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# Design of Economical Beam Section Replacing Light Weight Material Below Neutral Axis

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## ABSTRACT

This Study carried out on brick-filled reinforced concrete beams. The concrete just above neutral axis is less stressed where as the concrete below the neutral axis serves as a shear transmitting media. In RC beams less stressed concrete below neutral axis can be replaced by some light weight and low cost materials like light weight concrete, bricks etc. In this study partially utilized concrete of RC beam has been replaced by bricks, It will reduce the weight of the structure and also achieve the economy. Brick filled reinforced concrete beams acts like composite beams. We use method of initial functions for the analysis of brick filled RC composite beams Reinforced brickwork is also an alternative to reduce the use of concrete. The behavior of reinforced brick beams is similar to that of reinforced concrete beams. But in this type of structures large depth of sections obstructs the head room requirements. In such a situation RC beam is one of the alternatives, however, in RC beams strength of concrete lying near the neutral axis is not fully utilized. The concrete just above neutral axis is less stressed where as the concrete below the neutral axis serves as a shear transmitting media. Looking to the limitations of reinforced brick beams and RC beams, the concept of brick filled RC beams has been developed. Partially utilized concrete of RC beam has been replaced by bricks. In this way the economy of reinforced brick beams and strength of RC beams are tried to be combine in brick filled beams. The bond between brick and concrete layers at the brick concrete interface should essentially be very good. It should be ensured that no slip will occur between the two layers.

**Keywords:** R Bricks, RC Beams, Concrete, Composite Beam, Light Weight Concrete.

## I. INTRODUCTION

### General

Reinforced concrete is being used in most of construction activities. In recent days the problem faced by the construction industry is acute shortage of raw materials. Researchers have been investigating many alternative materials to suite the Indian scenario. Rice husk, saw dust, light weight aggregates, copper slag, fly ash, are some of the materials experimented. In the beams the concrete below the neutral axis does not take any tension .Hence the replacement of this concrete can reduce the materials used for construction that physical conditions are verified for in filled beam .brick filled RC composite beams.

A newly developed lightweight reinforced concrete (LSRC) section has been experimentally investigated section can be used either as beams or slabs .The section is made up of a reinforced concrete with lightweight block infill. LSRC developed LSRC members are suitable for large span construction due to the weight saving benefits and ease of construction. Sustainability means meeting the needs of the present generation without compromising the ability of future generations to meet their needs .Sustainability can be achieved by reducing, reusing and recycling the waste. It also means moving towards green technologies and reduces emission ofCO2. Production of cement is also one of the main causes of man-made carbon dioxide emissions. Reduction of greenhouse gases and environmental pollution is great concerned for all of us. So the authors have to reduce the use of cement from concrete structure make concrete more sustainable and environment friendly. This can be done by replacing cement in concrete with larger amounts of supplementary cementing materials, or by replacing less stressed or unutilized concrete by other low cost and environment friendly materials like alternative aggregates, bricks etc

## SCOPE OF PROJECT

As the day-by-day the use of cement is increase so that the section becomes costly. And production of cement contribute large amount of carbon dioxide in the air causes air pollution .so attempt is done to reduce the use of concrete so that cement also gets reduce and the section gets economical. And the concrete is replaced by lightweight materials.

### Objectives Of Work

1. T0 study the behavior of in filled concrete beams
2. To reduce the quantity of concrete required for section
3. To reduce the cost of the section
4. To reduce the dead weight of section
5. Sustainability can be achieved by replacing the partially used concrete

## II. METHODS AND MATERIAL

### LIGHT WEIGHT MATERIAL THAT WE USED

### BRICKS

Bricks remain one of the most important building materials in the country. Brick making is a traditional industry in India It has directly or indirectly caused a series of environmental and health problems.At a global level, environmental pollution from brick-making operations contributes to the phenomena of global warming and climate change.

**Photo 1.** Bricks of Perfect Shape

**Table 1.** Specification of bricks

| **Parameters** | **Clay Bricks** |
|---|---|
| Block Density (kg/m$^{3)}$ | 1900 |
| Compressive Strength (kg/cm$^2$) | 30 |
| Thermal conductivity (W/m.k) | 0.184 |
| Water Absorption (%) | 20% |
| Drying Shrinkage (mm/m) | No Shrinkage |

**Photo 2.** Cage of conventional beam setion

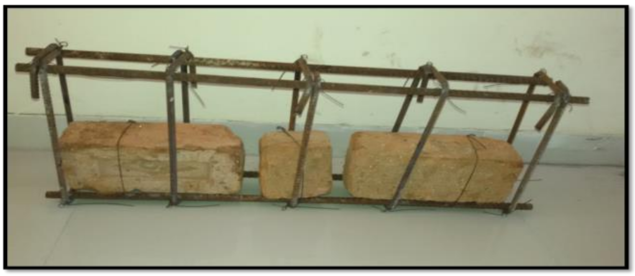

**Photo 3.** Cage of brick in filled beams section

**Photo 4.** Compaction of beams

**CELLULAR LIGHT WEIGHT CONCRETE BLOCKS (clc)**

Light weight foamed concrete has become more popular in recent years owing to the tremendous advantages it offers over the conventional concrete. Modern technology and a better understanding of the concrete have also helped much in the promotion and use of light weight foamed concrete

**Advantages of c/c blocks**

1. It has excellent compressive strength in excess of regular clay bricks/solid blocks,gurantees min. compressive strength of 3N/mm$^2$.
2. Bending strength is 15 to 20% of compressive strength
3. CLC bricks density is 750kg/m$^3$ which reduces dead load structures.
4. Huge saving in foundation and structure savings upto 30% on beam costs.
5. Good earthquake resistance properties.
6. Easy handling / faster construction.
7. Huge saving of lab our
8. It offers highest thermal insulation making cool summers and warm winters.
9. Reduced air conditioning expenses.
10. It is fire resistant.

**Photo 6.** Compaction of cubes

**Photo 7.** Cellular Lightweight Concrete blocks

**Technical Specifications**

**Table 2.** Specification of cellular lightweight blocks

| **Particulars** | **Units** | **Sizes** |
|---|---|---|
| Size | MM | 760x200 |
| Thickness | MM | 200 |
| Compressive Strength | N/MM$^2$ | <3 |
| Water Absorption | % | 12-15% |
| Normal Dry Density | Kg/M$^3$ | 750 |
| Thermal Conductivity | W/m$^0$k | 0.16 |
| Sound Absorption | Db | Upto 42 |
| Fire Resistance | Hrs | 4* |
| Thermal Resistance | M2-$^0$k/w | 0.46 |
| Heat Transmission Coefficient U | W/m$^2$-$^0$k | 2.13 |

**Lightweight materials Replacement Zone**

The replacement zone in reinforced concrete beam, where concrete below neutral axis may be replaced by bricks was obtained with the help of stress block, used for limit state design of RC beams.

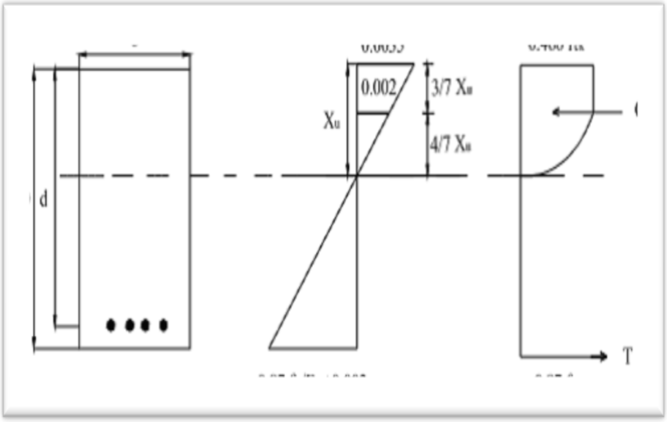


**Figure 1.** Stress Block Parameters for RC beams

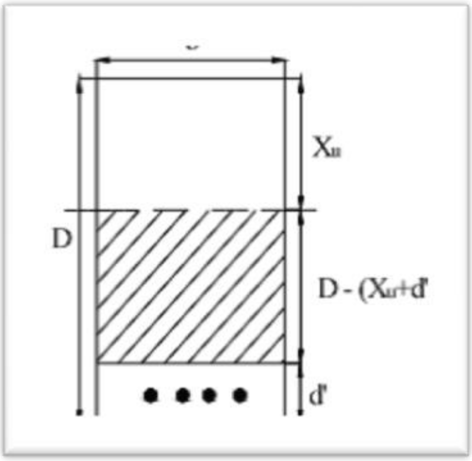


**Figure 2.** Brick replacement zone in RC beams

By equating total tension to total compression, Xu = (0.87 fy Ast)/ (0.36fckb) as per IS 456 2000 d' = (2 x cover + diameter of bar ) d' is the thickness of concrete layer available to maintain bond between steel and concrete. It is assumed the provision of thickness of concrete not less than the cover provided on each side of the tension reinforcement will satisfy the bond requirement.

Brick replacement zone = D - (Xu + d')

**TESTS ON MATERIALS**

All the ingredients used for preparation of the concrete, are thoroughly tested for their quality and physical properties in a well equipped laboratory attached to the plant for conformity to relevant Indian Standard Codes. The moisture probe determines the water content in the sand and aggregates. This accordingly helps in fixing the proportion of water to be added for the preparation of the mix. The sand being used is passed through the mechanized sieving system, before feeding for mixing.

Trial mixes are carried out and tested to ensure that each and every batch of concrete coming out of the plant meets the parameters of client's requirements. The sand being used is passed through the mechanized sieving system, before feeding for mixing.

**Cement**

**Initial and final setting time of cement**

For finding out initial setting time, and soundness of cement, and strength a parameter known as standard consistency has to be used. The standard consistency of a cement paste is define as that consistency which will permit a vicat plunger having 10mm diameter and 50mm length to penetrate to a depth of 33-35mm from the top of the mould.

**Procedure**

1. Unless otherwise specified this test shall be conducted at a temperature of 27 + 20C and 65 + 5% of relative humidity of the Laboratory.
2. Prepare a paste of 300 grams of cement with 0.85 times the water required to a give a paste of standard consistency IS: 4031 (Part 4) 1988.
3. The time of gauging in any case shall not be less than 3 minutes not more than 5 minutes and the gauging shall be completed before any sign of setting occurs.
4. Count the time of gauging from the time of adding water to the dry cement until commencing to fill the mould

5. Fill the vicat mould with this paste making it level with the top of the mould.
6. Slightly shake the mould to expel the air.
7. In filling the mould the operator hands and the blade the gauging trowel shall only be used.

**Initial Setting Time**

1. Immediately place the test block with the non-porous resting plate, under the rod bearing the initial setting needle.
2. Lower the needle and quickly release allowing it to penetrate in to the mould.
3. In the beginning the needle will completely pierce the mould
4. Repeat this procedure until the needle fails to pierce the mould for 5 + 0.5mm.
5. Record the period elapsed between the time of adding water to the cement to the time when needle fails to pierce the mould by 5 + 0.5mm as the initial setting time.

**Final Setting Time**

1. Replace the needle of the vicat apparatus by the needle with an annular ring
2. Lower the needle and quickly release.
3. Repeat the process until the annular ring makes an impression on the mould.
4. Record the period elapsed between the time of adding water to the cement to the time when the annular ring fails to make the impression on the mould as the final setting time.

**Precaution**

The time of gauging in any case shall not be less than 3 minutes not more than 5minutes.

## III. LITERATURE REVIEW

**Introduction**

Theoretical and experimental work done and some of the experimental studies performed in this field are presented in following papers.

**Literature Review**

W.Godwin Jesudhason, Dr. G. Hemalatha(2014). The Experimental investigation criteria to replace the portion below the neutral axis of the beam with Expanded polystyrene sheet (EPS). Expanded polystyrene sheet is a waste material obtained from the packing industries. It has good flexibility property. Normally in beams failureoccurs by Bending, but by embedding EPS sheet in concrete, shear cracks only occur while loading. Whileconsidering weight criteria EPS embedded beam weighslesser compared to conventional beam.(1)

Jain Joy, Rajesh Rajeev(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 un-utilized concrete is removed by replacing with any light-weight 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 used since it is used only as a filler material in concrete. Specimens of solid RC beams and Hollow RC beams are cast and tested for four point flexure. Then the results are compared and the effects are studied. The self weight of this developed RC beams are expected to be reduced with the decrease in concrete volume hence proving the beams to be economical. (2)

**Patel Rakesh, Dubey S.K., Pathak K.K(2013).**Observed that when the concrete below neutral axis is replaced by light weight materials such as bricks, clc blocks, Wooden blocks etc. so as to make the section economic. The strength of the light infill material is similar to the normal sections. Brick replacement zone is obtained with the help of stress block, used for limit state design of RC beams. Method of initial functions is used for the analysis of reinforced concrete brick filled composite beams. The method of initial function

(MIF) is an analytical method of elasticity theory. Moreover, by saving concrete we save cement which also reduces the green house gases emissions. In this way sustainability can be achieved.(3)

**S. B. Kandekar1, P. D. Dhake , M. R. Wakchaure(2013).**A beam is a one dimensional (normally horizontal) flexural member which provides support to 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, 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. So logically no concrete is required intension side. But this concrete needs to be provided on tension side to act as strain transferring media to steel and maybe called as 'sacrificial concrete'. If this concrete has no tension mere than strain transferring, then why to go for same grade of concrete which is used in upper zone? This is basic question which led to the idea of concrete grade reduction in tension zone for RCC beams to reduce construction cost.(4)

**Deepak Gowda. ,Dr. H. B. Balakrishna,**(2012) carried out experimenting it on brick-filled reinforced concrete beams.. In RC beams less stressed concrete below neutral axis can be replaced by some light weight and low cost materials like light weight concrete, bricks etc. In this study partially utilized concrete of RC beam has beam replaced by some light weight and low cost materials like light weight concrete by bricks. This will reduced the weight of the structure. Brick filled reinforced concrete beams acts like composite beams. Behaviour of reinforced concrete brick-filled beams is similar to that of reinforced concrete beams. Presence of bricks in the low stressed zone has not caused significant reduction in strength of reinforced concrete beams. It has been observed that the replacement of concrete by bricks in reinforced concrete beams does not require any extra labour time. Economy and reduction of weight in beams depends on the percentage replacement of concrete by bricks.(5)

**Arivalagan Soundararajan1, Kandasamy Shanmugasundaram (2010).**This paper presents an experimental study of normal mix, fly ash, quarry waste and low strength concrete(brick-bat lime concrete) contribution to the ultimate moment capacity of square steel hollow sections. Fifteen simply supported beam specimens of 1200-mm long steel hollow sections filled with normal mix, fly ash, quarry waste and low strength concrete and identical dimensions of hollow sections were experimented. Extensive measurements of such material properties, strain and deflection were carried out. Theoretical studies of ultimate moment capacity of a beam specimen were also calculated in this study for comparison's sake. These experimental investigation results showed that normal mix, fly ash, quarry waste and low-strength concrete enhance the moment carrying capacity of steel hollow sections. Furthermore, in these studies it can be found that normal mix, fly ash and quarry waste concrete can be used in composite construction to increase the flexural capacity of steel hollow sections.(6)

**M.R. Esfahania (2007)** Presented the flexural behaviour of reinforced concrete beams strength and using Carbon Fibre Reinforced Polymers (CFRP)sheets. The effect of reinforcing bar ratio on the flexural strength of the strengthened beams is examined. Twelve concrete beam specimens with dimensions of 150 mm width, 200 mm height, and 2000 mm length were costed and tested. Beam sections with three different reinforcing ratios, were used as longitudinal tensile reinforcement in specimens. Nine specimens were strengthened in flexure by CFRP sheets. The other three specimens were considered as control specimens. The width ,length and number of layers of CFRP sheets varied indifferent specimens. The flexural strength and stiffness of the strengthened beams increased compared to the control specimens.(7)

**Al-Khaiat and Haque 1998**The use of lightweight concrete in the construction industry has been gaining popularity in the past few decades. Although there have been many works done on the structural performance of lightweight aggregate concrete, these are mostly confined to naturally occurring aggregates, manufactured aggregates and aggregates from industrial by-products. If OPS concrete can be used for structural applications, it would not only beneficial towards the environment, but also be advantageous for low-income families as this concrete can be used for the construction of low cost houses, especially in the vicinity of oil palm plantations. For structural applications, the flexural behaviour of OPS concrete beams has to be closely scrutinised and clearly established. Therefore, this paper presents the results of anexperimental investigation on the flexural behaviour of reinforced OPS concrete beams. The beams were loaded incrementally until failure and their strength, cracking, deformation and ductility behaviour were examined.(8)

Hunaiti (1997) conducted a study on the strength of composite sections with foamed and lightweight aggregate concrete. In this research, test specimens of square steel hollow sections and square sections filled withfoamed and lightweight concrete were used to investigate the contribution of these concretes to the strength of cross-sections of composite members. There are few studies covering steel hollow beams filled with normal concrete and lightweight concretes. Some studies considered only the lightweight concrete(lightweight aggregates were produced from a wide variety of raw materials including clay, shale, slate pumiceand pearlite) and foamed concrete filled steel hollows. From this study find moment carrying capacity of the filled section.(9)

Govindan, P. and Santhakumar, A. R. (1984) Experimental study of brick filled reinforced concrete beam is done and it is observed that saving of 30% concrete is achieved The experimental programme is conducted on the beams with light weight brick core with ferrocement form. It is observed that beams achieved higher ultimate load when welded wire mesh is used in ferrocement forms.(10)

**Remark**

By taking a review of papers mentioned above we conclude that the concrete below neutral axis is less effective in taking tension. So by using the materials which are light weight and having some tensile strength and less shrinkage we can replace the concrete below neutral axis. By this the use of concrete is less in half the section and the section become economical.

## IV. RESULTS AND DISCUSSION

We cast number of specimen for various test and their results are listed below.

**Compressive strength of M30 grade of concrete**

**Table 3.** Compressive strength of M30 grade cubes

| Sr.no | Specimen (Cubes) | Compressive Strength($N/mm^2$) | Mean strength($N/mm^2$) |
|---|---|---|---|
| 1 | 7 Days | 14.3 | |
| 2 | 7 Days | 15.7 | 14.63 |
| 3 | 7 Days | 13.9 | |

**Costs of Beam Sections**

**Table 4.** Cost Comparison A

| Sr.No | Material | Quantity (For 1 Beam in KG) | Rate (Rs per Kg) | Amount (Rs) |
|---|---|---|---|---|
| 1 | Cement | 9.17 | 7 | 64.19 |
| 2 | Sand | 23.24 | 1.13 | 26.26 |
| 3 | Coarse aggregate | 28.41 | 0.37 | 10.51 |
| | Total cost for one beam | | | 100.96 |
| | Total cost for two beam | | | 201.92 |

### 4.3 Weight of Beam Sections

**Table 5.** Weight of beams sections

| Sr. No | Description | Weight in KN | Weight in Kg |
|---|---|---|---|
| 1 | Conventional | 0.756 | 77.06 |
| 2 | Brick infilled beam | 0.735 | 74.92 |
| 3 | CLC block infilled beam | 0.639 | 65.13 |

2. For Brick Infill Beam

**Table 6.** Cost Comparison B

| Sr.no | Material | Quantity (For 1 Beam in KG) | Rate (Rs per Kg) | Amount (Rs) |
|---|---|---|---|---|
| 1 | Cement | 5.04 | 7 | 35.28 |
| 2 | Sand | 12.78 | 1.13 | 14.44 |
| 3 | Coarse aggregate | 15.62 | 0.37 | 5.77 |
| 4 | Brick | 3 | 5 | 15 |
| | Total cost for one beam | | | 70.49 |
| | Total cost for four beam | | | 115.49 |

**Remark :** The cost of conventional beam is greater than cost of infilled beams . So it is beneficial to use the infilled in practice.

## V. CONCLUSION

Based on the results obtained in this study the following conclusions were drawn

1. Behaviour of reinforced concrete infilled beams is similar to that of reinforced concrete beams.
2. Presence of lightweight material in the low stressed zone has not caused significant reduction in strength of reinforced concrete beams. It has been observed that the replacement of concrete by lightweight material in reinforced concrete beams does not require any extra labour or time.
3. Economy and reduction of weight in beams depends on the percentage replacement of concrete by lightweight materials.
4. The shear strength of infilled beam is more than design shear strength.
5. The ultimate moment carrying capacity of infilled than design ultimate moment.
6. The infilled material can sustain more deflection.
7. The cost of in filled beams is less than conventional beams .So it can be practically used.
8. The weight of the structure is reduced due to lightweight material. So the overall weight of the structure is reduced.

**Limitation**

1. Method consumed a little bit more time than conventional method.
2. As rcc is the composite material, the bond between steel and concrete is not much effective as in normal section.

**Future Scope of Project**

1. This type of beams is used in bridge girders as their dimensions are very large we can use it for more area below neutral axis.
2. This can be used in the heavy precast members.

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