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ECO-FRIENDLY CONCRETE- A REVIEW

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Abstract: In the last decades, the use of residue in civil construction, especially in addition to concrete has been studied by many researches related to, besides to reduce the environmental polluter's factors. This may lead several improvements of the concrete properties. In recent years increasing attention towards utilizing less energy intensive materials, such as fly ash, rice husk ash, condensed silica fume and slag, in combination with cement to achieve energy saving. Within the concrete industry, the most successful examples have been using coal fly ash to make high-quality, durable concrete and recycling old, demolished concrete as aggregate for new concrete. From last few decades, other byproducts have been successfully used in concrete. These materials include: used foundry sand and slag from metal-casting industries; post-consumer glass; wood ash from pulp mills, sawmills, and wood-product manufacturing industries; sludge from primary clarifiers at pulp and paper mills; and de-inking solids from paper-recycling companies. This paper emphasizes on the use of industrial waste/by product which will give new dimension in concrete mix design and if applied on large scale would revolutionize the construction industry by economizing the construction cost and enable us to conserve natural resources.

Keywords: Recycle, Concrete, Slag, Foundry sand, Hyposludge.

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INTRODUCTION

Waste is described as unused discharge product generated from human life, social and industrial activity. Radioactive industrial waste is regulated separately (Chandra 1997).Concrete is basically made of aggregates glued by a cementitious materials paste, which is made of cementitious materials and water. Each one of these concrete primary constituents, to a different extent, has an adverse environmental impact and gives rise to different sustainability issues (Mehta 2001, 2002).The current concrete construction practice is thought unsustainable because, not only it is consuming enormous quantities of stone, sand, and drinking water, but also two billion tons a year of Portland cement, which is not an environment friendly material from the view of energy consumption and release of green-house gases (GHG) leading to global warming. Furthermore, the resource productivity of Portland-cement concrete products is much lower than expected because they crack readily and deteriorate fast. Since global warming has emerged as the most serious environmental issue of this time and since sustainability is becoming an important issue of economic and political conflicts, the next developments to watch in the concrete industry will not be the new types of concrete, manufactured with expensive materials and special methods, but low cost and highly durable concrete mixtures containing largest possible amounts of industrial and urban byproducts that are suitable for partial replacement ofPortland cement, virgin aggregate, and drinking water (Mehta 2004). Thus, in the construction sector, sustainable development is applicable on many levels, one of which is the production and the use of the recycled materials, especially concrete (as a percentage of the most commonly used construction material). The term "recycling", in general, is defined as a single use or multiple usages of waste materials as an effective substitute for a commercial product or as raw material in further industrial process. According to the available data regarding the construction materials, the bricks have the highest percentage of recycling i.e.35%.This paper is a review of the research work done in the last few years in order to promote recycling into concrete for common use in building construction, with the aim of emphasizing the feasibility, as well as the advisability, of such an action, meeting at the same time sustainability and durability.

Aim and Objective

This paper presents a detailed review about waste and recycled materials that can be effectively used in concrete as a constituent replacement. Waste management options and research published on the effect of waste materials on the fresh and hardened properties of concrete are reviewed.

Few significant and demonstrative examples of replacement of concrete matrix by industrial and urban byproducts are described below.

Recyclable materials

1. Hypo sludge/Waste Paper Pulp

"Paper making Industry generally produces a large amount of solid waste. Paper fibers canbe recycled only a limited number of times before they become too short or weak to makehigh quality paper. It means that the broken, low-quality paper fibers are separated out tobecome waste sludge i.e. Hypo sludge."(R.Srinivasan, et.al, 1999) determined the optimum percentage replacement of cement with hypo sludge. The optimum replacement percentage was found to be 30%.

JayeshkumarPitroda et.al (2013) suggest the innovative use of hypo sludge in concrete formulations as a supplementary cementitious material as an alternative to traditional concrete. The cement has been replaced by waste paper sludge accordingly in the range of 0% (without Hypo sludge), 10%, 20%, 30% & 40% by weight for M-25 and M-40 mix. He found that compressive strength reduces when cement replaced hypo sludge. As hypo sludge percentage increases compressive strength and split strength decreases. Use of hypo sludge in concrete can save the paper industry disposal costs and produces a 'greener' concrete for construction. The cost analysis indicates that percent cement reduction decreases cost of concrete, but at the same time strength also decreases. Environmental effects from wastes and residual amount of cement manufacturing can be reduced through this research.SumitBalwaik et.al (2012) performs experiment on waste paper pulp with partial replacement of cement in concrete. He found that, the slump increased up to 5% replacement of cement, above 5% the slump decreased as the paper pulp content in the concrete mixtures was increased. The most suitable mix proportion is the 5 to 10 % replacement of waste paper pulp to cement.RitzawatyBintiet.al (2008) did an investigation on use of waste material like glass, plastic and demolished concrete. The result indicated that, the strength of concrete mixes was improved by the partial replacement of fine aggregates with crushed glass aggregates, but the high alkali content of such would affect the long term durability and strength, both of which need long term investigation.

2. Gypsum

"Gypsum is also an indefinitely recyclable raw material. It can always reuse, because the chemical composition of the raw material in the products remains unchanged. Gypsum products can furthermore be counted amongst the very few construction materials where “closed-loop” recycling is possible, i.e. where the waste is used to make the same product again”

Degirmenci et al. (2007) found the potential of using Phosphogypsum (PG) in soil stabilization. They used class C fly ash and Portland composite cement. Their results showed that the treatment of soil with fly ash, PG and cement reduced the plasticity index that is an indicator of soil improvement. Also, unconfined compressive strength of unstabilized soil was lower than the stabilized soil with above material.Singh M. (2002) studied treating phosphogypsum for cement industries. He found that the purified Phosphogypsum can be used as an additive in the manufacture of ordinary Portland cement and Portland slag cement. He also found that the purified Phosphogypsum can be used for gypsum plaster production to be used in building material.Ganjian et al. (2007) used plasterboard gypsum waste in road bases, sub-bases and stabilized sub-grades. They concluded that crushed or ground plasterboard gypsum can be used as a source of sulphate activator with slag and kiln dust or by pass dust to form an activated pozzolona. They used 15% of ground plaster gypsum with 5% of bypass dust and 80% basic oxygen slag. The result was a high compressive strength material named Coventry Novel Cement to be used in road base and sub base construction.

3. Slag

“Slag is a partially vitreous by-product of smelting ore due to separating of the metal fraction from the worthless fraction. It can be considered a mixture of metal oxides; however, slag does can contain metal sulphides and metal atoms in the elemental form.”Mahieux et al. (2008) carried out a study on using BOS in hydraulic road binders. They used Basic Oxygen Slag (BOS) and Ground Granulated Blast Furnace Slag (GGBFS) from the same plant. The study found that although BOS in cement-based mortars had a poor hydraulic activity with no pozzolanic properties, the ternary blended binder mixing BOS, GGBFS and catalyst was successful. The mix with 52.5% of GGBFS, 42.5% of BOS and 5% of catalyst had compressive strength higher than 10 MPa at 28 days. It also had no problem with expansion.Heikal, et al. (2002) researched the setting time (initial and final) of Portland cement, granulated slag and by-pass cement dust composites. They found that the setting time of slag-cement paste was extended with slag content. An additional 2.5% mass by-pass cement dust increased the initial and final setting time of some mixes and decreased the final setting time of some other mixes.Shih et al. (2004) found the potential of using waste steel slag in making bricks. They found that if an appropriate amount of steel slag (less than 10%) added to the mixture using for brick making, the firing temperature would reduce. The compressive strength of this kind of brick and the shrinkage would drop if the amount of slag increases. The water absorption increased by increasing the slag content.

Al-Jabri et al. (2006) studied the effect of copper slag and cement by-pass dust on the mechanical properties of concrete. They did different trial mixes with different water to binder ratios 0.5, 0.6, and 0.7. Their results showed that 5% copper slag No by Pass Dust (BPD) substitution for Portland cement had similar strength to their control mixture (only OPC and aggregate) especially at lower w/b ratios of 0.5 and 0.6. Higher amount of cooper slag (13.5% with 1.5% of By Pass Dust as an activator) cement replacement had adverse effects on strength.Taha et al. (2007) did an investigation to use (BPD) mixing with copper slag, incinerator ash, sand and cement to make Controlled Low Strength Materials (CLSMs). (Engineered materials that have a specified compressive strength between 0.1 MPa and 8.3MPa at 28 days) CLSM may be used in backfilling walls or trenches for bedding material for pipes, it also is used as void fillings i.e. Sewers, tunnel shafts and some other underground structures. They compared the mixes without waste cementitious materials and mixes with waste materials and cement. The results indicated that all of their mixes produced a CLSM with a compressive strength that can be excavated manually with good mechanical properties with a good mix design. Mixes using the waste material, cement and sand yielded higher compressive strength than those mixes using waste materials as full replacement for cement. They recommended the waste material from their research should always be used in combination with cement in order to achieve their pozzolanic activity.

4. Waste Foundry Sand

"Waste foundry sands are generated by the metal casting industry. Foundries purchase new, virgin sand to make casting molds, and the sand is reused numerous times within the foundry. However, heat and mechanical abrasion eventually render the sand unsuitable for use in casting molds, and a portion of the sand is continuously removed and replaced with virgin sand. The spent foundry sand, that is, the sand that is removed, is either recycled in a non-foundry application or land filled. Estimates are that less than 15 percent of the 6-10 million tons of spent foundry sands generated annually are recycled."

T.R. Naik et al. (1994) conducted an investigation into the properties of fresh and hardened concrete containing waste foundry sand from ferrous foundries. The results showed that mixes containing foundry sand gave a much lower slump values. The lower slump values were attributed to the presence of binders that increased the water demand. In comparison the foundry sand mixes gave lower slump values than the control mix but higher than waste foundry sand. This showed that the lower slump values of mixes containing waste sand was not completely explained by the presence of binders but also the sand itself. Clean foundry sand has a higher absorption rate than building sand and also finer particles both factors increase water demand and reduce slump values.J.M. Khatib (2004) investigated a wider spread of mixes with different types of foundry sand; fine sand, blended sand and spent sand. As the amount of foundry sand increased, the compressive strength of the concrete reduced, this was found to be nearly linear decrease for all levels. The waste sand displayed similar compressive strength as mentioned by T.R. Naik et al (1994); lower than the control and decreased linearly with replacement levels increased. The blended sand mixes decreased the compressive strength as the amount of blended sand replacement increased. R. Bakis (2006) performed a study on the reuse of waste foundry sand in asphalt concrete production by partially replacing a fine aggregate with waste foundry sand. The results showed that replacement of 10% aggregates with waste foundry sand was found to be the most suitable for asphalt concrete mixes as higher replacement levels caused reduction in strength beyond tolerances.Singh (2000) performed experimental investigations to evaluate the strength and durability properties of concrete mixtures, in which natural sand was partial replaced with (WFS). Test results obtained shown that, (a) Concrete mixtures made withWFS exhibited higher compressive strength than control concrete. From the results, it was found that 28 day compressive strength increased by 8.25%, 12.25%, 17% and 13.45% for mixtures M-2 (5%WFS), M-3 (10% WFS), M-4 (15% WFS) and M-5 (20% WFS) respectively than control mixture M-1 (0% WFS). Comparative study of compressive strength at 28 and 91 days indicate that % increase in compressive strength decreases with the increase in WFS content at 91 days in comparison to 28 days, it was decreased by 7% to 1.98%.JafarBolouriBazaz(2002) investigated the properties of mortars and concretes containing different dosages of used foundry sand (UFS) as partial replacement of sand in both fresh and hardened conditions. According to the obtained test results, they concluded that, (a) UFS reduces the workability when added as natural sand replacement (at same w/c); higher amount of super plasticizer is required in order to maintain the same workability. The control mortar sample with w/c equal to 0.50 requires an addition of 0.5% by cement weight, while mortars containing UFS need an addition up to 1.8%. Similarly, concrete mixture containing UFS needs a super plasticizer dosage.

5. Over Burnt Bricks

"Over burnt or Jhama Bricks are inferior to the first class, second class and third class bricks. Over burnt Bricks are over burnt, have irregular shape, size, color and texture color of these bricks is dark blue/sometimes black. It was found that over burnt brick aggregates are much stronger, less absorptive, and denser in general than the ones from the picked or pick-Jhama (Type A) bricks"

Nyiutsa Samson Apebo, Aondowase John Shiwua,"(2006).In this study, the feasibility of utilizing these over burnt bricks as coarse aggregates in highway pavement projects was explored. Routine laboratory tests such as the Los Angeles abrasion, water absorption, specific gravity, and unit weight, were used to compare the properties of the over burnt bricks with the best possible quality picked or pick-Jhama (Type A) bricks from the same stockyards in Bangladesh. It was found that over burnt brick aggregates are much stronger, less absorptive, and denser in general than the ones from the picked or pick-Jhama (Type A) bricks. Therefore, these bricks may be conveniently and economically used as highway pavement coarse aggregates. Farhad Reza, (2009) investigated the properties of higher strength concrete made with crushed brick as coarse aggregate and found that higher strength concrete (fcu = 31.0 to 45.5 N/mm2) with brick aggregate is achievable whose strength is much higher than the parent uncrushed brick implying that the compressive strength of brick aggregate concrete can be increased by decreasing its water-cement ratio.

Mazhar-Ul-Hak. (2012) show that due to reduction of water-cement ratio from 0.33 to 0.50, the compressive strength improved by 34.4 and 35.2 %, respectively.

6. Crushed Mosaic Tile

"Crushed tile is an industrial waste that causes environmental pollution. Therefore the possible utilization of this material would reduce environmental pollution. The utilization of crushed tile as a coarse aggregate in concrete would have a positive effect on the economy".

I.B.Topcu and M.Canbaz stated that, in concrete production, Portland cement, river sand, 4-32 mm in size crushed stone and crushed tile as coarse aggregates in the replacement ratio of 0, 50 and 100 % were used. Mechanical and physical tests were conducted on specimens. The strength and unit weight of crushed tile aggregate concrete were decreased compared to the control concrete. Absorption and capillarity coefficients were increased compared to the control concrete.Khaloo A.R (1995) examined the suitability of ceramic industrial wastes and huge amounts of basaltic pumice as a possible substitute for conventional crushed fine aggregates. Experiments were carried out to determine mechanical properties such as compressive.Rania A. Hamza, Salah El-Haggar, and SafwanKhedr (2011) foundthat, there is a positive effect of granite slurry on cement brick samples that reach its optimum at 10% slurry incorporation. Absorption is the major drawback of slurry incorporation in cement bricks according to the ASTM C55 where water absorption requirement is fulfilled only at Zero, 10 %, and 20% slurry samples for grade S. The accelerated hydration, endued by heating, compensated the detrimental effect of volumetric changes associated with temperature variation. Most cement brick samples, including the control, are of normal weight according to both the Egyptian specifications and ASTM C55.All cement brick samples tested in this study comply with the Egyptian code requirement for structural bricks. This is not true when compared to ASTM C55. Instead, 10% and 20% marble and granite slurry yield Grade S. Most cement brick samples which contain marble and granite waste had sufficient abrasion resistance according to ASTM C902.Eva Vejmelkova 1, Tereza Kulovanaet.al (2012), states in their paper that waste ceramic ground to an appropriate fineness can be considered a prospective pozzolona material suitable for the replacement of a part of Portland cement in concrete industry. This solution may have significant environmental and economical consequences. Waste ceramic as recycled material used in concrete production presents no further CO2 burden to the environment, and its price is much lower as compared to Portland cement.

CONCLUSION

Based on the above literature following conclusions are drawn,

1. Hyposludge

It can be use as a cementitious material as an alternative to traditional concrete. As hypo sludge percentage increases compressive strength and split strength decreases. The optimum replacement percentage was found to be 30%. Use of hypo sludge in concrete can save the paper industry disposal costs and produces a ‘greener’ concrete for construction.

2. Gypsum

Purified Phosphogypsum can be used as an additive in the manufacture of ordinary Portland cement and Portland slag cement. The plasterboard gypsum waste can be used in road bases, sub-bases and stabilized sub-grades. 15% of ground plasters gypsum with 5% of bypass dust and 80% basic oxygen slag develops a high compressive strength material.

3. Slag

Basic Oxygen Slag (BOS) in cement-based mortars had a poor hydraulic activity with no pozzolanicproperties;the mix with 52.5% of GGBFS, 42.5% of BOS and 5% of catalyst had compressive strength higher than 10 MPa at 28 days. The setting time of slag-cement paste increases with slag content. Waste steel slag can beused in making bricks. Higher the amount of slag lowers the compressive strength and the shrinkage

4. Waste Foundry Sand

The mixes containing foundry sand gave a much lower slump values. Clean foundry sand has a higher absorption rate than building sand and also finer particles both factors increase water demand and reduce slump values. As the amount of foundry sand increased, the compressive strength of the concrete reduced, this was found to be nearly linear decrease for all levels. The replacement of 10% aggregates with waste foundry sand was found to be the most suitable for asphalt concrete mixes as higher replacement levels caused reduction in strength beyond tolerances. Used foundry sand (UFS) reduces the workability when added as natural sand replacement.

5. Over Burnt Bricks

It was found that, over burnt brick aggregates are much stronger, less absorptive, and denser. Therefore, these bricks may be conveniently and economically used as highway pavement coarse aggregates. The reduction of water-cement ratio from 0.33 to 0.50, the compressive strength improved by 34.4 and 35.2 %, respectively.

6. Crushed Mosaic Tile

It can be used as a possible substitute for conventional crushed fine aggregates. Most Cement brick samples which contain marble and granite waste had sufficient abrasion resistance. The waste ceramic ground to an appropriate fineness can be considered a prospective pozzolona material suitable for the replacement of a part of Portland cement in concrete industry. This solution may have significant environmental and economical consequences. Waste ceramic as recycled material used in concrete production presents no further CO2 burden to the environment, and its price is much lower as compared to Portland cement.

Concluding Remark

Concrete, the most ubiquitous material in the world. It is the composite material that ages over time and having the potential to change the economics of the construction industry. But the consumption of natural resources for making concrete triggers the environmental issues. To overcome these issues the alternatives discussed above can be effectively use.

REFERENCES

1. Al-Jabri, K. S., Taha, R. A., Al-Hashmi, A. and Al-Harthy, A. S. (2006) 'Effect of Copper Slag and Cement by-Pass Dust Addition on Mechanical Properties of Concrete. ‘Construction and Building Materials 20, (5) 322-331

2. Bakis, R. (2006) An investigation of waste foundry sand in asphalt concrete mixes. Waste Management and Research, 24(3), 269-274.by-Pass Cement Dust Composites.' Cement and Concrete Research 32, (11) 1805-1812

3. Chandra S., (1997) Waste Materials Used in Concrete Manufacturing. NOYES Publications, Westwood, New Jersey, U.S.A., 289 pages.

4. Degirmenci, N., Okucu, A. and Turabi, A. (2007) 'Application of Phosphogypsum in Soil

5. Eva Vejmelkova 1, Tereza Kulovanaet.al (2012),"Applications of Waste Ceramics as active Pozzolona in Concrete Production", IPSCIT Vol .28 pp 132-136.

6. Farhad Reza, August 2013," Use of Recycled Brick in Aggregates", Center for Transportation Research and Implementation Minnesota State University, Mankato.

7. Ganjian, E., Claisse, P. and Pouya, H. S. (2007) The Use of Plaster Board and Gypsum Waste in Road Bases, Sub-Bases and Stabilised Sub-Grade. Final Report Coventry University, Project Code BPD5-002, 148 pages

8. Ganjian, E., Claisse, P., Tyrer, M. and Atkinson, A. (2004) 'Preliminary Investigations into the Use of Secondary Waste Minerals as a Novel Cementitious Landfill Liner.' Construction and Building Materials 18, (9) 689-699

9. Heikal, M., Aiad, I. and Helmy, I. M. (2002) 'Portland Cement Clinker, Granulated Slag and

10. I.B.Topcu and M.Canbaz, 2007"Utilization of crushed tile as aggregate in concrete", Iranian Journal of Science and Technology, Transaction B, Engineering, Vol. 31, No. B5, pp561-565

11. J.M.Khatib, Z. K., and Bayomy, F. M. (1999), "Rubberized Portland cement concrete" Journal of Materials in civil engineering, ASCE, 11(3), 206-213.

12. JafarBolouriBazaz , MahmoodKhayati&NavidAkrami," Performance Of Concrete Produced With Crushed Bricks As The Coarse And Fine Aggregate" Iaeg2006 Paper Number 616.

13. JayeshkumarPitroda, Dr. L.B.Zala, Dr.F.S.Umrigar," Innovative Use Of Paper Industry Waste (Hypo Sludge) In Design Mix Concrete" International Journal Of Advanced Engineering Technology E-ISSN 0976-3945 IJAET/Vol. IV/ Issue I/Jan.-March., 2013/31-35.

14. Khaloo A.R (1995)"Crushed Tile Aggregate Concrete", cement, concrete and aggregate ASTM Journal,Vol 17 No.2.pp 119-125

15. Mahieux,P. Y., Aubert, J. E. and Escadeillas, G. (2008) 'Utilization of Weathered Basic Oxygen Furnace Slag in the Production of Hydraulic Road Binders.' Construction and Building Materials 23, (2), 742-747

16. Mazhar-Ul-Hak,SaeedAhmad,"Crushed Bricks in Road Construction"

17. Mehta, P. Kumar, "Concrete Technology for Sustainable Development," ACI Concrete International, Vol. 21, No. 11, 1999, pp 47-53.

18. Nyiutsa Samson Apebo, Aondowase John Shiwua," Effect of Water-Cement Ratio on the Compressive Strength of gravel - crushed over burnt bricks concrete." Civil and Environmental Research ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) Vol.3, No.4.

19. R. Srinivasan, K. Sathiya and M. Palanisamy," Experimental Investigation In Developing Low Cost Concrete From Paper Industry Waste".

20. Rania A. Hamza, Salah El-Haggar, and SafwanKhedr(2011),"Marble and Granite waste: Characterization and Utilization in concrete bricks" ,International journal of Bioscience, Biochemistry and Bioinformatics, Vol I, No 4 ,pp 286-291

21. RitzawatyBinti, MohamadShukeriand A. Naser Abdul Ghani," Concrete Mix with Wastepaper", 2nd International Conference on Built Environment in Developing Countries (ICBEDC 2008).

22. Singh, M. (2002) 'Treating Waste Phosphogypsum for Cement and Plaster Manufacture.' Cement and Concrete Research 32, (7) 1033-1038 Stabilization.' Building and Environment 42, (9) 3393-3398

23. SumitBalwaik, S.P.Raut,"Utilization of paper pulp by partial Replacement of cement in concrete"Inetrnatioal Journal of Engineering Research and Application, ISSN: 2248-9622, Vol.1 Issue 2, Page .300-309.

24. T.R Naik,,Kraus, N. Rudolph; Chun, Yoon-moon; Ramme, W. Bruce; and Singh S.Shiw, (2003) Properties of Field Manufactured Cast-Concrete Products Utilising Recycled Materials. Journals of Materials in Civil Engineering 15 (4).

25. T.R.Naik (2004). Use of Pulp and Paper Mill Residual Solids in Production of Cellucrete. Cement and Concrete Research, Volume 34, Issue 7, July 2004, Pages 1229-1234.

26. Taha, R. A., Alnuaimi, A. S., Al-Jabri, K. S. and Al-Harthy, A. S. (2007) 'Evaluation of Controlled Low Strength Materials Containing Industrial by-Products.' Building and Environment 42, (9) 3366-3372.