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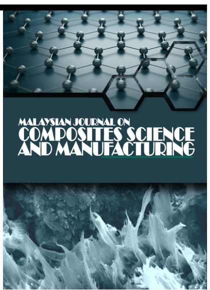

The Effects Strength & Density of Autoclaved Aerated Concrete Containing Semiconductor Electronic Molding Resin Waste (AAC-SEMRW) on Partition Panel Application

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ABSTRACT

Semiconductor Electronic Molding Resin Waste (SEMRW) a byproduct of IC package manufacturing, is widely utilized in the electronics industry. However, recycling this material in an efficient and sustainable manner remains critical, especially for promoting eco-friendly practices in construction. This study focuses on repurposing SEMRW autoclaved aerated concrete (AAC) for partition panel applications. Resin waste obtained from STMicroengineering Sdn Bhd was finely ground to a particle size of 0.1 ± 0.01 mm and incorporated into the AAC mixture in varying percentages—0%, 5%, 10%, 15%, 20%, 25%, and 30% containing with standard amounts of cement, quartz sand, water, and a 3% aluminum paste. The prepared mixtures were molded and curing into autoclaved machine for 4 hours. Experimental results indicated a reduction in both water absorption and pore formation as SEMRW content increased. Microstructural analysis using Scanning Electron Microscopy (SEM) revealed a more compact structure with higher RW proportions. The AAC-SEMRW composition containing 20% resin waste achieved the highest compressive strength values, with 7.29 MPa after 8 hours of curing in Autoclaved Machine. Furthermore, this composition exhibited the greatest residual compressive strength (8.22%) when exposed to elevated temperatures. Based on these findings, the 20% SEMRW formulation is identified as the optimal mixture, offering improvements in water absorption, compressive strength, and thermal resistance. This research contributes to sustainable waste management, provides an innovative green construction material, and enhances the performance of AAC for partition panel applications, reflecting a significant advancement in construction technology.

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1. Introduction

The construction industry is continuously seeking innovative ways to improve material efficiency while simultaneously addressing environmental sustainability concernsAmong these initiatives, there is a lot of interest in using industrial waste as a secondary raw material in building applications. For partition panel applications, one interesting method is to use semiconductor electronics materials with resin waste in autoclaved aerated concrete (AAC) [1]. AAC is light weight, thermal insulation, and easy of construction, making it ideal for non-load-bearing such as partition panels [2]. In addition to improving the physical characteristics of concrete, such as its compressive strength, youthful modulus, modulus of rupture, and density performance, the conversion of resin waste sand into AAC facilitates the effective recycling of industrial waste. Previous research was highlighted the potential benefits of using resin waste in concrete mixtures, with promising results in both material performance and environmental impact [3]. Semiconductor electronic molding resin waste (SEMRW) a byproduct of the semiconductor electronics manufacturing industry, is typically composed of high-performance polymer materials that exhibit excellent strength, thermal stability, and chemical resistance [4]. In 2023, the global semiconductor electronics materials market was valued at USD 62.4 billion and is projected to grow to USD 96.87 billion by 2033, with a CAGR of 4.54% from 2024 to 2033 as shown in Figure 1 [5].

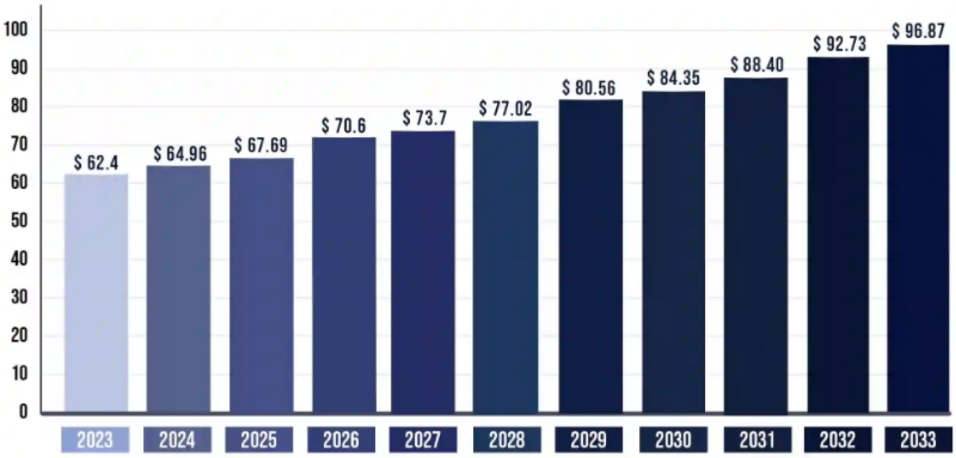

Fig.1. Semiconductor electronics materials market size from 2023 to 2033 [5]

When finely ground and added to concrete mixtures, resin waste has been found to act as sand replacement, contributing to a denser microstructure and improving the mechanical properties of the autoclaved aerated concrete, particularly compressive strength [6]. Salami *et al.,* stated the inclusion of polymeric resin waste in concrete mixtures could fill the voids between cement particles, leading to reduced porosity and enhanced compressive strength [7]. This densification effect is critical in autoclaved aerated concrete (AAC), where the lightweight of the material typically results in a more porous structure compared to conventional autoclaved aerated concrete [8]. The incorporation of resin waste potential effectively by reducing the number and size of pores, thereby increasing the overall compressive strength of the AAC [9].

Previous studies have explored the impact of adding different types of waste materials to AAC, with a particular focus on reducing porosity while maintaining the material's lightweight. Wang and Yusrianto *et al.,* conducted a study on the effect of polymeric resin waste on the microstructure of AAC, finding that the waste particles helped to decrease the porosity of the material [10]. The polymeric resin waste particles act as sand replacement, occupying the voids within the AAC matrix and thereby reducing the total pore volume. This reduction in porosity leads to a corresponding increase in density, which enhances both the mechanical and thermal properties of the AAC [11]. Moreover, the chemical composition of polymeric resin waste, which includes high-performance polymers, provides a stable matrix that resists degradation and maintains properties under mechanical load [12]. Raj *et al.,* investigated the resin waste in improving the durability and structural performance of AAC, concluding that the addition of resin waste could enhance the density of the material while maintaining its lightweight characteristics. This balance between density and porosity is crucial in applications such as partition panels, where both mechanical strength are important considerations [13].

One of the most significant benefits of incorporating SEMRW into AAC is the improvement in compressive strength. Several studies have confirmed that the addition of resin waste to AAC mixtures leads to significant improvements in this area. Manaf *et al.,* demonstrated that AAC containing resin waste exhibited higher compressive strength values compared to traditional AAC, with the waste particles reinforcing the material's internal structure. This is particularly important for partition panels, where compressive strength is a key factor in ensuring the stability and longevity of the construction. The mechanism behind this improvement in compressive strength lies in the interaction between the resin waste particles and the cementitious matrix [14]. Kumar *et al.,* suggested that the high thermal stability of SEMRW allows it to act as a reinforcing agent within the AAC, providing additional support to the concrete matrix under load. The resin waste particles effectively distribute the stress throughout the material, reducing the localized failure and increasing the overall compressive strength [15]. In addition, the polymeric nature of SEMRW allows for greater flexibility within the concrete matrix, which helps to absorb and dissipate energy during mechanical loading.

Another critical aspect of AAC containing SEMRW is its performance at elevated temperatures. AAC is often used in partition panels for buildings, where fire resistance and thermal stability are key considerations. Lalitha explored the thermal performance of AAC incorporating resin waste and found that the material exhibited improved fire resistance compared to traditional AAC. The high thermal stability of the resin waste ensures that the material maintains its structural integrity even at elevated temperatures, making it suitable for applications where fire resistance is essential. The incorporation of SEMRW into AAC not only enhances its compressive strength but also improves its residual strength after exposure to high temperatures [16]. Khan *et al.,* conducted experiments to evaluate the residual compressive strength of AAC containing resin waste after exposure to elevated temperatures. Their findings indicated that AAC with higher proportions of resin waste retained a significant percentage of its original compressive strength even after being subjected to temperatures of up to 600°C [17].

2. Literature Review

The replacement of natural sand in autoclaved aerated concrete (AAC) production has gained significant attention in recent years, driven by the need to address environmental concerns related to replace sand find sustainable alternatives that do not compromise the performance of AAC. Research on sand replacement methods has explored various materials such as fly ash, ceramic waste, quarry dust, and other industrial byproducts. These studies have primarily focused on the impact of sand replacements such as compressive strength, density, porosity, and strength under elevated temperatures [18]. A lightweight building material that is well-known for its fire resistance, thermal insulation, and ease of installation is autoclaved aerated concrete, or AAC. In order to improve sustainability and lessen its impact on the environment, the construction industry has recently placed more emphasis on using different waste materials in place of natural sand for producing AAC. These materials, including fly ash, glass waste, ceramic waste, and resin waste, have been explored for their ability to improve the mechanical and physical properties of AAC, particularly when cured using an autoclaved process under high temperature and pressure [19].

One of the most important mechanical characteristics for assessing the performance of concrete using sand substitutes is compressive strength. The impact of different sand replenishment techniques on the compressive strength of concrete has been the subject of numerous studies conducted between 2018 and 2024. The use of crushed ceramic waste as a partial substitute for sand in concrete was examined by Yusrianto *et al.,*. According to the study, AAC with 30% ceramic waste has a 4.5 MPa compressive strength. The angular shape of ceramic waste particles gave them more compressive strength, which improved the cement-aggregate bond [20]. Similarly, Lam examined the use of fly ash as a sand replacement. The study indicated that a 20% fly ash replacement in AAC led to an increased in compressive strength from 4.2 MPa (control AAC) to 4.6 MPa. The pozzolanic reaction of fly ash improved the microstructure of the concrete, filling voids and leading to enhanced compressive strength. However, other studies have shown more varied results [21]. Noshin *et al.,* explored the use of quarry dust as a sand replacement and observed that although the compressive strength was comparable to conventional concrete at 2.5 MPa, further replacement of sand led to a decrease in strength. For example, at 50% replacement, the compressive strength dropped to 2.0 MPa. The irregular particle size distribution of quarry dust was identified as a contributing factor to the reduction in strength, as it negatively affected the workability and compaction of the mix [22].

The possibility of fly ash, a byproduct of burning coal in power plants, as a substitute for sand in AAC has been extensively researched. When applied in the right amounts, fly ash's pozzolanic qualities can increase the strength and durability of AAC. The effects of substituting fly ash for 20% of the sand in AAC were investigated by Xusheng *et al.,*. Their research revealed that after 28 days of autoclave curing, the fly ash addition raised the compressive strength of AAC from 3.5 MPa (control) to 4.2 Mpa [23]. The higher strength was attributed to the pozzolanic reaction between fly ash and the calcium hydroxide in cement, leading to the formation of additional calcium silicate hydrates (C-S-H). In terms of density, the fly ash AAC showed a slight reduction from 550 kg/m³ to 530 kg/m³, indicating that the material remained lightweight. Porosity also decreased from 21% to 18%, contributing to the improved compressive strength and reducing the permeability of the material [24]. Dwarampudi *et al.,* further investigated the performance of AAC with varying percentages of fly ash (15%, 25%, and 35%) as a sand replacement. It is found the 15% and 25% fly ash AAC showed improvements in compressive strength (4.1 MPa and 3.9 MPa, respectively), the 35% replacement led to a decrease in strength (3.2 MPa), likely due to the excessive fly ash content weakening the matrix. The density decreased as fly ash content increased, with the 35% replacement showing a density of 510 kg/m³, compared to 560 kg/m³ for the control [25]. Porosity also showed a slight increase at higher fly ash percentages, which negatively impacted strength.

Glass waste, primarily derived from recycled glass bottles and industrial glass, has been explored as a sand replacement material in AAC due to its high silica content, which can contribute to the formation of C-S-H during the autoclaving process. Wen *et al.,* studied the replacement of 30% sand in AAC with crushed glass waste. The results indicated that, the compressive strength of the AAC increased from 3.6 MPa (control) to 4.4 MPa after 28 days of autoclaving [26]. This improvement was attributed to the high silica content of the glass, which enhanced the reactivity during the autoclave curing process, leading to a denser microstructure. The density of the AAC increased slightly from 580 kg/m³ to 600 kg/m³ due to the finer particle size of the glass waste, which reduced the porosity from 20% to 17%. The study also reported that the compressive strength after exposure to elevated temperatures (600°C) was 3.5 MPa, demonstrating good residual strength and thermal stability [27].

Salahaddin *et al.,* explored the use of varying percentages of glass waste (10%, 20%, and 30%) in AAC. It is demonstrating that the 20% and 30% glass replacement enhanced compressive strength (4.2 MPa and 4.5 MPa, respectively), 10% replacement showed no significant improvement over the control. The density remained within the range of 550–590 kg/m³, and porosity decreased as the glass content increased, with the 30% replacement showing the lowest porosity at 16%. After exposure to elevated temperatures, the 30% glass AAC retained 80% of its original strength, showing excellent thermal resistance [28].

Ceramic waste, often sourced from the demolition of ceramic tiles and other building materials, has been investigated for its ability to replace sand in AAC, particularly due to its high strength and durability. Meena *et al.,* conducted a study on replacing 25% of the sand in AAC with crushed ceramic waste. The results showed that the compressive strength of the AAC increased from 3.2 MPa to 3.8 MPa after 8 hours of autoclaving. The increased strength was attributed to the angular nature of the ceramic particles, which improved the interlocking within the cement matrix. The density of the ceramic AAC was slightly higher than the control (570 kg/m³ compared to 550 kg/m³), while porosity decreased from 22% to 18%. The compressive strength after exposure to elevated temperatures (500°C) was 3.1 MPa, suggesting that ceramic waste AAC had good thermal stability [29]. Tanash *et al.,* investigated the use of 15%, 30%, and 45% ceramic waste as sand replacement in AAC. The study found that 30% ceramic waste replacement resulted in the highest compressive strength of 4.0 MPa, while 45% replacement led to a reduction in strength (3.3 MPa), likely due to the excessive ceramic content disrupting the matrix. The density of the AAC ranged from 540 to 590 kg/m³, and porosity was lowest at 30% ceramic waste replacement (17%). After exposure to elevated temperatures, the 30% ceramic waste AAC retained 85% of its original compressive strength, showing excellent performance under thermal stress [30].

Fly ash, glass waste, ceramic waste, and resin waste have all been shown to enhance compressive strength, reduce porosity, and improve thermal stability when used in appropriate proportions. Fly ash and glass waste, in particular, exhibited significant improvements in compressive strength and reduced porosity, while ceramic and resin waste showed excellent residual strength after exposure to elevated temperatures. The findings highlight the potential of these waste materials to not only improve the performance of AAC but also contribute to more sustainable and eco-friendly construction practices.

3. Methodology

3.1 Preparation of AAC-SEMRW samples

STMicroelectronics Sdn Bhd, situated in the Muar Industrial Area of Johor, produces semiconductor electronic moulding resin waste (SEMRW). The trash was subsequently processed into granules in the Concrete Technology Workshop, UTHM Pagoh, using Fritsch's Planetary Mono Mill Pulverisette 6 Classic Line from Germany. Following the British Standard Specification for Test Sieves (BS 410), the resin waste was sieved using Cooper Technology's Sieve Shaker. As shown in Figure 2, sieves with 0.6 mm openings were used to obtain the required particle size of 0.6 ± 0.05 mm. Other sieve sizes of resin waste were not included in further production phases or additional examination.

Each sample's raw components were weighed using the mixing proportions listed in Table 1. The aluminium (Al) powder measurement errors were within ±0.02g, whereas the water and powder material measurement errors were within ±0.1g. In sample F, for instance, the ingredients were mixed in the following ratios: water (0.65%), cement (23%), lime (7%), sand (40%), and SEMRW (30%). An Allefix 2100W electric mixer was used to combine these materials for around fifteen minutes. To create a slurry, Al powder (0.1%) was then added and agitated for a further 15 seconds. After filling a mould two-thirds of the way with the slurry, it was gently agitated to cause air bubbles to rise to the top. The slurry expanded and filled the mould entirely in Figure 3 after the reaction, which lasted for around 30 minutes. For samples with codes CS through E, this procedure was repeated. After two hours of pre-curing at ambient temperature, the slurry was hydrothermally cured for eight hours at 200°C and 12 bar of pressure in an autoclave.

Fig.2. Material preparation (a) Resin waste (RW) from IC packages electronic industry; (b) Grinder Machine Fritsch's Planetary Mono Mill Pulverisette 6 Classic Line (c) Grinded resin waste

Table 1
The Different Composition of AAC-SEMRW as sand replacement

Sample Number	Sample of different ratio	Sand		Lime (%)	Cement (%)	Aluminum Paste (%)	Water (%)
		Sand (%)	SEMRW (%)				
CS-0	Control Sample (CS)	70.00	0.00	7	23	0.1	0.65
A-05	Sample A_ 65S_5SEMRW	65.00	5.00	7	23	0.1	0.65
B-10	Sample B_ 60S_2G_10SEMRW	60.00	10.00	7	23	0.1	0.65
C-15	Sample C_ 55S_2G_15SEMRW	55.00	15.00	7	23	0.1	0.65
D-20	Sample D_ 50S_2G_20SEMRW	50.00	20.00	7	23	0.1	0.65
E-25	Sample E_ 45S_2G_25SEMRW	45.00	25.00	7	23	0.1	0.65
F-30	Sample F_ 40S_2G_30SEMRW	40.00	30.00	7	23	0.1	0.65

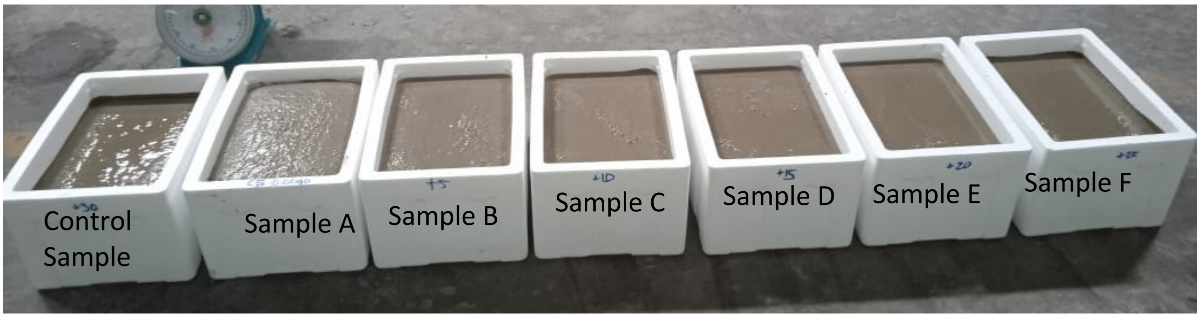

Fig. 3. The different composition of slurry in the box mold of AAC-SEMRW for sand replacement method

4. Results & Discussions

4.1 Compressive Strength Analysis

The AAC-SEMRW properties including compressive strength, Young's modulus, and modulus of rupture (MOR), were investigated. The results, summarized in Table 2, indicate that these properties were affected by the SEMRW content. With the appropriate composition, SEMRW was found to improve the compressive strength of the samples.

Table 2
The compressive strength, specific strength, modulus Young and modulus of rupture of AAC with different SEMRW contents

Sample Number	Compressive Strength (MPa)	Modulus Young (GPa)	Modulus Rupture (MPa)
CS-0	5.08	0.54	1.34
A-05	6.29	0.56	1.59
B-10	6.81	0.57	1.70
C-15	7.11	0.60	1.76
D-20	7.90	0.63	1.93
E-25	6.73	0.58	1.68
F-30	4.53	0.55	1.22

Figure 4 shows the compressive strength of AAC at various SEMRW contents. The data shows that the compressive strength increases with higher SEMRW content, rising from 6.29 MPa at 5% SEMRW to 7.90 MPa at 20% SEMRW, reflecting an increase of 23.3% to 55.5%. The maximum compressive strength of 7.90 MPa was observed at 20% SEMRW. This increase in strength is likely due to the pozzolanic effect of the resin waste. The optimal sample was found to be AAC containing 20% by weight of SEMRW. All SEMRW samples met the requirements for grade-6 based on their compressive strength values, except for the 30% SEMRW sample. According to the physical standards of AAC (ASTM C1693), AAC with compressive strength ranging from 4.8 MPa to 6.6 MPa qualifies as "AAC grade-6."

Resin waste typically contains significant levels of reactive silica and alumina phases, which makes its pozzolanic activity a valuable addition to cementitious materials Perez-Cortes *et al.,* [31]. The beneficial effects of pozzolanic materials on the compressive strength of AAC have also been studied by Zhuohui *et al.,* [32]. Similarly, Anand *et al.,* demonstrated that pozzolanic materials can positively impact the durability of AAC. Pozzolanic reactions contribute to the formation of tobermorite, which is the primary phase in AAC and plays a critical role in enhancing the compressive strength of the material [33]. Additionally, Mohsen *et al.,* observed that pozzolanic materials improve the long-term strength of Portland cement binders by reacting with the calcium hydroxide ($Ca(OH)_2$) generated during cement hydration [34]. This reaction further strengthens the mechanical and physical properties of AAC, a finding supported by Fode *et al.,* who also investigated the positive impact of pozzolanic materials on AAC's mechanical and physical properties [35].

In this study, it is suspected that the resin waste played a similar role in improving the compressive strength of the samples. According to Wenze *et al.,* an appropriate amount of resin waste can enhance the strength of concrete. However, when the resin waste content increased from 25% to 30%, a decrease in compressive strength was observed, although the strength remained approximately 32.3% higher than the control sample at 25% resin waste content [36]. As explained by Shaofeng *et al.,* this reduction in strength could be due to an insufficient amount of calcium hydroxide formed during cement hydration, leading to unreacted silica. The decline in compressive strength of AAC may also be attributed to the high volume of resin waste, which could cause some silica to remain unreacted [37].

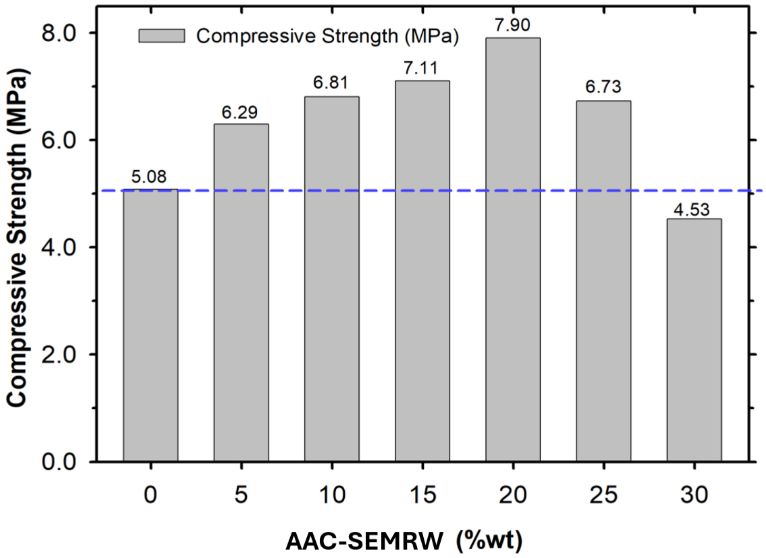

Fig. 4. The compressive strength of AAC with different SEMRW contents

4.2 Modulus Young & Modulus Rupture Analysis

Figure 5 shows the Young's modulus and the modulus of rupture of fresh AAC with varying SEMRW concentrations. Indicating that Young's modulus increases linearly with compressive strength, the results for both parameters are consistent. Specifically, compressive strength causes a 20% weight increase in Young's modulus. The results demonstrate a clear linear relationship between Young's modulus and compressive strength. Aerated concrete's modulus of elasticity, sometimes referred to as Young's modulus, can be described as a function of both density and compressive strength, with both increasing as the two variables do Gonglian *et al.,* [37]. Young's modulus and compressive strength in lightweight concrete have also been linked by other researchers, such as Poongodi and Murthi. According to their research, lightweight concrete's Young's modulus rises linearly with its compressive strength [38]. The modulus of elasticity for autoclaved aerated concrete can also be described as a function of density and compressive strength, increasing with increasing density and compressive strength, according to Kothapally *et al.,* [39].

However, there is currently no formula available to represent the elastic modulus for densities ranging from 1120 to 1440 kg/m^3, with existing equations overestimating collected data by 16% to 104% Devi *et al.,* [40]. Moreover, there is a dearth of published studies and information regarding the Young's modulus of AAC. Similar to Young's modulus, the modulus of rupture shows a linear relationship with compressive strength (see Figure 5). This linear relationship arises when the modulus of rupture is stated as a function of compressive strength. The modulus of rupture, sometimes referred to as flexural strength, tensile strength, or bending strength, is used to assess a specimen's strength prior to failure. The modulus of rupture increased when the SEMRW level increased, despite the fact that it only increased by 15% by weight. At 15% SEMRW concentration, the greatest modulus of rupture, 0.72 MPa, was recorded. This peak value was consistent with the samples' maximum compressive strength and Young's modulus readings.

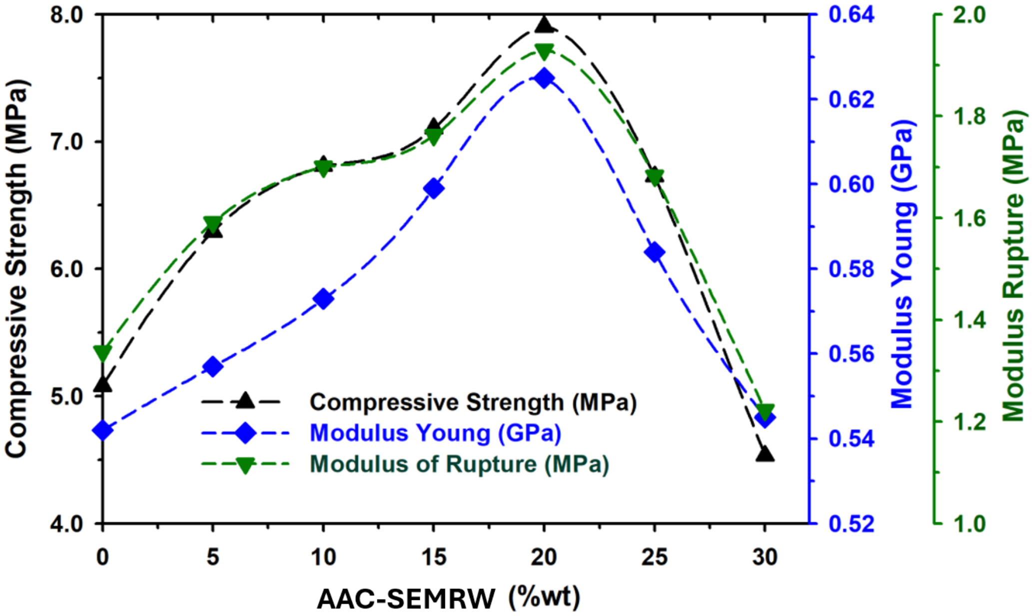

Fig. 5. The correlation between the modulus Young and modulus of rupture with compressive strength of AAC versus different SEMRW contents

4.3 Bulk Density Analysis of AAC-SEMRW

The bulk density of AAC-SEMRW with varying compositions is displayed in Figure 6. The bulk densities increase gradually from 0.61% to 1.95% for SEMRW weights ranging from 5% to 25%. For 15% SEMRW, the highest bulk density was 605.29 kg/m3, or 1.95% higher than that of the control sample (CS1). However, the bulk density gradually decreased from 603.49 kg/m3 to 592.65 kg/m3 as the SEMRW increased from 20% to 30% wt. Every sample's bulk density was greater than CS, with the exception of 30% SEMRW. The influence of the sample's various placements throughout the autoclaving process is the reason for the decreased bulk density for 20% SEMRW to 30% SEMRW. Furthermore, the bulk density was determined using ASTM C1693-09 without a drying procedure, resulting in samples with varying water contents.

The results showed that the bulk density of the samples was barely affected by the substitution of SEMRW for natural sand. The tiny particle sizes of both SEMRW, which have similar densities, may be the cause of this. A uniform dispersion of tiny particles and spaces was the result of the SEMRW utilised in this investigation being substantially finer than quartz sand. The constant weight distribution among the samples was facilitated by this homogeneous distribution. This observation is consistent with research by Mingyaun *et al.,* who examined the AAC density utilising waste materials in place of sand. AAC-SEMRW has a bulk density ranging from 593.71 kg/m3 to 605.29 kg/m3. The bulk density value indicated that AAC-CW1 did not satisfy the requirements for grade-2 AAC. According to ASTM C1693-09, grade-2 AAC has a standard dry density of 400–500 kg/m3 and a maximum dry density limit of 550 kg/m3 [41].

The CS density exceeded the AAC grade 2 density restriction by 7.95%. The density result was still below 10% of the maximum dry density restriction, with the exception of AAC-15SEMRW. All density measurements, meanwhile, exceed the typical dry density by more than 10%. Significant variance is shown by the greatest error in bulk density, which was found to be 21.06% for 15% SEMRW when compared to the maximum normal dry density. Furthermore, AAC-CW1's bulk density was 13.97% to 16.40% higher than the required density of 520 kg/m³. The 15% SEMRW had the largest variation, 16.40%. Since the samples were not properly ventilated in an oven set at temperatures between 212 and 230°F (100 and 110°C) for at least 24 hours, this higher bulk density may be the result of insufficient drying conditions [42].

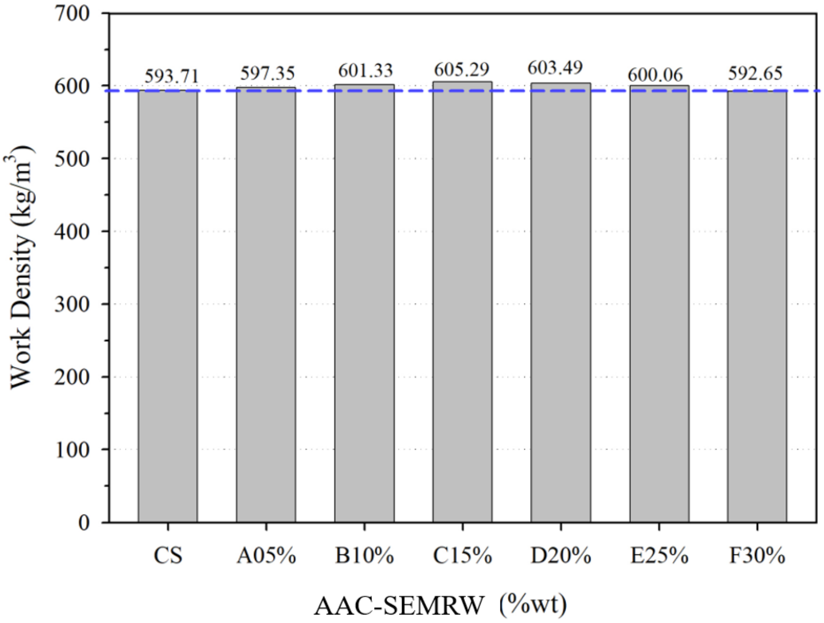

Fig. 6. The work density of AAC with different SEMRW contents

4. Conclusions

This research explored the effects of semiconductor electronic molding resin waste (SEMRW) on the properties of autoclaved aerated concrete (AAC). The results indicated a positive relationship between SEMRW content and the compressive strength of AAC, with values increasing from 6.29 MPa at 5% SEMRW to a peak of 7.90 MPa at 20% SEMRW. This improvement translates to a substantial increase of 23.3% to 55.5%, positioning 20% SEMRW as the ideal composition for maximizing compressive strength. Remarkably, all SEMRW-containing samples met the requirements for AAC grade-6, as specified by ASTM C1693, except for the sample containing 30% SEMRW, which exhibited weakened strength. The materials characteristics of the resin waste contributing to the enhancement of compressive strength, aligning with previous research that highlighted the role of pozzolanic materials in improving the durability and mechanical properties of AAC. The findings also revealed that increasing the SEMRW content up to 15% positively influenced the modulus of rupture. Additionally, the Young's modulus and modulus of rupture analysis exhibited a linear correlation with compressive strength, further emphasizing the interrelation of these mechanical properties. The bulk density of AAC-SEMRW showing a gradual increase with SEMRW content up to 25%, followed by a decline at 30% SEMRW. The fine particle size of SEMRW facilitated a uniform distribution within the AAC matrix enhancing the overall performance of the material. This research highlights the potential of utilizing SEMRW as a sustainable alternative in AAC production, providing advantages such as improved compressive strength, mechanical properties, and minimal effects on bulk density. The findings contribute to advancing waste management strategies within the construction sector supports the development of environmentally friendly building materials.

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References

[1] Aydın, Merve, and H. Alperen Bulut. "Evaluation of the effect of E-waste on the permeability properties of polymer concrete composites and their behavior in aggressive environments." *Archives of Civil and Mechanical Engineering* 24, no. 3 (2024): 194. https://doi.org/10.1007/s43452-024-01006-4

[2] Michelini, Elena, Daniele Ferretti, Lorenzo Miccoli, and Fulvio Parisi. "Autoclaved aerated concrete masonry for energy efficient buildings: State of the art and future developments." *Construction and Building Materials* 402 (2023): 132996. https://doi.org/10.1016/j.conbuildmat.2023.132996

[3] Rafiza, Abdul Rahman, Ahmad Fazlizan, Atthakorn Thongtha, Nilofar Asim, and Md Saleh Noorashikin. "The physical and mechanical properties of autoclaved aerated concrete (AAC) with recycled AAC as a partial replacement for sand." *Buildings* 12, no. 1 (2022): 60. https://doi.org/10.3390/buildings12010060

[4] Danish, Aamar, Mohammad Ali Mosaberpanah, Togay Ozbakkaloglu, Muhammad Usama Salim, Kiran Khurshid, Muhammed Bayram, Mugahed Amran, Roman Fediuk, and Diyar N. Qader. "A compendious review on the influence of e-waste aggregates on the properties of concrete." *Case Studies in Construction Materials* 18 (2023): e01740. https://doi.org/10.1016/j.cscm.2022.e01740

[5] Prescedence Research. *"Semiconductor Mataerials Market Size Report 2024-2033." Semiconductor Materials Market*, Retrieved on Sept, 2024 at https://www.precedenceresearch.com/semiconductor-materials-market

[6] Priyan, M. Vishnu, R. Annadurai, George Uwadiegwu Alaneme, Durga Prasad Ravella, S. Pradeepkumar, and Bamidele Charles Olaiya. "A study on waste PCB fibres reinforced concrete with and without silica fume made from electronic waste." *Scientific Reports* 13, no. 1 (2023): 22755. https://doi.org/10.1038/s41598-023-50312-z

[7] Salami, Babatunde Abiodun, Ashraf A. Bahraq, Mohd Moin ul Haq, Opeyemi A. Ojelade, Ridwan Taiwo, Sarmed Wahab, Adeshina Adewale Adewumi, and Mohammed Ibrahim. "Polymer-enhanced concrete: A comprehensive review of innovations and pathways for resilient and sustainable materials." *Next Materials* 4 (2024): 100225. https://doi.org/10.1016/j.nxmate.2024.100225

[8] Feng, Wudi, Zhen Li, Qing Long, Shengwen Tang, and Yunfeng Zhao. "Study on the properties of autoclaved aerated concrete with high content concrete slurry waste." *Developments in the Built Environment* 17 (2024): 100338. https://doi.org/10.1016/j.dibe.2024.100338

[9] Zou, Dujian, Zichao Que, Dongchen Su, Tiejun Liu, Ao Zhou, and Ye Li. "Sustainable use of recycled autoclaved aerated concrete waste as internal curing materials in ultra-high performance concrete." *Journal of Cleaner Production* 373 (2022): 133910. https://doi.org/10.1016/j.jclepro.2022.133910

[10] Yusrianto, Efil, Noraini Marsi, Izzati Abdul Manafb, and Hafizuddin Hakim Shariff. "Performance of Autoclaved Aerated Concrete (AAC) Containing Recycled Ceramic and Gypsum Waste as Partial Replacement for Sand." *International Journal of Nanoelectronics and Materials (IJNeaM)* 17, no. 3 (2024): 452-458. https://doi.org/10.58915/ijneam.v17i3.1168

[11] Fatriliani, I.S., Rosidawani, Hanfiah, Iqbal, M.M., and Idris, Y. *"Mechanical and Physical Characteristics of Aerated Concrete with Fly Ash Variantions." Journal of Advanced Reseach in Applied Sciences and Engineering Technology*, vol.34, no.2 (2024): 374-385 https://doi.org/10.37934/araset.34.2.374385

[12] Abhilasha, Rajesh Kumar, Rajni Lakhani, Raghav Kumar Mishra, and Shahnavaz Khan. "Utilization of solid waste in the production of autoclaved aerated concrete and their effects on its physio-mechanical and microstructural properties: alternative sources, characterization, and performance insights." *International Journal of Concrete Structures and Materials* 17, no. 1 (2023): 6. https://doi.org/10.1186/s40069-022-00569-x

[13] Raj, Amit, Arun Ch Borsaikia, and Uday S. Dixit. "Bond strength of Autoclaved Aerated Concrete (AAC) masonry using various joint materials." *Journal of Building Engineering* 28 (2020): 101039. https://doi.org/10.1016/j.jobe.2019.101039

[14] Manaf, Izzati Abdul, Noraini Marsi, Efil Yusrianto, Muhammad Hafifi Daniel Salamat, Noraniah Kassim, Mariah Awang, Hafizuddin Hakim Shariff, Mohd Ridzuan Mohd Jamir, and Roslinda Ali. "Evaluation of physical properties of autoclave aerated concrete (AAC) based glass-gypsum waste into concrete." *Malaysian Journal of Chemical Engineering and Technology (MJCET)* 5, no. 1 (2022): 1-7.

[15] Kumar, Gaurav, Tushar Bansal, Moinul Haq, Utsav Sharma, Amit Kumar, Pooja Jha, Dayanand Sharma, Hesam Kamyab, and Edison Alejandro Villacreses Valencia. "Utilizing E-Waste as a Sustainable Aggregate in Concrete Production: A Review." *Buildings* 14, no. 8 (2024): 2495. https://doi.org/10.3390/buildings14082495

[16] Lalitha, G. "Development of high strength Sustainable E-Waste concrete." *Materials Today: Proceedings* 51 (2022): 2479-2484. https://doi.org/10.1016/j.matpr.2021.11.623

[17] Khan, Mohsin Ali, Mian Muhammad Usman, Fahad Alsharari, Ahmed M. Yosri, Fahid Aslam, Majed Alzara, and Marwa Nabil. "Metaheuristic artificial intelligence (AI): Mechanical properties of electronic waste concrete." *Construction and Building Materials* 394 (2023): 132012. https://doi.org/10.1016/j.conbuildmat.2023.132012

[18] Vishnupriyan, M., R. Annadurai, Kennedy C. Onyelowe, and Nakkeeran Ganasen. "Review on electronic waste used as construction materials-a scientometric analysis." *Cogent Engineering* 10, no. 2 (2023): 2283307. https://doi.org/10.1080/23311916.2023.2283307

[19] Volk, R., J. J. Steins, P. Stemmermann, and F. Schultmann. "Comparison of different post-demolition autoclaved aerated concrete (AAC) recycling options." In *IOP Conference Series: Earth and Environmental Science*, vol. 1078, no. 1, p. 012074. IOP Publishing, 2022. https://doi.org/10.1088/1755-1315/1078/1/012074

[20] Yusrianto, Efil, Noraini Marsi, Izzati Abdul Manaf, Hafizuddin Hakim Shariff, and Noraniah Kassim. "Effects of compressive strength and young modulus of gypsum-ceramic waste on autoclaved aerated concrete (GCW-AAC)." In *AIP Conference Proceedings*, vol. 2955, no. 1. AIP Publishing, 2023. https://doi.org/10.1063/5.0182547

[21] Lam, N. N. "Influence of fly ash and recycled AAC waste for replacement of natural sand in manufacture of Autoclaved Aerated Concrete." In *IOP Conference Series: Earth and Environmental Science*, vol. 505, no. 1, p. 012001. IOP Publishing, 2020. https://doi.org/10.1088/1755-1315/505/1/012001

[22] Noshin, Sadaf, Ali Hamza, Muhammad Uzair, Hafiz M. Shahzad Aslam, Atteq Ur Rehman, Mazhar Yasin, Frooq Mustafa Joyia et al. "Effect of quarry dust on mechanical properties of rice husk ash-based concrete for sustainable environment." *International Journal of Nanoelectronics and Materials (IJNeaM)* 17, no. 2 (2024): 194-203. https://doi.org/10.58915/ijneam.v17i2.683

[23] Xusheng, Du, Xu Zhe, Li Junjiang, and Wang Lei. "Effects of lime content on properties of autoclaved aerated concrete made from circulating fluidized bed ash." *Developments in the Built Environment* 18 (2024): 100406. https://doi.org/10.1016/j.dibe.2024.100406

[24] Ding, Xiaobo, Hangyu Du, Enfeng Wu, Peng Yi, Yongqiang Li, Yaoming Luo, and Wei Liu. "Investigating the Hydration, Mechanical Properties, and Pozzolanic Activity of Cement Paste Containing Co-Combustion Fly Ash." *Buildings* 14, no. 5 (2024): 1305. https://doi.org/10.3390/buildings14051305

[25] Dwarampudi, Manasa, and B. Venkateshwari. "Performance of light weight concrete with different aggregates—a comprehensive review." *Discover Civil Engineering* 1, no. 1 (2024): 46. https://doi.org/10.1007/s44290-024-00015-9

[26] Wen, Bo, and Xuefeng Wang. "Study on the preparation and properties of glass powder autoclaved aerated concrete." In *Advances in Frontier Research on Engineering Structures*, pp. 504-513. IOS Press, 2023. https://doi.org/10.3233/ATDE230240

[27] Kozhageldi, Nurtay, Chang Seon Shon, Inzhu Yerbolat, Islam Orynbassarov, Dichuan Zhang, and Jong Ryeol Kim. "Thermal Performance Evaluation of Non-Autoclaved Aerated Concrete Produced with Crushed Waste Glass Bottle Aggregate and Glass Fiber." In *Materials Science Forum*, vol. 1077, pp. 243-249. Trans Tech Publications Ltd, 2022. https://doi.org/10.4028/p-1689hp

[28] Salahaddin, Sevar Dilkhaz, James H. Haido, and George Wardeh. "The behavior of UHPC containing recycled glass waste in place of cementitious materials: A comprehensive review." *Case Studies in Construction Materials* 17 (2022): e01494. https://doi.org/10.1016/j.cscm.2022.e01494

[29] Meena, Ram Vilas, Jinendra Kumar Jain, Harshwardhan Singh Chouhan, and Ankit Singh Beniwal. "Use of waste ceramics to produce sustainable concrete: A review." *Cleaner Materials* 4 (2022): 100085. https://doi.org/10.1016/j.clema.2022.100085

[30] Tanash, Alaa Omar, Khairunisa Muthusamy, Ahmed Mokhtar Albshir Budiea, Muhammad Ashraf Fauzi, Gul Jokhio, and Rajan Jose. "A review on the utilization of ceramic tile waste as cement and aggregates replacement in cement based composite and a bibliometric assessment." *Cleaner Engineering and Technology* 17 (2023): 100699. https://doi.org/10.1016/j.clet.2023.100699

[31] Perez-Cortes, Pedro, Ines Garcia-Lodeiro, María Cruz Alonso, and Francisca Puertas. "Cementation of spent radioactive ion-exchange resin ashes using alkali-activated cements: Physicochemical and structural

changes." *Cement and Concrete Composites* 149 (2024): 105517. https://doi.org/10.1016/j.cemconcomp.2024.105517

[32] Ma, Zhuohui, Linbo Jiang, Hongqiang Liao, and Fangqin Cheng. "Research on the methods for improving the compressive strength of solid waste-based high-strength autoclaved aerated concrete." *Construction and Building Materials* 361 (2022): 129645. https://doi.org/10.1016/j.conbuildmat.2022.129645

[33] Anand, Pradyut, Anand Kumar Sinha, and Puja Rajhans. "Statistical modeling for strength prediction in autoclaved aerated concrete blocks manufactured with construction and demolition waste utilization." *Practice Periodical on Structural Design and Construction* 28, no. 4 (2023): 04023048. https://doi.org/10.1061/PPSCFX.SCENG-1330

[34] Mohsen, Mohamed O., Mervat O. Aburumman, Malak M. Al Diseet, Ramzi Taha, Mu'tasim Abdel-Jaber, Ahmed Senouci, and Ala Abu Taqa. "Fly ash and natural pozzolana impacts on sustainable concrete permeability and mechanical properties." *Buildings* 13, no. 8 (2023): 1927. https://doi.org/10.3390/buildings13081927

[35] Fode, Tsion Amsalu, Yusufu Abeid Chande Jande, and Thomas Kivevele. "Effect of natural pozzolana on physical and mechanical properties of concrete." *Advances in Civil Engineering* 2024, no. 1 (2024): 3356641. https://doi.org/10.1155/2024/3356641

[36] Geng, Wenze, Chunguang Li, Deliang Zeng, Jiayou Chen, Hongtao Wang, Zhenzhong Liu, and Longcheng Liu. "Effect of epoxy resin surface-modified techniques on recycled coarse aggregate and recycled aggregate concrete." *Journal of Building Engineering* 76 (2023): 107081. https://doi.org/10.1016/j.jobe.2023.107081

[37] Zhang, Shaofeng, Ditao Niu, and Daming Luo. "Enhanced hydration and mechanical properties of cement-based materials with steel slag modified by water glass." *Journal of Materials Research and Technology* 21 (2022): 1830-1842. https://doi.org/10.1016/j.jmrt.2022.10.001

[38] Poongodi, K., and P. Murthi. "Correlation between compressive strength and elastic modulus of light weight self-compacting concrete using coconut shell as coarse aggregate." *Australian Journal of Structural Engineering* 22, no. 2 (2021): 85-95. https://doi.org/10.1080/13287982.2021.1926061

[39] Kothapally, Thangamani, Ushadevi Patil, Chigullapally Mounika, Gandi Mounika Naidu, and Evgeny Vladimirovich Kotov. "Experimental investigation on strength characteristics of autoclave aerated concrete block using natural pozzolanas." In *MATEC Web of Conferences*, vol. 392, p. 01005. EDP Sciences, 2024. https://doi.org/10.1051/matecconf/202439201005

[40] Devi, Ningombam Reena, Prateek Kumar Dhir, and Pradip Sarkar. "Influence of strain rate on the mechanical properties of autoclaved aerated concrete." *Journal of Building Engineering* 57 (2022): 104830. https://doi.org/10.1016/j.jobe.2022.104830

[41] Zhang, Mingyuan, Huayan Yao, Yuting Liu, Jiarui Gan, and Lingxiao Tang. "Pore characteristics and mechanical behaviors of autoclaved aerated concrete produced from coal bottom ash and tailings." *Engineering Reports* 6, no. 3 (2024): e12834. https://doi.org/10.1002/eng2.12834

[42] Khunt, Yash, Vatsal Nathwani, Hetavi Patel, Tejas Joshi, and Dhiren Gandhi. "Investigation on properties of autoclave aerated concrete using different pre-curing and curing techniques." *Materials Today: Proceedings* (2023). https://doi.org/10.1016/j.matpr.2023.04.047