Effect of Limestone Aggregate on High Strength Concrete in Both Fresh and Hardened States

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Abstract

Limestone is mainly constituent of chemical compound calcium carbonate ($CaCo_3$). It is basically called sedimentary rock substance. As per researchers it forms 10% of total volume of Sedimentary rock. The extrusion & Implementation of limestone in any form deals with ease of work and as a less pollutant for Environment, hence it can be massively used and utilized as a replacement to coarse aggregate in construction. This study deals with introduction of usage of local available limestone aggregates in concrete mix as a replacement for using normal coarse aggregates. In this research article Effect of limestone aggregate on Fresh and Hardened properties of high strength concrete were discussed, Substitution of the Local Available and Naturally occurring limestone aggregates as a Partial replacement for normal coarse aggregate material made for M50 grade. Adopting a suitable W/C ratio, Number of Specimens was casted and tested for different ages. The tests were conducted on casted specimens and results were discussed in detail in the discussion part of the article. From the test results, it clearly shows that usage of limestone aggregates in concrete will lie in range between 50% - 75 % replacements for M50. On further addition of Limestone aggregates in concrete it leads to decrease in strength properties and swelling is observed cause of repulsive charges of aggregates.

Keywords- limestone aggregate concrete, partial replacement for M50 grade and Fresh and Hardened properties

I. INTRODUCTION

This Research article deals with introduction to usage of local available limestone aggregate in concrete mix design as a replacement to normal coarse aggregates in concrete mixes. In order to overcome the rate of demand or shortage of the locally available natural coarse aggregates, Substitution of using naturally occurring limestone aggregates in concrete, as an 0%, 25%,50%,75%,100% substitution for normal coarse aggregate material is done. Before the replacement of limestone aggregates, it is recommended to understand the physical, chemical & biological characteristics of these limestone property. various tests have been conducted over these physical tests on limestone aggregates like specific gravity, flakiness Index, elongation index test ,crushing strength test, impact tests on coarse aggregates, water absorption tests, while these experimental results gives the appreciable values which are almost accepted by IS-Code provisions. Limestone is mainly constituent of chemical compound calcium carbonate ($CaCo_3$). It is basically called sedimentary rock substance. As per researchers it forms 10% of total volume of Sedimentary rock. It is quite most available and cheaper material and readily can be used as alternate replacement of coarse aggregate. When limestone is pulverized and mixed with water it acts a good Binding material and can be used to construct walls and columns. In early clay and lime is used to produce bricks which poses a good engineering properties for construction. Where lime-surki mixed with jiggery in a specific proportion it will be tough & of very less pervious and can be used for massive water retaining structures. The physical properties and Chemical composition can be illustrated in the following Tables:

Table 1: physical properties of limestone aggregates

Serial no.	*Property type*	*Characteristic property*
1	*Hardness*	*2.9 to 3.9 on Moh's Scale*
2	*Porosity*	*Quite low*
3	*Water Absorption*	*Less than 2%*
4	*Weather Impact*	*Resistant*
5	*Compressive Strength*	*60-170 N/mm^2*
6	*Density*	*1500 to 2600 Kg/m^3*

Table 2: composition of limestone

Serial no.	*Component*	*Chemical formula*	*Percentage%*
1	*Calcium oxide*	*Cao*	*5.1-5.2*

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2	*Potassium oxide*	*K_2o*	*4.3-4.4*
3	*Magnesium oxide*	*Mgo*	*2.3-2.4*
4	*Phosphorous pent oxide*	*P_2o_5*	*0.4-0.5*
5	*Silicon dioxide*	*Sio_2*	*60-60.7*
6	*Aluminum oxide*	*Al_2o_3*	*14.7-14.8*
7	*Titanium dioxide*	*Tio_2*	*0.8-0.9*
8	*Strontium oxide/strontium*	*Sro*	*0.05-0.1*
9	*Sodium oxide*	*Na_2o*	*4.75-4.8*
10	*Ferric oxide*	*Fe_2o_3*	*6.3-6.4*
11	*Zirconium oxide*	*Zro_2*	*0.05-0.1*

II. EXPERIMENTAL WORKS ON INGREDIENT MATERIALS

Table 3: Physical properties of Cement

Sl. No	*Property*	*Results*	*Tolerance limits as per IS-8112-1989*
1	*Specific gravity*	*3.0116*	*3.15*
2	*Finess*	*2.5%*	*Not more than 10%*
3	*Normal consistency*	*30%*	*Not more than 35%*
4	*Setting time Intial*	*25 min*	*Should not be lesser than 30 min*
5	*Setting time Final*	*300 min*	*Should not be lesser than 600 min*

Table 4: sieve analysis of fine aggregates

Sl. no	*Sieve size mm*	*Weight of Aggregates retained in gm*	*% By weight of aggregate retained*	*Cumulative % of weight Retained*	*% Finer*	*% for Zone-2 as per IS:383-1970*
1	*4.75*	*90*	*9*	*9*	*91*	*90-100*
2	*2.36*	*134*	*13.4*	*22.4*	*77.6*	*75-100*
3	*1.18*	*193*	*19.3*	*41.7*	*58.3*	*55-90*
4	*0.6*	*180*	*18*	*59.7*	*40.3*	*35-59*
5	*0.3*	*250*	*25*	*84.7*	*15.3*	*8-30*
6	*0.150*	*104*	*10.4*	*95.1*	*4.9*	*0-10*
7	*Pan*	*49*	*4.9*	*100*	-	-
	Total=	*1000*			*287.4*	
Fineness Modulus=287.4/100 = 2.874						

Table 5: physical Properties of fine aggregate

Sl. no	*Property*	*Results*
1	*Specific gravity*	*2.763*
2	*Water absorption*	*2%*
3	*Fineness Modulus*	*2.874*

Table 6: sieve analysis of coarse aggregates

Sl. no	*Sieve size mm*	*Weight of Aggregates retained*	*% By weight of aggregate retained*	*Cumulative % of weight Retained*	*% Finer*
1	*25*	*0*	*0*	*0*	*100*
2	*20*	*1490*	*29.8*	*29.8*	*70.2*
3	*16*	*1090*	*21.8*	*51.6*	*48.4*
4	*12.5*	*870*	*17.4*	*69*	*31*
5	*10*	*650*	*13*	*82*	*18*
6	*8*	*520*	*10.4*	*92.4*	*7.6*
7	*6.3*	*250*	*5*	*97.4*	*2.6*
8	*4.75*	*120*	*2.4*	*99.8*	*0.2*
9	*Pan*	*10*	*0.2*	*100*	*0*
				Total=622	
Fineness Modulus=622/100 = 6.22					

Table 7: physical properties of Coarse aggregate

Sl. No	*Property*	*Results*
1	*Specific gravity*	*2.811*
2	*Bulk density*	*2200*
3	*Water absorption*	*2%*
4	*Fineness modulus*	*6.22*

Table 8: sieve analysis of limestone aggregates

Sl. no	*Sieve size mm*	*Weight of Aggregates retained*	*% By weight of aggregate retained*	*Cumulative % of weight Retained*	*% Finer*
1	*25*	*0*	*0*	*0*	*100*
2	*20*	*1725*	*34.5*	*29.8*	*70.2*
3	*16*	*933*	*18.66*	*53.16*	*46.84*
4	*12.5*	*857*	*17.14*	*70.3*	*29.7*
5	*10*	*497*	*9.94*	*80.24*	*19.76*

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6	*8*	*452*	*9.04*	*89.28*	*10.72*
7	*6.3*	*307*	*6.14*	*95.42*	*4.58*
8	*4.75*	*161*	*3.22*	*98.64*	*1.36*
9	*Pan*	*68*	*1.36*	*100*	*0*
				Total=622	
Fineness Modulus=616.84/100 = 6.1684					

Table 9: physical properties of limestone

Sl. No	*Property*	*Results*	*Tolerance limits*
1	*Specific gravity*	*2.798*	*As per IS-2386 lies in between 2.58-2.80*
2	*Bulk Density*	*1800 kg/m3*	*In Range of 1600-2400 kg/m3*
3	*Water absorption*	*2%*	
4	*Fineness*	*6.1684*	*As per IS: 2386(part-1) lies in range of (6-7) for 20 mm Aggregate size*
5	*Impact strength*	*16.15%*	*Should Not more than 30% For concrete works*
6	*Crushing strength*	*20.57%*	*Should Not more than 30% For concrete works*

III. TEST RESULTS FOR FRESH PROPERTIES

The main Intension of Finding Fresh properties are to get the measurement of workability. Workability can be defined as ease with which concrete can be placed without much amount of Segregation. Important component of workability is termed as "Consistency". In common words it can be defined as, how wetter the mix results more workable is concrete. In fact if the mix is too wet then it results in more segregation and Bleeding. On the other side, if mix is too dry then it is Difficult to place and compact the concrete. For this research related the workability by finding: 1.The slump test.2.Vee-Bee Consist meter and 3.Compaction Factor test

Table 10: Results for Fresh properties of Concrete

Sl. no	*Type of grade*	*Type of cement*	*% of Replacement*	*W/C ratio*	*Slump in mm*	*Vee-Bee degree in seconds*	*Compaction factor*
1	*M50*	*43- Grade Ordinary port land cement*	*0%*	*0.33*	*6*	*27*	*0.9*
2			*25%*	*0.33*	*10*	*25*	*0.915*
3			*50%*	*0.33*	*12*	*24*	*0.93*
4			*75%*	*0.33*	*16*	*23*	*0.94*
5			*100%*	*0.33*	*20*	*22*	*0.95*

A. Comments on Fresh Properties of Concrete

- Since manual Mix is done for all trials, the concrete has shown High workable in M50 grade.
- For M50 grade workability has shown slight improvement due to addition of Super plasticizers and its values were tabulated above.
- Coming to Vee-Bee consist meter test, the concrete Fallibility under vibration is determined in Vee-Bee degrees.
- The compaction factor determines the compaction ability of concrete under a standard height of fall as per BIS. This test as shown Medium workable for M50 grade concrete and values are shown above.

IV. TEST RESULTS FOR HARDENED PROPERTIES

The Behavior of Hardened concrete is important and unique property for all mix-proportions. Determining those index properties will help in predicting its behavior, when used with RCC. For any mix to satisfy Indian standard provisions it has to go through some specific tests by BIS. Some of tests performed are:

1. Compression strength 2.Split tensile strength 3.Flexural Strength

Table 11: Test results of compressive strength for 7, 14 and 28 days

Sl. No	*% Replacements*	*Compressive Strength*		
		M50 grade		
		7 Days	*14 Days*	*28 Days*
1	*0%*	*42.59*	*45.40*	*51.02*
2	*25%*	*42.014*	*46.29*	*54.86*
3	*50%*	*47.55*	*50.34*	*55.93*
4	*75%*	*46.04*	*48.96*	*54.81*
5	*100%*	*CUBES SWELLED*		

A. 100% Replacement Observation of M50 grade

- All 100% Replacement cubes of M50 grade undergone excessive swelling, when subjected to curing within 24 hrs.
- Due to excessive heat of hydration and swelling sides of moulds disintegrated apart causing moulds to detach.
- Reason may be due to rapid reaction of lime towards cement in presence of water at hydration process.

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- As the cement content in M50 grade is more, Presence of lime content is also more and when this lime and limestone together contributed to excess heat of hydration and shrinkage has led to disintegration of moulds.
- Photo showing the disintegrated section is given below. One can easily understand and observe the bulging and detaching of sides prior to the loading.

Fig. 1: Swelling of cubes for 100% Replacement of limestone aggregate

Table 12: Test results of split tensile strength for 7, 14 and 28 days

Sl. no	*% Replacements*	*Split tensile Strength*		
		M50 grade		
		7 Days	*14 Days*	*28 Days*
1	*0%*	*3.27*	*3.36*	*3.40*
2	*25%*	*3.31*	*3.40*	*3.44*
3	*50%*	*3.22*	*3.26*	*3.34*
4	*75%*	*3.34*	*3.41*	*3.44*
5	*100%*	*3.10*	*3.31*	*3.40*

Table 13: Test results of Flexural strength for 7, 14 and 28 days

Sl. No	*% Replacements*	*Flexural Strength*	*Flexural Strength*
		M25 grade	*M50 grade*
		28 Days	*28 Days*
1	*0%*	*4.24*	*4.4*
2	*25%*	*4.13*	*4.35*
3	*50%*	*3.95*	*4.26*
4	*75%*	*3.79*	*4.14*
5	*100%*	*3.53*	*4.10*

V. RESULTS AND DISCUSSION

The testing of all the Cubes, Cylinders and Prism were done in Adhichunchanagiri Institute of Technology of Civil Engineering Department Chikmagaluru. Here, an attempt has made to find the Compressive strength of cubes, Split tensile strength of Cylinders and Flexural strength of Prism at the rate of 0%, 25%, 50%, 75% and 100% Replacement of Limestone as coarse aggregate. With relevant percentage of limestone aggregates for M50 grade at the days of 7, 14, and 28 for cubes, Cylinders and Prism with Loadings are shown in graphs.

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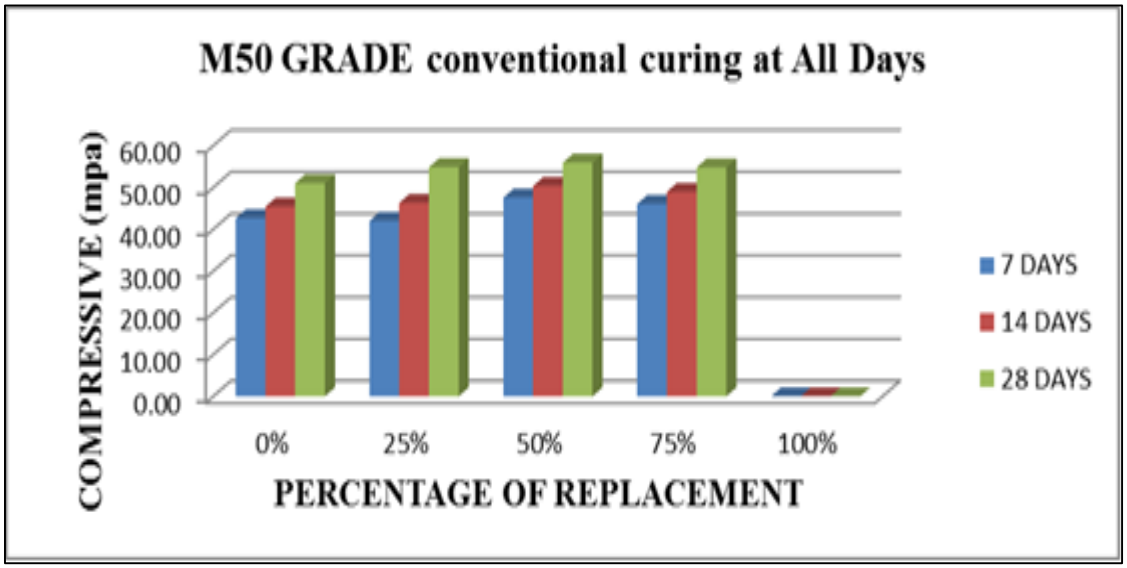

Fig. 2: compressive strength of M50 grade of all % of Limestone concrete at for different curing period.

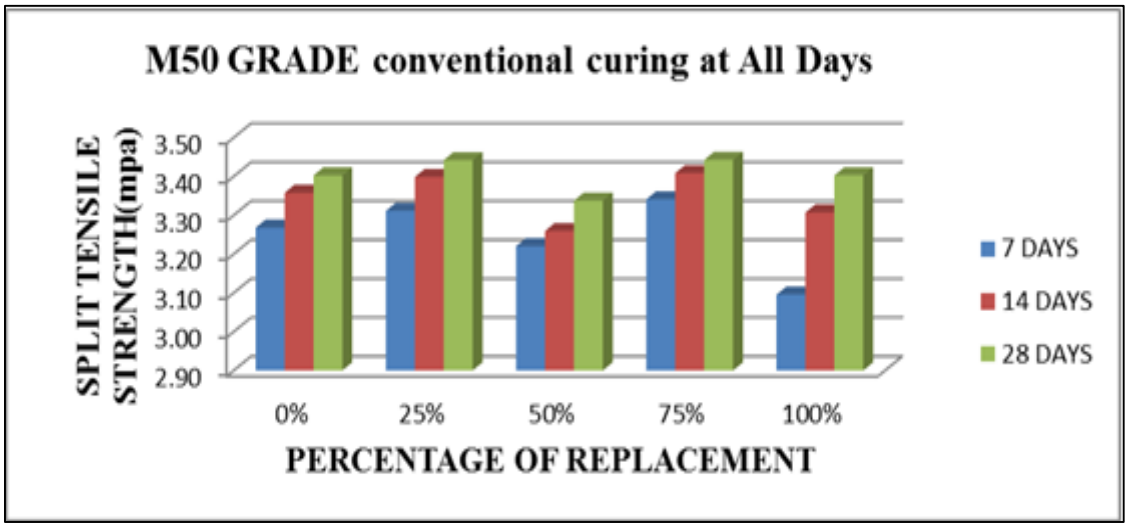

Fig. 3: Split tensile strength of M50 grade of all % of Limestone concrete at for different curing period.

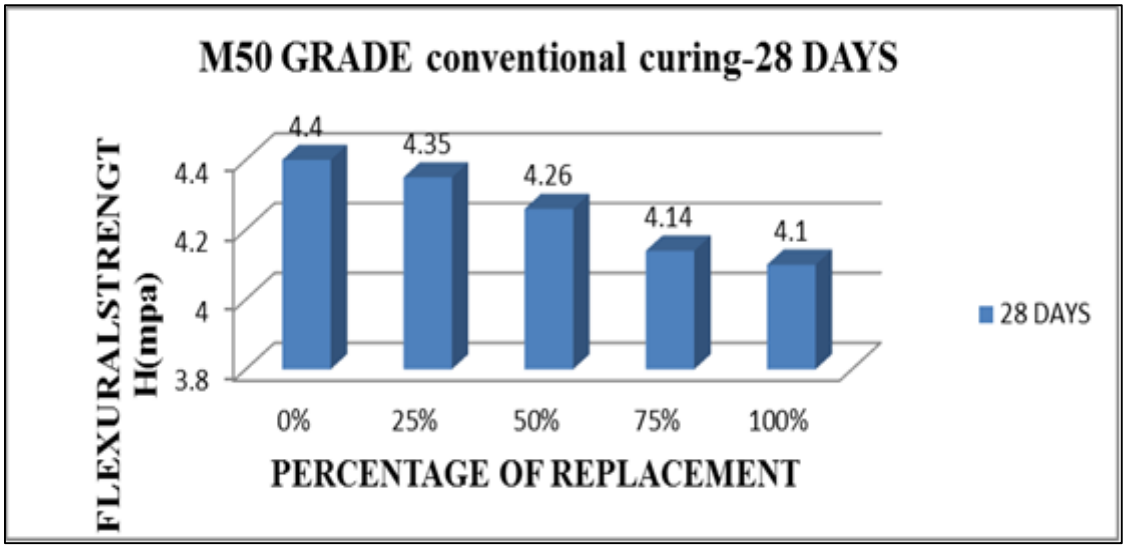

Fig. 4: Flexural strength of M50 grade of all % of Limestone concrete at for different curing period.

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VI. SUMMARY AND CONCLUSION

Limestone used in M50 grade with optimum SP of 2% and Metakaoline with 10% Replacement to cement shown good results rather than transitional failure, aggregate failure is observed.

1) Compressive strength yielded good strength for limestone replacement of 50 % - 75%. Due to excess heat of hydration 100% replacement cannot be obtained, prior resulted in swelling and Bursting of Cube specimens.
2) Split tensile strength also yielded good results, limestone can be replaced by 25% - 75% range can be taken.
3) In Flexural strength as percentage of replacement increases flexural strength decreases. This may be due to repulsive force between aggregates and low resistant to abrasion. It must be restricted to 25% replacement for coarser aggregate.

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