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Study of E-Waste on Strength of Self-Healing concrete: A Review

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Abstract

There are various research and studies have been carried out on the use of waste in concrete to enhance its properties. The studies find the effect of waste material on workability as well as strength of the concrete. Following are some studies available to determine the properties of concrete by replacing the coarse aggregate by E-Plastic waste. In the same way the researches are based on the Bacterial concrete or in other words we can say self-healing concrete, to determine the behaviour and properties of self-healing concrete.

Key Words – Concrete , Self-Healing , E-Waste, Bacterial concrete,Workability

Introduction

Concrete is a composite material, consisting of chemically unreactive substances such as coarse aggregate and fine aggregate which are usually referred to as gravel and sand which are bonded together by cement and water. Concrete is used in almost all types of civil engineering works, railways, airports, defence installation etc. In ancient times people used clay as binding substances. Later on, Egyptians started using lime and gypsum together. That was the time when lime came to be considered as the primary construction material. In 1824 "Joseph Aspdin" burned limestone and clay grounded them and developed Portland cement.

Aggregates are to be chosen very carefully because they are inert substances and any impurity in them can react with other components of concrete. In aggregates, the aggregates with size less than 4.75mm are considered as fine aggregates and more than 4.75mm are considered as coarse aggregate. When all the components are added together they form a thick paste which can be moulded to any desired shape. When mix is placed after moulding, curing is done. Once we added cement into concrete the hydration process initialized, due to which the water into concrete also participated in the hydration process and evaporated. To complete hydration concrete requires more water, from here curing came into account. Technically the C-S-H gel i.e. Calcium-Silicate-Hydrate gel is formed after curing, which is the main binder in concrete.

Basically, curing is the reaction of cement and water. There are three stages of curing concrete. In the first stage the strength gain is minimum and occurs just after the water is added. The second stage takes place after initial setting of concrete, here the rate of strength development is more as compared to first stage, this stage took about 6-7 hours to complete. The final stage i.e. third stage takes place at the end in which complete hydration is done, in this process heat generated is less with lower rate of strength development.

Literature Review Summary:

Gavhane, et al. (2016), In their study they replace coarse as well as fine aggregate by E-Waste which is collected from broken computer parts such as mouse, keyboard, CPU, etc. at various percentages of 0%, 10% and 20% and tested at 7, 14 and 28 days. The specific gravity of the collected E-Waste was found to be 0.84. By replacing coarse aggregate by 10% of E-Waste gives almost same results as conventional concrete in compression. But when they are tested for split tensile strength and flexure strength the strength reduced by 10.62% and 19.65% as compared to conventional concrete. In the same way replacement of coarse aggregate by 20% gives undesirable results i.e. both compressive as well as tensile strength decreases. At the other hand the workability of concrete increases after replacement. So, it could be concluded that it reduces the amount of admixture to make the concrete workable so it reduces the admixture cost as compared to the conventional concrete and gives desirable strength at 10%.

Manjunath (2016), Replacement of coarse aggregate was done by E- plastic waste. The replacement percentages are 0%, 10%, 20% and 30% with specific gravity of 1.1. The specimens were tested at 7, 14 and 28 days. By increasing E-Waste, the workability decreases. In the same way compressive strength will also decreases as increase in percentage of E-Waste. But at 10% replacement the compressive strength is somehow equivalent to that of control mix. It could be concluded from this study that, effect of water-cement ratio on strength is not useful for E-Waste plastic due to reduction in bond strength because of plastic aggregates.

Dawande, Jain and Singh (2015), For the study the E-Waste was collected from the local area contains TV, Radio, CD, etc. with specific gravity of 1.17. The coarse aggregate was replaced by e-plastic with 0%, 10%, 15% and 20% and tested at 7, 14 and 28 days. Here, the study comprises two parts, one is replacement of coarse aggregate with e-plastic waste and another is replacement of coarse aggregate with e-plastic along with 10% fly ash as additive. There recorded a decrease in compressive strength as the percentage of E-plastic increases but give desirable results when replaced by 10%. When, replacement is done by adding fly ash much more promising results were seen. Which shows by adding fly ash the optimum percentage of E-Waste was obtained to be 25% and solely it was only 10% of replacement of coarse aggregate.

Kumar and Baskar (2014), High Impact Polystyrene (HIPS) plastic was used which is taken from the computer and its accessories with size 6-12mm and specific gravity 1.29. Partial substitution of coarse aggregate is done as 10%, 20%, 30%, 40% and 50%. Three different grades of concrete were prepared i.e., M20, M25 and M30 with water-cement ratio of 0.45, 0.49 and 0.53. 7 and 28days of testing were done. The observations show a decrease in slump with a percentage increase in HIPS content. Compressive strength decreases as the percentage of HIPS increases. Both flexure strength and split tensile strength decreases as the HIPS content increases. They have also done response surface analysis through design expert software and predicted a model by 25% HIPS replacement and the water-cement ratio of 0.49. The results are very close to the experimental data.

Sabau and Vargas (2018), Used Acrylonitrile Butadiene Styrene (ABS) plastic for partial replacement of coarse aggregate. Computer accessories and other electronic devices consist of ABS i.e., because of its mechanical behaviour and resistance against chemical attacks. Coarse aggregate was replaced by ABS plastic with specific gravity 0.93 by 40%, 50% and 60%. An increase in workability and a decrease in compressive strength was observed. The maximum reduction in compressive strength was 44% corresponds to 60% replacement. The outcomes also elucidate that the concrete prepared was lightweight concrete because of a 22% reduction in weight by employing 60% of e-plastic waste.

Santhanam and Anbuarasu (2019), Reported that High strength concrete can be prepared using e-plastic waste. They used PCBs as a partial replacement of coarse aggregate with a specific gravity of 0.8. A concrete of M60 grade was prepared. Admixture “Polycarboxylate Ether” was used. Aggregates replaced by 0%, 8%, 12% and 16% by volume. The samples are tested at 7, 14, and 28 days. The result shows an increase in compressive strength as the percentage of E-Waste increases. Through the results, it can be concluded that even High strength concrete of grade M60 can be prepared by using E-Waste as a replacement for coarse aggregate, it increases the mechanical strength of concrete and was an environment-friendly approach.

Mantkar and Deshmukh (2015), E-Waste was collected from various local bodies. Worked on two grades of concrete M20 and M25. Coarse aggregate was partially replaced by E-Waste by percentage 0%, 5%, 10%, 15% and 20%. The testing was done on 7, 14 and 28days. The result shows that the replacement of 5 to 10% gives strength very close to the control mix. While, at 20% replacement, the decrease in strength was about 37.84% for the M20 grade of concrete. The conclusions carried out says that 5- 6% replacement of E-Waste was suitable for roads and (G+2) building constructions, but, over 10% was not desirable for use in construction because of reduction in strength.

Needhidasan and Sai (2019), Reported an increase in strength up to a certain percentage by using circuit boards chips of size 20mm. The replacement is done by 0%, 8%, 12% and 16% of coarse aggregate. The testing was done at 7, 14, and 28days. Workability decreases as the percentage of E-Waste increases. Up to 12% replacement compressive strength increases about 3.73% while decreases at 16% replacement. The result also shows that the replacement of fly ash with cement along with coarse aggregate replacement is more effective than replacing coarse aggregate solely. The flexural strength increases as the percentage of E-Waste increases. The maximum increase in flexural strength was observed as 19.51%. Similarly, the split tensile strength also increases as E-Waste increases. The maximum increase was observed as 48.48% as compared to the controlled mix.

Conclusions

In all the above presented papers E-Waste is used as partial replacement of coarse aggregates and papers illustrated about self-healing bacterial concrete. After the study of various research papers, it is found that E-Waste plastic can be used up to 10 to 15% as replacement of coarse aggregate. While, Bacteria should be added in about 3 to 5% as additive along with a calcium source. From various literatures it can be concluded that Calcium Lactate is a good calcium source for bacteria and bacteria can be used with ABS Plastic waste which is used in the study.

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References

1. IS:10262 (2019). *Concrete Mix Proportioning-Guidelines*. New Delhi: Bureau of Indian Standards. https://civiconcepts.com/wp-content/uploads/2020/11/4.IS-10262-2019-New-Mix-design.pdf
2. IS:1199 (1959). *Methods of Sampling and Analysis of Concrete*. New Delhi: Bureau of Indian Standards.
3. IS:2386 (1963). *Methods of Test For Aggregate For Concrete*. New Delhi: Indian Standards Institution. https://law.resource.org/pub/in/bis/S03/is.2386.5.1963.pdf.
4. IS:383 (2016). *Coarse and Fine Aggregates for Concrete - Specification*. BUREAU OF INDIAN STANDARDS. http://skgcgroup.com/wp-content/uploads/2020/02/IS%20383-2016.pdf.
5. IS:516 (1959) *Methods of Tests For Strength of Concrete*. New Delhi: Bureau of Indian Standards.
6. IS:5816 (1999) *Splitting Tensile Strength Of Concrete-Method of Test*. New Delhi: Bureau Of Indian Standards. https://www.iitk.ac.in/ce/test/IS-codes/is.5816.1999.pdf.
7. IS:8112 (2013) *Ordinary Portland Cement, 43 Grade — Specification* Bureau Of Indian Standards. https://www.iitk.ac.in/ce/test/IS-codes/is.8112.2013.pdf.
8. Abishek Kumar A. A, Eveena Stephen, Merin George, Ansaf muhammad, Naveen Charles. 2020. *Evaluation of Strength and Durability Properties for Various Amount of Bacillus Subtilis Bacteria in Concrete*. International Journal of Engineering Research & Technology (IJERT) 548-551. http://www.ijert.org.

9. Aditya Tadimeti, Jeff Sutton. 2020. *The Effects of Different Aquatic Environments on the Rate of Polyethylene Biodegradation by Bacillus subtilis*. Journal of Emerging Investigators ll: 1-7. www.emerginginvestigators.org.

10. Ahirwar, Sunil, Pratiksha Malviya, Vikash Patidar, and Vikash Kumar Singh. 2016. *"An Experimental Study on Concrete by using EWaste as partial Replacement for Course Aggregate*." IJSTE - International Journal of Science Technology & Engineering | Volume 3 | Issue 04 7-13. www.ijste.org.

11. Balde, C.P, Forti, Kuehr, and Stegmann. 2017. *The Global E-Waste Monitor 2017.* Bonn/Geneva/Vienna: United Nations University (UNU), International TelecommunicationUnion (ITU) & International Solid Waste Association(ISWA). https://www.itu.int/en/ITU-D/Climate-Change/Documents/GEM%202017/Global-E-Waste%20Monitor%202017%20.pdf.

12. Bennett, Natalie. 2021. *Twitter*. june 29. https://twitter.com/natalieben/status/1409902839434973184.

13. C. Manvith Kumar Reddy, B. Ramesh, Macrin D, Kanth reddy. 2020. "*Influence of bacteria Bacillus subtilis and its effects on flexural strength of concrete*." Materials Today: Proceedings 1-6. doi:https://doi.org/10.1016/j.matpr.2020.07.225.

14. 2019-20. *Central Pollution Control Board Annual Report*. Delhi, India: Ministry of Environment, Forest & Climate Change. https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTI0M18x NjE2NTYxOTAxX 21lZGlhcGhvdG8xMTgzNi5wZGY=.

15. 2021. *Central Public Works Department*. Delhi: Government of India. https://cpwd.gov.in/Publication/DSR_2021_VOL_I_ENGLISH_Dir.pdf.

16. 2021. *Children and digital dumpsites: E-Waste exposure and child health.* Geneva: World Health Organization. file:///C:/Users/91942/Downloads/9789240023901-eng.pdf.

17. 2016. *CNN International.* February 5. https://edition.cnn.com/2016/02/05/asia/gallery/mumbai- deonar-garbage-dump/index.html.

18. Dawande, Bharat, Devansh Jain, and Gyanendra Singh. 2015. "*Utilization of E-Waste as a Partial Replacement of Coarse Aggregate in Concrete*." International Journal for Scientific Research & Development 6-9. www.ijsrd.com.

19. F. Khademi, K. Behfarnia. 2016. *"evaluation of concrete compressive*

strength using artificial neural network and multiple linear regression models." international journal of optimization in civil engineering 423-432. https://www.researchgate.net/publication/297532369.

20. Forti, Vanessa, Cornelis peter Balde, Ruediger Kuehr, and Garam Bel. 2020. *The Global E- Waste Monitor 2020.* Rotterdam: World Health Organization, 1-120. http://ewastemonitor.info/wp-content/uploads/2020/12/GEM_2020_def_dec_2020-1.pdf.

21. Gavhane, Aditya, Dinesh Sutar, Shubham Soni, and Praveen Patil. 2016. "*Utilisation of E - Plastic Waste in Concrete*." International Journal of Engineering Research & Technology 594-601. http://www.ijert.org.

22. Henk M. Jonkers, Erik Schlangen. 2008. "*Development of a bacteria-based self healing concrete." Tailor Made Concrete Structures –* Walraven & Stoelhorst 425-430. https://www.researchgate.net/publication/267716612.

23. 2018. "India Environment Portal." *http://www.indiaenvironmentportal.org.in/.* March 22. http://www.indiaenvironmentportal.org.in/files/file/E-%20Waste%20(Managment)%20Amendment%20%20Rules,%202018.pdf.

24. 2021. *International E-Waste day 14 October 2021.* October 14. https://weee-forum.org/iewd-about/.

25. jogi, Pavan Kumar, and T.V.S Vara Laxmi. 2021. "*Self healing concrete based on differentbacteria: A review.*" MaterialsToday Proceedings 1246-1252. doi:https://doi.org/10.1016/j.matpr.2020.08.765.

26. Joseph, Jacob. 2013. *A Gentle Introduction to Neural Network.* https://clevertap.com/blog/neural-networks/.

27. Kumar, K. Senthil, and K. Baskar. 2014. "*Response Surfaces for Fresh and Hardened Properties f Concrete with E-Waste (HIPS)*." Journal of Waste Management (Hindawi Publishing Corporation) 1-15. doi:10.1155/2014/517219.

28. Manatkar, Pravin A., and Ganesh P. Deshmukh. 2015. "*Use Of Non-Metallic E-Waste As A Coarse Aggregate In A Concrete*." International Journal of Research in Engineering and Technology 242-246. doi:10.15623/ijret.2015.0403040.

29. Manjunath, Ashwini. 2016. "*Partial replacement of E-plastic Waste as Coarse-aggregate in Concrete*." International Conference on Solid Waste Management. Bangalore: Procedia Environmental Sciences. 731-739. doi:10.1016/j.proenv.2016.07.079.

30. Meltem Özturan, Birgül Kutlu, Turan Özturan. 2008. "C*omparison Of Concrete Strength Prediction Techniques With Artificial Neural Network Approach*." Building Research Journal 56: 23-36.
31. N. Ganesh Babu, Dr. S. Siddiraju. 2016. "*An Experimental Study on Strength and Fracture Properties of Self Healing Concrete*." International Journal of Civil Engineering and Technology (IJCIET) 7 (3): 398-406. http://www.iaeme.com.

32. Needhidasan, S., and Puli Sai. 2019. "*Demonstration on the limited substitution of coarse aggregate with the E-Waste plastic in high strength concrete*." Materials Today: Proceedings 1- 6. doi:10.1016/j.matpr.2019.11.255.

33. Nielsen, Michael. 2019. "Neural Networks and deep learning." December.http://neuralnetworksanddeeplearning.com/chap1.html.

34. Nikoo, Mehdi. 2015. "*Prediction of Concrete Compressive Strength by Evolutionary Artificial Neural Networks*." Advances in Material Science and Engineering. doi:https://doi.org/10.1155/2015/849126.

35. Paul, sulav indra. 2021. "Identification of marine sponge-associated bacteria of the Saint Martin's island of the Bay of Bengal emphasizing on the prevention of motile Aeromonas septicemia in Labeo rohita." *Aquaculture* 1-13. doi:doi:10.1016/j.aquaculture.2021.737156.

36. Peters, Edward N. 2006. *Chapter 9-Plastics: Information And Properties*. Vol. Volume 1. New York: Mechanical Engineers' Handbook: Materials and Mechanical Design, Third Edition. file:///C:/Users/91942/Downloads/Quantitative_Methods_of_Materials_Select.pdf.

37. Raut, Sagar R., Roshani S. Dhapudkar, and Monali G. Mandaokar. 2018. "*Experimental Study on Utilization of E -Waste in Cement Concrete." The International Journal of Engineering and Science (IJES) 82-86*.

38. Renée M. Mors, Henk M. Jonkers. 2019. "*Bacteria-based self-healing concrete: evaluation of full scale demonstrator projects*." RILEM Technical Letters 138-144. doi:http://dx.doi.org/10.21809/rilemtechlett.2019.93.

39. Renée M. Mors, Henk M. Jonkers. 2012. "*Bacteria-based self-healing concrete-an itroduction." 32-39.*

40. Sabău, Marian, and Johnny R. Vargas. 2018. "*Use of e-plastic waste in concrete as a partial replacement of coarse mineral aggregate."* Computers and Concrete 377-384. doi:10.12989/cac.2018.21.4.377.

41. Santhanam, Needhidasan, and Gokulraj Anbuarasu. 2019. "*Experimental*

study on high strength concrete (M60) with reused E-Waste plastic." Materials Today: Proceedings 1-7. doi:10.1016/j.matpr.2019.11.107.

42. Sarle, Warren S. 1994. "Neural Networks and Statistical Models." *Nineteenth Annual SAS Users Group International Conference.* NC, USA. 1-13.

43. Supriyo, Babul. 2020. "*Ministry Of Environment, Forests And Climate Change*." Lok Sabha. Delhi, India: Government Of India.Http://Loksab

44. 2020. *The Logical Indian.* https://thelogicalindian.com/story-feed/sports/tokyo-olympics-medals-E-Waste.

45. 2020. *Tokyo 2020 Medal Project: Towards an innovative future for all.* https://olympics.com/tokyo-2020/en/games/medals-project/.

46. Turner, Andrew. 2018. "*Black plastics: Linear and circular economies, hazardous additivesand marine pollution*." *Environment International* 308-318. doi:https://doi.org/10.1016/j.envint.2018.04.036.