International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

Enhancing the Properties of Crumb Rubber Modified Concrete with Synthetic Resin

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Abstract - *In the modern era, India contributes around 6-7% of the waste tyre generation around the world. The production of trash rubber tires in India is increasing by 12% per year growth in the tyre manufacturers. Therefore, Many researchers carried their research work in the field of CR-modified concrete as it reflects the better outcome and helps in reducing the waste from the environment. The first ever CR modified concrete was developed in 1990s.*

Crumb rubber (CR) scrap is a substance obtained by shredding the tires into uniform small granulates. The properties of CR depend upon the source of scrap tires which are usually: car tires and truck tires. In this paper treated and non-treated CR was used at 6%, 12% and 18% by the weight of Fine Aggregates to enhance the properties of concrete (M35).

Key Words: Treated and Un-treated Crumb Rubber, Synthetic Resin, Green Concrete.

1. INTRODUCTION

It has been recognized that the production of hard trash and the related disposal difficulty in the present era is a major issue that has a huge impact on the environment and human life. The hazardous and non-biodegradable trash is being generated in enormous quantity brings a huge danger to our environment.

In the modern era, India contributes around 6-7% of the waste tyre generation around the world. The production of trash rubber tires in India is increasing by 12% per year growth in the tyre manufacturers.

The possibilities of recycling the trash gave positive consequences for recycling including reusing trash tires, with respect to the present quantities of tires that had been thrown in landfills. Moreover, concrete is the largest usable material in the construction field around the globe, it has been suggested to adopt scrap tires by substituting the raw material. The annual generation of concrete in the whole world takes about 9 billion tons of raw aggregate and about 2 billion tons of raw cement.

Many researchers carried their research work in the field of CR-modified concrete as it reflects the better outcome and helps in reducing the waste from the environment. The first ever CR modified concrete was developed in 1990s.

Fig -1: Scrap tyres in an open area and waste tyres dump on fire.

Scrap rubber tires are used in construction industries extensively as they can easily replace the fine aggregates and coarse aggregates from the concrete and produce green concrete.

Crumb rubber (CR) scrap is a substance obtained by shredding the tires into uniform small granulates. The properties of CR depend upon the source of scrap tires which are usually: car tires and truck tires.

2. OBJECTIVES OF PRESENT STUDY

Keeping the gaps in the literature review in mind, the following are the objectives of the current research work:

- To prepare the design mix of concrete as per IS 10262:2009 of M35 grade of reference concrete.
- To prepare the design mix of rubber-modified concrete samples by substituting the fine aggregate (sand) with treated and untreated crumb rubber as aggregate at varying proportions.
- To calculate the density and slump of rubber-modified mix samples entailing varying crumb rubber percentage.
- To calculate the compressive strength of rubber-modified concrete entailing treated and untreated crumb rubber.
- To obtain the optimum percentage of crumb rubber for both the cases i.e. treated and untreated based on experimental results and conclude the outcome for field application.

3. RESEARCH METHODOLOGY

To accomplish the objectives of the current experimental investigation, a broad investigational program had been carried out as per different Indian standards for designing and testing. The various steps which were involved in analyzing the impact of the present study related to green concrete are as follows:

- The reference M35 Grade concrete mix was designed as per "Indian Standard for Concrete Mix Proportioning (IS 10262: 2009)" by using locally available natural aggregates.
- OPC cement was used as a binder in all the mixes.
- The replacement of fine aggregates was carried out with treated rubber with synthetic resin and untreated Crumb rubber tyre in different proportions i.e. 0, 6, 12 and 18 % by weight.
- The properties of fresh concrete such as slump and density concrete mix were calculated and the impact on workability and density were determined.
- C.S. and S.T.S. of concrete mix entailing untreated rubber modified at varying crumb rubber proportions were determined.
- The process of pre-treatment of rubber aggregates with synthetic resins was carried out before concrete mix preparation and samples were tested for its C.S. and S.T.S. Moreover, a comparative study was conducted between the control mix, untreated rubber modified mix, and treated rubber modified mix based on the above-mentioned laboratory test results.
- An optimum proportion of crumb rubber was recommended based upon the above-mentioned laboratory test results.

4. MIX DESIGN

The reference concrete mix design was prepared as per Concrete Mix Design Indian Standard 10262: 2009. Then the fine aggregates were replaced at different levels of replacement with crumb rubber.

- Characteristic compressive strength at 28 days = 35 N/ mm2
- Maximum Size of Aggregate= 20 mm (angular)
- Degree of quality control= Good
- Type of exposure= severe
- Workability= 75 mm (slump)
- Maximum water Cement ratio= 0.45

Target Mean Strength (Fck)= 35 + (1.65×5) = 43.25 N/mm2

Water Cement Ratio

Adopting water cement ratio: 0.40 (which is less than maximum water cement ratio, as per IS: 456)

Water content: 186 ltrs (as per IS: 10262-2009, for 25 to 50 mm slump)

For 75 mm slump, 3% water is increased: 186 + (0.03 × 186) = 191.58 litre

For preparing concrete samples, super plasticizers were used, therefore, water content may be used by 20%: 191.58 x 0.8 = 153.26 ltrs/m3

Table -1: Specific Gravity of different material

Cement	3.15
Fine Aggregates	2.59
Coarse Aggregates	2.72
Super Plasticizer	1.05
Water	1

Cement Content

Water cement ratio: 0.4

Cement content: 153.26/0.4 = 383.15 kg/m3

Minimum cement content as pr IS: 456 is 320 kg/m3. Therefore, ok.

Propotion of Coarse Aggregates and Fine aggregates

Proportion of C.A. for w/c ratio 0.5: 0.62

Corrected Volume of C.A. (for every decrease in 0.5 w/c ratio, volume is increased by 0.1%): 0.62 + 0.2= 0.64

Therefore, Volume of F.A.: 1-0.64 = 0.36

Final Concrete Mix Quantity

Volume of concrete	:	1 m3
Volume of cement	:	383.15 / (3.15 x 1000)
	:	0.12 m3
Volume of water	:	153.26 / (1 x 1000)
	:	0.153 m3
Vol of Super Plasticizer (1%):		3.83 / (1.05 x 1000)
	:	0.004 m3
Total mass of aggragtes	:	1 - 0.12 - 0.153 - 0.004
	:	0.723 m3
Mass of C.A	:	0.723 x 0.64 x 2.72 x 1000
	:	1259.60 kg/m3
Mass of F.A.	:	0.723 x 0.36 x 2.59 x 1000
	:	674.15 kg/m3

Therefore, total quantity of different materials for preparing M35 reference concrete are as follows:

Cement	:	383.15 kg/m3
Water	:	153.26 ltrs/m3
F.A.	:	674.15 kg/m3
C.A.	:	1259.60 kg/m3

Plasticizer : 3.83 kg/m3

5. RESULTS

Following are the concrete mixes which were prepared for the present study:

Table -2: Different concrete samples prepared

Notation	Description
C	Control Mix
CR6	Mix with 6% untreated CR
TCR6	Mix with 6% treated CR
CR12	Mix with 12% untreated CR
TCR12	Mix with 12% treated CR
CR18	Mix with 18% untreated CR
TCR18	Mix with 18% treated CR

Results of Compressive Strength Test

The C.S. of concrete is a very significant property, as it is used to access the condition of concrete at different curing period and its characteristics strength. The C.S. test was performed for various concrete mixes of modified concrete (treated rubber and untreated rubber) at 7, 28 and 56 days as per IS: 516-1959. The test results of C.S. are being represented in Table 3. From the results of this test, it has been observed that on substituting natural F.A. with the CR, there is a significant decrease in C.S. in concrete than reference concrete (control mix).

Table -3: Results of Compressive Strength Test

Notation	Compressive Strength MPA		
	7 days	28 days	56 days
C	34.40	47.17	52.67
CR6	27.30	35.46	41.16
TCR6	32.61	42.26	47.43
CR12	21.16	27.16	32.52
TCR12	26.54	34.06	38.96
CR18	13.16	20.27	24.87
TCR18	17.47	25.37	31.33

Results of Split Tensile Strength Test

The S.T.S. test was performed for various concrete mixes of modified concrete (treated rubber and untreated rubber) at 7, 14 and 28 days as per IS: 5816-1999. Table 4 represents the outcomes gathered from S.T.S test for all the mixes of modified concrete. The influence of adopting untreated rubber and treated rubber as a substitution to F.A. on the S.T.S. of concrete reveals that there is an opposite correlation between tensile strength and CR content as tensile strength decrease with the increase in the percentage of CR.

Table -4: Results of Split Tensile Strength Test

Notation	Compressive Strength MPA		
	7 days	28 days	56 days
C	3.22	3.83	4.35
CR6	2.50	3.10	3.43
TCR6	2.59	3.33	3.78
CR12	2.05	2.58	2.86
TCR12	2.22	2.80	3.20
CR18	1.62	2.02	2.30
TCR18	1.77	2.36	2.80

6. CONCLUSIONS

In the present research studies, there are two different ways to manufacture rubber modified concrete:

1) By substituting natural fine aggregate in concrete of M 35 grade with untreated crumb waste tyre particles and
2) By replacing natural fine aggregate in normal concrete of M35 grade with crumb rubber particles treated with synthetic resin (PVA).

With the addition of untreated and treated crumb rubber to the control mix at different proportions, both the strength i.e. compressive strength and split tensile strength decreases as the percentage of crumb rubber increases in the concrete mix. However, the strength reduction at 6, 12, and 18 % were less in treated rubber modified concrete as compared to untreated rubber modified concrete. This shows that pre-treatment of crumb rubber aggregates with synthetic resin has improved the compressive and split tensile strength of rubber-modified concrete.

REFERENCES

1. Malek K. Batayneh, Iqbal Marie and Ibrahim Asi, “Promoting the use of crumb rubber concrete in developing countries”, Waste Management 28 (2008) 2171–2176, 2008.

2. Dragica JEVTIĆ, Dimitrije ZAKIĆ and Aleksandar SAVIĆ, “Achieving Sustainability of concrete by recycling of solid waste materials”, Mechanical Testing And Diagnosis, ISSN 2247-9635, 2012 (II), Volume 1, 22-39, 2012.

3. http://edugreen.teri.res.in/explore/solwaste/types.htm &gws_rd=cr&ei=O3K2WO3gCMPf gAaekZnQDg

4. http://www.thehindu.com/business/Turning-waste-tyre-into-%E2%80%98green-steel%E2%80%99/article14518524.ece

5. Fedroff, D., Ahmad, S., and Savas, B. Z, "Mechanical properties of concrete with ground waste tire rubber." Transportation Research Record. 1532, Transportation Research Board, Washington, D.C., 66–72, 1996.

6. Fattuhi, N. I., and Clarck, L. A, "Cement-based materials containing shredded scrap truck tire rubber." Constr. Build. Mater., 10(4), 229–236, 1996.

7. Zanzotto, L. and Wirth R., "Performance of asphalt binders and paving mixes modified by crumb rubber." Proc., 21st Canadian Waste Management Conf. (CD-ROM), Calgary, Canada, 1999.

8. Chanbane, B., Sholar, G.A., Musselman, J.A., Page, G.C., "Ten-year performance evaluation of asphalt-rubber surface mixes". Transportation Research Record No. 1681, Transportation Research, Washington, DC, pp. 10–18, 1999.

9. Mohammadi I and Khabbaz H, "Challenges associated with optimisation of blending, mixing and compaction temperature for asphalt mixture modified with crumb rubber modifier (CRM)". Appl Mech Mater 256–259:1837–1844, 2012

10. Dimitrios, G. G., and Al-Hosain, "Non Destructive Evaluation of Rubber Modified Concrete, Infrastructure Condition Assessment", Rubber Modified Concrete Evaluation, Polytechnic University, Six Metro-tech, Brooklyn, NY,11201, 111-120, 1995.

11. Hernandez-Olivares, F. Barluenga, G. Bollati and M. Witozek, B., "Static and dynamic behaviour of recycled tyre rubber-filled concrete". Cement Concrete Research 32, 1587– 1596, 2002

12. Siddique, R., Naik and T.R.. "Properties of concrete containing scrap tire rubber – an overview". Waste Management 24, 563–569, 2004.

13. Li, G. Stubblefield, M.A. Garrick, G. Eggers, J. Abadie and C. Huang, "Development of waste tire modified concrete". Cement Concrete Research 34, 2283–2289, 2004

14. Marzouk, O.Y., Dheilly, R.M. and Queneudec, M., "Valorization of post-consumer waste plastic in cementitious concrete composites". Waste Management 27, 310–318, 2007.

15. Kaloush K, Way G and Zhu H, "Properties of crumb rubber concrete", Transp Res Rec 1914:8–14, 2005

16. Allen F, "Crumb rubber concrete precast of the future". Precast Solut 3:26–27, 2004.

17. Najim KB and Hall MR, "A review of the fresh/hardened properties and applications for plain (PRC) and selfcompacting rubberised concrete (SCRC)", Construction and Building Materials 24(11): 2043–2051, 2010

18. Al-Sakini JS, "Behaviour and Characteristics of Chopped Worn-Out Tires Lightweight Concrete", MSc thesis. University of Technology, Baghdad, Iraq, 1998.

19. http://www.scraptirenews.com/crumb.php

20. Hernandez-Olivares and F., Barluenga, G., "Fire performance of recycled rubber-filled high-strength concrete". Elsevier Cent and Concrete Research 34 (1), 109–117, 2004.

21. Nadim A. Emira and Nasser S. Bajaba, "Utilization of Waste Crumbed Rubber Tire As Fine Concrete Aggregate", Yanbu Journal Of Engineering and Science, Vol.4,april 2012 (1433H), 2012.