International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 08 | Aug 2022 www.irjet.net p-ISSN: 2395-0072

Impact On Abrasion Resistance of Concrete Using M-sand with Polypropylene and Steel Fibre as Fibre Reinforcement

[1]**Ashish Kumar Yadav**, *M. Tech Scholar (structural engineering), Civil Engineering Department, Institute of Engineering and Technology, Lucknow (UP), India*
[2]**Vishal Rawat, Asst. Professor**, *Civil Engineering Department, Institute of Engineering and Technology, Lucknow (UP), India*

---***---

Abstract - *In this investigation an attempt has been made to investigate the effect of m-sand by partial replacement of fine aggregate along with fibre reinforcement on the surface properties of concrete such as abrasion resistance. Abrasion caused in concrete surface mainly due to heavy steel wheel movement in the industrial areas and also in hydraulic structures by water born particles and debris flow. In this study abrasion resistance was measure as per IS 1706:1972 using surface abrasion testing machine. Compressive strength of concrete also determined along with abrasion resistance. Result of this investigation concluded that the compressive strength is proportional to the surface wear resistance and using m-sand partially as fine aggregate improves the surface abrasion resistance. Fibre reinforcement improves the abrasion resisting property of concrete. The comparison between compressive strength and abrasion resistance has been made in terms of R^2 of the linear regression.*

Key Words: Abrasion resistance, steel fibre, manufactured sand, polypropylene fibre.

1. INTRODUCTION

Abrasion erosion is a significant issue from the perspective of strength in structures that support hydraulic dynamics, such as dams, spillways, and under-water piles loaded with debris that frequently flow in hilly areas. Additionally, industrial pavements that sustain heavy steel wheel traffic and pavements in mountainous areas that frequently need to be de-iced with de-icing salts require abrasion resistance. The primary goals of this analysis are to examine the abrasion resistance of concrete using manufactured sand at its appropriate content and to look into the impact of steel and polypropylene fibres. In the construction of pavements and other buildings, river sand has primarily been employed as fine aggregate. The need for river sand is necessitated by the world's accelerating rise of infrastructural development. Additionally, the price of the sand is rising as the supply of suitable natural sand material close to the construction site is depleted. Therefore, it is necessary to find an alternative for river sand, and the finer materials from crushing operations are a better option. River sand is in short supply, and its continuous supply cannot be guaranteed, hence using manufactured sand (m-sand) as a substitute has become necessary[1]. Due to the sliding and scraping action of the wheels, pavements suffer wear and tear and abrasion when cars drive across them. Therefore, when the concrete pavement is exposed to such abrasive forces, abrasion resistance of the concrete is a crucial requirement. It is challenging to measure the damage brought on by various abrasion forces, and no one test approach is adequate to gauge concrete's resistance to wear[2]. The compressive and flexural strengths of concrete increase when m-sand particle surface roughness increases, but flexural strength of concrete decreases as m-sand particle crushing value increases. The compressive strength of m-sand concrete and its crushing value do not appear to be correlated. Due to the naturally rough and angular nature of m-sand particles, m-sand PCC usually exceeds river sand PCC in terms of flexural strength and abrasion resistance as long as the crushing value of m-sand particles is less than 26.5 percent[3]. In this investigation, incorporation of steel fibre and polypropylene fibre was done on separate specimens to check the effect of fibre reinforcement on the abrasion resistance of concrete. Both the flexural and compressive strengths were significantly increased by the addition of steel fibres. This increase might be related to the improved compaction ability. Addition of steel fibre (156 kg/m3) reduced weight loss by 42 percent due to abrasion and 19 percent increase shown in flexural strength. The superplasticizer and improved fibre dose can have better physical effects at a given paste content and mechanical synergistic outcomes with sufficient qualities of flow[4]. Ultrahigh-strength steel fiber-reinforced concrete's strength and resistance to abrasion were studied by Febrillet et al. in 2000. In their research, the impact of steel fibre addition, water-binder ratio, and compaction method on the mechanical and abrasion resistance of ultrahigh-strength steel fiber-reinforced concrete was examined. They came to the conclusion that abrasion resistance is best improved by combining the inclusion of steel fibres with hot-press compaction for ultrahigh-strength mortar[5]. In 2001, Sadegzadeh et al. published the findings of a comparative study on the effects of three types of fibreglass, polypropylene, and steel on various physical characteristics of concrete. Four dosage rates—1, 5, 10, and 20 kg/m3 of concrete were used, one for each type of fibre. Their experimental results have clearly shown that the dosage rates were a key determining element in the significant increases in abrasion resistance that were brought about by the inclusion of all three types of fibre[6]. Because of the linear relation between compressive strength and abrasion resistance, compressive strength parameter plays a vital role to determine abrasion resistance of concrete. In the first phase of the investigation, optimization of m-sand was done on the basis of compressive strength. And then appropriate content of steel fibre and polypropylene fibre along with m-sand was determined on the basis of compressive strength analysis. After optimization of all material, specimens with all optimum materials were prepared for abrasion test using abrasion testing machine as per IS 1706:1972[7].

2. MATERIAL PROPERTIES

2.1 Cement

This concrete mixture contains Portland pozzolana cement by Ultratech that conforms with IS 1489.1:1991. According to IS 4031.1988, all cement property tests were carried out in laboratories. Cement specifications are given in table1.

Table - 1: cement specifications.

Test	Values	Requirements as per IS 12269:2013
fineness	7 percent	< 10 percent
Normal consistency	28 percent	25-35 percent
Initial setting time	105 minutes	>30 minutes
Final setting time	203 minutes	< 600 minutes
Soundness of cement	1.65 mm	< 10mm
Specific gravity	3.15	---

2.2 Aggregates

2.2.1 Fine aggregate

M-sand and natural river sand are the two types of fine aggregate employed in this experiment. Both fine aggregate classified in Zone II according to IS 383:2016[8]. River sand had a specific gravity and water absorption of 2.65 and 1.4 percent, respectively, while m-sand had 2.68 and 1.62 percent.

2.2.2 Coarse aggregate

The primary matrix of the concrete is made of coarse aggregate. In this experiment, 20mm and 10mm natural coarse aggregate was employed, and it was tested in accordance with IS 2386-1963. The specific gravity was found to be 2.7, and its water absorption rate was 1%.

2.3 Type of Fibres

2.3.1 Steel fibre

Hooked end steel fibre was used in this work, table 2 and figure 1 indicate the specifications for these fibres.

Table - 2: End hooked steel fibre specifications.

Specifications	Value
Length	30mm
Least dimension	0.60mm
Aspect ratio	60
Density	7850kg/m^3

Chart – 1: End hooked steel fibre (30mm)

2.3.2 Polypropylene fibre

In this experiment, monofilament fibre of 24 mm in length was employed, provided by JOGANI IMPEX LLP.

Fig. 2: polypropylene fibre (24mm)

2.4 Superplasticizer

This concrete mixture contains Sikka viscocrete 5207 NS, which has a specific gravity of 1.12.

3. EXPERIMENTAL PROCEDURE

Concrete mix was prepared as per IS 10262:2019 [9] with the w/c ratio of 0.39 using M35 grade of concrete. To investigate the optimum dosage of m-sand, specimens were prepared with varying dosage of m-sand. Cubes of 150mm³ were casted for compressive test. As per previous literature abrasion resistance was increased with lower w/c ratio and increased characteristic strength of concrete. So, it is considered that specimen with high compressive strength may show better abrasion resistance. So, the optimization of all admixtures was done on the compressive strength viewpoint. Five specimens with 15%, 30%, 45%, 60%, 75% of m-sand were prepared along with a specimen of conventional concrete. Compressive test was performed using CTM with cubical specimens of 150mm³ as per IS516:1959. After optimization of m-sand, steel fibre at the rate of 0.5, 0.75, 1.0 and 1.25 percent by volume was used to cast new specimens with optimum content of m-sand that is 60 percent. And for optimization of polypropylene fibre content, cubes for compressive test were casted with 0.5kg/m³, 1.0kg/m³, 1.5kg/m³, 2.0kg/m³ with 60 percent m-sand. After optimizing all admixtures content, cubes of 70.6mm³ were casted for abrasion test. The abrasion test was performed on abrasion testing machine as per IS 1706:1972. First fix the specimen in the holding device and abrasive dust (corundum aluminium Oxide Al_2O_3) of 20 ± 0.5 g was spread over the disc. Total 220 revolution was made in 10 parts with 22 revolutions in each. Abrasion testing setup shown in figure 4.

Chart -2: Compressive Testing Machine (CTM)

Chart – 3: Abrasion Testing Machine

4. RESULT AND DISCUSSION

4.1 Compressive strength

Concrete shows better compressive strength with 60% m-sand as fine aggregate. Compressive strength increased by 16 percent with 60 percent m-sand as shown in figure 5.

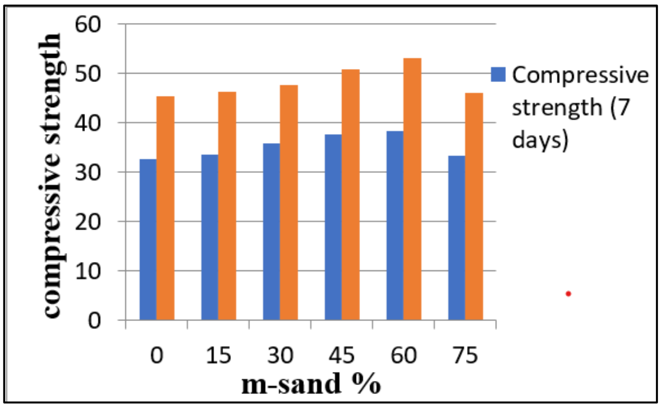

Chart – 5: compressive strength of concrete with increasing percentage of m-sand.

It clearly indicates that 60 percent of m-sand is the appropriate proportion for concrete mix. Following that, several percentages of steel fibre and polypropylene were used with the optimal amount of m-sand. Figure 6 and 7 represents the compressive strength of concrete specimens with various volume fractions of steel fibre and various dosage of polypropylene fibre.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 08 | Aug 2022 www.irjet.net p-ISSN: 2395-0072

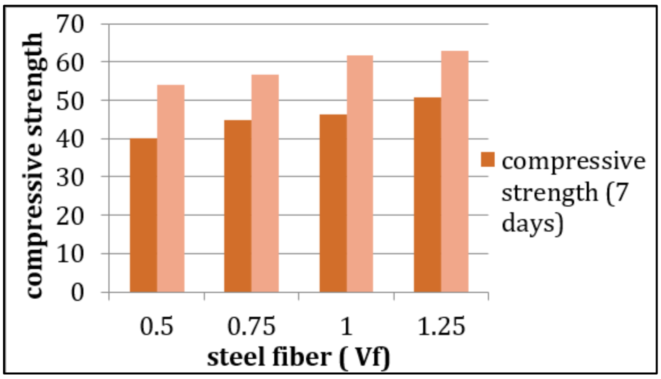

chart -6: compressive strength of concrete with 60% m-sand and varying percentage of steel fibre.

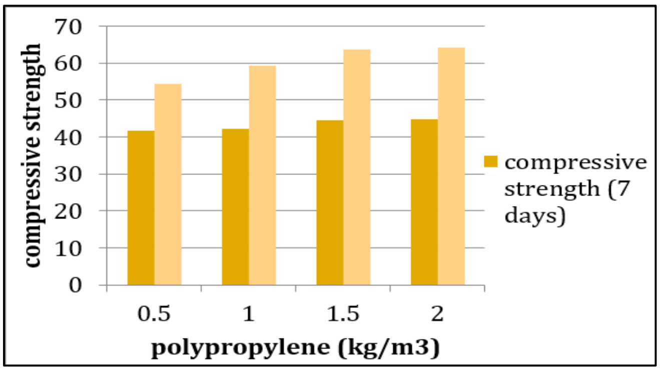

chart – 7: compressive strength of concrete with 60% m-sand and varying dosage of polypropylene.

As per result shown in figure 6 and 7, compressive strength initially increased with increasing steel fibre from 0 to 1 percent by volume of concrete. Exceeding steel fibre volume fraction from 1 percent does not improve compressive strength more efficiently. So, as per results the considered optimum content of steel fibre is 1 percent by volume of concrete. And in case of polypropylene fibre reinforced concrete, optimum content for the same fibre was adopted 1.5kg/m³ as per investigation results.

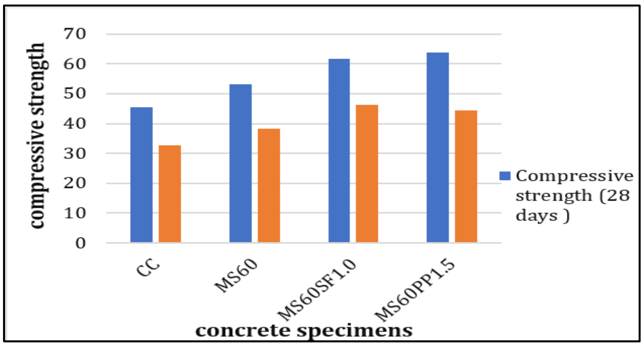

Fig. 8: compressive strength of various specimens with optimum dosage of materials.

Abbreviations: CC-conventional concrete, MS60-concrete with 60% m-sand, MS60SF1.0- concrete with 60% m-sand and 1% steel fibre by volume, MS60PP1.5- concrete with 60% m-sand and 1.5 kg/m³ polypropylene.

4.2 Abrasion Resistance

For the abrasion test of concrete, 4 groups of specimens were prepared. One for conventional concrete, second for 60 percent of m-sand as fine aggregate, third and fourth group with the optimum content of steel fibre and polypropylene fibre with 60 percent m-sand in both. Abrasion resistance of concrete was found better with polypropylene fibre. And steel fibre also improves the abrasion resistance of concrete when it used at optimum dosage. Depth of wear and total loss in weight had been measured for all four specimens. Loss in weight for conventional concrete comparing with steel fibre and polypropylene fibre at their optimum dosage are given in figure 9. Relation between abrasion loss and compressive strength was determined using linear regression analysis in terms of regression coefficient R^2, and strong relation shown between compressive strength and abrasion loss of concrete. As compressive strength increases, loss of weight due to abrasion decreases shown in figure 11.

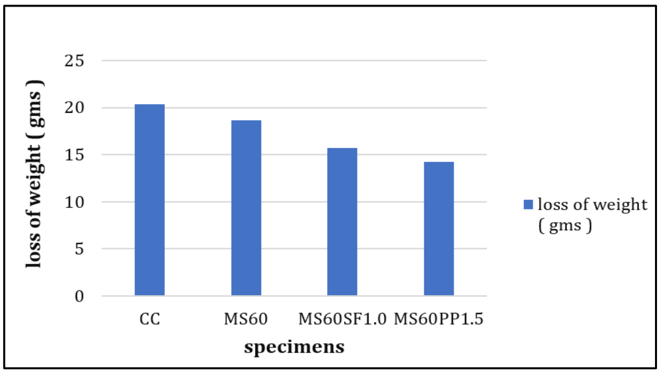

Fig. 9: loss of weight due to abrasion in various concrete samples

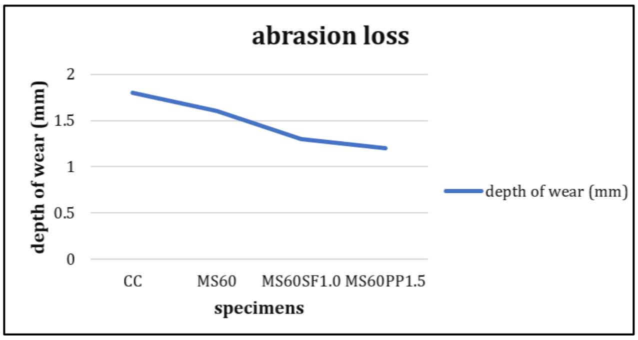

Fig. 10: depth of wear due to abrasion in various concrete samples

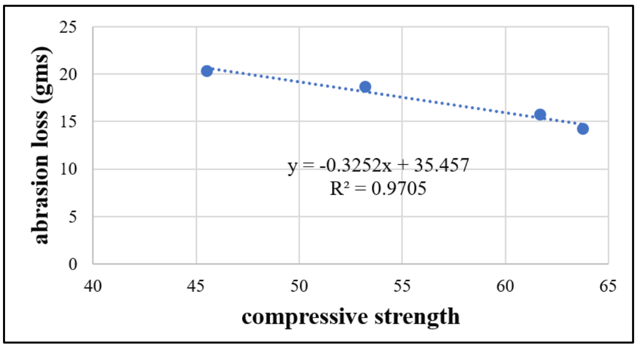

Fig. 11: relation between abrasion loss (gm) with compressive strength of various concrete samples

5. CONCLUSION

- As per the results of this investigation, m-sand is the better replacement of river sand at its optimum content of 60 % by weight of fine aggregate. As compressive strength of concrete associated with m-sand is quite high as compare to conventional concrete.

- Concrete with 60 percent m-sand by weight of fine aggregate and 1 percent of steel fibre by volume of concrete reduces abrasion loss about 23 percent as compared to conventional concrete.

- Polypropylene is better suited fibre to made concrete more abrasion resistance as it also improves compressive strength. Reduction in abrasion loss with 1.5kg/m^3 of polypropylene is about 30 percent.

- Abrasion resistance of concrete have strong relation with compressive strength. As per regression analysis, it shows abrasion loss decreases with increasing compressive strength.

REFERENCES

[1] S. K. Rao, P. Sravana, and T. C. Rao, “Investigating the effect of M-sand on abrasion resistance of Fly Ash Roller Compacted Concrete (FRCC),” Constr. Build. Mater., vol. 118, pp. 352–363, 2016, doi: 10.1016/j.conbuildmat.2016.05.017.

[2] J. J. B. A.M. Neville, concrete technology. 2010. doi: 10.6004/jnccn.2015.0201.

[3] B. Li, G. Ke, and M. Zhou, “Influence of manufactured sand characteristics on strength and abrasion resistance of pavement cement concrete,” Constr. Build. Mater., vol. 25, no. 10, pp. 3849–3853, 2011, doi: 10.1016/j.conbuildmat.2011.04.004.

[4] B. Felekoğlu, S. Türkel, and Y. Altuntaş, “Effects of steel fiber reinforcement on surface wear resistance of self-compacting repair mortars,” Cem. Concr. Compos., vol. 29, no. 5, pp. 391–396, 2007, doi: 10.1016/j.cemconcomp.2006.12.010.

[5] Febrillet, N., Akihiro, K., Yukihiro, I., and Kouji, I. _2000_. “Strength and abrasion resistance of ultra-high strength steel fiber reinforced concrete.” Trans. Jpn. Concr. Inst., 22, 243–252.

[6] Sadegzadeh, M., Kettle, R. J., and Vassou, V. _2001_. “Influence of glass, polypropylene and steel fibres on physical properties of concrete.” Proc., 1st Int. Conf. on Concrete and Development C and D, Ministry of Housing and Urban Development, Tehran, Iran, 483–492.

[7] IS 1706:1972, "method for determination of resistance to wear by abrasion of natural building stones" , Bureau of Indian Standards, p. 1-7, 1972.

[8] IS:383:2016, “Coarse and Fine Aggregate for Concrete-Specification,” Bureau of Indian Standards, pp. 1–21, January, 2016.

[9] IS 10262:2019, Concrete Mix Proportioning-Guidelines, Bureau of Indian Standards, January 2019.