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Concrete Made With Waste Materials - A Review

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Abstract

The rapid population increase, industrial activities and living trends are generating variety of waste materials. These on the one hand require costly disposal practices and invaluable land while on the other hand pollute the different natural resources and environment. Further, a lot of natural resources are being depleted at a much faster rate now than ever before. The use of waste or waste by product for substitutions of cement and aggregate has greatly contributed to sustainable development practices. The replacement of cement and aggregates by waste materials either in part or in whole improves the mechanical properties too viz., compressive strength, flexural strength, tensile strength, bond strength, modulus of elasticity and reduces permeability, chloride penetration and chloride diffusion of concrete. The workability of waste concrete is generally improved. In this paper, a review of the effects of waste inclusion on the properties of fresh and hardened concrete is presented.

Keywords*: Waste materials; Flexural strength; Modulus of elasticity; Permeability*

1. INTRODUCTION

There are several types of wastes being generated from various industries and modern trends of living. Some of these wastes are harmful, if properly unattended to and require costly treatment and disposal to avoid harming the environment besides being costly, these require large amount of land which may otherwise be used for beneficial purposes. With the growth of population, the quantum of wastes being generated is increasing continuously. One of the methods to properly utilize and consume these wastes lies in the construction industry practices, wherein these wastes may be used and stabilized, so as to prevent further pollution of our natural sources.

The construction sector's major contribution towards the preservation of environment and sustainable development lies in the reuse and recycling of the waste materials. Industrial activities generate a huge amount of different types of wastes that are recycled or stored in disposal land fill sites which could affect seriously the environment. Owing to the increasing demand for construction projects which in turn increases the amount of raw material used, the incorporation of subproducts in concrete industry has become a common practice in the last few decades. Of 1ate the inclusion of different types of by products in cement based materials has become a common practice (Bouzoubâa et al. 2003, Li et al. 2002, Concrete London 2003, Naik et al. 2003, Naik et al. 2004). Most of the investigations have mainly focused on the use of sub-products as supplementary materials, admixtures or recycled aggregates in concrete. It is expected that various other types of solid and industrial waste by-products can also be used in concrete making. Different types of wastes viz. municipal waste, agricultural waste, demolition waste etc. create serious disposal problems in terms

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of disposal cost and environmental degradation. In recent years many studies were performed to find possibilities for incorporating municipal solid waste (MSW) into building material or structures. The MSW bottom ash is now widely used in construction activities as coarse material in compacted base layers (Hill et al. 2001, Pecqueur et al. 2001, Reichelt and Pfrang-Stotz, 2002, Forteza et al. 2004). A concrete made using municipal waste presents another alternative to the conventional concrete (CC) (<http://www.ns.ec.gc.ca/community/storysolterre.html>; 2003, Dhir et al. 2000, Rahal 2005). This paper presents a review of the uses of different wastes or waste by products in construction industry with focus on concrete making.

The important properties of Waste Material Gmcrete (WMC) in green and hardened states are presented below.

Workability

The property of concrete which determines the amount of useful internal work necessary to produce full compaction is known as workability. The workability of fresh concrete depends mainly on the material, mix proportion and environmental conditions. Jabri et al (2000) reported that the concrete containing copper slag as replacement of fine aggregate, showed significantly increased workability with increase in replacement level. This increase is attributed to the low water absorption of copper slag and its glassy surface (Ayano, 2009). Santharamai and Manoharan (2005) reported that concrete made using fresh ceramic waste as coarse aggregate was more cohesive and workable than the conventional concrete (CC) due to low water absorption and smooth surface texture. Choi et al (2005) reported that the workability of concrete containing waste polyethylene terphthalate (PET) bottles as lightweight aggregate (WPLA) was significantly improved with increase in replacement level. Topcu and Sengal (2004) concluded that the workability of concrete using waste concrete aggregates (WCA) decreased with increase in its proportion. Fonteboa and Abellal (2008) reported that workability of recycled concrete (RC) is slightly more than that of CC. Adesanya and Raheem (2009) reported that in corn cob ash (CCA) blended cement concrete, the workability decreased with increase in CCA content.

Density

Choi et al (2005) reported that density of WPLA concrete is 2-16% less than that of CC. Topcu and Sengal (2004) concluded that the unit weight of concrete using WCA decreased with increase in its proportion. This decrease was in the range of 15-20%. It is also reported the specific gravity of WCA was far lower than that of normal crushed aggregates.

Cracking

Meddah and Bencheikh reported (2009) that the addition of waste polypropylene fibre(WPF) showed an important increase in the ductility and post - peak behavior of the waste fibre reinforced concrete(WFRC). Suzuki et al reported that internal water curing provided by the incorporation of waste porous ceramic coarse aggregate (PCCA) promises to be a reliable technique to mitigate autogeneous shrinkage and the induced capillary internal stresses.

Compressive Strength

Achtemichuk et al reported that in controlled low strength material with fine recycled aggregate, the strength is increased when slag is used in the range of 10-20%, however, beyond this range the strength is decreased. Jabri et al (2000) reported a slight increase in compressive strength upto 50% replacement of fine aggregate by copper slag however, beyond this; the compressive strength was reduced significantly due to increase in free water retained in mix. Santharamai and Manoharan (2004) reported that the ceramic waste concrete is not significantly different from the conventional crushed stone aggregate concrete. Choi et al (2005) reported that WPLA concrete at 25% replacement level had no significant difference as compared to CC but on further increase in replacement level, the compressive strength decreased. Suzuki et al (2009) reported that the compressive strength of porous coarse aggregate concrete at 28 days was higher by 20% as compared to the CC. Fonteboa and Abellal (2008) reported that compressive strength of RC is almost similar to that of CC at 28 days. Nehdi and Sumner (2003) reported that the concrete made using waste latex paint (WLP) has compressive strength almost similar to that of CC at 28 days. Pacewska et al. (2009) reported that utilization of zeolitic waste material obtained through fluidized bed cracking catalyst (FBCC), as replacement of cement upto 20% increased the compressive strength by 40-60% at 28 days. Adesanya and Raheem (2009) reported that CCA blended concrete showed improved compressive strength at later ages. Oner et al (2009) reported that 40% replacement of cement by fly ash marginally increased the compressive strength.

Tensile Strength

Jabri et al (2000) reported increase in tensile strength (13 -15 %) upto 50% copper slag content. Santharamai and Manoharan (2004) reported that the tensile strength of ceramic waste concrete is 18% below than CC. Suzuki et al reported a slight decrease in tensile strength of porous ceramic coarse aggregate(PCCA) concrete. Fontehoa and Abellal (2008) reported that the tensile strength of RC at 7 and 115 days are slightly more (1.5 and 1.42% respectively) than CC, however, at 28 days it is slightly lower. Choi et al (2005) reported that the tensile strength of WPLA concrete is 8.7-10% of its compressive strength, which is within the range of 7-11% in the case of CC.

Flexural Strength

Jabri et al (2000) reported a marginal decrease in the flexural strength of copper slag concrete. Santharamai and Manoharan (2004) reported that the flexural strength of concrete made using ceramic waste is about 6% lower than CC. Nehdi and Sumner (2003) reported that the concrete with WLP showed increased flexural strength in the range of 7-17%. Topcu and Sengal (2004) reported a decrease (13%) in the flexural strength of concrete when normal aggregates were fully replaced by WCA.

Bond Strength

Sarswathy and Song (2007) reported that incorporation of rice husk ash (RHA) upto 30% replacement level increases the bond strength by 4 -23 %.

Modulus of Elasticity

Santharamai and Manoharan (2004) reported that the modulus of elasticity of ceramic waste concrete is slightly less than CC. Choi et al (2005) reported that the ratio of modulus of elasticity and compressive strength (E_c/f_c) of WPLA concrete is in the range of 6.27-7.46x10^2. Suzuki et al (2009) reported a marginal decrease in Young's modulus of high performance concrete (HPC) mix containing PCCA at 28 days in comparison to the controlled mix. Fontehoa and Abellal (2008) reported that the static modulus of elasticity of RC is lower (7.5-11.3%) than CC.

Durability

AchtemIchuk et al reported that the use of controlled low strength material along with fine recycled aggregate showed excellent resistance to degradation at 20 and 30% slag content in concrete without OPC. Chalee et al (2009) reported that replacement of cement by fly ash upto 50% reduced the chloride penetration and steel corrosion in concrete. Nehdi and Sumner (2003) reported that WLP decreased the rapid chloride penetrability by about 55%.

Thus, it is seen that the concern for environmental pollution, environmental protection, optimum use of natural resources and reuse of wastes are increasing throughout the world as population and industrial activities are increasing and relocating in various parts of world. This is mainly because the nature is reacting adversely against some of the human/ industrial activities and concern for future generations.

From the above review it may be concluded that in general, the waste substitution improved the workability of concrete. However, in case of CCA blended concrete it was lower than the conventional concrete. The cohesiveness of concrete mix is improved depending upon the waste. The density of concrete using waste material is generally lower. The specific gravity of WCA is lower than the normal crushed aggregate. The incorporation of the waste, depending upon its type, improves the ductility and post peak behavior and reduces shrinkage, capillary internal stresses and curing requirements. The compressive strength of concrete made using wastes was either improved significantly or was comparable to the conventional concrete depending upon the waste type. The tensile strength of waste concrete may increase or decrease depending upon the waste type. The flexural strength of waste concrete may increase or decrease depending upon the waste type. The bond strength of waste concrete may increase depending upon the waste type. The modulus of elasticity of waste concrete is lower than CC. The durability of waste concrete is improved and also the corrosion problem of reinforcement is reduced depending upon the waste type.

REFERENCES

Achtemichuk, Sasha, Justin Hubbard, Richard Sluce and Medhat H. Shehata, "The utilization of recycled concrete aggregate to produce controlled low-strength materials without using Portland cement" Cement and Concrete Composites Volume 31, Issues 8, September 2009, Pages 5640- 569.

Adesanya, D.A., A.A. Raheem, " A study of the workability and compressive strength characteristics of corn cob ash blended cement concrete" Construction and Building Materials, 23 (2009), pp 311-317.

Ayano, T., O. Kuramoto and K. Sakata, "Concrete with copper slag as fine aggregate" J. Soc. Material Science Japan **49** (10) (2000), pp. 1097–1102.

Bouzoubâa, N, Fournier B. Current situation of SCMs in Canada. Materials Technology Laboratory Report MTL 2003-4(TR), MTL/ CANMET; 2003. 28 p.

Challe, Y. W., P. Ausapanit and C. Jaturapitakkal, " Utilization of fly ash concrete in marine environment for long term design life analysis", Material & Design, 31, 3, 1242-1249 (2010).

Choi, Yun-Wang, Dae-Joong Moon, Jee-Seung Chung, Sun-Kyu Cho, "Effects of waste PET bottles aggregate on the properties of concrete" Cement and Concrete Research Volume 35, Issues 4, April 2005, Pages 776-781.

Dhir, R.K., T. Leelawat and M.C. Limbachiya, Use of recycled concrete aggregate in high-strength concrete, Mater Struct **33** (2000), pp. 574–580.

Environment Canada, Atlantic Region. 'Reusing construction and demolition waste" www .ns.ec.gc.ca/ community/storysolterre .html>; 2003.

Environmental working party of the concrete society's materials group, Environmental topics avoidance of waste: beneficial use of industrial by-products as constituents of concrete, Concrete (London) 37 (5) (2003), pp. 43–45.

Fonteboa, B. González, F. Martínez-Abella, "Concretes with aggregates from demolition waste and silica fume: Materials and mechanical properties" Building Environment, **43** (2008), pp. 429–437.

Forteza, R., M. Far, C. SeguI and V. Cerda, Characterization of bottom ash in municipal solid waste incinerators for its use in road base, Waste Management **24** (2004) (9), pp. 899–909.

Hill, A.R., A.R. Dawson and M. Mundy, Utilization of aggregate materials in road construction and bulk fill, Resources, Conservation and Recycling **32** (2001) (3–4), pp. 305–320.

Jabri, Khalifa S. Al, Makoto Hisada, Salem K. Al-Oraimi and Abdullah H. Al-Saidy, "Copper slag as sand replacement for high performance concrete" Cement and Concrete Composites Volume 31, Issues 7 Aug 2009, pp. 483-488.

Li, B., W. Liang and Z. He, Study on high-strength composite Portland cement with a larger amount of industrial wastes, Cement and Concrete Research 32 (8) (2002), pp. 1341–1344.

Meddah, Mohammed Seddik and Mohamed Bencheikh, "Properties of concrete reinforced with different kinds of industrial waste fibre materials" Construction and Building Materials Volume 23, Issue 10, October 2009, pp 3196-3205.

Naik, T.R., R.N. Kraus, Y.M. Chun, B.W. Ramme and S.S. Singh, Properties of field manufactured cast-concrete products utilizing recycled, Mater J Mater Civil Eng 15 (4) (2003), pp. 400–407.

Naik T.R., Y.M. Chun, R.N. Kraus, B.W. Ramme and R. Siddique, Precast concrete products using industrial by-products, ACI Mater J 101 (3) (2004), pp. 199–206.

Nehdi, Moncef, Jon Sumner, "Recycling waste latex paint in concrete" Cement and Concrete Research Volume 33, Issue 6, June 2003, Pages 857-863.

Oner, A., S. Akyyz and R. Yildiz, " " An experimental study on strength development of concrete containing fly ash and optimum usage of fly ash in concrete" Cement & Concrete Research 35 (2005), pp. 1165–1171.

Pacewska, B., M. Bukowska, I. Wili[illegible]ska, M. Swat, " Modification of the properties of concrete by a new pozzolan—a waste catalyst from the catalytic process in a fluidized bed" Cement and Concrete Research 39 (2009), pp 145-152.

Pecqueur, G., C. Crignon and B. Quenee, Behaviour of cement-treated MSWI bottom ash, Waste Management **21** (2001) (3), pp. 229–233.

Rahal, K., Mechanical properties of concrete with recycled coarse aggregate, Building Environment 42 (2005), pp. 407–415.

Reichelt, J. and G. Pfrang-Stotz, Technical properties and environmental compatibility of MSWI bottom ashes and other industrial by-products used as recycled materials in road construction, IT3 Conference 'Incineration and Thermal Treatment Technologies', New Orleans, Louisiana (2002).

Saraswathy, V., and Ha-Won Song "Corrosion performance of rice husk ash blended concrete" Construction and Building Materials Volume 21, Issue 8, August 2007, pp 1779-1784.

Senthamarai, RM., P. Devadas Manoharan, "Concrete with ceramic waste aggregate" Cement and Concrete Composites Volume 27, Issues 9-10, pp. 863-970, 2005.

Suzuki, Masahiro, Mohammed Seddik Meddah, Ryoichi Sato, "Use of porous ceramic waste aggregates for internal curing of high-performance concrete" Cement and Concrete Research Volume 39, Issues 5, May 2009, Pages 373-381.

Topçu, Ilker Bekir, Selim Sengel, "Properties of concretes produced with waste concrete aggregate" Cement and Concrete Research Volume 34, Issues 8, August 2004, Pages 1307-1312.