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Engineering Properties of Concrete with Laterite Aggregate as Partial Coarse Aggregate Replacement

Norul Wahida Kamaruzaman, Khairunisa Muthusamy*

Faculty of Civil Engineering & Earth Resources, Universiti Malaysia Pahang, Malaysia

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ABSTRACT

The increasing utilization of natural aggregate for concrete production has created negative impact towards environment. Thus, investigation on searching for alternative material which has potential to replace the use of granite aggregate in concrete mix is very much in need. This paper presents the engineering properties of concrete containing laterite aggregate as partial coarse aggregate replacement. Granite aggregate has been replaced by 10, 20, 30, 40 and 50% with laterite aggregate. All the specimens were subjected to water curing until it is ready to be tested. Tests on compressive strength, flexural strength and modulus of elasticity have been carried out at the age of 7, 14, 28 and 60 days. The results revealed that replacement of laterite aggregate up to 30% able to produce laterite concrete exhibiting the targeted strength which is 30 MPa.

1. Introduction

Quarry activities are the most important industry in the country as it supplies aggregates for concrete production which is widely used in construction industry. The main sources of aggregates in Malaysia are granite, and limestone in varies dimension and ornamental [1]. However, quarry activities have a direct impact on the environment [2] such as imbalance ecosystem. The main impact factors may differ from place to place and depend on the level of economic and social development of the areas [3]. Demand for these natural aggregate is projected to increase in tandem with economic growth which aspires to attain developed status in year 2020 [1].

Thus, continuous usage of natural aggregate leads to the depletion of aggregate [4]. In year 2010, Mineralogy Department of Malaysia [5] revealed the aggregate production curve from 300 quarries all over Malaysia was reduced from 79,912,682 to 77,633,789 tonnes in year 2006 and 2007 whereas in year 2008 and 2009 the aggregate curve further declined from 75,883,000 to 75,000,000 [5]. This situation indicates that finding new material for concrete mix is very much in need.

Laterite aggregate was known as high weathered aggregate which is widely available in tropical region such as Malaysia, Indonesia, Thailand, Nigeria, India and Australia [6], [7], [8]. Laterite previously was used in pavement [9] and as partial aggregate replacement for concrete making [10], [11], [12], [13] outside Malaysia. However, performance of concrete produced using Malaysian laterite aggregate as partial coarse aggregate replacement is yet to be studied. Thus, this paper presents the engineering properties of concrete containing laterite aggregate as partial coarse aggregate replacement.

2. Experimental Procedure

2.1 Concrete ingredients

In this research, ordinary Portland cement and tap water confirming to BS EN 197 [14] and BS 3148 [15] was used. For fine aggregate, river sand obtained from Berkelah Quarry, Pahang was used as filler. Laterite and granite were used as coarse aggregate.

Laterite shown in Figure 1 was taken from Mempaga, which is located in the state of Pahang. Granite as illustrated in Figure 2 was supplied from Bukit Rangin, Pahang. Laterite and granite aggregates consist of 20mm maximum grading size. The physical properties and chemical elements of the used aggregates are tabulated in Table 1 and 2 respectively. All the aggregates types meeting the requirements of BS 882 [16].

Figure 1 Laterite aggregate obtained from Mempaga, Pahang.

Figure 2 Granite aggregate supplied from Bukit Rangin, Pahang.

Aggregate properties	Laterite	Granite
Specific gravity	2.54	2.69
Water absorption (%)	1.07	0.92
Moisture content (%)	0.52	0.45
Soundness (%)	98.6	99.2
Deleterious material (%)	0.52	0.42
Crushing value	30.7	28.8
Ten percent value	10.2	8.4
Impact value	28.7	26.2
Flakiness index (%)	8.5	6.3
Elongation index (%)	8.0	6.1

Table 1 The physical properties of the used coarse aggregate

2.2 Concrete mix design and testing

Concrete mix design of Grade 30 was prepared according to BS 1881 [17]. Two types of mix have been used in this study that is control mix consisting 100% granite aggregate and laterite concrete containing various percentage of laterite aggregate. The laterite aggregate replacement used is from 10% to 50% with 10% interval. The mix proportion of the mixes is tabulated in Table 2.

A total of 72 cubes 150mm, prisms 150x150x750mm and cylinders 150mm diameter with 300mm height were casted and demoulded after 24 hours. Then the specimens were subjected to water until the testing date. Compressive strength test, flexural strength test and modulus of elasticity have been conducted following the procedure outlined in BS EN 12390-3 [18], BS 1881-118 [19] and BS 1881-121 [20] respectively. Specimens have been tested at 7, 14, 28 and 60 days.

	Cement (kg/m^3)	Granite (kg/m^3)	Laterite (kg/m^3)	Sand (kg/m^3)	w/c
Control	365	1170	-	660	0.45
LC10	365	1053	117	660	0.45
LC20	365	936	234	660	0.45
LC30	365	819	351	660	0.45
LC40	365	702	468	660	0.45
LC50	365	585	585	660	0.45

Table 2 Mix proportion of concrete

3. Results and Discussions

3.1 Compressive strength

Compressive strength test was conducted on the specimens to determine the influence of laterite aggregate as partial coarse aggregate replacement towards compressive strength of concrete. Figure 3 shows the results of compressive strength of specimens at various age stages; 7, 14, 28, and 60 days. From the results, the compressive strength of LC10 is comparable with plain concrete. The results revealed that replacement of laterite aggregate up to 30% able to produce laterite concrete exhibiting the targeted strength which is 30 MPa. However, replacement beyond 30% causes significant strength reduction. Addition of too much laterite aggregate which capable possess lower density compared to granite leads lower strength.

Substituting natural aggregates, at different replacement levels, by Malaysian laterite aggregates definitely have influence on the mechanical behavior of the concrete. This is probably due to variation in the physical characteristic of laterite aggregate compared to granite in term of denseness, surface texture and shape. Previous researcher [21] has highlighted that the coarse aggregate properties have influence towards the concrete properties.

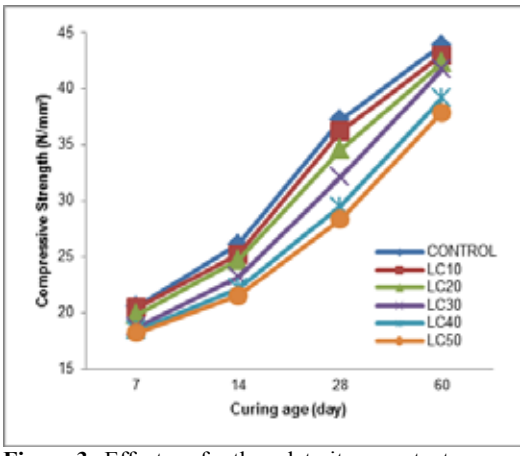

Figure 3 Effect of the laterite content on the compressive strength.

3.2 Flexural strength

Flexural strength test was conducted in order to measure the specimens' ability to resists deformation under load. The results obtained for the flexural strength performance of concrete as shown in Figure 4 demonstrates a similar trend to that observed in the compressive strength development.

For a given concrete mix and at a given age, increasing the amount of the laterite aggregate in the mixture has led to a slight decrease of the flexural strength. The flexural strength loss could be attributed to the weak bonding strength between the hydrated cement paste and the blended aggregate consists of laterite and granite which possess different characteristic.

The flexural strength was approximately 14-15% from the compressive strength value. Since flexural strength of concrete is about 10-20% of compressive strength depending on the type, size and the volume of aggregate used [22], the value obtained in the testing is within the range. Basically, the performance of concrete specimens which consist 10 to 50% of laterite aggregate exhibit good flexural strength.

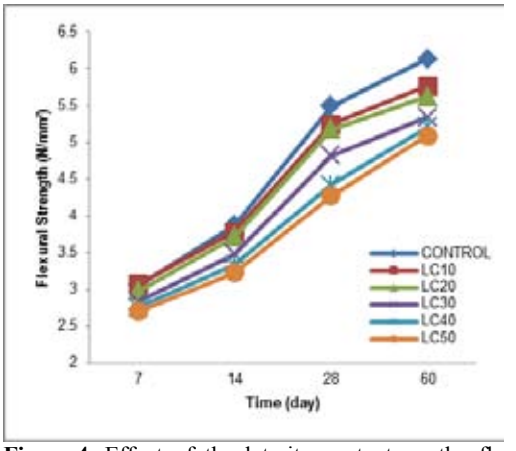

Figure 4 Effect of the laterite content on the flexural strength.

3.3 Modulus of elasticity

Modulus of elasticity test was conducted to examine the influence of laterite aggregate towards concrete elasticity in various replacement percentages. The modulus of elasticity result as shown in Figure 5 follows a similar trend to development of compressive strength. Increase in the laterite aggregate replacement cause the concrete to be less stiff [23]. The low values of the elastic modulus of concrete made with the laterite aggregate might be because of the corresponding low strength characteristics of the laterite aggregate when compared to the granite.

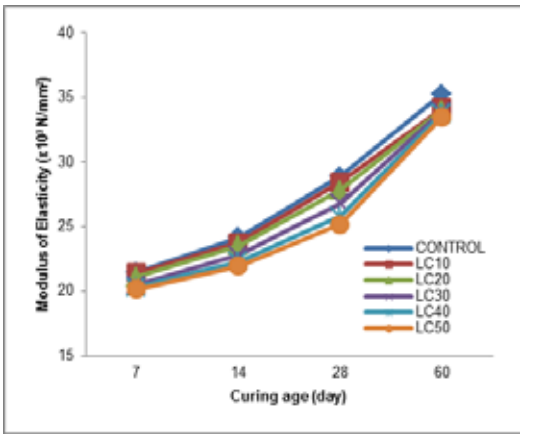

Figure 5 Effect of the laterite content on the modulus of elasticity

4. Conclusion

The use of laterite aggregate as partial coarse aggregate replacement has influence towards engineering properties of concrete. The study discovered that replacement of 10% laterite aggregate can produce laterite concrete exhibiting comparable strength with normal concrete. Replacement of laterite aggregate up to 30% was able to produce laterite concrete exhibiting the targeted strength which is 30 MPa.

Nomenclature

The terms that used in the paper are listed as follow:

LC : laterite concrete
wc : water cement ratio

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References

W. Zulasmin, (2007) "Towards a sustainable quarry industry in Malaysia- Limestone and granite quarry industry".

Yong PC, (2009), "Utilization of recycled aggregate as coarse aggregate in concrete", *Unimas E-Journal of Civil Engineering*, vol. 1, no. 1/August, 1-6.

Malaysia Mineralogy Department, (2010) "Towards sustainable construction bulletin 2010".

Shafii F, (2006) "Achieving sustainable construction" 5-6.

Malaysia Mineralogy Department, (2011), "2009 Minerals Yearbook".

Madu RM, (1980) "The performance of lateritic stones as concrete aggregates and road chippings," *Management*, vol. 1.

Raju K, (1972), "Properties of laterite aggregate concrete," *Materiaux et Construction*, vol. 307, no. 1, 307-314

Ryduchowska D.T, (1986), "The effect of aggregate variation on the compressive strength," *Concrete*, vol. 16, 135-142.

Koranteng-yorke B, (2010), "Structural integrity of laterite soils for asphaltic concrete", University of Birmingham

Ata O, (1991), "Influence of method and duration of curing and of mix proportions on strength of concrete containing laterite fine aggregate," *Concrete*, vol. 26, no. 4, 453-458.

Adepegba D, (1975), "A comparative study of normal concrete with concrete which contained laterite instead of sand," *Building Science*, vol. 10, no. 2, 135-141.

Ikponmwosa E and Salau M.A, (2010), "Effect of heat on laterised concrete," *Journal of Science and Technology,* vol. 4, no. 01, 33-42.

Udoeyo F.F, Iron U.H, and Odim O.O, (2006), "Strength performance of laterized concrete," *Construction and Building Materials*, vol. 20, no. 10, 1057-1062.

BS EN 197-1:2011 Cement. Composition, Specifications and Conformity Criteria for Common Cements.

BS 3148:1980 Water for making concrete.

BS 882 Specification for aggregates from natural sources for concrete.

BS 1881-108 Method for making test cubes from fresh concrete.

BS EN 12390-3:2009 Method for determination compressive strength of test specimens.

BS 1881-118:1983 Method for determination of flexural strength.

BS 1881-121:1983 Method for determination of static modulus of elasticity in compression.

Park F, (1998), "Aggregate toughness / abrasion resistance and durability / soundness tests related to asphalt concrete performance", *Test*, no. 98.

CIP 16:2000 Flexural Strength Concrete, *National Ready Mix Concrete Association*.

Kumar P.S, (2006), "A study on high performance concrete using sandstone aggregates," Universiti Malaysia Sabah.