INFLUENCE OF AGGREGATE REPLACEMENT UPON THE CHARACTERISTIC STRENGTH OF CONCRETE CONTAINING MALAYSIAN LATERITE

Norbaizurah Rahman[1], Norul Wahida Kamaruzaman[2] and Khairunisa Muthusamy[3]
[1,3] Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang
[2] Faculty of Engineering, Science & Technology, Infrastructure University Kuala Lumpur

ABSTRACT
Strength development of concrete indicates the significance of curing temperature in the activation of hydration process. This study addresses the effect of aggregate replacement upon the characteristic strength of concrete containing Malaysian laterite aggregate (MLA). In this study, MLA was utilized to partially replace of coarse aggregate at 0%, 10%, 20%, 30%, 40% and 50% (by weight of coarse aggregate) and cured at three different curing regime (water curing, natural curing and air curing) until the testing day. The results show that up to 30% in concrete mix, showed that the concrete is able to attain the targeted strength which is 30 MPa.

Keywords:
Laterite Aggregate, Partial Coarse Aggregate Replacement, Laterized Concrete, Alternative Concrete Mix, Concrete Strength

INTRODUCTION

Concrete is a composite material consists of cement, water, fine and coarse aggregates. Generally, about 60–75% of the volume concrete occupies by the fine and coarse aggregates form the skeleton of the concrete. The properties and types of aggregate would affect the performance and economical value of the concrete (Rawaz Kurda, 2018). The upsurge in demand for concrete every year has become a massive pressure on supply of constituent materials of concrete to satisfy the demands (Natt Makul, 2020). Utilization natural resources such as river sand and granite as aggregates in concrete have led to deterioration of ecosystems. Therefore, the current research focus is on alternate materials for fine and coarse aggregates.

Laterite has been applied as an aggregate in construction field at early 1800s in South India (Basavana Gowda *et. al.*, 2018). The term Laterite was introducing by Francis Buchanan in 1807 during a surveillance trip through the western piece of peninsular India. It was derived from the Latin word 'later' to illustrate a ferruginous, vesicular, unstratified and porous material with yellow ochre (Zubair Saing et. al., 2018). Large deposits of laterite in Malacca, Johore, Negeri Sembilan, Kedah, Pahang, Kelantan and Selangor which have not been completely utilized even though it is a popular building material in Malaysia (Mohammad Razip Selamat et. al., 2017). Therefore, to add value toward this waste by using it as a partial replacement of aggregate and it's achieve towards sustainability.

The main focus of this study to investigated the properties of laterite aggregate according to BS EN 12620 (2008) and the effect of curing regimes on workability and characteristic strength of concrete (compressive strength, flexural strength and modulus of elasticity) containing Malaysian laterite aggregate (MLA) as partially coarse aggregate replacement.

METHODOLOGY

Materials

In this study, the laterite aggregate was taken from Kampung Jawa, Damansara, Bukit Setongkol and Mempaga while granite was obtained from Bukit Rangin. All aggregate that been used in this study were obtained from Kuantan, Pahang. The coarse aggregate used is in the size range from 5mm to 20mm with the accordance to the standard (BS EN 12620, 2008).

Experimental Programme

The 20 mm laterite aggregate particles which were in saturated surface-dry condition were used as the alternative coarse aggregate. Then, the physical and mechanical characteristic of MLA was determined to choose the best laterite aggregate and can be used further as a partial replacement of coarse aggregates. Approximately 216 concrete samples were prepared by using three types of mould's dimension. For compressive strength, cube size with 150 mm dimension was use whereas for flexural strength, the size for the beam was 150 mm x 150 mm x 750 mm was adopted. For modulus of elasticity experiment, the dimension of the specimen's cylinder mould is 300 mm height with 150 mm diameter was used. To determine the compressive strength, flexural strength and modulus of elasticity of concrete specimens towards the replacement of coarse aggregate with laterite aggregate, the tests were conducted with accordance to BS EN 12390-3 (2009); BS EN 12390-5 (2009) and BS 1881-121 (1983) respectively. The mix proportion was designed by using DoE mix design with 0%, 10%, 20%, 30%, 40% and 50% replacement upon coarse aggregate weight. Complete mixture compositions are described in Table 1.

Table 1: Proportion of Concrete

	Cement(kg/m^3)	Granite(kg/m^3)	Laterite(kg/m^3)	Sand(kg/m^3)	Water (kg/m^3)
Control	365	1170	-	660	164
LC10	365	1053	117	660	164
LC20	365	936	936	660	164
LC30	365	819	819	660	164
LC40	365	702	702	660	164
LC50	365	585	585	660	164

RESULT AND DISCUSSION

Workability

Figure 1 presents the workability result of inclusion MLA in OPC concrete. From the result, higher replacement percentage of MLA, show lower workability of fresh concrete. However, it is still within the range of design slump; 30-60mm. This is due to the water absorption mechanism of MLA which reduces the water content in fresh concrete. The MLA properties has slightly higher of porosity might contributing to the higher absorption of water or mitigation inside the particle arrangement (Samuel et. al., 2019). That is why, the MLA tends to absorb more water as compared to granite aggregates. Thus, higher replacement percentage of MLA in concrete mix would exhibit lower slump value trend.

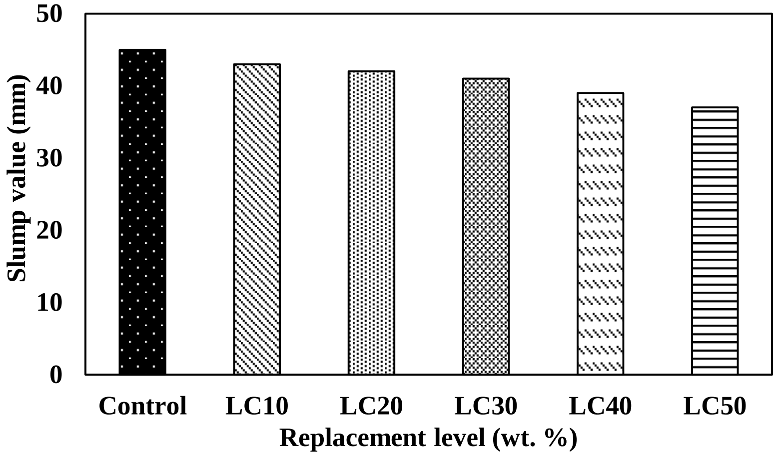

Figure 1: Workability Result Inclusion of Malaysia Laterite Aggregate in Concrete

Characteristic Strength of Concrete

Compressive Strength, Flexural Strength and Modulus of Elasticity

Figure 2 illustrates the compressive strength on 7, 14, 28 and 60 days of concrete age for 0%, 10%, 20%, 30%, 40% and 50% MLA replacement. It is presented that the compressive strengths of concrete samples were affected directly by the aggregate replacement percentages. It can be seen also from the graphs that the compressive strengths of concrete samples were similar to the control sample. However, the strength development is limited to certain replacement percentage which is up until to 30% only. It is evidence that by replacing 30% of MLA, it is still meeting the desired design strength at 28 days which is 30 MPa. The strength deterioration might occur due to the absorptive characteristic of MLA (Richard Ohene Asiedu, 2017) which tends to absorbs more water in the concrete mix proportion and led to structural disintegration. The importance of complete hydration process was highlighted by Vytautas Jocius (2016) that leads to the hardening of concrete specimens to achieve designed concrete strength (Wenhui Zhao et. al., 2020; Yan Feng et. al., 2019; El-Gamal, 2014).

The pattern of the flexural test results could be observed is similar to the compressive strength result, as presented in Figure 3. The flexural strength of the control specimen is higher than MLA concrete specimen. It was also observed that the flexural strengths decrease with increment inclusion of MLA in concrete and continued to increase with age of curing. Under the flexure loading, the cracks were initiated in the interfacial zone at low stresses and extend into the mortar matrix at high stresses and the resistant to cracks results from the cement paste only (Mohd, 2014). Therefore, it shows that the aggregates might influence the strength and flexibility of concrete performances (Sneka, 2018) as aggregates contain approximately 70 to 80 % of constituents of concrete.

Figure 4 shows the result of modulus of elasticity inclusion of MLA in concrete in different percentage of replacement. The modulus of elasticity of concrete (Ec) is associated with structural deformations that must be kept within limits to prevent excessive deformations that cause cracks and other pathologies in concrete structures especially in alternative concrete mixtures (Antonio Carlos, 2017). Based on the observation, the modulus of elasticity is increases as the concrete age increases. In addition, the modulus of elasticity of control concrete is significantly enhanced than the MLA concrete due to the properties of aggregate. Based on the experimental results, the modulus of elasticity can be increased by changing the mineralogical source of the coarse aggregate.

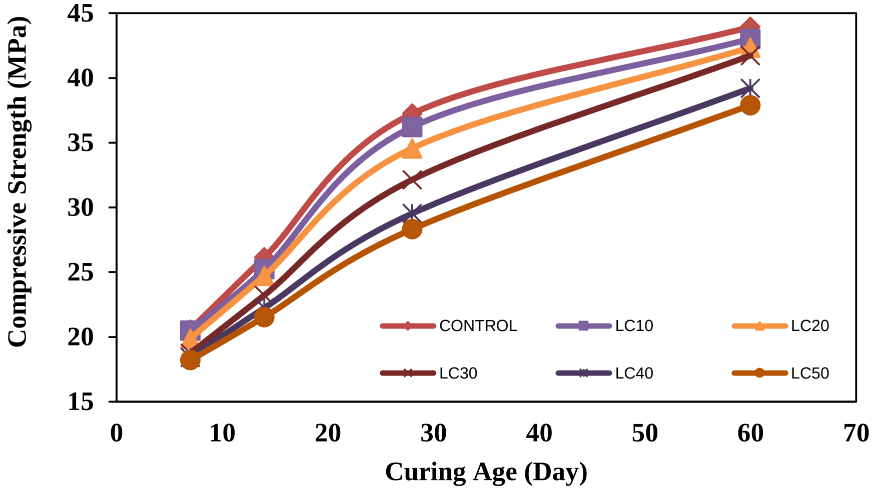

Figure 2: Compressive Strength of Concrete

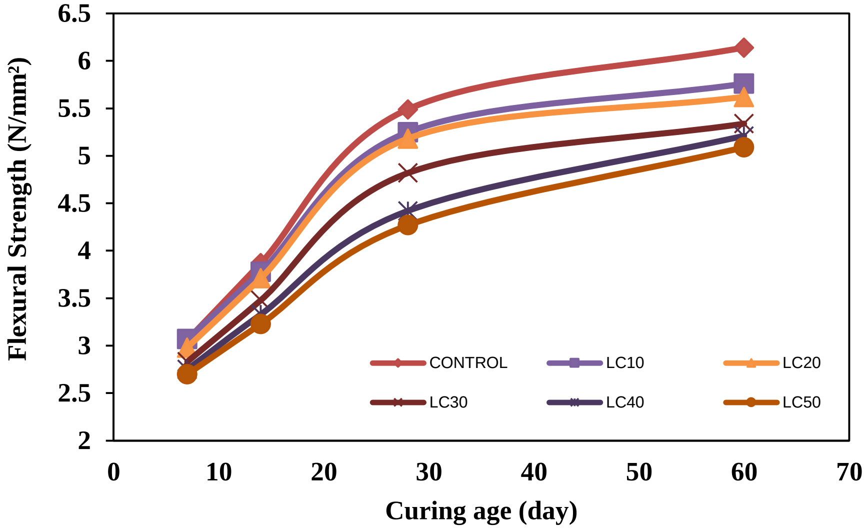

Figure 3: Flexural Strength of Concrete

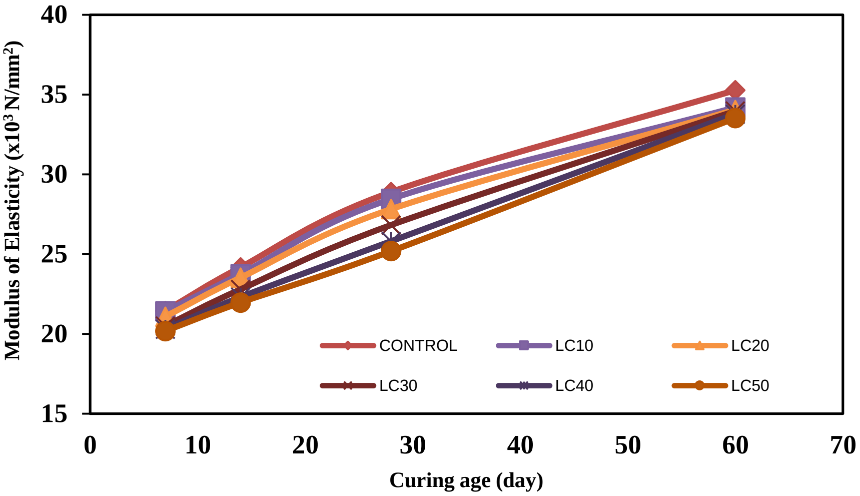

Figure 4: Modulus of Elasticity of Concrete

CONCLUSION

Based on the results on compressive strength, flexural strength and modulus of elasticity of concrete containing laterite aggregate as a partial replacement, it can be concluded that Malaysia Laterite Aggregates (MLA) can be used as partial replacement of coarse aggregate up to 30% replacement as it able to achieve targeted strength at 28 days of concrete age.

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