Introducing a novel lightweight cement-based (gem-tech) material for structural applications

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INTRODUCING A NOVEL LIGHTWEIGHT CEMENT-BASED (GEM-TECH) MATERIAL FOR STRUCTURAL APPLICATIONS

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SUMMARY:

This paper will review a maiden research on the GEM-TECH material that established the optimum mix for the material for the best strength to weight ratio and also examine the proposed procedures that is being followed in an ongoing research that would examine the mechanical and structural behaviour of the material when used in structural sections as replacement for conventional concrete.

In an ongoing research, several samples of the GEM-TECH material have been prepared and expected to be air cured and tested for the various mechanical and durability properties after 56 days. However some results from the tests on mechanical properties after 28 days had shown good compressive strength values for a lightweight material for that age compared to other forms of foamed concrete. A maiden research to the material had also seen the material attain a compressive strength of up to 27Mpa for a density of about 1800kg/m^3.

Keywords:

Lightweight concrete, GEM-TECH material, compressive strength,

INTRODUCTION

Over the years, concrete has been the dominant structural construction material and has a very wide range of application with billions of tonnes produced every year. Its excessive weight on foundations has been a major flaw especially when used to construct high rise buildings and this is a serious problem in areas prone to earthquake forces. The keenness to come up with a more effective lightweight structural material (not just void fillers and partition walls) that will in turn lessen the entire weight of structures on their foundation has resulted in tremendous evolution in concrete research. In recent years, research had been done on some lightweight materials. Nambiar and Ramamurthy (2006) had developed empirical models for predicting strength and densities of foam concrete, Jones and McCarthy (2005) gave an introductory study on the potential of foamed concrete to be used as structural (load carrying) material. Some other have explored the use of some lightweight aggregate such as scoria (Yasar, Atis and Kilic 2003), expanded clay (Li, Chen and Zhao 2011), oil palm shell (Shafigh et al. 2014) etc.

The GEM-TECH technology offers a highly workable material that does not contain coarse aggregate (same principle as foamed concrete) that gives a good strength to weight ratio with its consistent liquid nature when freshly mixed allowing for pumping with no need for vibrating or tamping hence reducing labour cost (see **Error! Reference source not found.**).

Figure 6: GEM-TECH material pumped into slab and beam moulds

1.1. THE GEM-TECH Material

The GEM-TECH material is a unique product of GEM-TECH Technology made up of cement, sand, water and the GEM-SOL catalyst and results in an outstanding consistent distribution of

air cells that are non-collapsible forming a very consistent structure with low density characteristics with good compressive strength values. The GEM-SOL catalyst acts as a glue that holds the air cells in place in their distinct position so that they do not collapse throughout the curing stage like the other foam concretes thereby forming a consistent mix with good strength.

1.2. The GEM-TECH Machine

The GEM-TECH machine (see **Error! Reference source not found.**) is a patented machine that employs precision engineering to achieve a consistent mix with uniform mixing of the constituent materials (sand, cement, water and the GEM-SOL catalyst). Dan-jumbo (2015) in a maiden research on the material had described the operation of the machine in detail.

Figure 7: the GEM-TECH machine for mixing the material

EXPERIMENTAL METHODS

Experiments lined up to ascertain the mechanical properties of the material are;

- Compressive strength tests (100 x 100 x100mm cubes)
- Flexural strength tests (2 point loading)
- Elastic modulus test (150mm cylinders)
- Tensile split test

Durability properties would be examined from the following tests;

- High pressure permeability test
- Rapid chloride penetration test
- Freeze/ thaw resistance test

The results from the test on mechanical properties would form the basis for characterising the material so as to effectively model its behaviour and response to loading using finite element analysis software (ANSYS).

RESULTS

The result from tests so far after 28 days is presented in **Error! Reference source not found.**. These values are appreciably high considering its density compared to values from other researches on foamed concrete as compiled in the work of Ramamurthy et al. (2009). The values from the flexural strength test after 28days show that the samples designed with target density of 1600kg/m^3 had an average flexural strength value of 1.98N/mm^2 compared to 1.83N/mm^2 of 1810kg/mm^3 target strength. Similarly, the mix of target strength of 1600kg/m^3 showed a slightly higher tensile split strength value than that of the 1810kg/m^3 target strength (1.09N/mm^2 against 0.73N/mm^2).

DISCUSSION

Compressive strength test had already been carried out after 7,14 and 28 days and as expected the compressive strength had developed gradually with time, whereas the material loses moisture during air curing and its ‘wet’ density reduces and tends towards the target design density. So far, the samples with target density of 1600kg/m^3 had shown a faster rate of strength gain, however it is expected that by 56 to 90 days the samples with target density of 1810kg/m^3 would give better strength values. The faster rate of strength gain for the less dense samples can be attributed to a faster rate of moisture loss as moisture tends to escape to the surface faster due to more pores in its structure.

Due to the absence of coarse aggregate interlock, a low flexural strength was attained and its failure pattern tends to be brittle, shearing almost vertically through the centre of the prism.

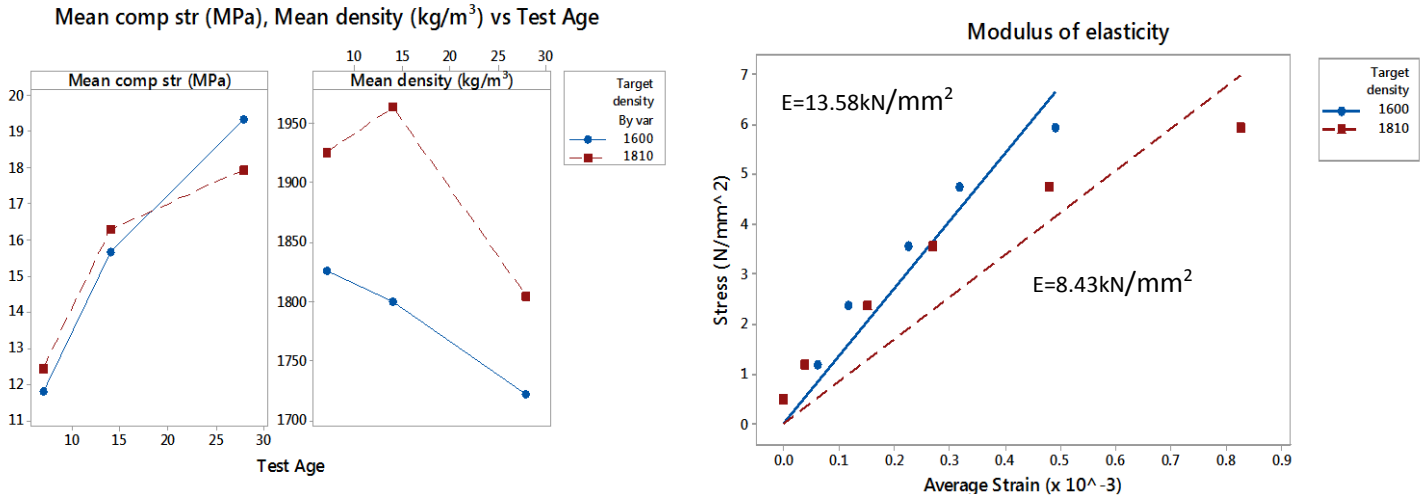

Figure 8: Results from compressive strength test and elastic modulus test

CONCLUSION

The GEM-TECH material shows a good strength to weight ratio and has the potential of attaining a compressive strength of up to 25N/mm^2 by 56 days and therefore can be considered for structural applications as it is above the 20N/mm^2 limited established by BS 8500-1 (2006). Other durability properties (permeability, chloride ingress, etc.) of the material would also be carried out after 56 days to establish is suitability and then compared to that of conventional concrete with equivalent strength. A positive result from the research would birth a revolution in the construction industry as the GEM-TECH material is cheap, workable and would solve the issue of excessive weight of concrete on foundations.

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