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Performance of Concrete Using Light Waste PET Fibre

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Abstract. The volume of polymeric wastes like polyethylene terephthalate bottles (PET) is increasing at a fast rate. PET bottles annual consumption represents more than 300,000 million units. The majority of the PET waste is sent to landfill. Since PET waste is not biodegradable, it can remain in nature for hundreds of years. Previous investigations already confirmed the potential of PET waste in replacing aggregates in concrete and represents better option than send it to landfill. This paper reviews researches published on the performance of concrete containing PET wastes. In this researches PET waste will be incorporated with an established binder namely fly Ash. The increase of workability is caused by the small spherical shapes of the fly ash that reduces the friction between cement and aggregates. Then it will results in an increase in the workability and flow of fresh concrete. Overall, the decision of using recycled waste plastic as fiber in structure for the design of structures provides enough benefits that will make it worthwhile to be considered as an economical attractive option. Once the use of performance concrete using light fibre becomes more popular and the importance of research contribution in providing technical knowledge on this new material becomes apparent. Furthermore this paper will bring new name for the new combination waste material is called Performance of Waste Light PET Fibre Concrete (WLPFC).

Introduction

Concrete containing a hydraulic cement, water, fine and coarse aggregate and discontinuous discrete fibers is called fibre reinforced concrete (FRC). Many researches have been extended to study various kinds of wastes especially for investigating the performance of concrete reinforced by fiber. The addition of wastes, apart from environmental benefits also produces good effects on the properties of final concrete products.

Polyethylene terephthalate (PET) is one of potential waste which could be used in various applications. Efforts have been made to explore their usage in concrete such as that of fibre on concrete performance [1]. The development of new construction materials using recycled PET fibre is important to both the construction and the PET recycling industries. Previous researches revealed that PET waste fibre in concrete has significant role in terms of bonding and strength [2]. PET Waste has very weak bond with cement paste. Increasing of PET waste increases the size of porosity and interfacial transition zone in concrete matrix and resulted in reduction in strength of concrete [3]. Nevertheless, the bonding between cement and PET waste can be improved by the present of good binder material [4]. Lack of knowledge discuss on the addition of PET in combination with binder development of fibre concrete. Therefore, it is appropriate time to conduct study on concrete incorporates fly ash as a binder and PET fiber as waste fibre. This combination will be named as light waste PET fiber concrete (WLPFC).

Studies Related to LWPFC

Plastics consumption now a day has become an integral part of our lives. The amounts of plastics consumed annually have been increasing steadily. Table 1 shows the details about the amount of

plastic consumption and plastic waste data in certain area. The table shows that 48% of plastic waste was sent to the landfill. This data show that only small quantity of plastic wastes was used for other application.

Table 1 : Plastic consumption and plastic waste data [5]

Area	Quantity (million tonnes)	
	Plastic consumption	Plastic waste at landfill
United State of America in 2003	26.7	7.1
Western Europe in 2004	43.5	11.5
Asian in 2006	56.7	41.3
Malaysia in 2006	2.3	1.1

Table 2 lists the composition of plastic packaging waste in Asian reported in European Commission DG Environment [6]. It shows that bottles and flasks account the highest percentage with 67% at landfill as compared to other plastic products. Meanwhile, bottles also show the lowest percentage of the recycled plastic waste among other plastic products of about 8%. It also shows that plastic bottles are of the highest number plastic waste at landfill. Recycling conserves resources embodied in plastic waste but requires inputs to perform the transformation process. Dispose of the plastic products to the landfill poses drawbacks on the environment and public health. A better approach should be developed to address the problem of the high disposal plastic waste to the landfill.

Table 2 : Composition of plastic packaging waste in Asian 2007 [6]

Plastic products	Percentage, % (weight)		
	Landfill	Incinerated	Recycled
Bottles and flask	67	25	8
Films, bags, sacks	49	30	21
Jar, boxes, tubs	35	30	35
Cases	34	12	46
Others	10	-	-

One of the possible solutions is to use recycled PET as short fibres reinforcement in structural concrete. PET in Fibre Reinforced Concrete (FRC) can provide crack control and ductility enhancement for quasi-brittle concrete as well as mass consumption alternative. Apart from it has merit of recycling as wasted materials [4]. Various methods have been studied to incorporate the PET as fibers in concrete to improve the weakness of the normal concrete.

Different studies have been done on the usage of PET of different tensile strength, volume of fibre, and water/ cement ratios. Figure 1.1 shows a summary of previous studies using waste PET in concrete. It was observed that the compressive strength increased up to 2% by the replacement of 1–2 volume percentage of fine aggregate of PET bottle fibers and it gradually decreases for 4 volume percentage addition and above [9]. Hence additions of fibre with 0.05% to 2% volume are reasonable. However, it resulted in lower strength when high volume percentage of PET fibre incorporated with matrix cement due to high porosity formation between waste plastic, aggregate, and cement. Therefore, to overcome in-consistency problems of PET as fibre in concrete, a further study needs to be done especially for verifying the best binder when PET incorporated with cement matrix. Fly ash is the most significant admixture to tackle these problems.

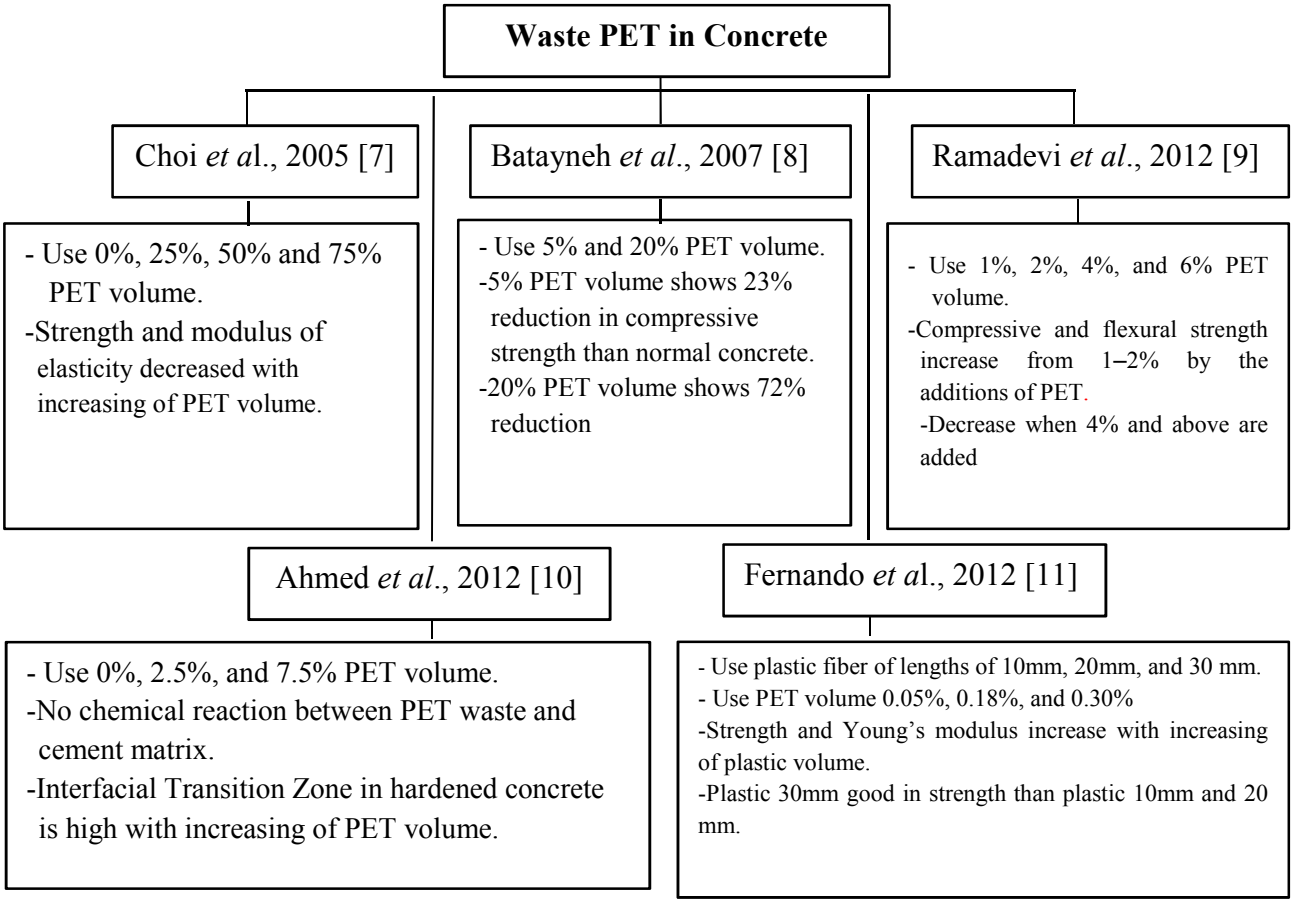

Fig. 1 : Previous studied on the utilization of waste PET in concrete

Fly ash is very good in improving workability and PET concrete flow which can result in reduction of porosity level and honeycomb structure at lower water ratios [3]. The combination of recycled waste PET as fibre in concrete and fly ash as mineral admixtures is a good trend to produce an environment sustainable material. This combination called as performance of Light Waste PET Fibre Concrete (WLPFC).

Conclusion

PET is widely known material used in food and beverage packaging products and the majority of these used products is discarded to landfill. The problem is complicated since plastic wastes are unbiodegradable and may cause environmental disturbance. Treatment method through incineration can emit toxic gas like dioxin that could be dangerous to human health. One of the potential means in solving this problem is to recycle the PET in construction industry. Taking into account that recycling of waste PET in construction industry has proven to be a better mean as compared to direct disposal. Focused researches in some specific areas are desired for a more comprehensive application. In addition, this further research may be directed include producing mix design of PET with concrete, determine of the mechanical properties, and application in load carrying concrete structures.

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References

[1] Marzouk O, Dheilly R, & Queneudec M. (2007). Valorization of Post-Consumer Waste Plastic in Cementitious Concrete Composites. *Waste Management*, 27, 310–8.

[2] Panyakapo P. & Panyakapo M. (2007). Reuse of Thermosetting Plastic Waste for Lightweight Concrete. *Waste management,* 28, pp. 1581-1588.

[3] Sata,V., Jaturapitakkul, C. & Kiattikomol, K. (2007). Influence of Pozzolan from Various By-Product Materials on Mechanical Properties of High-Strength Concrete. *Construction and Building Materials,* 21**,** pp. 1589-1598.

[4] Kim et al. (2010). Material and Structural Performance Evaluation of Recycled PET Fiber Reinforced Concrete. *Cement & Concrete Composites*, 32, pp. 232-240.

[5] Siddique R., Khatib J. & Kaur I. (2007). Use of Recycled Plastic in Concrete: A Review. *Waste management*, 28, pp. 1835-1852.

[6] European Commission DG ENV: 2011. Plastic Waste in The Environment, *Institute European Environmental Policy*, France.

[7] Choi Y, Moon D, Kim Y, & Lachemi M. (2009). Characteristics of Mortar and Concrete Containing Fine Aggregate Manufactured From Recycled Waste Polyethylene Terephthalate Bottles. *Construction Building Material*. 23, 2829–35

[8] Batayneh, M., Marie, I., Asi, I., 2007. Use of selected waste materials in concrete mixes. Waste Management 27 (12), 1870–1876.

[9] K.Ramadevi & R. Manju., 2012. Experimental Investigation on the Properties of Concrete With Plastic PET (Bottle) Fibres as Fine Aggregates. *International Journal of Emerging Technology and Advanced Engineering,* 2(6), pp. 42-46.

[10] Ahmed Soufiane Benosman, Mohamed Mouli, & Hamed Taibi., 2012. Mineralogical Study of Polymer-Mortar Composites with PET Polymer by Means of Spectroscopic Analyses. *Materials Sciences and Applications*, 3, 139-150.

[11] Fernando Fraternali, Vincenzo Ciancia, Rosaria Chechile., 2011. Experimental study of the thermo-mechanical properties of recycled PET fiber-reinforced concrete. *Composite Structures*, 93(9), pp. 2368–2374.