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Behavior of Lintels Using of Expanded Metal Reinforcement

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ABSTRACT—*The principle objective of this paper is to demonstrate the strength in lintels that can be achieved by using expanded metal reinforcement instead of the conventional steel reinforcement. Lintel is an important structural member provided over openings to transfer the load of masonry over opening. Normally structural design of lintel is ignored and bars of 8mm, 10 mm or even 12mm diameter are used with varying lintel depth of 100mm to 200mm. Considering load carrying capacities of such lintels it observed that materials are not fully utilized. This results in excessive use of materials and resources which in turn results in exploitation of economy. Considering huge materials involved in lintels in multistoried buildings, there is a need to achieve economy in this area. The use of unnecessary steel reinforcement can be avoided by using a innovative material called Expanded Metal Reinforcement (EMR) for economy in materials and fabrication cost. Therefore, an experimental program is undertaken to determine structural behavior lintels using EMR. The work includes comparison of flexural resistance, deflection, and cost of lintels using EMR with unreinforced and conventional lintel.*

Keywords—deflection, expanded metal reinforcement, flexural strength, lintel, masonry.

1, INTRODUCTION

The lintels are the structural members which mainly transfer the loads of the above masonry to the abutments over a wide opening. When a opening is to be maintained, the transfer of loads to the abutments is generally carried out by the use of various types of arches or lintels. Due to decrease in number of purely stone structures, the use of arches has decreased to a great amount but one the other hand the use of RCC lintels is on a rise due to its both compressive and tensile capacities.

Lintels are generally of three types, viz. RCC lintels, precast lintels and concrete lintels. Lintel is generally designed with a nominal reinforcement of 8mm-12mm bars without actually calculating the strength needed. The major motivation was drawn to eliminate the uneconomical design concept of the lintels and to design a section which attains a near exhausting stage at a given loading.

Therefore the use of Expanded Metal Reinforcement (EMR) was experimented to check the flexural strength and economic factors.

2, ANALYSIS OF A LINTEL

A lintel acts as a simply supported beam under flexure. The shear force diagram is linear and the bending moment diagram is parabolic in nature.

When load *w kN/m* is acting throughout the span of the beam, the maximum shear force is *wl/2kN* and the maximum bending moment is $wl^2/8$ *kNm*. Therefore, the bending stress will be

σ= My/I_x

Where

- σ is the bending stress
- *M* - the moment about the neutral axis
- *y* - the perpendicular distance to the neutral axis

I_x - the second moment of area about the neutral axis *x*

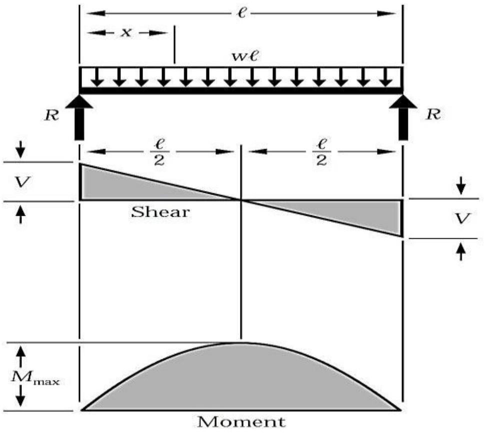

Figure.1 SFD and BMD of a simply supported beam under UDL

3, DESIGN OF RCC LINTEL

In the method of design based on limit state concept, the structure shall be designed to withstand safely all loads liable to act on it throughout its life; it shall also satisfy the serviceability requirements, such as limitations on deflection and cracking. The acceptable limit for the safety and serviceability requirements before failure occurs is called a ‘limit state’. The aim of design is to achieve acceptable probabilities that the structure will not become unfit for the use for which it is intended, that is, that it will not reach a limit state. Consider the lintel designed using limit state guidelines with minimal reinforcement to estimate the load it can carry.

Lintel with Steel Reinforcement
Given:
Section of beam: 100x150mm
Reinforcement: 8mm #4 no.
Fe250 grade steel
M20 grade concrete
Depth of neutral axis is given by,
xu= (0.87*fy*Ast)/(0.446*fck*b) = 32.86mm
xu limit= 0.53d= 53mm………(IS 456:2000, clause 38.1)
xu<xu limit >> the section is under reinforced
Mu Limit= 0.133*fck*b*d2= 2.011kNm
Equating Mu limit with the maximum bending moment,
Wl2/8=MuLimit
∴Wl2/8=2.011

>> W=16.088kN/m
Working load = 16.088/Factor of safety... (IS800:2007, clause 3.5.1)
=16.088/1.5
= 10.72kN/m
Self-weight= 0.1*0.15*25 = 0.375kN/m
Net Load permissible: 10.345kN/m
Therefore, a lintel of given section designed by minimal reinforcement can sustain a load of 10.345kN/m.

4, LINTEL LOADING

The loads acting on the lintel are generally triangular loads but for added factor of safety we have considered them as rectangular loads. The triangle is a 45^o-45^o-90^o triangle with base or the lintel length of 1000mm. So the height of the rectangle by calculations is 500mm. The weight of bricks in the rectangular area will act as load to the lintels.
Density of bricks=1920kg/m3= 1920*9.81=18835N/m3.
Uniformly distributed load ‘W’ will act on lintel.

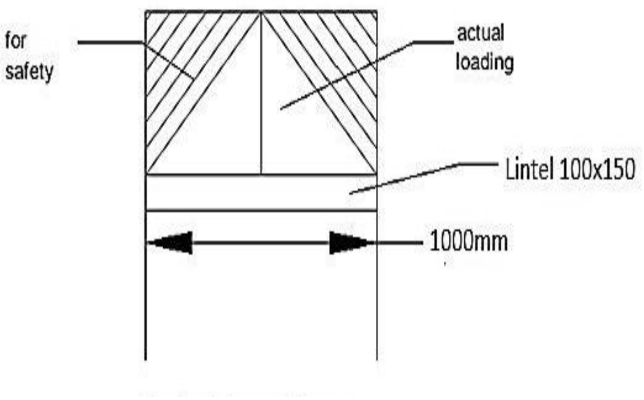

Figure.2Loading to which a lintel is subjected

Figure.3Expanded Metal Reinforcement

∴ W= (density in N/m3)*(Height*depth of rectangle)
=18835*0.5*0.15= 1.412kN/m
From the above results, it is quite clear that the loads, a minimally reinforced lintel can carry are far too greater than the loads actually present due to the masonry.

Experimental Work

Taking above results as a motivation for the experiment, the use of a new material called Expanded Metal Reinforcement (EMR) was made as reinforcement. EMR is a mesh made of mild steel with a thickness of about 4mm. So using EMR as reinforcement in two layers, lintels were cast of dimensions 100mm x 150mm x 1000mm to test under two point loading (for uniform and pure flexure) after 7 days of curing.

Materials used for the experiment were,Cement, Crushed Sand, 10mm and 20mm Aggregates, Water, Wooden Formwork, Expanded Metal Reinforcement (Figure. 3)

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Figure.4Method for inserting the EMR

Figure.53 EMR Lintels cast and EMR maintained under tension

Concrete of M20 grade was used. Indian Standard Method was used in preparing the concrete mix of the corresponding grade. The slump observed was 25mm. Details of the mix design are as follows:

TABLE I
Components of Concrete

Sr. No.	Component	Ratio
1	Cement (53 grade)	1
2	Crushed Sand	1.464
3	10mm Aggregates	1.347
4	20mm Aggregates	2.020
5	Water	0.43

4.1 Casting of Lintels:

The casting of lintels was done using wooden formwork which was made of two types. One type had slits made on both the ends for laying down EMR after a layer of concrete and the other type had no slits which was used only for casting concrete lintels without reinforcement. The lintels were then cast by filling concrete in three layers with compaction after each layer. For lintels with EMR, after the first layer of concrete the EMR was slid throughout and was kept under tension. Similarly after second layer of concrete the second layer of EMR was slid and maintained under tension (Figure. 5). Then the final concrete layer was put and the setup was kept undisturbed for 24 hours. The lintels without EMR were cast in just three layers with proper compaction. The curing of the lintels was done for 7 days by keeping them under water.

TABLE II
Beams Specifications

Sr. No.	Symbol	Type of Beam	Length(mm)	Width(mm)	Height(mm)
1	B1	Without EMR	1000	150	90
2	B2	Without EMR	1000	150	95
3	B3	Without EMR	1000	150	90
4	BS1	With EMR	1000	150	95
5	BS2	With EMR	1000	150	100
6	BS3	With EMR	1000	150	97

4.2 Limitations of Experimental Work:

During the experiments, some obstacles were faced which affected the results in some factors. Due to time constraint, only 7 day strength was considered. The other factor was due to time constraint, only one type of EMR could be tested. EMR of various thicknesses were not available for carrying out the tests.

4.3 ScalabilityTesting of Lintels Under Two Point Loading (Figure. 6):

The maximum shear force is given by P/2kN and the maximum bending moment is PL/6kNm.

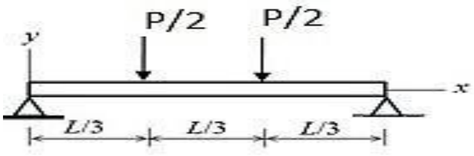

Figure.6Two Point Loading on Lintel

TABLE III
Beams without EMR

Name	L	W	H	Span (mm)	P (kN)	Max BM(kNm)
B1	1000	150	90	720	4.83	0.5796
B2	1000	150	95	600	4.2	0.42
B3	1000	150	90	600	6.24	0.624

Where,
L=length,W=Width,H=Height.
The Average maximum bending moment is 0.54kNm.
Therefore the average moment of resistance is 0.54kNm.

TABLE IV
Beams with EMR

Name	L	W	H	Span(mm)	P (kN)	Max BM(kNm)
BS1	1000	150	95	600	5.1	0.51
BS2	1000	150	100	600	5.9	0.59
BS3	1000	150	97	600	6.2	0.62

The Average Maximum Bending moment is 0.5733kNm
Therefore the average moment of resistance is 0.5733kNm.
Now the working load can be calculated as,
Wl2/8=moment of resistance.
>> W=12.740kN/m
Applying factor of safety as 1.5
Safe load = 8.493kN/m
Self-weight= 0.1*0.15*25 = 0.375kN/m
Net load= 8.493-0.375
=8.118kN/m.

5, DISCUSSION

In the EMR used beams it is seen that there is no sudden failure. One gets a warning before the failure of the lintel which is not the case in concrete lintels. Also, in RCC beams, strength obtained is 10.345kN/m which is very high than required to perform the job of a lintel. So lintels with EMR give the same strength as concrete but they are more reliable because there is no sudden failure. The load vs. deflection (Figure.7) shows that the EMR lintel has ductile properties.

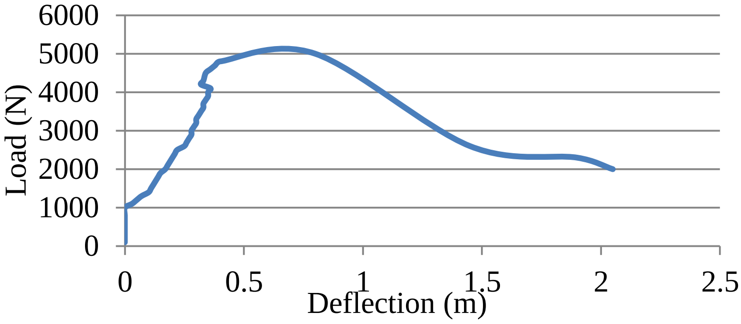

Figure.7 The graph of load vs. deflection for beams with EMR

VI. CONCULSION

In the RCC lintels, strength obtained is much higher than actually required. In the EMR lintels, same strength as that of concrete lintels is obtained, but concrete has brittle failure whereas EMR makes the lintels ductile. Hence ample amount of warning period is available before failure. In the current EMR lintels, the amount of mesh used was less but if

EMR of higher thickness is used and with slightly a greater amount, then its strength obtained would increase as compared substantially as compared to concrete lintels.

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