

# A FEASIBILITY STUDY OF CONCRETE WITH IRON ORE WASTE AS AGGREGATE REPLACEMENT

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## Abstract

The rising demand for concrete, coupled with the depletion of natural aggregates, has encouraged the use of industrial waste products as sustainable alternatives. This study investigates the feasibility of using iron ore waste as a partial and complete replacement for fine aggregates and coarse aggregates in M30 grade concrete. Concrete mixes were prepared with varying levels of iron ore waste replacement (0%, 25%, 50%, 75%, and 100%), and their mechanical performance was evaluated using slump test, compressive strength test and split tensile strength test. The primary objective is to assess the impact of iron ore waste on the strength characteristics of concrete and determine its suitability as an environmentally friendly construction material. The findings are expected to highlight the potential of iron ore waste to enhance concrete properties while contributing to effective waste management and the conservation of natural resources.

**Keywords:** Iron ore waste, sustainable concrete, Replacement of fine and coarse aggregates, workability, compressive strength, split tensile strength.

## I. Introduction

Concrete is the most widely used building material globally, and its demand is increasing due to rapid urbanization and infrastructure development. The extensive use of concrete puts immense strain on natural resources, particularly river sand and traditional coarse aggregates, which are being extracted at unsustainable rates. Excessive mining of these materials has led to environmental issues such as the degradation of riverbeds, a decline in biodiversity, lower groundwater levels, and rising material costs. Consequently, the construction sector is increasingly concentrating on sustainable alternatives that can minimize environmental impact while sustaining or improving concrete performance.

India is a major global producer and exporter of iron ore. Mining is crucial for extracting natural ore. But it generates significant quantities of iron ore waste, including fines, tailings and overburden materials. Effective waste management and disposal are essential to minimize environmental challenges such as land degradation, dust pollution, and contamination of nearby water bodies. Iron ore waste, a by-product generated during mining, crushing, beneficiation, and extraction process of iron ore. In recent years, there has been growing interest in the sustainable utilization of iron ore waste as part of India's commitment to resource conservation and environmentally responsible engineering practices. Both researchers and businesses are investigating new ways to use this waste, particularly in building. By using iron

ore waste to partially or fully substitute natural fine and coarse aggregates in concrete, the need for natural resources decreases, and an effective waste management solution is provided.

## II. Literature Review

Ugama et al.(1) conducted a study where iron ore waste was used as a partial substitute for aggregates in concrete blocks. The control mix was a conventional concrete mixture utilizing sand as the fine aggregate, while the other mixes incorporated a partial replacement of 20-100% of the fine aggregate with iron ore waste. Furthermore, their experimental results demonstrated that as the percentage of iron ore waste in the mixture increased, the concrete workability decreased. It was observed that when 20% of the aggregate in the concrete was replaced with iron ore tailings, the resulting concrete exhibited superior performance in both compressive and tensile strength compared to concretes with 0% iron ore replacement.

Alzaed (2) investigated how iron ore affect the compressive strength of concrete. The research detailed an experiment where varying amounts of iron ore were added to concrete mixtures, which were then cured for 28 days. The goal was to understand the influence of the iron filling concentration on both the compressive and tensile strengths of the concrete. The specific percentages of iron ore fillings tested were 0%, 10%, 20% and 30% of the mix. The findings showed a consistent increase in the concrete's compressive strength as more sand was replaced by iron fillings. Additionally, a slight effect on tensile strength was noted when the percentages exceeded 10%.

## III. Materials and Specimens

Ordinary Portland Cement (53 grade), Fine aggregates, Coarse aggregates, Iron ore waste, Superplasticizer, potable water were used in the experimental performance.

**Specimens:** In this study 13 concrete mixes were prepared: one nominal mix (mix 1, M30 grade concrete) and 12 modified mixes with Iron ore replacement as fine and coarse aggregates at varying proportions of 0%, 25%, 50%, 75% and 100%. For each mix, cubes (150 x 150 x 150mm) were casted to conduct compressive strength, and cylinders (150 x 300mm) were casted to conduct split tensile strength.

## IV. Methodology

This study involves initially gathering cement, fine aggregates, coarse aggregates, superplasticizer, and iron ore waste. Their fundamental properties are tested to confirm their suitability for concrete production. M30 grade concrete mixes are subsequently designed according to IS10262:2019 standards, incorporating iron ore waste as a replacement for both fine and coarse aggregates at varying percentages: 0%, 25%, 50%, 75% and 100%. Each mix is prepared using a mechanical mixer, and slump tests are carried out to evaluate workability. The fresh concrete is then cast into cubes and cylinders, demoulded after 24 hours and the specimens are cured in water for 7 days and 28 days. After curing, compressive and split tensile strength tests are performed as per IS 516:2018 to evaluate the mechanical performance of each mix. The results are compared to determine the effect of iron ore waste on the strength and workability of M30 grade concrete.

## V. Mix Design and Proportioning

Mix design as per IS10262:2019 standard details a structured approach for proportioning concrete components to achieve strength, workability and durability targets. The process begins by determining the target mean strength based on characteristic strength and standard deviation. A water-cement ratio is then selected based on both strength and durability considerations given in IS456:2000. Next, the water content and cement content are determined based on expected workability and aggregate characteristics. The proportions of fine and coarse aggregates are calculated using their specific gravities, grading, and volume method. Finally, trial mixes are conducted and adjustments are made to achieve required slump and strength. This method ensures that the final concrete mix is economical, workable, and meets the performance requirements for the selected grade. A total 13 mixes (Mix 1 - 13) were prepared. Mix 1 is the nominal mix (M30).

- Trail 1: Iron ore as Fine aggregate (0%, 25%, 50%, 75% and 100%) → Mix 2-5
- Trail 2: Iron ore as Coarse aggregate (0%, 25%, 50%, 75% and 100%) → Mix 6-9
- Trail 3: Iron ore as Fine & Coarse aggregate (0%, 25%, 50%, 75% and 100%) → Mix 10-13

## VI. Results and Discussion

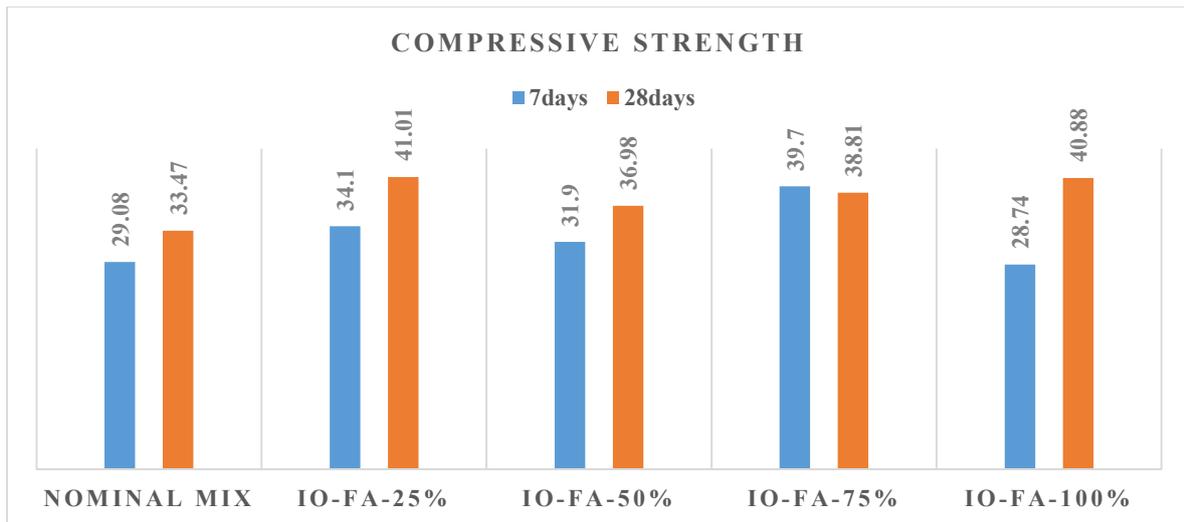
The Results of fresh properties of concrete such as slump are performed and hardened properties such as Compressive strength and split tensile strength are discussed below.

### Compressive strength

The Compressive strength test is performed to determine the load-carrying capacity of hardened concrete. The cube specimens are tested by using the compressive testing machine after specified curing period for different percentages of iron ore replacement Mix1(0%), Mix2(25%), Mix3(50%), Mix4(75%) and Mix5(100%) as fine and coarse aggregates. The compressive strengths after respective curing periods are noted in table 1,2 and 3.

**Table 1: Iron ore as Fine aggregate replacement**

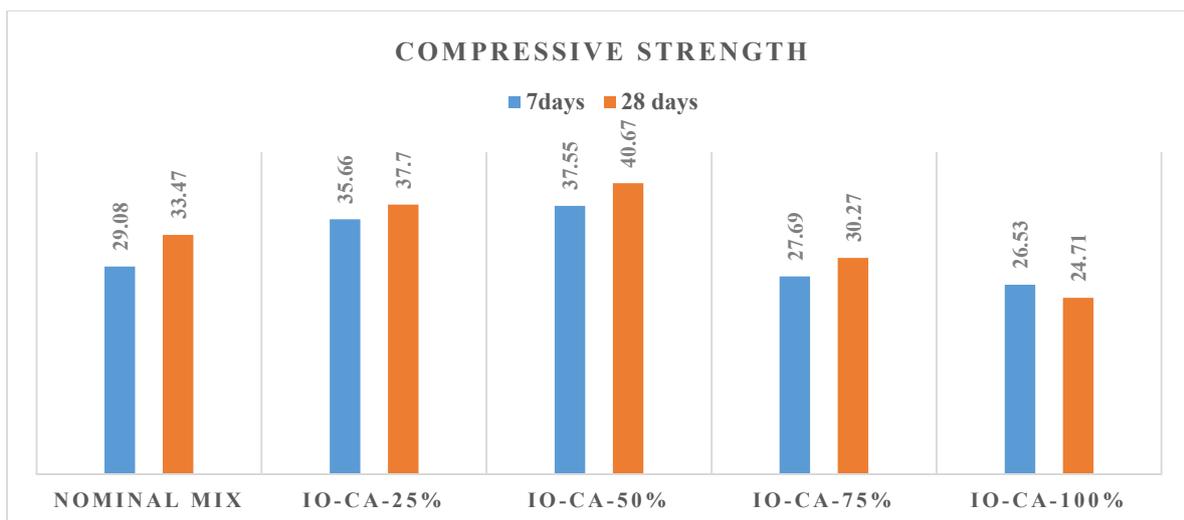
Mix	Compressive strength (N/mm <sup>2</sup> )	
	7 days	28 days
Nominal Mix	29.08	33.47
IO-FA-25%	34.1	41.01
IO-FA-50%	31.9	36.98
IO-FA-75%	39.7	38.81
IO-FA-100%	28.74	40.88



The Compressive strength of concrete increases with the partial replacement of fine aggregate by iron ore, with the highest 7-day strength observed at 75% replacement and the highest 28-day strength at 25% and 100% replacement.

**Table 2: Iron ore as coarse aggregate replacement**

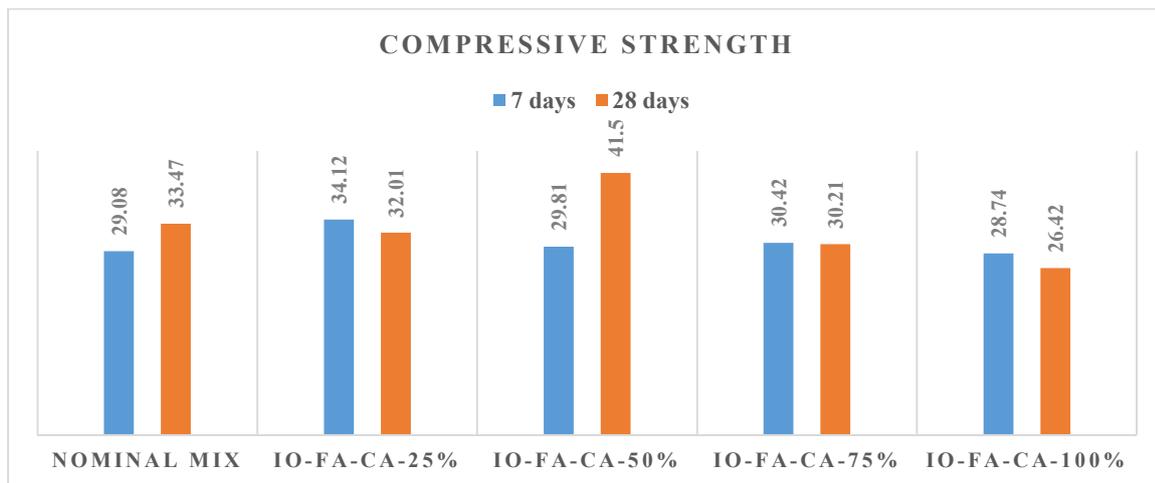
Mix	Compressive strength (N/mm <sup>2</sup> )	
	7 days	28 days
Nominal mix	29.08	33.47
IO-CA-25%	35.66	37.7
IO-CA-50%	37.55	40.67
IO-CA-75%	27.69	30.27
IO-CA-100%	26.53	24.71



The Compressive strength increases significantly at 25% and 50% iron ore replacement for coarse aggregates, with 50% giving the highest strength at both 7 and 28 days. However, strength decreases at higher replacement levels (75% and 100%), indicating that partial replacement up to 50% is optimal for improving concrete performance.

**Table 3: Iron ore as both fine and coarse aggregate replacement**

Mix	Compressive strength (N/mm <sup>2</sup> )	
	7 days	28 days
Nominal mix	29.08	33.47
IO-FA-CA-25%	34.12	32.01
IO-FA-CA-50%	29.81	41.50
IO-FA-CA-75%	30.42	30.21
IO-FA-CA-100%	28.74	26.42



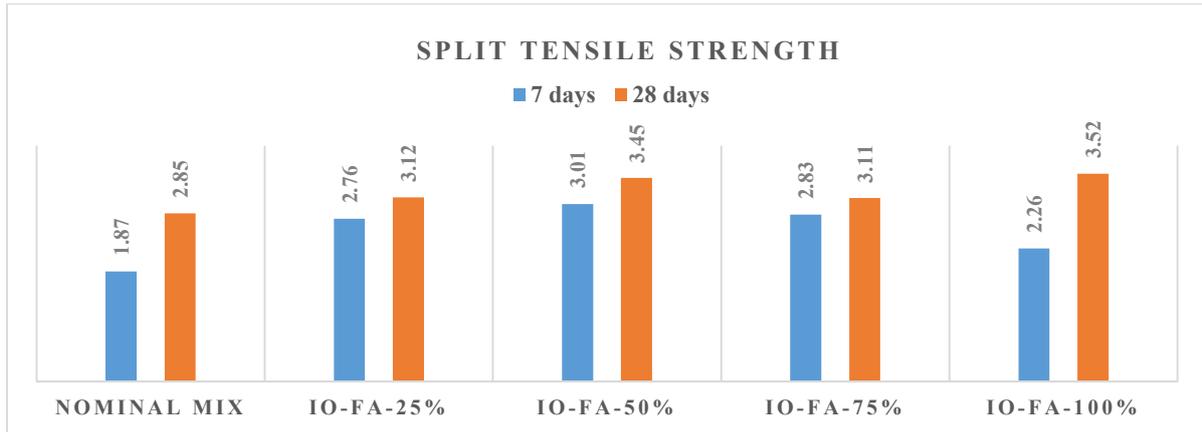
When the iron ore is used as both fine and coarse aggregate, the compressive strength improves noticeably at 25% and reaches its highest value at 50% replacement. Beyond 50%, the strength decreases, including that combined replacement of iron ore is most effective and optimal at the 50% level for enhancing concrete performance.

### Split Tensile strength

The Tensile strength is performed to determining bond strength between concrete members. The cylinder specimens are tested by using the compressive testing machine after specified curing period for different percentages of iron ore replacement Mix1(0%), Mix2(25%), Mix3(50%), Mix4(75%) and Mix5(100%) as fine and coarse aggregates. The Split tensile strengths after respective curing periods are noted in table 4,5 and 6.

**Table 4: Iron ore as Fine aggregate Replacement**

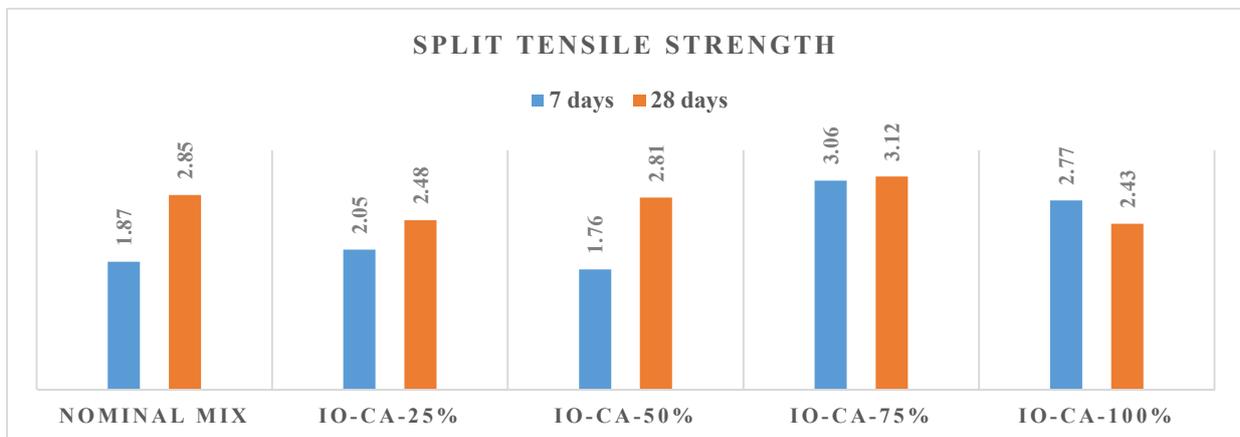
Mix	Split tensile strength (N/mm <sup>2</sup> )	
	7 days	28 days
Nominal mix	1.87	2.85
IO-FA-25%	2.76	3.12
IO-FA-50%	3.01	3.45
IO-FA-75%	2.83	3.11
IO-FA-100%	2.26	3.52



The maximum improvement is observed at 50% replacement, after which the strength remains comparable or slightly increases at 100%. Overall, iron ore proves to be an effective fine aggregate replacement for improving tensile performance.

**Table 5: Iron ore as coarse aggregate replacement**

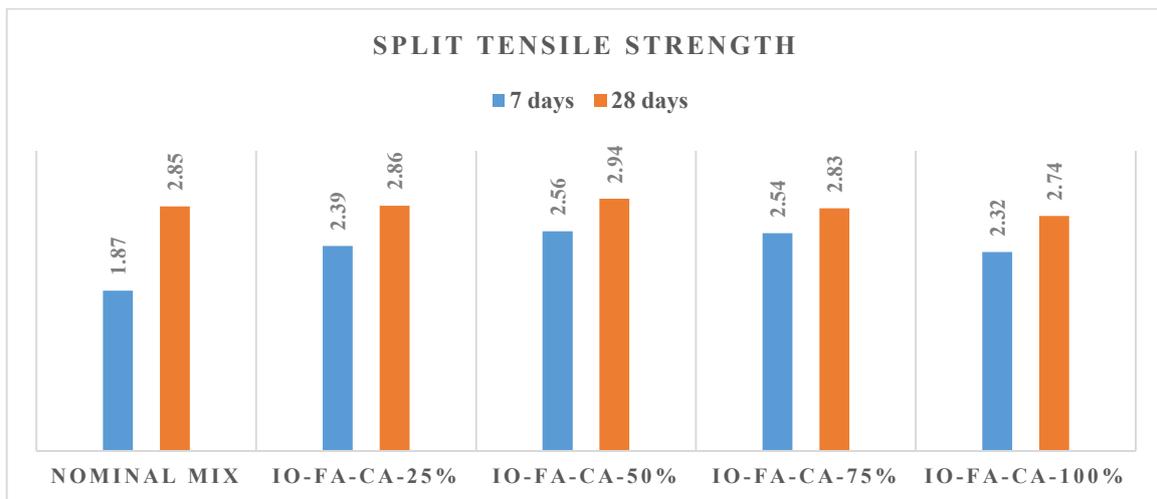
Mix	Split tensile strength (N/mm <sup>2</sup> )	
	7 days	28 days
Nominal mix	1.87	2.85
IO-CA-25%	2.05	2.48
IO-CA-50%	1.76	2.81
IO-CA-75%	3.06	3.12
IO-CA-100%	2.77	2.43



The split tensile strength generally improves with iron ore as aggregate, with the best performance at 75% replacement. Overall, iron ore enhances tensile strength compared to the nominal mix.

**Table 6: Iron ore as fine and coarse aggregate replacement**

Mix	Split tensile strength (N/mm <sup>2</sup> )	
	7 days	28 days
Nominal mix	1.87	2.85
IO-FA-CA-25%	2.39	2.86
IO-FA-CA-50%	2.56	2.94
IO-FA-CA-75%	2.54	2.83
IO-FA-CA-100%	2.32	2.74



The split tensile strength generally improves with iron ore as both fine and coarse aggregate, with the best performance at 50% replacement. Overall, iron ore enhances tensile strength compared to the nominal mix.

## VII. Conclusion

The following conclusions are made based on the above experimental work.

- Compressive strength improved for both fine aggregate and coarse aggregate replacements, with maximum strength generally at 50 – 75% replacement.
- Iron ore replacement as coarse aggregate mixes showed the highest 28-day strength at 50% replacement due to better interlocking of angular particles.
- Tensile strength increased up to 50-75% iron ore replacement, with combined fine and coarse aggregates mixes giving better results than the nominal mix.
- Overall, the best mechanical performance was achieved between 50-75% iron ore replacement, proving iron ore waste effectively enhances concrete strength and supports sustainable material use.

## VIII. References

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