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Performance Of M40 Grade Concrete With Partial Replacement Of Fine Aggregate By Steel Slag And Dolomite Aggregate

[1]P. Upendra Rao, [2]M. Sudha Rani, [3]P. Satyanarayana, [4]Y.O.S.S.N.Sunil Babu ,[5]Sri. R. Vaishnava Kumar
[1 2 3 4]Student, [5]Assistant Professor
[1]Department of Civil Engineering,
[1]R.V.R & J.C College of Engineering, Guntur, India

Abstract: Concrete is widely employed in the construction business these days and is essential to a building's structural elements. Concrete is a composite material composed of cement, water, and fine and coarse aggregate. Aggregate is a crucial component of these components in the creation of concrete. Natural sand is utilized as a fine aggregate in those aggregates. Due to the scarcity of sand, materials such as robo sand, steel slag, copper slag, clay aggregate, pumice aggregate, and quarry dust might be used in its place. Examining the manufacture of concrete utilizing steel slag and dolomite stone aggregate in place of fine aggregate is the main goal of this study. Using a number of experimental mixes with varying water binder ratios and super plasticizer contents, the current study examines the properties of hardened concrete of M40 grade concrete before achieving a good mix proportion. Steel slag aggregate and dolomite aggregate will replace the fine aggregate in the final mix's attained proportion by adjusting the fine aggregate percentage as 0%, 25%, 50%, 75%, and 100% by volume replacement. Nine different mixes of M40 grade concrete are made for this project. This includes four mixes of steel slag as fine aggregate with percentages of replacement to natural sand (0%, 25%, 50%, 75%, and 100%) and four mixes of dolomite aggregate and percentages of replacement to natural sand (0%, 25%, 50%, 75%, and 100%). The results of the slump cone and compaction factor tests are used to assess the workability of the concrete qualities. By determining the concrete's compressive strength, split tensile strength, and flexural strength, its attributes are ascertained. After the specimens have been cured for seven and twenty-eight days, non-destructive tests include ultrasonic pulse velocity and rebound hammer tests. Results show that replacing steel slag in concrete up to 50% results in fair results for split tensile, compressive strength, and flexural strength; replacing steel slag in concrete up to 25% results in fair results for split tensile, compressive strength, and flexural strength; and that values vary slightly as the proportion of steel slag and dolomite aggregate in the mix increases; above 25% of dolomite aggregate replacement in concrete results in split tensile and compressive strength that are somewhat decreased and fall within a significant range. Test results indicate that adding steel slag and dolomite aggregate to concrete strength blends clearly improves hardened properties.

Index Terms – Dolomite Aggregate, Steel slag, Compressive Strength, Split Tensile Strength, Flexural Strength.

I. Introduction

The population of India is growing quickly. The need for buildings is always rising as a result of the population growth. A composite building material, concrete is made up of cement, water, coarse and fine aggregates, and occasionally admixtures. Its great compressive strength, resilience, and adaptability make it a popular choice for construction. After 28 days of curing, concrete with a characteristic compressive strength of 40 MPa is referred to as M40 grade concrete. For structural elements that need to support a lot of weight, this high-strength concrete is utilized. Concrete technology has advanced as a result of the growing demand for building materials, with an emphasis on resource efficiency and sustainability. The use of substitute materials as partial substitutes in concrete mix design is becoming more popular among other tactics. This study investigates the mechanical characteristics, longevity, and general appropriateness of M40 grade concrete for structural purposes by partially substituting steel slag and dolomite aggregate for fine aggregate. High-strength concrete, known as M40 grade, is frequently utilized in large-scale infrastructure projects where compressive strength and longevity are essential. The main fine aggregate in concrete mixtures has historically been natural river sand, but excessive sand mining has prompted environmental concerns and necessitated the use of substitute materials. Because of their availability, mechanical strength, and capacity to improve the qualities of concrete, steel slag and dolomite are two viable substitutes.

Emphasize the harm that excessive mining of natural sand does to the ecosystem and the significance of locating sustainable substitutes for fine aggregates. This establishes a foundation for investigating materials that can aid in managing industrial waste and protecting natural resources, such as steel slag and dolomite aggregate. Slag made of steel: Steel slag, a by-product of the steelmaking process, is dense and has good binding properties. Due to its many performance-related, financial, and environmental advantages, this method is becoming more and more common in sustainable building. This is a thorough examination of the application and necessity of replacing steel slag in concrete. Globally, one of the biggest producers of CO2 emissions is the cement industry. Steel slag, which generally has a lower carbon footprint than traditional cement, can be used to replace some of the cement, lowering the total greenhouse gas emissions related to the manufacture of concrete. It is frequently less expensive to purchase steel slag than conventional cement. Especially in places where steel slag is easily accessible, adding it to concrete can lower the total cost of producing concrete. Steel slag can improve concrete's tensile and compressive strengths, among other mechanical characteristics. Early strength development can be enhanced, and in certain situations, long-term strength can also be increased.

Concrete can become more workable and easier to mix and pour when steel slag is added, particularly if it takes the place of fine particles or a portion of the binder. Depending on where it comes from and how steel is made, steel slag can have different qualities. Appropriate testing and quality control are required because this may result in inconsistent concrete performance. Aggregate Dolomite: Dolomite rock, a sedimentary carbonate mineral mainly made up of calcium magnesium carbonate ($CaMg(CO_3)_2$), is the source of dolomite aggregate. Because of its strength, resilience, and chemical stability, this natural material is frequently utilized in building. Dolomite aggregates help concrete last longer in sulphate-rich settings, as those found in wastewater treatment facilities or marine constructions. Dolomite's calcium and magnesium content helps lessen concrete's susceptibility to sulphate assaults, which can result in expansion, cracking, and weakening. In general, dolomite aggregates absorb less water than some other aggregates, such as limestone. This lessens the porosity of concrete, increasing its overall longevity and resistance to freeze-thaw cycles. Because of their specific gravity and hardness, dolomite aggregates can help concrete have a higher compressive strength. Dolomite particles' high density and robust bonding qualities can strengthen concrete's structural integrity and qualify it for load-bearing applications. In regions where dolomite is plentiful, dolomite aggregates are frequently less costly than some other premium aggregates. Dolomite can save building costs by partially replacing conventional aggregates, particularly in large-scale infrastructure projects. Because dolomite is occasionally a by-product of mining activities, using it as an aggregate can help reduce waste. The construction sector supports circular economy principles by reusing dolomite in concrete rather than disposing of it in landfills. Compared to some other aggregate materials, such shale or limestone, dolomite aggregates could be more heat resistant. In high-temperature settings or when thermal expansion and contraction must be kept to a minimum, this can enhance concrete's performance.

II.MATERIALS

Cement is of IS 10262:2009 Confirmed 40 grade of OPC as per IS Zone III fine aggregate of natural sand having specific gravity 2.55 similarly IS 383:2016 confirmed 40mm, 20mm and 10mm size stone aggregate. To make concrete, you'll need four basic ingredients: cement, sand, aggregate, water and additional mix, Steel slag, Dolomite aggregate.

2.1 Physical properties of Dolomite aggregate:

Colour	Colourless, white, pink, green, brown. Black
Streak	White
Luster	Vitreous, pearly
Cleavage	Perfect, three directional
Mohr's hardness	3.5 to 4
Crystal system	Hexagonal
Tenacity	brittle

2.EXPERIMENTAL PROGRAM

The Description of proportion of mixed design

Table 1 Mix proportions

SI.NO	%Dolomite	Cement	Fine Aggregate	Fly Ash	Coarse Aggregate	Water	Dolomite		Super Plasticizer
1	20	420.78	716.69	92.36	799.25	125	169.3		4.2

By using the above mixed proportion concrete mixes were prepared concrete cubes of size 100mm x 100mm x 100mm, concrete cylinder of size 100mm x 200mm and concrete beams of size 500mm x 100mm x 100mm were casted. these casted specimens were placed in the curing tank. After de-molding until the day of testing. For testing this specimen UTM is used to get compressive flexural split tensile strengths. After 7 days and 28 days of age compression tests were conducted to specimens and similarly flexural strength test and split tension test were performed to specimen at age of 28 days.

3.RESULT & DISCUSSION

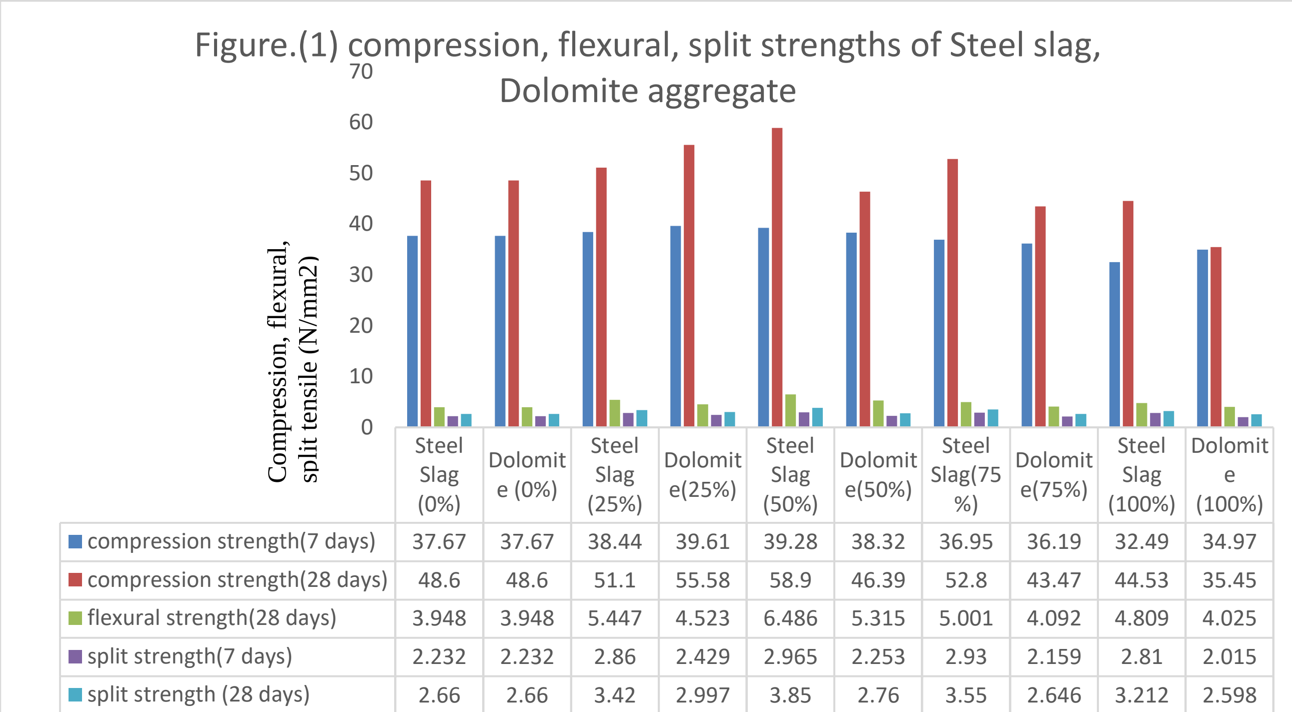
In this research Steel slag and Dolomite aggregate is used as a partial replacement material to Portland cement. The designations given for compression, tension, and flexural strength .

Table 2 provides the ratios of (compression, flexural, split tension) strength of concrete with Steel slag, Dolomite aggregate and corresponding strength of concrete.

Table.2

Percentage (%)		Compressive strength		Flexural strength	Split tensile strength	
		7days	28days	28days	7days	28days
0%	Steel Slag	37.67	48.60	3.948	2.232	2.66
	Dolomite Aggregate	37.67	48.60	3.948	2.232	2.66
25%	Steel Slag	38.44	51.1	5.447	2.86	3.42
	Dolomite Aggregate	39.61	55.58	4.523	2.429	2.997
50%	Steel Slag	39.28	58.9	6.486	2.965	3.85
	Dolomite Aggregate	38.32	46.39	5.315	2.253	2.760
75%	Steel Slag	36.95	52.8	5.001	2.93	3.55
	Dolomite Aggregate	36.19	43.47	4.092	2.159	2.646

100%	Steel Slag	32.49	44.53	4.809	2.81	3.212
	Dolomite Aggregate	34.97	35.45	4.025	2.015	2.598



Rebound hammer test:

Percentage		**UPV(m/sec) 28days**	**Quality grading**	**Rebound hammer**
0%	Steel slag	5464	Excellent	32,40,42
	Dolomite			
25%	Steel slag	5376	Excellent	32,38,42
	Dolomite	5155	Excellent	28,32,26
50%	Steel slag	5182	Excellent	34,44,40
	Dolomite	5128	Excellent	38,42,38
75%	Steel slag	5128	Excellent	30,32,38
	Dolomite	5181	Excellent	34,30,36
100%	Steel slag	5291	Excellent	28,26,32,
	Dolomite	5102	Excellent	46,40,42

Table.3 Rebound hammer test result

As shown in FIG.1

FIG.1 – REBOUND HAMMER

UPV (ultrasonic pulse velocity):

An ultrasonic pulse velocity (UPV) test is an in-situ, non-destructive test to check the quality of concrete and natural rocks. In this test, the strength and quality of concrete or rock is assessed by measuring the velocity of an ultrasonic pulse passing through a concrete structure or natural formation as shown in FIG.2

Table.4 UPV (ultrasonic pulse velocity)

Pulse Velocity (Km/second)	Concrete Quality (Grading)
Above 4.5	Excellent
3.5 to 4.5	Good
3.0 to 3.5	Medium
Below 3.0	Doubtful

FIG.2 - ULTRASONIC PULSE VELOCITY

4.1 Compressive Strength

On analyzing the above test results, it is observed that at 28 days of curing age of the specimens the compressive strength of concrete with 25% replacement of dolomite aggregate is increase the strength and 50% replacement of steel slag have more strength than that of the control mix (0%). Therefore, it is possible that 25% cement can be saved without affecting the strength of the mix for Dolomite and 50% for steel slag. At 7 days of curing age of the specimens the compressive strength of concrete with 25%replacement of sand with Dolomite aggregate (20) and 50% replacement of sand with steel slag(50) is more strength as compared to other mix proportion as shown FIG.3

FIG.3 – COMPRESSION STRENGTH

4.2Flexural Strength

On analyzing the above test results it is observed that at 28 days of curing age of the specimens the flexural strength of concrete with 50% replacement of sand with Dolomite aggregate (50%) and 25% replacement of sand wit Steel slag (25) having high strength compared to other ratio FIG.4

FIG.4 FLEXURAL STRENGTH

4.2Tensile Strength

From the test results it is observed that at 28 days of curing age of the specimens the tensile strength of alkali-activated concrete with 25% replacement of sand with Dolomite aggregate (25) increased as compared to other sand replacement ratio's like 0,50,75,100% , with 50% replacement of sand with steel slag(50) is increased as compare other proportions. In 7days of curing age of the specimens the compressive strength of the concrete with 25% of sand replacement with Dolomite aggregate and 50% of sand replacement with steel slag have more strength as compare to other ratio as shown FIG.5

FIG.5 – TENSILE STRENGTH

CONCLUSION

By using industrial waste as aggregate in concrete, disposal risks and future accumulations of garbage can be reduced or eliminated. Along with lowering disposal costs, this sustainable technique will address the environmental issue brought on by the disposal of this garbage. Therefore, the goal of this study was to produce concrete by using part of the reactive and nonreactive industrial wastes as fine aggregate. The following conclusions are reached in light of the experimental findings:

the concrete with the use of River sand and dolomite aggregate is found to be economical and environment friendly.

- Workability of the concrete is decreasing with increase in steel slag content in slump cone test and compaction factor test. But the slump value indicates the true slump.
- Workability of the concrete is slightly decreasing with increase in dolomite aggregate content in slump cone test and compaction factor test. But the slump value indicates the shear slump.
- Cube crushing strength increases as steel slag aggregate increases up to 50% and then decreases. Compressive strength increases as dolomite aggregate increases up to 25% and then decreases. The % of improvement in compressive strength is 21.19 % by replace with steel slag or dolomite aggregate respectively.
- Split tensile strength increases as steel slag aggregate increases up to 50% and then decreases. Split tensile strength increases as dolomite aggregate increases up to 25% and then decreases. The % of improvement in split tensile strength is 44.7 % by replace with steel slag or dolomite aggregate respectively.
- Flexural strength increases as steel slag aggregate increases up to 50% and then decreases. flexural strength increases as dolomite aggregate increases up to 25% and then decreases. The % of improvement in flexural strength is 64.46 % by replace with steel slag or dolomite aggregate respectively.
- In the ultrasonic pulse velocity test results indicate the better performance in quality of concrete is "Excellent

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