A STUDY ON MECHANICAL PROPERTIES OFCONCRETE WITH CONCRETE GRADE VARIATION IN TENSION AND COMPRESSION ZONES

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ABSTRACT

In a normal beam (simply supported) two zones generally arises, compression zone at top of the member and tension zone at bottom of the member.A beam is a flexural member which provides support to the slab and vertical walls and is subjected to bending. As concrete is weak in tension, steel is introduced in the tension zone to take the tension. But as strength of concrete is ignored in tension zone with respect to compression zone andhence, logically no concrete is required in tension side. But this concrete needs to be provided on tension side to act as strain transferring media to steel. So the concrete having no other role other than strain transferring why do we provide the same grade of concrete below neutral axis? So, with the idea of concrete grade reductioning in tension zone for RCC beams we can reduce construction cost without sacrificing the strength and serviceability.

Keywords- Neutral axis, Tension zone, Compression zone, Mechanical properties.

I.INTRODUCTION

A partial beam is a normal beam cast with two grades concrete, one above and other below the neutral axis. Partial beam is a beautiful result of the application of engineering in building construction works to achieve economy as well as reduction in the environmental impact due to construction works. The role of concrete below the neutral axis is of new use. So, in order to reduce the cost and effective usage of materials, the concrete below the neutral axis is filled with light or low grade concrete.Neutral axis is a line or a plane through a beam or plate connecting points at which no extension or compression occurs when it is bent.When a rectangular beam is supported at both ends and loaded transversely the upper fibers are compressed and the lower extended, the stresses being the greatest in the outer fibers, and proportionally less towards the middle of the depth, until a layer is reached where they both vanish.This research is aimed at studying the mechanical properties ofconcrete having different grades of concrete above and below neutral axis.

ADVANTAGES OF PARTIAL BEAM:

1. Reduction in usage of cement
2. Saving of materials and hence economical
3. Eco friendlier
4. Attainment of strength without compromising the serviceability.
5. Reduction in overall cost of construction (by nearly 10 %) and hence economical.
6. Reduction in impact on environment (by decreasing the emission of CO_2 produced during cement production).

II. RESEARCH SIGNIFICANCE

One of the major concerns in construction industries is to enhance the structural properties of concrete. Many researchers clearly demonstrated the development of structural properties of cement concretehaving grade variations in Tension and Compression zones. Since the concrete below neutral axis is of no use logically a study is made in using low grade concrete in tension zone. It reduces the consumption of cement.And also lowers the construction cost without compromising in strength aspect.This research is aimed to determine whether lowering the concrete grade below neutral axis leads to significant strength reductioning than control concrete. The Compressive strength, Splittensile strength, Flexural strength of the concrete specimen are studied and the results are compared to control mix. From the Compressive strength, Split tensile strength and Flexural strength, we get to understand the overall performance of concrete.

III.EXPERIMENTAL PROGRAM

i)Materials:

Cement:- Ordinary Portland cement of 53 grade was used in this experimental investigation.The specific gravity of cement is found to be 3.15

Table 1: Compounds in cement

Compound	Formula	
Tricalcium aluminate	$Ca_3Al_2O_6$	(C_3A)
Tetracalcium alumina ferrite	$Ca_4Al_2Fe_2O_{10}$	(C_4AF)
Belite or dicalcium silicate	Ca_2SiO_5	(C_2S)
Alite or tricalcium silicate	Ca_3SiO_4	(C_3S)
Sodium oxide	Na_2O	(N)
Potassium oxide	K_2O	(K)
Gypsum	$CaSO_4.2H_2O$	(CSH_2)

Fine Aggregates:- River sand passing through 4.75mm and conforming to zone II is used. Specific gravity of fine aggregates is 2.56 and its fineness modulus is 2.6

Coarse Aggregates:- Crushed broken stone angular in shape was used as coarse aggregates. The size of Coarse aggregates used is 20mm having specific gravity of 2.74 and fineness modulus is 3.92

Water:-Clean, potable free from suspended particles and chemical substance was used for both mixing and curing of concrete.

ii)Mix design: In present study M15, M20, M25, M30 and M40 grade concrete was designed as per IS: 10262-2009. The mix proportions arrived are given in Table 2 below.

Table2: Mix proportions arrived.

Mix	Water	Cement	FA	CA
M15	0.57	1	2.04	3.73
M20	0.55	1	1.85	3.7
M25	0.5	1	1.75	3.21
M30	0.45	1	1.55	2.84
M40	0.4	1	1.27	2.54

The specimen casted and its sizes are given below in Table3**.**

Table 3: Size of specimens

Specimen Type	Size(mm)
Cube	150x150x150
Cylinder	150x300
Prism	100x100x500

Fig 1. Casted specimens

Concrete specimens with reference mix of grade M25, M30 and M40 are casted. The same set of specimens were castedwith low grade concrete below the neutral axis. Concrete specimens with M25 and M30 grade are replaced with M15 grade below the neutral axis. Similarly, concrete specimens with M40 grade of concrete is replaced with M20 grade below the neutral axis. Three specimens were casted and the average results were taken for compressive strength, Split tensile Strength and Flexural strength. After setting, the cube moulds were removed and cubes were kept in water tank for curing and tested at 7days & 28 days.

IV. TEST RESULTS

Compressive Strength of cubes: The result of compressive strength were plotted in below Table4 and shown in Fig 2. Results indicate that there is not much difference in Compressive strength for the control mix and for the mix replaced with low grade concrete below the neutral axis. But however the specimen with low grade below neutral axis almost reaches the compressive strength but lesser than that of reference mix.

Table 4: Compressive strength of M30 grade of concrete at different ages

Mix ID	Compressive strength (N/mm^2)	
	7 Days	28 Days
R1	25.39	30.64
R1-1	21.91	34.26
R2	29.64	45.30
R2-1	24.99	40.73
R3	33.15	45.67
R3-1	22.80	40.23

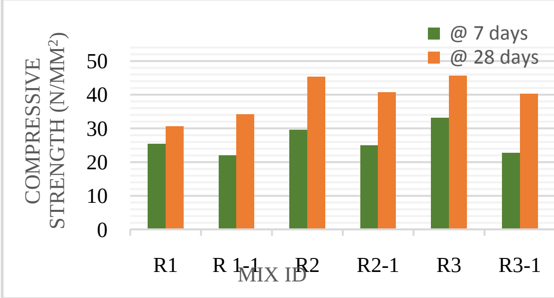

Fig 2. Cube compressive strength

Split tensile strength of cylinder: The results for split tensile strength on cylinder specimens are tabulated in Table 5 given below and is plotted in Fig 3.

Table 5: Split tensile strength of M30 grade of concrete at different ages

Mix Description	Split tensile strength test (N/mm^2)	
	7 Days	28 Days
R1	1.65	1.74
R1-1	1.42	3.37
R2	2.24	4.35
R2-1	1.31	2.71
R3	2.25	2.86
R3-1	1.82	2.65

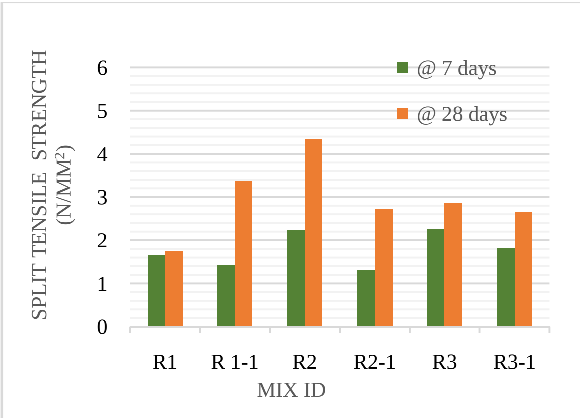

Fig 3. Split Tensile strength

Flexural Strength: The stress in a material before it starts yielding. Table 6 and Fig 4. illustrated the values of flexural strength for various types of concrete. Similar to Compressive strength and Split tensile strength, the flexural strength of prism specimens is almost the same. A few percentage decrease in strength may be due to ineffective compaction between two layers.

Table 6: Flexural strength of M30 grade of concrete at different ages

Mix Description	Flexural strength test (N/mm^2)
	28 Days
R1	3.64
R1-1	3.59
R2	4.13
R2-1	4.09
R3	4.49
R3-1	4.41

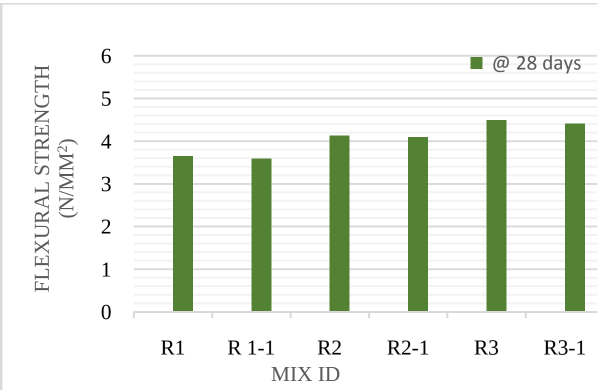

Fig 4. Flexural strength

Compressive strength on cylinder: The compressive strength on cylinder is found to be almost same for all mixes when comparing it with the reference mix. The test results are shown in Table 7 and the comparison of test results is shown in Fig 5.

Table 7: Compressive strength at 28days

Sl. no	**Mix ID**	**Compressive strength (N/mm^2)**
1	R1	26.44
2	R1-1	25.94
3	R2	25.82
4	R2-1	25.31
5	R3	33.10
6	R3-1	21.83

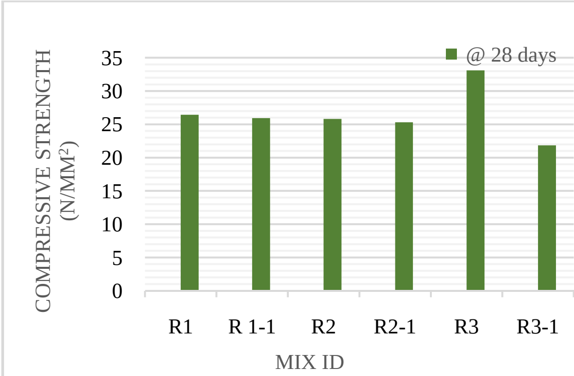

Fig 5. Comparison of Cylinder compressive strength at 28days

Ultrasonic pulse velocity: Pulse velocity technique is an important assessment for predicting the quality of concrete for different mixture proportion of concrete. Dynamic young's modulus was calculated for the specimens from the velocity obtained for the specimens.$\mathbf{E=(V^2\rho/g)*10^{-2}}$where **E** is the Dynamic Modulus of Elasticity(Gpa). **V** is the ultrasonic pulse velocity in km/s, **ρ** is the density of the cylindrical concrete specimens in kg/m^3 and **g** is the acceleration due to gravity (9.81 m/s^2). The values of Dynamic young's modulus at 28days curing age are given in the Table 8 and in Fig 6.

Table 8: Dynamic Young's modulus from Ultra Sonic Pulse velocity

Mix ID	**Density (kg/m^3)**	**Average velocity (km/s)**	**Concrete quality grading**	**Dynamic Young's Modulus (Gpa)**
R1	2688.33	3.1	Medium	26.33
R1-1	2606.81	3.09	Medium	25.37
R2	2544.88	3.87	Good	38.85
R2-1	2456.47	3.29	Medium	27.10
R3	2567.70	4.23	Good	46.83
R3-1	2618.96	3.77	Good	37.94

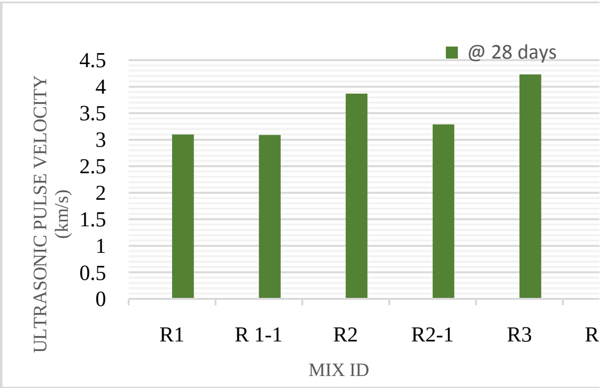

Fig 6.Comparison of Ultra sonic pulse Velocity

V. DISCUSSIONS

Based on the test results and discussions the following conclusions are arrived,

1) It was observed from the test results that the compressive strength of concrete specimens replaced with low grade concrete below neutral axis showed lesser compressive strength than Reference Mix but not lesser than the required strength.

2) It was observed from the test results that the M25+M15 and M30+M15 showed similar results compared to that of their reference mixes than the mix with M40+M20 grades of concrete as it showed little lesser strength.

3) The split tensile strength and flexural strength decreased to nearly 10% than that of the reference mix.

3) It is also being concluded that the Ultrasonic pulse velocity for different concrete mixture proportions showed good improvement for various mix combinations.

VI. CONCLUSION

Based on the investigation, the following conclusions were drawn.

- It is seen that there is not much difference in the flexural strength of control specimen and that of specimen with low grade concrete below neutral axis.
- The flexural strength of prism increases with the increase in grade of concrete used.
- It is also seen that the materials below the neutral axis is ineffective.
- Thus in the overall study, it can be concluded that behaviourof concrete specimen with low grade concrete below neutral axis behaves in the same manner as that of conventional concrete.

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