

A critical review on mechanical and durability properties of concrete containing fly ash and waste glass as partial replacement of cement and sand

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ABSTRACT: With the population growth and continuous development, the concrete demand is increasing years by years. The similar phenomena also applicable to its raw materials. However, the exploitation of concrete raw materials will result in various types of environmental issues. Therefore, it is significant to seek alternative materials for the concrete raw materials such as fly ash and waste glass. Hence, the objective of this paper is to review and summarize the effect of using fly ash (FA) and waste glass (WG) as cement and sand replacement on the concrete properties. From the previous studies, it reveal that using FA as cement replacement able improve the compressive strength, split tensile strength and durability performance of concrete due to the pozzolanic reaction and filler effect of FA. In addition, it infer that using WG as sand replacement also beneficial to the mechanical and durability performance of concrete. It is because of the pozzolanic reaction of WG. Also, it is due to the angular shape of WG where it able provide better interlocking bond between cement and glass sand. Lastly, it notices that combine use of FA and WG will also bring positive effects on the concrete properties, no matter used as cement or sand replacement. In conclusion, the concrete properties will experience some improvements if it is incorporated with suitable replacement percentage of FA and WG.

Keywords: *Fly ash; Waste glass; Concrete replacement*

1. INTRODUCTION

Concrete is a construction material that composed by cement, coarse aggregate, sand and water [1]. The application of concrete is very widely due to its variety of advantages [2]. Therefore, with the population growth and continuous development, the concrete demand is increasing years by years. The similar phenomena also applicable to its raw materials. However, the exploitation of concrete raw materials will result in various types of environmental issues. For instance, approximately 1 ton of carbon dioxide will be released for every ton of cement production and the released carbon dioxide is the domain contributor to the greenhouse effect and global warming [3].

Furthermore, in order to reduce environment deterioration and also move toward the sustainable development, it is significant to seek alternative materials for the concrete production. In the past, there are much

research had been conducted to seek concrete alternative materials from the waste products or recyclable materials. The materials used including fly ash, silica fume, waste glass and plastic [4]. Hence, in order to make readers having a direct views on the topic of concrete replacement, this paper going to review and summarize the effect of alternative materials on the concrete properties where the paper will only focus on the effect of FA and WG.

2. EFFECT OF FLY ASH ON CONCRETE PROPERTIES

Fly ash is a waste product of coal combustion in the power plant. Typically, it is used as cement replacement material in the concrete production. In year 2013, Reddy [5] infer that the compressive strength, split tensile strength and acid attack resistance of concrete will be improved if incorporating appropriate percentage of FA. The improvement is because of the pozzolanic reaction and also filler effect of FA. In addition, the study also reveal that the optimum replacement percentage of FA are 20% for mechanical properties and 15% for durability performance.

Other than the strength properties, Manomi *et al.* [6] also conclude that the incorporation of FA is beneficial to the durability performance of concrete. It present that the higher the replacement percentage of FA, the lower the sorptivity value. This statement also supported by Chand *et al.* [7] which revealed that the chloride penetration resistance of concrete is being improved after replacing cement with a combination of FA and silica fume. The improvement is due to the filler effect of FA and silica fume. The voids in concrete are filled which caused the permeability of concrete is reduced.

3. EFFECT OF WASTE GLASS ON CONCRETE PROPERTIES

Waste glass representing unwanted or disposed glass products whereas glass products is products that formed from the super-cooling of a mixture. The mixture comprised by soda ash, silica, limestone and so on. Typically, the WG can be used as cement replacement or sand replacement in the concrete production. In this paper, the effect of using WG as sand replacement on the concrete properties will be focused.

In year 2020, Tamanna *et al.* [8] infer that the compressive strength, split tensile strength and flexural strength of concrete will be improved if adding suitable

replacement percentage of WG. It is because of the angular shape of WG able provide better interlocking bonding between the glass particles and cement. In contrast, the strength properties of concrete will experience some reductions if replacing excess quantity of WG. It is because of the excess quantity of WG will weaken mechanical bond of concrete. In the next year, the similar results also obtained by Steyn *et al.* [9]. However, Steyn *et al.* [9] has revealed different opinions on the improvement and reduction of concrete strength. It state that the improvement is because of the pozzolanic reaction of WG and the reaction will result in the formation of denser concrete structure. On the other hand, Steyn *et al.* [9] infer that the reduction is because of the excess quantity of WG will increase the brittleness of concrete.

Other than the strength properties, Tamanna *et al.* [8] also revealed that incorporating appropriate replacement percentage of WG will bring benefits to the durability performance of concrete. The study present that the chloride ions penetration resistance is being improved up to 40% of WG replacement. Once the replacement percentage excess 40%, the resistance is decreasing. It is because of the excess quantity of WG will result in voids formation. It is because of the excess quantity of WG will result in voids formation. In addition, the study also conclude that using small particle size of WG as sand replacement able reduce the alkali silica reaction (ASR) expansion. It is because the small size of WG able reduce the penetration of alkali, prevent the formation ASR gel and reduce the expansion

4. BINARY EFFECT OF FLY ASH AND WASTE GLASS ON CONCRETE PROPERTIES

In year 2001, Tuncan *et al.* [10] had conducted a research which aim to investigate the effect of using a combination of FA and WG as cement replacement on the concrete properties. The replacement percentage used are 10%FA+15%WG, 20%FA+15%WG as well as 30%FA+15%WG. The study reveal that the compressive strength and split tensile strength of fly ash glass based concrete are being improved. It is because of the incorporation of FA and WG has create a denser concrete structure. This statement also being supported by the Verma and Varshey [11] who obtaining similar results as Tuncan *et al.* [10]. In addition, the Tuncan *et al.* [10] and Ali [12] also reveal that the incorporation of FA and WG in the concrete is beneficial to its durability performance. The water permeability resistance of concrete being improved due to the formation of denser concrete structure.

5. CONCLUSION

From the above, it can conclude that:

- The mechanical and durability performance of concrete will be improved with appropriate replacement percentage of FA. It is because of the pozzolanic reaction and filler effect of FA.
- The mechanical and durability performance of concrete will be improved with appropriate

replacement percentage of WG. It is because of the pozzolanic reaction and also the better interlocking bonding that provided by the angular shape of WG.

- The binary use of FA and WG in the concrete replacement is feasible and it will bring positive influences on the concrete properties.

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