UNIVERSITI TEKNOLOGI MARA

PERFORMANCE OF DRY MIX PRESSURE COMPACTED CONCRETE INCORPORATING EXPANDED POLYSTYRENE AS WALL PANEL

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ABSTRACT

Dry mix concrete (DMC) is vital to enhance speedy concrete production but to ensure a sustainable environment, replacing the aggregates with lightweight crushed expanded polystyrene (EPS) waste materials is recommended. However, entrained air in the EPS with zero force is a significant concern that can produce an inferiority of strength in the DMC. Since the incorporation of EPS in DMC reduced workability and cohesiveness, leading to weak bonding between the composite mix, the method of compaction with pressure was employed for DMC. This research aimed to analyse the statistical data and optimise the design mixture of dry mix concrete with EPS (EPS-DMC) according to the maximum strength and appropriate density. Then, the EPS-DMC was assessed for its morphology characterisation, mechanical properties and thermal conductivity (k-value) by the hot box method. Besides that, another objective was to determine the ultimate load of EPS-DMC as a lightweight slender wall panel. This study was investigated three variables, including the three mix proportions of cement with sand (c:s) of 1:3, 1:3.5, and 1:4; the partial EPS replacement by volume at 0%, 35%, 40%, 45%, 50%, and 55%; and the different levels of pressure compaction at 500 psi, 600 psi, and 700 psi. Using Analysis of Variance (ANOVA), the design model by three factors interaction was found to fit with the response of compressive strength and density, which this model was significant. The optimum concrete design mixture of 1:3 with 45% EPS replacement (3EP45) at 700 psi was confirmed from the optimisation of the design mixture simulated via the Response Surface Method. The optimum design mixture of EPS-DMC was adopted for the wall panel for testing under compression uniformly distributed load (UDL) and eccentric load by experimental work and FEA by Abaqus software. The FEA results exhibited the ultimate load, displacement and stress-strain similar to the experimental work. The findings show that the EPS-DMC maximum compressive strength achieved in 3EP45 is 17.97 N/mm^2, with a density of 1797 kg/m^3. It discovered that EPS-DMC increased its strength by up to 45% of EPS replacement and decreased its performance by 50% of EPS. The modulus of elasticity, flexural strength and pulse velocity of EPS-DMC were all found to agree with the compressive strength. The EPS affected the microscale structure at the interfacial transition zone (ITZ) since the accumulated water around the crushed EPS enhanced cement hydration. Meanwhile, the micro-pores formed outside the aggregate in control DMC specimen due to less water for cement hydration, where the air pockets were trapped. For the thermal conductivity, the k-value reduced from 1.53 W/m°C to 0.47 W/m°C in the range of 0% to 50% EPS replacement and the k-value appropriate function is directly proportional to the density property. The ultimate load subjected to UDL and eccentric loadings were 872 kN and 587 kN, respectively. The stress value of the double-stack wall panel was significantly lower than the single-stack wall panel, as it was affected by a reduction of the stress resistance to fracture at a high slenderness ratio. However, the panel without reinforcement exhibited better post-peak behaviour than the panel with reinforcement. The lack of cohesiveness of the DMC was responsible for the weak stress in the centre section where the reinforcement was embedded. Finally, this research concluded that the EPS-DMC has the potential to be used as a wall panel, where it can withstand the applied load. The new EPS-DMC design was realised via the use of pressure compaction execution ideal for lightweight structural concrete produced with concrete consolidation, strength, and performance credibility.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

Most of our society's community centres, buildings and indispensable infrastructure development are built and installed using dry mix concrete (DMC) (Amhudo et al., 2018). Due to the DMC products performing time effectiveness and profitability, the dry casting concrete industry has experienced tremendous growth. (Sulistyana et al., 2014). Furthermore, using DMC on-site saves the cost of 35% by preventing damage due to concrete adhesion to the wall formwork, 10 % by reducing the time scaffoldings are needed and 25 % in brick wall erection (Willis, 1969; Sulistyana et al., 2014). Thus, it shows that the DMC is still relevant for all construction needs and shares normal concrete's origin comprising of aggregates in the cement matrix and sustainability attributes.

Despite this, using normal concrete from conventional wet casting cannot support the high capacity of concrete production. The wet casting concrete must sit for 24 to 48 hours to set up, properly cure and stiffen before being stripped out of the mould. Moreover, preparing for the next cast requires scrubbing and coating with oil that lubricates the mould. It ensures the concrete is easily released once it has dried and prevents it from sticking to the mould to produce a uniform hard finish surface with precise dimensions. For instance, the early strength of wet casting concrete is lower than DMC casting because it requires a certain period for strengthening and perfect hydration (Panesar and Chidiac, 2007; Matalkah et al., 2021).

On the other hand, the processes of DMC introduce a low amount of water during mixing with the corresponding concrete mixture. The DMC is required to cast through the pressure compaction method, due to it has zero slump. Consequently, DMC has a minimal separation between aggregate particles since the air voids in the mixture are escaped, rapidly improving compressive strength (Sulistyana et al., 2014). Thus, incorporating pressure compaction for DMC reduces shrinkage and creep because most of the aggregates are directly in contact with each particle rather than divided by the cement-water paste during the wet casting (Willis, 1969).

In some circumstances, the DMC research is still being exhausted to enhance its