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Characterisation on Grade of Concrete Waste Particle Reinforced Aluminium AA7075 Based Composite

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Abstract: A composite is a material made up of elements generated by physically merging pre-existing monolithic compounds to produce a new material having properties separate from the original composition. In the engineering area, AMC is commonly employed in the product. This is owing to its performance and unique qualities as a result of the reinforcement's added features. The investigation materials for this study were aluminium alloy AA7075. The solid-state technology is used in this work to explore the influence of waste concrete as a reinforcement material in metal matrix composites because it has significantly lower operation costs and energies than traditional recycling by casting. The mechanical and physical qualities of waste concrete materials for Grades 40 and 30 with zinc stearate as a binder were examined. On each reinforcement composition, recycled aluminium chi AA7075 was reinforced with 2.5 %, 5 %, 7.5 %, 10 %, and 12.5 % waste concrete materials, as well as 1 % zinc stearate. The current study looked at the density, apparent porosity, water absorption, micro-hardness, compression, and microstructure of aluminium matrix composites. The addition of 1 wt. % zinc stearate to the decrement of density for metal matrix composites down to 7.5 wt %. waste concrete materials then rose with the increment of waste concrete materials percentage. Chip AA7075 hardness increased as the mass fraction of waste concrete materials increased, from 46.71 Hv to 49.15 Hv for both grades and zinc stearate, and subsequently decreased from 49.15 Hv to 33.32 Hv for Grade 40. In other hand for Grade 30 mass fraction of concrete waste has increase from 28.23 Hv to 55.33 Hv then decrease to 45 Hv. The Young's Modulus of chip AA7075 for reinforcement with waste concrete Grade 40 and constant zinc stearate composition has also improved from 11.31 N/m^2 to 11.656 N/m^2 but then it's decreasing as the amount of waste concrete in the composition increasing and it's also happen to AA7075 for reinforcement with waste concrete materials Grade 30 and constant addition of zinc stearate composition where the Young's Modulus increasing from 11.31 N/m^2 to 13.24 N/m^2 and decreasing when the composition of waste concrete increase.

Keywords: AMC, Waste Concrete, Zinc Stearate

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1. Introduction

Aluminium alloy is very string yet light materials that have been found in almost everything in today's market. An alloy is a combination of metals that, when combined, are more useful than the individual metals. Small amounts of other metals, known as alloying elements, can be conceived of as "improving" a base metal (in this example aluminium). Alloys have transformed our engineering skills by providing stronger, more conductive or more resilient materials for designing new ideas. Aluminum is a common metal with a wide range of useful alloys; so many, in fact, that the Aluminum Association has classified them into classes based on alloying elements. The subject of this article is type 7075 aluminium alloy, which belongs to the 7xxx series of alloys that use zinc as their primary alloying ingredient. Industrial trash recycling is a topic of enormous relevance in today's world in any industry, but especially in the aluminium industry. Aluminium recycling has the potential to save natural resources, cut energy consumption, reduce greenhouse gas emissions, and save the environment. The use of direct hot extrusion of aluminium chip in the recycling of aluminium is investigated in this study, with an emphasis on the final product, characteristics, and processing route. The technique turns new scrap aluminium chips generated by industry straight into aluminum-based composites or alloys. Aluminium recycling is one of the strategies for repurposing scrap aluminium after it has been processed in other items. The most common way to recycle aluminium is to simply re-melt it. Although aluminium metal has only been used and produced on an industrial scale for a century, the industry has evolved to the point where it is now second only to steel and iron among metal producers, as illustrated in Figure 1. Shazarel Samsudin stated in a research study on revolutionary in solid states recycling techniques in aluminium that researchers believe that the advantages of solid state or direct recycling of aluminium are significant. It has the potential to save money while also providing better environmental protection and energy efficiency than traditional remelting recycling. Furthermore, a large proportion of carbon footprint can be reduced (Evolutionary in Solid State Recycling Techniques of Aluminium, 2016). This shows that aluminium is most used metals and also in recycling aluminium also has been proven can be done in many ways. The traditional which are remelting the aluminium has commonly been used in such way that benefits the industry but also have a bad disadvantage in it.

Aluminium matrix composites (AMCs) are a type of lightweight, high-performance aluminium centred material. Continuous/discontinuous fibres, whisker, or particles, in volume fractions ranging from a few percent to 70%, could be used to reinforce AMCs. AMC properties can be adjusted to meet the needs of various industrial applications by combining the right matrix, reinforcement, and processing technique. Several grades of AMCs are currently produced using various methods. Three decades of rigorous research have yielded a plethora of new scientific understanding about the intrinsic and extrinsic impacts of ceramic reinforcement on AMC physical, mechanical, thermomechanical, and tribological properties. AMCs have been used in high-tech structural and functional applications including as aerospace, defence, automotive, and medical devices in recent years (Surappa etal., 2003)

Aluminium matrix composites (AMCs) are a type of lightweight, high-performance aluminium centred material. Reinforced aluminium matrix composites (AMCs) are used as major structural materials in aircraft, military and automobile components. AMCs are materials made up of ductile metallic alloys reinforced by hard particles, giving them attractive properties. Due to its low density and strong mechanical qualities, aluminium matrix composite is becoming more popular in a range of industries, as is the case with most metal matrix composites. AMC properties can be adjusted to meet the needs of various industrial applications by combining the right matrix, reinforcement, and processing technique. Several grades of AMCs are currently produced using various methods (Mirle Surappa et al., 2003).

Particle reinforced metal matrix composites (MMCs) are promising for use in major industries due to their high strength-to-weight ratio and elastic modulus, as well as the appealing combination of the toughness and ductility of a metal matrix with the strength and hardness of brittle ceramics commonly used as a reinforcement material. MMCs have recently become ubiquitous in the automotive and aerospace industries. Improved mechanical properties of composites in many studies using aluminium as a matrix known as Aluminum Matrix Composites (AMC) and reinforced with a filler Bamboo Leaf Slag (BLA) with a composition of 0,2,3,4 percent Wt (Alaneme K.K., 2013) or increasing lack purity aluminium matrix with another metal alloy (Al-Mg-Si) with a composition of 10 wt percent (M. Gupta, M.K. Surappa, 1995 (Chennakesava Reddy A and Sundararajan S, 2005).

Concrete is a viable material that can withstand high temperatures during a fire or in close proximity to furnaces. During a fire, however, exposure to high temperatures can pose a threat to any built buildings, causing substantial damage to reinforced concrete structures. Despite the fact that concrete is a non-combustible material, fire can modify the physical, chemical, and mechanical properties of the concrete once it is exposed to high temperatures. Furthermore, it will reduce the concrete's strength, volume stability, and modulus of elasticity. As a result, while considering weight carrying capacity and rebuilding fire-damaged buildings, the concrete properties' exposure to fire is significant. Concrete is a composite material made up of cement, water, and particles that occupy nearly 65 percent to 75 percent of the volume of the concrete. The rapid industrial expansion has resulted in the depletion of raw materials in concrete, such as natural aggregates, which has become a severe concern all over the world.

The investigation of experimental experiments aimed at improving the properties of aluminium matrix composites reinforced with waste concrete. The major goal of experimental research is to increase the material's strength so that it may be used in a variety of applications.

2. Materials and Methods

2.1 Aluminium

The aluminium alloy AA7075 has been used in a range of industries, including aviation, automotive, and aerospace, due to its high strength. This alloy had aluminium (A), zinc (Zn), magnesium (Mg), copper (Cu), and additional elements.

	Temper	Thickness in. (mm)	Tensile strength ksi (MPa)	Yield strength ksi (MPa)	Elongation %
AA 7075	0 Sheet & plate	0.015~2.00 (0.38~50.80)	40 (max) (276)	21 (max) (145)	9~10
	T6 Sheet	0.008~0.249 (0.203~6.32)	74~78 (510~538)	63~69 (462~476)	5~8

Figure 1. Mechanical Properties of Aluminium AA7075 (Q.S Hsu, 2015)

.2.2 Reinforced Materials

The waste concrete was collected from our supervisor. It was being label as Grade 40 and Grade 30 with curing days of 7 days. Then the waste concrete will be divided towards five type of concentrations which were 2.5 %, 5.0 %, 7.5 %, 10 % and 12.5 %. The chemical composition of the waste concretes is as shown as below in Figure 2.

Sample ident
Concrete Grade 30

Application	<Omnian>
Sequence	1 of 1
Position	Large sample
Measurement time	17-Mar-2022 08:40:35
Time zone	UTC+08:00
Username	

Normalisation factor	1.480

Compound	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**P2O5**	**SO3**	**Cl**	**K2O**	**CaO**	**TiO2**	**V2O5**	**Cr2O3**
Conc	0.0	1.830	11.239	42.973	0.593	1.866	0.195	2.617	34.190	0.512	108.6	2.4
Unit	ppm	%	%	%	%	%	%	%	%	%	ppm	ppm

.7-Jan-2022 14:11:39 UTC+08:00 **Sample results** Page

Sample ident
Concrete

Application	<Omnian>
Sequence	1 of 1
Position	Large sample
Measurement time	17-Jan-2022 11:48:33
Time zone	UTC+08:00
Username	

Normalisation factor	1.320

Compound	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**P2O5**	**SO3**	**Cl**	**K2O**	**CaO**	**TiO2**	**V2O5**	**Cr2O3**
Conc	0.0	0.552	7.975	46.618	0.444	1.475	0.181	2.034	33.425	0.335	59.5	69.5
Unit	ppm	%	%	%	%	%	%	%	%	%	ppm	ppm

Figure 2. Chemical composition of Waste Concrete Grade 30 and Grade 40

2.3 Preparations of Chip AA7505

The recycled aluminium chip was prepared using a variety of ways. Each stage ensures that all of the specimens used in the experiment are properly made, which contributes to the accuracy of the results. The aluminium alloy AA7075 was the primary raw material employed in this research.

The experiment was carried out in the machining laboratory, FKMP, UTHM, using a high-speed milling machine. The parameters of the milling machine to ensure the uniform size of aluminium chip are presented in Table 1.

Table 1. Specification of Chip Production

Tool	10 mm diameter, 2 flute carbide
Operation	Drying cutting without coolant
High cutting velocity	345.5 m/min
Depth of cut	1 mm
Feed, f	11000 mm/min

2.4 Waste Concrete Preparation

The cube concrete was provided to this study as the initial phase in the concrete preparation process. As a result of the larger size of concrete, the crashing technique is used to reduce the size of the concrete by using Ball Mill Machine. Crasher had been used, but the concrete had not completely turned to powder, so we had to do it manually till it did.

2.5 Mixing and Compaction process

In order to prepare the specimens, the mixing procedure and the cold compaction process were both applied. Each stage ensures that all of the specimens used in the experiment are properly made, which contributes to the accuracy of the results. AA7075 recycled aluminium chips, concrete, and zinc stearate were used to make all of the specimens.

A compaction process was used to carry out the mixing procedure. All of the powdered components were combined using this equipment. This mixing process can combine three components in a random order, namely aluminium chips, concrete, and zinc. Table 2 shows the varied percentages of aluminium chip and concrete used in the mixing process for six distinct samples. In AMC, different compositions of Grade 40 and Grade 30 (at 7 curing days) of concrete are utilised as reinforcement: 2.5 percent, 5 percent, 7.5 percent, 10 percent, and 12.5 percent, with a total sample size of ten and one without reinforcement. Mixing, cold compaction with a pressure of 9 tonnes, and sintering in a tube furnace at a temperature of 552°C are used to create AMC specimens. To improve the structural stability of AMC, 1% zinc stearate is employed as a binder during the mixing process.

Table 2. Composition of experiment sample

Sample	1	2	3	4	5	6
Aluminium chip AA7075 (%)	100	97.5	95	92.5	90	87.5
Concrete (%)	0	2.5	5	7.5	10	12.5

All of the specimens were made with a 14mm diameter mould. A uniaxial hydraulic machine, also known as a press machine, was used to perform the cold compaction technique, which had a 9-ton operating pressure and a 20-minute holding period at room temperature. Because high pressure during compaction resulted in a higher density of the specimen, it was done at this high pressure to reduce the material's porosity and improve the results.

2.6 Sintering Process

The sintering procedure was utilised to reduce the specimen's porosity and increase properties like strength. This is because the sintering process changes the microstructure of particles that are close together. The specimens will be located inside the tube furnace and the argon gas will be turned on for 1 hour to ensure that the tube will be occupied with the gas and the air will not be located. Tube furnace will be operated according to the control programme schedule follows the sintering profile. Sintering time will be 7 hours.

After that the temperature will be maintained for 30 minutes to remove the binder which are zinc stearate. Temperature will be steadily increased to sintering temperature at the same heating rate. Subsequently, same temperature will be maintained for 1 hour. Lastly, the sample will be cooled to room temperature will cooling rate of 5°C/min.

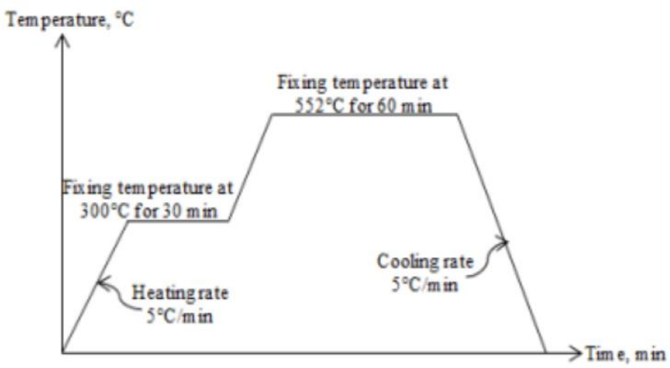

Figure 3. Sintering profile (Joharudin, 2020)

2.7 Physical Test and Hardness Test

Physical tests such as density, water absorption, and porosity were conducted and investigated in this study. An optical microscopic study of the microstructure of the selected specimen was also performed. The goal of this physical examination was to determine the condition of the specimen.

The hardness of the material was measured using a micro-hardness test in this investigation. A very little or thin simple instrument can be used to do this. A Vickers tester with a load of 980.7 mN and a duration of 10 s with eight repeats was used in this experiment.

2.8 Compression Test

The ultimate compressive strength of the specimen was determined using the compression test. When the specimen is subjected to compressive loading, the relationship between stress and strain is identical to when the specimen is subjected to tensile loading. Up to a certain point of tension, the specimen behaved elastically. Plastic deformation commenced when the value was exceeded. The compression test will be handled by using Universal Tester Machine with maximum load of 50KN.

3. Results and Discussion

3.1 Physical Properties

Physical testing was used to determine the relationship between density (g/cm3), apparent porosity (percent), and water absorption (percent) of metal matrix composite samples using the Archimedes principle. The Mettler Toledo weighing machine was used for the density test. The sample must be cooked for three hours in distilled water and then allowed to rest for twelve hours. The density, apparent porosity, and water absorption tests all require this test. . Table 3 show the results of physical test for both grade of waste concrete. Figure 4 will shows the results of the Density test for both grade of waste concrete.

Table 3. Physical test for Waste Concrete Grade 40 and 30

Sample	Density (g/cm^3)	Apparent porosity (%)	Water Absorption (%)
Al 100%	2.5489	12.7531	8.7638
Al 97.5% + Concrete 2.5% + Zinc Stearate 1%	2.3855	24.8361	13.6257
Al 95% + Concrete 5.00% + Zinc Stearate 1%	2.2906	24.5469	13.1000
Al 92.5% + Concrete 7.5% + Zinc Stearate 1%	2.2527	24.3667	12.8987
Al 90% + Concrete 10% + Zinc Stearate 1%	2.2362	22.3389	12.5701
Al 87.5% + Concrete 12.5% + Zinc Stearate 1%	2.1501	18.5200	11.9032

Sample	Density (g/cm^3)	Apparent porosity (%)	Water Absorption (%)
Al 100%	2.5489	12.7531	8.7638
Al 97.5% + Concrete 2.5% + Zinc Stearate 1%	2.5637	28.8505	13.2413
Al 95% + Concrete 5.00% + Zinc Stearate 2%	2.4068	22.5186	13.8930
Al 92.5% + Concrete 7.5% + Zinc Stearate 1%	2.3927	21.1290	12.5903
Al 90% + Concrete 10% + Zinc Stearate 1%	2.2316	20.8152	12.1766
Al 87.5% + Concrete 12.5% + Zinc Stearate 1%	2.1113	14.4422	11.5607

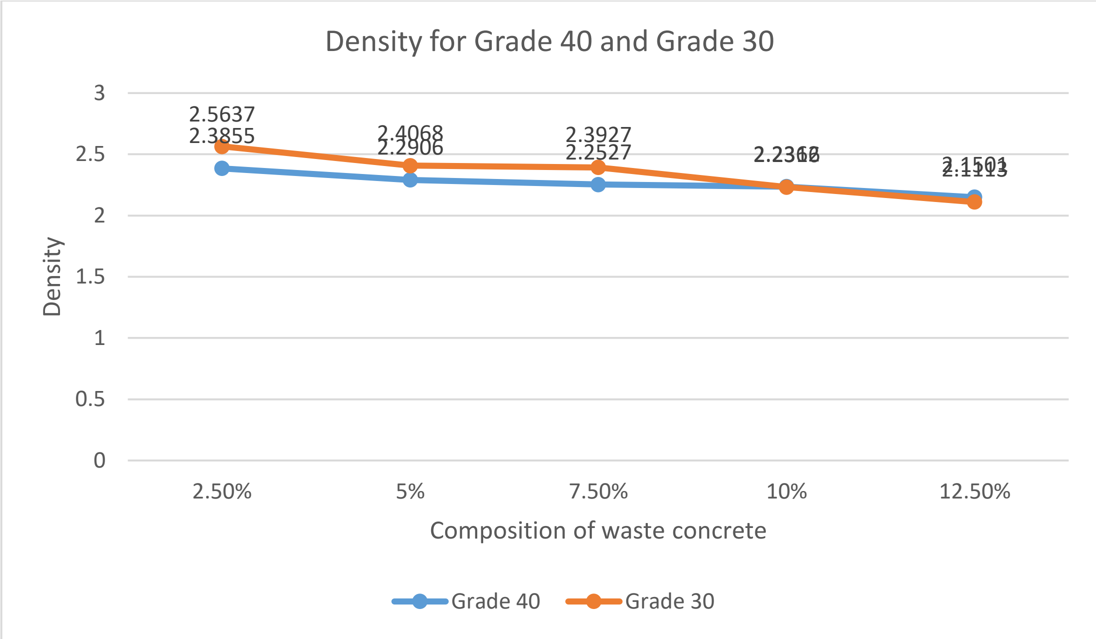

Figure 4. Density for Grade 40 and Grade 30

Density in the aluminium matrix composite was observed to rise with reinforcement percent, however density decreased when porosity levels in the composite increased. The physical parameters of metal matrix composite reinforced waste concrete material and zinc stearate are shown in Figure 2 for Grade 40 and Grade 30. The findings show that when the weight % of waste concrete increases, the density decreases. The results were compared to samples of pure aluminium chips (100 wt%). The density of 2.5 wt % aluminium was 2.3855 g/cm3, which was greater, but the density of 7.5 wt % waste concrete Grade 40 was 2.2527 g/cm3, which was lower. It also had a lower density than the Sample with 100% AA7075, which had a density of 2.5489 g/cm3. It may also be seen in Grade 30 waste concrete, where the density value begins to decline from 100 wt % aluminium at 2.5489 g/cm3 to 2.1113 g/cm3 at 12.5 wt % waste concrete materials. The degradation outcomes of AA7075 reinforced with waste concrete and zinc stearate are then revealed by apparent porosity and water absorption.

3.2 Microhardness Test

By raising the reinforcement percentage or decreasing the reinforcement particle size, the hardness of aluminium matrix composites can be improved. The presence of porosity, on the other hand, has a significant impact on hardness. Microhardness testing is performed on the sample, which is utilised for small or thin composite samples. The test was performed under load of 490.5 µN repeating eight times about 10 minutes duration of time. The test has been performed using standard ASTM E384. Observing the sample that has been placed under the lens after fixing the position. Pressure applied on sample for 10 seconds to indent diamond shape on the sample surface. The sample had an average of eight times hardness indentation. The values of microhardness (Hv) are shown in Table 4. Figure 5 shows the hardness and different composition of waste concrete affected the Hv value.

Table 4. Microhardness Test

Micro-Hardness Vickers test results (Hv) for Grade 40

Element Composition	Composition	Hardness, Hv
A	Al 100%	35.21
B	Al 97.5% + Concrete 2.5% + Zinc Stearate 1%	47.00
C	Al 95% + Concrete 5.00% + Zinc Stearate 1%	33.32
D	Al 92.5% + Concrete 7.5% + Zinc Stearate 1%	49.15
E	Al 90% + Concrete 10% + Zinc Stearate 1%	48.34
F	Al 87.5% + Concrete 12.5% + Zinc Stearate 1%	46.71

Micro-Hardness Vickers test results (Hv) for Grade 30

Element Composition	Composition	Hardness, Hv
A	Al 100%	35.21
B	Al 97.5% + Concrete 2.5% + Zinc Stearate 1%	45.00
C	Al 95% + Concrete 5.00% + Zinc Stearate 1%	55.33
D	Al 92.5% + Concrete 7.5% + Zinc Stearate 1%	46.30
E	Al 90% + Concrete 10% + Zinc Stearate 1%	50.29
F	Al 87.5% + Concrete 12.5% + Zinc Stearate 1%	28.33

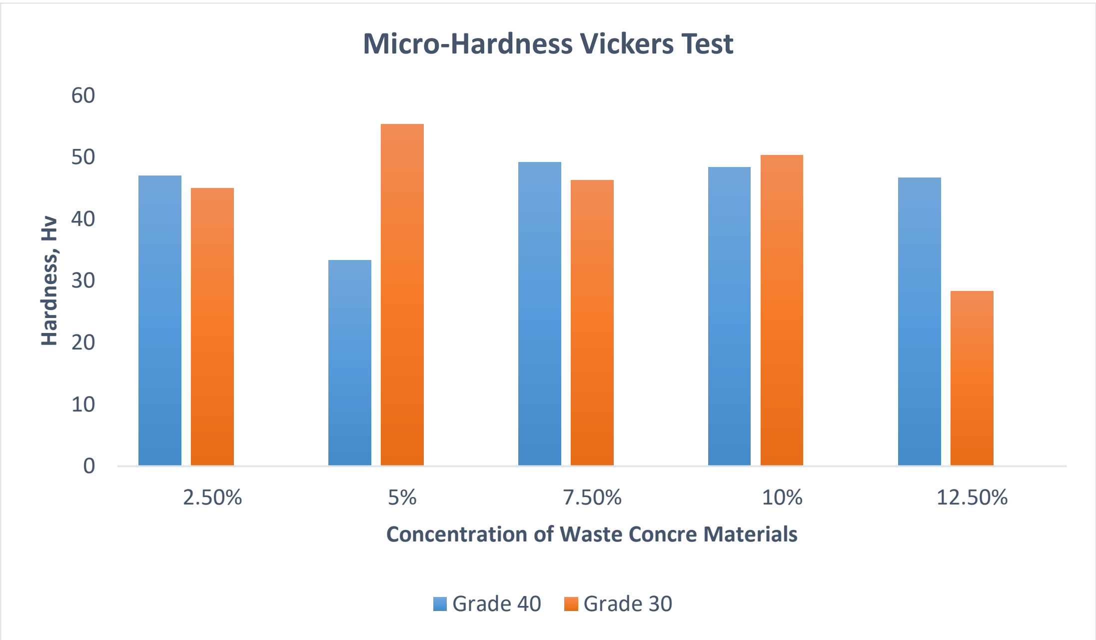

Figure 5. Micro-Hardness Vickers Test

3.3 Compression Test

Through stress and strain, the compression test may evaluate the material's Young's Modulus and stiffness. Compression machine testing was used to compress and distort the sample at a speed of 1mm/min. The sample may be deformed as a result of the compressive load applied to the brittle sample, which can result in a crushed sample during testing, whereas ductile material will have elasticity and plasticity. Table 5 show the value of Young’s Modulus for both grade of waste concrete. From figure 6 Young's Modulus and stiffness strength of AMC were dominated by Aluminium chip AA7075 (95%) + Waste Concrete Materials Grade 40 (5%) + Zinc Stearate (1%) due to the mechanism of reinforcement that nearly balanced with the addition composition of waste concrete materials Grade 40 with 3 wt. percent and Zinc Stearate 1 wt. % of the sample. Grade 30 Aluminium chip AA7075 (95%) + Waste Concrete Materials Grade 40 (5%) + Zinc Stearate (1%) has the highest Young's Modulus and stiffness, indicating that the reinforcement is nearly balanced, with the addition of concrete waste materials and zinc stearate being the main reason for these results.

Table 5. Young’s Modulus Grade 40 and Grade 30

Young’s Modulus for Grade 40

Element Composition	Composition	Young’s Modulus
A	Al 100%	11.310
B	Al 97.5% + Concrete 2.5% + Zinc Stearate 1%	11.176
C	Al 95% + Concrete 5.00% + Zinc Stearate 1%	11.656
D	Al 92.5% + Concrete 7.5% + Zinc Stearate 1%	11.276
E	Al 90% + Concrete 10% + Zinc Stearate 1%	10.411
F	Al 87.5% + Concrete 12.5% + Zinc Stearate 1%	9.113

Young’s Modulus for Grade 30

Element Composition	Composition	Young’s Modulus
A	Al 100%	11.310
B	Al 97.5% + Concrete 2.5% + Zinc Stearate 1%	12.752
C	Al 95% + Concrete 5.00% + Zinc Stearate 1%	13.240
D	Al 92.5% + Concrete 7.5% + Zinc Stearate 1%	10.053
E	Al 90% + Concrete 10% + Zinc Stearate 1%	9.453
F	Al 87.5% + Concrete 12.5% + Zinc Stearate 1%	10.133

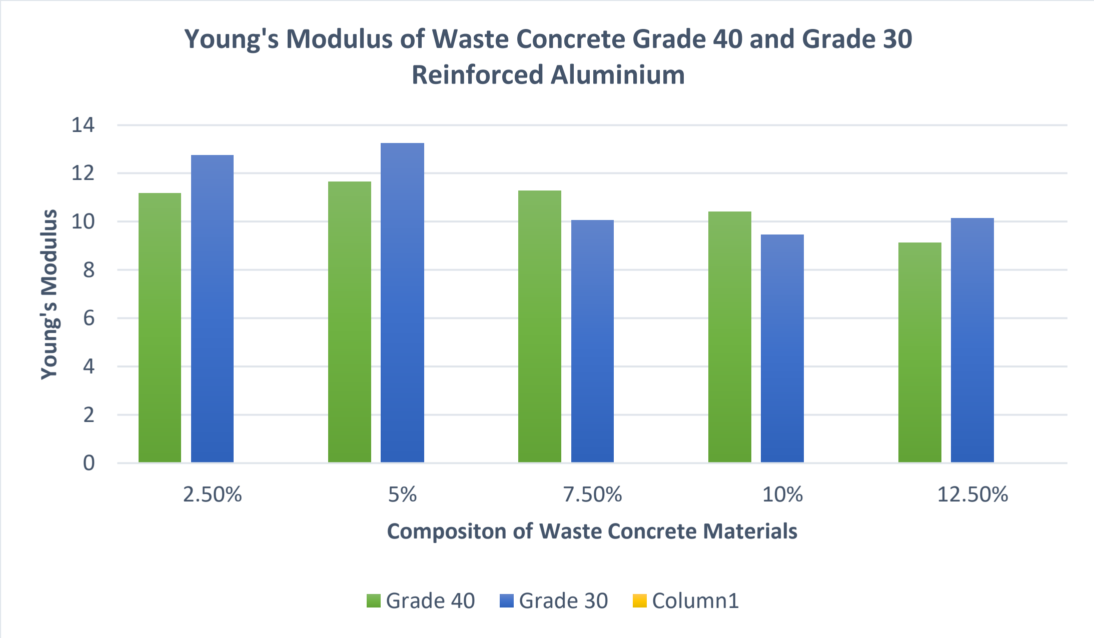

Figure 6. Young's Modulus

4. Conclusion

In conclusion, the summarized of current study is as follows:

1. Waste concrete and Zinc stearate can be used as aluminum matrix composites reinforcing agent and binder.
2. Industrial wastes become economic resources if waste concrete are used to produce composites. This also solves the issue of waste concrete problem of disposal waste.
3. The density of composite metal matrix has been risen to 5 wt% of waste concrete for both grade and then reduced by enhanced mass fraction of waste concrete. The porosity of composite metal matrix increase at increasing composition of waste concrete.
4. The hardness of composite of metal matrixs was seen to be decreased with composite more than 12.5 wt% of waste concrete.

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