International Journal of Emerging Technologies in Engineering Research (IJETER)
Volume 4, Issue 12, December (2016) www.ijeter.everscience.org

# Effect of Swimmer Bars on Reinforced Concrete Beams

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**Abstract – Shear failure of reinforced concrete beams is usually sudden, occur without sufficient advanced warning. This type of shear failure is considered to be high risk type of failure. The cost and safety of shear reinforcement in reinforced concrete beams led to the study of other alternatives. Designers try to avoid the shear mode of failure when designing reinforced concrete beam due to the sudden nature of shear failure. Swimmer bar system is a new type of shear reinforcement. It is a small inclined bar, with its both ends bent horizontally for a short distance and welded to both top and bottom flexural steel reinforcement. Regardless of the number of swimmer bars used in each inclined plane, the swimmer bars from plane-crack interceptor system instead of bar-crack interceptor system when stirrups are used. Test results of reinforced concrete beams will be presented. The effectiveness of the new swimmer bar system as related to the old stirrup system will be discussed. Beam deformation is also measured in the laboratory.**

**Index Terms – Swimmer bars, deflection, shear, crack, stirrup.**

## 1. INTRODUCTION

Beams are common members in reinforced concrete structures. Several types of beams can be used in the same structure. Reinforced concrete beams can also take unlimited number of different shapes.

In case of beams tensile stresses are induced in bottom layers because of positive bending moment . Hence main bars are provided at bottom of the beam . All the tensile stresses are assumed to be taken care by reinforcement provided . The tensile strength of concrete is neglected in design process . The balanced section is obtained when strains in steel and concrete reach their maximum limits .

In case of under reinforced beam , the term under reinforced refers to the section in which steel provided is lesser than that of balanced section , Under reinforced sections are generally weak in tensile stresses .In these sections concrete does not reach its maximum strain limits, whereas the reinforcement steel provided reaches its maximum limits. In these type of sections the neutral axis shifts upwards to maintain equilibrium.

As steel reaches its maximum yield stress, the section failure is initiated at this stage .But under reinforced concrete beams generally give a warning of impending failure by the following signs. In the first stage the beam undergoes substantial deflection but it does not effect the properties of the beam .In the second stage the beams undergo excessive cracking of concrete under the bottom reinforcement i.e., the cover provided at the bottom falls off due to the reinforcement provided above it reaches its maximum strain limits .

The over reinforced sections however is avoided because , these sections does not show any sign before failure .In these sections when concrete reaches its ultimate strain value before reinforcement steel provided reaches its yield value . In this case neutral axis shifts downward to maintain equilibrium. Sudden failure occurs without giving any warning by crushing of concrete. Hence IS code always recommends to avoid over reinforced sections.

In beams the combination of shear and bending stresses lead to introduction of principle stresses which impose diagonal tensions in the beam section. Thus Bending is generally accompanied by shear. Practically shear failures are difficult to predict. Retrofitting of RCC beams with multiple shear cracks is not considered an option (AL-Nasra and Wang,1994) for the failure of beams. RCC beams must have adequate resistance against bending and shear stresses so that the performance of the beam is effective and much safer in the long run. To ensure adequate safety against these shear stresses shear reinforcement is to be provided. At the ultimate limit state, the combined effects of bending and shear may exceed the resistance capacity of the beam causing tensile cracks. The shear failure is difficult to predict accurately despite extensive experimental research.

The longitudinal bars do not provide any resistance to diagonal tension failure. Generally concrete has the capacity to resist shear , however this depends on grade of concrete and area of steel provided for the section .

These diagonal tensile stresses resulting by combination of shear and bending is responsible for cracks. These cracks in further stages are responsible for failure of beams. Generally the inclined shear cracks occur from middle height near support of beams at an inclination of around 45˚ and these cracks extend upto the compression zone of the beam. When Provision of effective shear reinforcement intersects these diagonal cracks, it can minimse resist these shear forces to a particular limit. To resist these cracks shear reinforcement is provided generally in the form of vertical stirrups, bent-up bars generally inclined at 45˚ or the combination of both bent-up bars .

Stirrups are most commonly used as shear reinforcement , as stirrups provide ease while installation these facing between stirrups depends on shear forces induced in the beam. As the space between stirrups decreases at supports , congestion is likely to occur which results in cost increase and the time taken for casting is also increased. Generally stirrups are provided as two-legged , four-legged , multy-legged types . Stirrup is bent round the tensile reinforcement and is anchored to hanger bars, which keep the stirrups in position .

Bent-up bars also longitudinal bars, which are bent-up near the support. These bars take care of bending moments occurring at the mid span along with other longitudinal bars. And also as these bars are diagonally bent-up near the support they also take care of diagonal tension which is the main reason for occurrence of cracks. The main defect of bent-up bars is the difficulty while installation, and also bent-up bars cannot be provided in smaller beams where lesser number of bars are provided.

## 2. SWIMMER BARS

A swimmer bar can be defined as an inclined bar provided to take care of shear with its both ends welded or anchored to the top and bottom longitudinal bars. The welded swimmer bars are traditionally used for decreasing the shear failure in beam or reduces the cracks and increasing the load bearing capacity. The various types of swimmer bars are given below.

**Advantages of swimmer bars are**

- Beams reinforced with swimmer bars systems add stiffness to the reinforced concrete beams and improves it load carrying capacity.
- Swimmer bars are increase in strength compared with the traditional stirrups beam.
- The beam which is reinforced by, which is considered substantial improvement given that the same amount of steel is used for both beams.
- Defflection is reduced than compared with normal stirrups.
- Crack widths are highly reduced compared to normal beams.
- Capacity of resisting the occurrence of Shear cracks are decreased.

**TYPES OF SWIMMER BARS**

A swimmer bar can be defined as an inclined bar provided to take care of shear with its both ends welded or anchored to the top and bottom longitudinal bars.

Swimmer bars are generally of three types

1. Singleswimmerbar system.
2. Rectangular swimmer bar system .
3. Rectangular swimmer bar system with cross-bracings.

Several explorations are introduced in the field of swimmer bars recently, the addition of stiffness in the rectangular swimmer bar system is also introduced. For larger and complex beams the rectangular swimmer bar system is divided in to smaller rectangles i.e., a rectangle swimmer bars is divided in multiple rectangular swimmer bar system by addition of horizontal and vertical bars.

The swimmer bar system is an integral part of longitudinal steel bars at top and bottom. The main purpose of swimmer bar system is to increase resistance to shear in the RCC beams, decrease the formation of cracks, crack width , length of cracks, their by reducing the deflection of beam.

**Single swimmer bar system.**

**Rectangle swimmer bar system.**

**Rectangular swimmer bar system with cross bracings.**

## 3. AMERICA CONCRETE INSTITUTE (ACI) CODE PROVISION FOR SHEAR DESIGN

According to the ACI code (2011) , the design of beams for shear is to be based on the following relation:

(1)Vu = øVn

Where: Vu is the total shear force appled at a given section of the beam due to factored loads and Vu = Vc + Vs is the nominal shear strength, equal to the sum of the contribution of the concrete and the web steek if present. Thus for certical stirrups.

(2)Vu ≤ ø Vc+(ø Av fyc d/S)

And for inclined bars

(3)Vu= ø Vc + ø Av Fyc d ( sin∞+cos∞ )/S

Where : Av is the area of one stirrup, $\alpha$ is the angle of stirrups with the horizontal, and S is the stirrup spacing.

The nominal shear strength contribution of the concrete (including the contribution from aggregate interlock, dowel action of the main reinforcing bars, and that of the un-cracked concrete) can be simplified as shown in Equation 4.

(4)Vu=0.17λ√$\sqrt{fc}$bw d

Where: bw and d are the section dimensions, and for normal weight concrete,

λ=1.0. This simplified formula is permitted by the ACI code expressed in metric units.

## 4. OBJECTIVES OF THE STUDY

The Defflection and Shear cracks of beams for 28 days is find out and compared with traditional RCC beams of different mix proportions.

From detailed literature review in chapter-2 the following points are evident:

**General:**

- From detailed literature review in chapter the following points are evident:
- The use of swimmer bars is necessitated in beam reinforcement to achieve better results.
- By using swimmer bars as a replacement of stirrups in beam reinforcement we can reduce the shear failure in beams.
- The stiffness of beam increases by using swimmer bars.
- It also efficiently takes care of deflections in beam due to applied loads.
- The cracks widths due to shear failure in beams can be rapidely decreases by using swimmer bars.

**Scope and objective:**

The objective of the work are stated below

- ❖ The objectives of the work are stated below
- ❖ To develop more stiffer reinforcement for beams.
- ❖ To evaluate shear failure of beams , shear failure test has been carriedout at 28 days test.
- ❖ To study the deflection on beam load deflection test has been carriedoutans results are recorded.
- ❖ To determined shear failure by recording the cracks widths when different load is applied.

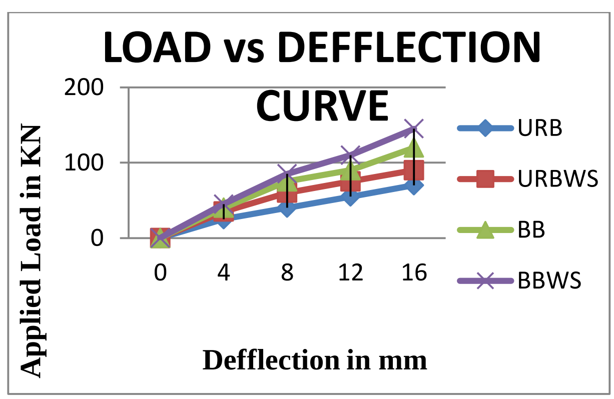
**CONCRETE MIX DESIGN**

Table. Mix proportions for M30 grade concrete

| Water | Cement | Fine agg. | Coarse agg. |
|---|---|---|---|
| 160 lit | 400kg | 710.6kg | 1280.6kg |
| 0.45 | 1 | 1.87 | 3.37 |

Hence the mix is 1:1.87:3.37 (Designed for M30)

## 5. EXPERIMENTAL RESULTS




Defflection of Beams for M30

## 6. CONCLUSION

1. The Beams are reinforced by welded Swimmer bars showed 25% increase in strength compare with the traditional normal stirrups beam, It is considered substantial improvement given that the same amount of steel is used for both type of beams.
2. Also the deflection is reduced by 14%, at the same time the number of shear cracks were less, and the widths of these cracks were slight less.
3. Beams is Reinforced with welded swimmer bar system and its add stiffness to the specimens and it improves load carrying capacity.
4. The new welded swimmer bar system can be at a great advantages than the traditional stirrups are less , and size of the cracks are slightly less.
5. The stiffness and strength increases with increase in grade of concrete.
6. With the increase in grade of concrete, the deflection decreased.
7. Effect of swimmer bars is similar to all grades of concrete.
8. Hence with lesser area for shear reinforcement in the form of welded swimmer bars , the depth can be reduce and shear strength can be increased ,Which reduces the cost of shear reinforcement.

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