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PREDICTION OF SHEAR CAPACITY OF CONCRETE BEAMS WITHOUT SHEAR REINFORCEMENT

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ABSTRACT
Shear failure of the concrete beam depends upon various parameters. On the basis of various parameters, numerous studies have been done to assured the actual behaviour of shear failure**.** After a long research still it is controversial regarding the exact shear behaviour of reinforced cement concrete structure elements. This paper deals with the review of available data base and shear models to predict the shear strength of reinforced concrete beams without web reinforcement. An attempt has been made to study shear strength of strength concrete beams with different shear span to depth ratios (a/d = 1, 2 & 3) without web reinforcement and compare the test results with the available shear models. Six shear models for comparison are considered namely, ACI 318-02, Canadian Standard, CEP-FIP Model, ZsuttyEquation,BazantEquationandIndian Code IS 456 2000. The results revealed that the most excellent fit for the test data is provided by Zsutty's Equation and a simplified equation is proposed to predict the shear capacity strength concrete beams without shear reinforcement.

KEYWORDS: shearmodel,shear span to depth ratio(a/d).

INTRODUCTION
Reinforced concrete is being used extensively in the construction industry all over the world. The use of high strength concrete has increased due to its obvious advantages like increased modulus of elasticity, chemical resistance, freeze thaw resistance, lower creep, lower drying shrinkage and lower permeability. The calculation of stresses in concrete is difficult due to its heterogeneous nature and inclusion of reinforcement further complicates the situation. Extensive research work on shear behavior of normal as well as high-strength concrete beams has been carried out all over the world. The major researchers include Ferguson, Taylor, Cossio, Berg, Mathey and Watstein,Zsutty, Kani, Elzanaty*et al*., Roller and Russel, Ahmad and Lue, Barrington, Shin *et al*., Kim and White, Tompos and Frosh, Ahmad *et al.*, Reineck*et al.*, and many more. Despite the extensive research work, shear behavior of high-strength reinforced concrete beams is still controversial and needs further research.

Shear failure of the concrete beam depends upon various parameters. On the basis of various parameters, numerous studies have been done to assured the actual behaviour of shear failure. After a long research still it is controversial regarding the exact shear behaviour of reinforced cement concrete structure elements.Various researchers has been done the experiments on beams without web reinforcement and found the following factors influenced the shear behaviour of beams. The various factors are (i) Shear span to effective depth ratio (a/d) (ii) Longitudinal steel ratio (ρ) (iii) Aggregate type (iv) Strength of concrete (v) Type of Loading (vi) Support conditions. The intention of all the researchers is to find out the accurate judgment of shear failure or justify the shear strength capacity of structure with the most acceptable equation which is derived on the base of their respective experiments.

LITERATURE REVIEW
This section contained the various literature studies on shear behavior and its numerical comparison with other standard code and proposed equation.

Ahmad et al (2011)

Ahmad et al proposed a equation for finding out the shear strength of reinforced concrete normal beams without stirrups. A total of 334 data sets for normal beams without web reinforcement have been extracted from past research .All these 334 cases were reported to have failed in shear. They had a compressive strength in the range of (12.2 MPa≤ fc' ≥ 69 MPa),the shear span to depth ratio, a/d, ranged from (2 to 8.67) and tensile reinforcement ratio (ρw) ranged from (.35 to 6.64 %) .Among from data the equation prepared which is applicable in general loading conditions to find the shear force.

$$Vc = \frac{vc}{bwd} = 1.637(\rho w\ fc')0.35\left(\frac{Vd}{M}\right)0.3\ (MPa)$$

Different models to predict shear capacity

Most well known shear models which are used to calculate shear resistance of beams without web reinforcement are:

a) ACI Equation (318-02)

According to ACI Building Code 318 , the shear strength of concrete members without transverse reinforcement subjected to shear is given two equations. The simplified equation is as follows:

$$Vc = \left(0.16\sqrt{fc} + 17\ Vu\ x \frac{d}{Mu}\right) bw\ x\ d \qquad (For\ a/d \geq 2.5)\ldots\ldots\ldots\ldots (1)$$

$$Vc = \left(3.5 - \frac{2.5Mu}{Vu}\ x\ d\right)\ x\ \ x\ Equation\ 1 \qquad (For\ a/d\ <\ 2.5)\ldots.\ \ldots. (2)$$

Karim et al (2000) have expressed certain imperfection in above equation (1) as it underestimates the effect of shear span to depth ratio on shear resistance.

b) Canadian Equation

According to Canadian Standard , the shear strength of concrete members is given by following equation:

$$Vc = 0.2\sqrt{fc}\ bw\ x\ d\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The Canadian standard has not considered the effect of shear span to depth ratio and longitudinal tension reinforcement effect on shear strength of concrete.

c) Shear design by CEP-FIP model

According to CEP – FIP Model, the shear strength of concrete members is given by following equation:

$$Vc = [0.15\left(\frac{3d}{a}\right)2/3\ \ (1 + \sqrt{200}/d\ \ )x(100p\ fck)2/3\ ]\ bwxd \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The CEP – FIP model as formulated in Eq (3) takes into formula, the size effect and longitudinal steel effect, but still underestimates shear strength of short beams.

d) Shear design by Zsutty equation

Zsutty (1987) has formulated the following equation for shear strength of concrete member

$$Vc = 2.2\ (fc\ p\frac{d}{a})1/3\ \ bw\ x\ d \qquad (For \frac{a}{d} \geq 2.5)\ldots\ldots\ldots\ldots\ldots (5)$$

$$Vc = \left(2.5\frac{d}{a}\right)\ x\ Equation\ 5 \qquad (For \frac{a}{d} \geq 2.5)\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Most of researchers suggested that Zsutty equation is more appropriate and more simple to predict the shear strength of both shorter and long beams as it takes into account size affect and longitudinal steel effect. Sam and Hong(2006) reported that that the Zustty's equation has given the best model amongst the models studied.

e) Shear design by Bazant equation (1987)

Bazant has formulated the following equation for shear strength of concrete members:

$$Vc = \left[0.54\sqrt[3]{p}\left(\sqrt{fc} + 249\sqrt{\frac{p}{(a/d)^3}}\right)\ x\ \frac{1 + \sqrt{(5.08/do)}}{\sqrt{(1 + d/25do)}}\right] bw\ x\ d$$

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Where,
fc= compressive strength of concrete at 28 days in MPa,
bwd= width and depth of effective cross section in mm,
p=longitudinal reinforcement ratio
a/d= shear span to depth ratio

The Equation stated by Bazant (1987) to predict shear strength of concrete members looks complicated but takes into account all the parameters involved in predicting the shear strength of concrete members.

f) Indian Code IS 456 2000:
The design shear strength of concrete in beams without shear reinforcement is based on the percentage of longitudinal reinforcement which is calculated based on the formula:

$$\tau c = \frac{0.85}{6\beta} \times \sqrt{0.8fck}\left(\sqrt{1+5\beta}-1\right)$$

Where,

$$\beta = \frac{0.8fck}{6.89Pt} > 1$$

$$Pt = \frac{100As}{bwd}$$

Using the above formula the shear strength of beams without shear reinforcement is given in IS 456: 2000. The code has not taken into account the effect of shear span/ depth (a/d) ratio.

MATERIALS AND METHODS

Material properties

Cement
The cement used in this experimental work is "Ulttratech 53 grade Ordinary Portland Cement". All properties of cement are tested by referring IS 12269 - 1987 Specification for 53 Grade Ordinary Portland Cement.

Water
Potable water available in laboratory is used for mixing & curing of concrete.

Tests Conducted On Aggregates
Natural sand from Pravara River confirming to IS 383-1970is used. Various tests such as specific gravity, water absorption, impact strength, crushing strength, sieve analysis etc. have been conducted on C.A. & F.A. to know their quality & grading.

Tension Reinforcement
8 mm, 12 mm, 16 mm diameter bars were used as tension reinforcement.

MIX DESIGN

The majority of the construction works in study area are residential buildings with multiple floors and they are not more than three floors. The minimum grade of concrete recommended is M30 (IS: 456-2000) and a target strength of 38.25 MPa is fixed in this work. The design mix proportions for the required target strength is asfollows,

Cement: Sand: Coarse Aggregate: w/c = (1:1.87:3.37:0.45)

SPECIMEN DETAILS

Tests will carried out on eighteen beams, simply supported under two points loading. All the beams have constant cross section of 100mm x 150mm. The length of beam will worked out to be 1.2 m for corresponding a/d ratio = 1, 2 &3 respectively. All the three series of beams will provided with 2 numbers of 16 mm,12 mm &

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8 mm diameter HYSD bars as longitudinal reinforcement to avoid any possible failure by flexure and the grade of concrete was kept constant.

TEST PROCEDURE

The beams will tested under two points loading on 100 Ton Universal Testing Machine. The test specimen will be simply supported on rigid supports. Two point loads will apply through a rigid spread beam. Based on the shear span to depth ratio, the support of the spread beam will adjusted. TwoLVDT's were provided, one at the centre of the span and other at the centre of the shear span to measure deflections. The load and deflections will monitor for every 5 seconds. The load that produced the diagonal crack and the ultimate shear crack will record. Crack patterns will mark on the beam. The average response of three beams tested in a series, will take as the representative response of the corresponding series.

CONCLUSION

Experimental study done by the various researchers is imply the shear behavior cannot be controlled by taking one parameter .There is a number of parameter and take care of every parameter is important. Following are the parameter.

- Shear span to depth ratio effect more dominant on the load transfer mechanism and propagation of crack in the beam during the loading condition. As soon as shear span to depth ratio is increased. The beams more prominent to flexural failure.
- Analysis of the research results revealed that shear strength and failure mode depends on shear span and longitudinal reinforcement ratio.
- The use of high strength steel can change the mode of failure.
- The shear strength and failure mode is largely depending upon the percentage of tensile reinforcement. The ductility zone can be taken care by the tensile reinforcement without brittle
- The load carrying capacity is more with less deflection if the a/d ratio is less

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