Reinforced AER-TECH Novel Material A Structurally Effective Material

Dan-Jumbo, F, Saidani, M & George, S

Original citation:
Dan-Jumbo, F, Saidani, M & George, S 2017, 'Reinforced AER-TECH Novel Material A Structurally Effective Material' *International Journal of Advanced Research in Engineering and Technology (IJARET)*, vol 8, no. 8, pp. 827-832
http://www.iaeme.com/ijciet/IJCIET_Paper.asp?sno=8667

ISSN 0976 - 6308
ESSN 0976 - 6316

Publisher: IAEME Publishing

International Journal of Civil Engineering and Technology (IJCIET)
Volume 8, Issue 8, August 2017, pp. 827–832, Article ID: IJCIET_08_08_085
Available online at http://http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=8&IType=8
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

REINFORCED AER-TECH NOVEL MATERIAL A STRUCTURALLY EFFECTIVE MATERIAL

F.G. Dan-Jumbo, M. Saidani and S. George
Faculty of Engineering and Computing, Department of Built Environment,
Coventry University, Priory Street, Coventry CV1 5FB, United Kingdom

ABSTRACT

The Aer-Tech material was initially envisaged as a void filling and fireproofing material, but recent research findings has shown great structural potential. The structural effect of Aer-Tech material conforms with the analogy as stated in (Moseley, Hulse and Bungey.1999) that areas of tension on a reinforced Aer-Tech material are prone to undergo cracking. Ultimately, the ductility of reinforced Aer-Tech beam is primarily important in justifying structural capability of the material. Since, from structural standard it is paramount for a ductile structural material to undergo large deflection at near maximum load carrying capacity, by providing ample warnings to an impending failure. This paper had shown clearly that Aer-Tech material displacement ductility ratio taken in terms of $\mu = \Delta_u/\Delta_y$*, which is the ratio of ultimate moment to first yield deflection. Where* Δ_u *is the deflection at ultimate moment and* Δ_y *is the deflection when the steel yield. In general, high ductility ratios confirm that structural member is capable of undergoing large deflection prior to failure. Consequently, the result of this investigation on Aer-Tech reinforced beam ductility, shows that Aer-Tech material possess relatively good ductile characteristics as beam shows clear signs of cracks on beam long before failure. Other results of Aer- Tech material stress and strain behaviour had further confirm Aer-Tech material as a structural effective material comparable to conventional concrete since the ultimate experimental failure load of Aer-Tech material is 38.7 KN, whilst the theoretical calculated ultimate load is 35 KN. The nearness of experimental and theoretical failure load confirms structural capability of Aer-Tech material.*

Key words: Investigating, Deflection, Material, Structural, Lightweight, Aer-Tech Material.

Cite this Article: F.G. Dan-Jumbo, M. Saidani and S. George. Reinforced Aer-Tech Novel Material A Structurally Effective Material, International Journal of Civil Engineering and Technology, 8(8), 2017, pp. 827–832.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=8

1. INTRODUCTION

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 (see Fig.1). 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).

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.

3. RESULTS AND ANALYSIS

Three reinforced beam were tested for each Aer-Tech mix of 4.78:1, 4.44:1 and 5.,

Table 3.1 Experimental strain

Load	Demec1	Demec2	Demec3	Demec4	Demec5
0	0.00908	0.00916	0.009317	0.00943	0.008814
3	0.009084	0.009148	0.00968	0.009793	0.009184

3.2. REINFORCED AER-TECH MATERIAL STRAINS AND COMPRESSIVE STRESS.

Specifically, the strain results on reinforces Aer-tech beam were measured in every load increments. The strain distribution results are presented in table 3.1.

More so, at the given service load of 3KN to 30KN the strain results ranges from 2283x 0.403x10^5 to 3035 x 0.403x10^5.Whilst, the measured strain just prior to failure varied from 3198x 0.403x10^5 to 3231x0.403x10^5 respectively. Fig 3.1 shows the strain distribution effect in Aer-Tech material on application of load. The strain diagram confirms that strain occurs across the depth of the beam. The illustration in fig3.1 show clearly that demec strain reading does reduces at the top on increasing load for demec 1and 2 , but increases as load increases on demec 3,4 and 5. This behaviour is supported by the bending theory that plane sections of a structural member remain plane after straining. Importantly, results obtained are consistent with works of other researchers (Delsye C.L. Teo, Md. Abdul Mannan and John V. Kurian, 2006)

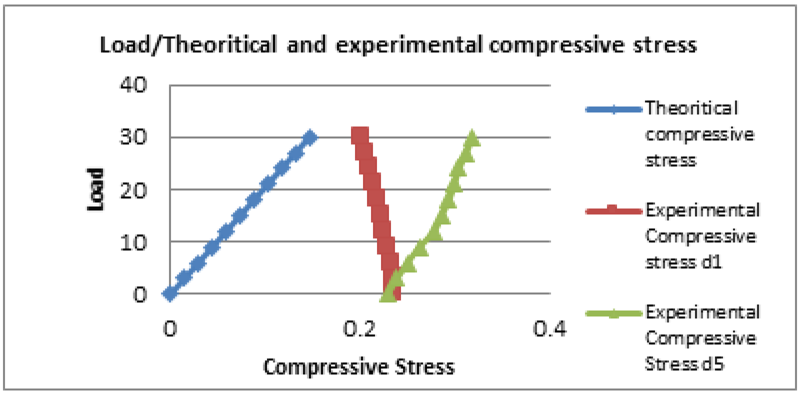

Figure 3.1 Against Theoretical and experimental compressive Stress

The illustration on figure 3.1 shows that the theoretical compressive stress and experimental stress of demec 5 are directly proportional to load application. Explicitly, what happens is that the greater the load application on an Aer-Tech material the higher the compressive stress effect developed.

More so, this significant structural behaviour of Aer-Tech material do lead to first appearance of cracks at the bottom of the reinforced Aer-Tech beam. Intrinsically, as the load increases from 3KN to 12KN the initial slight crack appearance becomes more noticeable. These cracks are simply known as diagonal tension cracks. The structural effect of Aer-Tech material conforms with the analogy as stated in (Moseley, Hulse and Bungey.1999) which state that where ever tension occurs in a material, strongly indicates greater chances of crack appearance within same place.

Comparatively, using the values of experimental strain at the top surface of the beam (demec 1) and the bottom base of the beam (demec 5) by calculating the theoretical result using

$f= E_c$ X ε_c from the figure and the table, it could be observed that the theoretical results are lower than the experimental ones and that could be because the material matrix is getting disturbed, or it could be because the theoretical values are values without any losses that could be due changing the area of the beam surface or due to shrinking.

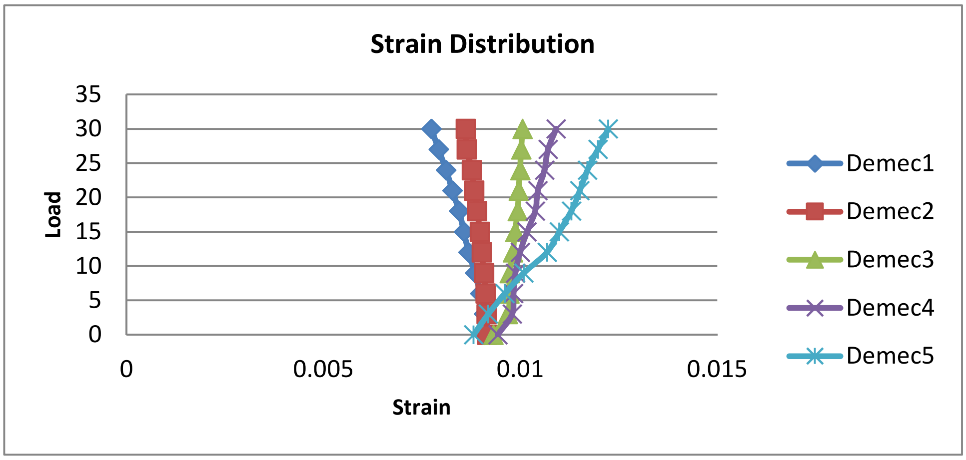

Figure 3.2 Strain Distribution Effect

2.2. BEAM BEHAVIOUR IN SERVICE AND COLLAPSE

Ultimately, all beams showed typical structural behaviour in flexure. Also, during the test of the three beams no horizontal cracks were observed at the level of the reinforcement, which confirms non occurrence of bond failure.

2.3. DEFLECTION BEHAVIOUR OF AER-TECH SINGLY REINFORCED BEAM

Figure 3.3 shows that experimental deflection is lower than the theoretical deflection. The illustration of load against deflection graph confirms that in both experimental and theoretical results, the relationship between load and deflection is linear.

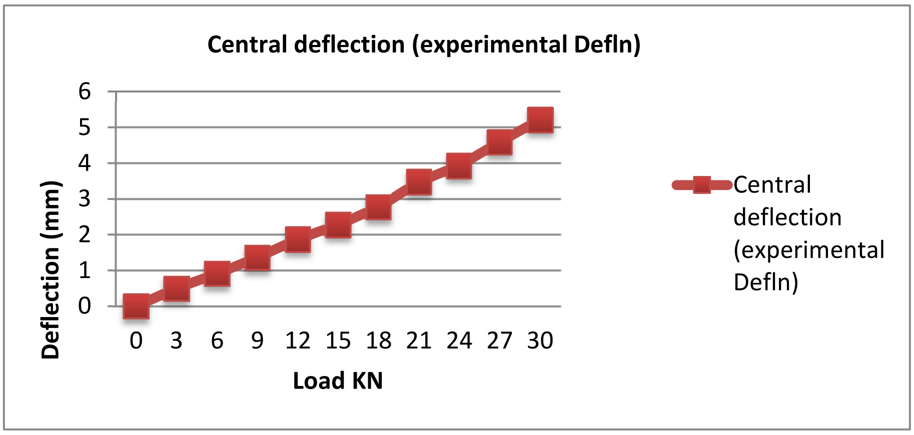

Figure 3.3 Experimental and theoretical deflection values for reinforced beam mix one

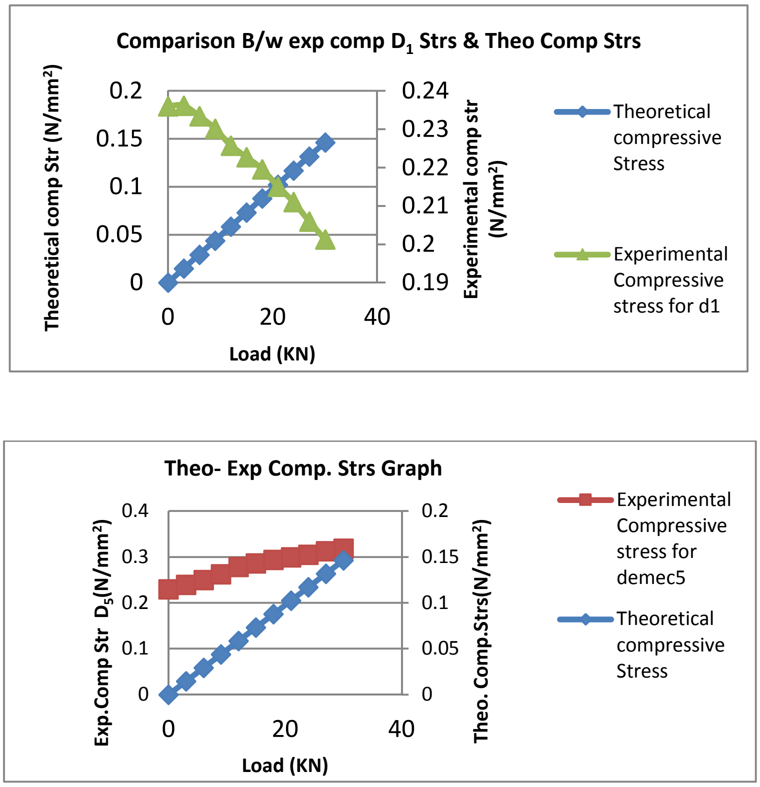

Figure 3.4 Load Against compressive Stress for Demec 1,3 & 5

3.1. REINFORCED AER-TECH BEAM DUCTILITY BEHAVIOUR

Ultimately, the ductility of reinforced Aer-Tech beam is primarily important in justifying structural capability of the material. Since, from structural standard it is paramount for a ductile structural material to undergo large deflection at near maximum load carrying capacity, by providing ample warnings to an impending failure. Table 3.1. Shows that ductility of tested Aer-Tech reinforced beam. Thus the displacement ductility ratio is taken in terms of $\mu = \Delta_u/\Delta_y$, which is the ratio of ultimate moment to first yield deflection. Where Δ_u is the deflection at ultimate moment and Δ_y is the deflection when the steel yield. In general, high ductility ratios confirm that structural member is capable of undergoing large deflection prior to failure. Consequently, the result of this investigation on Aer-Tech reinforced beam ductility, shows that Aer-Tech material possess relatively good ductile characteristics as beam shows clear signs of cracks on beam long before failure. This can be attributed to its inherent pore structure formation due foam content.

3.2. MODES OF FAILURE

Aer-Tech reinforced beams had two different modes of failure. Figure 3.5 show modes of failure for mix four and mix two respectively. As is shown from figure 3.5, the beam failed in total bending. The ultimate experimental failure load of Aer-Tech material is 38.7 KN, whilst the theoretical calculated ultimate load is 35 KN. The nearness of experimental and theoretical failure load confirms structural capability of Aer-Tech material.

Appreciably, the theoretical failure load calculated in accordance to BS8110, obviously lower than the failure load derive from the lab. Their differences are probably caused by the assumption that the compressive and tensile forces were equal. However, the strain distribution diagram shows that strain at the bottom is greater than the strain at the top. Apparently, what happens is the theoretical failure may not have taken into account that the tensile stress is still subjected to the reinforcement bars after the concrete has cracked. Whilst, in case of the experimental failure load a higher experimental failure load was achieved, since the steel reinforcement in the beam continue taking the tension developed until it reaches its ultimate yielding point where it no longer could with stand any further load increase, it therefore breaks at a higher ultimate failure load as compared to theoretical failure load.

But by measuring the angle of the crack in figure 3.5 it was found to be 35º which indicated that the beam failed in combined mechanism of bending and shear stresses.

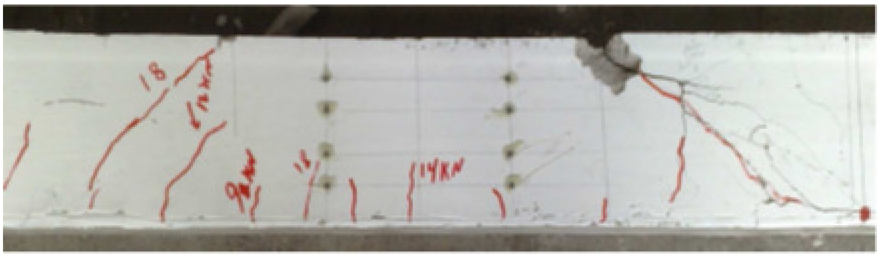

Figure 3.5

3.3. CONCLUSIONS

The experimental investigation of reinforced Aer-Tech beam has shown that Aer-Tech structural behaviour is comparable to other lightweight concrete. Below are some of the conclusions made, based on experimental results.

- Structural assessment Aer-Tech material has shown that the Aer-Tech beam suffered tension at the bottom and compressive forces at the top, which resulted in the diagonal tension cracks being produced mid span at the bottom of the beam.
- Also result of reinforced Aer-Tech beam had shown that as load application increases on reinforced beam tension increases until failure occurs.
- The experimental performance of a 28 days Aer –Tech beam test, has shown that the experimental ultimate moments of Aer-Tech reinforced beam is 3.62% higher than the theoretical ultimate moments.
- The deflection of Aer-Tech material calculated using BS8110 under service load can be used to give reasonable predictions. More so, the deflections under the service load for singly reinforced beams were within their allowable limit provided by BS8110.
- Importantly, the Aer-Tech reinforced beam test gave a high elastic modulus of 25.99 MPa, an indication Aer-Tech material of the flexural capability.

ACKNOWLEDGEMENT

This study forms part of a research programme supported by Aer-Tech development Ltd

REFERENCES

[1] British Standards BS8110 (2000). Testing Hardened Concrete: Part 14.

[2] Nambiar, E. K. K. and Ramamurthy, K. (2006). Air-void characterization of foam concrete. *Elsevier,* 37 221-230.

[3] Narayanan, N. and Ramamurthy, K. (2000). Structure and properties of aerated concrete: a review. *Elsevier Science Ltd.*

[4] Neville, A.M. and J.J. Brooks, J.J. (2004). *Concrete Technology*, Pearson Education Pvt. Ltd., Singapore.

[5] A. Short and W. Kinniburgh. (1978). Lightweight concretes, Applied Sciences Publishers, London.

[6] A Review on Fiber Reinforced Concrete, Grija.S, Shanthini.D, Abinaya.S. International Journal of Civil Engineering and Technology, 7(6), 2016, pp.386–392.

[7] A.S. Vijay Vikram, Dr. S. Arivalagan, A Short Review on the Sugarcane Bagasse with Sintered Earth Blocks of Fiber Reinforced Concrete, Volume 8, Issue 6, June 2017. pp. 323-331.

[8] J.Premalatha, M.Palanisamy and R.Manju, A Study on Seismic Responses of Reinforced Concrete (Rc) Buildings with Lateral Force Resisting Systems, International Journal of Civil Engineering and Technology, 8(7), 2017, pp. 1239–1254.

[9] British Standards (1997): Structural use of concrete – Part1: Code of Practice for Design and Construction. BS 8110-1.