTURE



Ubi S.E ¹✉, Nkra P.O ², Agbor R.B ³, Ewa D.E ¹, Nuchal M. ¹

¹ Department of Civil Engineering Cross River University of Technology (CRUTECH), Calabar, Nigeria

² Department of Works, University of Calabar, Calabar, Nigeria

³ Environmental Biotechnology unit, Department of Genetics and Biotechnology, University of Calabar, Calabar, Nigeria



DOI: <https://doi.org/10.29121/ijetmr.v7.i9.2020.769>

Article Citation: Ubi S.E, Nkra P.O, Agbor R.B, Ewa D.E, and Nuchal M.. (2020). EFFICACY OF BASALT AND GRANITE AS COARSE AGGREGATE IN CONCRETE MIXTURE. International Journal of Engineering Technologies and Management Research, 7(9), 1-9. <https://doi.org/10.29121/ijetmr.v7.i9.2020.769>

Published Date: 08 September 2020

Keywords:

Granite
Flexural Strength
Basalt
Coarse Aggregate
Compressive Strength

ABSTRACT

This present research was on the comparison of the efficacious use of basalt and granite as coarse aggregates in concrete work. In order to obtain the basis for comparison, physical and structural tests were conducted on the different materials of the concrete and the concrete samples respectively. Physical test results revealed that basalt have a specific gravity of 2.8 and 2.5, while granite have a specific gravity of 2.9 and 2.6. In density, basalt have a density of 1554.55kg/m³ while granite had a density of 1463.64kg/m³. Aggregate impact test conducted on both aggregates revealed a percentage of 11.05% for basalt and 12.63% for granite. The following structural tests were carried out: compressive strength tests, flexural and tensile strength test and the comparative results are as follows. Compressive strength for basalt 36.39N/mm² while 37.16N/mm² for granite. 24.81N/mm² tensile strength for basalt while 12.57N/mm² for granite, 31.83N/mm² flexural strength for basalt while 27.97N/mm² for granite. From the above results, it can be deduced that basalt has higher strength properties than granite. Therefore, more suitable for coarse aggregate in achieving higher strength with some quantity of other composition of the concrete mix when compared to granite.

1. INTRODUCTION

Technological advancement is one of the ways of achieving sustainable development globally. The discovery of concrete technology has brought different innovative ideas into its usage. The process of using appropriate ingredients of concrete and estimating relative quantity in order to produce the desired concrete that could stand the test of time in terms of material strength, durability and workability is termed concrete mix design. Sobera and Tose (2003). Concrete which is made of cement, fine aggregates (sand) and coarse aggregates is mixed with water, harden with time, served as construction material in engineering sites. Concrete technology deals with the application of concrete at a particular proportion. However, in our contemporary society and due to civilization, many persons have deviated from thatched buildings into the constructive use of concrete materials in designing of houses, bridges, and erosion ways. Construction of buildings involves the usage of concrete in the foundations, columns, beams, slabs and other load carrying areas. Basalt are igneous rock that possess low silica content. They are dark and has a rich source of iron and magnesium. Some basalts appear glassy while others are very fine-grained. Basalt are classified on the

basis of chemical and petrographic in two main categories, the tholeiitic and alkali basalt. Kasim et al. (2017) evaluated the aggregates properties on the mechanical and absorption characteristics of geopolymer mortars. Three different types of aggregates consisting of river sand, crushed limestone and combined sand-limestone were used in geopolymer mortar. The findings revealed that the crushed limestone produces the highest compressive and splitting tensile strength while the combined sand-limestone shows the lowest water absorption and sorptivity capacity. Krzysztof et al. (2018) examined the effect of the morphology of coarse aggregate on the properties of self-compacting high-performance fibre-reinforced concrete. It was reported that the morphology of the coarse aggregate had an impact on the rheological properties of the fresh concrete mixture. Mehdi et al. (2018) reported on the optimum oil palm shell content as coarse aggregate in concrete based on mechanical and durability properties. The findings revealed that oil palm shell content should not exceed 60% of the total volume of coarse aggregate. Dobiszewska et al. (2019) evaluated the effect of basalt powder addition on properties of mortar. The result revealed that the addition of the basalt powder in place of cement decreases the compressive strength. The flexural strength of the mortar was improved at specific instances. Kumar et al. (2015) investigated the use of granite waste as partial substitute to cement in concrete. The granite slurry was used as partial substitute in proportions ranging from 5% to 20% by weight of cement in concrete. The comprehensive strength, tensile strength and flexural strength were tested. The findings shows that locally available granite slurry is a good partial substitute to concrete.

2. MATERIALS AND METHODS

In more than two decades, lots of materials have been offered in full range for testing to suit the requirements of local, national and international civil engineering contractors, consultants as well as manufacturers, the resource industry and government agencies.

2.1. AGGREGATE CRUSHING TEST PROCEDURE

Specimen of aggregate in standard mould were subjected to a compression test under standard load conditions. The dry aggregate were made to pass through 12.5mm sieves, retained and sieved in a 10mm sieves, this was filled in a cylindrical measure of 11.5mm diameter with a 18cm height in three layers. Each layer is tempered 25 times with a standard tamping rod. The test sample was weighed and placed in the test cylinder in three layers each layer was being tamped again.

2.2. SPECIFIC GRAVITY AND WATER ABSORPTION, SIEVE ANALYSIS AND SPLIT TENSILE STRENGTH

The Aggregate impact test, Specific gravity and water absorption test, sieve analysis test and splitting analysis were performed using standard laboratory procedures as adopted by Ramakanta (2012); BS: 1881: Part 118: 1983; IS: Part 1-2 (2016) respectively.

2.3. EXPERIMENTAL METHOD

Different experimental method were adopted to test the components in order to determined physical properties of aggregate of basalt, physical properties of concrete and the density of concrete as shown in Table 1-3 and figure 5 respectively.

2.4. PHYSICAL PROPERTIES OF AGGREGATE

The physical properties of aggregate of basalt showing the specific gravity and particle size distribution is presented in Table 1 & 2.

Table 1: Specific Gravity

Material	River Fine	Coarse Aggregate (Basalt)	Coarse Aggregate (Granite)
Specific Gravity, (Gs)	2.75	2.8	2.9

From the given Table, basalt has shown that it has more strength than granite and is a better coarse aggregate material.

Table 2: Particle size distribution

Sieves	Weight retained (g)	Cumulative weight retained	Percentage retained	Percentage cumulative	Percentage passing	Specification
20mm						
14mm						
10mm						
6mm						
5mm						
4.75mm	38	38	0.38	3.8	96.2--	
3.35mm	34	72	0.72	7.2	92.8	
2.36mm	38	110	1.1	11	89	
1.18mm	178	288	2.88	28.8	71.2	
600mic	383	671	6.71	67.1	32.9	
425mic	19	690	6.9	69	31	
300mic	217	907	9.07	90.7	9.3	
212mic	56	963	9.63	96.3	3.7	
150mic	14	977	9.77	97.7	2.3	
75/63mic	7	984	9.84	98.4	1.6	
passing 63mic	3	987	9.87	98.7	1.3	
Total	1000g					

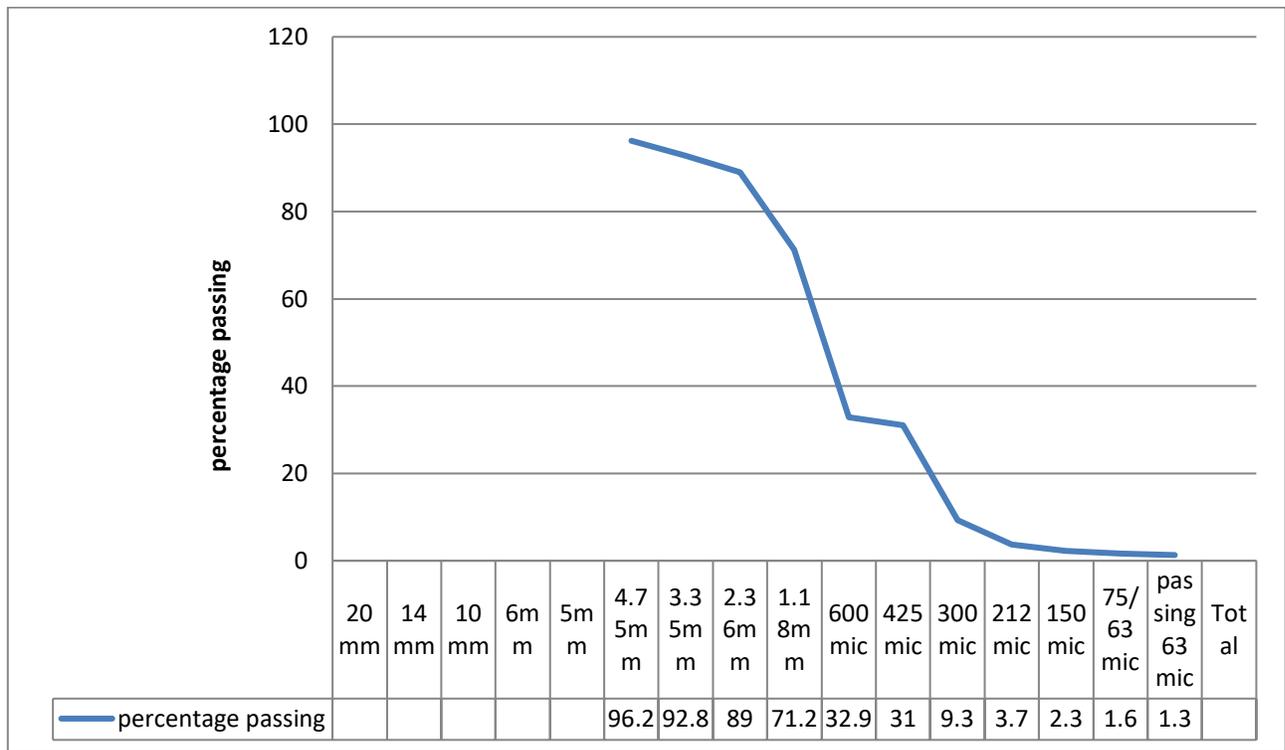


Figure 1: Particle size distribution

Fig. 5: A Graph Showing The Sieve Analysis

2.5. AGGREGATE IMPACT VALUE

For basalt, Total weight of aggregate = $w_1 = 362g$, $w_2 = 0.040g$ hence,

$$\text{Aggregate impact value} = \frac{w_2}{w_1} \times 100 = \frac{0.040}{362} \times 100 = 11.05\%$$

For granite $w_1 = 364g$, $w_2 = 0.046g$,

$$\text{Aggregate impact value} = \frac{w_2}{w_1} \times 100 = \frac{0.046}{364} \times 100 = 12.63\%$$

Both basalt and granite, from the given results, possess the property of toughness and are strong materials(giving results of between 10-20%).

2.6. AGGREGATE CRUSHING VALUE

For Basalt, Total Weight of Aggregate = $w_1 = 2.585\text{kg}$, $w_2 = 0.759\text{kg}$

Hence,

$$\text{Aggregate Crushing Value} = \frac{w_2}{w_1} \times 100 = \frac{0.759}{2.585} \times 100 = 29.36\%$$

For Granite, Total Weight of Aggregate = $w_1 = 2.617\text{kg}$, $w_2 = 0.027\text{kg}$,

$$\frac{w_2}{w_1} \times 100 = \frac{0.027}{2.617} \times 100 = 1.03\%$$

Given the result shown, basalt possess high resistance during crushing and gradual application of compressive load than granite. Hence, basalt is more preferred than granite.

2.7. PHYSICAL PROPERTIES OF CONCRETE

2.7.1. WORKABILITY OF CONCRETE

The workability of the fresh concrete was determined by slump test.

The slump test is a measure of the consistency of the concrete as shown in Table 3.

Table 3: Slump Properties

Maximum size of coarse aggregates	Aggregate type	Slump(mm)		
		10-30	30-60	60-180
20	Crushed		180	205
	Uncrushed		210	235
40	Crushed		160	185
	Uncrushed		190	215

Slump for granite = 140mm; Slump for basalt = 90mm

According to the COREN method of concrete mix design, both aggregates exhibit properties of a high slump.

2.8. DENSITY OF CONCRETE

From $V = \pi r^2 h$, where r is the radius = 0.0375m, h is the height = 0.05m therefore; $V = \pi \times 0.0375^2 \times 0.05 = 0.00022\text{m}^3$

Original mass of cylinder $M = 0.746$, mass of granite $M_g = 1.068\text{kg}$, mass of basalt $M_b = 1.088\text{kg}$. $M_g - M = 1.068 - 0.746 = 0.322$, $M_b - M = 1.088 - 0.746 = 0.342$

$$\text{Hence, Density of granite } \gamma_g = \frac{M}{V} = \frac{0.322}{0.00022} = 1463.64\text{kg/m}^3$$

$$\text{Density of basalt } \gamma_b = \frac{M}{V} = \frac{0.342}{0.00022} = 1554.55\text{kg/m}^3$$

The result showed granite to be less dense than basalt.

3. RESULTS AND DISCUSSION

The structural analysis properties of concrete and their responses are presented in Table 4, 5, 6, 7, 8 and 9 respectively.

3.1. COMPRESSIVE STRENGTH TEST FOR GRANITE

The compressive strength test for granite as shown on table 4 show a steady rise in the value of compressive strength as the number of days increased. The maximum strength was obtained after 28days of curing; while Fig. 2, shows a relationship between the increase in compressive strength and the number of days.

Table 4: Compressive strength result for granite

3 Days Compressive Strength Tests (Granite)						
S/N	M(Kg)	Casting Date	Crushing Date	Crushing Force (Kn)	Compressive Strength (N/Mm ²)	Average Strength (N/Mm ²)
M ₁	2.615	28/11/18	1/12/2018	206.69	20.67	18.62
M ₂	2.539	28/11/18	1/12/2018	143.41	14.34	
M ₃	2.631	28/11/18	1/12/2018	208.48	20.85	
7DAYS						
M ₁	2.481	28/11/18	6/12/2018	216.04	21.6	22.26
M ₂	2.513	28/11/18	6/12/2018	228.72	22.87	
M ₃	2.491	28/11/18	6/12/2018	222.95	22.3	
14 DAYS						
M ₁	2.512	28/11/18	18/12/18	267.25	26.73	24.47
M ₂	2.53	28/11/18	18/12/18	237.55	23.76	
M ₃	2.544	28/11/18	18/12/18	229.32	22.93	
21 DAYS						
M ₁	2.57	28/11/18	24/12/18	244.51	24.45	30.88
M ₂	2.451	28/11/18	24/12/18	348.82	34.88	
M ₃	2.701	28/11/18	24/12/18	333.21	33.32	
28 DAYS						
M ₁	2.456	28/11/18	30/12/18	370	37	37.16
M ₂	2.457	28/11/18	30/12/18	390	39	
M ₃	2.512	28/11/18	30/12/18	355	35.5	

3.2. COMPRESSIVE STRENGTH FOR BASALT

The result for the compressive strength for basalt as shown in Table 5 indicate a relatively higher valued compared to that of granite after 28 days of curing. The relationship between number of days and compressive strength for basalt; while comparison between the compressive strength of granite and bassalt after 28days is as presented on Table 5. This implies that, granite have a lesser compressive strength than basalt i.e the compressive strength of basalt is relatively higher than that of granite.

Table 5: Compressive Strength For Basalt

Compressive Strength Tests (Basalt)						
S/N	M(kg)	Casting Date	Crushing Date	Crushing Force(kN)	Compressive Strength (N/mm ²)	Average strength (N/mm ²)
3 DAYS						
M ₁	2.466	28/11/18	1/12/2018	197.37	19.74	23.2
M ₂	2.501	28/11/18	1/12/2018	257.38	25.74	
M ₃	2.51	28/11/18	1/12/2018	241.19	24.12	
7DAYS						
M ₁	2.592	28/11/18	6/12/2018	239.58	23.96	24.89
M ₂	2.711	28/11/18	6/12/2018	227.24	22.72	
M ₃	2.581	28/11/18	6/12/2018	279.99	28	

14 DAYS						
M ₁	2.6	28/11/18	18/12/18	219.85	21.99	26.29
M ₂	2.65	28/11/18	18/12/18	324.6	32.46	
M ₃	2.6	28/11/18	18/12/18	244.29	24.43	
21 DAYS						
M ₁	2.468	28/11/18	24/12/18	319.01	31.9	31.83
M ₂	2.47	28/11/18	24/12/18	316.63	31.66	
M ₃	2.709	28/11/18	24/12/18	319.28	31.93	
28 DAYS						
M ₁	2.479	28/11/18	30/12/18	393.16	39.32	36.39
M ₂	2.542	28/11/18	30/12/18	308.36	30.84	
M ₃	2.52	28/11/18	30/12/18	390	39	

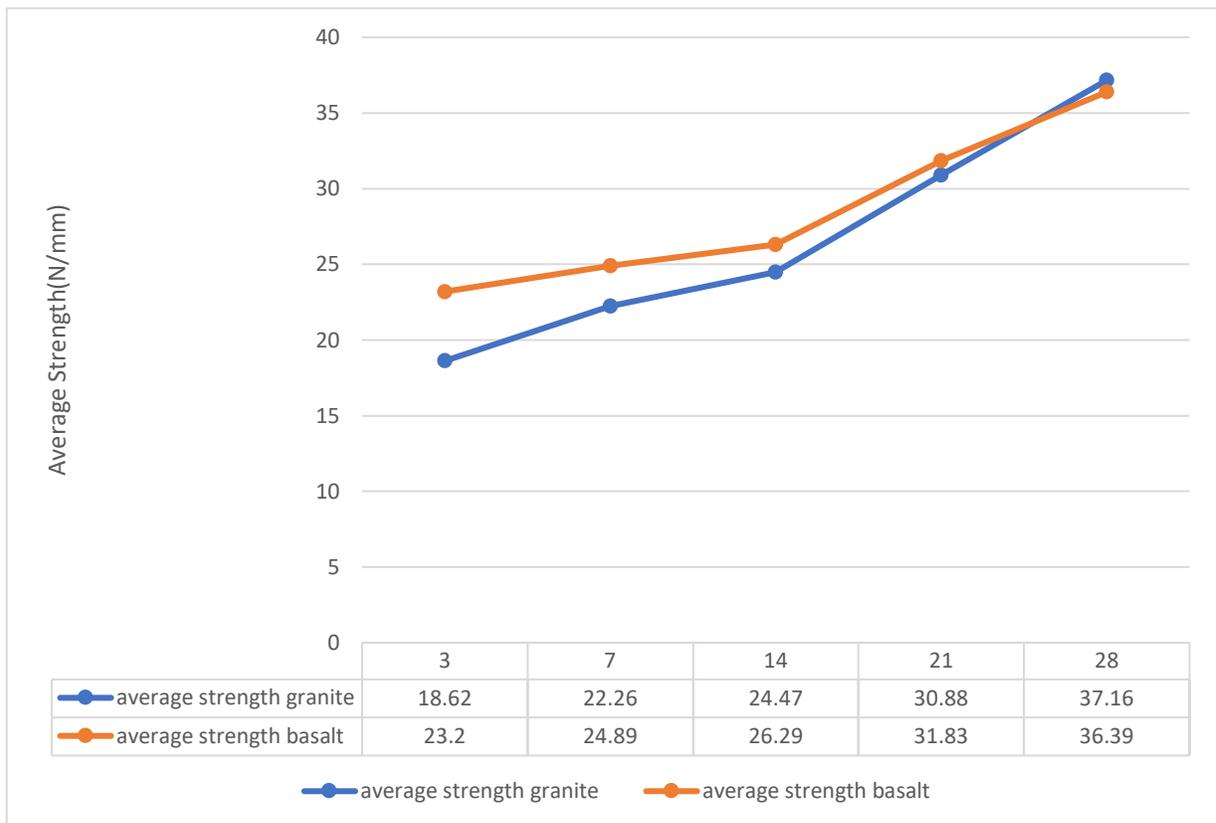


Figure 2: Compressive strength for granite and basalt

3.3. SPLIT TENSILE STRENGTH TEST

The cylinder split tensile strength result for granite in Table 7, shows the result for the cylinder split tensile strength test for granite after 28 days. The result shows the average tensile strength was 12.57N/mm². Split tensile strength base on days of crushing and applied force was calculated from

$$T = \frac{2P}{\pi Ld}$$

Where: P is the applied load, L is the length of cylinder say 300mm and d is the diameter of cylinder say 150mm.

Table 6: Cylinder Split Compressive Strength Test of Granite at 28 Days

28 DAYS			Cylinder Split Tensile Strength Tests (Granite)			
S/N	M(kg)	Casting Date	Crushing Date	Applied Force (kN)	Split tensile Strength (N/mm ²)	Average strength (N/mm ²)
M ₁	14.7	12/12/2018	18/12/18	96.37	13.63	12.57
M ₂	13.2	12/12/2018	18/12/18	69.1	9.77	
M ₃	15	12/12/2018	18/12/18	101.16	14.3	

3.4. CYLINDER SPLIT TENSILE STRENGTH FOR BASALT

The result for the cylinder split tensile strength test for basalt after 28days is shown on Table 8. The result shows the average tensile strength is 24.81N/mm²; while Fig. 2 also show the comparison of the cylinder split tensile strength test for basalt and granite. It showed that the tensile strength for granite lagged that of basalt by over 50 percent. The Table 8 also highlight the split tensile strength result with days weight of sample casting date crushing date, applied force and split tensile strength calculated from

$$T = \frac{2P}{\pi Ld}$$

Where: P is the applied load, L is the length of cylinder say 300mm and d is the diameter of cylinder say 150mm.

Table 7: Cylinder Split Tensile Strength For Basalt

28 Days			Cylinder Split Tensile Strength Tests (Basalt)			
S/N	M(kg)	Casting Date	Crushing Date	Applied Force (kN)	Split tensile Strength (N/mm ²)	Average strength (N/mm ²)
M ₁	14.7	12/12/2018	18/12/18	195.57	27.67	24.81
M ₂	13.2	12/12/2018	18/12/18	220.41	31.18	
M ₃	15	12/12/2018	18/12/18	110.21	15.59	

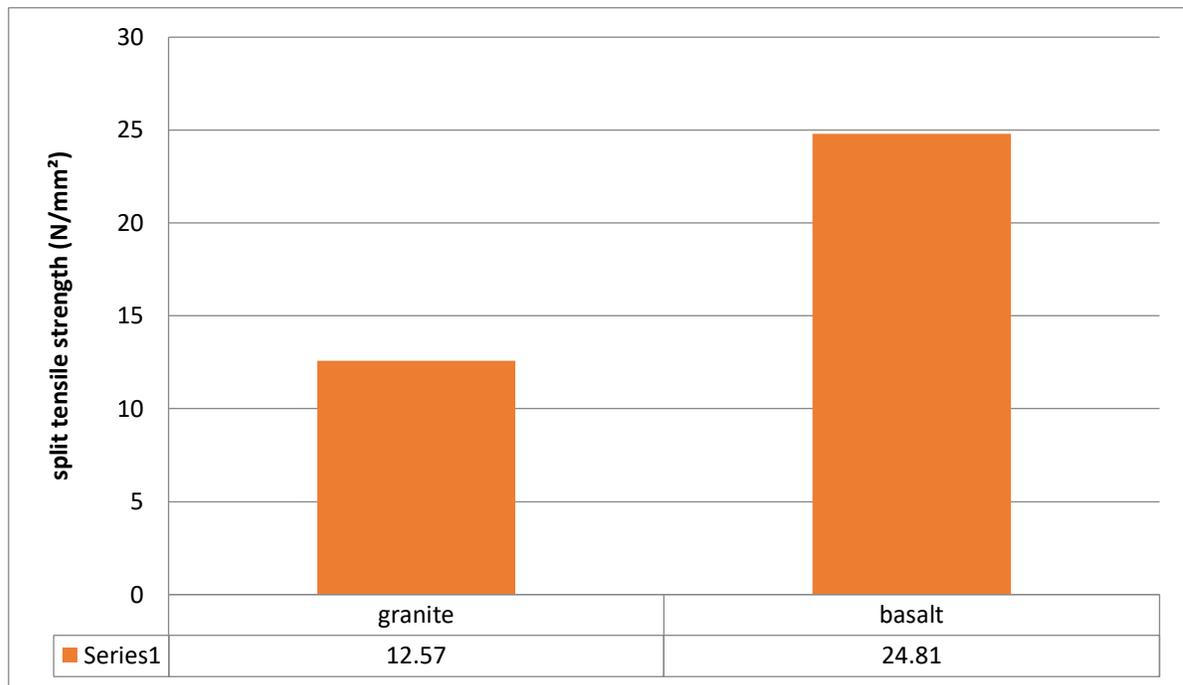


Figure 3: Comparison of granite to basalt

3.5. FLEXURAL STRENGTH TEST

The beam strength of flexural after 28days is 27.97N/mm² for granite test and the test for basalt is 31.83N/mm² respectively. The result for the Beam flexural strength test for granite after 28days is as shown in Table 8. Table 9 shows the result for the beam flexural strength test for basalt after 28days; while Fig. 3 is a comparison of the beam flexural strength test for basalt and granite. This showed that the beam flexural strength test for granite is lesser than that of bassalt, hence, flexural strength is calculated from

$$F_b = \frac{3P * L}{b * d}$$

Where: P is the applied load, L is the length of sample say 300mm, b is the breath of sample say 150mm and d is the depth of sample say 150mm.

Table 8: Beam flexural strength test of granite at 28days

28 Days Beam Flexural Strength Tests (Granite)						
S/N	M(kg)	Casting Date	Crushing Date	Applied Force(kN)	Flexural Strength (N/mm ²)	Average strength (N/mm ²)
M ₁	16.93	12/12/2018	18/12/18	68.16	27.26	27.97
M ₂	17.64	12/12/2018	18/12/18	49.63	19.85	
M ₃	16.94	12/12/2018	18/12/18	91.99	36.79	

Table 9: Beam flexural strength test (basalt)

28 Days Beam Flexural Strength Tests (Basalt)						
S/N	M(kg)	Casting Date	Crushing Date	Applied Force(kN)	Flexural Strength (N/mm ²)	Average strength (N/mm ²)
M ₁	16.93	12/12/2018	18/12/18	60.86	24.34	31.83
M ₂	17.64	12/12/2018	18/12/18	82.15	32.86	
M ₃	16.94	12/12/2018	18/12/18	95.7	38.28	

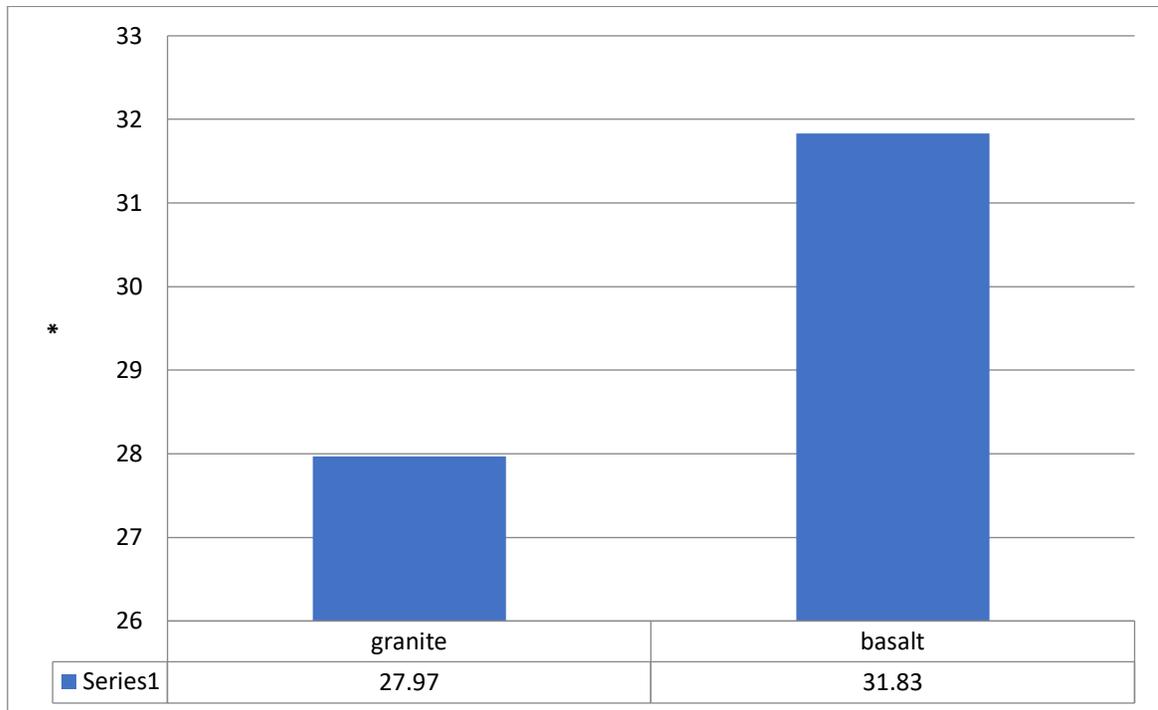


Figure 4: Flexural strength comparison of granite to basalt

4. CONCLUSION

It was concluded from the test results that compressive strength increases the basalt percentage and enhances the mix strength over the conventional granite mix. This is due to the fact that basalt is denser and more durable and less water absorbing than granite. Also higher workability is obtained for more basalt aggregate content mix which reduces the cost of labour.

SOURCES OF FUNDING

None.

CONFLICT OF INTEREST

None.

ACKNOWLEDGMENT

None.

REFERENCES

- [1] Dobiszewska M., Pichor W and Szoldra P. (2019): Effect of Basalt powder addition on properties of mortar. MATEC WEB of Conference, 262.
- [2] Kasim M., Soram M., Dia E.N and Safia M.O (2017). Effect of aggregate properties on the mechanical and absorption characteristics of geopolymer mortar. Engineering science and Technology, an international Journal, 20(16):1642-1652.
- [3] Kumar Y.Y., Vardhan C.M.V and Anitha A. (2015). Use of granite waste as partial substitute to cement in concrete. International Journal of Engineering Research and Application 5(4):25-31
- [4] Krzysztof O., Lukasz S., Damian S., Daniel W., Tomasz G., Konrad O and Ireneusz U. (2018). Effect of the morphology of coarse aggregate on the properties of self-compacting high- performance Fibre-reinforced concrete. Material, 11(8): 1372
- [5] Mehdi M., Payam S and Muhammad A (2018). The optimum oil palm shell content as coarse aggregate in concrete based on mechanical and durability properties. Advances in Material Sciences and Engineering.
- [6] IS: 456 – 2000 (Fourth Revision) Indian Standard Plain and Reinforced Concrete Code of Practice.
- [7] IS: 10262-2009 (first revision), Concrete Mix Proportioning Guidelines.
- [8] IS: 383-1970 (Second Revision), Specifications for Coarse and Fine Aggregates from Natural Resources for Concrete.
- [9] Ramakanta S., Byung J.S., Ji S.I. and Chul W.L (2012). A review of recent advances in catalytic hydrocracking of heavy residues. Journal of Industrial and Engineering Chemistry, 27: 12-24
- [10] Sobera G. and Jose V., Relationship between gas adsorption and the shrinkage and creep of recycled aggregate concrete, Cement, Concrete & Aggregates 25 (2) (2003).