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Assessment of the Severity of CO_2 Emission from Anthill Soils Used as Replacement for Shale in Cement Manufacture

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Abstract

This paper assessed the replacement of shale in the production of cement with anthill soil. It also looked into the severity of carbon (IV) oxide (CO_2) emission of the anthill soil during the production of the cement. This was compared with that emitted when shale alone is used. Various tests were carried out on the anthill soil, shale and limestone. The test results were analysed and it was discovered that the emission of carbon (II) oxide gas using anthill soil is benign when compared to that of shale.

Keywords: cement, anthill soil, CO_2

Introduction

Cement is defined as a binder. It sets and hardens independently and can bind other materials together (Watson 1978). It is one of the most important materials used for construction all over the world. It is usually mixed with other inert materials such as sand, gravel, crushed stones etc. to produce concrete. It is produced from limestone and shale (clay). Due to the importance of cement as a construction material, and the geographic abundance of the main raw material (limestone), cement is produced in virtually all countries (Hendricks et al 2003).

During the production of cement a lot of airborne pollution in the form of dust, gases, noise etc. take place. During the process, CO_2 (green house gas) is emitted into the atmosphere. It has been established that 7 - 10% of global CO_2 emissions originate from cement production and that 1 tonne of cement produces 0.55 tonne of chemical CO_2 in a reaction that takes place at 14500^0C (BFF Autumn 2005).

Cement industry is said to be the second largest CO_2 emitting industry, it produces about 7-10% of global man-made CO_2 emissions. 50% of the total CO_2 emitted during production of cement are from chemical reaction (BFF Autumn 2005).

Cement as it is widely known is an important component in the production of concrete. Cement mainly consists of shale (aluminum silicate) and limestone (calcium carbonate). Despite its importance, cement usage portraits danger for the environment.

CO_2 emission is dangerous to the environment and therefore cannot be ignored. It has devastating effect on mankind. CO_2 emission thickens the atmospheric layer, thereby resulting in less infrared rays getting escaped into space (). It traps the heat from the sun within the earth's atmosphere, causing an increase in the earth's temperature. This has become so insignificant within the last thirteen (13) years (Hansen 2007) despite the fact that the increment in temperature over a period of one hundred (100) years is 1.3 degrees Fahrenheit or slightly less than one degree Celsius (IPCC 2007). There has always been a climate change in the past but they are natural, e.g. change was recorded in the sun's energy and the changing position of continental plates. In the two cases mentioned above, there was rise in temperature but mankind got adapted to the changes because it was over a long period of time (>500 years) (Hansen 2007). But, the concern of the current rise in temperature is its suddenness and the short span over which it is occurring (about 30 years) and this is due to deforestation, burning of fossil fuel and other manufacturing activities e.g. cement manufacturing (USNAS, 2008). All these activities lead to concentration of green house gases.

The effect of rise in temperature is known throughout the world as global warming which was first coined by Wally Broekker in a paper he delivered in August 8, 1975. The effect of this phenomenon has been devastating in occurrence of flood almost everywhere in the world as a result of rise in sea level, rare weather conditions and desert encroachment to mention a few. The awesome weather and tenable rise in sea level has led to the 1999 sudden forty-five seconds earthquake in Izmit, Turkey that left 17000 dead in its wake (USNAS 2008). The Atlantic hurricane season equally came to focus; in 1997 the Pacific typhoon ran all year round contrary to its normal occurrence between June and August (USNAS 2008).

All these are attestation to the rise in temperature or global warming of which cement manufacturing is an integral part researchers are looking for alternatives to shale in the production of cement in order to reduce the quantity of CO_2 emission albeit reduced concentration of greenhouse gases.

Hence, the cement industry has contributed in no small measure to the global warming that is experienced all over the world due to the emission of CO_2. This is the reason why researchers are looking for alternatives to shale in the production of cement in order to reduce the quantity of CO_2 emission during the manufacture of cement.

Methodology

This study was conducted in the Soil Mechanics laboratory of the Civil Engineering Department of Federal Polytechnic, Ilaro, Nigeria, between January and July 2011.

For the purpose of this work, samples of anthill soils and components used in the production of cement were collected and subjected to various tests. The cement components; Aluminum silicate (shale) and Calcium carbonate (limestone) were collected from Ewekoro Cement Factory in Ogun State, Nigeria, while the anthill soil samples were collected from four locations; Ibese, Papalanto, Egbado College and Federal Polytechnic Ilaro West Campus, all in Ogun State, Nigeria.

The soil samples were air dried and then the following tests were carried out on them; sieve analysis, Atterberg limit test and silt test.

The two experiments carried out on the cement components (shale and limestone) were Gravimetric analysis and carbon (II) oxide tests.

Sieve analysis was used to assess the particle size distribution of the soil while the Atterberg test was used to obtain information about the soil to estimate its strength and settlement characteristics and classify it as cohesive soil by determining the liquid limit (LL) and plastic limit (PL). The silt test was used to determine the amount of silt in each of the anthill soil samples.

The Gravimetric analysis was done to determine the amount of weight loss during the heating of anthill soil samples separately, and cement components i.e. shale and limestone together to form cement. While the CO_2 test was also carried out on all the samples to measure the CO_2 contents in each of the samples.

Analyses Of Results

The results obtained from various tests were as shown in Table I and analysed as follows:

In the Sieve analyses of the various samples of anthill soil, it was observed that the percentages of clay and silt contents in each of them vary. The clay percentages of 35.45%, 47.53%, 26.0% and 57.5% were recorded for Federal Poly. Ilaro, Ibese Town, Egbado College and Papalanto Road locations respectively.

Also, the coefficient of uniformity (CU) and coefficient of curvature(CC) were also calculated for all the soil samples. The CC values were greater than 1 in Federal Polytechnic and Papalanto Road samples, while they are less than 1 in the other two samples.

TEST	FEDERAL POLY, ILARO	IBESE TOWN	EGBADO COLLEGE, ILARO	PAPALANTO ROAD
Coefficient of Uniformity (CU)	1.84	2.93	2.61	2.67
Coefficient of Curvature(CC)	1.27	0.95	0.93	1.11

Classification Clay content	WG 354.5g (35.5%)	SP 475g (47.5%)	SP 260g (26%	WG 575g (57.5)
Liquid Limit (LL)	27.0	39.0	29.0	34.7
Plastic limit (PL)	18.13	33.7	20.8	32.7
Plasticity Index	8.87	5.33	8.19	2.05

Table I: Showing the Results of various Tests

From the classification test result, it was deduced that the soil samples taken from Federal Poly. Ilaro and Papalanto were well graded while the remaining two samples were not.

From the plasticity tests, the Federal Polytechnic Ilaro sample has a liquid limit (LL) of 27%. This is less than the recommended 35% (Craig 1987), therefore the soil is of low plasticity. Ibese soil sample had a liquid limit of 39% which is higher than the recommended value of 35%. Hence, it is classified as a moderate plastic soil. Egbado College Sample had a liquid limit (LL) value of 29% which is less than 35%, hence it is classified that it is of low plasticity.

Papalanto Road sample had a liquid limit of 34.7% hence; it is classified as soil of low plasticity because the value is still less than the recommended value of 35%.

Gravimetric analysis was performed on cement components (shale and limestone). Later the test was performed on the components by substituting shale with the various soil samples.

	CO_2 EMISSION			
	SILTED CLAY		**DE-SILTED CLAY**	
SAMPLES	**TIME TO TURN MILKY**	**TIME TO TURN COLOURLESS**	**TIME TO TURN MILKY**	**TIME TO TURN COLOURLESS**
Federal Poly, ilaro	1min. 15secs.	Unable	1 min. 20secs.	Unable
Ibese town	1min. 30secs	4min. 45secs	1min. 28secs	4min. 40secs
Egbado College, Ilaro	1min. 25secs	4min. 20secs	1min. 33secs	4min. 52secs
Papalanto Road	0min. 57secs	4min. 05secs	1min. 05secs	4min. 26secs
Shale + limestone	1min. 20secs	4min. 30secs	-	-

Table II: Showing result of CO2 emission by each sample

Conclusion

From Table II, it was observed that carbon dioxide emission from locally sourced anthill soils is benign. This is so if the material is well graded i.e. if the soil has coefficient of curvature (CC) that is greater than 1. This is attested to by taking into account the time it took the milky lime

water to turn colourless. In fact, in a particular situation, it did not even turn to colourless suggesting low CO_2 emission which is an indicator of less severity on the environment.

The anthill soils have low plastic limits i.e. PL< 35, hence they have low CO_2 emission which suggests that emitted CO_2 is less harmful to the environment.

Also, the presence of silt in the samples led to more CO_2 emission, meaning that the presence of silt in soil samples increase the CO_2 produced.

Recommendation

- It is hereby recommended that anthill soils may be used in the production of cement if they are well graded and have coefficient of curvature (CC) greater than 1.

- Also, efforts should be made to remove silt from the soil to be used in the production of cement. If all these are adhered to, CO_2 emission will be less harmful to the environment and the fight against global warming and its devastating effects would have been reduced.

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