Nature Environment and Pollution Technology
An International Quarterly Scientific Journal | ISSN: 0972-6268 | Vol. 14 | No. 4 | pp. 963-966 | 2015

Original Research Paper

Eco-friendly Solution to Mitigate the Toxic Effects of Hazardous Construction Industry Waste by Reusing in Concrete for Pollution Control

G. K. Arunvivek*†, G. Maheswaran and S. Senthil Kumar*****
*Department of Civil Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore, India
**Department of Civil Engineering, VSA School of Engineering and Management, Salem-636 010, Tamilnadu, India
***Department of Civil Engineering, K.S.R College of Engineering, Tiruchengode-637 215, Tamilnadu, India
†Corresponding author: G. K. Arunvivek

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com
Received: 22-01-2015
Accepted: 15-03-2015

Key Words:
Wastewater
Ready mix concrete
Hazardous substance
Pollution control

ABSTRACT

Pollution is a critical environmental issue. Currently an enormous amount of wastewater and fresh concrete waste aggregates are being produced by the ready mix concrete industry throughout the world. The concrete washout water and excess fresh concrete aggregates are hazardous for disposal due to their high pH value (pH >12). Improper disposal of such wastewater and fresh concrete aggregates results in high environmental pollution. This study envisages an overview of the current state of knowledge about the reuse of hazardous wastewater and concrete in an environmentally acceptable manner. This study was motivated by the necessity to recycle the wastewater and fresh concrete aggregates resulting from washing out the concrete mixing trucks. Laboratory investigation was conducted and from the test results, it is identified that the performance and properties of concrete is not affected by the reuse of this hazardous wastewater and recycled aggregates.

INTRODUCTION

Yearly, around 12 billion tons of concrete is produced worldwide. Ready Mix Concrete (RMC) plays a noteworthy role in concrete industry due to the large quantum of concrete being utilized every year. Though RMC has lots of advantages, disposal of wastewater generated from RMC plants which contains cement slurry sludge and unused concrete aggregated is a great problem for RMC producers (Borger et al. 1994, Chini & Muszynski 2001, Chatveera et al. 2006, Chatveera & Lertwattanaruk 2009). At the end of each work day the chutes, drums of concrete trucks, hoppers of concrete pump, conveyors, etc. should be cleaned thoroughly. About 700-1300 litres of washout water, which contains cement slurry sludge is generated (Ibrahin Al-Ghusain & Mohammed Terro 2003, Low et al. 2007) and 8-10 tons of fresh concrete waste is generated per day per plant due to reclaiming of over-ordered concrete and cleaning of leftover concrete in mixing drums (Manzi et al. 2013). The pH value of this washout water ranges between 12.5 and13.0 (Marco Paolini & Rabinder Khurana 1998). According to Water Quality Act (Part 116), this wash out water is a hazardous substance. If this wastewater is disposed in water bodies, it will harm the aquatic living beings because the aquatic life can live in water that has a pH range 6.5 to 9.0. Fresh concrete waste is generally dumped into the landfills. Nowadays, due to rapid urbanization and industrial growth, the availability of landfills is considerably reduced with each passing year. So the disposal of this waste is a great burden for the concrete industry and improper disposal of such waste results in many environmental problems (Yeong-Nain Sheen et al. 2013, Shi-Cong Kou et al. 2012). Hence, reusing the concrete washout water and aggregate in concrete has great benefits in disposal cost as well as protection of the environment from pollution (Sandrolini & Franzoni Elisa 2001, Nan et al. 2002, Parker & Slimak 1977). Thus, this investigation aims to reuse and study the effects of this washout water and sludge on mechanical properties of concrete.

MATERIALS AND METHODS

Materials

Concrete washout water: Concrete washout water samples were collected from a ready mix concrete batching plant and kept in tightly sealed plastic containers. The washout discharge from truck wash contains cementitious materials and chemical admixture residue. Due to high content of dissolved limestone solids, the washout water is caustic and has a high pH value ranging between 12.5 and 13.0. In general the washout water contains dissolved solids which include sulphates and hydroxides from cement, and chlorides from the use of calcium chloride as admixture. The properties of potable water and washout water used in this study are depicted in Table 1.

Recycled fresh concrete waste aggregate: Both natural and recycled fresh concrete waste aggregates were used in

Table 1: Chemical composition of slurry mixed washout water and potable water for significant parameters.

Parameter	Potable Water	20% Slurry mixed Portable water	40% Slurry mixed Portable water	60% Slurry mixed Portable water	80% Slurry mixed Portable water	100% Slurry mixed washout water
pH	7.76	12.91	12.93	12.96	12.98	13.02
TDS (mg/L)	1472	3224	3734	4655	5395	5945
Chloride (mg/L)	148	153	161	165	170	179
Sulphate (mg/L)	135	139	146	152	161	169

this study. Recycled aggregate was obtained from a reclaimer system of ready mix concrete plant. In order to improve the quality of recycled fresh concrete waste aggregate, Rinsed Air-Dried (RAD) method was used. The rinsed air-dried aggregates were prepared by applying high pressure water on the surface of the recycled aggregate, after that the aggregates were thoroughly rinsed with water. Due to the application of water, the maximum quantity of adhering mortar, which is present in the surface of the recycled aggregates, was detached. Then the aggregates were dried at ambient temperature before using them in concrete.

Concrete constituents: Ordinary Portland cement of grade 53 was used in this study. Crushed angular aggregates of 20 mm size were used as coarse aggregate and natural river sand was used as fine aggregate for the production of concrete.

Methodology

In this study, the experimental part was divided into two different sections; the first section focuses on the influence of sludge water on the properties of concrete and the second one deals with the role of recycled aggregate in concrete. Cement slurry mixed washout water was blended with fresh potable water and used as mixing water for production of concrete. The mixing water for the test concrete consisted of 0%, 20%, 40%, 60%, 80 and 100% recycled washout water blended with fresh potable water. In this study, M_{40} grade of concrete was used and the water cement ratio was kept as 0.48. Mix SW_1, SW_2, SW_3, SW_4 and SW_5 denote the concrete mixed with 20%, 40%, 60%, 80% and 100% cement slurry mixed washout water. M_1 denotes the control mix concrete made with potable water. Similarly the amount of recycled fresh concrete waste aggregate content was varied by replacing it with natural aggregate in various ratios. Mix RAC_1, RAC_2, RAC_3, RAC_4, RAC_5 and RAC_6 denote the concrete samples made with recycled fresh concrete waste aggregate at natural aggregate level of 15 %, 20%, 40%, 60%, 80% and 100%.

In order to investigate the effects of washout water and recycled aggregate on mechanical properties of concrete, concrete cubes of size (100×100×100 mm), prisms of size (500×100×100 mm) and cylindrical concrete specimens of size (150×300 mm) were cast. After 3, 7, 28 and 56 days of curing, concrete cubes were tested for compressive strength. Similarly, prism and cylindrical concrete specimens were tested for flexural and split tensile strength after 7 days and 28 days of curing. Test results were compared with concrete specimens cast with fresh potable water and natural aggregate.

RESULTS AND DISCUSSION

The compressive, flexural and split tensile strength of the concrete samples, cast with fresh potable water, cement slurry mixed washout water and recycled aggregates are shown in Fig. 1 to Fig. 3. The compressive, flexural and split tensile strength increase in mix SW_1 is noted. The test results indicated that the strength of concrete samples made with washout water exceeded in all testing ages with the compressive strength reached by the reference mix, which was produced with the exact same proportions but with fresh water used as concrete mixing water. This could be due to the fact that cement fines and dissolved solids present in washout water could help improve the packing against the surface aggregates of concrete. The test results clearly indicate that the concrete washout water can be used as mixing water in concrete without any dilution or treatment. If the washout water, which contains cement slurry, is used as mixing water, excess slurry in washout water reacts with hydrated Portland cement and forms ettringite ($3CaO.AI_2O_3.3CaSO_4.32H_2O$). Ettringite is a hydrous calcium alumino sulphate mineral (white needle like crystals) (Fig. 4); it forms due to a reaction of calcium aluminate with calcium sulphate which is present in the slurry. This ettringite may form a thick layer in the transition zone and reduce the bonding between cement paste and aggregate which results in lower compressive strength.

It can be observed that the compressive, flexural and split tensile strength increase in mix RAC_1. The strength of concrete samples made with 15% recycled aggregate exceeds in all testing ages with the strength reached by the reference mix. Test results clearly indicating that, up to 15% recycled aggregate can be replaced for natural aggregate in

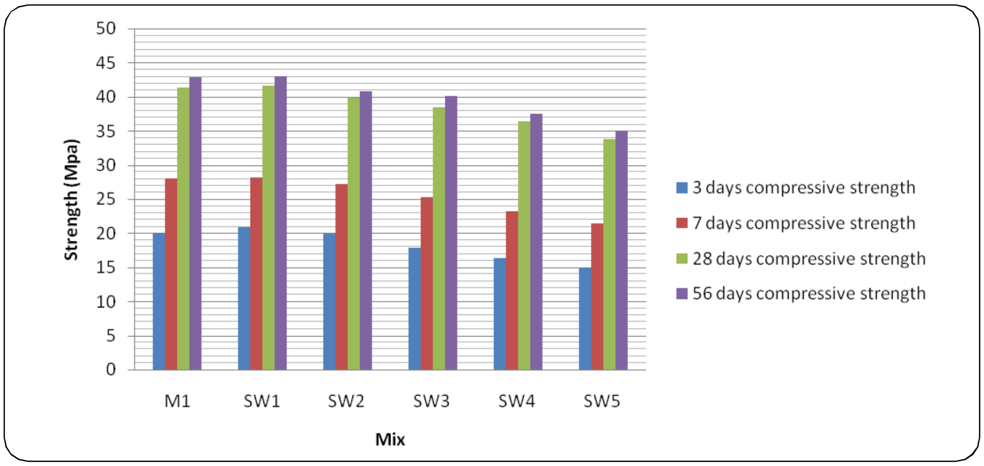

Fig. 1: Compressive strength of concrete after 3, 7, 28 and 56 days of curing for various mixes.

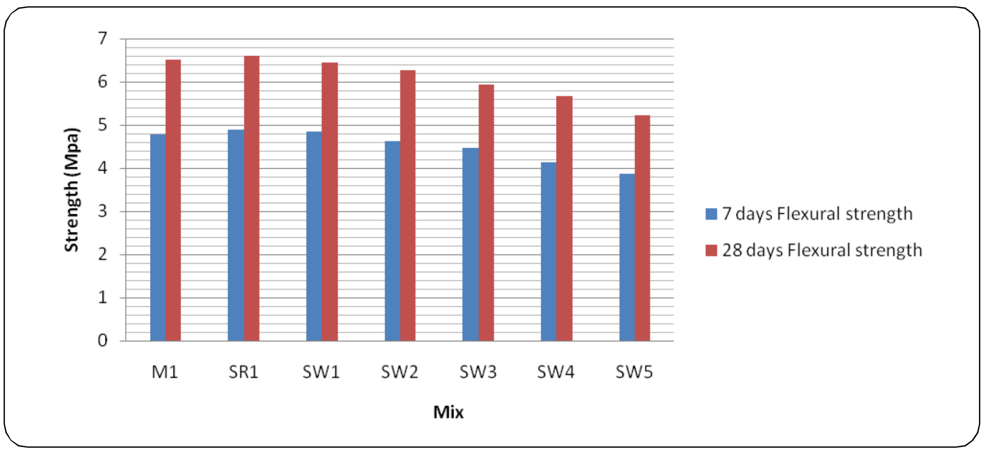

Fig. 2: Flexural strength of prisms after 7and 28 days of curing for various mixes.

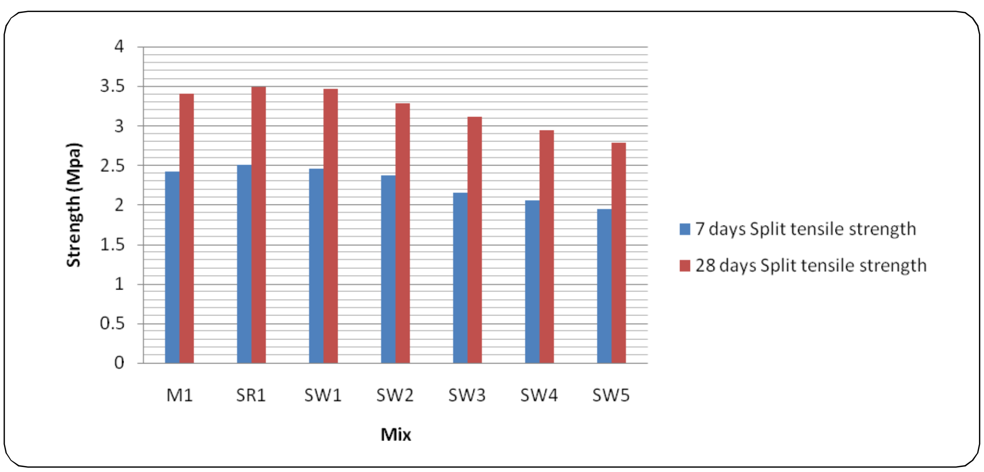

Fig. 3: Split tensile strength of cylinders after 7 and 28 days of curing for various mixes.

Fig. 4: Ettringite formation in concrete due to presence of excess cement slurry in washout water.

concrete. Concrete containing 20% and more than that of recycled aggregates attains less compressive strength than the control concrete at all ages. The main reason for strength reduction is that, more amount of recycled aggregates increases the porosity of concrete, because the recycled fresh concrete aggregates are porous in nature. Increase in porosity results in weaker bonding between aggregate and cement matrix. Hence, it is beneficial to replace 15% recycled aggregate in concrete for better results.

CONCLUSION

The research findings suggests that the washout water can be used as mixing water in concrete and 15% recycled aggregates can be replaced instead of natural aggregate without any adverse effects on mechanical properties of concrete. This investigation clearly indicates that the problem of disposing washout water and excess fresh concrete aggregate from ready mix concrete plants in an environmentally acceptable manner can be eased by reusing the same in concrete. Instead of disposing this discarded hazardous waste as pollutant in environment, it can be totally reused for making concrete without any treatment, which helps in pollution control and sustainable development. On the whole the reuse of washout water and recycled aggregate in concrete is advantageous in both economical and environmental aspects.

REFERENCES

Borger, J., Carrasquillo, R.L. and Fowler, D.W. 1994. Use of recycled wash water and returned plastic concrete in the production of fresh concrete. Advanced Cement Based Materials, 1: 267-274.

Chatveera, B., Lertwattanaruk, P. and Makul, N. 2006. Effect of sludge water from ready-mixed concrete plant on properties and durability of concrete. Cement and Concrete Composites, 28: 441-450.

Chatveera, B. and Lertwattanaruk, P. 2009. Use of ready-mixed concrete plant sludge water in concrete containing an additive or admixture. Journal of Environmental Management, 90: 1901-1908.

Chini, A.R. and Muszynski, L.C. 2001. Reuse of wastewater at concrete plants in Florida in the production of fresh concrete. Magazine Concrete Research, 53: 311-319.

Ibrahin, Al-Ghusain and Mohammed Terro, J. 2003. Use of treated waste water for concrete mixing in Kuwait. Kuwait Journal of Science and Engineering, 30: 213-228.

Low, G. L., Ng, K.Y., Ng. W.L., Tam, C.T. and Heng, R.B.W. 2007. Use of recycled cement based slurry water for making concrete. Journal - The Institution of Engineers, Malaysia, 68: 47-55.

Manzi, S., Mazzotti, C. and Bignozzi, M.C. 2013. Short and long-term behavior of structural concrete with recycled concrete aggregate. Cement & Concrete Composites, 37: 312-318.

Marco Paolini and Rabinder Khurana 1998. Admixtures for recycling of waste concrete. Cement and Concrete Composites, 20: 221-229.

Nan, Su, Buquan, Miao and Fu-Shung, Liu 2002. Effect of wash water and underground water on properties of concrete. Cement Concrete Research, 32: 777-782.

Parker, C.L. and Slimak, M. W. 1977. Waste treatment and disposal costs for the ready-mixed concrete industry. The American Concrete Institute, 74(7): 281-287.

Sandrolini, F. and Franzoni Elisa 2001. Waste wash water recycling in ready mixed concrete plants. Cement Concrete Research, 31: 485-489.

Shi-Cong Kou, Chi-Sun Poon and Hui-Wen Wan 2012. Properties of concrete prepared with low-grade recycled aggregates. Construction and Building Materials, 36: 881-889.

Yeong-Nain Sheen, Her-Yung Wang, Yi-Ping Juang and Duc-Hien Le 2013. Assessment on the engineering properties of ready-mixed concrete using recycled aggregates. Construction and Building Materials, 45: 298-305.