

# Structural Behavioral Analysis of Mild Steel as Main Steel in Slabs and Its Employment in Low Cost Housing

Vivek Gupta<sup>1</sup>, Animish Bapat<sup>2</sup>, Ravikant Pawar<sup>3</sup>, Anil Shelar<sup>4</sup>

U.G. Student, Department of Civil Engineering, Maharashtra Institute of Technology, Pune, India<sup>1</sup>

U.G. Student, Department of Civil Engineering, Maharashtra Institute of Technology, Pune, India<sup>2</sup>

U.G. Student, Department of Civil Engineering, Sinhgad College of Engineering, Pune, India<sup>3</sup>

Professor, Department of Civil Engineering, Cusrow Wadia Institute of Technology, Pune, India<sup>4</sup>

**ABSTRACT:** The world population, today, is growing exponentially. Providing them with suitable shelter involves huge financial investment. Engineers and environmentalist are constantly making new trends in order to optimize this low cost housing construction with minimum money involvement and maximize the benefit for the end consumers. On the other hand, if energy is considered, steel and concrete contains large amount of embodied energy and thus its usage should be efficiently modeled. As a result, the use of steel practically in buildings should be less as much as possible but actual case is different we have tried to compare the actual site happenings with our work and have come to a solution that when possible to certain conditions even mild steel can be used on site as a main component. Further in the paper, we have structurally studied the behavior of mild steel and tor steel individually on the basis of spacing between individual bars and the influential area covered by each bar. Certainly we have come to a conclusion that mild steel can be used in low cost housing as well as in building structures with constraint space in earthquake zone requiring ductility. Certain assumptions were considered while examining the slabs and this theory is based on assumption that on site practices are very casual and the actual steel provided in the slabs is much more than what is actually desired by design to get safe structures.

**KEYWORDS:** Influence Area, Spacing on site, Flexural Strength, Deflection.

## I. INTRODUCTION

**Reinforced concrete:** For a strong, ductile and durable construction the reinforcement needs to have the following properties at least like high relative strength, high toleration of tensile strain, and good bond to the concrete, irrespective of pH, moisture, and similar factors. Also thermal compatibility, not causing unacceptable stresses in response to changing temperatures and durability in the concrete environment, irrespective of corrosion.

### **Property of mild steel compare to the tor steel:**

Mild steel reinforcement is type of steel in which carbon content is very low compared to tor steel. The main property of mild steel is it has more elasticity and has more ductility. Elasticity means property by virtue of which a material deformed under the load and can regain its original dimension back after the removal of load. Ductility means ability of material to be drawn out longitudinally to a reduced section without fracture under the action of tensile forces.

### **Influence area**

Every reinforcement bar has its own influence area. The concrete which comes within influence area has ability to resist against the development of these micro cracks due to the temperature variation shrinkage of concrete. The concrete in the influence area also has property to resist tensile stress (in some amount), flexural stress and specially shear stress. The transfer of this property of the steel to the concrete is up to its influence area. The surrounding area of

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

steel reinforcement covered with the concrete has ability to resist development of micro-crack due to shrinkage and temperature variation which is called as the reinforcement influence area.

## Shape of influence area

The shape of influence area depends upon the shape of the steel reinforcement. Usually the shape of influence area is circular because the shape of the reinforcement is circular. But in the case of the tor 415 and tor 500 there is special arrangement for greater friction called ribs may change the shape of influence area. The shape of influence area also depends upon the homogeneity of concrete. If the concrete is properly mixed the shape of influence area may change.

## Size of the influence area

The size of influence area depends upon the density and diameter of the reinforcement bar and also it depends upon the ribs arrangement on the surface of the reinforcement bar. It also depends upon the quality, which is grade of the concrete and the homogeneity of the concrete.

## Influence area in the slabs

Below the adjacent influence area of the reinforcement does not coincide with each other. In this diagram the concrete area between the adjacent influence area does not have any strength to resist the development of the crack due to temperature variation and shrinkage of the crack during initial hardening of the concrete. These initial micro-cracks due to the temperature variation and shrinkage of concrete open up and propagate and lead to the major crack in the concrete system after loading on the concrete.

## Actual provision of spacing in the site

The structural slab is designed by the Limit state method of design. In which, slab is designed by taking into consideration the required load and other requirements, spacing is calculated. Let's call this spacing as designed spacing which is calculated by the limit state method of design. But the designed spacing is sometimes more than 300mm which is not sufficient to fulfill the requirement of overlapping the influence area of adjacent reinforcement bars, Hence the designer choose the spacing which have the sufficient overlapping of the influence area of adjacent reinforcing bar. But provision of less spacing of designed diameter bar increases the area of steel in section which will lead to the uneconomical section. This reduction in the spacing reduces cracking due to temperature variation and shrinkage cracking in the concrete section but makes it over reinforced section increasing the load carrying capacity of section over its requirement.

Therefore for construction of one way slab using the mild steel as main steel and its effects on strength and capital wise optimization is our main topic of interest. Proving the use of mild as main consists of designing and comparing it from the tor steel. We have specifically tested the prototype of 3 slabs consisting of three different spacing of main steel reinforcement bars and 2 slabs reinforced with tor steel Fe500 and the last one reinforced with mild steel, using threepoint loading on Universal Testing Machine (UTM).

## II. METHODOLOGY

### Slab 1:

The mould was prepared according to the required dimensions needed and then we further moved towards the final preparation of the mould. As concrete would have stuck to the mould after curing we decided to provide a polyvinyl chloride cloth over the base and also over the vertical planks. Then we oiled the PVC cloth and sides for prevention of water seepage. After that we prepared the reinforcement arrangement according to the design. We provided 8# bar in longer direction and 6Ø in shorter direction. We made a reinforcement mesh with 8# bar parallel in longer direction and mild steel transverse to it. We provided main steel bar exactly in the center of the width of the slab prototype and mild steel at 200 mm c/c in the slab prototype. We placed the reinforcement mesh exactly in the mould over the cover blocks. Slab 1 measure  $1.5m * 0.22m * 0.95m$ .

### Slab 2:

The method of slab 2 is same as that for slab 1 mentioned above. Slab 2 measured  $1.5m * 0.15m * 0.11m$ . We provided 8# bar in longer direction and 6Ø in shorter direction. We made a reinforcement mesh with 8# bar parallel in longer direction and mild steel transverse to it. We provided main steel bar exactly in the center of the width of the slab prototype and provided mild steel at 150 mm c/c in the slab prototype. We placed the reinforcement mesh exactly in the mould over the cover blocks.

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017



**Fig (D) Mould preparation for slab 2  
with reinforcement details.**

### Slab 3:

The method of slab 3 is same as that for slab 1 mentioned above. Slab 3 measured  $1.5m * 0.16m * 0.09m$ . We provided 6# bar in longer direction and 6Ø in shorter direction. We made a reinforcement mesh with 6# bar parallel in longer direction and mild steel transverse to it. We provided main steel bar exactly in the center of the width of the slab prototype and provided mild steel at 160 mm c/c in the slab prototype. We placed the reinforcement mesh exactly in the mould over the cover blocks.



**Fig (E) Reinforcement detail for Slab 3**

### III. EXPERIMENTAL WORK

#### Slab 1 testing:

On the day of testing, the markings were done on the slab that is the effective length/span was divided in three equal parts at 40cm each. An assembly of load plate was prepared which was to impart a three point load to the slab. The load plate rested on the middle section of the slab. Also a deflection measuring device was fitted in the middle section of the slab to measure the deflection of the slab. The least count of the device was 0.01 mm. The load was imparted by the UTM to the Plate load assembly further to the slab. Around 4 to 5 Kilo-newton load, a crack was seen in the concrete on the bottom surface of the slab which was exactly 46 cm away from the edge. After the cracked load the further load was taken by the Reinforcement steel.

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017



**Fig (E) Three point Loading Assembly**

From the observed graph on UTM the Ultimate load is **11.60 KN**.  
Also from the observations the Concrete cracking load lies in between 4KN and 5KN.  
**So from interpolation the exact Cracking Load = 4.74KN**

### **Slab 2 testing:**

On the day of testing, the markings were done on the slab that is the effective length/span was divided in three equal parts at 40cm each. An assembly of load plate was prepared which was to impart a two point load to the slab. The load plate rested on the middle section of the slab. Also a deflection measuring device was fitted in the middle section of the slab to measure the deflection of the slab. The least count of the device was 0.01 mm. The load was imparted by the UTM to the Plate load assembly further to the slab. Around 5 to 6 Kilo-newton load, a crack was seen in the concrete on the bottom surface of the slab which was exactly 43.5 cm away from the edge. After the load obtained at cracking the further load was taken by the Reinforcement steel.

From the observed graph on UTM the Ultimate load is **14.90 KN**.  
Also from the observations the Concrete cracking load lies in between 5 KN and 6 KN.  
**So from interpolation the exact Cracking Load = 5.83 KN**

### **Slab 3 testing:**

On the day of testing, the markings were done on the slab that is the effective length/span was divided in three equal parts at 40cm each. An assembly of load plate was prepared which was to impart a two point load to the slab. The load plate rested on the middle section of the slab. Also a deflection measuring device was fitted in the middle section of the slab to measure the deflection of the slab. The least count of the device was 0.01 mm. The load was imparted by the UTM to the Plate load assembly further to the slab. Around 5 to 6 Kilo-newton load, a crack was seen in the concrete on the bottom surface of the slab which was exactly 19 cm away from the left side of inner assembly marked edge. After the cracked load the further load was taken by the Reinforcement steel.

From the observed graph on UTM the Ultimate load is **9.90 KN**.  
Also from the observations the Concrete cracking load lies in between 5 KN and 6 KN.  
**So from interpolation the exact Cracking Load = 5.35 KN**

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

### IV. EXPERIMENTAL RESULTS

#### Performance Verification in the Context of Limit State of Collapse - Flexure

Slab No.		I	II	III
Span in m		1.2	1.2	1.2
Width In m		0.220	0.150	0.160
Cover in mm	Required	30	30	30
	Adopted	25	25	25
Depth in m	Overall	0.095	0.116	0.102
	Effective	0.066	0.087	0.069
Live Load in kN/m <sup>2</sup>		2	2	2
BM in kN.m at Design		0.385	0.385	0.385
Steel	Grade Fe	500	500	250
	Area Required	132 mm <sup>2</sup> /m width	132 mm <sup>2</sup> /m width	330 mm <sup>2</sup> /m width
	Area Provided	227 mm <sup>2</sup> /m width (42 % more than required)	333 mm <sup>2</sup> /m width (60 % more than required)	350 mm <sup>2</sup> /m width (6 % more than required)
	Wt. per m width per m length in kg	1.78	2.75	2.85
Adopted Bar Dia. in mm		8	8	6
Pitch in mm c/c	Design	438	438	85
	Max. Allowed	228	228	208
	Adopted	220 (50 % less than design)	150 (66 % less than design)	80 (Almost same as design)
Expected MR in kN.m		1.330	1.75	0.814
MR in kN.m at Failure		0.950	1.12	0.802
Remark		MR at Failure is 60 % More than Design BM and 29 % less than expected MR	MR at Failure is 66 % More than Design BM and 36 % less than expected MR	MR at Failure is 52 % More than Design BM and 1.5 % less than expected MR

#### Performance Verification in the Context of Serviceability - Deflection

Sr. No.	Slab pitch/width	Permissible short term deflection	Actual Deflection in Slab	Remark
1.	220mm	3.24mm	0.47mm (85 % less than permissible)	OK
2.	150mm	2.34mm	2.0mm (15 % less than permissible)	OK
3.	160mm	3.43mm	1.375mm (60 % less than permissible)	OK



# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

## Remarks:

As per the calculations and results of the all three prototype of slabs we came to the conclusion that the MR generated by the all the three slabs is greater than the factored Max Mu for that respective slab prototypes. This proved that the design done for the slab prototype for each of them respectively gave out proper results, the only thing which worked negatively was they failed to achieve the MR expected from them which was worked out by the beam analogy method; each bar and its influential section was considered as a single beam and the check was placed.

## Project Point of view:-

- The mild steel proved efficient for the load for which it was designed as well as beneficial as compared to the slab prototype having 8# main reinforcement and spacing adopted between the main steel bars was provided with respect to the original spacing i.e. the theoretical spacing so obtained.
- The short term deflection generated by the mild steel slab prototype is much less than the permissible and comparing it with the tor steel 2<sup>nd</sup> slab prototype the deflection produced is much less thus proving to be suitable from short term deflection characteristic.

## CASE STUDY

Case study for a slab considering width 1m, to calculate amount of steel (kg) per meter width with use of tor 8 bars vs mild 6 bars

### A. Structural Case Study

1. Slab 1 having volume 1.5m\*0.22m\*0.95m with provision of tor 8 bars.  
Adopted pitch = 220 mm  
No of bars = 1000/220 = 5 bars per meter width of prototype.  
$$\text{Kg/m width} = \frac{5 \times 50 \times 1000 \times 7850}{10^9} = 1.78 \text{ kg/ m width}$$
2. Slab 2 having volume 1.5m\*0.15m\*0.116m with provision of tor 8 bars.  
Adopted pitch = 150 mm  
No of bars = 1000/150 = 7 bars per meter width of prototype  
$$\text{Kg/m width} = \frac{7 \times 50 \times 1000 \times 7850}{10^9} = 2.75 \text{ kg/ m width}$$
3. Slab 3 having volume 1.5m\*0.16m\*0.102m with provision of mild 6 bars.  
Adopted pitch = 80 mm  
No of bars = 1000/80 = 13 bars per meter width of prototype  
$$\text{Kg/m width} = \frac{13 \times 28 \times 1000 \times 7850}{10^9} = 2.85 \text{ kg/ m width}$$

Thus from the above examples we can see that Slab number 2 and slab number 3 almost require same amount of steel but as pitch is reduced bars come close to each other improving the influence area and resistance to cracking. Because more ductility is imparted to the structure as mild steel possesses greater elasticity than tor steel. More ductile material spreads in more distributed way.

### B. Cost Analysis Case Study

1. In slab 2, requirement = 2.75 kg/m  
Cost of tor steel per kg = Rs.40  
Thus requirement = 2.75\*40 =Rs. 110/m
2. In slab 3, requirement = 2.85 kg/m  
Cost of mild steel per kg = Rs.39  
Thus requirement = 2.85\*39 = Rs.111.15/m

Therefore the above costs showcase that mild 6 bars exceed cost by rupee 1.15, which is negligent. But at same time mild 6 bars prove to be more structurally adequate. And further research proves that in Continuous support condition, tor steel bar requirement exceed cost over mild steel bars. This analysis is done under simply supported conditions.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

## V. CONCLUSION

From scientific point of view elasticity of mild reinforcement is more compared to tor reinforcement so that use of mild steel in the slab can act as a seismic pulse resister and behave as earth quake resistant structure. Increase in the carbon content in the reinforcement reduces the elasticity of the reinforcement but increase the stiffness with respect to low carbon steel. Use of mild 6 bars compels us to provide them close to each other. Thus more ductile material spreads over more distributed way. Thus resistance to impact load and earthquake load increases. Use of mild reinforcement in the slab reduces the spacing between them according to the design and increase the overlapping of the influence area in concrete which may be used to resist stress in which concrete is weak.

From Economy point of view construction Industry needs a reformation at the basic level. Our concept and idea gained an impetus when the requirements and qualities served by mild steel were almost the same compared to tor steel. According to our observations for simply supported conditions the weight required for mild 6 per meter length almost equals the requirement for tor 8 whereas structurally mild 6 bars dominate over tor 8 bars. As our project suffices almost each and every aspect from structural and financial point of view this research paper can be adopted on construction sites which completely stands alone as a new concept in the market. Our project focuses on the application of this structural concept to the every Low cost housing project in and around India. Our project will be beneficial to all the Government projects (affordable housing schemes). It can always be related to the Management concept, “*a mere saving in money, when agglomerated, makes a huge difference to the Project Budget*”.

## REFERENCES

### 1) Books: -

- [1] Dr. B. C. Punmia, Er. Ashok Kr. Jain, & Dr. Arun Kumar Jain: *Reinforced Concrete structures Vol.1, Seventh edition 1990.*
- [2] M. S. Shetty (1982) : *Concrete Technology(Theory and Practice)*
- [3] O. P. Jain, & Jain Krishna (2008): *Plain and Reinforced concrete (Vol.1)*
- [4] P.C.Varghese (2008): *Limit State Design of Reinforced Concrete.*
- [5] Dr. S.R Karve, & Dr. V.L Shah, Fourth Edition 1995: *Limit state theory and design of Reinforced Concrete (I.S. 456 – 2000)*
- [6] I.C.Syal, & A.K.Goel (2007): *Reinforced Concrete Structures.*
- [7] American Concrete Institute (2004): *Guide for Concrete floor and slab construction, ACI Committee 302.*

### 2) Standards referred:

- [1] \_\_\_\_\_ *Concrete Mix Proportioning – Guidelines, IS 10262:2009, First revision, Bureau of Indian Standards, New Delhi.*
- [2] \_\_\_\_\_ *Handbook on Concrete Mixes – Based on Indian Standards, First Published March 1983, SP 23:1982, Bureau of Indian Standards 1990.*
- [3] \_\_\_\_\_ *Plain and reinforced concrete – Code of practice, IS 456, Fourth revision, September 2000, Bureau of Indian Standards, New Delhi.*

### 3) Papers:-

- [1] Séblin. B, Jahazeeah Y, Sujeebun, S Manohar, Wong Ky. B 2- *Material Science- MECH 2104.*
- [2] Prabir C, Basu, Shylamoni P, & Roshan A. D.- *Characterisation of steel reinforcement for RC structures: An overview and related issues.*
- [3] Cullen M. Moleejane, Kazeem O. Sanusi ,Member, IAENG, Olukayode L. Ayodele, Graeme J. Oliver: *Microstructural Features and Mechanical Behavior of Unalloyed Medium Carbon Steel (EN8 Steel) after Subsequent Heat Treatmen.* Proceedings of the World Congress on Engineering and Computer Science 2014 Vol II WCECS 2014, 22-24 October, 2014, San Francisco, USA.
- [4] ISF - RWTH-Aachen: *Classification of Steels, Welding of Mild Steels.*
- [5] Prof. S.R Satish Kumar, & A.R Santha Kumar: *Properties of steel,* Indian Institute of Technology, Madras.