INFLUENCE OF ELEVATED TEMPERATURE ON PHYSICAL PROPERTIES AND COMPRESSIVE STRENGTH OF CONCRETE CONTAINING LATERITE AS PARTIAL FINE AGGREGATE REPLACEMENT

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ABSTRACT

Negative impact of sand mining includes erosion, loss of biodiversity, and soil contamination by chemicals from mining processes also one reason why laterite is being used as replacement. The impact of temperature rise on mass loss, compressive strength, and physical appearance on performance of concrete containing various percentage of laterite replacement has been investigated. Depletion of fine sand aggregate has led to production of concrete containing laterite as partial fine aggregate replacement. Laterite concrete can be used for structures such as buildings and also special structures for special purposes. The behaviour of laterite concrete upon fire outbreak is important to be known. In this study, the physical properties and compressive strength of concrete containing laterite aggregate as partial fine aggregate replacement has been carried out. Two types of mix have been used in this experimental work that is plain concrete (control specimen) and laterite concrete of various percentage of laterite aggregate. All the specimen were water cured for 28 day before testing. The specimens were exposed to a range of temperature beginning from 28°C until 800°C. Water cooling method was used to cool down the specimen after exposed to subjected temperature. It was found that the mass loss and compressive strength of the concrete decreased as the temperature increase. From the results, the strength of laterite concrete with 20% replacement of fine aggregate is better than plain concrete.

ABSTRAK

Kesan negatif perlombongan pasir termasuk hakisan, kehilangan biodiversiti dan pencemaran tanah oleh bahan kimia daripada proses perlombongan juga salah satu sebab mengapa laterit digunakan sebagai gantian. Kesan kenaikan suhu pada kehilangan jisim, kekuatan mampatan, dan penampilan fizikal ke atas prestasi konkrit yang mengandungi pelbagai peratusan penggantian laterit telah diuji. Susutan pasir agregat halus telah membawa kepada pengeluaran konkrit yang mengandungi laterit sebagai sebahagian penggantian agregat halus. Konkrit laterit boleh digunakan untuk struktur seperti bangunan dan struktur khas untuk tujuan khas. Sifat konkrit laterit apabila terdedah kepada suhu tinggi penting untuk diketahui. Dalam kajian ini, sifat fizikal dan kekuatan konkrit laterit yang mengandungi batu laterit sebagai pengganti agregat halus separa di dalam konkrit telah dijalankan. Dua jenis campuran telah digunakan dalam kerja-kerja eksperimen ini iaitu konkrit biasa (spesimen kawalan) dan konkrit laterit pelbagai peratusan agregat laterit. Semua spesimen diawet dalam air selama 28 hari sebelum diuji. Spesimen telah terdedah kepada pelbagai suhu bermula dari 28°C hingga 800°C. Kaedah penyejukan air digunakan untuk menyejukkan spesimen selepas terdedah kepada suhu tertakluk. Didapati bahawa kehilangan jisim dan kekuatan mampatan konkrit menurun apabila suhu meningkat. Daripada keputusan, kekuatan konkrit laterit dengan penggantian 20% daripada agregat halus adalah lebih baik daripada konkrit biasa.

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LIST OF SYMBOLS

%	Percent
MPa	Megapascal
°C	Degree celcius
mm	Millimetre
f_c	Compressive strength in MPa (N/mm^2)
F	Maximum load at failure
A_c	Cross-sectional area of the specimen
N/mm^2	Newton per millimetre square

LIST OF ABBREVIATION

OPC	Ordinary Portland cement
ASTM	American Society for Testing and Materials
BS	British Standard
DOE	Department of Environmental
PC	Plain concrete
LC	Laterite concrete
LC20	Laterite concrete with 20% replacement
LC40	Laterite concrete with 40% replacement
LC60	Laterite concrete with 60% replacement
LC80	Laterite concrete with 80% replacement

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Concrete is a material that widely used in the construction as a primary materials for buildings and also special structures for special purposes, such as nuclear reactors or chimneys. It is possibly exposed to an unexpected fire of extreme temperatures. As the concrete had been used for a special purpose, there is increasing of risk of exposing it to a high temperatures. The physical properties such as colour and mechanical properties such as strength and performance must have some changes. The chemical composition of the concrete also change considerably. The strength of concrete reduce with increasing of temperature and rate of strength loss is influenced by compressive strength of the concrete.

Generally, concrete may provides the best resistance properties towards fire of any building materials. This good resistance is due to materials of concrete used which when they react with fire, the materials will has high heat capacity, low thermal conductivity, and also has low strength degradation with temperature. This low rate of heat transfer and loss of strength will enables the concrete to act as an effective fire resistance to protect itself from damage of fire and also between adjacent spaces. When a high temperature is subjected to a concrete structure, for example a building on fire, it is necessary and required that the people inside the building can leave safely before the structure of the building collapse.

1.2 PROBLEM STATEMENT

Depletion of natural fine aggregate has lead to production of concrete containing laterite sand as partial fine aggregate replacement. Laterite sand can be used as partial fine aggregate replacement in concrete. However, the effect of using laterite aggregate as partial fine aggregate replacement towards fire resistance is unknown. In this project, laterite rock is used as a partial fine aggregate replacement in concrete to see what will happen on physical and compressive strength properties when the concrete is subjected to an elevated temperature.

1.3 OBJECTIVES

The objectives of this project is :

i. To study the effect of elevated temperature on physical properties of concrete containing laterite rock as partial fine aggregate replacement.

ii. To identify the compressive strength properties of the concrete containing laterite rock as partial fine aggregate replacement.

1.4 SCOPE OF STUDY

To reach the objectives of this project, several analysis and testing were carried out in the laboratory to get the results. Variables of this project are temperatures and contents of laterite rocks used as partial fine aggregate. Two types of mix have been used that is plain concrete and laterite concrete of various percentage of laterite aggregate. The samples size about 150 x 150 x 150 mm were heated in the oven with different elevated temperatures from 28°C to 800°C for one hour. The changes in properties of samples for every temparatures were identify. Water cooling method were used to cool down the specimen after heating in the furnace.

1.5 SIGNIFICANCE OF RESEARCH

Concrete have a high probability to expose to an extreme or very elevated temperatures. The properties and behavior or the concrete at elevated temperatures also important to predict the safety of a building in particular conditions. The performance of laterite concrete elements used in a building such as columns, beams, and slabs that subjected to high temperatures would be known. This is why it is important to understand the effect of elevated temperatures on physical and compressive strength properties of the concrete containing laterite aggregate.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The use of laterite as partial fine aggregate replacement in concrete production is because of the decreasing in the amount of natural sand. The effect of heat by elevated temperature on concrete is influenced by a few causes such as materials used and thermal properties. There are various properties of concrete that can be discussed. At elevated temperature, the compressive strength of concrete also depends on water-cement ratio, type and size of aggregate, admixtures used, and also curing method.

Laterite concrete is one of the fine aggregate content that has been substituted whether partially or wholly with laterite soil it natural form (Salau , 2003). Concrete commonly contributes the best fire resistance properties towards any building material (Rout, 2010). When the concretes mixtures associate chemically, it produces a form of material that is basically inert and contain low thermal conductivity, higher heat capacity, and low strength deterioration with the temperature. The slower rate transfer of heat and loss of strength will allow the concrete to perform as an efficient fire shield to protect itself from damage of fire (Venkatesh, 2014).

2.2 LATERITE ROCK

Laterite soils formed in wet and hot tropical areas and the climate is humid or subtropical. It was found as the higher weathered soils in classification system. Laterite soil has been available and be one of main building materials in Nigeria for a long time ago. Problems in the fundamental economic of building materials because of the high cost have urge the need to seek for another option (Osunade, 1984). Laterite rock are the product of very comprehensive and long lasting tropical rock which build up by the high rainfall and elevated temperatures (Schellmann, 1991). Figure 2.1 illustrate the laterite soils which can be found in tropical area.

Figure 2.1 : Laterite soil

2.2.1 Properties of laterite rock

Lateritic soils features that very significant are of their colour, contain high clay (claylike). It also have low exchange capacity of cation (Ko, 2014). The colour of the laterite soils is depends on the amount of Al and Fe exists. It was in pink colour to grey/brown then to red colour with massive, pisolitic and clayey (Randive, 2011). Laterite contains very wide of various proportions minerals. The impact of aggregate strength also been found. Higher iron-oxide contents will produce higher mechanical strength, durability and specific gravity. There were also no absoption occur as it has a

negative correlation with strength (Johnson, 1972). Insufficient in the amount of Nitrogen and very low in lime content are also the characteristics of laterite soils (Raychaudhuri, 1980). Iron minerals presence and its solid arrangement strength does affect the strength and hardness of laterite soils (Kasthurba, 2008). Table 2.1 shows the physical properties of laterite rock and granite and Table 2.2 shows percentage of elements that present in laterite soils.

Table 2.1 : Properties of laterite rock and granite

Physical Properties	**Laterite**	**Granite**
Water absorption	1.34	0.92
Flakiness index	9.2	6.3
Elongation index	9.6	6.1
Specific gravity	2.53	2.69
Aggregate crushing value	33.9	28.8
Ten percent fines	18.5	8.4
Aggregate impact value	32.9	26.2
Moisture content	0.64	0.45

Source : Kamaruzaman et al. (2012)

Table 2.2 : Major element analysis of laterites

Elements	**Percentage (%)**
Silicone dioxide (SiO_2)	1.2
Titanium dioxide (TiO_2)	2.96
Aluminium oxide (Al_2O_3)	37.21
Manganese dioxide (MnO)	0.05
Manganese oxide (MgO)	0.29
Calcium oxide (CaO)	0.91
Sodium oxide (Na_2O)	2.69
Potassium oxide (K_2O)	0.03
Phosphorus pentoxide (P_2O_5)	1.01
Sulphur (S)	0.59
Chromium (III) oxide (Cr_2O_3)	0.06
Nickel (II) oxide (NiO)	0.02
Barium oxide (BaO)	0.03
Loss on ignition (LOI)	31.39
Total	99.99

Source : Randive (2011)

2.2.2 Availibility in the world

Laterite soils are available in all over the world where the conditions are tropical region and humid. It also available when have an intense chemical weathering and leaching of soluble minerals sources. In tropical area, they were found almost everywhere (Badmus, 2010). The countries that have a lot of laterites are our country, Malaysia, Indonesia, India, Burma, Australia, Africa and some parts of South America (Ramakrishnan, 1972). It was found that the composition of mineralogist at the selected of west Malaysian area laterite soils was based on the hypothesis of lateritic soil formation (West, 1970).

Laterite was available all over the world as it was found in the countries with climatic conditions that has tropical region in high temperatures and also high in rainfall. (Dumbleton, 1970). Laterite was found in Nigeria in a large amount all over across country as it find its uses in building, house construction and also road construction (Aleva, 1994). Lateritic soils were originally the products from the tropical weathering that normally found in region where natural drainage in available (Amu, 2011). Figure 2.2 shows the maps where laterite soils can be found in the world.

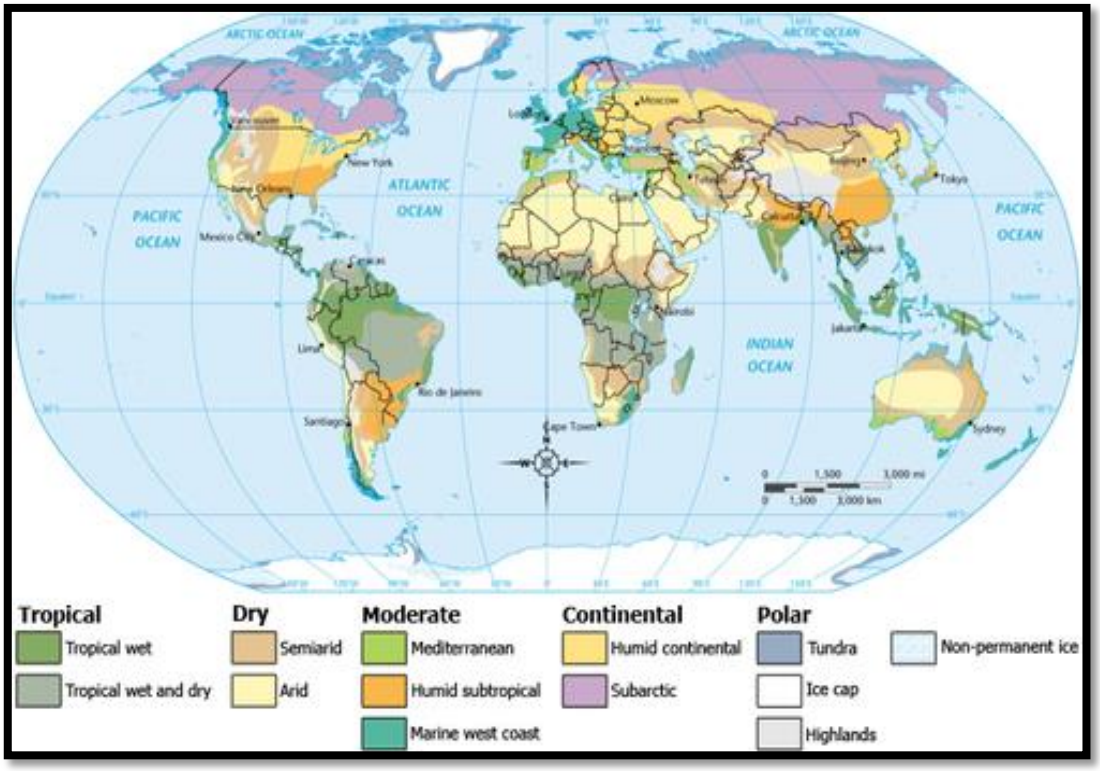

Figure 2.2 : Maps of Lateritic Soil

Source : http://www.mapsofworld.com/world-maps/world-climate-map.html

2.2.3 Use of laterite in construction industry

The demand for local manufactured building materials were exaggerated in many countries because of inequality between the demands for housing and also expensive rate of building materials with the reduction of traditional building materials. In Nigeria town area, the most common material used to build the wall are the conventional sandcrete blocks and fired clay bricks. Fired clay bricks production is very labour demanding and the process is usually accomplished by using specific trees that lead to deforestation (Joel, 2008)

Due to environmental problem, the clay bricks only can be produced where proper and convenient clay soil deposite is available (Joel, 2008). Laterite used as cement-enhanced bricks also get the chances and potential to produces a low cost housing for economic growth in Nigeria (Gasu, 2012). Different sites in Kano produces

a great laterite bricks when the laterite was sustained with 3% to 7% of cement content (Holmes, 1983). Figure 2.3 and 2.4 below shows the bricks that was made by laterite soils.

Figure 2.3 : Laterite bricks

Source : http://krownaxies.tradeindia.com/customized-laterite-bricks-1665938.html

Figure 2.4 : Laterite bricks

Source : http://www.chinadaily.com.cn/photo/2011-04/14/content_12328689.htm

Laterite rocks can be used in production of concrete. The size of laterite rocks that has been reduce to a smaller size to be a fine aggregate has finally used as partial fine aggregate replacement in concrete (Salau, 1998). The laterite presence in laterized concrete structure has improves its condition and post-cracking availibility (Salau, 1990). A study conducted to investigate the effect of laterite as partial coarse aggregate replacement was carried out.

From the assessment on Malaysian laterite aggregate, 10% replacement of laterite aggregate in concrete, the achievement of the concrete strength result is satisfactory enough. Target strength can be reached up to 30% replacement of laterite aggregates (Kamaruzaman, 2012). 20% of the cement mixture of concrete tiles and same amount of laterite soil and granite with unfired process is used to gain optimum grade and properties. Cement that enhanced laterite soils are likely choosed for base course of construction (Millogo, 2008). The presence of laterite in concrete structures improves the serviceability conditions and cracking capability (Salau, 1990). Figure 2.5 illustrate the wall that was made by using laterite bricks.

Figure 2.5 : Laterite concrete wall

Source : http://www.dreamstime.com/royalty-free-stock-image-laterite-brick-wall-tilted-out-close-up-image20369056

Figure 2.6 : Laterite coarse aggregates

Figure 2.6 above shows the laterite coarse aggregate that can be found tropical area. Lateritic aggregates are suitable and very good material for the used in road chipping and aggregates for concrete (Madu, 1980). The mean of tolerable fine aggregates replacement with lateritic soil is abouy 20% was pointed out by Joshua and Lawal, 2011. Laterites are typical materials used in tropical and equatorial countries and have been used for a long time in construction of road as fill materials and aggregate for base and layer of foundation (Khalil, 2014). Other than that, financing problem are some meaningful in developement of road in developing countries was drown because of high cost in getting the materials and the construction. More than three quarters of total road in many tropical countries consist of earth or unimproved roads (Madu, 1973). The construction of road by using laterite aggregate as materials for the road base was illustrated in Figure 2.7 below.

Figure 2.7 : Lateritic road

Source : http://www.khmertimeskh.com/news/8847/road-upgrading-works-as-social partnership/

2.3 EFFECT OF ELEVATED TEMPERATURE ON NORMAL CONCRETE

Normal concrete is a composite material with contents like sand, aggregate, cement and water had reached compressive strength of 10 to 40 Mpa after 7 days. Normal concrete usually achieve 80% of its strength after 28 days. The effect of temperature towads a concrete structure (beam) that subjected to fire was studied (Gupta, 2012).

2.3.1 Compressive strength

Several beams was tested towards temperature of 650°C for different time of periods. Cracking loads, crack propogation and also ultimate load had been recorded for every beam (El-Hawary, 1996). After exposed to an elevated temperature of about 1200°C, the compressive strength and tensile strength was decreased a lot (Chan, 1999). The degree of spalling in concrete will increase the period of concrete to expose to fire (Abdelalim, 2009). When using the ordinary portland cement (OPC), sand, crushed