STATEMENT OF RESEARCH INTEREST

JOE-SAM NKUAH

Research Area and Approach

My primary research interest is in the area of concrete technology with much emphasis on concrete strength properties, concrete cracks remediation by using biologically activated mechanism (Bio Self-Healing Crack Concrete), detecting cracks in composite concrete structures by using Nano sensors (Piezoelectric and Laser Induce Graphene).

Concrete as material, has a high tendency of forming cracks allowing aggressive chemicals to penetrate into it causing corrosion of embedded steel bars. Cracks are the main causes of concrete deterioration. Also negligence to proper practice and observance of concreting process such as curing may cause cracks and affect the strength properties of concrete.

My research point of focus is capitalized on three aspects: finding the contribution of concreting technique (for example curing) in crack formation, developing a self-healing concrete by using microbial induce calcium precipitate technique and detecting cracks by using Nano sensors.

My M.Tech thesis focused on developing a self-healing bio concrete and out of which I discovered, encapsulation of stiffen bacterial spores sand and pumice immobilization of bacterial spores as technique for adding bacterial cell into concrete matrix.

My Bachelor's thesis also proposed wet jute sack covering as the best curing method to be used in Ghana.

My current research is focused on using graphene induced sensors to monitor structure health. I am currently at the proposal writing stage.

Past Research Experience

M.Tech Thesis - *Self-healing development and performance assessment of bio cementitious concrete*

In this work, I introduced new techniques such immobilization of bacterial spores in pumice solution, encapsulation of stiffen bacteria sand as way of adding *Bacillus Subtilis* spores into engineered cementitious composites (ECC), normal mortar and concrete alongside with calcium lactate, urea and yeast extract as nutrient source for the bacteria.

After carrying out all the tests of culturing, growing and checking pH and temperature resistivity of the bacteria, three bacterial cell solutions of concentrations (10^4,10^6,10^8) cells/ml were prepared and mixed with M25 mortar and normal concrete with mix ratios 1:1 , 1:1.32:2.5 respectively and water/cement ratio of 0.5. Again the bacterial cell solution was mixed with M40 ECC of water/binder ratio of 0.33 and sand/ binder ratio of 1: 0.84.

Performance assessment was carried out on the specimens and the following results were obtained; at a concentration of 10^4cell/ml of bacterial cells, the compressive strength of concrete begins to increase to an optimum value at 10^6cell/ml and declines at 10^8cell/ml, bacterial incorporated concrete specimens with crack width of 0.015 mm, 0.018 mm and 0.02 mm were completely sealed by $CaCO_3$ precipitate at the end of 56 self-healing days. Compressive strength of concrete was raised by 35.20% and 31.59% at the end of 28 curing days. Self-healed cracked concrete specimen regained flexural strength of 73.6% and 82.22% at the end of 56 self-healing days. Sorptivity at end of cracked self-healed specimen was reduced by 81.9%.

The new material formed at crack areas was $CaCO_3$ according to the X-Ray Diffraction spectra obtained. Based on these factors, it was concluded that the developed bio self-healing cementitious concrete showed excellent performance assessments in terms of compressive strength, sorptivity reduction, flexural strength, crack repair and crack recovery strength at the end of 56 self-healing day.

Bachelors Thesis – *Effects of curing methods used in Ghana on density and compressive strength of concrete*

One of the recommendations from Ghana institute of engineers report on concrete structures 2016 was to investigate the effects of various curing methods used in Ghana on the strength properties of concrete. This recommendation came as a results of cracks formation in newly constructed structures, roads and concrete culverts etc. In the report most of these problem was attributed the lack concrete technology knowledge by local masons.

Due to this, I subjected M35 concrete to the three curing techniques for 7, 14 and 28 days to investigate the effects they have on density and compressive strength of concrete. These curing methods were, pond curing, wet local jute sack covering curing and air dry curing. The strength crushing test results indicated that ponding curing had the highest average compressive strength of 44.0 N/mm^2 and density of 2.50 g/cm^3 followed by wet local jute sack covering attaining compressive strength of 43.95 N/mm^2 and density of 2.40 g/cm^3 at the end of 28 curing days. Air dry curing attained the lowest compressive strength 37.5 N/mm^2 and density of 2.37g/cm^3. By using Pearson correlation method, I found out that, there exist a positive correlation between compressive strength and density of the concrete specimens thus, the higher the density, the higher the compressive strength. Ponding method of curing was found to be the best of all the curing methods but not all concrete specimen can be cured in pond in terms of size and scale of project, so wet jute sack covering curing which had an average compressive strength closer to that of the pond curing was recommended to be used in Ghana. Afterwards a lot of the local masons were educated to adopt wet jute sack curing method.

Future Research Direction

Concrete is a nonlinear composite material often viewed as complex and unpredictable. Because of this complexity, primary analytical methods to quantify the relationship between its microstructure and its properties have been a challenging issue. My future research would be focused on computerized base software systems. I will channel my focus on creating a data base holistic tool to analyzed relationship between concrete microstructure and predict fresh and hardened concrete properties by using artificial intelligent, object augmented features and computer simulation models. This tool could also be used to check quality control and quality assurance.

Selected References

1. *Ghana institute of engineers concrete report 2016*
2. *Joesam Nkuah, Sandeep Singla, Self-Healing Development and Performance Assessment of Bio Cementitious Concrete, International Journal of Scientific Technology Research (Scopus index journal), Volume 9 - Issue 2 February Edition 2020. Corpus ID: 214640772*
3. *Joesam Nkuah, Effects of Curing Methods Used in Ghana on the Density and Compressive Strength of Concrete, Department of Civil Engineering, Central University Publication 2017 Edition (http://www.central.edu.gh/111)*