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Fresh and Mechanical Properties of Concrete with Replaced Coarse Aggregate by E-waste

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Abstract:
The environment, natural resources, and waste recycling must all be preserved in today's world. One of the world's most serious environmental challenges is the toxic nature of electrical (E) waste. As a realistic means of disposing of E-waste and reducing the extraction of natural aggregate using E-waste as aggregate in concrete, hence reduces harm to the environment and aids in sustainable development. Therefore, in this study, the fresh and mechanical properties of mixtures with replacing coarse aggregate by nonmetallic printed circuit board (NMPCB) in volume ratios of 0%, 5%, 10%, 15%, 20%, 25%, and 30%. The experimental results indicated that the density, slump value, concrete compressive strength, flexural strength, split tensile strength, ultrasonic pulse velocity, and rebound number were reduced in various ratios by increasing the replacement ratio of NMPCB. These results may be attributed to the low strength, flakiness shape, and smooth surface of NMPCB particles compared to coarse aggregate. Moreover, the replacement of E-waste by up to about (10-20) % does not significantly reduce the mechanical properties. Therefore, it is a good alternative material for lowering aggregate usage, which lowers the cost of materials and is an eco-friendly way to dispose of E-waste.

Keywords: *E-waste; Coarse Aggregate; Fresh Properties; Mechanical Properties; Ultrasonic Pulse Velocity*

1. Introduction

Electronic wastes, which can sometimes be referred to as "E-waste," are the solid wastes that are disposed of with electrical or other electronic devices once their useful existence has come to an end or those items that are currently essentially worthless garbage [1, 2]. In most of the world's countries, e-waste is the component of municipal solid garbage that has had the greatest annual growth [3-5]. This is because of the wide range of applications that the electronic industry has developed, the extensive marketing campaigns that manufacturers and suppliers run, and the consuming habits of contemporary society. The concern about providing this substance, which may offer a large rate of toxicity due to the properties of its constituent ingredients, as an environmentally responsible destination is present concurrently with this expansion [6-8]. If not managed appropriately, the many sorts of chemicals and compounds included in E-waste can seriously maltreatment both human well-being and the environment. The situation, the preservation of natural resources, and the recycling of waste materials are the subjects of attention. The most practical method for disposing of enormous amounts of E-waste material is to address the disposal of reusing E-waste in the concrete industry [9-11].

Approximately 53.6 million tons of electronic garbage were produced globally in 2019. Globally, this equates to 7.3 kg of electronic trash per person on average, and it is predicted that this will rise to 65.3 million tons by 2025 [12]. In E-waste, one of the most difficult parts to recycle is the non-metallic printed circuit board (NMPCB), due to their intricate production processes requiring several specialty chemicals and priceless materials. Therefore, it is crucial that all stakeholders pay attention to the management of NMPCB waste as it becomes more and more crucial. Additionally, it might be quite difficult to locate effective removal methods [13].

Since resin and glass fibers with a great aspect ratio, a large elastic modulus, and minimal elongation structure in 50–70% of NMPCB waste, there are opportunities to use it as a possible high-strength raw material alternative as a construction material.

On the other hand, the most adaptable building material with the highest consumption rates is concrete. The extraction of concrete ingredients, like fine and coarse aggregate, becomes expensive and has a negative influence on the environment by causing erosion of the bank and river bed. Consequently, employing NMPCB trash as a source of raw materials, maybe as an aggregate, for the creation of concrete is an effective alternative. Recently, many studies have been conducted on using NMPCB as an innovative replacement of cement, filler, and fine or coarse aggregate in concrete production. Wang et al. [14] examined the result of powder of waste NMPCB as an additive to cement mortar and initiated that the flexural and compressive strength of cement mortar changed to some extent, while both the tensile bond strength and the hardened weight decreased significantly. Sua-iam and Chatveera [13] investigated the viability of utilizing NMPCB dust as a binder to substitute conventional cement for the production of self-compacting concrete by the volume ratio of 0%, 5%, 10%, 15%, 20%, 25%, and 30%. They claimed that as the NMPCB dust replacement ratio was raised, the mechanical characteristics and workability declined. Some researchers [9, 15-17] investigated the impact of NMPCB on the fractional replacement of sand on concrete properties with a compressive strength of about 20 MPa. These investigations showed that replacing the fine aggregate at a rate of between 5 and 10 percent appears to enhance the behavior of concrete effectively, making NMPCB an appropriate replacement option and offering a safer way to get rid of this e-waste without upsetting the ecological balance. Meanwhile, other researchers [16, 18, 19] considered the response of NMPCB as a fractional replacement of gravel with a ratio of 5 to 20 percent on various properties and durability of concrete. They claimed that as the replacement proportion increased, the uniformity of newly laid concrete worsened. NMPCB reduces the concrete unit weight, compressive strength, elasticity modulus, and flexural strength. In specimens containing NMPCB, durability characteristics, water absorption, and special electrical resistance have increased. Marimuthu and Ramasamy [20] investigated the influence of NMPCB in the form of fibers after removing nonmetallic materials by adding it in ratios of 1%, 2%, and 3% of cement's weight. Comparing NMPCB fiber concrete to control concrete, the experimental results showed that the former exhibited greater strength. To assess the quality of NMPCB fiber concrete, tests using a rebound hammer and ultrasonic pulse velocity were also conducted. When the compressive strength of NMPCB fiber concrete and the results of the rebound hammer test were compared, they were found to be in close agreement. Therefore, based on experimental findings and NMPCB's effects on the environment, up to 10% of the coarse aggregate in control concrete can best be replaced with NMPCB.

Drawing conclusions from the literature review, it can be said that there are limited studies on the replacement of both fine and coarse aggregate by NMPCB in concrete production, and there are many more that need to be investigated in this area. Moreover, most of the limited available studies were performed on concrete with low compressive strength; investigating the impact of NMPCB on the strength and behavior of medium and high-strength concrete is desirable. Therefore, this study intensive on studying the fresh and hardened properties of concrete with replacement of course aggregate by NMPCB in volume ratios of 0, 5%, 10%, 15%, 20%, 25%, and 30%.

1.1 Research Significance

The emphasis on management and collecting E-waste matters, particularly NMPCB, in today's philosophy is proposed to lessen any undesirable environmental effects and to lessen pollution. In addition to being costly, the extraction of fine and coarse aggregate for concrete has a detrimental effect on the environment by leading to bank and river bed erosion. As a result, it is an excellent awareness to use NMPCB waste as a source of raw materials in the concrete industry. Moreover, the recycling of disposed E-waste in concrete production is a crucial environmental necessity and financial saving. Therefore, this study tries to address the visibility of recycling of NMPCB instead of course aggregate in concrete production.

1.2 Experimental Program

This study's objective is to look at the fresh properties, mechanical properties, and nondestructive tests of concrete specimens with different replacement ratios of coarse aggregate by NMPCB particles. For this purpose, two mixes were used to get two types of concrete with a target concrete compressive strength of 30MPa for the mixture (A) and 40MPa for the mixture (B). For each type of concrete, seven mixtures were used with NMPCB replacement ratios of 0, 5, 10, 15, 20, 25, and 30% instead of coarse aggregate. The concrete specimens cast and tested for each mixture were six cubes of 100×100×100mm, three prisms of 75×75×375mm, and six cylinders of 100x200mm.

2. Materials

2.1 Cement

The cement used for preparing the mixtures was ordinary Portland cement type-I grade R42.5, which meets the ASTM C150[21] and C114[22] standard specifications. It was new and free from any foreign matters and subjected to tests to ensure quality control in the laboratory. The properties of cement are tabulated in Table 1.

Table 1: Physical and chemical analysis of cement

Physical Analysis		
Physical Tests	Results	ASTM C150-11[21]
Initial setting time	125 min.	Not less than 45min.
Final setting time	250 min.	Not more than 600min.
Compressive strength 3 days age	26.2 MPa	14.7 MPa, lower limit
Compressive strength 7 days age	51.2 MPa	22.5 MPa, lower limit
Fineness Modulus of Cement	300 m^2/kg	230 m^2/kg, lower limit
Soundness Expansion	2mm	≤ 10mm
Chemical Analysis		
Contents	Results	ASTM C150-11 and ASTM C114-11[22]

SiO2	23.37%	20% Min
CaO	57.75%	
Al2O3	5.1%	6% Max
Fe2O3	0.3%	6% Max
MgO	3.46%	5.0% Max
SO3	1.90%	2.8% Max
K2O	0.39%	
Mn2O3	0.14%	
Loss on Ignition	0.93%	3.0% Max
Insoluble Residue	0.26%	0.75% Max

2.2 Fine and Coarse Aggregate

The coarse and fine aggregates were well-graded natural clean aggregates with specific gravities of 2.70 and 2.68, respectively. The coarse aggregate's bulk density and water absorption were 1.4% and 1457 kg/m3, respectively. The accessible local quarries provided the fine and coarse aggregates. The coarse aggregate had a maximum aggregate size of 12.5 mm. The grading curve and ASTM limits [23] for fine aggregate and coarse aggregate are shown in Figure 1 (a) and (b).

2.3 Non-metallic Printed Circuit Board (NMPCB)

The utilized NMPCB as a fractional replacement of course aggregate was collected from the waste materials, which were from TVs, computers, and other electronic gadgets. These waste materials consist of non-biodegradable ingredients that last in nature to thousands of years. Recycling the NMPCB is important because it helps to diminish waste production in the environment and ingesting of certainly obtainable aggregate resources. The NMPCB was recycled to coarse aggregate by removing all metal parts and wires; then, it was shredded by a special machine into countless sizes and grouped into several ratios for the concrete mix. The shredded NMPCB was selected to get a graded material with a maximum size of 12.5mm, as shown in Figure 2. The grading curve and ASTM limits for NMPCB is shown in Figure 1 (c). The shredded NMPCB was comparable to the coarse aggregate gradation with a bulk loose density of about 872 Kg/m^3, which was tested based on ASTM C29[24], and water absorption of 2.6%.

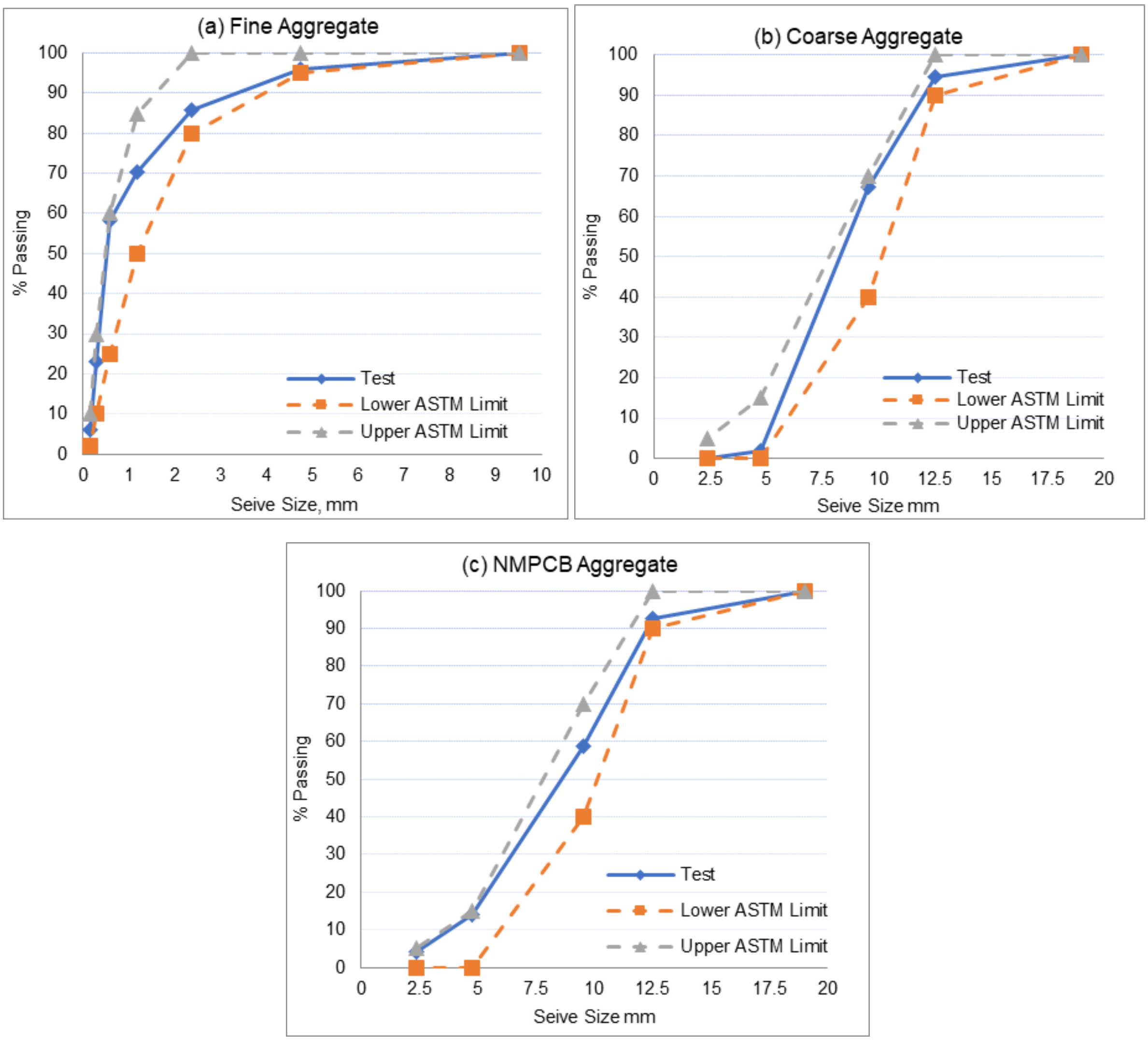

Figure 1: Grading curves and ASTM limits for (a) Fine aggregate, (b) Coarse aggregate, and (c) NMPCB.

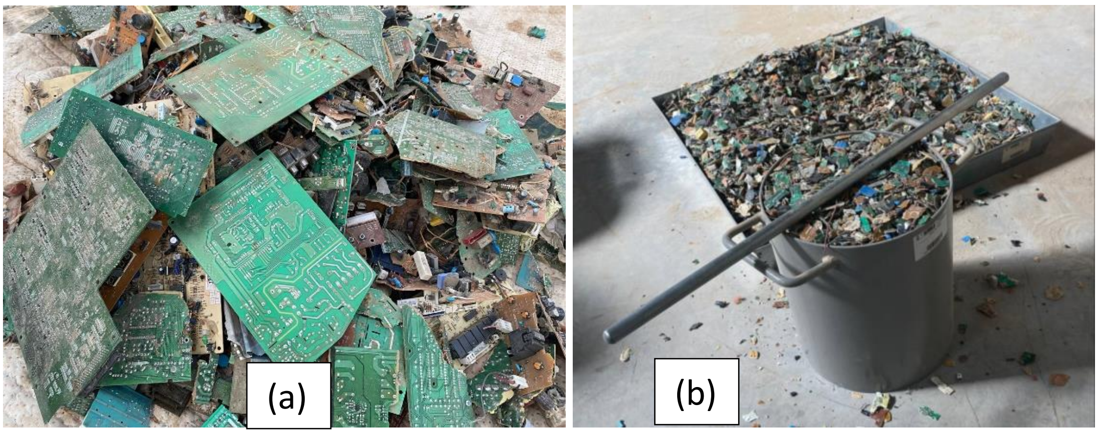

Figure 2: (a) Electronic Gadget Wastes, (b) Shredded NMPCB (coarse aggregate)

2.4 Mixing, Casting and Curing

Table 2 displays the specifics of the chosen mix proportions for each composition. To achieve uniform concrete with satisfactory qualities, the raw materials were mixed using a standard electrical tilting mixer with a 0.022 m^3 maximum capacity. The coarse aggregate, fine aggregates, and

NMPCB were put into the mixer along with 30% of the mixing water to moisten them. The mixing process was then let to run for around a minute before the cement and remaining water were added. As seen in Figure 3, the mixing process was carried out repeatedly until homogenous concrete was formed. The casting process began with the concrete mix being layered three times within the molds, and the molds were vibrated using a typical vibration table in accordance with ASTM C192[25]. The samples underwent a 28-day curing process in a curing tank within the laboratory.

Figure 3: mixing of raw materials by tilting mixer

Table 2: Concrete Mix Proportions

Mixtures	Cement, Kg	Sand, Kg	Gravel, Kg	W/C	NMPCB, Kg	NMPCB % By Volume
A1	304	911	1062.8	0.55	0.0	0
A2	304	911	1009.7	0.55	31.8	5%
A3	304	911	956.5	0.55	63.6	10%
A4	304	911	903.4	0.55	159.4	15%
A5	304	911	850.2	0.55	127.2	20%
A6	304	911	797.1	0.55	159.0	25%
A7	304	911	744.0	0.55	190.8	30%
B1	361	831	1012.0	0.55	0.0	0
B2	361	831	961.4	0.55	30.3	5%
B3	361	831	910.8	0.55	60.6	10%
B4	361	831	860.2	0.55	90.9	15%
B5	361	831	809.6	0.55	121.1	20%
B6	361	831	759.0	0.55	151.4	25%
B7	361	831	708.4	0.55	181.7	30%

3. Results and Discussion

The goal of this study was to investigate the replacement of coarse aggregate by E-waste in order to preserve the natural aggregates as well as protect the environment from E-waste. For this purpose, two mixes were selected, mix A and mix B, for each mix the coarse aggregate was replaced by NMPCB in ratios; 0%, 5%, 10%, 15%, 20%, 25%, and 30%. A total of 14 mixtures were equipped, and specimens were cast, cured, and tested to measure the fresh properties, mechanical properties, and nondestructive tests. Photos of concrete specimens during the test are shown in Figure 4, and the tested specimens' outcomes are shown in Table 3.

Table 3: Results of Specimens

Mixtures	Density, kg/m3	Slump, mm	Compressive strength, fcu, MPa		Split tensile strength, fct (MPa)	Flexural strength, fr (MPa)	UPV, Km/s	rebound number
			7 days	28 days				
A1	2344.3	48	24.0	33.29	3.71	2.90	24.60	23.38
A2	2321.3	46	21.4	32.35	3.37	2.56	24.75	22.50
A3	2318.6	40	19.2	28.65	3.21	2.33	25.15	22.08
A4	2273	37	19.4	26.73	2.99	2.16	25.55	22.00
A5	2268.6	34	18.4	24.51	2.69	1.49	26.15	18.54
A6	2211	30	18.5	23.58	2.61	2.28	27.35	17.13
A7	2198	28	14.6	21.26	2.76	2.56	29.25	16.54
B1	2370	65	27.6	41.57	3.95	3.04	23.50	25.08
B2	2356	62	23.9	39.44	3.67	2.84	24.85	23.75
B3	2338.3	55	23.3	35.93	3.55	2.53	25.10	23.58
B4	2315.6	43	20.9	33.60	3.08	2.47	25.40	19.83
B5	2917	40	22.4	31.45	2.80	2.24	25.80	19.63
B6	2262.6	34	18.7	29.76	2.69	2.52	26.70	18.21
B7	2232	30	17.0	23.68	2.78	3.26	27.70	17.00

Figure 4: Concrete specimens during the tests

3.1 Slump Test

For all the mixtures, the fresh concrete was examined for workability using a slump cone. The slump tests were achieved according to ASTM C143[26], the results are shown in Figure 4. From Figure 4, it is clear that the slump flow reduces with an increase in the NMPCB replacement ratio, which lowers workability. For both types of concrete, as the physical condition of NMPCB particle concentration rises with increasing the replacement ratio, the slump decreases as a product of the ability of cement paste to bond with NMPCB particles with angularity and flakiness of the NMPCB particles. Moreover, the water absorption of NMPCB is about 2.6%, which is more than the natural aggregate and causes a reduction in mixing water. The reduction in slump value ratio was about (40-50) % for specimens with a 30% replacement ratio. This reduction in slump and workability can be solved by adding admixtures, which may be investigated in future works. Similar results were observed by some researchers [15, 17, 19, 20, 27]; however, the reduction values of slump were in variable ratios based on the size of NMPCB particles.

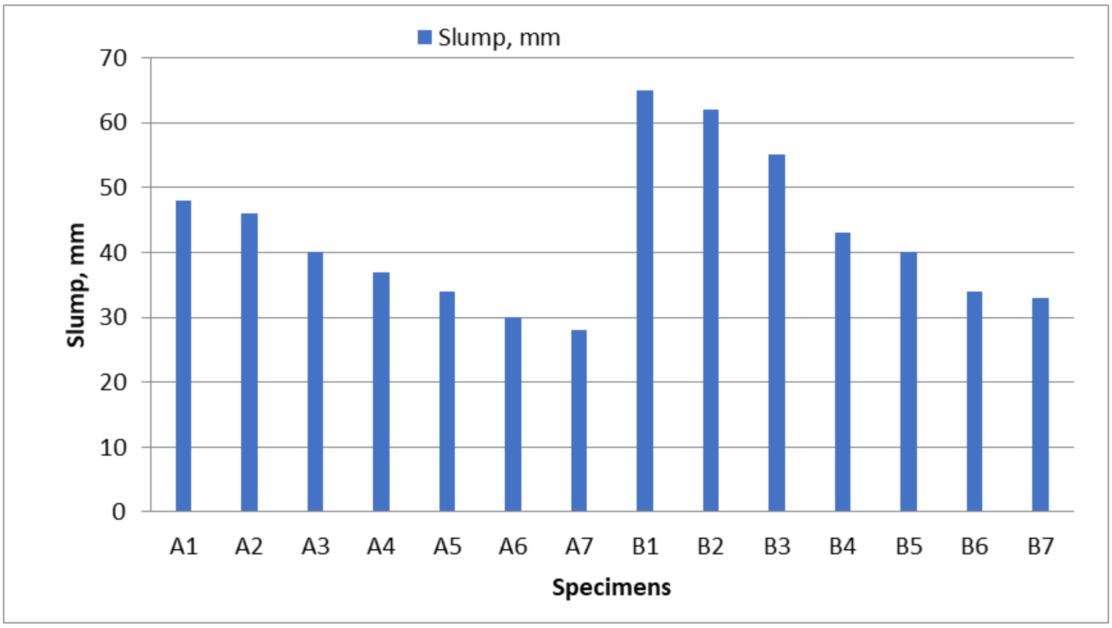

Figure 5: Slump Test Results

3.2 Concrete Compressive Strength

Concrete compressive strength is the furthermost important possession used in the design of reinforced concrete structures. Cube compressive strength, FCU, of concrete specimens was gained by testing 100×100×100mm cubes based on the specification of BS 1881[28]. The specimens were removed from the curing tank and allowed to dry for 24 hours at room temperature before testing, following the successful conclusion of the 28-day curing period. It is maintained that the compressive strength loading rate is 0.3MPa/s as per the BS 1881. The outcomes of concrete compressive strength are shown in Table 3 and indicated more clearly in Figure 6.

The coarse aggregate was replaced by NMPCB and mixed with proportions of 5%, 10%, 15%, 20%, 25%, and 30% for both types of concrete mixes. The target compressive strength of reference mixes was achieved to be 33.29 MPa and 41.57 MPa for type A and type B mixes, respectively. It has been observed that with increasing the NMPCB ratios the concrete compressive strength decreased significantly. For concrete mix A, the percentage of reduction in compressive strength was 2.8%, 13.9%, 19.7%, 26.4%, 29.2 and 36.1% for replacement ratios of 5%, 10%, 15%, 20%, 25%, and 30% respectively. Meanwhile, for concrete mix B, the percentage of reduction in compressive strength was 5.1%, 13.5%, 19.1%, 24.3%, 28.4 and 43.0% for replacement ratios of 5%, 10%, 15%, 20%, 25%, and 30% respectively. The reduction in concrete compressive strength may be attributed to different parameters like low strength of NMPCB particles compared to coarse aggregate, flake shape of NMPCB particles, which have a small thickness of about 2mm that break easily, and smooth surface of NMPCB particles that possess weak adhere performance with the cement paste which may participate to a local decrease of mechanical strength. On the other hand, the self-weight of concrete decreased slightly with increasing the NMPCB ratios for 30% addition of NMPCB; the self-weight of cubes reduced by about 6% in both concrete mixes. Therefore, the lessening in compressive strength is associated with reduced self-weight compared to reference mixes. These are due to the differences in mechanical properties between the natural aggregate and NMPCB particles in terms of strength, shape, density, and water absorption. Diverse outcomes were reported by many researchers. Shinu, and Needhidasan [29] found similar results to this study's. Ponthinanam et al. [16] reported a larger reduction ratio in compressive strength; they indicated that the reduction ratios in concrete compressive strength were about twice the used replacement ratios. On the other hand, Santhanam et al. [27] confirmed that the replacement of coarse aggregate with NMPCB by about 20% slightly decreased the compressive strength.

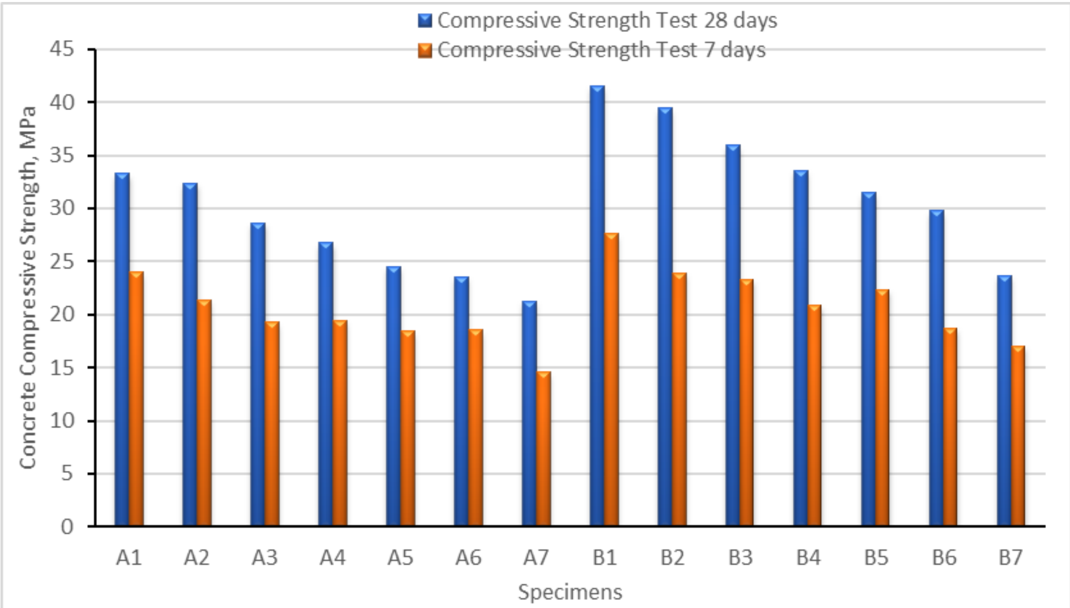

Figure 6: Concrete compressive strength results

3.3 Split Tensile Strength

Three 100×200mm cylinders were cast and experienced to measure the splitting tensile strength, and the outcomes of average strength are given in Table 3 and Figure 7. The splitting tensile strength of the specimens is an indirect tensile strength achieved according to ASTM C 496[30] under a rate of loading between (1.2-2.4) MPa/min. The concrete splitting tensile strength, comparable to compressive strength reduced with the increase of NMPCB replacement ratios. The reduction in split tensile strengths for mix A was 9.3%, 13.7%, 19.5%, 27.6%, 29.8%, and 25.5% for replacement ratios of 5%, 10%, 15%, 20%, 25%, and 30%, respectively. These ratios for mix type B were 7.0%, 10.1%, 22.0%, 29.0%, 31.9%, and 29.6%, respectively. It is clear that the decrease trend line is sharper at small replacement ratios. Nevertheless, the specimens with higher replacement ratios of 25% and 30% showed less strength reduction ratios than others. The reduction in splitting tensile strength behavior may be caused by the equivalent factors that caused the lessening in concrete compressive strength. Furthermore, the low reduction in tensile strength at high replacement ratios may be attributed to the fact that the flaky particles may work as fibers in providing tensile strength and bridging the crack faces.

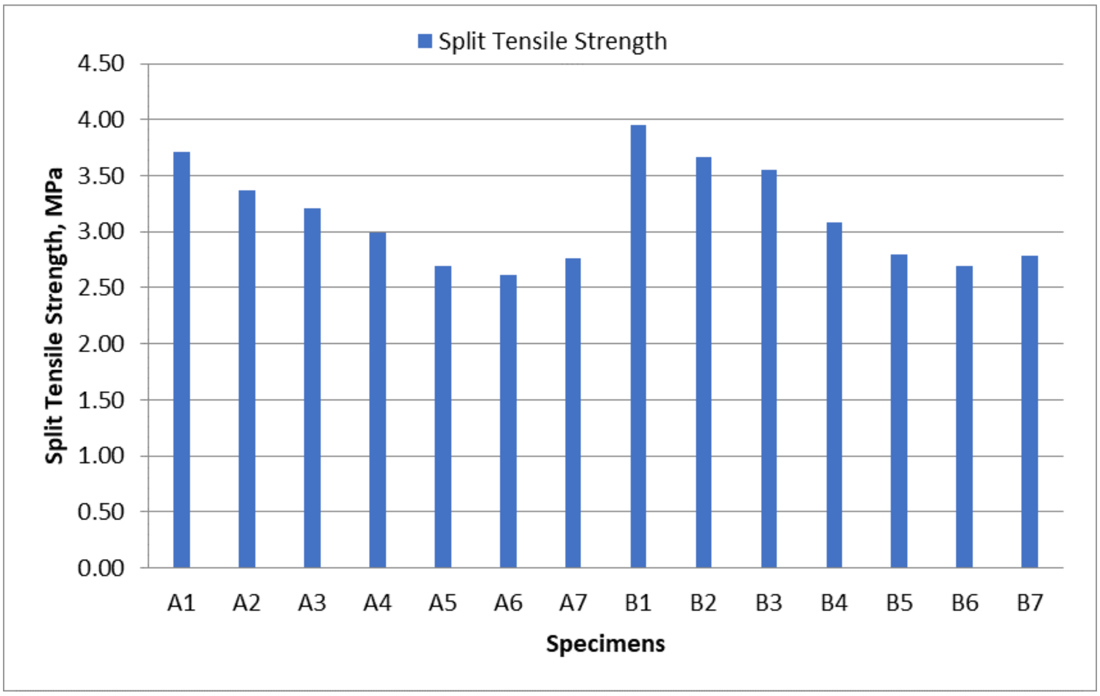

Figure 7: Concrete split tensile strength results

3.4 Flexural Strength

Another indirect tensile strength test is the flexural strength of prisms, which follow the behavior of split tensile strength according to ASTM C78[31]. The four-point flexural strength test results for each of the tested combinations are displayed in Table 3 and Figure 8. Generally, the flexural strength fell down with increasing the NMPCB replacement ratios. The reduction in flexural strength for mix A was 11.6%, 19.7%, 25.5%, 31.8%, 21.5%, and 16.6% for replacement ratios of 5%, 10%, 15%, 20%, 25%, and 30%, respectively. These ratios for mix B were 6.5%, 16.6%, 18.7%, 26.2%, 17.1%, and 14.1%, respectively. It is clear the trend line in both mixes continues to decrease up to a 20% replacement ratio; after that, the trend line grows and restores part of its reduced strength. This improvement in flexural strength in mixes with replacement ratios of 25% and 30% may be attributed to that the large flaky particles work as fibers and improve the tensile strength behavior. This behavior has also been reported by Marimuthu and Ramasamy [20] as they added the NMPCB to concrete in the shape of fibers, and they noted its constructive effect on improving the tensile strength of concrete.

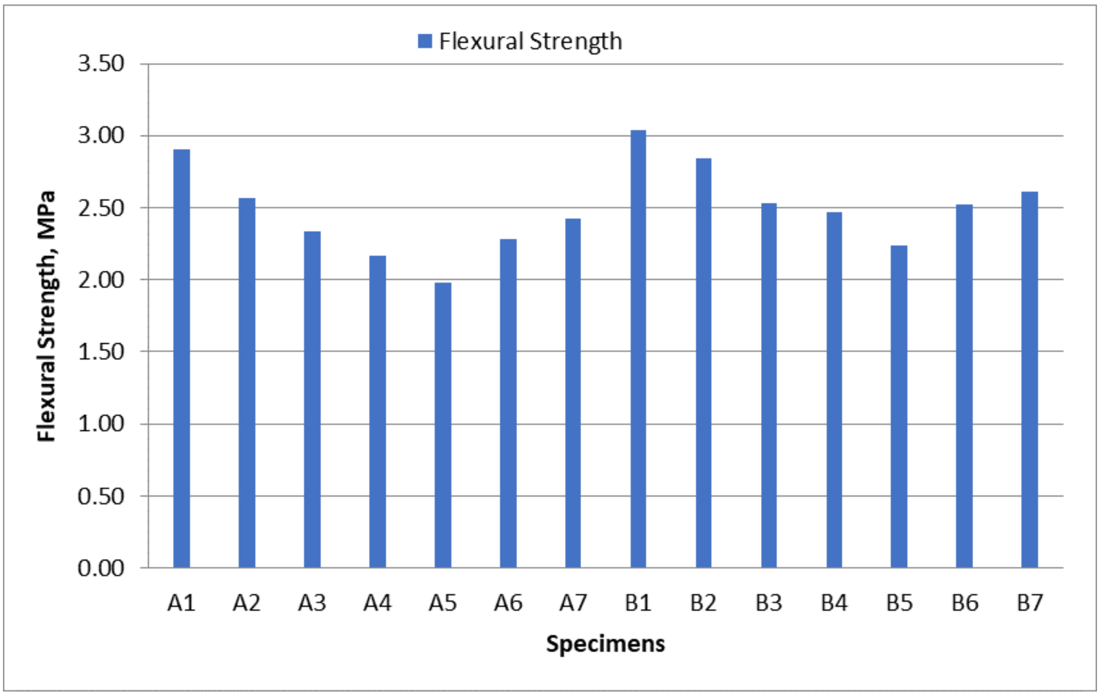

Figure 8: Concrete flexural strength results

3.5 Ultrasonic Pulse Velocity, UPV

Ultrasonic Pulse Velocity (UPV) is a nondestructive test that measures how long it takes an ultrasonic wave to penetrate concrete. Slower velocities show that the concrete has many cavities and cracks, whereas higher velocities show that the material's quality and continuity are good. The presence of NMPCB slower the velocity of UPV therefore, it was expected to increase the time needed to transmit through the concrete specimens. BS (1881): Part 203[32] explains how long a pulse needs to travel through concrete. Next, a straightforward formula is used to calculate the UPV:

$$UPV = \frac{Length\ of\ Specimens}{Time\ to\ travel\ through\ concrete} \quad \text{m/s or km/s} \qquad \ldots\ldots. (1)$$

Numerous parameters that affect concrete compressive strength are known also to affect the UPV, but not always in the same way or to the same degree [33]. The type of aggregate, aggregate gradation, and aggregate volume content are among the factors that influence both UPV and concrete compressive strength. Concrete that includes maximum aggregate content, will likely have the maximum UPV at the same strength level [34]. The type of cement affects both pulse velocity and, on the other side, concrete compressive strength. It was discovered that higher water content in concrete increases the spread velocity proportionally to the variation in water content [35]. In this study, the presence of E-waste as coarse aggregate in concrete reduced the concrete compressive strength, in a similar way it will affect the travel of ultrasonic pulse velocity through the concrete specimens.

The results of measured UPV for all specimens of concrete cubes of size 100×100×100mm are plotted in Figure 9. It can be detected that with the growth of the NMPCB replacement ratio in both mixes, the UPV value reduced, which indicates the presence of NMPCB particles causes a marginal reduction in the UPV value. Previous studies showed that concrete with high quality has a UPV in the range of 3.5–4.5 km/s. The UPV value for mix A reduced from 4.06 km/s for the reference mix to 3.4km/s for mix with 30% replacement ratio. The reduction ratios in UPV for mix A were 0.6%, 2.2%, 3.7%, 5.9%, 10.1%, and 15.9% for replacement ratios of 5%, 10%, 15%, 20%, 25%, and 30%, respectively. These ratios for mix B were 5.4%, 6.4%, 7.5%, 8.9%, 11.9%, and 15.2%, respectively.

It is clear that the reduction ratios in UPV results are much lower than that of reduction in concrete compressive strength.

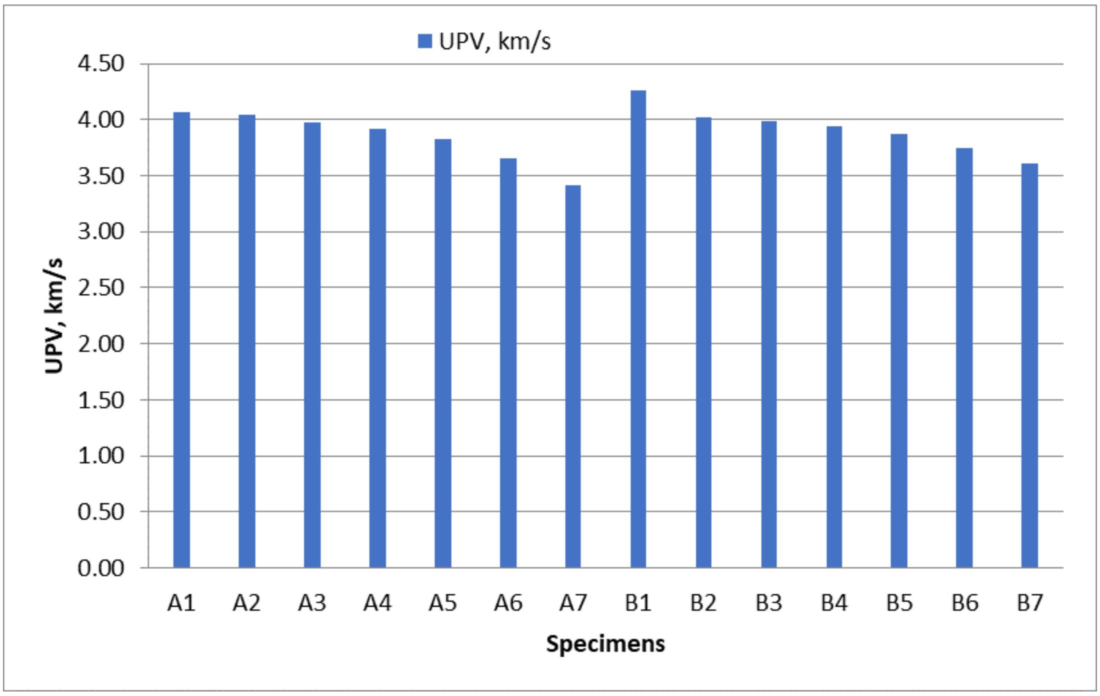

Figure 9: UPV results of concrete specimens

3.6 Rebound Hammer Test

The rebound hammer test is a modest nondestructive test for defining the strength of concrete indirectly by means of the rebound index. The rebound number does not measure the compressive strength directly; it only gives an indication of the strength of the concrete and is a measure of the surface hardness of concrete. In this study, the rebound hammer test is used according to ASTM C805[36] to measure the concrete strength of a concrete cube of size 100×100×100 mm with various replacement ratios. The rebound number was taken as the average of three readings on each face of the cube face, and for each concrete mixture, three cubes were tested at the age of 28 days. The average rebound number values for all concrete mixtures are shown in Figure 10. It can be noted that the rebound number declined when the replacement ratio enlarged in a way that correlated with the trend line of concrete compressive strength.

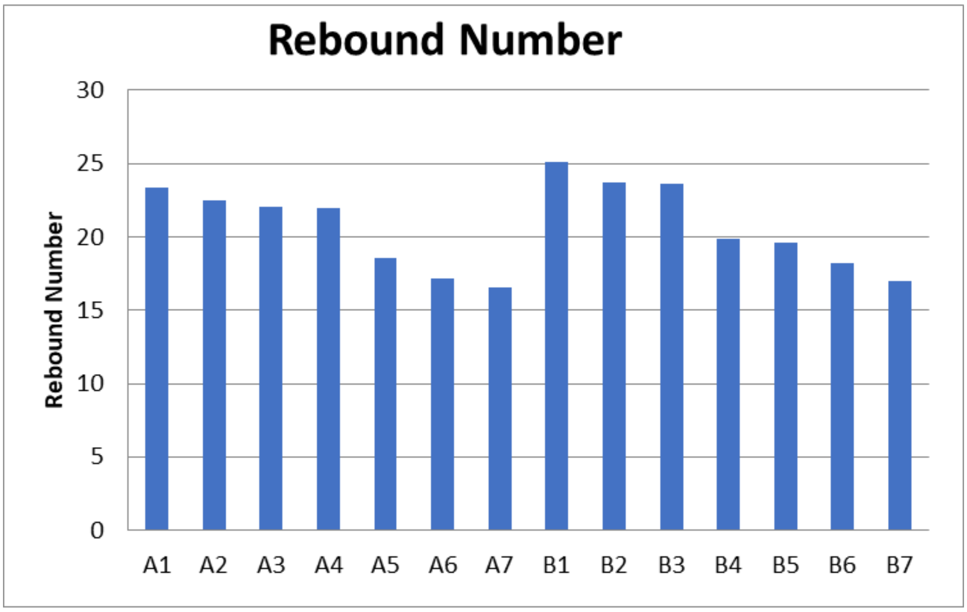

Figure 10: Rebound hammer test results

4. Conclusions

The current study investigates the visibility of recycling E-waste as a harmful substance to the environment and utilizing it for replacement of coarse aggregate. The characteristics of a total of 14 mixtures have been measured and investigated, which led to the following conclusions:

- In today's world, protecting the environment, preserving natural resources, and recycling waste are essential. The disposal of reusing E-waste in the concrete manufacturing is the furthermost practicable way to dispose of vast amounts of electronic waste material. Thus, employing e-waste as aggregate in concrete reduces environmental impact and promotes sustainable development as a workable method of getting rid of e-waste and reduces the amount of aggregate extracted, which harms the environment by eroding river beds and banks.
- The concrete compressive strength reduced with growing the replacement ratio of NMPCB. This may be attributed to the low strength of NMPCB particles compared to coarse aggregate, the flake shape of NMPCB particles, and the smooth surface of NMPCB particles that possess weak adhere performance with the cement paste. Meanwhile, the density of concrete was also reduced, which is a desired property.
- The flexural strength and split tensile strength reduced with the increase of NMPCB ratio up to 20% replacement ratio. For replacement ratios of 25% and 30%, the tensile strength improved relatively due to the large, flaky particles that work as fibers and contribute to tensile strength resistance.
- The UPV value for the tested specimens was also reduced with the increase of the NMPCB replacement ratio in both mixes, which indicated that the presence of NMPCB particles caused a marginal reduction in the UPV value.
- The average rebound number for all concrete mixtures decreased as the replacement ratio increased in a way that correlated well with the concrete compressive strength results.
- The replacements of E-waste in the range of (10-20) % do not considerably lessen the mechanical properties, particularly if it is used with admixtures. Therefore, it is a good alternative material for lowering aggregate usage, which lowers the cost of materials. Moreover, utilizing E-waste products can be an affordable and eco-friendly way to dispose of them, helping to protect the environment and preserve natural resources.

5. Conflict of interest

There is no conflict of interest.

6. Authors' Contribution

The first author, D.A. A., worked on methodology, experimental works, and reviewing and editing. The second author, G. B. J., worked on **c**onceptualization, investigation, data analysis, and text writing. The last author, M. R. J., worked on **e**xperimental works and Resources.

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