UNIVERSITI TEKNOLOGI MARA

EXPERIMENTAL AND ACOUSTIC EMISSION INVESTIGATION OF RECYCLED CONCRETE AND EXPANDED PERLITE AGGREGATE DAPPED WET CONNECTIONS FOR PRECAST CONCRETE WALL PANELS

AMRIL HADRI BIN JAMALUDIN

Thesis submitted in fulfilment
of the requirements for the degree of
Doctor of Philosophy
(Civil Engineering)

Faculty of Civil Engineering

February 2026

ABSTRACT

The utilization of precast wall panels has gained prominence due to its potential for enhancing construction speed, quality, and sustainability. One critical aspect of precast construction is the connection between wall panels, where it is one of the proven to be the weakest link in the system. Rigidity of the connection between panels was also a point of concern. This study was a part of bigger project in developing a new precast wall system with recycled concrete aggregate (RCA) and expanded perlite aggregate (EPA) in partial replacing natural fine aggregate, with primary and secondary objectives were to investigate the mechanical performance of the dapped wet connection models and their variations which are dapped wet (T1), horizontally lightly reinforced dapped wet (T2), vertically lightly reinforced dapped wet (T3), and cross dapped wet (T4) in the vertical wall-to-wall connection in application for precast wall panels, by focusing on shear load, respectively. The third objective was to assess the damage occurred with respect to their crack propagations through visual inspection, which was then verified using acoustic emission (AE) technique in the fourth objective. The investigation includes experimental testing that includes three pair of specimens for each connection type which are then subjected to shear loading to evaluate their shear strength capacity, strain, and connection flexibility behaviour as well as the resulting crack propagation throughout the test. The test was verified through Acoustic Emission (AE) technique using Location Events and Energy Level (eu) parameter. In terms of maximum shear load, the proposed T2 (230.06 kN) sample shows significant improvement when compared to their control, followed by T1 (143.35 kN), and T3 (109.22 kN). Sample of T4 (171.18 kN) however show a significant drop in maximum shear load compared to its control (225.5 kN). All proposed samples of T2, T3, and T4 shows a diagonal crack pattern on the wall panels, with T4 shows the most distinctive diagonal crack paths due to the geometrical confinement of the connection. AE overlay maps confirmed that cracking initiated and intensified primarily in the interface region, with sample of T4 follows complex fracture evolution, albeit with lowest peak AE energy. In conclusion, T2 and T3 emerged as the most structurally reliable in terms of shear loadings where the incorporation of light reinforcement, combined with the use of RCA and EPA offered a well-balanced trade-off between strength, stiffness, flexibility, as well as ductility. The findings of this study will contribute to a better understanding of the behavior of dapped wet connection and its variations and provide preliminary guidance for their design in precast concrete wall panels.

ACKNOWLEDGEMENT

First and foremost, I would like to thank you Allah for His blessing. I would also like to express my most sincere gratitude to my main supervisor, Prof. Madya Dr. Noorsuhada Md. Nor for giving the opportunity to me in pursuing this study. Her patience in giving me an opportunity to learn acoustic emission technique and application, as well as supervising my work were greatly appreciated. Her guidance, encouragement and support throughout the research as well as her enthusiasm and understanding have always encouraged me to move forward with confidence.

I would also like to thank my co-supervisor, Prof. Dr. Azmi Ibrahim, for both his guidance, encouragement, and supports throughout the research.

I would also like to thank Pusat Kecemerlangan Kejuruteraan dan Teknologi JKR (CREaTE) (grant no. JAR 2001) for providing financial support for this research, including Ir. Nor Azian Binti Aziz, Ir. Dr. Thong Jia Wen, Mrs. Fatma Sakinah Binti Razali, and Mr. Muhammad Afiq Bin Tambichik in providing valuable information, advice and technical support on my work.

Special thanks to all technician at the Heavy Structural Laboratory and Concrete Laboratory, Faculty of Civil Engineering, Universiti Teknologi MARA (UiTM) Shah Alam and Universiti Teknologi MARA (UiTM) Cawangan Pulau Pinang, Kampus Permatang Pauh, who have always lent a helping hand when needed especially Mr. Muhammad Tarmizi Ismail, Mr. Mohd. Salleh Abdullah, Mr. Habibullah Mahmud, Mr. Azri Syafiq Kamarozaman, Mr. Baharuddin Bahrol Zaman, Mr. Mohd. Shahmir Mohd. Said, Mr. Shahrilnizam Abd. Samad, and Mr. Mohd. Shafrizat Mohd Sumali. I would also like to thank his friends and families, including Dr. Soffian Noor Mat Saliah for valuable advice, as well as their continuous support during the completion of this thesis.

Finally, this thesis is dedicated to my wife, Raja Noor Fazliani Binti Raja Ibrahim, my lovely kids, Ahmad Firash Bin Amril Hadri, Amni Farisha Binti Amril Hadri, and Ali Farish Bin Amril Hadri, and both my father and mother, Jamaludin Bin Ya'acob, and for their continuous support and encouragement.

TABLE OF CONTENTS

CHAPTER 1
INTRODUCTION

1.1 Background of Study

In the contemporary construction industry, the Industrialised Building System (IBS) has emerged as a transformative force, revolutionizing traditional building practices through its emphasis on efficiency and innovation. The IBS, characterized by its streamlined and prefabricated components, has become instrumental in addressing the increasing need for swift, cost-effective, and sustainable construction solutions. Among the various components of IBS, precast wall panels play a pivotal role, serving as essential elements that contribute to the overall efficiency and quality of construction projects.

According to the Construction Industry Development Board (CIDB) Malaysia, IBS is classified into five categories: precast concrete framed buildings, precast concrete wall buildings, reinforced concrete buildings with precast concrete slabs, steel formwork systems, and steel-framed buildings and roof trusses. Typical IBS precast concrete components used in Malaysia's construction industry include structural elements, non-structural elements, and connections (CIDB, 2017).

Precast wall panels, particularly when used in non-load bearing applications, offer numerous advantages in terms of speed and ease of construction. Vertical wall-to-wall connections, which link these panels together, are critical in ensuring the panels' stability and overall structural integrity. While these walls are not designed to bear significant loads, the connections still need to be carefully designed and constructed to ensure proper alignment, resistance to environmental factors, and longevity of the system. Traditional connection methods, such as grout-filled with steel connectors, can sometimes lead to issues related to alignment, cracking, and durability. These problems can compromise the overall performance and longevity of the system. The quality of the connections can impact the performance of the wall system, especially in terms of minimizing movement, preventing cracks, and maintaining durability over time. To overcome these challenges, this research proposes the development of an alternative connection design that enhances durability, reduces cracking, and improves the overall alignment of non-load bearing walls in IBS applications.