# Effect Of Longitudinal Reinforcement On Shear Strength Of High Strength Concrete - Fracture Mechanics

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***Abstract-*** *Over the last decades, a great number of experimental campaigns on the behaviour of high- and normal-strength reinforced concrete beams without shear reinforcement failing in shear have been published, and some excellent rational models to explain the physical phenomena have been developed. However, their implementation into design codes still requires considerable simplification. With the aim of taking into account this large amount of information available and to re-evaluate the current codes of practice extensive research was performed. An artificial neural network was developed to predict the shear strength of reinforced beams and, based on its results, a parametric study was carried out to determine the influence of each parameter affecting the failure shear strength of beams without web reinforcement. Finally, new simple expressions are proposed for the design of high-strength and normal-strength reinforced concrete beams without shear reinforcement. The new expressions correlate with the empirical tests better than any current code of practice does.*

## I. INTRODUCTION

Fracture is a problem that society has faced for as long as there have been man-made structures. The problem may actually be worse today than in previous centuries, because more can go wrong in our complex technological society. Major airline crashes, for instance, would not be possible without modern aerospace technology. Fortunately, advances in the field of fracture mechanics have helped to offset some of the potential dangers posed by increasing technologicalcomplexity. Our understanding of how materials fail and our ability to prevent such failures has increased considerably however, and existing knowledge of fracture mechanics is not always applied when appropriate.Recently in cities many superstructures are built on large and tall scales. High strength concrete has been used as a primary building material. The fracture property of a reinforced concrete member has been studied by many researchers from those results although shear fracture is complicated. The fracture mechanics was clarified and the design equation was sufficiently accurate .The flexural behaviour of reinforced concrete (RC) members has been well understood such that their flexural strengths are predicted with reasonable accuracy over a wide range of cases by contrast, it is difficult to predict the shear strengths of RC members accurately due to the uncertainties in the shear transfer mechanism, especially after cracks are initiated. For more accurate prediction of the shear strengths, many sophisticated approaches have been proposed based on mechanical or physical models of structural behaviour/failure, fracture mechanics, and nonlinear finite element analyses. The constant and variable angle truss models are known to provide reliable bases and to give reasonable results for the shear strengths of members with shear reinforcement.

## II. LITERATURE REVIEW

*Reference [2]* conducted experiment on shear capacity equations for rectangular reinforced concrete beams. They studied the effect of three variables (fc’, ρ and a/d).In the present study beams were cast in steel forms with the tension reinforcement near the bottom. No shear reinforcement are provided in the beams. Beams were tested as simply supported in a reaction frame and load was applied with the help of manually operated hydraulic jack. They concluded that According to ACI contribution of fc’ is about 80 to 90 % of the total shear before any cracking is observed, which is against the Kani's as well as our experimental research. Residual shear strength of a beam after shear cracking remains constant as a/d is decreased upto 2.5, then it increases rapidly as a/d is further decreased below 2.5 showing minimum capacity at a/d = 2.5.

*Reference [3]*.Conducted experiment to predict the shear strengths of reinforced concrete beams, many deterministic models have been developed based on rules of mechanics and on experimental test results. While the constant and variable angle truss models are known to provide reliable bases and to give reasonable predictions for the shear strengths of members with shear reinforcement, in the case of members without shear reinforcement, even advanced models with complicated procedures may show lack of accuracy or read to fairly different predictions from other similar models. For this reason, many research efforts have been made for more accurate predictions, which resulted in important recent publications. This paper develops probabilistic shear strength models for reinforced concrete beams without shear reinforcementbased on deterministic shear strength models, understanding of shear transfer mechanisms and influential parameters, and experimental test results reported in the literature. Using a Bayesian parameter estimation method,the biases of base deterministic models are identified as algebraic functions of input parameters and the errors of the developed models remaining after the bias-correction are quantified in a stochastic manner. The proposed probabilistic models predict the shear strengths with improved accuracy and help incorporate the model uncertainties into vulnerability estimations and risk-quantified designs.

*Reference [4]* investigated forcommon floor structural systems used in the Middle East are reinforced concrete hollow block slab with shallow wide beams (hidden beams).

*Reference [5]* Researched to predictthe shear strength of high strength concrete beams (70 Mpa) with different shear span to depth ratios (a/d = 1, 2, 3 and 4) without web reinforcement.

## III. PROBLEM DEFINITION

From the literature study it is seen that most of the work is conducted on fracture which occurs due to shear of reinforced concrete. As increase in shear stress which causes increase in length and width of crack, and also changes the path of crack. To estimate the shear resistance of beams, standard codes and researchers all over the world have specified different formulae considering different parameters into consideration. The parameters considered are varying of different codes and researches, making it difficult to choose an appropriate model or code for predicting shear resistance of reinforced concrete. So there is need to prepare appropriate solution for determining shear capacity.

1. 1. To estimate the shear resistance of beams, standard codes and researchers all over the world have specified different formulae considering different parameters into consideration. Making it difficult to choose an appropriate model or code for predicting shear resistance of reinforced concrete. So there is need to prepare appropriate solution for determining shear capacity.
2. To study the shear behaviour of high strength concrete beam without shear reinforcement with reference to the effect of longitudinal reinforcement ratio ‘ρ’.
3. Evaluation of energy equations applied to shear strength of high strength concrete.

## IV. EXPERIMENTAL PROGRAM

### 4.1. Material used:

In this, the OPC-53 grade cement is used the properties by experimentally as follows:

Table1 Physical Properties Of Cement

| Sr. No. | Properties | Value | Requirement as per IS-12269-1987 |
|---|---|---|---|
| 1 | Standard Consistency | 26% | 28% |
| 2 | Fineness | 4% | ≤10% |
| 3 | Initial setting time | 65 | ≥30 minutes |

The properties of coarse-aggregate used,

Table2 Physical Properties Of Coarse Aggregate

| Sr. No. | Properties | Value | |
|---|---|---|---|
| | | 10 mm | 20mm |
| 1 | Surface Texture | Crystalline | |
| 2 | Particle shape | Angular | |
| 3 | Specific gravity | 2.70 | 2.72 |
| 4 | Water absorption | 2.84% | 2.68% |
| 5 | Crushing value | 13.20% | 12.72% |

The properties of fine-aggregate used,

Table3 Physical Properties Of Fine Aggregate

| Sr.No. | Properties | Value |
|---|---|---|
| 1 | Type | Natural |
| 2 | Surface Texture | |
| 3 | Specific gravity | 2.64 |
| 4 | Water absorption | 2.98% |
| 5 | Moisture content | 10.36% |

The properties of admixture (MasterGlenium SKY 8276) used,

Table 4 Physical Properties Of Admixture

| Sr. No. | properties | value |
|---|---|---|
| 1 | Aspect | Light brown liquid |
| 2 | Relative Density | 1.12*0.02 at 25 |
| 3 | pH | *6 |
| 4 | Chloride ion content | *.2% |
| 5 | Specific gravity | 1.12 |

### 4.2. Mixture proportion:

The different mix proportion of concrete with various grades of high strength concrete contain:

Table 5 The Quantity Of Material For $1m^3$high Strength Concrete

| Ingredients | M50 | M60 |
|---|---|---|
| w/c content | 0.31 | 0.27 |
| Cement(kg/m3) | 447.1 kg | 515.8 kg |
| Fine-aggregate (kg/m3) | 768.1 kg | 746.76 kg |
| course-aggregate (kg/m3) | 1085.76 kg | 1055.6 kg |
| Water content | 134.12 kg | 134.12 kg |
| admixture solution | 4.47 kg | 5.15 kg |

### 4.3 Specimen details:

Tests were carried out on 24 beams, simply supported under two point loading. All the beams had constant cross section details in following table. The length of beam will be worked out to be 0.7m, for corresponding A/d ratio &Longitudinal Reinf. (ρ%) = 1, 1.5,2 & 2.5 Respectively. Beams were provided with HYSD bars as longitudinal reinforcement to avoid any possible failure by flexure and the grade of concrete will be M50 and M60 which is high strength concrete. The percentage of steel kept constant.

Table 6 Details Of Casting Specimens

| A/d | Longitudinal Reinf. (ρ%) | Beam Size | Grade of Concrete | | Speci-men |
|---|---|---|---|---|---|
| 1 | 1.0 | 150×150×700 | 50 | 60 | 6 |
| | 1.5 | 150×150×700 | 50 | 60 | 6 |
| | 2.0 | 150×150×700 | 50 | 60 | 6 |
| | 2.5 | 150×150×700 | 50 | 60 | 6 |

## V. RESULTS AND DISSCUSION

Table 7 Experimental Results Of Shear Stress

| A/d ratio | Longitudinal Reinf. (ρ%) | Experimental results Shear stress (N/mm2) For M50 | Experimental results Shear stress (N/mm2) For M60 |
|---|---|---|---|
| 1 | 1 | 6.44 | 7.23 |
| | 1 | 6.14 | 7.1 |
| | 1 | 6.23 | 7.06 |
| | 1.5 | 9.22 | 10.33 |
| | 1.5 | 9.37 | 10.77 |
| | 1.5 | 9.61 | 10.51 |
| | 2.0 | 10.36 | 11.47 |
| | 2.0 | 10.95 | 11.19 |
| | 2.0 | 10.66 | 11.13 |
| | 2.5 | 11.31 | 12.05 |
| | 2.5 | 11.67 | 11.88 |
| | 2.5 | 11.50 | 12.12 |

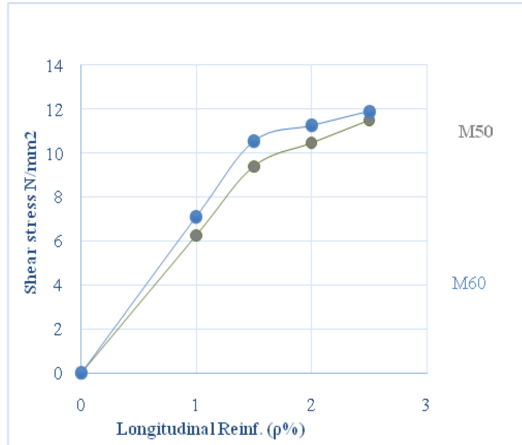


Fig. 1 Longitudinal Reinf. (P%) Vs Shear Stress N/Mm2 For M50 And M60

The variation of Longitudinal Reinf. with Experimental results Shear stress of HSC beams designed for M50 and M60 using Fe500 grade of steels without shear reinforcement for ρ%= 1, 1.5, 2, and 2.5 are shown in Table 23 which indicate the increase Longitudinal Reinf. has shown increment in shear capacity of the beam. The shear capacity increased with ρ% which signify that at lower ρ% i.e., up to 2 for M50 and M60 and above ρ% =2 shear capacity of beams for M60 is not satisfactory. At lower ρ% (up to 1.5), the failure was observed to be sudden compared to failure pattern observed for higher ρ% (2 to 2.5).

According to the Griffith theory equation,

$$V_c=0.446/\sqrt{H}(\sqrt{(Es/Ec)})\,(H/As)(1/3)\rho(1/6)(1-\sqrt{\rho})(2/3)\ \text{КПСbH}\ldots\ldots\ldots(1)$$

Above equation states that, shear capacity of beams is inversely proportional to the depth of beams and directly proportional to modular ratio, longitudinal reinforcement, fracture toughness.

From our experimentation, we are observing that shear capacity of beams is mainly depend upon a/d ratio, longitudinal reinforcement and grade of concrete.so by considering these parameters.

The term (H/As) can be neglected as in this experiment we have kept shear span to depth ratio (a/d) constant. So in above formula we can replaced (H/As)(1/3) term andkeeping modular ratio same, the equation can be modified as,

$$\tau_c= 0.8/\sqrt{H}\sqrt{Es/Ec}\,.\rho(1/6)(1-\sqrt{\rho})(2/3)\ .\text{КПС}\ldots\ldots(2)$$

Table 8 Exp & Eq Values Of Shear Stress For Longitudinal Reinf.(P%)=1,1.5,2,2.

| Shear stress N/mm2 | | | |
|---|---|---|---|
| M50 | | M60 | |
| EXP | EQN | EXP | EQN |
| 6.27 | 7.26 | 7.45 | 7.69 |
| 9.4 | 10.39 | 10.54 | 11.008 |
| 10.46 | 10.88 | 11.89 | 11.52 |
| 11.49 | 11.6 | 12.5 | 12.05 |

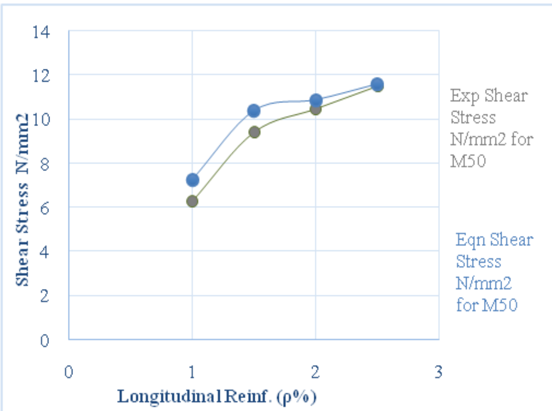


Fig 2 Exp & Eq Values Of Shear Stress For M50

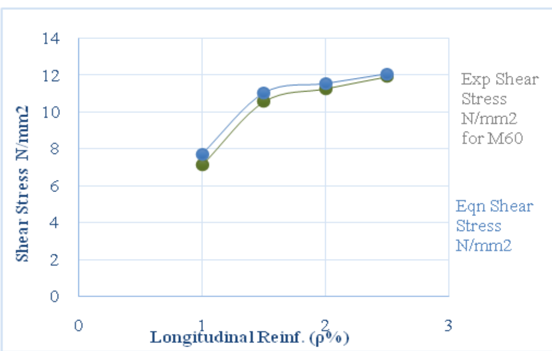


Fig 3 Exp &Eq Values Of Shear Stress For M60

By observing above graph, it is states that experimental values of shear stress is nearby Equation values. Equation (2) satisfies the values of shear stress.so we can say that the modified equation based on Griffith theory can be stated as new empirical equation of shear capacity which based on fracture mechanisms.

## VI. CONCLUSION

1. The shear capacity of beams has been increased with the increase of the longitudinal steel. This fact is well illustrated by ACI code.
2. Grade of concrete, longitudinal reinforcement are the most infusing parameters in the deformational & shear behaviour of HSC beams.
3. The failure of the beams with lower values of longitudinal steel is mainly due to flexure cracks and the shear reinforcement plays no or very little role in improving the shear capacity or restricting the beam failure. Hence the longitudinal steel level may be selected between 1% and 2.5%.
4. The shear capacity of beamswith reinforcement has been decreased with the increase in shear to depth (a/d) ratio but this decrease is not much pronounced in case of beams with longitudinal reinforcement.

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