STRAIN UNIFORMITY OF AL-GLASS COMPOSITES

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ABSTRACT. The impact of pressure and the effect of particle size on the mechanical property of Aluminium-Glass composites are reported in this study. The samples area, thickness range and particle size are respectively 34.0 x 35.0 mm^2, 20.8 - 22.10 mm and 26.5 nm. The constituents of the same particle size were made into solids by applying constant pressure of 300 bars. Results obtained from observation showed that composition of Aluminium in Glass, compaction pressure and particle size greatly affected the strain-time relationship of the compacted materials. It was revealed that samples were found with strain stability between 10-40 and 80-100 % wt of Al in composites.

Introduction. Strain stability is the ability of a body or system assuming equilibrium or a steady state, after undergoing an infinitesimal change. Moreover, it is the ability of a body to regain balance at the moment of giving it any distortion. Stress stability is defined as an increase in stress which corresponds to an equal increase in time. Similarly, strain stability entails an increase in strain which has equal increase in time. In the compacted material, the strain / time relationship does not accommodate points of fracture and rupture up to the yield point. Stress values are usually measured from compressive strength of the material along side with strain and time [1, 2]. The strain stability of a material could imply constant rate of change of strain. In other words, the material that can withstand higher stress has a greater capacity to resist fracture. The fracture toughness is thus improved upon from the contribution of stress and strain stabilities of the material.

Aluminium a good candidate is considered as a result of its ductility, strength used in diverse areas and structural stability in glass [3, 4]. Glass has low ductility and the need for reinforcement and support of a material of considerable fracture toughness and temperature stability is applied [5, 6 & 7]. Therefore, attention in this study is focused on determining the strain stability of Al-Glass composites at constant pressure and same particle size. Moreover, Aluminium-Glass composites were proposed for industrial and domestic purposes.

Experimental Procedure.

The materials used for the study include Aluminium powder of purity level of 99.50 %, particle sizes of 26.5 nm obtained from British drug House (BDH), England. The specimen slide was treated in acid and trioxoethelene for 20 minutes to remove unwanted stains from the surfaces of slides. Glass powder of particle size of 26.5 nm which had earlier been crushed and pulverized before sieving with a mechanical mesh at Centre for Energy Research and Development (CERD) in Obafemi Awolowo University, Ile-Ife, Nigeria was used. Weighing was done with digital weighing balance (Model, BT 200) of sensitivity 0.001g. Sodium silicate liquid (from China of purity level of 95.0 %) was added drop by drop.

A manually operated press capable of producing one composite at a time with an average thickness of 21.5 mm and cross sectional area of 1156 mm^2 was used for molding the samples. Formula for mixing in percentage is Al_xGlass_{100-x} x= 0.00, 10.0, 20.0, 30.0…100 The Aluminium and Glass powders in grams were mixed together in 9 different ratios at 300 bars. Sodium silicate liquid added was between 12.5-14.5 % of Al-Glass Mixture. The mixing was carried out in a mechanical shaker and mixer for a period of 20-30 minutes. These samples were presented for compression test with compressive test machine at increased composition of Al in composites at the mechanical section of CERD.

Results.

Table 1. Compressive Strain with Time at the point of Breakage for composites Al_xGlass_{100} of 26.5 nm and 300 bars.

S/No	**Composites**	**Compressive Strain (mm/mm)**	**Time at the point of Breakage (s)**
1	Al_0Glass_{100}	0.3900	5.50
2	$Al_{10}Glass_{90}$	0.1500	2.90
3	$Al_{20}Glass_{80}$	0.1040	41.70
4	$Al_{30}Glass_{70}$	0.2567	102.90
5	$Al_{40}Glass_{60}$	0.1190	47.70
6	$Al_{50}Glass_{50}$	0.2110	3.90
7	$Al_{60}Glass_{40}$	0.1915	3.80
8	$Al_{70}Glass_{30}$	0.1828	3.10
9	$Al_{80}Glass_{20}$	0.0203	4.40
10	$Al_{90}Glass_{10}$	0.2117	4.60
11	$Al_{100}Glass_0$	0.0203	4.40

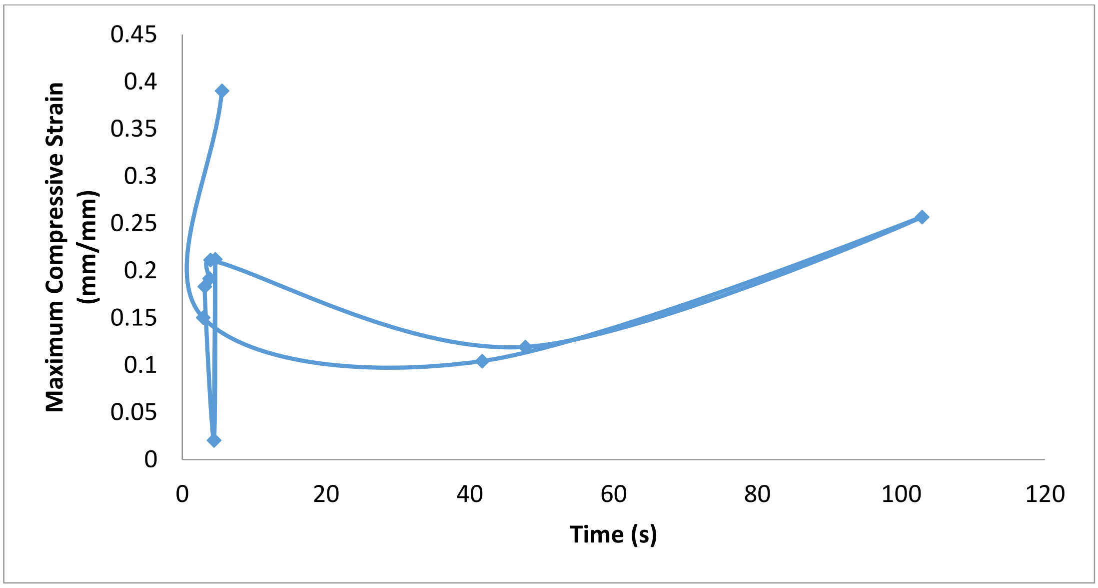

Fig. 1. Maximum Compressive Strain with Time at the point of Breakage for All the composites of 26.5 nm.

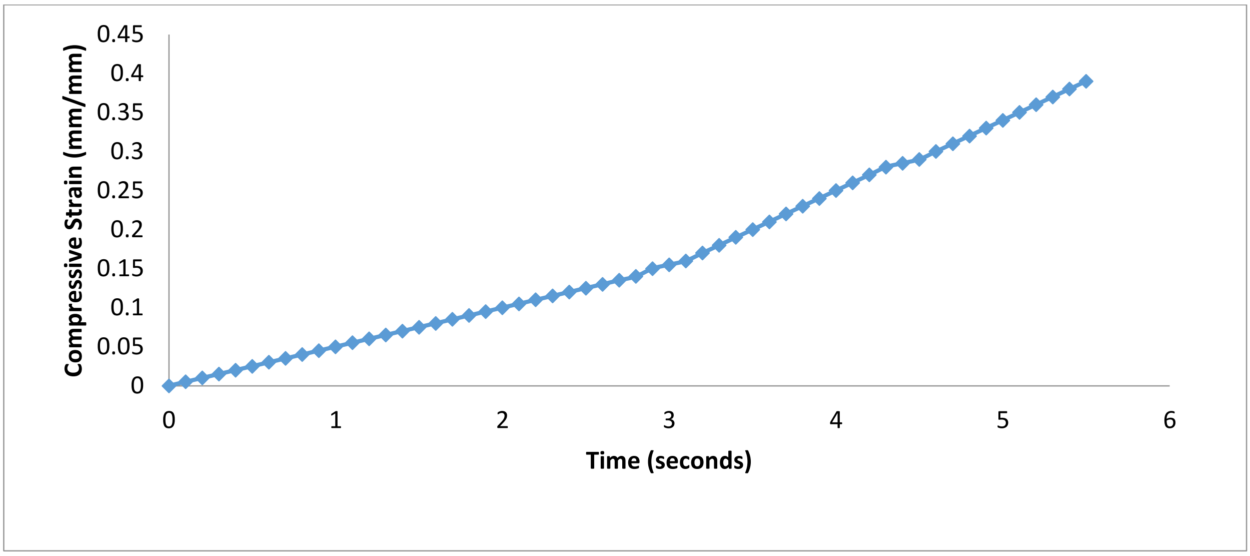

Fig. 2. Compressive Strain with Time for Al_0Glass_{100} of 26.5 nm.

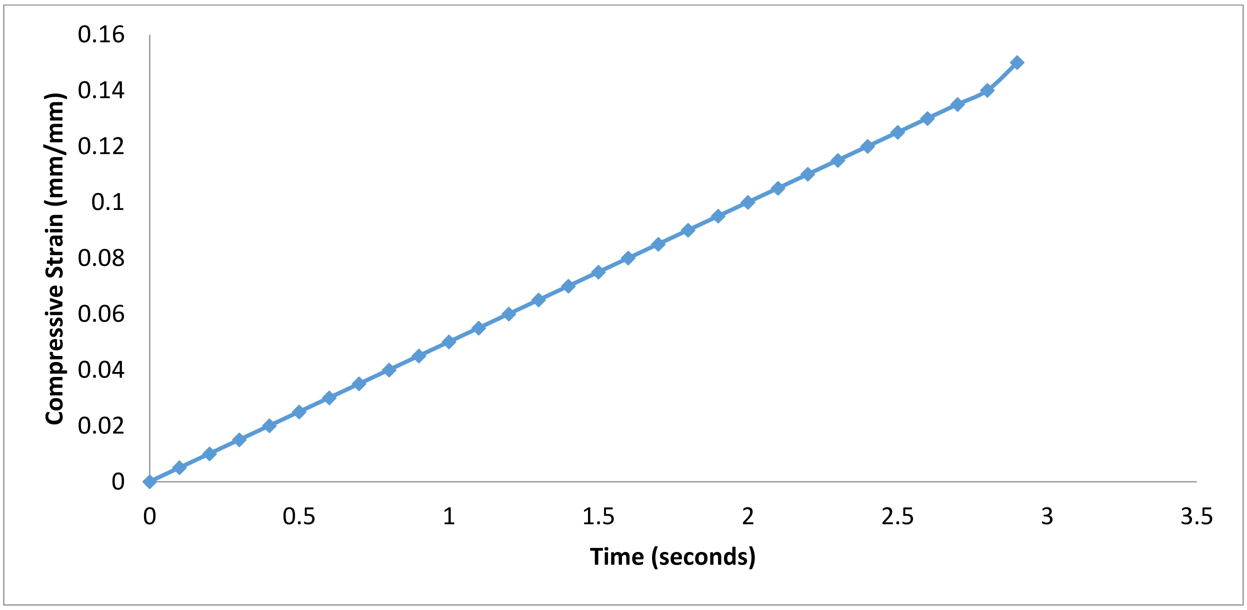

Fig. 3. Compressive Strain with Time for $Al_{10}Glass_{90}$ of 26.5 nm.

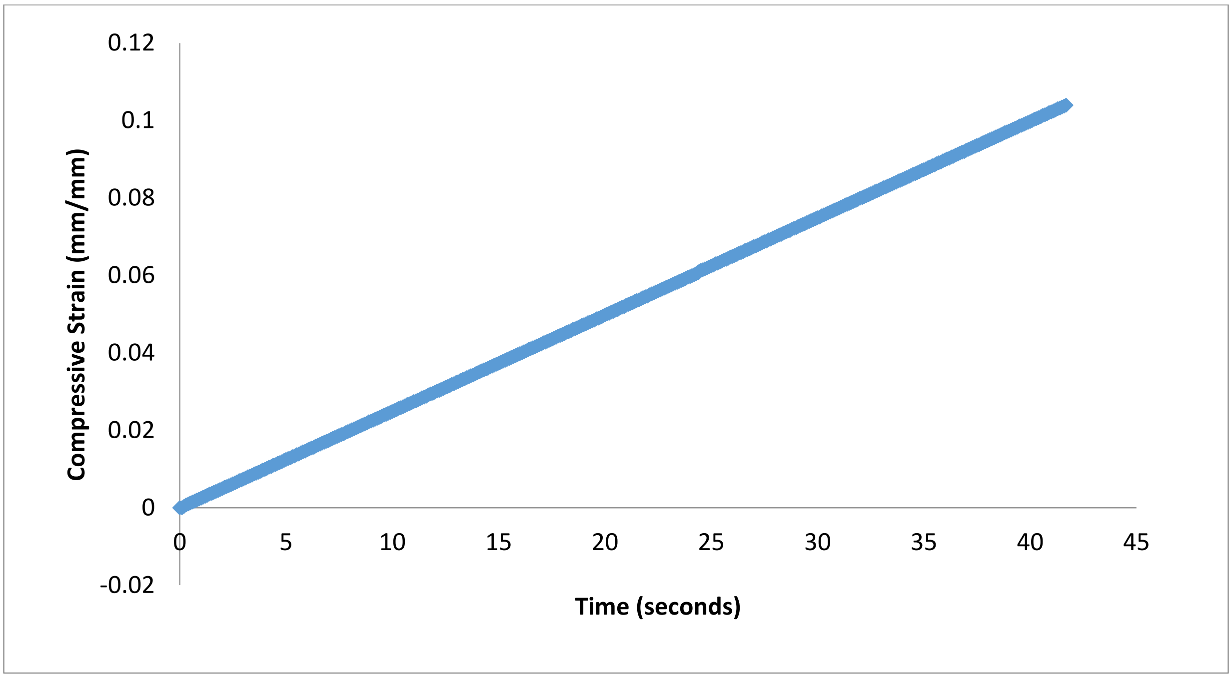

Fig. 4. Compressive Strain with Time for $Al_{20}Glass_{80}$ of 26.5 nm.

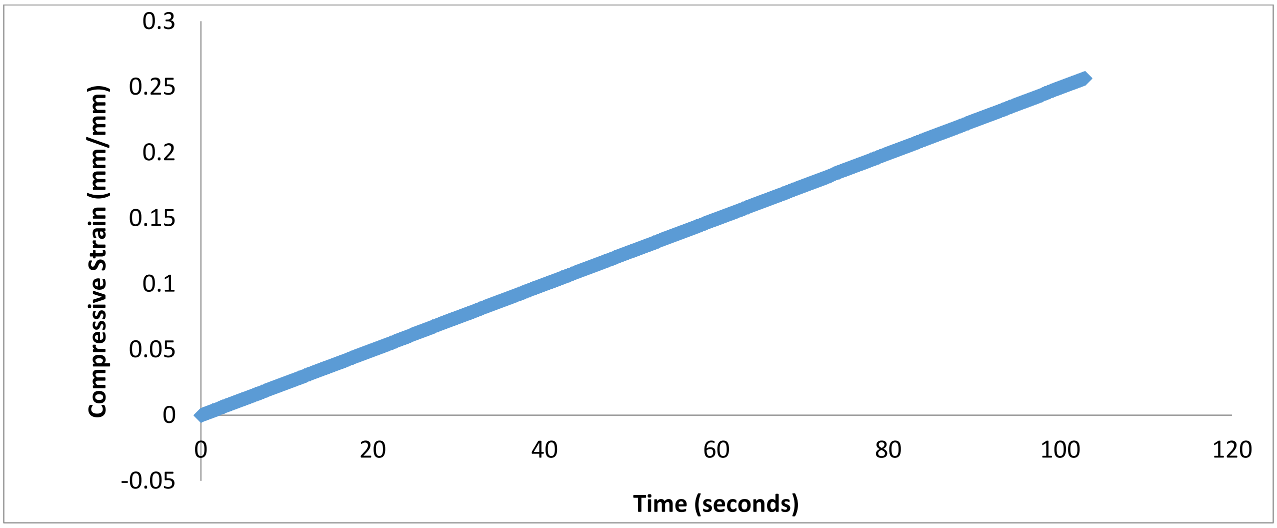

Fig. 5. Compressive Strain with Time for $Al_{30}Glass_{70}$ of 26.5 nm.

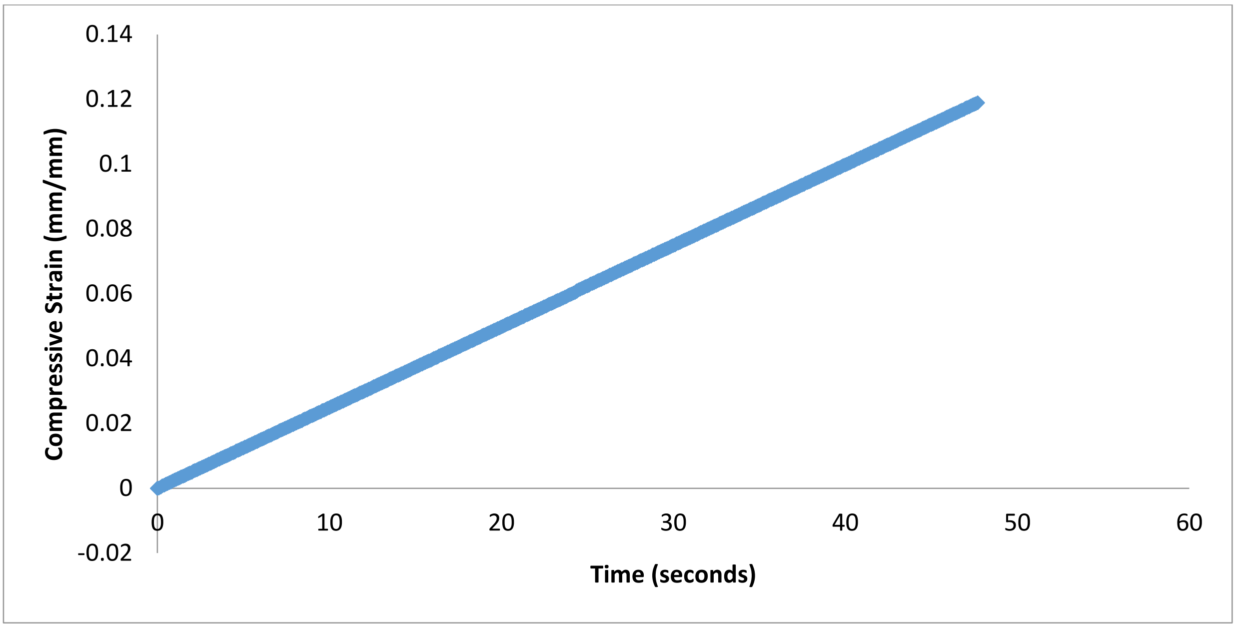

Fig. 6. Compressive Strain with Time for $Al_{40}Glass_{60}$ of 26.5 nm.

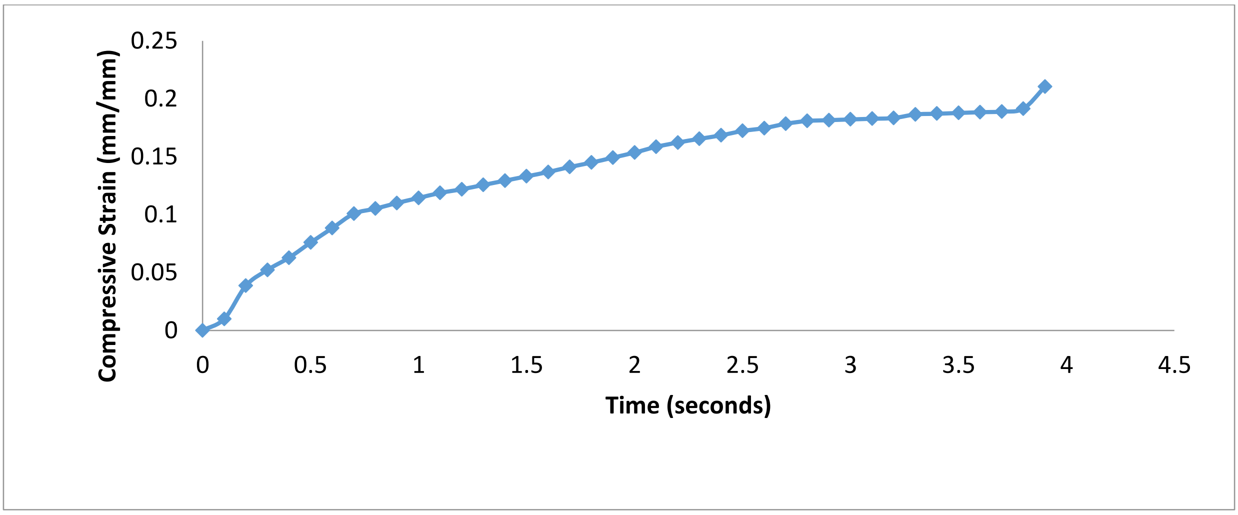

Fig. 7. Compressive Strain with Time for $Al_{50}Glass_{50}$ of 26.5 nm.

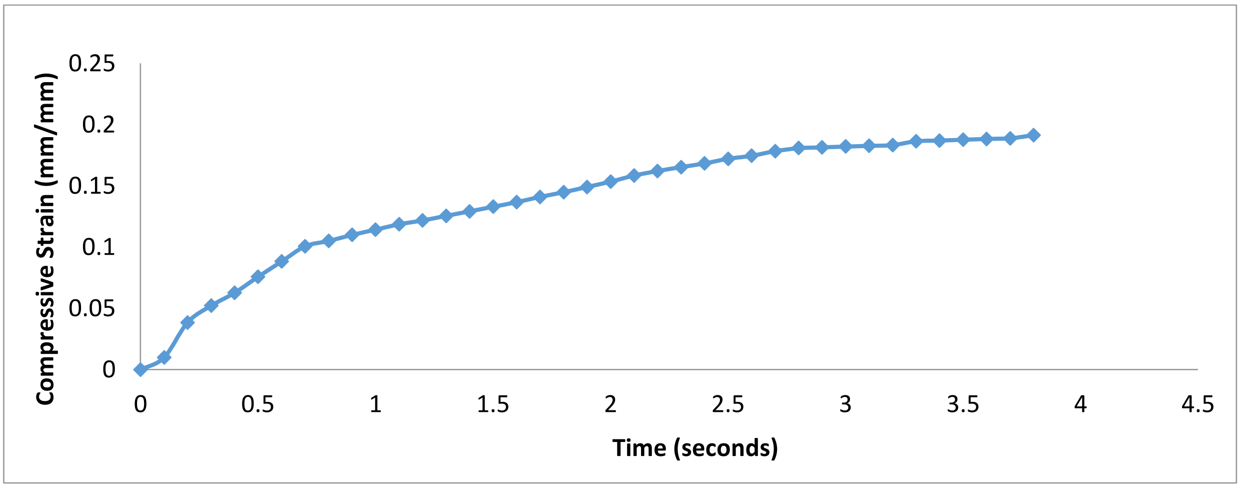

Fig. 8. Compressive Strain with Time for $Al_{60}Glass_{40}$ of 26.5 nm.

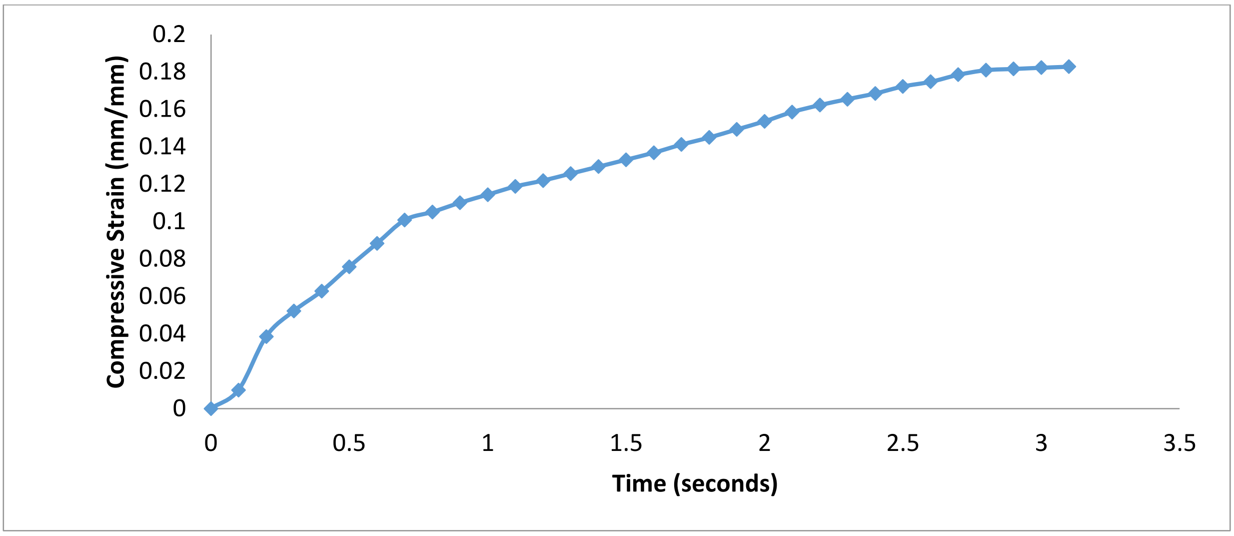

Fig. 9. Compressive Strain with Time for $Al_{70}Glass_{30}$ *of 26.5 nm.*

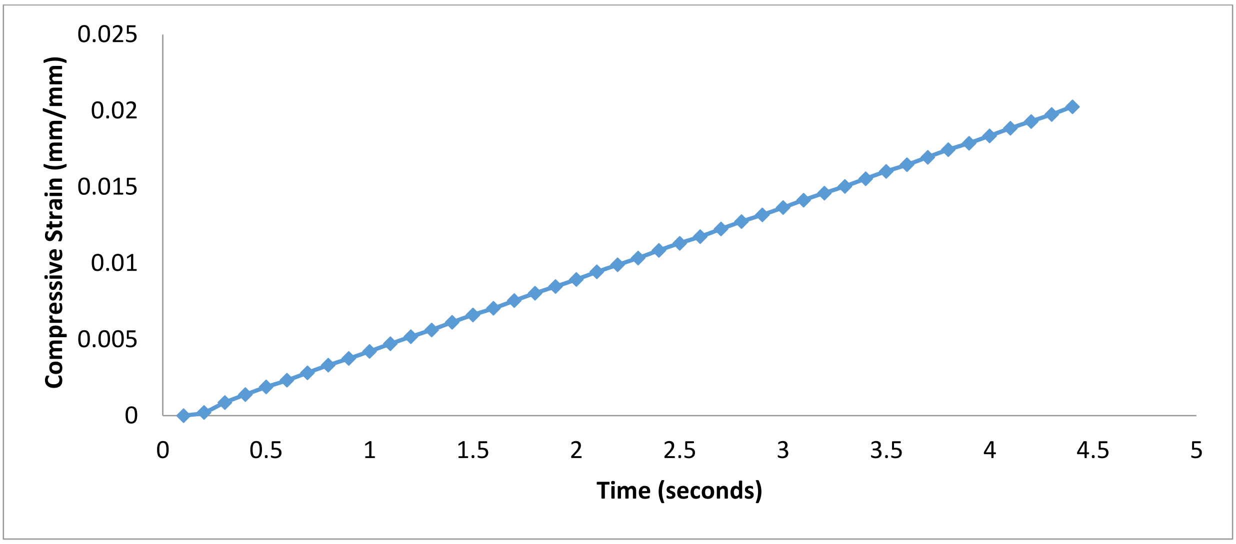

Fig. 10. Compressive Strain versus Time for $Al_{80}Glass_{20}$ *of 26.5 nm.*

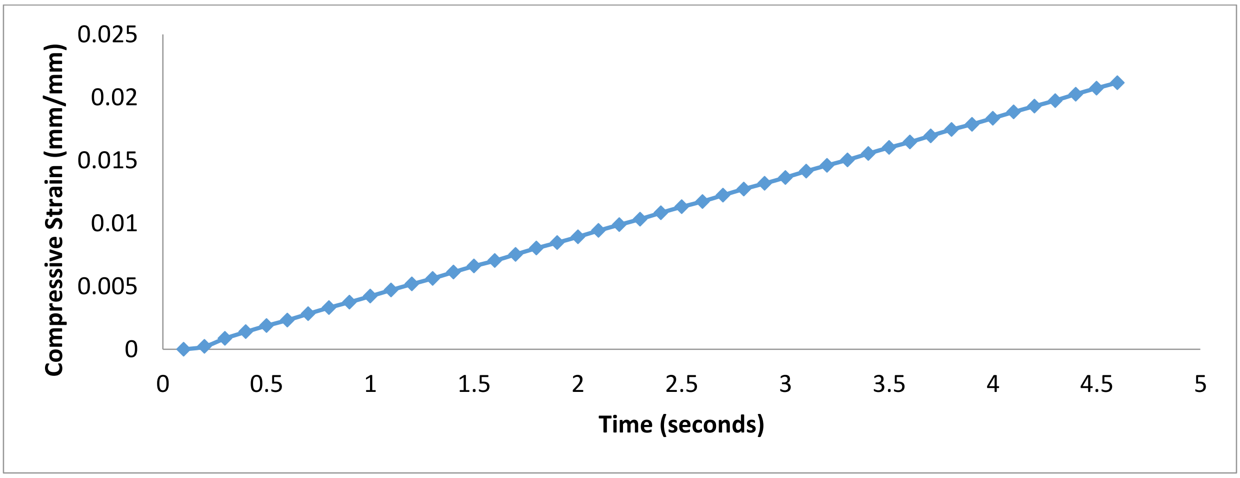

Fig. 11. Compressive Strain versus Time for $Al_{90}Glass_{10}$ *of 26.5 nm.*

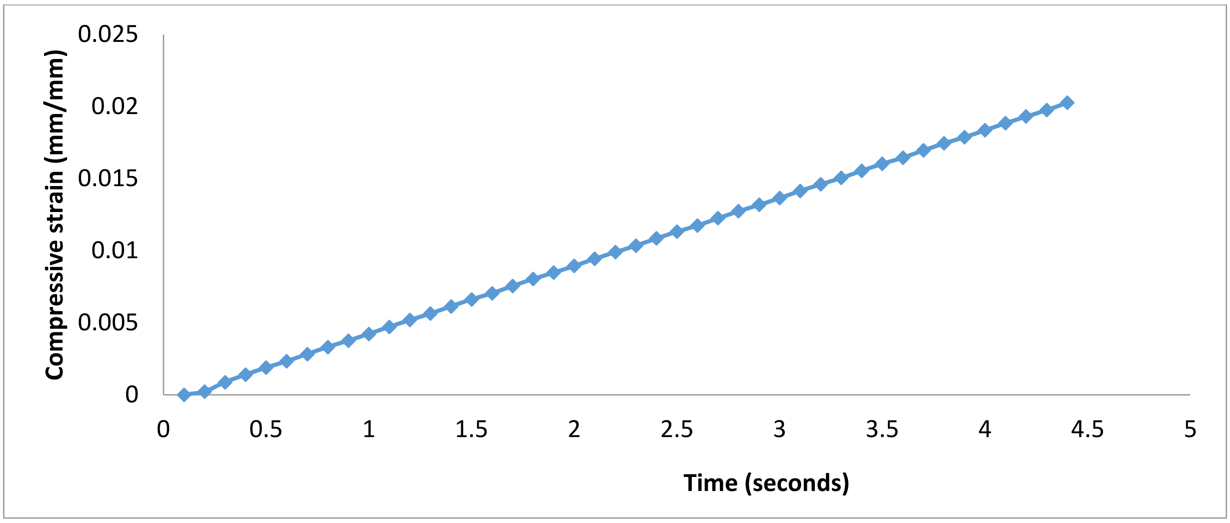

Fig. 12. Compressive Strain versus Time for $Al_{100}Glass_0$ of 26.5 nm.

Discussion. Elemental Composition of the Samples.

In Table 1 the strain has the highest value for 0 % weights of Aluminum in composites at 300 bars and 26.5 nm. The time has highest value for 30 % weights of Aluminium in the composites at constant pressure and same particle size. As for the lowest values, the lower and upper limit of strain and time were noted respectively at 80 - 100 % and 10 % weight of Aluminium in composites for 300 bars.

Strain, Time, Strength and Strain Stability.

Figure 1 shows the variation of maximum compressive strain versus time at the point of breakage or yield point at 26.5 nm and constant pressure. The display involves the combination different curves with maximum points separated. Figures 2 – 12 depict the strain value of 300 bars and 26.5 nm particle size whereby the strain – Time relationships were found to be stable over specified ranges which are indications that the material has the tendency of exhibiting strain stability. The composite Al_oGlass_{100} in Figure 2 is not a candidate of strain stability with the display of deviation from straight course before the point of breakage. The samples $Al_{10}Glass_{90}$ and $Al_{20}Glass_{80}$ in Figures 3 and 4 are substances of strain stabilities. Moreover, Figures 5 and 6 displayed the variation of Strain – Time for $Al_{30}Glass_{70}$ and $Al_{40}Glass_{60}$ of 26.5 nm particle size. The result showed that as the strain increases the time increases gradually along the straight line. The increase in Strain - Time became noticeable for the composites without fracture along the paths. These samples are classified as having strain stabilities.

The variations of Strain - Time for samples $Al_{50}Glass_{50}$ and $Al_{60}Glass_{40}$ and $Al_{70}Glass_{30}$ at 26.5 nm particle size are shown in Figures 7 – 9. The results depict gradual increase in Strain - Time along the curves although with no ruptures up to the point of breakage yet these are indications that the displays are not uniform. These suggest they are not candidates of the strain stability just before the point of breakage.

It should be noted that samples that contain points of rupture and fracture are not candidates of strain stability. Composites with Strain –Time relationship which are in form of curve are not in support of strain stability. In other words, it must not exhibit the above mentioned flaws. Moreover, the strain stability of a sample must display gradual increase in strain with corresponding equal increase in time. The point of breakage did not necessarily coincide with the maximum compressive strain which was found in the samples observed. Strain stabilities were observed in Figures 10 - 12 for samples $Al_{80}Glass_{20}$ $Al_{90}Glass_{10}$ and $Al_{100}Glass_0$ as an increase in strain corresponds to equal increase in time. The Figures also revealed that the samples at 26.5 nm have no points of fracture or rupture over the specific range. Although, the sample in Figure 12, which is pure Aluminium, is noted with strain stability from observation yet it has the capability to strengthening and stabilizing the structure of glass at specific compositions from the results shown above.

Summary. Ceramic materials are known to be fragile in nature; however, they have been found to be very useful and applicable in making many objects. These applications include; bottles, cup, bowls, plates, homes / domestic decorations, laboratory hardware and building projects. Aluminium on the other hand, is a ductile metal and useful in many areas such as car body, ship building airplanes, sliding window frame, door frames and roofing sheets etc.

The combination of Aluminium as a buffer layer with other metal had been noted to generate improve performance in various device applications and utilization. Therefore, the mechanical properties of glass could be adjusted for suitable application and utilization with appropriate reinforcement of Aluminium in glass.

In the study, Al-Glass composites were molded by applying compaction pressure using sodium silicate as the binder. Improved strain uniformity of Al-Glass was obtained while strain stabilities were observed from 10-40 and 80-100 % weights of Aluminium in composites at 26.5 nm particle size. It has been shown that the composites have different ranges of strain stabilities.

The essence of the research is important, as the material could be useful in modifying the properties of glazy materials. The material could also be useful for decoration such as flower vase and other house hold aesthetics. It is recommended that when Aluminium and glass are bonded or formed together it can be used as sliding windows in financial institutions, automobile industries and table tops in Furniture Companies and home accessories.

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