UNIVERSITI TEKNOLOGI MARA

JIIICaS 2024
JOHOR INTERNATIONAL INNOVATION, INVENTION COMPETITION AND SYMPOSIUM

PROCEEDINGS OF JOHOR INTERNATIONAL INNOVATION INVENTION COMPETITION AND SYMPOSIUM 2024 (JIIICaS 2024)

"Flourish and Nurturing Sustainable Innovation for a Prosperous Nation"

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JOHOR INTERNATIONAL INNOVATION, INVENTION COMPETITION AND SYMPOSIUM

Editorial Board

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Preface

In the name of Allah, the Almighty who gives us the enlightenment, the truth, the knowledge and with regards to Prophet Muhammad (peace be upon him) for guiding us to the straight path. We thank to Allah for giving us guidance and strength to write this e-book.

This e-book compiles the extended abstracts that submitted to Johor International Innovation Invention Competition and Symposium 2024 (JIIICaS2024), where JIIICaS2024 is a virtual platform for all creative minds to share and present their invention and innovation. Each abstract gives a brief background on the innovation or project.

We hope that this e-book will help the readers to get to know the innovation done by the students and get some ideas to develop future innovation products.

Foreword Rector

Assalamualaikum warahmatullahi Wabarakatuh, Salam Sejahtera, Salam Malaysia MADANI and Salam UiTM Dihatiku.

In the name of Allah, the Most Gracious, the Most Merciful.

It is a great honor to welcome you to the Johor International Innovation, Invention, Competition, and Symposium 2024 (JIIICaS 2024). This event connects various disciplines, focusing on education and engaging educators, students, researchers, and innovators from all walks of life.

Innovation is not just about ideas; it demands perseverance, creativity, and determination to turn those ideas into reality. The remarkable projects showcased today highlight the dedication and spirit of all participants. Initiatives like this not only explore new technologies but also cultivate skills and leadership among our youth. At Universiti Teknologi MARA (UiTM) Johor Branch, we are fully committed to fostering a dynamic culture of innovation, promoting the commercialization of new products, and encouraging meaningful collaborations with industry and society.

As we celebrate this event, I would like to extend my heartfelt gratitude to all sponsors, judges, the College of Computing, Informatics and Mathematics, UiTM Pasir Gudang Campus as the event organizer, as well as to the researchers and participants for their hard work in making this event a success. Let us continue striving for innovation and excellence. May the ideas presented today inspire us and lay the groundwork for future achievements.

Thank you.

Associate Professor Dr. Saunah Zainon
Rector
Universiti Teknologi MARA (UiTM)
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(A-ST121) EPRCA INTERLOCKING BLOCK

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ABSTRACT

Construction waste is expected to increase in step with the projected 50% increase in global egg production and consumption by 2035. This growth is mainly due to the impact of increasing construction activity caused by faster urbanisation and population growth. In addition, poor strategic planning and management of projects often leads to mistakes such as poor execution, excessive ordering of materials and incorrect storage, which increases the amount of waste. This increased output of waste leads to environmental problems that coincide with simultaneous economic expansion, limited landfill capacity and strict waste disposal laws. The main objective of this study is to evaluate the flexural strength of Interlocking blocks (IB) under three-point loading containing 30% recycled concrete aggregate (RCA) instead of sand and eggshell powder (ESP) instead of cement. Pozzolanic materials, 10% silica fume and admixtures and 1% superplasticiser (Sika ViscoCrete-2192) are added to the combination. Compression tests were carried out to determine the ideal percentage of eggshell powder (5%, 10% and 15%). The strengths were determined after a curing time of 7, 14 and 28 days. The result shows that the addition of 30% recycled concrete aggregate and 5% eggshell powder to the blocks increases their compressive and flexural strength. The use of ESP and RCA at 5% and 30% respectively to replace cement and fine aggregate therefore has a major impact on improving the critical performance of IBS.

Keywords: interlocking block, cement, eggshell powder, sand, recycled concrete aggregates

1.0 INTRODUCTION

Sustainable development in the construction industry can be advanced through the recycling and utilization of construction and demolition waste (CDW), including recycled concrete aggregate (RCA). While RCA helps reduce waste and conserve natural resources, challenges such as higher porosity, lower density, and alkali-silica reactions (ASR) require ongoing research for mitigation and management. As the global concrete demand grows, driven by rising populations, the need to conserve resources and minimize waste becomes increasingly important. Malaysia, with a population of 29.4 million in 2019, will see further growth in residential demands, exacerbating the pressure on natural resources.

Old eggshells (ES) from pastry shops, quick food establishments, and chick incubators create big problems for the environment when they sit in landfills untreated over many

years, causing damage to nearby ecosystems and triggering allergy symptoms. However, it can turn those leftover eggshells into a powder and use it in construction, replacing regular lime in concrete. This not only lowers the amount of cement needed but also recycles wasted eggshells. An even better idea is to use eggshell powder (ESP) instead of cement altogether. It's a sustainable alternative since eggshells are widely available trash materials. Previous research says that ES is actually a major environmental issue among bio-waste types. Incorporating such unwanted stuff like ES into mortar mixes can help make building processes more environmentally friendly and promote waste reduction campaigns.

Research is focused on creating sustainable interlocking blocks (IB) with RCA, addressing issues like excessive weight, poor adaptability, and functional constraints seen in solid block designs. The goal is to develop eco-friendly interlocking block designs that improve construction adaptability, functionality, and offer lightweight solutions. Bridging the gap between pavement-oriented interlocking block designs and limited options for structural applications is crucial. Prioritizing environmental consciousness, waste reduction, and efficient resource management within the evolving technology landscape is essential for the construction industry to successfully shift towards a circular and regenerative model.

2.0 OBJECTIVE

This study's primary goal is to determine the flexural strength of interlocking blocks (IB) with three points of loading that consist of 30% recycled concrete aggregate (RCA) in place of sand and eggshell powder (ESP) in place of cement under three different loading scenarios.

3.0 METHODOLOGY

This research focuses on the development and evaluation of sustainable concrete mixtures, incorporating recycled materials such as eggshell powder (5%, 10%, 15%) and recycled concrete aggregates (30%), alongside cement, silica fume (10%), sand, and a superplasticizer (1%). Two sets of concrete samples with dimensions of 50mm x 50mm x 50mm and 160mm x 40mm x 40mm were prepared and subjected to compression and flexural tests at 3, 7, 28, and 56 days of curing. A total of 84 samples across seven mix designs were tested to determine the mechanical properties of the mixtures. Compression tests were conducted on 36 cube samples (50mm x 50mm x 50mm) to ascertain their ultimate compressive strength according to ASTM C140/C140M-18 standards and ISO/IEC 17025 accredited procedures. These tests aimed to measure the resistance of the concrete to crushing forces and assess the quality of the hardened material.

Additionally, the study introduced three designs of interlocking blocks, each sized at 280mm x 125mm x 100mm, cured for 7, 14, and 28 days, totalling 18 samples as shown in table 1. The flexural strength of these blocks was evaluated using a Universal Testing Machine, adhering to BS EN 13523-7(2001) standards. The test results provide insight into the blocks' structural performance and load-bearing capabilities prior to failure. Drawing from British Standard BS 6073 – 1:1981, the interlocking block designs, including a control interlocking block (CIB) and the Single Inclined Connection Interlocking Block (SICIB) illustrated in figure 1, were crafted to meet specific

dimensions and performance criteria. The SICIB features inclined interlocking elements inspired by tongue and groove joints, coupled with a chamber edge design, to improve the engagement and structural integrity of masonry walls. The research aims to enhance the sustainability and efficiency of construction materials and methods, contributing valuable data on the use of waste materials in concrete production and the efficacy of innovative interlocking block designs.

Table 1: The list of interlocking concrete blocks samples and the total

No	Sample	Curing Age (Days)		
		7	14	28
1	Control Design	3	3	3
2	Single Inclined Connection Interlocking Block	3	3	3
Total Sample		6	6	6

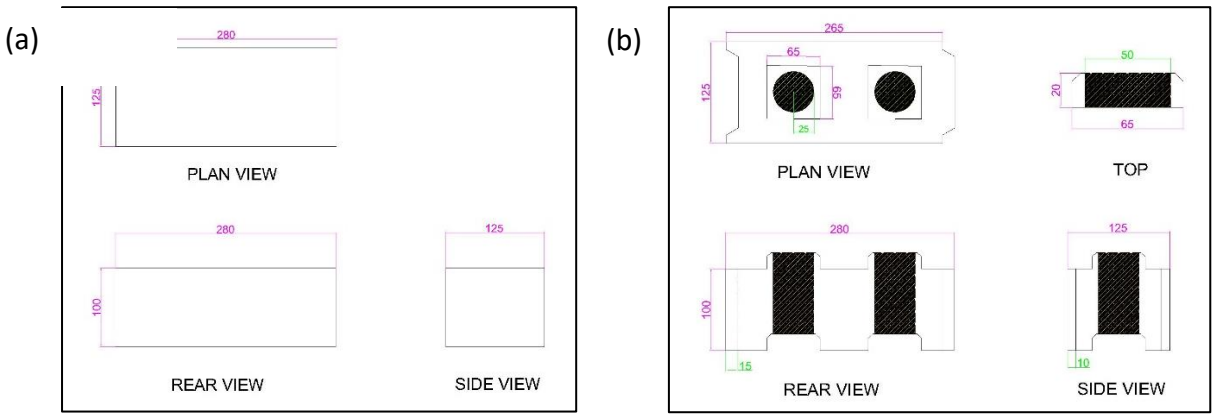

Figure 1: The schematic diagram: (a) control interlocking block (CIB); (b) single inclined connection interlocking block (SICIB)

4.0 RESULTS

Table 2 presents the relationship between the average compressive strength of hardened mortar containing eggshell powder (ESP) and 30% recycled concrete aggregates (RCA). Higher ESP percentages and extended curing times result in improved strength, with samples containing 5% ESP showing a strength increase from 18.18 MPa to 38.12 MPa between 3 and 56 days of curing. However, compressive strength varies depending on the ESP percentage and curing duration. Increasing ESP content raises initial compressive strength for example, at 3 days, 5%, 10%, and 15% ESP led to 18.18 MPa, 18.72 MPa, and 17.26 MPa, respectively. Highest compressive strength starting with 10% ESP, followed closely by 5% ESP but it had increased the strength at 7 days to 56 days. Meanwhile 15% ESP be the second highest compression strength compared to 10% ESP. This highlights the significance of optimizing ESP percentage to attain desired strength properties in mortar mixes, demonstrating that moderate ESP amounts contribute to stronger mortar while higher percentages may not result in additional gains.

Table 2: Compression strength of hardened mortar cube

Days	3	7	28	56
Control	19.12	23.37	35	38.18
5%	18.18	23.78	37.59	38.12
10%	18.72	18.38	28.16	28.84
15%	17.26	20.98	30.60	31.35

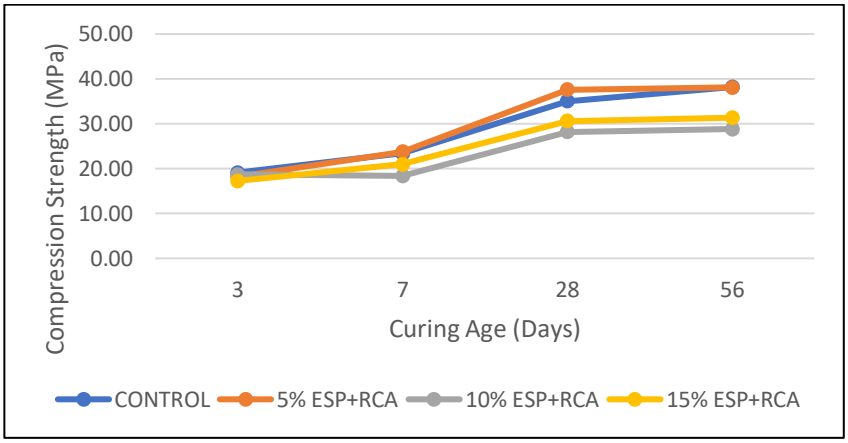

Figure 2: Comparison of compression strength of cubes

The study discussed in the extended abstract explores the usage of eggshell powder (ESP) and 30% recycled concrete aggregates (RCA) as a viable cement substitute and sand substitute in concrete mixtures. Blends comprising 5%, 10%, and 15% ESP, together with a consistent 10% silica fume (SF) content, demonstrated comparable strength levels to control samples without ESP. However, the ideal replacement ratio for ESP, considering the flexural strength tests, proved to be 5% as shown in table 2 and have been illustrated in figure 2. The 5% ESP mixture surpassed the control sample's flexural strength at 7 and 28 days, whereas the control sample outperformed at 3 and 56 days. Still, the 15% ESP mixture exhibited comparable strength to the control at 3 days but had a slight decrease at 28 days, and a significant drop at 56 days. When ESP substitution went beyond 5%, the mortar's strength declined at all ages compared to the control. This reduction in strength indicates that excessive ESP weakens the cement-aggregate bonds, resulting in decreased flexural strength when ESP replacement surpasses the recommended 5%. Furthermore, employing ESP in combination with SF promotes the conservation of natural resources, making a 15% substitution of ESP with SF environmentally friendly.

The study discusses the performance of control interlocking blocks and single inclined connection interlocking blocks (SICIB) of various ages. Table 3 reveals that the average maximum force for SICIB is 4.099 N/mm^2 in control mixture and 3.677 N/mm^2 for 5% ESP+RCA mixture, occurring at 28 days, while the 7 days samples exhibit a minimum strength of 2.828 N/mm^2. Both SICIB and CIB display a progressive increase in stress from 7 days to 28 days. The difference between SICIB and CIB strength values remains relatively small; however, CIB reaches its peak stress earlier. Both types of blocks show an upward trend in average strength, but CIB reaches its optimum values earlier, suggesting a better performance. Although the 28 days SICIB sample shows a decrease in strength compared to the CIB, it still maintains a high level. Moreover, the average load difference between SICIB and CIB are acceptable, although both of them shows better performance within the difference of the design.

According to Figure 3, the blue bar and line represent the control sample, while the yellow bar and line signify the 5% ESP+RCA mixture, making the distinction between various designs evident. Ultimately, the investigation uncovers that the SICIB and CIB exhibit comparable performance.

Table 3: Average flexural strength of CIB and SICIB

No	Sample	Control Sample			5% ESP+RCA		
		7	14	28	7	14	28
1	Control Interlocking Block (CIB)	5.333	6.334	10.000	4.240	4.539	5.162
2	Single Inclined Connection Interlocking Block (SICIB)	2.828	2.984	4.099	3.577	3.585	3.677

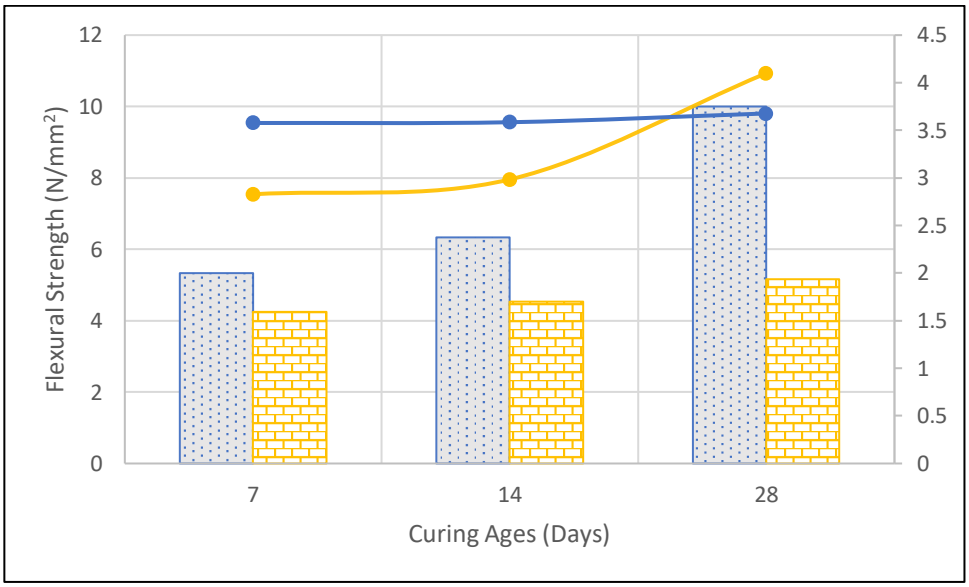

Figure 3: Comparison of CIB and SICIB by control sample and 5% ESP+RCA

5.0 CONCLUSION

In nutshells, the construction industry can really benefit from following circular economy ideas, such as reusing materials from demolished buildings. One good example is using recycled concrete aggregate (RCA) instead of normal aggregates in concrete. Although there are problems when adding RCA to interlocking blocks, people are actively working on solving these issues and making the performance of alternative materials better. There is an increasing need for greener building materials, so it's important to keep looking for new ways and innovations to build in an eco-friendly manner. By paying attention to the environment, reducing waste, and using new technologies, the construction industry can change to be more sustainable and renewable. Research suggests that adding eggshell powder (ESP) in mortar production, particularly at a 5% replacement of cement, is a smart choice that considers both performance and sustainability. Utilizing alternative materials like ESP can help build greener structures without losing important features. Paying close attention to the right mixture ratios, like using RCA instead of fine aggregates, will

makes sure that the performance is maximized and the change to sustainable construction is smoother.