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Analysing Zone of Compression and Tension of RC Beam and Plain Beam

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Abstract:- The purpose of this thesis was to investigate about two zones of beam namely as Compression and tension zone. Compression zone and tension zone are the two zones that are specified for a beam. At the top and bottom of the neutral axis, respectively, are compression and tension zones. Steel is essential for supporting reinforced concrete beams in this instance, especially in the tension zone. Here we have conducted test on different specimen with different reinforcement at tension zone of concrete with different depths of beam specimen. In Case One - We have used equal reinforcement in both zones. In Case Two - Higher reinforcement in Tension zone and low reinforcement in compression zone. In Case Three – Reinforcement only in tension zone. Comparing all three cases we found that the strength achieved in case Two is nearly more than 90% as compare to case One.

Keywords:- *Neutral Axis ,Compression Zone, Tension Zone, Flexural Strength, Mix Design.*

I. INTRODUCTION

Beams made of reinforced concrete are structural components that can support transverse external loads. Along their length, the loads produce torsion, shear forces, and bending moments. Concrete is also quite weak in tension and powerful in compression. As a result, in reinforced concrete beams, steel reinforcement employed to absorb tensile stresses. Beams also carry the weight of other beams, walls, columns, and slabs. The loads are transferred to the columns that sustain them. Beams can also be cantilevered, continuous, or merely supported. They may have a rectangle, square, or other shape. Tshaped, and L-shaped sections. Beams can be singly reinforced or doubly reinforced, but in this project we can use doubly reinforced. Fine and coarse aggregate are combined to form concrete, a composite material, which is then joined by a fluid cement (cement paste) that eventually solidifies (cure). Concrete is the most frequently used building material and the second most used substance in the world after water.

➢ *Scope*

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As a result, in reinforced concrete beams, steel reinforcement employed to absorb tensile stresses. Beams also carry the weight of other beams, walls, columns, and slabs. The loads are transferred to the columns that sustain them. Beams can also be cantilevered, continuous, or merely supported. They can be created as L-shaped, T-shaped, rectangular, or square pieces. In this project, we can employ doubly reinforced beams instead of single- or double-reinforced ones.

➢ *Objective of Proposed Work*

- *To analyses the beam sections above and below natural axis.*
- *To observe failure of beam in form of fractures.*
- *To calculate flexure strength of beam.*
- *To conclude the required reinforcement for tension zone and compression zone.*

II. LITERATURE REVIEW

S. B. Kandekar(2013), A beam is a one dimensional (normally horizontal) flexural member which provides supportto the slab and vertical walls. In a normal beam (simply supported) two zones generally arise,viz. compression zone at top and tension zone at bottom. As concrete is weak in tension, steelis introduced in the tension zone to take the tension, but as strength of concrete is ignored in tension zone with respect to compression zone. So logically no concrete is required in tensionside. But this concrete needs to be provided on tension side to act as strain transferring mediato steel and may be called as 'sacrificial concrete'.

Leaf David and Laman JeffreyA (2013), they presented laboratory test results and analyze the ultimate flexural strength of the tested composite beams using currently available methods and compares to observed behavior. Composite beam test demonstrations conducted at the Pennsylvania State University on identically constructed members have revealed that composite beams fail before reaching predicted strength. Observations of failed composite beams include longitudinal cracking of the concrete slab and interlayer slip between the concrete slab and the steel beam. Their observations include the presence of interlayer slip, indicating that full interaction is not achieved.

Jain Joy (2014): The objective of the investigation is to develop a Reinforced Concrete Beam with hollow neutral axis which may replace the position of reinforced concrete beam in near future. However, in RC beams strength of concrete lying in and near the neutral axis is not fully utilized. So this unutilized concrete is removed by replacing with any lightweight material. The material incorporated in the concrete beam is PVC pipe, which occupy the concrete volume in the neutral axis, where the compression and tension is zero thereby making the beam hollow. The properties of PVC is not been.

Aswathy S Kumar (2015): The experimental results showed that the increase of concrete compressive strength developed the load capacity strength and ductility Concrete is the primary structural component, that exist in buildings and bridges. In recent days the problem faced by the construction industry is acute shortage of raw materials. In case of simply supported reinforced concrete beam, the region below neutral axis is in tension and above neutral axis isin compression. As concrete is weak in taking tension, steel reinforcements are provided in this zone. We have to consider concrete below the neutral axis act as a stress transfer medium between the compression and tension zone. Partial replacement of the concrete below the neutral axis is an idea that can create reduction in weight and savings in materials.

Paul Mathews M. and KuriakoseAnuja Mary (2015), they studied flexural behavior of PCC beams and also flexural test of beams with hollow neutral axis. In this project, low grade concrete is placed near the neutral axis zone of the beams. They have found and concluded that the flexural strength of beams increases with increase in grade of concrete used. It is also seen that the materials in the neutral axis zone is ineffective. Ahmed Abdullah Mansor (2020) : The use of high-strength concrete (HSC)started about four decades ago in world. Using (HSC) supports the applications in civil engineering such as reduce the size of buildings columns, increase the girders length, and increase the buildings stores as well as the economic benefits. The paper aims to investigate the effect of using various compressive strength of concrete mixes on the behavior and load capacity of reinforced concrete beams in terms of cracking, yield, failure loads, deflection and ductility. The experimental program included the cast of six reinforced concrete beams with 1.75 m length and cross section of 200 × 300 mm. The beams specimens were tested under two points loads. Several concrete mixes were tried to obtain the concrete compressive strengths 30.9, 40.3, 51.2, 60.1, 71.6 and 89 MPa that used for every specimen beam.

III. MATERIAL AND PROPERTIES

➢ *Cement*

53 Grade OPC Cement is a vital component of the infrastructure sector and is produced in a variety of compositions for a wide range of applications. Cements may have the names of their main components, their intended use, the object to which they are applied, or one of their distinguishing characteristics. When used in construction, cement is sometimes given names based on its alleged places of origin, such as Roman cement, or on how closely they resemble other materials, such Portland cement, which creates concrete that resembles the Portland stone used in British construction. The name "cement" comes from the Latin word "caementum," which refers to stone chips, as those used in Roman mortar, rather than the binding substance itself.

➢ *Water*

Water is crucial to the chemical process of hydration as well as the curing of concrete. As a result, water used for mixing and curing must be pure and free of contaminants such oils, alkalis, salt, sugar, organic compounds, or other elements that could harm steel or concrete. For mixing concrete, drinking water is typically considered sufficient. Potable water, recycled water from the concrete industry, or tap water should all be utilized in pervious concrete in the same quantities as in conventional concrete. Controlling water quality is crucial since pervious concrete is sensitive. Chemical tests or determining the average cute compression test of concrete at 18 days should be less can be used to determine the suitability of the water.

➢ *Coarse Aggregate*

At first, aggregates were thought of as little more than a cement substitute in concrete. However, it is now understood that the properties of concrete in both its plastic and hardened states can be significantly influenced by the type of aggregate used in the mix. Their characteristics are essential to the characteristics of concrete because they can make up 80% of the concrete mix. Heavyweight, normal weight, lightweight, and ultra-lightweight aggregates are the four broad classifications for aggregates. However, only regular weight and lightweight particles are utilized in the majority of concrete processes. The other forms of aggregate are used for specialized purposes, such as thermal insulation with lightweight concrete and nuclear radiation shielding with heavy weight.

➢ *Fine Aggregate*

Following are the seven strategies that were employed for evaluating physical properties: • Sieve Analysis: In line with South African National Standards (SANS) 201:2008 [42], the portion of the sample bigger than 0.425 mm underwent sieve analysis to determine the aggregate's fine content and dust content. • Hydrometer Analysis: This method, which calculates sedimentation principles, is the most frequently used for analyzing the fine-grained fraction of a soil's grain size distribution. In this work, dispersion agents were used to conduct hydrometer analyses on the five WFS (two clay sands and three chemically bonded molding sands) using the TMH1 1986 method..

➢ *River Sand*

Natural river sand is coarse in texture and a mild shade of brown in color. Although it is mostly utilized in construction, homeowners can also use it for little projects. River Sand, as its name implies, is produced naturally in rivers. It is generally used to mix concrete in tiny batches. Additionally, top dressing yards, basic masonry work, and soil amendments can all be done with it.

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IV. CONCRETE MIX DESIGN

➢ *Design of M -20 Concrete Grade*

- *Characteristic Strength (𝑓𝑐𝑘) : 20 N/mm2*
- *cement grade: OPC 53 Grade Cement confirming to IS-12269- 1987*
- *Sand (fine aggregate) : River Sand*
- *Size of CA : 20 & 12mm Crushed Angular*
- *Exposure : Mild*
- *Min.Cement Content : 300 kg/m^3*
- *Degree of quality control : Good*
- *Exposure Condition : Normal*
- *Supervision Degree - Good • Maximum w/c ratio adopted : 0.45*
- *Max. Water Content/ Cum : 186 liters (as per SP 23-1982) Table 42, pg-113*
- *Method of concrete placing : Machine Mix with optional Hand Mix*
- *Mortar Plasticizer : Ask-o-Mix*

➢ *Target Strength*

$$Ft = fck + 1.65 \times S$$

(Assuming standard deviation S' for M-20 grade = 4.0)

$$Ft = 20 + 1.65 \times 4.0$$

$$ft = 26.6 \text{ N/ mm2}$$

Trial	Proportion	W/C	Test Result for 7 Days (Mpa)				7 Days Avg.Strength (MPa)	Target Strength 28 days (MPa)	Remark
A.	1:2.09: 3.05	0.45	12.35	14.93	15.2	14.6	14.27	26.6	Final

➢ *Testing of Ingredients*

Study of materials to be used for concrete has been done. Various tests havebeen carried out on the materials used in RCA. The following are the tests carried out on materials:

- *Specific Gravity Fine-Aggregate*
- *Sp.Gr. Coarse Aggregate*
- *Impact Test On Coarse Aggregate*
- *Abrasion Value Test*
- *Silt Content On FA*
- *Agg Crushing Value - Test*
- *Sieve Analysis of Fine Aggregate*

Table 1 Tests Results on Course Aggregate

Sr.No	Properties	Value
1.	Impact value	8.14 %
2.	Crushing Value	16.47 %
3.	Specific Gravity	2.49
4.	Fineness Modulus	3.11
5.	Abrasion Value	21 %

Table 2 Tests Results on Fine Aggregate

Sr.No	Properties	Value
1.	Silt Content	3.33 %
2.	Specific Gravity	2.78
3.	Fineness Modulus	3.86
4.	Bulking of Sand	25 %

V. CASTING OF STRUCTURAL ELEMENTS

➢ *Cube Casting*

Fig 1 All the Moulds are filled with Concrete

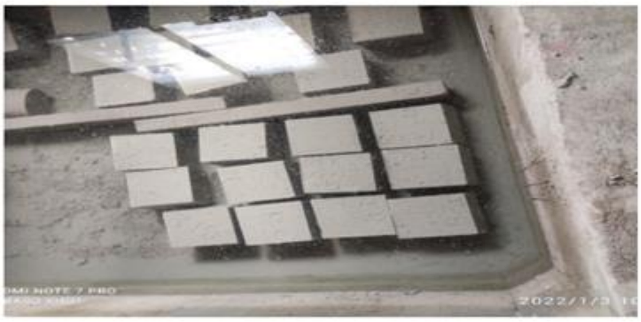
Fig 2 All the Moulds are kept into the Water for Curing

➢ *Beam Casting*


Fig 3 RCC Beam Filled


Fig 4 RCC Beam kept for Curing


Fig 5 Beam kept for Curing

VI. RESULTS AND DISCUSSION

Below the Measured compressive strengths on 150 mm × 150 mm cubes made in accordance with IS4031 Part 6.

➢ *Strength of Compression for Cubes*

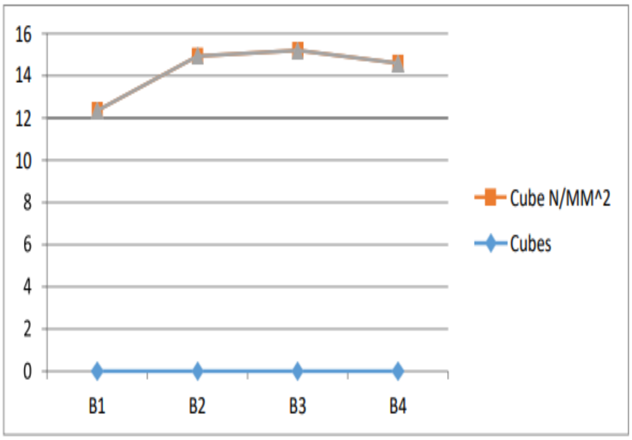

Fig 6 7 Days [Cube]

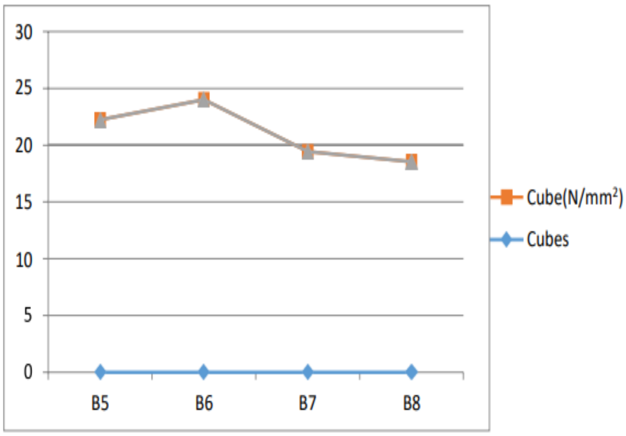

Fig 7 14 Days [Cube]

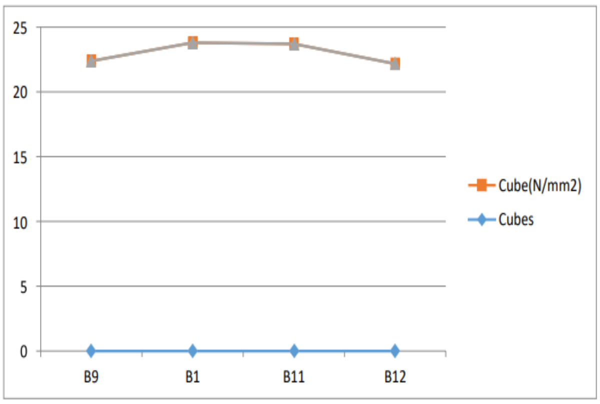

Fig 8 28 Days [Cube]

➢ *Flexural Strength of Beam*

Table 3 Plain Beam

Beam details	Flexural strength(N/mm^2) 14 Days	Flexural strength(N/mm^2) 28 Days
PB1	5.3	6.04
PB2	4.8	7.2
PB3	12.08	11.55
PB4	10.2	11.8

Here, we have casted two sets of two category of Plain Beam.

PB1 & PB2 = 2 NOS OF Beam of Size 150 x 150 x 800 cm^3.

PB3 & PB4 = 2 NOS of Beam of Size 150 x 230 x 800 cm^3.

➢ *Rcc Beam*

The beam specimen is prepared by using Steel and concrete. We have casted the beam for the size as follows –

- 150 x 150 x 800 cm^3
- 150x 230 x 800 cm^3

These beam are prepared by using variable reinforcement at Compression and Tension Zone respectively.

Table 4 Rcc Beam

Beam Notation	Reinforcement	Tested At
150 X 150 X 800 cm^3 - A		
A1 AND A2	12 mm Dia Bar at Both Zones	14 Day + 28 Day
A3 AND A4	10mm @ Compression Zone + 12mm @ Tension Zone	14 Day + 28 Day
A5 AND A6	No Compression Reinforcement + 12mm @ Tension Zone	14 Day + 28 Day
150 X 230 X 800 cm^3 - B		
B1 AND B2	12 mm Dia Bar at Both Zones	14 Day + 28 Day
B3 AND B4	10mm @ Compression Zone + 12mm @ Tension Zone	14 Day + 28 Day
B5 AND B6	No Compression Reinforcement + 12mm @ Tension Zone	14 Day + 28 Day

Table 5 Flexural Strength

SR.NO	BEAM DESCRIPTION	FLEXURAL STRENGTH	
		14 DAYS	28 DAYS
1	150 X 150 X 800		
	A1	9.8	-
	A2	-	8.92
	A3	10.85	-
	A4	-	9.05
	A5	9.87	-
	A6	-	11.47
2	150 X 230 X 800		
	B1	6.04	-
	B2	-	5.42
	B3	5.16	-
	B4	-	7.49
	B5	4.5	-
	B6	-	7.5

Even by using less Diameter Steel at top in A3 we have achieved Up to 110 % of Strength at 14 days of Beam size 150x150x800mm. By using less diameter steel at top in A4 we have achieved 100 % of Strength at 28days of same sized beam. The size of Beam 150x230x800mm by using less diameter of Steel at top in B3 we have achieved above 85 % Strength at 14 days. And by using less diameter if steel at top in B4 we have achieved above 120% of strength at 28 Days of Same sized beam.

Table 6 Resistance Moment for an RC Beam Age: 14 Days

Moment of Resistance for RC beam (Age: 14 Days)

SR.NO	BEAM DESCRIPTION	Moment of Resistance (kN-m)	
		Experimental	Theoretical
1	150 X 150 X 800		
	A1	8.34	9.54
	A3	9.02	9.54
	A5	8.32	9.54
2	150 X 230 X 800		
	B1	11.98	15.84
	B3	10.25	15.84
	B5	8.98	15.84

For Beam size [150 X 150 X 800] The concrete beam is shown in the table as a result. A1, A3 and A5 (M20) has achieved moment of resistance of 8.34 kNm, 9.02kNm and 8.32 kNm which almost matches theoretical value 9.54 kNm. For Beam size [150 X 230 X 800] Concrete beam B1, B3 and B5 has reached a point of resistance that is almost 60 to 70 percent of the 14-day theoretical value.

Table 7 Resistance Moment for an RC Beam Age 28 Days

Moment of Resistance for RC beam (Age: 28 Days)

SR.NO	BEAM DESCRIPTION	Moment of Resistance (kN-m)	
		Experimental	Theoretical
1	150 X 150 X 800		
	A2	7.52	9.54
	A4	7.64	9.54
	A6	9.68	9.54
2	150 X 230 X 800		
	B2	10.76	15.84
	B4	14.86	15.84
	B6	15.04	15.84

For Beam size [150 X 150 X 800] The concrete beam RC beam A2 and A4 (M20) has obtained a moment of resistance of 7.52 kNm, which is roughly around 80% of the theoretical value of 9.54 kNm, as shown in the result table. Concrete beam A6 has achieved moment of resistance of 9.68kNm which is nearly equal to theoretical value. For Beam size [150 X 230 X 800], B2 has achieved nearly 67% of moment of resistance than theoretical value. B4 and B6 has reached a point of resistance that is up to 90% of the 28-day theoretical value.

VII. SUMMARY AND CONCLUSION

- It is observed that the section above neutral axis is more feasible to compression and the reinforcement in compression zone is required to me minimum as compared to tension zone of concrete.
- Beam failure occurred in the form of flexural cracks developed from the tension side.
- As the compression reinforcement and tension reinforcement zone is equal the strength achieved is nearly equal to the beam having minimum reinforcement in compression zone.
- For Beam size [150 X 150 X 800], moment of resistance is achieved nearly 90% increase in strength section. For Beam size [150 X 230 X 800] moment of resistance is achieved nearly 110 % to 150% of increase in strength.
- Using minimum area of reinforcement at compression zone can provide the effective desired strength by considering the economic factor in the construction sector this section will be more economical.

SCOPE FOR FUTURE WORK

There is some kind of way that the work or project can be taken forward in one or the other way. There are many possibilities to carry the previous work done with different way by using different technique, by adding other inputs, by utilizing the records of previous work experience. Further expansion can be done by using Recycled material for making of concrete and re-used which can reduce the cost of project and give better results. Future work indirectly relates to the extension of your work and get something out of it which can be possibly done and presented in front of experts with their guidance.

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