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An Experimental Study on Compressive Strength of Conventional Concrete Using 5% of Novel E-waste as a Partial Replacement of Coarse Aggregate in Comparing with Conventional Concrete

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Abstract

The primary study is to evaluate the differences between conventional concrete and M30 grade concrete with 5% novel E-waste as a replacement. Novel E-waste 20 mm, superplasticizer, cement (53 grade PPC), fine aggregate (sieve size 4.75 mm), coarse aggregate (sieve size 20 mm), and water. There are 2 groups that were considered. Group-1 (control group/conventional concrete) and group-2 (experimental group/Novel E-waste concrete). The first group has 18 samples, and the second group has 18 samples, Total samples of N = 29. G-power of 0.8 with alpha and beta qualities of 0.05, and 0.2 with a confidence interval (CI) of 95% have been carried out, with independent sample t-test value ($p < 0.05$). According to Analysis of Variance using SPSS (Statistical Package for the Social Sciences) software, it is clearly identified that the compressive strength of conventional concrete is 32.08 N/mm^2. The compressive strength of novel E-waste concrete is 31.6 N/mm^2. There is a significant difference and the significance value of 0.000 ($p < 0.05$) and also standard deviations are 8.7512 and 7.0012, respectively. The novel E-waste concrete with the superplasticizer has less compressive strength when compared to the normal concrete.

Keywords

Novel E-waste, Superplasticizer, Compressive strength, Concrete, Fine aggregate, Coarse aggregate, M30 grade

Introduction

As per the global warming committee describes that E-waste is being generated at a rate of 50 million tons per year. It is the challenging way to analysis the properties of the materials and accompany with any other substances. In order to deal with the problem, it's likely to be used in concrete mixes. It is a very precious man-made gift, which can be used all over world is concrete. It is a substance with an extremely diverse makeup. It is a binding and composite material made of cement paste as the binding component and coarse and fine filler elements [1]. Aggregate determines the maximal qualities of concrete and its workability [2]. The physical, chemical, thermal properties, and grading of aggregate are the major factors that affect the mechanical properties of concrete. The cementitious properties like fly-ash, silica-fume, and other waste products are used in the manufacturing of concrete [3]. The hazardous and inert waste products from the electronics and electrical sectors are separated into two groups and are exceedingly difficult to dispose of novel E-waste, also referred to as inert waste, is the term used to describe broken, discarded electrical equipment.

In other words, utilization of waste products in concrete may be named as Green Concrete. About 17900 results in Google Scholar and this type of research leads to reducing waste production from the global. Novel E-waste that has passed its prime is one of the new waste materials used in the concrete industry [4]. The most practical application of novel E-waste is thought to be its use in the concrete industry to address the problem of disposing of enormous quantities of novel E-waste material. Concrete can contain coarse aggregates made from electronic trash [5]. However, it is crucial to emphasize that recycling garbage does not yet have a financial benefit because of the high production costs. A typical view of E-waste is shown in figure 1. About mining and electronic waste (e-waste) for recycling-extracting metallic products and their transformation into nanomaterials.

Green concrete is also a technique which can be justified by the amount of % added tin the concrete mix. Thus, helps in reducing the negative impacts on the environmental conditions [6]. The modified concrete technology, which is a replacement for traditional concrete, will lead to the concrete's enhanced strength. Water and high-temperature resistance are both good qualities [7]. The growth of novel E-waste is a developing concern that poses major pollution risks to human life [8]. Therefore, it is important to evaluate environmental options, paying specific attention to recycling ideas. Electronic waste (Novel E-waste) is the term used to denote loosely rejected surplus, out-of-date, or damaged gadgets. The rapid advancement of technology and low starting cost are the main contributors to the rapidly expanding surplus of electronic trash in the world. Due to this, several tons of novel E-waste must be disposed of annually [9]. Due to the presence of various different compounds and environmental issues, novel E-waste can cause major difficulties for human health if it is not treated appropriately [9]. Many studies struggled to partially replace novel E-waste with coarse because there was a lack of coarse aggregate for the foundation of concrete [10]. This study looked at the potential use of electronic trash in concrete and its effects on the environment.

Figure 1: E-waste.

Materials and Method

Basic properties of the materials used for the experimental work are established below. The experiment was undertaken in Saveetha School of Engineering's concrete laboratory, which is part of the civil engineering department. The project is divided into two groups: standard M30 grade concrete (control group) and 5% of novel E-waste partially replaced for the coarse aggregate, M30 grade superplasticizer (experimental group) (modified concrete). The cement used in all mixtures was obtained from locally available market (PPC) of 53 grade, manufactured by ultra tech confirming with IS 12269. The river sand was dispatched in zone 3 as per IS 383-1970. It is well sieved by passing through a 4.75 mm sieve. Whereas the coarse aggregate comprising 60% of 20 mm aggregate and remaining 40% in 12 mm passing IS 383-1970. Novel E-waste is the waste generated by the electrical and electronic industry. The E-waste materials are segregated by type of plastic materials and sizes. Ensure that heavy and toxic materials should not be mixed along with concrete [11]. All the E-waste materials are sieved with passing 12.5 mm and retained in 10 mm. As per IS 456:2009 standard, water with a 0.40 water- to-cement ratio, conforming is used for concrete mix.

The entire project activities, the standard Portland pozzolana cement was used, a single batch of 53-grade Ultratech cement was used as the standard Portland pozzolana cement. The finest cement on the market. Fine aggregate is made from river sand that has been sieved to a size of 4.75 microns. The fine aggregate fineness modulus has increased to 2.74, and the gravity of fine aggregate has increased to 2.63. Aggregate, coarse: for projects with nominal size of aggregate passes through 80, 40, 20, 12.5, 10, and 4.75. The coarse aggregate was taken from Tambaram quarry with proper shape [12]. Water, locally available water is used. Basic tests for all concrete ingredients in concrete were tested with IS standards and mixed through a concrete mixture machine and cast in the concrete molds.

After the curing period, the specimens are taken - n. were taken and u and wiped with cotton cloth and corners are visualized with the naked eye. After the cube is visualized and then it is taken out for testing. The compressive strength of the materials was assessed during the test. The dimensions of the cube were length 150 x 150 x 150 mm. Figure 2 shows conventional concrete mixing. Within 28 days, curing the samples were aged. The compressive strength was measured using CTM with a capacity of 2000 kN. Novel E-waste concrete with superplasticizer showed better compressive strength than regular concrete. Figure 3 shows the experimental testing arrangements. Data was collected by inserting the cube into the crushing jaws, then operating the machine to develop cracks in the specimen. The display then shows the resultant value in kN/mm^2, which we had to collect and convert into N/mm^2.

Figure 2: Conventional concrete mixing.

Statistical analysis

The data were analyzed using the SPSS software with t-test performed individually. It shows how to analytically distinguish between conventional and replacement coarse aggregate (Novel E-waste) in concrete. The compressive strength, concrete grade, water/cement ratio, cement grade, and days of curing were all independent variables; however, the study had no dependent variables. The mean, standard deviation, and standard error of the mean for compressive strength were also determined using this method. Figure 4 shows the bar chart shows the compressive strength for conventional concrete was carried out of 5% novel E-waste concrete with the mixing of admixture. X-axis: comparison between the conventional and novel E-waste concrete with the addition of admixture Y-axis: mean strength ± 1 standard deviation.

Figure 3: Testing.

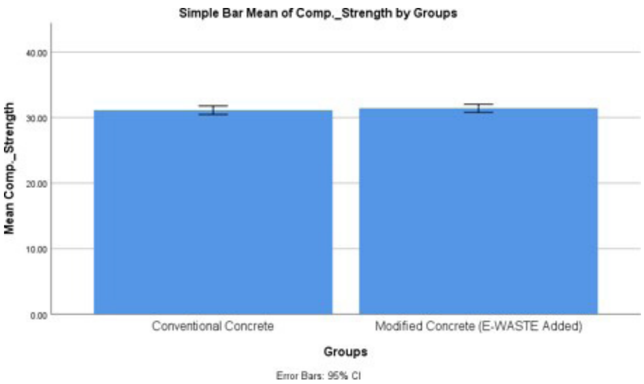

Figure 4: Bar graph shows, the X-axis: comparison between the conventional and E-waste concrete with the addition of superplasticizer. Y-axis: mean compressive strength ± 1 standard deviation.

Results

The work gives insight into the relationship between novel E-waste concrete that showed a compressive strength of 29.6 N/mm^2, whereas regular concrete had a nominal strength of 32.91 N/mm^2. Conventional concrete had a compressive strength of 8.751, while novel E-waste concrete and superplasticizer had a compressive strength of just 7.02. Table 1 shows the compressive strength of conventional concrete. Table 2 shows the compressive strength of the novel E-waste concrete. Compressive strength has a significant Levene's-test for equality of variances value of 0.073. The compressive strength of 18 samples after being combined with a superplasticizer is displayed in the table. values for compressive strength of 18 samples made without regular concrete.

Table 1: Compressive strength of the conventional concrete.

S. No.	Weight (Kg)	Strength (kN)	Compressive strength (N/mm²)
1	8.203	709	31.51
2	8.170	686	30.48
3	8.575	695	30.88
4	8.012	702	31.20
5	8.487	691	30.71
6	8.474	708	31.46
7	8.081	711	31.60
8	8.587	698	31.02
9	8.793	704	31.28
10	8.412	724	32.17
11	8.201	714	31.73
12	8.661	688	30.57
13	8.803	709	31.51
14	8.793	697	30.97
15	8.816	701	31.15
16	8.021	722	32.08
17	8.486	685	30.44
18	8.213	663	29.46

Table 2: Compressive strength of the novel E-waste concrete.

S. No.	Weight (Kg)	Strength (kN)	Compressive strength (N/mm²)
1	8.413	712	31.64
2	8.334	708	31.46
3	8.012	689	30.62
4	8.154	705	31.33
5	8.224	721	32.04
6	8.815	692	30.75
7	8.303	701	31.15
8	8.202	698	31.02
9	8.712	711	31.60
10	8.832	704	31.28
11	8.106	709	31.51
12	8.276	724	32.17
13	8.000	675	30.00
14	8.128	732	32.53
15	8.812	706	31.37
16	8.60	718	31.91
17	8.53	697	30.97
18	8.291	723	32.13

Table 3 shows the represented group statistics for both sample groups. The mean accuracy values for the two groups of novel E-waste, superplasticizer concrete, and ordinary concrete, were compared with the accurate prediction using a p-value of 0.05 and an error bar of 95%, as shown in the table and the error bars representing mean detection accuracy. Table 4 shows independent samples t-test results.

Discussion

Satisfactory compressive strength attains with 5 per of novel E-waste [9]. The compressive strength of novel E-waste concrete with superplasticizer increased by 220% when compared to regular concrete. In M30 grade of concrete increase in fibers contents affects the permeability ratings and compressive strength. Compressive strength at different coarse aggre-

Table 3: Represents group statistics for both sample groups. Mean (32.12,31.41), standard deviation (0.65,0.64), and standard error mean (0.15,0.14).

	Groups	N	Mean	Std. deviation	Std. error mean
Compressive strength (N/mm²)	Conventional	18	31.12	0.65	0.15
	E-waste	18	31.41	0.62	0.14

Table 4: Independent samples t-test results: There is a statistical significance difference observed for compressive strength in an independent sample t-test p = 0.000 as it is less than p < 0.05.

		Levene's test for equality of variances		T-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% CI of the difference	
									Lower	Upper
Compressive strength	**Equal variance assumed**	3.417	0.073	-1.001	34	0.000	-31.469	31.428	-95.337	32.400
	Equal variance not assumed	-	-	-1.001	17.147	0.000	-31.469	31.428	-97.732	34.795

gate replacement levels was shown that when the replacement amount increased, the curing strength of novel E-waste concrete at 7 days dropped [13]. For the compressive, there was no statistical significance difference.

Based on the threshold limit being 0.05, the independent value shows no significant differences between the groups in compressive strength [14]. It demonstrated that the sluggish hydration process caused by a rise in the amount of novel E-waste in concrete affected the rate of strength gain at young ages [15]. The major factors affecting the results, such as the materials proportions and aspect ratio, the mixing process of the concrete, the condition of the mixing concrete, the casting of the concrete in the molds, compaction of the concrete, and curing of the specimens for the results, should be limited, and surface drying of the specimens should be done before the actual testing process, otherwise, it may result in improper results of the specimens. Limitation [16], when compared to the normal or conventional concrete mix, this process costs more, while the mixing process necessitates more care of the hands, especially in the manual mixing process, and the availability of the proper admixture is more difficult when compared to conventional concrete. The modified concrete technology, which is a replacement for traditional concrete, will lead to the concrete's enhanced strength. Water and high-temperature resistance are both good qualities.

Conclusion

After the test was performed the results showed increased novel E-waste Strength. The mean compressive strength of novel E-waste with the addition of superplasticizer of M30 grade was 31.41 N/mm^2. Increase in compressive strength compared to conventional concrete was 11.18 %.

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None.

Conflict of Interest

None.

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