IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A Comprehensive Cost Analysis of Eco-Engineered Self Compacting Concrete Using MWP,M-Sand,and PolyPropylene Fibers

[1]O.Ankamma Raju, [2] Dr.T.V.S.Vara Lakshmi.

[1]Research Scholar, [2]Assistant professor.

[1]CivilEngineering Department,[2]Civil Engineering Department,

Acharya Nagarjuna University, Guntur, Andhra Pradesh.

Abstract:

Self Compacting Concrete (SCC) was developed in Japan during the late 1980s as an innovative solution to counter labor shortages and address inconsistencies in concrete placement quality. Its exceptional flowability and ability to fill complex formwork without the need for mechanical vibration have revolutionized modern construction practices, offering improved surface finishes and uniformity. While numerous studies have explored its mechanical and durability properties, the economic implications of SCC particularly the cost variations introduced by material choices remain less studied. This research focuses on comparing the material costs between nominal SCC mixes and those incorporating polypropylene fibers. By assessing these cost factors, the study aims to evaluate the financial viability of fiber-reinforced SCC in practical applications. The analysis will provide a comprehensive understanding of both the economic and performance-related aspects of SCC. The findings are expected to aid contractors, engineers, and decision-makers in choosing more efficient and cost-effective concrete solutions for future construction projects.

Key words– Self Compacting Concrete, Form Work, Concrete, Poly Propylene fibers,Construction.

I. INTRODUCTION

The world's most widely used building material, has an annual global output of 5.3 billion cubic meters, ranking second only to water in consumption. The production of Ordinary Portland Cement (OPC), a crucial component of concrete, reached approximately 4.1 billion tones by 2020, raising significant environmental concerns due to its substantial energy and resource usage .The cement industry alone contributes about 7% of total global CO_2 emissions, primarily during the calcinations process of limestone and raw material heating in clinker production. Urgent measures are needed to mitigate global carbon emissions and safeguard ecosystems in the face of climate change. Researchers are exploring eco-friendly strategies such as utilizing industrial waste like Marble waste powder and blast furnace slag from thermal power plants to mitigate the environmental impact of concrete production. Self-compacting concrete (SCC) typically incorporates a greater proportion of fines (particles passing through 100 microns) and super plasticizers per unit volume compared to traditional concrete. While the amount of fine aggregates remains similar, SCC necessitates a reduced quantity of coarse aggregates compared to conventional concrete. This advanced concrete type spreads effortlessly and fills congested areas and reinforcement structures without requiring mechanical compaction or risking material separation. Initially conceptualized by Prof. Okamura in 1986 at Ouchi, SCC offers improved ease of placement, accelerated construction rates, and cost reduction through decreased labor and time requirements. The first prototype of SCC was developed in 1989 by Prof. Ozwa at the University of Tokyo. When compared to vibrating concrete of comparable composition, self-compacting concrete exhibits greater strength, enhancing the interface between aggregates and cement. Additionally, self-compacting concrete can be placed at heights exceeding 5 meters and at a significantly faster rate than traditional concrete.

IDENTIFICATION OF COSTS ASSOCIATED WITH SELF COMPACTING CONCRETE

Before delving into an analysis of the factors influencing self-compacting concrete (SCC) costs, it's essential to identify them. Costs can be classified as benefits favoring SCC, such as reduced labor requirements, particularly advantageous for high-altitude concrete placements. Furthermore, there's a decrease in vibrator usage, cutting operational and maintenance expenses and extending vibrator lifespan. SCC also lowers surface finishing costs and labor expenses by producing a surface that requires no additional finishing. The reduced truck turnaround time saves on fuel, truck rentals, and operator charges. With SCC's self-flowing nature, labor demand during concrete placement diminishes, leading to reduced labor costs. The minimal occurrence of imperfections on the concrete surface decreases maintenance and labor expenses. Enhanced durability lowers surface maintenance costs. SCC enables the construction of thinner concrete sections, reducing concrete quantities and costs. Quieter operations due to reduced truck turnaround time and vibrator usage result in lower medical expenses for personnel. Costs that do not align with the advantages of SCC (Costs) include additional expenses on materials like super plasticizers and admixtures, which elevate the overall mix cost. The necessity for skilled individuals to oversee material selection, manufacturing processes (ensuring proper material dosage), testing, handling, and placement contributes to increased total costs. Moreover, there are expenses associated with maintaining formwork due to the high pressures involved.

II. LITERATURE REVIEW

Marble waste, a byproduct of the marble processing industry, has shown pozzolanic and filler properties. Studies indicate that replacing 10–20% of cement with marble waste can significantly reduce SCC production costs while maintaining compressive strength. Aliabdo et al. (2014)[1] found that marble powder reduced both cost and carbon emissions without compromising mechanical properties. The micro-filler effect also improved durability and workability in SCC mixes. Manufactured sand (M-sand) is an economical and sustainable alternative to natural river sand. Replacing fine aggregate with M-sand not only helps reduce dependency on natural resources but also leads to cost savings due to local availability. Vijay kumar et al. (2012) [4].and Pofale&Deoet al.(2010) [5] observed improved mechanical properties and reduced cost in SCC with partial or full replacement of natural sand by M-sand. The incorporation of polypropylene fibers enhances crack resistance, toughness, and ductility. While the fibers themselves are relatively expensive, their inclusion at low dosages (typically 0.1–0.3% by volume) can reduce long-term maintenance costs by improving durability and reducing shrinkage cracks. However, Dubal&Naktode et al., (2024)[3] emphasize the need for cost-benefit evaluation when adding fibers to SCC.Recent studies have examined SCC incorporating both waste marble and M-sand, reinforced with polypropylene fibers. Kumar et al. (2022)[2] reported that replacing 15% of cement with marble waste and using M-sand in combination with 0.2% polypropylene fibers led to an approximate 10% cost reduction while enhancing compressive and flexural strength. The combined use of these materials improves sustainability and economy, making SCC more accessible for practical applications.

III.MATERIALS USED

Manufactured sand,(M-Sand) also referred to as manufactured fine aggregate (MFA), is crafted by downsizing larger aggregate fractions into sand-sized particles. M-sands find widespread application in blends, especially in locales where natural sand is scarce or transporting it proves too costly.Confiber stands out as a polypropylene fiber engineered to fortify cementitious mortars and concrete mixes seamlessly integrating into the concrete blend. It's widely acknowledged that conventional concrete mixes are susceptible to plastic shrinkage during the setting stage, which can lead to undesirable cracking. These fibers composed of Alkali Resistant Polypropylene, exhibit resilience against acids and other chemicals, effortlessly assimilating into concrete compositions. Their fibrillated structure ensures superior binding and anchoring of aggregates within concrete and plaster Mortar. Marble dust emerges as a byproduct of the marble manufacturing process, generated abundantly during cutting operations. Approximately 25% of the initial marble mass is lost as dust, posing environmental concerns if left unaddressed, including elevated soil alkalinity and potential impacts on plants and human health. 53 Grades OPC cement serves as the binding agent, a chemical constituent essential in mixes for solidifying and bonding various materials. La Hyper Crete S20 marks a breakthrough hyper plasticizer, formulated with modified poly carboxylic ether. The distinct mode of action of poly carboxylic ether in La Hyper Crete S20 significantly enhances cement dispersion efficiency, thereby reducing water requirements for mixing. Notably, La Hyper Crete S20 is chloride-free and exhibits compatibility with all cement types

IV.MIX DESIGN

The Self-Compacting Concrete (SCC) mix design is based on the use of marble waste powder as a supplemental cementitious material, manufactured sand as a partial substitute for natural fine aggregates, and multiple trials to determine the best rheological and mechanical properties. Super plasticizer (La Hyper Crete S20).The super plasticizer meets IS: 9103-1999 (reaffirmed 2004), Edition 2.2 (2007 - 2008), ASTM C494, Types G and F standards, with a specific gravity of 1.06 ± 0.02 (at $27^{0\ C}$ ± 30 C). In addition, ordinary Portland cement (OPC 53) matching IS 12269-1987 was utilized with a specific gravity of 3.15 . The fine aggregate utilized in this study has an oven-dry bulk specific gravity of 2.63, absorption of 1.45, and moisture content of 0.2%.Furthermore, the aggregates used in the concrete mixes were grade. And denoted as fallows

Table1: Mix Designation Format

Mix Designation	Mix
CM(Control Mix)	M30 MS0 MWP0 PP 0
M0	M30 MS20 MWP20 PP 0
M1	M30 MS20 MWP20 PP 0.5
M2	M30 MS20 MWP20 PP 1.0
M3	M30 MS20 MWP20 PP0 1.5
M4	M30 MS20 MWP20 PP 2.0
M5	M30 MS20 MWP20 PP 2.5

Table 2: Mix Quantities of M30 Grade Concrete SCC

Mix	CM	M0	M1	M2	M3	M4	M5
Cement(kg/m^3)	395.8	316.8	316.8	316.8	316.8	316.8	316.8
Fine Aggregate (kg/m^3)	1052.5	842	842	842	842	842	842
Coarse Aggregate(kg/m^3)	731.3	731.3	731.3	731.3	731.3	731.3	731.3
M -Sand(kg/m^3)	0	210.5	210.5	210.5	210.5	210.5	210.5
Marble Waste Powder(kg/m^3)	0	79.2	79.2	79.2	79.2	79.2	79.2
P P Fibers(kg/m^3)	0	0	1.9	3.9	5.9	7.9	9.8
Super Plasticizers(Lit)	2.37	2.37	2.37	2.37	2.37	2.37	2.37
Water (Lit)	190	190	190	190	190	190	190

Table 3: Cost of Materials

Material (kg/m³)	C Mix kg/m³	Mix 0 kg/m³	Mix 4 kg/m³	Price Of Material(TON)	Cost Of CM	Cost Of Mix 0	Cost Of Mix 4
Cement	395.8	316.8	316.8	7600	3002	2407.6	2407.6
Fine Aggregate	1052.5	842	842	450	473	378.9	378.9
Coarse Aggregate	731.3	731.3	731.3	400	292.4	292.4	292.4
M -Sand	0	210.5	210.5	1250	0	263.12	263.12
Mwp	0	79.2	79.2	320	0	25.28	25.28
P P Fibers	0	0	7.9	180000	0	0	1422
S.P	2.37	2.37	2.37	250000	592.5	592.5	592.5
Water (Lit)	190	190	190	0	0	0	0
Total(Rs)					**4363**	**3960**	**5382**

IV.RESULTS AND DISCUSSION

1. From the table2&3 the results and discussions are The incorporation of 20% Marble Waste Powder (MWP) as a partial replacement of cement and 20% M-Sand as a partial replacement of fine aggregate proved to be an economical and sustainable alternative for Self-Compacting Concrete (SCC).
2. The total material cost of the conventional SCC mix (CM) was found to be ₹4363 per m³, whereas Mix M0 recorded a cost of ₹3960 per m³, resulting in a cost reduction of approximately 9.24%.
3. The cost savings achieved in Mix M0 are primarily attributed to the reduced cement content and the utilization of low-cost industrial waste materials such as marble waste powder and manufactured sand.
4. Mix M4 exhibited the highest cost among the selected mixes, with a total cost of ₹5382 per m³, which is approximately 35.9% higher than Mix M0 and about 23.4% higher than the conventional mix.
5. The cost contribution of the super plasticizer remained constant for all mixes, indicating that the variation in total cost was mainly influenced by the replacement materials and fiber dosage.
6. From an economic perspective, Mix M0 represents the most cost-effective SCC mixture while simultaneously promoting sustainable construction through the utilization of industrial by-products.
7. The study demonstrates that eco-engineered SCC incorporating MWP and M-Sand can effectively reduce material costs Therefore, the adoption of MWP and M-Sand in SCC is recommended for sustainable and economical construction, while the use of polypropylene fibers should be considered where enhanced structural performance justifies the additional cost.

V.Acknowledgement

The authors greatly acknowledge the full-fledged support by the Acharya Nagarjuna university College of Engineering and Technology Acharya Nagarjuna University, Guntur ,Andhra Pradesh, India. The complete works were carried out in the laboratory of the Civil Engineering Department, Acharya Nagarjuna University. The great support of the University Management Team and Researchers were extremely acknowledged here with thankfulness.

References

1. Aliabdo, A. A., Elmoaty, A. E. M. A., &Auda, E. M. (2014). Re-use of waste marble dust in the production of cement and concrete. *Construction and Building Materials, 50*, 28–41. https://doi.org/10.1016/j.conbuildmat.2013.09.005
2. Kumar, D., Gautam, V., &Srivastav, A. (2022). Laboratory study on mechanical properties of self-compacting concrete using marble waste and polypropylene fiber. *Cleaner Materials, 6*, 100156. https://doi.org/10.1016/j.clema.2022.100156
3. Dubal, A. C., &Naktode, P. L. (2024). Effect of polypropylene fiber on the properties of self-compacting concrete with M-sand. *Educational Administration: Theory and Practice, 30*(2), 1245–1250.
4. Vijayakumar, G., Vishaliny, H., &Govindarajulu, D. (2012). Studies on glass powder as partial replacement of cement in concrete production. *International Journal of Emerging Technology and Advanced Engineering, 2*(10), 434–440.
5. Pofale, A., &Deo, S. V. (2010). Performance of concrete by replacing natural sand with artificial sand. *International Journal of Engineering Research and Technology, 1*(3), 1–5.
6. Mazloom, M., Ramezanianpour, A. A., & Brooks, J. J. (2009). Effect of polypropylene fibers on the properties of self-compacting concrete. *Construction and Building Materials, 23*(7), 2906–2913. https://doi.org/10.1016/j.conbuildmat.2009.02.005.
7. Bhanja, S., &Sengupta, B. (2016). Modified mix design for fiber-reinforced self-compacting concrete. *Materials and Structures, 49*, 5081–5092. https://doi.org/10.1617/s11527-016-0825-y
8. Ulubeyli, G. C., Bilir, T., &Artir, R. (2016). Durability properties of concrete produced by marble waste as aggregate or mineral additives. *Procedia Engineering, 161*, 543–548. https://doi.org/10.1016/j.proeng.2016.08.630
9. Ashish, D. K., &Verma, S. K. (2023). Self-compacting concrete with partially substitution of waste marble: A review. *International Journal of Concrete Structures and Materials, 17*, 50. https://doi.org/10.1186/s40069-023-00585-5
10. Nayak, Y. B. G., Pandit, P., & Lakshmi, A. (2023). Effect of polypropylene fibers on strength and durability performance of M-sand SCC. *Construction and Building Materials, 364*, 129789. https://doi.org/10.1016/j.conbuildmat.2023.129789
11. Ahmad, J., Aslam, F., &Khedher, K. (2021). Performance of sustainable self-compacting fiber reinforced concrete with substitution of marble waste and coconut fibres. *Scientific Reports, 11*, 23184. https://doi.org/10.1038/s41598-021-01931-x
12. Onyelowe, K. C., et al. (2025). Mechanical properties of self-compacting concrete reinforced with hybrid fibers and industrial wastes under elevated heat treatment. *Scientific Reports, 15*, 12753. https://doi.org/10.1038/s41598-025-96899-3
13. Garko, M. N., Dulawat, S., Ahmad, E., &Ubayi, S. S. (2025). Examining marble waste as material in concrete: A brief review. *Environmental Research and Technology, 8*(2), 471–486. https://doi.org/10.21601/ert.1390719
14. Prakash Chandar, S., &Dhanu, S. (2022). A critical review of SCC with M-sand as fine aggregate. *AIP Conference Proceedings*, 2393(1), 020034. https://doi.org/10.1063/5.0077622
15. Wen, W. (2025). The combined effect of marble powder and polypropylene fiber on self-compacting concrete repair materials. *Journal of Composite Materials, 59*(8), 1125–1139. https://doi.org/10.1177/15589250251322922.