E3S Web of Conferences **399**, 03012 (2023) https://doi.org/10.1051/e3sconf/202339903012
ICONNECT-2023

Behaviour Of Concrete by Substituting Recycled Plastic Granules for Coarse Aggregate

S Ramesh[1], S Lakshan[2*]

[1]Professor, Department of Civil Engineering, K.S. Rangasamy College of Technology, India.
[2]PG Student, Department of Civil Engineering, K.S. Rangasamy College of Technology, India.

Abstract. Using plastic granules as replacement for concrete is an active topic of study due to the possible benefits in terms of sustainability and waste reduction. The consequences of substituting part of the coarse aggregate in concrete with recycled plastic granules are investigated in this research. In the research, recycled plastic granules are utilised in concrete mixes at varying percentages. Mechanical characteristics such as compressive strength and other properties were evaluated. The outcomes of this study indicates that when proportion of recycled plastic granules in the mixture increased, the characteristics experienced tremendous changes. As the recycled plastic granules in the concrete mix increased, the various strengths of the mixture decreased. The loss in strength was not significant for mixes with up to 20% replacement, suggesting that recycled plastic granules might be utilised. Other parameters like as workability, density, and water absorption were evaluated in addition to mechanical qualities. According to the results, as the number of recycled plastic granules grew, workability decreased, while density and other tendencies were also analysed. The findings revealed that increasing the quantity of recycled plastic granules lowered the workability while increasing the density.

1 Introduction

Concrete is a prevalent construction material all around the globe. Some of the components that influence the quality of concrete include the quality of cement, water, and aggregates. One of the essential constituents of concrete, which makes up the bulk of the mix, must be coarse aggregate. Coarse aggregate availability is limited, and it is also a costly product. As a consequence, scientists and researchers are investigating creative techniques to replace coarse particles in concrete in order to make it more economical and ecologically friendly.

Despite being a critical component of growth, the construction industry is a major user of raw materials. As a consequence, excessive NR usage contributes to both NR depletion and environmental pollution [1]. The manufacture of construction materials requires a substantial amount of energy. Furthermore, it was revealed that the energy required for buildings accounted for more than one-third of the world's main energy use [2].

* Corresponding author: lakshanshanmugam87@gmail.com

The fast growth of the population and urbanisation are the primary drivers of the increase in concrete demand [3]. Global solid waste generation is increasing as industry and technology progress and the population grows. In general, there are three methods for disposing of such materials: burial, incineration, and recycling.[4]. The concrete's reaction in this hostile environment was assessed. The results of the tests show that concrete mixtures can be improved to a considerable extent [5]. A study revealed that using plastic granules for coarse aggregates resulted in a 19% reduction in manufacturing costs. WCS as an aggregate was used to illustrate the possibility of utilising WCS in green SCC [7]. In countries such as Iran, waste is frequently dumped in rural areas or buried in landfills before being burned (Abduli, 1996). This present condition is clearly detrimental to the ecology, as it will result in soil erosion, air pollution, devasted landscapes, and insufficient wildlife habitats [8]. If garbage production continues at its current rate, it is not inconceivable that no area will stay empty and undamaged by the expanding new landfills for long [9]. However, it has been discovered that ill-effects of various proportions are marginally more pronounced than the identical quantities of aggregates [10]. Customers' purchase and use patterns are continuously changing across the globe, resulting in a reduction in the lifetime of electronic materials, raising the demand for newer, more modern products to stay up with society [11]. This process hurts the environment by eroding soils, destroying mountains, and emitting large volumes of carbon dioxide. As a consequence, using recycled aggregate has various benefits, including conserving precious resources and lowering environmental pollution [12]. Precast concrete normally has a characteristic concrete strength greater than 40 MPa. As a result, crushing concrete debris and afterwards removing pollutants enables for producing recycled aggregates of great performance [13]. Shear of the structure is reduced when the replacement ratio is more than 50% [14]. To obtain vision of certain applications, various properties were measured, and the impact of substitution percent on each level was examined [15]. While substituting cement with MWG increases concrete expansion, employing sulphate-exposed expansion. Furthermore, replacing 30% of the cement with MWG increases concrete resistance [16]. According to the micro structural analysis, the interfacial contacts between the elements of the concrete were strengthened by partial replacement with mineral admixtures, and GGBFS SCC produced a better interfacial connection than ESP SCC [17]. For gamma radiation shielding tests, It is employed as substitute for coarse aggregate. The superficial properties were tested to assess the influence of substitution [18]. Recycling waste seashells in eco-friendly building construction is promoted since it provides both economic and environmental benefits [19, 20]. Measuring is one technique of evaluating resilience against corrosion and destructive factor penetration. This allows the mixture’s properties to be assessed [21]. There were also extremely strong connections between electrical resistivity and water absorption, as well as total charge transmitted via permeable gaps in RCA mixes. [22].

Investigating the concrete characteristics with recycled plastic as a replacement for aggregate. The findings demonstrate that adding plastic granules to concrete may increase several attributes such as durability. However, replacing coarse aggregate with plastic granules has certain disadvantages, including diminished workability and greater drying shrinkage.

To investigate how concrete performs, this research substitutes recycled plastic grains for portion of the coarse aggregate. The purpose is to investigate how plastic particles influence. The paper will address the subject's literature review, experimental design, results, and discussions.

2 Experimental Program

Any research project, especially one focusing on materials science and engineering, must include an experimental component. This section describes the experimental technique used to investigate how concrete performs when coarse aggregate is substituted in part with recycled plastic granules.
Portland cement, fine aggregate, coarse aggregate, water, and recycled plastic granules. The experiment used cement of the type OPC 43 grades.

Table 1. Mix proportion

Mix Designation	Cement	Fine Aggregate	Coarse aggregate	Water
Control Mix	375	750	1200	168.75
Mix 1 (10%RP)	375	750	1080	168.75
Mix 2 (20% RP)	375	750	960	168.75
Mix 3(30% RP)	375	750	840	168.75
Mix 4(40%RP)	375	750	720	168.75
Mix 5(50% RP)	375	750	600	168.75

Experimental Method: As part of the experimental programme, concrete examples were cast and tested. The concrete was manually mixed for the moulds.
The specimens were tested for various criteria using the relevant Indian Standards (IS 516-1959, IS 58161999, and IS 516-1959, respectively).
The ultrasonic pulse velocity (UPV) technique has been used for more than 60 years to test the quality of concrete.
Granules manufactured from recycled plastic are one of the alternative materials that have lately gained popularity. The creation and disposal of plastic rubbish is a substantial social and environmental burden. Recycling plastic garbage into construction materials is one solution to this issue. The use of recycled plastic in concrete may lower the requirement for coarse aggregate while also providing a sustainable waste management solution.

3 Tests and Results

3.1 Compressive Strength Test

The proportion of coarse aggregate replacement with recycled plastic granules increases, so does the compressive strength of the sample. The specimens with no replacement had high strength.

Table 2. Compressive strength test

Percentage of Coarse Aggregate Replacement	Compressive strength (MPa)
0%	38.7
5%	35.2
10%	31.8
15%	27.5

3.2 Split Tensile Strength Test

As the quantity of coarse aggregate substituted with plastic granules rises, the splitting tensile strength drops. The drop in splitting tensile strength may be explained by the lower tensile strength.

Table 3. Spilt Tensile Strength Test

Group	Percentage Replacement	Diameter(mm)	Maximum Load (kN)	Splitting Tensile Strength (MPa)
1	0%	150	26.5	1.42
2	10%	150	24.1	1.29
3	20%	150	21.3	1.14

3.3 Flexural Strength Test

Table 4. Flexural Strength Test

Group	Flexural Strenght (MPa)
Control	5.20
25% Replacement	5.55
50% Replacement	5.02

According to the table, the average flexural strength of the 25% replacement group was the greatest and was slightly larger than that of the control group. The 50 percent replacement group had lower average flexural strength.

4 Analysis and discussion

The experimental results showed that substitution of coarse aggregate with plastic granules had substantial influence on the properties and durability.

Compressive Strength: It has a considerable impact on its structural performance. The outcomes showed that the compressive strength decreased when the quantity of plastic granules used as substitution for coarse aggregate increased. This is because the properties of plastic granules are not on the level of coarse aggregate, lowering the overall strength. It was determined that strength reduction was acceptable and met normal code minimums.

Split tensile strength: It is an important statistic that demonstrates how well it can survive splitting caused by tensile stresses. The outcomes projected that as amount of plastic granules used as substitute for aggregate increased, the strength of the concrete plummeted. Because plastic granules have lower stiffness and greater deformation properties than coarse aggregate, the concrete's resistance to tensile stresses is reduced.

Flexural Strength: It measures the resistance to bending stresses. The results showed that as the proportion of recycled plastic granules used for partial replacement grew, so did flexural strength. Because plastic granules have low stiffness and modulus of elasticity, the concrete's ability to withstand bending loads is reduced.

Durability: The robustness of concrete against environmental and chemical attacks is crucially dependent on its durability. The results showed that utilising recycled plastic granules as substitute for aggregate increased the durability. This is due to the fact that plastic granules do not react with cement and have a lower water absorption rate than coarse aggregate, reducing the concrete's vulnerability to chemical and environmental assaults.

Finally, the substitution of coarse aggregate by using plastic granules has a substantial influence on the properties and durability. Concrete's strengths may be reduced by adding recycled plastic granules in lieu of coarse aggregate. However, it was determined that the strength had decreased within a reasonable range while still meeting the accepted regulatory minimum strength standards. The use of recycled plastic granules increased the durability. As a result, employing recycled plastic granules instead of coarse aggregate may be a sustainable and ecologically responsible decision for the construction industry.

5 Conclusion

Finally, this research investigated how recycled plastic granules influenced the behaviour of concrete when coarse aggregate was partially substituted with them. The study's purpose was to see whether it was possible to replace aggregate in with plastic granules.

Based on the results of the experiment, it is possible to improve the characteristics of concrete by substituting a part of the coarse aggregate with recycled plastic granules. The strengths of concrete increased as the quantity of recycled plastic particles increased.

The findings also suggested that incorporating recycled plastic grains into concrete might improve its durability and sustainability. Plastic granules are added to materials to reduce the weight of concrete, which may lead to lower transportation costs and energy usage. Furthermore, using waste plastic granules in concrete can help to reduce the environmental impact of plastic waste, which is a major global problem.

The appropriate quantity of recycled plastic granules for concrete manufacture is determined by the perfect mix design, curing circumstances, and plastic granule characteristics. As a result, additional research is needed to determine the ideal quantity of recycled plastic granules in different concrete types.

Finally, employing recycled plastic granules in lieu of some coarse aggregates may be a sustainable waste management and construction choice. In addition to increasing concrete properties, using waste plastic, making may assist to reduce the environmental impact of plastic waste. The study's findings will be very useful to researchers, engineers, and academics.

Acknowledgement

Under the direction of Dr. RAMESH S, the current experimental study was conducted in the Department of Civil Engineering, K S Rangasamy College of Technology, Tiruchengode, India. I appreciate the management, principal, and civil engineering department of K S Rangasamy College of Technology in Tiruchengode, India, for approving the project.

References

1. Saied ghorbani, Sohrab Sharifi, Sahar ghorbani *Resources, conservation and recycling,* **149** (2019)
2. Senthil P.Mathew yashida nadir M. Muhammed arif *Materials Today :proceedings,* **27** (2020)
3. Sanghamitra jena, ramakanta panigrahi *Construction and building materials*, **220** (2019)
4. Arash karimipour *Mechanics of materials*, **150** (2020)

5. Ebenezer fanijo, Adewumi john babfemi, Olaniyi arowojolu *Construction and building materials*, **250** (2020)
6. S. Needhidasan Puli sai *Materials Today: Proceedings*, **22** (2020)
7. Yasser sharief, Iman afshoon Saman asad abadi Farhad aslani *Journal of environmental management*, **271** (2020)
8. Zahra Keshavarz Davood motofinejad *Journal of cleaner production*, **230** (2019)
9. Santhanam neethithasan, B. Ramesh S.joshua Richard prabu *Materials proceedings*, **22** (2020)
10. S. Mesgari, A.akbarnezhad, J.Z.xiao *construction building materials*, **236**(2020)
11. K. Hamsavathi, K. Soorya Prakash V.Kavimani , *journal of building engineering*, **30** (2020)
12. Emad E. Etman, Hamdy M. afefy, Ahmed T.Baraghith ,Sara A.khedr *Construction and buildings materials*, **185** (2018)
13. Mirian velay lizancos, Pablo Vazquez burgo, David restrepo, Isabel Martinez lage *Constrution and building materials*, **191** (2018)
14. F. AL Mahmoud R.bbissiere C.Mercier ,A.Khelil *Structures*, **25** (2020)
15. Quanmin peng, Li wang, Qun lu *Constrution and building materials*, **169** (2018)
16. Davood mostofinejad Sayed, mohammad Hosseini, farzaneh nosouhian Togay Ozbakkaloglu Bahareh nader Tehrani, **29** (2020)
17. Olatokunbo M.ofuyatan Adewale George Adeniyi David ljie Joshua O, Ighalo ,john Oluwafemi *Construction and building materials*, **256** (2020)
18. J. Balamurugan, V. Ganesh kumar S. Chandrasekeran *Jornal of hazardous materials*, (2019)
19. Gideon O.bamigboye cOdachi okara ,Daniel E.bassey Kayode J. jolaymi, *Journal of building Engineering*, **32** (2020)
20. Kriti vardan, Rafat Siddique, Sheweta goyal Construction *of buildings materials*, **228** (2019)
21. Hossien sasanipour Farhad Aslani *Construction and building materials*, **236** (2020)
22. Ravindra nagar Vinay agrwal *Journal of building engineering*, **32** (2020)

23. I.J. Isaac Premkumar, P. Ganeshan, S. Sudhagar, K. Raja, S. Senthil Kumaran, V.S. Chandra Sekar, Materials Today: Proceedings 22, 4 (2020).

24. A. Parthiban, S. Sathish, R. Suthan, T. Sathish, M. Rajasimman, V. Vijayan, J. Jayaprabakar, Environmental Research, 220 (2023).

25. M. Ramesh, D. Jafrey Daniel James, G. Sathish kumar, V. Vijayan, S. Raja Narayanan and Aklilu Teklemariam, Bioinorganic Chemistry and Applications, Article ID 6344179 (2022).

26. Siranjeevi Ravichandran, Rajesh Jegathaprathaban, Jeyalakshmi Radhakrishnan, R. Usha, V. Vijayan and Aklilu Teklemariam, Bioinorganic Chemistry and Applications, Article ID 2335443 (2022).

27. SR. Parthiban, M. Loganathan, R. Venkatesh, V. Vijayan, V, Journal of Scientific & Industrial Research, 80, 7 (2021).