

# **Flexural Behaviour of Reinforced Beam Made With Light Weight Aggregate Concrete**

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**ABSTRACT:** Light weight concrete made with partial replacement of ordinary Portland cement by 20% of fly ash, fine aggregate by 10% of saw dust and coarse aggregate by 10% of coconut shell. This study is carried out to reduce the self weight of concrete and thus to reduce the load on the foundation of reinforced concrete buildings. Total of 6 under reinforced beam were casted with various pattern of shear reinforcement and constant top and bottom reinforcement and flexural test was carried out on the specimen. Failure criteria, cracking behaviour, deflection characteristic and ultimate moment capacity of beam are studied.

**KEYWORDS:** Light weight aggregate concrete, shear reinforcement, cracking behaviour and deflection

## **I. INTRODUCTION**

The most important factor which governs the design of reinforced concrete building is the loading condition to which the building is subjected to act during its life time. Each and every building should be designed against dead load, live load, wind load, snow load and earthquake forces etc. Among these loads dead load plays a major role because it is the load which is constantly acting on the building. Dead load is based on the unit weight of the materials used in the buildings.

Unit weight of plain concrete and reinforced concrete made with cement, sand and gravel was 24 KN/m<sup>3</sup> and 25KN/m<sup>3</sup>. Since the unit weight of concrete is high, it increases the self weight of concrete which in some extent make it as an uneconomical structural material. Attempts have been made to reduce the self weight of concrete and to increase the efficiency of concrete as the structural material.

Density of conventional concrete is 2200 kg/m<sup>3</sup> to 2600 kg/m<sup>3</sup>. The concrete whose density is less than the normal concrete, then this type of concrete is known as light weight concrete. In recent years, light weight concrete has become more popular owing to the tremendous advantage it offers over the conventional concrete. When the density of concrete is reduced this in turn leads to reduction of dead load acting in the structure consequently reduced load in the foundation, leading to greater economy in construction. Thus making possible to construct high rise building in soft soil. This also gives a greater reduction in the weight of precast elements and thus reducing the handling load, which it turn ensure the safety of construction.

Structural light weight concrete is a concrete having 28 day compressive strength is more than 17 N/mm<sup>2</sup> and 28day unit weight not exceeding 1850 kg/m<sup>3</sup>. In the current study the light weight concrete is casted and checked whether it satisfy the criteria of structural light weight concrete and the flexural behaviour is studied.

## **II. LIGHT WEIGHT CONCRETE**

The Light weight concrete made with partial replacement of ordinary Portland cement by 20% of fly ash, fine aggregate by 10% of saw dust and coarse aggregate by 10% of coconut shell. The percentage of replacement is chosen based the experimental result that has been carried by individually replacing cement by fly ash, river sand by saw dust and gravel by coconut shell by varying the percentage of replacement. M20 grade of concrete is been taken for the study and the mix design is carried out as per IS 10262-1982 and mix proportions are arrived and replaced by the percentage of weight. Thus the quantity of materials required for the mix is derived.

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Before mixing of concrete the following pre treatment should be carried out. Fly ash and Ordinary Portland Cement should be sieved in 90 micron sieve and then used. Saw dust should be dried in sunlight for a day to be free from moisture and then sieved in IS 4.75mm. Next, the saw dust should be blended with sand before mixing it in concrete to ensure uniform dispersion of sand and saw dust. The coarse aggregate which pass through 22mm IS sieve and retain in 20mm IS sieve is taken so that the aggregate size of 20mm is achieved. Coconut shell is broken into angular shape and flaky pieces are eliminated. Coconut shell has a major disadvantage of absorbing water during mixing in concrete. This is eliminated by soaking the coconut shell in for a minimum of 8 hours to the maximum of 24 hours. So that the mixing water is not absorbed by coconut shell and it is available for hydration of cement.

### III. MATERIALS

Cement, river sand, gravel, fly ash, saw dust and coconut shell has been used in the study. Physical properties of these material is studied before casting if the specimen is carried out. The test results are summarized below:

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| <ul style="list-style-type: none"><li>• Cement:<br/>Specific gravity = 3.15.<br/>Initial setting time = 45mins<br/>Final setting time = 260mins<br/>Fineness modulus = 1</li><li>• River sand:<br/>Specific gravity = 2.6<br/>Surface texture = smooth<br/>Fineness modulus = 2.85</li><li>• Gravel:<br/>Particle shape = Angular<br/>Impact value = 15.3</li></ul> | <ul style="list-style-type: none"><li>• Fly ash:<br/>Specific gravity = 2.30<br/>Fineness modulus = 7.64</li><li>• Saw dust:<br/>Surface texture = smooth<br/>Fineness modulus = 3.34</li><li>• Coconut shell:<br/>Impact value = 4.26<br/>Shell thickness = 2.5-2.9mm</li></ul> |
|---|--|

### IV. EXPERIMENTAL PROGRAM

To determine the compressive strength of concrete and its density and to identify whether it comes under the category of light weight aggregate concrete and it satisfy the requirements of structural light weight concrete. Three cube of size 150mm is casted. The cubes are cured in water for 28 days and density and compressive strength is determined.

Six reinforced concrete beams are casted with same flexural reinforcement and various pattern of shear reinforcement. The various pattern of shear reinforcement are

- Straight- This is the pattern which is normally used as shear reinforcement in beam.
- 45° - shape of the stirrups is rectangular but they are tied at 45° inclined to the perpendicular.
- U-shaped - Top of the stirrups is omitted and the stirrups are tied to the top reinforcement.
- Confined - A bar is added in the middle of rectangular stirrups to make the concrete confined in nature
- Spiral - A continuous pattern of shear reinforcement which is followed in spiral column is used in beam but in single direction.
- X-type - The spiral pattern of shear reinforcement is provided in both the opposite direction, thus when viewed from its side it is X in shape.

Among the pattern of shear reinforcement, first four patterns can be made easily but spiral and x type pattern need skilled labour. 6mm  $\phi$  bar is provided and the spacing of shear reinforcement is 150mm in all the six beams.

Maximum and minimum percentage of reinforcement of the beam is calculated as per IS456:2000 and the percentage of reinforcement is fixed as 1% for all the beams. Hence three number of 12mm $\phi$  bar is provided as bottom reinforcement and a nominal of two number of 10mm $\phi$  bar is provided as top reinforcement in all the six beams.

Size of the beam is 150mm x 200mm x 1500mm. The six beams are casted in with light weight aggregate concrete with similar bottom and top reinforcement. Clear cover of 25mm is provided in the top and bottom of the beam.

The beams are cured with water for 28 days and flexure test is carried out on all the six beams. Failure criteria, cracking behaviour, deflection characteristic and ultimate moment capacity of beam are studied.

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## V. RESULTS AND DISCUSSION

### Density and Compressive strength of light weight aggregate concrete:

The density of light weight aggregate concrete is found by taking the weight of 150mm cube and interpolating its weight to one metre cube. Thus density is found to be  $1793\text{kg/m}^3$  which are less the  $1850\text{ kg/m}^3$ .

The 150mm cube made with light weight aggregate concrete is tested for its compressive strength after 28days of curing. The test is performed as per IS516:1959. The average compressive strength of cube was found to be  $18.34\text{N/mm}^2$  which is more than  $17\text{ N/mm}^2$ . Thus it satisfies the criteria if structural light weight concrete. Hence the beam is casted and can be checked for its structural behaviour of it when it is used in conjunction which reinforcement.

### Flexure test on beam:

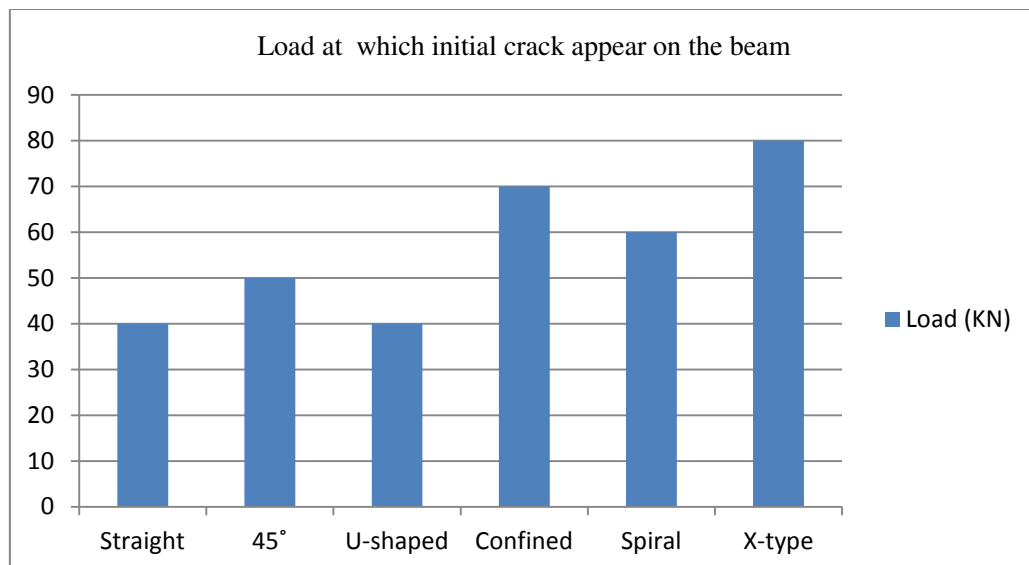
- General Observation:

All beams showed typical structural behaviour in flexure. No horizontal cracks were observed at the level of the reinforcement, which indicated that there were no occurrences of bond failure. Vertical flexural cracks were observed in the constant-moment region and final failure occurred due to crushing of the compression concrete with significant amount of ultimate deflection. Since all beams were under-reinforced, yielding of the tensile reinforcement occurred before crushing of the concrete cover in the pure bending zone. When maximum load was reached, the concrete cover on the compression zone started to spall. Eventually, crushing of the concrete cover occurred during failure. At failure, the crushing depth of the concrete varied from 60 to 120 mm. All the beams fail under shear because the flexure reinforcement is strong enough to carry the load. The study also aims at the best pattern that is suitable to carry the shear force to maximum extent.

- Cracking behaviour:

During loading of the beam no vertical cracks are occurred in the beam and this indicate there is no bond failure. Cracking behaviour of all the beams are similar but the formation of initial crack is at different load and also the ultimate capacity of load that the beam can carry this depends on the way which forces are transferred in the beam.

### Formation of initial crack:



- Ultimate capacity of the beam:

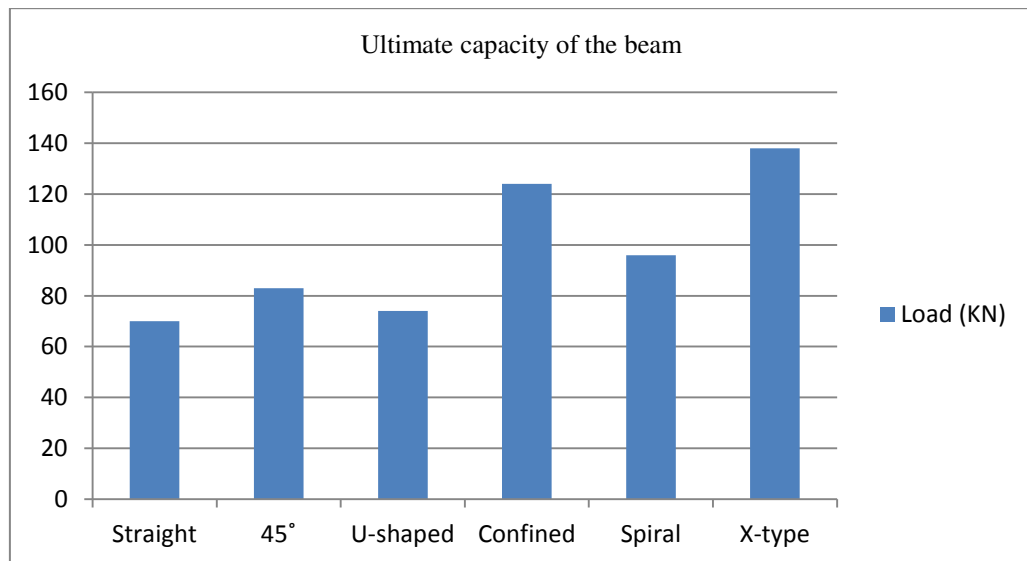
Ultimate capacity of the beam is varied only due to the transfer of shear in the beam. Shear crack develops in diagonally to the direction of load but in  $45^\circ$  the stirrups are inclined in the direction of load so that it carry more load when compared to straight and u shaped pattern. X type and confined are similar in load carrying

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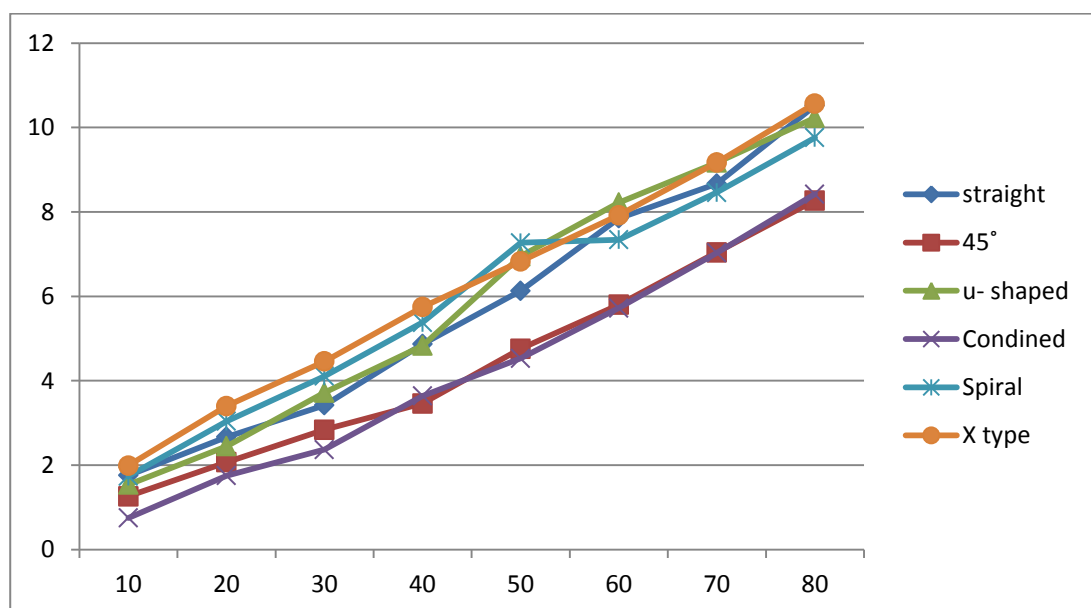
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capacity than the other because the stirrups are provided with little more reinforcement than the others. But the ultimate capacity is more than increase in reinforcement this indicate that these patterns can be in used in places where the shear forces are more.



- Deflection behaviour:**

The deflection does not vary much upon on the loading because the flexural reinforcement is the main reason which is responsible for deflection. In these six beams the flexural reinforcement does not vary hence the deflection is similar



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## VI. CONCLUSION

The test results showed that the behaviour of light weight concrete made with 20% replacement of OPC by fly ash, 10% replacement of fine aggregate by saw dust and 10% replacement of coarse aggregate by coconut shell are found satisfactory to be used as structural light weight concrete.

Spiral is mainly used in column than in beams because it is easy for workmanship in beams than in column. U shaped and straight has similar behaviour. Thus pattern of shear reinforcement is chosen based on the shear force acting on the section for normal case straight or 45° pattern can be used and in areas of larger shear force confined or X- type can be used.

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