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Study of E-Waste on Strength of Self-Healing Concrete

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ABSTRACT

The aim is to reduce the cost of construction and enhance the properties of the concrete. Also, E-Waste is a global problem for both developing and developed nations. The reason is, there is no method of disposal of E-Waste other than some traditional ones. Landfill and incineration are commonly used for disposal of E-Waste but, landfill needs a wide landmass and also pollute the groundwater by leaching. On the other hand, incineration cause air pollution. So, using E-Waste in concrete is the better idea as compared to these traditional methods. Different researchers worked over the utilization of E-Waste in concrete. In their research, they use E-Waste as coarse aggregate, fine aggregate, admixture and so on, and perform both strength and durability test over them. The researches show the possibility of substitution of raw materials with E-Waste. In the present study coarse aggregate is replaced by ABS plastic with various percentages which are 5%, 10%, 15% and 20%. Concrete structures have a lifespan of about 50-100years. But, deterioration of structure starts in 10years and sometimes within a year of the construction. Small cracks are generated into the structure after certain years which are either structural cracks or superficial cracks. To deal with this the various researches shows bacterial self-healing concrete. The self-healing ability of concrete was discussed in various papers so in this paper we are conducting an analysis on strength properties of self-healing bacterial concrete by adding bacteria (Bacillus Subtilis) with calcium source. The bacteria (Bacillus Subtilis) were added at 3% and 5% and Calcium Lactate as calcium source was added at 5% and 10% respectively in the research. Thus, the study deals with economical aspect not only for construction but also for maintenance purposes.

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.

Compressive strength test is carried out using compression testing machine (CTM), grade of concrete is determined after a curing period of 28 days. The major portion of strength of concrete is observed after 28 days of curing thus this strength is used in almost all engineering purposes. For cement concrete roads we generally use the

ultimate strength after 90 days by keeping in mind that there are very few commercial vehicles that travel on a particular span during the period of 90 days. But, due to general practice of identifying the strengths after 28days the IRC provides the multiplying factor to determine the 90days strength through 28days strength.

Objectives of the project:

This research focused on reducing environmental pollution generated by E-Waste Plastic which is harmful for environment as well as human health. In the same way tried to reduce the construction cost of concrete by using waste materials as substitute and introducing the modern technique of self-healing concrete.

Following are the objectives of the study:

- Find out the effect on strength of concrete by partial replacing coarse aggregate with E-Waste Plastic.
- Find out the effect on strength of concrete by adding Calcium Lactate (a calcium source for bacteria) in concrete.
- Find out the effect on strength of concrete by adding Bacteria (Bacillus Subtilis) and Calcium Lactate in concrete.
- To determine the optimum percentage of Bacteria and Calcium Lactate in concrete mix.
- Find out the effect on strength of concrete by adding E-Waste Plastic and Bacteria along with the calcium source in concrete mix.
- To evaluate the cost and savings in concrete construction.
- To analysis of results based on previous literatures

Result & Discussions

Table 1 Test result of OPC 43 grade Cement

Test	**Result**
Specific Gravity	3.15
initial setting time	35 minutes
final setting time	363 minutes
7 days compressive strength	32.9
28 days compressive strength	45.32
Fineness	9%
Consistency	27%

Table 2 Result of fine aggregate

Test	**Result**
Specific gravity	2.62
fineness modulus	2.63
Loose density	1579 kg/m^3
compacted density	1590 kg/m^3
grading zone	2

From the above sieve analysis, it is confirmed that the fine aggregate belongs to ZONE 2

Table 3 Grading of fine aggregate as per sieve analysis

S. No.	**Is Sieve**	**Weight Retained**	**Cumulative Weight Retained**	**Cumulative Percent Retained**	**Cumulative Percent Passing**
1	10mm	0	0	0%	100%
2	4.75mm	26	26	5%	95%
3	2.36mm	53	79	16%	84%
4	1.18mm	79	158	32%	68%
5	600µ	53	211	42%	58%
6	300µ	158	369	74%	26%
7	150µ	105	474	95%	5%
8	PAN.	26	500		
	Total	500		263%	

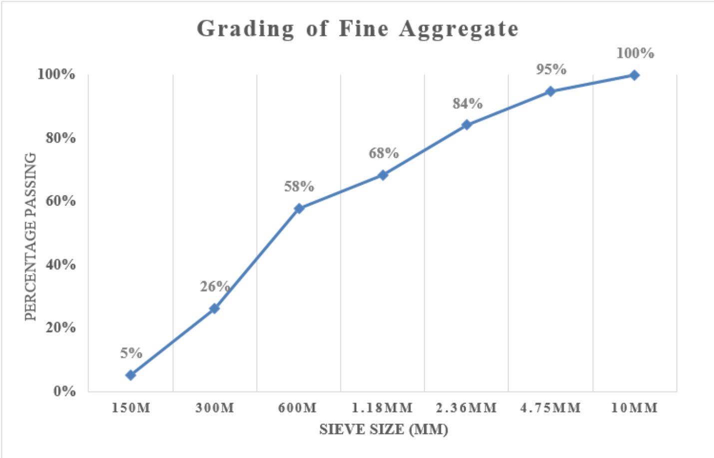

Fig. 1 Grading of fine aggregate

Table 4 Test Results of Coarse Aggregate

Test	**Result**
Specific Gravity	2.91
Water absorption	0.61%
Crushing Value	21.90%
Impact value	10.02%
Abrasion value	20.20%
Density	1743.2 Kg/m3

Table 5 Grading of 20mm Aggregate

Sieve	**Weight Retained (Gram)**	**% Retained**	**Cumulative % Retained**	**% Passing**
40	0	0%	0%	100.00%
20	2610	26%	26%	73.90%
10	6980	70%	96%	4.10%
4.75	410	4%	100%	0.00%
Total	10000			

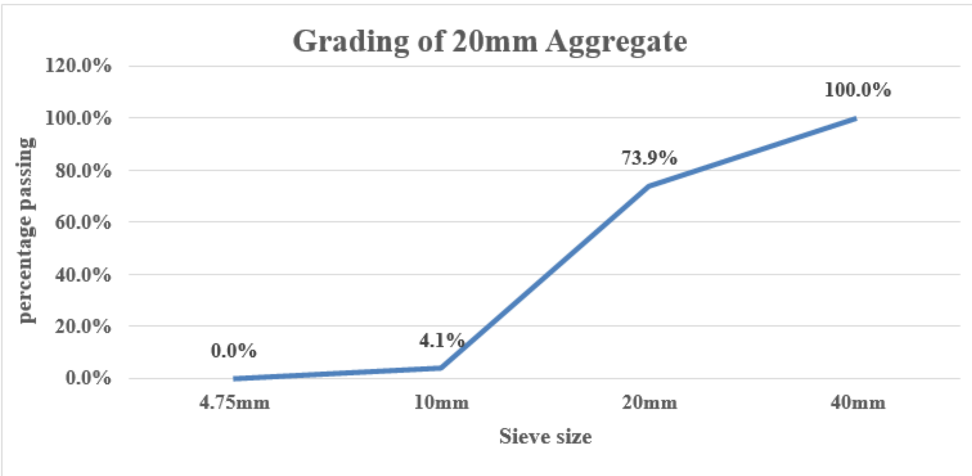

FIG. 2 GRADING OF 20MM AGGREGATE

Fig. 2 Grading of 20mm aggregate

Table 6 Grading of 10mm Aggregate

Sieve	Weight Retained (Gram)	% Retained	Cumulative % Retained	% Passing
20mm	0	0%	0%	100.00%
10mm	590	12%	12%	88.20%
4.75mm	4096	82%	94%	6.28%
2.36mm	145	3%	97%	3.38%
pan	169	3%	100%	0.00%
Total	5000			

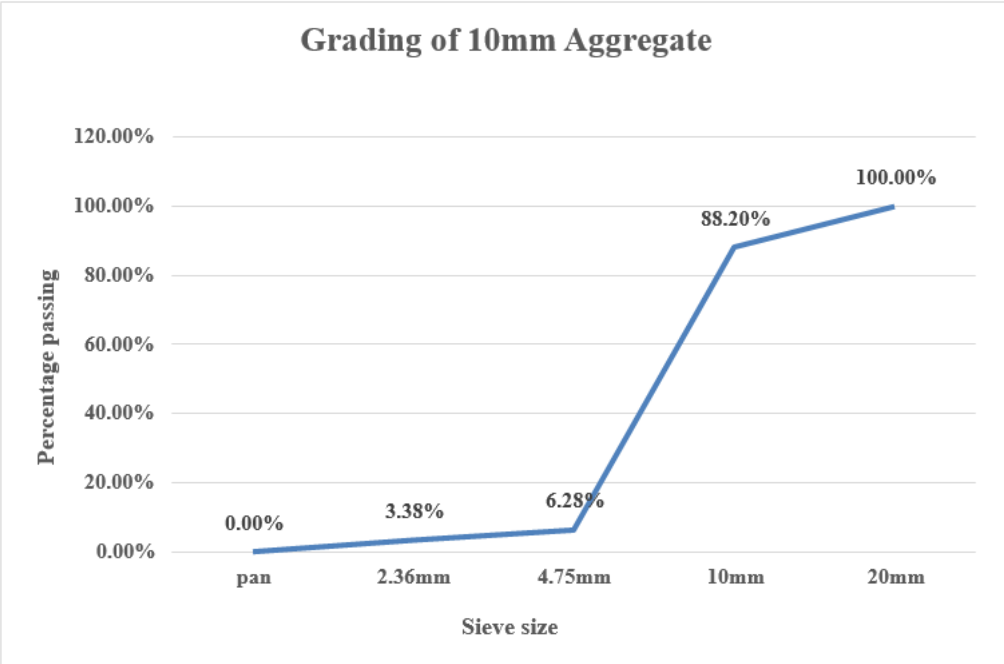

Fig. 3 Grading of 10mm aggregate

Table 7 Grading of Mixed Aggregate

Sieve Size	Aggregate Size		Blended Aggregate	Desired Proportion
	20mm (50%)	10mm (50%)		
40mm	100.0%	100.00%	100.00%	100
20mm	73.9%	100.00%	86.95%	90 to 100
10mm	4.1%	88.20%	46.15%	25 to 55
4.75mm	0	6.28%	3.14%	0 to 10

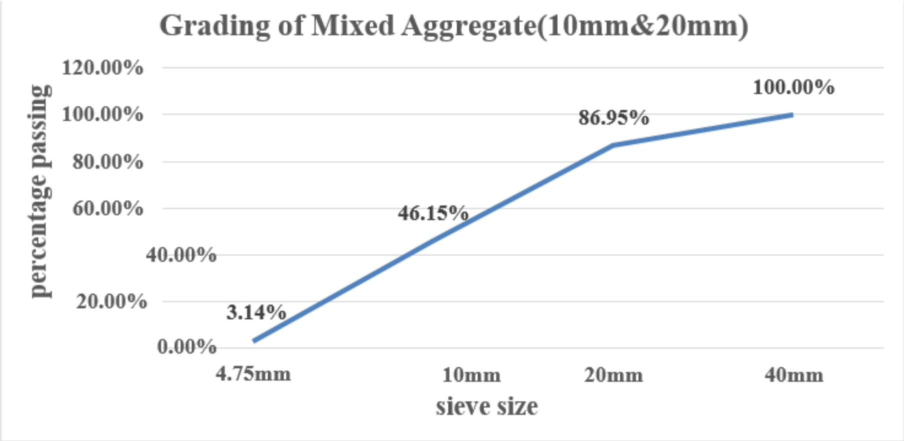

Fig. 4 Grading of Mixed aggregate 10mm and 20mm

Table 8 Grading of all in aggregate

Sieve Size	Aggregate (66%)	Sand (34%)	Blended Proportion	Desired Proportion
40mm	100.00%	100.00%	100.00%	100
20mm	86.95%	100.00%	91.39%	95 to 100
4.75mm	3%	94.80%	34.30%	30 to 50
600µ	0%	57.80%	19.65%	10 to 35
150µ	0%	5.20%	1.77%	0 to 6

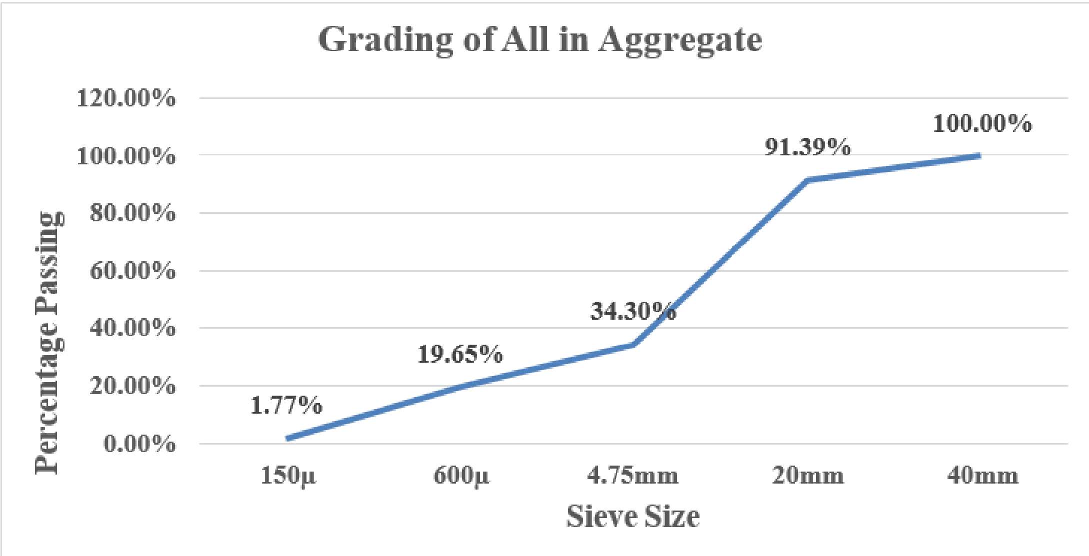

Fig. 5 Grading of All in Aggregate

Table 9 Value of Slump for different concrete mixes

Mix	E-Waste (R)	Bacteria (B)	Calcium Lactate (L)	Slump (mm)
C	0%	0%	0%	78
R1	5%	0%	0%	80
R2	10%	0%	0%	83
R3	15%	0%	0%	85
R4	20%	0%	0%	88
B1	0%	3%	0%	81
B2	0%	5%	0%	88

L1	0%	0%	5%	76
L2	0%	0%	10%	72
L+B	0%	3%	5%	79
L+B+R	10%	3%	5%	84

Table 10 Compressive Strength of Concrete with Coarse Aggregate Replacement by E-Waste

Mix	**E-Waste (%)**	**Compressive Strength (MPa)**	
		7 days	**28 days**
C	0%	28.41	41.19
R1	5%	28.83	41.78
R2	10%	29.41	42.96
R3	15%	28.38	40.3
R4	20%	27.82	39.17

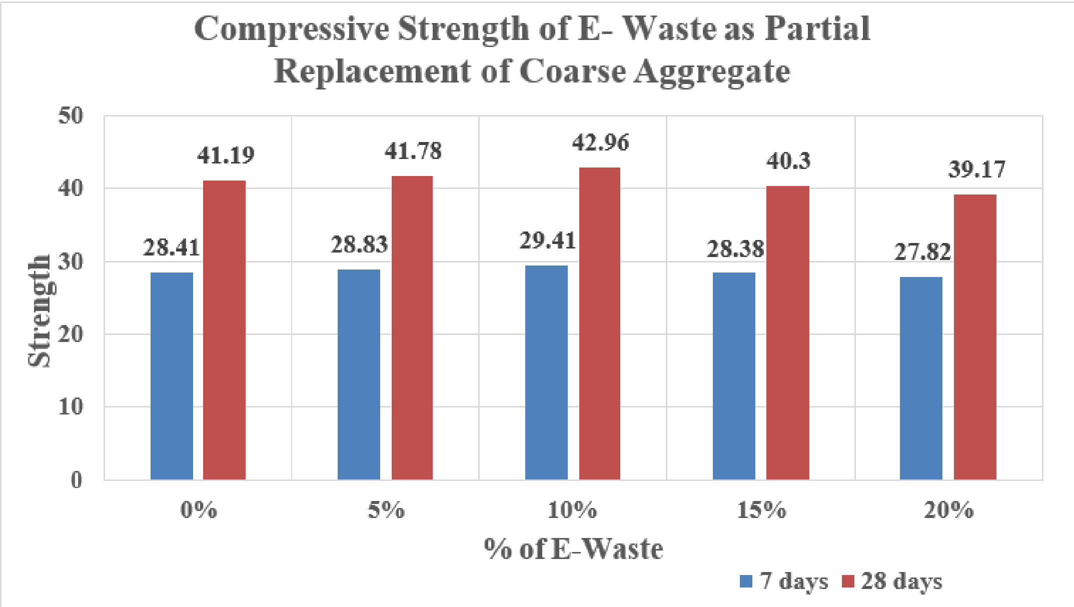

Fig. 6 7 days and 28 days Compressive Strength at varying percentage of E-Waste

Table 11 Split Tensile Strength of Concrete with Coarse Aggregate replacement by E-Waste

Mix	**E-Waste (%)**	**Split Tensile Strength (MPa)**	
		7 days	**28 days**
C	0%	3.77	4.29
R1	5%	3.89	4.38
R2	10%	3.96	4.44
R3	15%	3.89	4.38
R4	20%	3.71	4.24

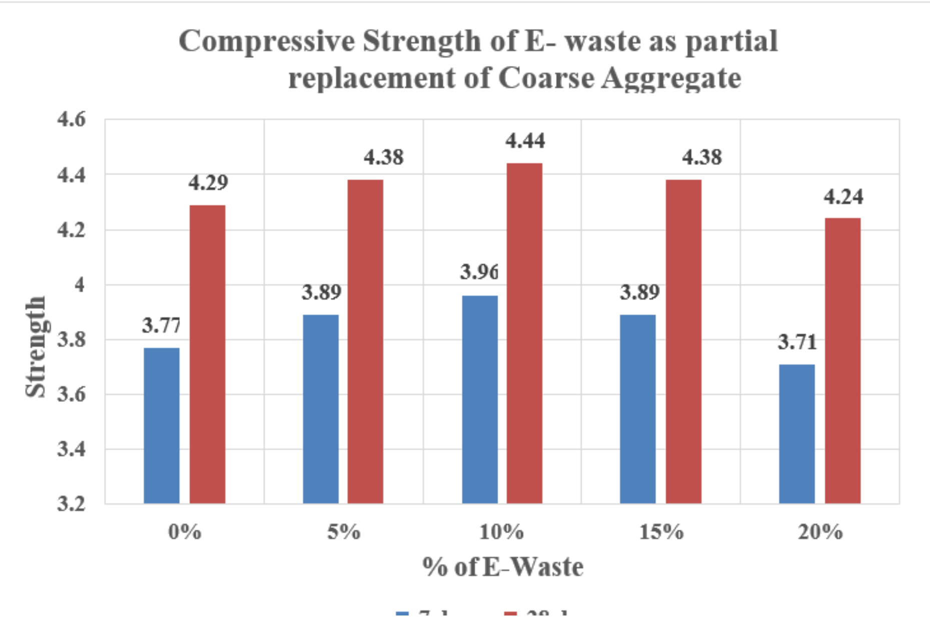

Fig. 7 7 days and 28 days Split Tensile Strength at varying percentage of E- Waste

Table 12 Compressive Strength Test Results of Concrete by adding calcium Lactate

Mix	Calcium Lactate (%)	Compressive Strength (MPa)	
		7 days	28 days
C	0%	28.41	41.19
L1	5%	28.34	40.36
L2	10%	21	30.48

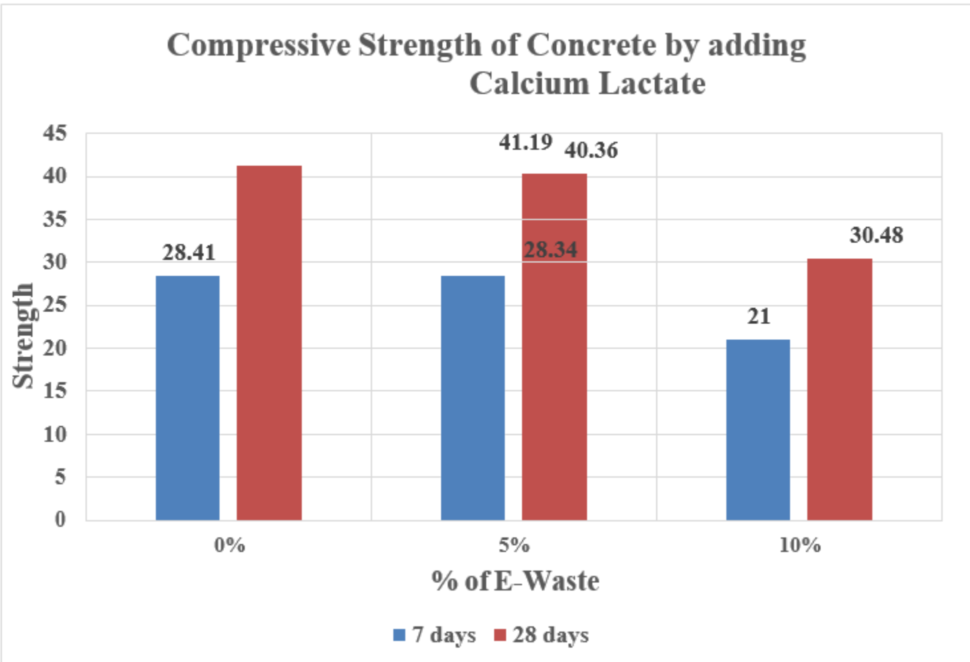

Fig. 8 7 days and 28 days Compressive Strength at varying percentage of Calcium Lactate

Table 13 Split Tensile Strength Test Results of Concrete by adding calcium Lactate

Mix	**Calcium Lactate (%)**	**Split Tensile Strength (MPa)**	
		7 days	**28 days**
C	0%	3.77	4.29
L1	5%	3.88	4.42
L2	10%	3.28	3.79

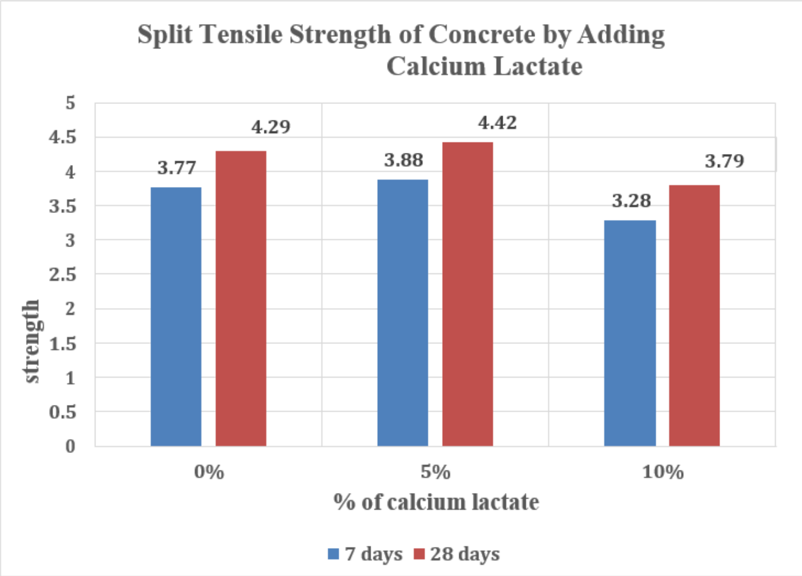

Fig. 9 7 days and 28 days Compressive Strength at varying percentage of Calcium Lactate

Table 14 Compressive Strength Test Results of Concrete by adding Bacteria

Mix	**Bacteria (Bacillus Subtilis) (%)**	**Compressive Strength (MPa)**	
		7 days	**28 days**
C	0%	28.41	41.19
B1	3%	31.17	43.91
B2	5%	26.73	37.48

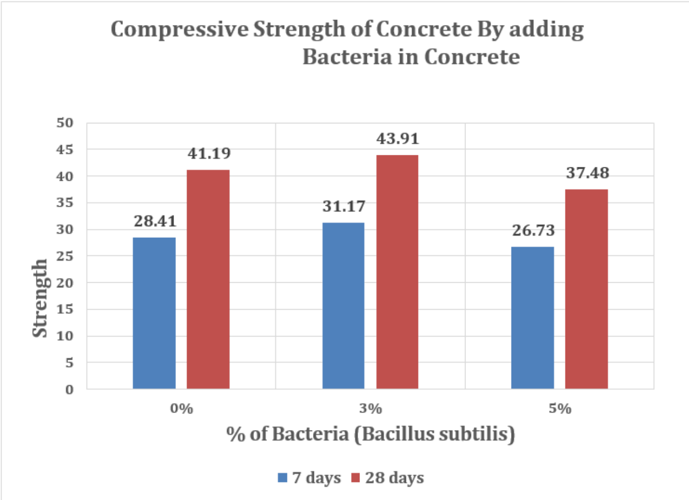

Fig. 10 7 days and 28 days Compressive Strength at varying percentage of Bacteria (Bacillus Subtilis)

Table 15 Split Tensile Strength Test Results of Concrete by adding Bacteria

Mix	Bacteria (Bacillus Subtilis) (%)	Split Tensile Strength (MPa)	
		7 days	28 days
C	0%	3.77	4.29
B1	3%	3.97	4.58
B2	5%	3.69	4.21

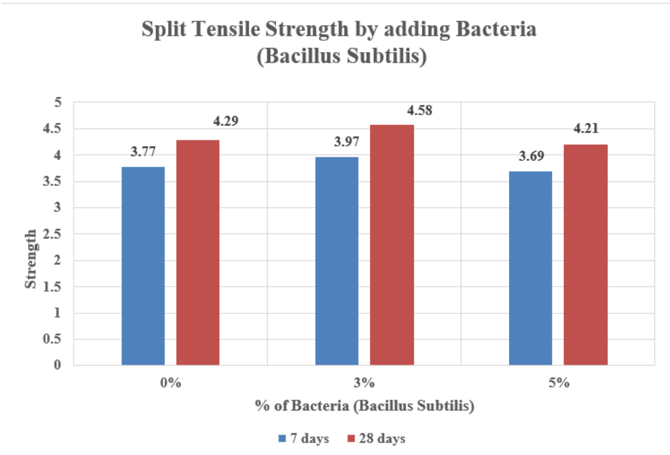

Fig. 11 7 days and 28 days Split Tensile Strength at varying percentage of Bacteria (Bacillus Subtilis)

Table 16 Compressive Strength Test Results of Concrete by adding calcium Lactate and Bacteria

Mix	Calcium Lactate (%)	Bacteria (%)	Compressive Strength (MPa)	
			7 days	28 days
C	0%	0%	28.41	41.19
L1	5%	0%	28.34	40.36
B1	0%	3%	31.17	43.91
B+L	5%	3%	30.28	43.13

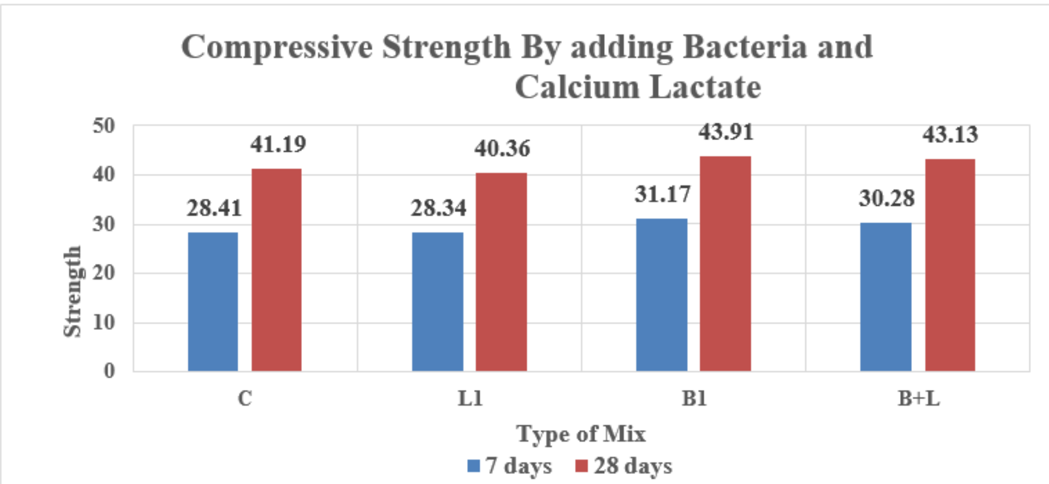

Fig. 12 7 days and 28 days Compressive Strength by adding Bacteria and Calcium Lactate

Table 17 Split Tensile Strength Test Results of Concrete by adding calcium Lactate and Bacteria

Mix	**Calcium Lactate (%)**	**Bacteria (%)**	**Split Tensile Strength (MPa)**	
			7 days	**28 days**
C	0%	0%	3.77	4.29
L1	5%	0%	3.88	4.42
B1	0%	3%	3.97	4.58
B+L	5%	3%	4.41	5.08

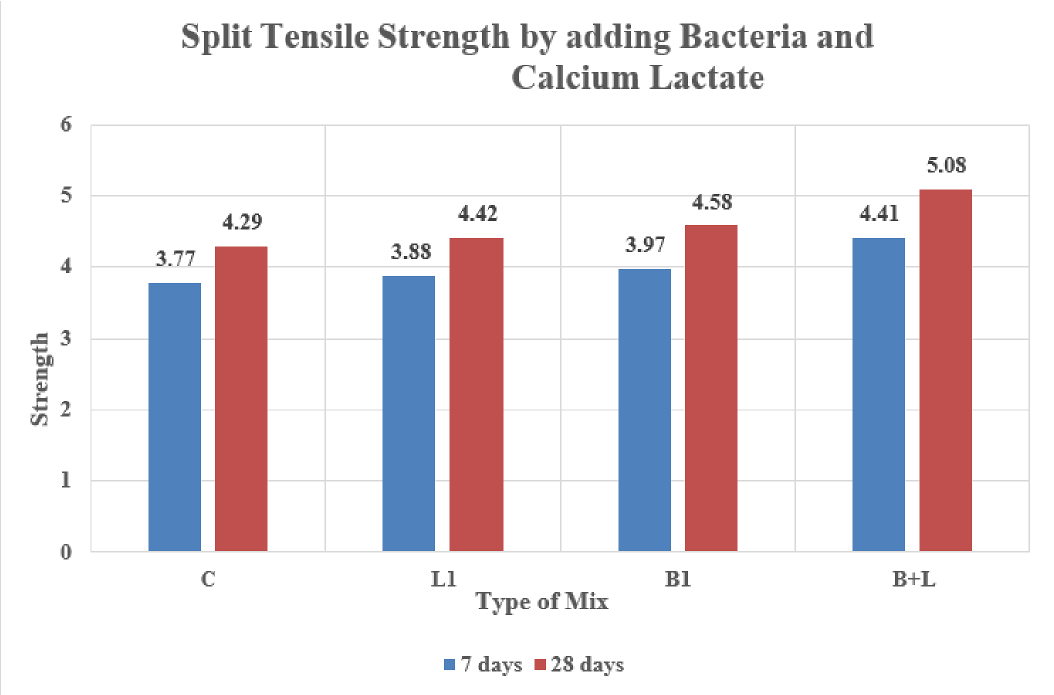

Fig. 13 7 days and 28 days Split Tensile Strength by adding Bacteria and Calcium Lactate

Table 18 Compressive Strength Test Results of Concrete by adding calcium Lactate, Bacteria and E-Waste

Mix	**Calcium Lactate (%)**	**Bacteria (%)**	**E-Waste (%)**	**Compressive Strength (MPa)**	
				7 days	**28 days**
C	0%	0%	0%	28.41	41.19
L1	5%	0%	0%	31.17	43.91
B1	0%	3%	0%	28.34	40.36
B+L	5%	3%	0%	30.28	43.13
B+L+R	5%	3%	10%	31.93	44.87

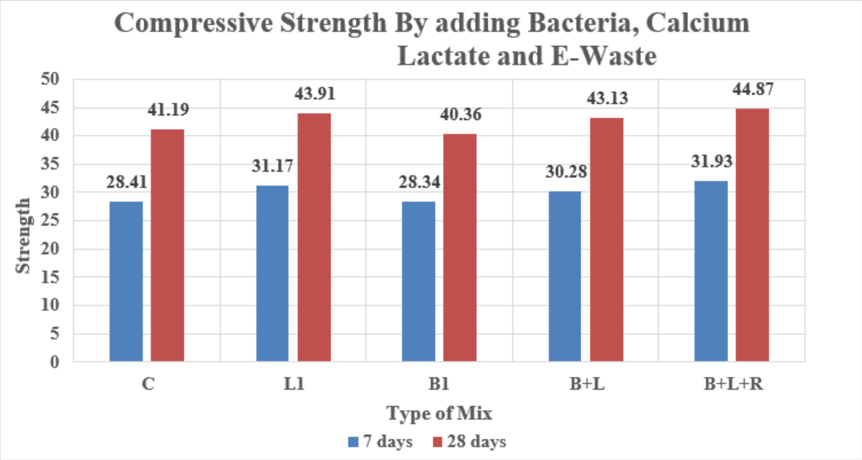

Fig. 14 7 days and 28 days Compressive Strength by adding Bacteria, Calcium Lactate and E-Waste

Table 19 Split Tensile Strength Test Results of Concrete by adding calcium Lactate, Bacteria and E-Waste

Mix	Calcium Lactate (%)	Bacteria (%)	E-Waste (%)	Split Tensile Strength (MPa)	
				7 days	28 days
C	0%	0%	0%	3.77	4.29
L1	5%	0%	0%	3.97	4.58
B1	0%	3%	0%	3.88	4.42
B+L	5%	3%	0%	4.41	5.08
B+L+R	5%	3%	10%	4.52	5.16

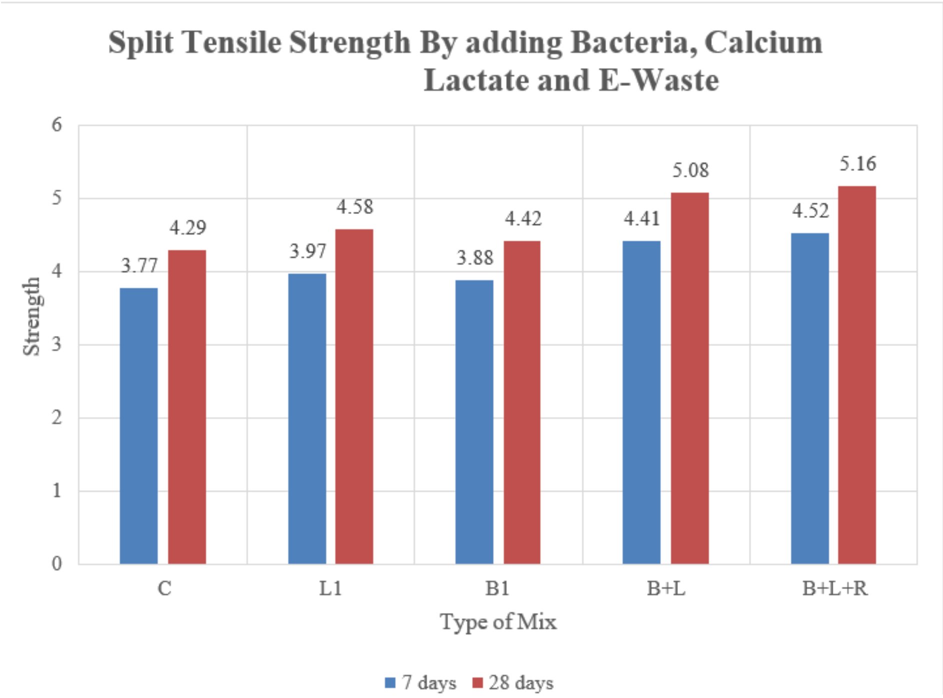

Fig. 15 7 days and 28 days Split Tensile Strength by adding Bacteria, Calcium Lactate and E-Waste

Conclusions

Following conclusions can be drawn from this experimental study-

1. Optimum strength seen at the 10% replacement of Coarse Aggregates with E- Plastic Waste. By replacement of 10% of coarse aggregate the compressive strength and split tensile strength increased by 4.30% and 3.50% as compared to conventional concrete.
2. Coarse Aggregate replacement with E-Plastic Waste, the strength increases up to 10% replacement, further on increasing the replacement percentage strength starts decreasing.
3. On adding bacteria up to 3% compressive strength increased by 6.6% whereas the split tensile strength increased by 6.76% as compared to conventional concrete. by increasing the percentage up to 5% of bacteria the strength starts decreasing.
4. Addition of Calcium Lactate by 5% decreases the compressive strength by 2.02% while the split tensile strength increases to 3.03% by comparing conventional concrete. At the other hand on increasing the Calcium Lactate to 10% both compressive as well as split tensile strength decreases.
5. Addition of Calcium Lactate and Bacteria together by 5% and 3% gives increase in Compressive Strength and split tensile strength up to 4.71% and 18.41%.
6. By adding E-Plastic, Bacteria and Calcium Lactate by 10%, 3% and 5% increases compressive and split tensile strength by 8.93% and 20.28% as compared to conventional concrete.
7. By replacement of Coarse aggregate with E-Waste Plastic aggregates the cost of construction decreased up to 3.44%.
8. Cost analysis shows that by replacement of 10% of coarse aggregate with e- plastic waste saves ₹55600 per Km of Road length.

REFERENCES

9. 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
10. IS:1199 (1959). *Methods of Sampling and Analysis of Concrete.* New Delhi: Bureau of Indian Standards.
11. 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.
12. 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.
13. IS:516 (1959) *Methods of Tests For Strength of Concrete.* New Delhi: Bureau of Indian Standards.
14. 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.
15. 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.
16. 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.
17. 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.
18. 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.
19. Balde, C.P, Forti, Kuehr, and Stegmann. 2017. *The Global E-Waste Monitor 2017.* Bonn/Geneva/Vienna: United Nations University (UNU), International Telecommunication Union (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.
20. Bennett, Natalie. 2021. *Twitter.* june 29. https://twitter.com/natalieben/status/1409902839434973184.
21. 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.
22. 2019-20. *Central Pollution Control Board Annual Report.* Delhi, India: Ministry of Environment, Forest & Climate Change. https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTI0M18xNjE2NTYxOTAxX21lZGlhcGhvdG8xMTgzNi5wZGY=.

23. 2021. *Central Public Works Department.* Delhi: Government of India. https://cpwd.gov.in/Publication/DSR_2021_VOL_I_ENGLISH_Dir.pdf.

24. 2021. *Children and digital dumpsites: E-Waste exposure and child health.* Geneva: World Health Organization. file:///C:/Users/91942/Downloads/9789240023901-eng.pdf.

25. 2016. *CNN International.* February 5. https://edition.cnn.com/2016/02/05/asia/gallery/mumbai- deonar-garbage-dump/index.html.

26. 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.

27. 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.

28. 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.

29. 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.

30. 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.

31. 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.

32. 2021. *International E-Waste day 14 October 2021.* October 14. https://weee-forum.org/iewd- about/.

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

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

35. 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.

36. 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.

37. 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.

38. 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.

39. 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.

40. 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.

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

42. 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.

43. 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.

44. 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.

45. 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*.

46. 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.

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

48. 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.

49. 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.

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

51. Supriyo, Babul. 2020. "*Ministry Of Environment, Forests And Climate Change*." Lok Sabha. Delhi, India: Government Of India. Http://Loksabhaph.Nic.In/Questions/Qresult15.Aspx?Qref=18458&Lsno=17.

52. 2020. *The Logical Indian.* https://thelogicalindian.com/story-feed/sports/tokyo-olympics- medals-E-Waste.

53. 2020. *Tokyo 202Medal Project: Towards an innovative future for all.* https://olympics.com/tokyo-2020/en/games/medals-project/.

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