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AIR VOID CHARACTERISTICS OF AER-TECH NOVEL MATERIAL

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ABSTRACT

This study critically accessed the pore structure of Aer-Tech material through a scanning electronic microscopy test carried out on two basic mix samples, specimen with fibre glass and specimen without fiber glass. The research results had shown that mix with fiber glass have even distribution of fine and close pores resulting to high compressive strength and reduced void content, whilst mix without fiber glass shows clearly uneven distributed large size pores and open pores resulting to low compressive strength due to higher presence of void space. The scanning electronic microscopy of Aer-Tech sample had shown that through its image analysis that the Aer-tech microscopic structure are compassed with billions of air pores evenly connected. Appreciably, on axial compression co elapse acting similar to steel material. It is also observed that for sample without fibre glass there are a few large sized pores present and their number also increases with an increase in foam volume, which may be due to the possibility of merging and overlapping of pores at higher foam content. From the images It is observed that for mix with fibre the air void space are seen to be very high, whereas for mix without fibre the air void spacing are relatively very small as compared to the former. Further results through particle size analysis had shown that mix without fibre glass confirms that its particle sizes within the range of 0-100µm do not exceed 5 on the percentage by volume of particle size distribution, whilst the Aer-Tech material with fibre glass spans above 5 and 6.

Key words: Aer-Tech material, fiber glass, scanning electronic microscopy

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1. INTRODUCTION

Aer-Tech material is a binder paste or mortar, in which billions of air bubbles are mechanically entrained into the binder paste by high speed mixers. It is characterized with high flowability, low self weight which automatically classified it a light weight material, minimal consumption, controlled strength and excellent thermal insulation properties.

Aer-Tech has evolved out of concrete but where stone aggregates were replaced with air cells. The Aer-Tech machine equipment uses a patented screw, mixing system and atomised liquid dosing system which produces a regular, consistent homogeneous mix. The atomiser injects air cells as small as 20 micron into the mix replacing the stone aggregate and the mixing screw mixes sand, cement and water with consistency and even distribution, creating a geodesic structure. The consistent structure created provides the strengths achieved without using any stone aggregates. This remarkable consistent distribution of air cells creates a geodesic structure, which in effect makes the material unique.

Similar studies have shown that base mixes of uniform distribution of air-cells in a plastic mortar give a higher strength (Nambiar and Ramamurthy, 2006). It is also said that bigger pores in a base mix influence the strength. This is correct as the pore system in cement-base material is conventionally, classified as gel-pores, capillary pores, macro- pores due to deliberately entrained air. However, the gel pores do not influence the strength of Aer-Tech material through it porosity. But the capillary pores and other large pores are responsible for reduction in strength and elasticity (Neville and Brooks, 2004). In accordance to (Xingang Yu and Shisong Luo,2010) microstructure and pore structure of foam concrete are responsible for high strength and permeability. Previous studies by Cebcci (1981) shows that air entraining agents introduce large air voids and do not alter the characteristics of the fine pore structure of hardened cement paste appreciably (Kearsely and Visagie, 2002) reported that the air- void size distribution is one of the most important micro properties influencing the strength of foam concrete. Also further studies by (Xingang Yu and Shisong Luo,2010) confirms that reduction in particle size of sand caused an improvement in strength.

2. EXPERIMENTAL PROGRAMME

2.1. Material and Mixture Composition

The constituent material used to produce Aer-tech material were comprised of: Pro-chem cement conforming to BS8110, pulverized river sand finer than 300µ (specific gravity 2.5), and foam produced by aerating a foaming agent (Aer-Tech Sol) (dilution ratio 1:5 by weight) using an indigenously Aer-tech machine calibrated to a density of 1810kg/m^3.

Two kinds of Aer Tech material were prepared for this paper, the Aer-Tech material without fibre glass and the material with fiber glass. Appreciably, two sets of specimen were taken; the first sets were specimen to be passed through an SEM machine, whilst the second sets are specimen for particle size analysis. More so, for the SEM the two slice specimen of mix with fibreglass and the mix without fibreglass were shape to a sizable dimension to fit properly into the SEM machine. The SEM machine is a microscopy tool used to observe real-time objects as a stereographic magnified image. During, this test an electron beam is focused on the Aer-Tech specimen in machine. This causes surface and sub-surface atomic reaction within the specimen. Specific electrons are released from the material. These are detected and converted to electrical signals which are amplified to produce a real- time image.

More so, higher level magnifications are achieved through accurate manipulation of the electron beam and the system can be used for topographical, composition and elemental analysis.

Imaging was performed in high vacuum with the application of a conductive coating. The samples were made conductive with a carbon and gold layer. The accelerating voltage of the scanning electron microscope was 15 kV. Besides for the particle size analysis the two specimens were grinded into powder form and passed through the particle size sieve.

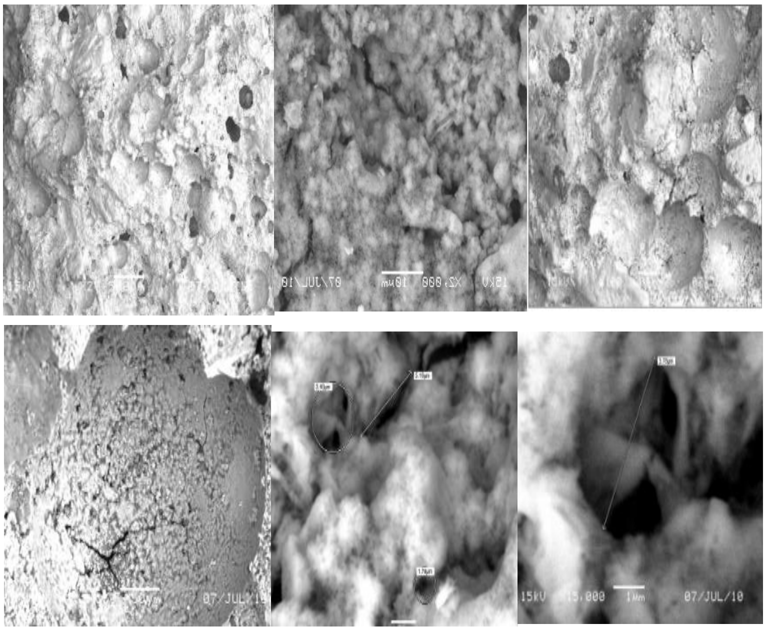

Figure 1 Aer Tech material SEM images without fibre

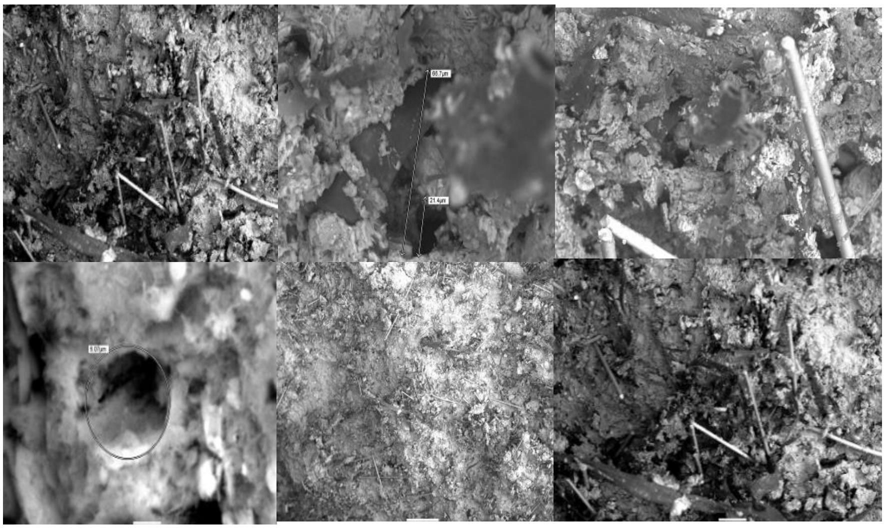

Figure 2 Aer-Tech SEM images with fibre

Comparatively, the above figures has shown microscopic capillary structure of two different mix of Aer-Tech material.

3. RESULTS AND ANALYSIS FOR THE SCANNING ELECTRONIC MICROSCOPY

Table 1 Determining the number of visible voids within a measured area

Specimen	Measuring Area Of Specimen(mm^2)	Numbers of visible voids	Original Specimen density
Cu301	0-100	6	1805
Cu401	100-150	9	1810
Cu501	150-200	11	1803
Cu601	200-250	15	1807
Cu701	250-300	18	1800

3.1. Analysis for the Scanning Electronic Microscopy

Void Characteristics of Aer-Tech using the SEM

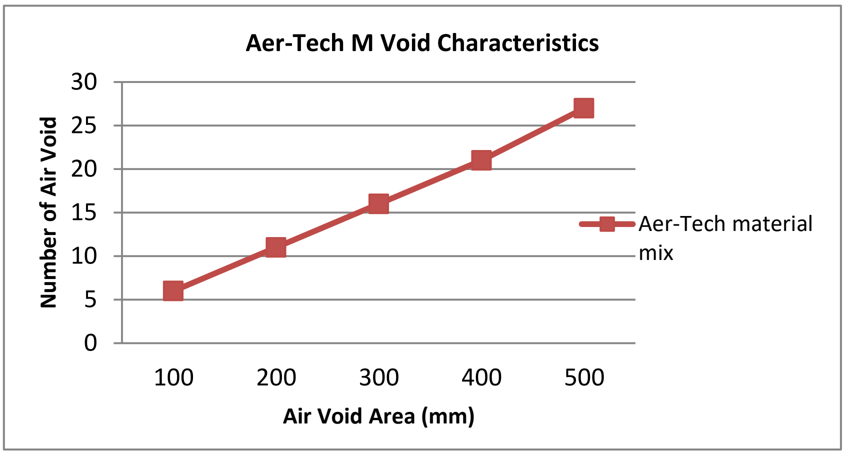

Figure 3 Aer-Tech Void characteristics

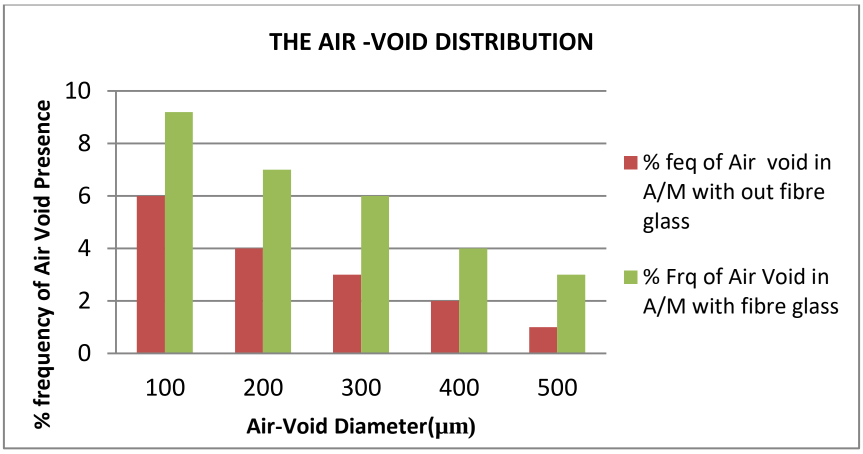

Figure 4 Air Void Distribution

The number of visible air-void sizes in fig 1 shows that the billions of the Aer-Tech air void are of uniform size, embedded in close microstructure of the material. There are a few bigger sized pores present and their number also increases with an increase in foam volume, which may be due to the possibility of merging and overlapping of pores at higher foam content.

Also referring to distribution of air void in fig 3 and fig 4, at low dosage of foam volume the air-void distribution is more uniform than at high foam volume content. This material behavior of Aer-Tech specimen conforms to findings in literature that says that uniformity is relatively predominant in foam concrete with cement–fly ash mixes as compared to cement–sand mixes such that at higher foam volume, merging of bubbles results in wide distribution of voids sizes leading to lower strength.(Nambiar and Ramamurthy,2007).

Comparatively, fig 1 And fig 2, had shown that images of scanning electronic microscopy of Aer-Tech material specimen with and without fibre glass contains air void.

This comparison is further illustrated in fig 4, where percentage frequency of air void distribution is shown to be higher for Aer-Tech mix with fibre, hereby confirming clear signs of merging and overlapping of air bubble due to presence of fibre glass.

Whilst in a similar fashion a more uniform distribution is observed in the images of Aer-Tech mix without plasticizers and reduced percentage of air –void present in Aer-Tech mix without fibre glass, confirming evidence that Aer-Tech product has a pore structure which consist of gel pores, capillaries, and millions of air –entrained and entrapped pores which do not collapse, but coalesce on application uni axial force.

3.2. Air-Void Shape Parameter

For a cellular material like Aer-Tech the shape is an important parameter in strength determination. The shape factor defines the geometry of the voids and is a function of outer perimeter and surface area for each void obtained through image analysis and is given by

Shape factor (SH) = Perimeter/4π(Area) Shape factor equals unity for a perfect circle and is larger for irregular shaped voids.

Considerably, from the fig 1 and fig 2 it is evident that shape of the voids present is similar, appearing in in an ellipsoidal oriented pores shape, whilst only negligible number of voids is having irregularity due to merging of air void at higher foam volume.

3.3. Air-Void Spacing Factor

The SEM had also measured the smallest distance through the matrix between two voids in both figures 1 and 2. This air void spacing parameter is an important factor in determination of strength and density of Aer-Tech material as it gives a clear range of vicinity where the air void are located. From the images It is observed that for mix without fibre the air void space are seen to be very high, whereas for mix with fibre the air void spacing are relatively very small as compared to the former. This particular observation confirms reason why strength of Aer-Tech material with fibre glass tend to be low, following evidence of close proximity in air void spacing.

3.4. Particle Size Analysis Data for Aer-Tech Material Composition

Figures 5 to 6 show particle size analysis for the Aer-Tech material for two set of mixes. Figure 5 and 6 shows clearly the graphic behavior of a mix without fibre glass. It is imperative to say that from the graph the particle size distribution had shown that the highest sieve volume for maximum material size within the ranges of 100-1000micrometre did not exceed a percentage volume presence of 5. Intrinsically, this had confirmed that lack of fibre glass in mix allows a homogeneous size distribution.

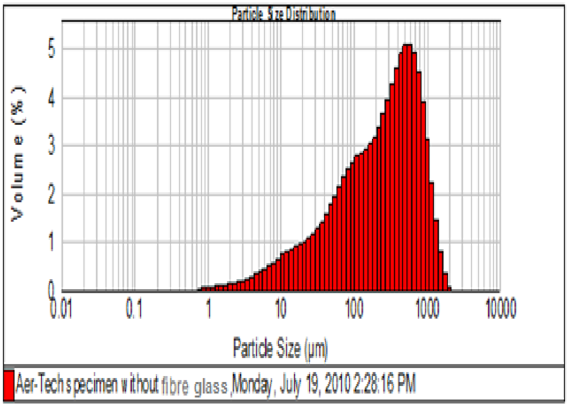

Figure 5 Mix without Fibre glass

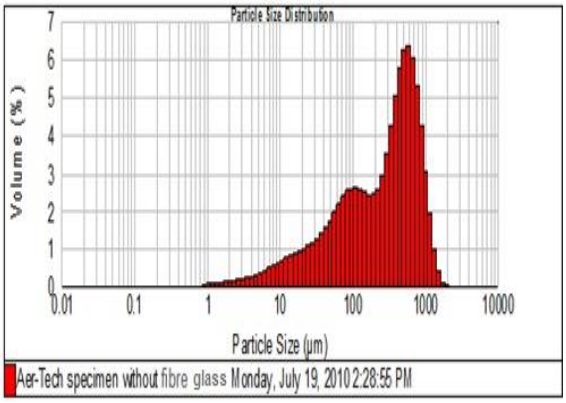

Figure 6 Mix without Fibre glass

Whilst, figure 7 and 8 are Aer Tech mix with fiberglass, their particle size distribution analysis has graphically shown that the mix has higher percentage volume maximum material size through sieve than that of the Aer- Tech material mix without fiberglass. Precisely, while the Aer-Tech mix without fiberglass do not exceeds 5 in its particle size distribution by percentage volume of material within a range of 100-1000micrometre, its corresponding mix with fibre glass exceeds 5 towards 7 by percentage volume of material passed through the sieve.

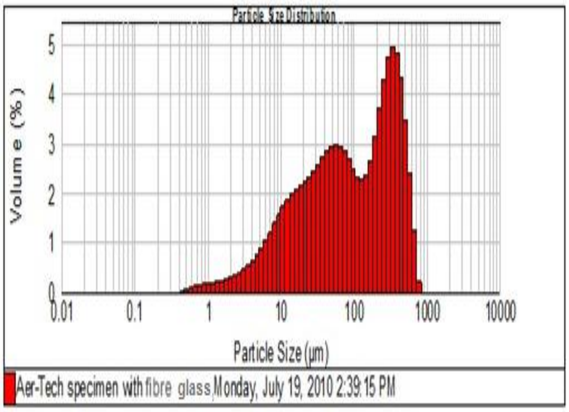

Figure 7 Mix with Fibre glass

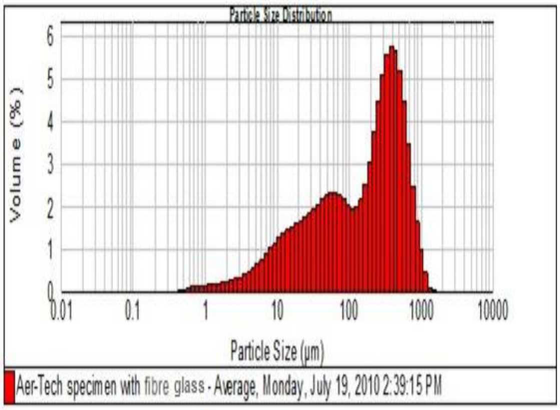

Figure 8 Mix with Fibre glass

4. CONCLUSIONS

Conclusively, it clear that the addition of fibre to material composition of Aer-Tech mix will result to distortion in its microstructure which adversely reduces the compressive strength of the material. It is important to note that as the pore volume fraction of a foam increases, the structure progresses from closed cell to reticulated as windows (perforations between cells) form and widen. The important observation is that even with the porosity above 90%, the foam is almost entirely closed cell.

- From the Scanning electronic microscopy, pictures showing microscopic structure of Aer-tech material with fibre mesh and that of Aer-tech material without fibre mesh had confirmed that the presence of fibre in Aer-Tech mix clearly distort the expected closed cell structure of air void in the mix.
- The presence fibre in Aer-tech mix, mostly result into reduction in compressive capability in the material.
- The particle size test had confirmed that Aer-Tech material without fibre glass do not exceeds 5 on the percentage by volume of particle size distribution, whilst the Aer-Tech material with fibre glass spans above 5 and 6.

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