Effect of Shear Span To Depth Ratio (Upto 2.5) On Shear Strength of High Strength Concrete - Fracture Mechanics Approach

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Abstract- *Although High strength concrete has been increasingly used in construction industry during the last few years, current code of practice (IS 456: 2000) gives same values for various grade of concrete 40 Mpa and above. As the grade of concrete increases, there is increase in brittleness and smoother crack surfaces which affects significantly the shear strength. Comparisons with experimental data indicate that the proposed equation estimates properly the effects of primary factors, such as concrete strength, longitudinal steel ratio, grade of steel, shear span-to-depth ratio, and effective depth. In this project the new shear strength equation is developed by referring the shear equations proposed by different researchers and codes. These equations are analysed by keeping certain parameters constant.The effect of varying shear span to depth ratio on shear strength of concrete is studied, it has been found that ,the shear failure of reinforced beam without stirrups is a very complex fracture process and exhibits the noticed size effect. Hence, the lack of valid physically sound analytical model for the prediction of shear bearing capability of reinforced concrete beams without stirrups need more researches on application of fracture mechanics model to predict shear bearing capability of reinforced concrete members. The new analytical formula can accurately estimate the size effect in shear fracture, the contributions of the shear span-depth ratio, the reinforcement ratio and the concrete quality to shear strength and reasonably interpret the failure mechanism of reinforced concrete beams without stirrups*

Keywords- High strength concrete, shear to depth span ratio steel reinforcement.

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 technological complexity. Our understanding of how materials fail and our ability to prevent such failures has increased considerably since World War II. Much remains to be learned, 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] This paper contain conducted experiment on shear capacity equations for rectangular reinforced concrete beams. They studied the (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

Reference [3].Conducted experimentto predict the shear strengths of reinforced concrete beams, many deterministic models have been developed based on rules of mechanics and on experimental test results.

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 study the shear behaviour of High Strength Concrete Beams without Shear Reinforcement with reference to the effect of shear span to effective depth ratio (a/d) and longitudinal reinforcement ratio ‘ρ’.
2. Evaluation Energy equations applied to shear strength of high strength concrete.

IV. EXPERIMENTAL PROGRAM

A-Material used:

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

TABLE NO 1-PHYSICAL PROPERTIES OF CEMENT

Sr. No.	Property	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,

TABLE NO 2- PHYSICAL PROPERTIES OF COARSE AGGREGATE

Sr.No.	Properties	Value	
		10 mm	20mm
1	Surface Texture	Crystalline	
2	Particle shape	Angular	
3	Specific gravity	2.7	2.6
4	Water absorption	1.29%	1.23%

The properties of fine-aggregate used

TABLE NO-3PHYSICAL PROPERTIES OF FINE AGGREGATE

Sr.No.	Properties	Value
1	Type	Natural
2	SLump cone test	75 mm
3	Specific gravity	2.64
4	Water absorption	1.27%
5	Moisture content	10.36%

The properties of admixture (Master Glenium SKY 8276) used

TABLE NO 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	Choride ion content	.2%
5	Specific gravity	1.12

B. Mixture proportion:

The different mix proportion of concrete withvarious grades of high strength concrete contain:The different percentage of Highstrength concrete in specimens study are given below,

TABLE NO- 5-THE QUANTITY OF MATERIAL FOR $1M^3$ HIGH STRENGTH CONCRETE

Ingredients	M60	M50
w/c content	0.27	.31
Cement(kg/m^3)	515.8 kg	447.1 kg
Fine-aggregate N.S.(kg/m^3)	746.76 kg	768.1 kg
course-aggregate C.S.(kg/m^3)	1055.6 kg	1085.76 kg
Water content	134.12 kg	134.12 kg
admixture solution	5.15 kg	4.47 kg

C. 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, 0.85m, 1.0m and 1.15m for corresponding a/d ratio = 1, 1.5,2 & 2.5 Respectively. All the four series of beams were provided with 12 mm diameter 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 No 6-Details Of Casting Specimens

% Steel	a/d Ratio	Beam size
	1	150×150×700
1	1.5	150×150×850
	2	150×150×1000
	2.5	150×150×1150

D. Compressive Strength Test:

Based on experimental work carried out for different are expressed below.

Compressive strength test was carried out at the age of 28 days.According to IS UTM having capacity 2000kn testing machine with a uniformarate of application of load.

TABLE NO–7 EXPERIMENTAL RESULTS OF SHEAR STRESS

a/d	Experimental results Shear stress (N/mm^2) OF GRADE M 50	Experimental results Shear stress (N/mm^2) OF GRADE M 60
1	6.46	7.01
1	6.39	7.20
1	6.21	6.83
1.5	5.64	6.20
1.5	5.12	5.63
1.5	5.56	6.11
2.0	3.62	4.02
2.0	3.45	3.80
2.0	3.03	3.33
2.5	2.44	2.68
2.5	2.27	2.49
2.5	2.19	2.40

With above results, it is observed that grade of concrete is directly proportional to Shear span to depth ratio (a/d).but change of grade of concrete is not much affecting the a/d .However, change in a/d ratio affecting the shear stress of the beams. It is observed that , above beam specimens areunder mode1 failure that is tensile stress normal to plane of crack (opening mode).

According to the Griffith theory equation,

$$V_c = 0.446/\sqrt{H}\left(\sqrt{(Es/Ec)}\right)(H/As)^{(1/3)}\rho^{(1/6)}(1-\sqrt{\rho})^{(2/3)}K\Pi_C bH \ldots(1)$$

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 depth 'H' can be replaced by shear span to depth ratio (a/d).Area of steel and longitudinal reinforcement are kept constant so we can neglect the term 'As'.so in above formula we can replaced 'H' term by a/d ratio and keeping modular ratio same, the equation can be replaced by,

$$\tau c = 1 \frac{\sqrt{(Es/Ec)}}{\left(\frac{a}{d}\right)} k\Pi c * \rho \ldots\ldots\ldots(2)$$

TABLE NO 8-EXPERIMENTAL & EQUATION VALUES OF SHEAR STRESS FOR A/D=1,1.5,2,2.5 WITH GRADE M 50

For a/d=1,1.5,2,2.5	
Shear stress N/mm2	
EXP	EQN
6.46	7.85
5.64	5.17
3.63	2.66
2.44	2.32

TABLE NO 9-EXPERIMENTAL & EQUATION VALUES OF SHEAR STRESS FOR A/D=1,1.5,2,2.5 WITH GRADE M 60

For a/d=1,1.5,2,2.5	
Shear stress N/mm2	
EXP	EQN
7.02	8.14
6.24	5.4
3.43	2.76
3.02	2.41

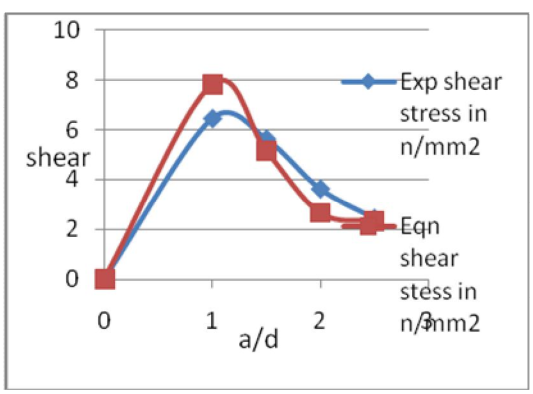

FIGURE NO 1-A/D VS SHEAR STRESS

By observing above graph, it is states that experimental values of shear stress is nearby Equation values .so equation (3) 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.

IV. CONCLUSIONS

With the discussion on shear models and the experimental studies conducted on HSC Beams the following conclusions are drawn.

The shear failure of reinforced beam without stirrups is a very complex fracture process and exhibits the noticed size effect. Hence, the lack of valid physically sound analytical model for the prediction of shear bearing capability of reinforced concrete beams without stirrups need more researches on application of fracture mechanics model to predict shear bearing capability of reinforced concrete members.

The new analytical formula can accurately estimate the size effect in shear fracture, the contributions of the shear span-depth ratio, the reinforcement ratio and the concrete quality to shear strength and reasonably interpret the failure mechanism of reinforced concrete beams without stirrups.

The equation stated above includes almost all the parameters required to predict the shear capacity beams without shear reinforcement. Therefore a single simplified equation can be used to predict the shear capacity of HSC beams using artificial sand with a/d = 1, 1.5, 2 and 2.5.

The longitudinal reinforcement ratio, strength of the concrete, shear span to depth ratio, value and depth of the beam are the most influencing parameters in the deformational and shear behaviour of the HSC beams without shear reinforcement.

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It is further verified that fracture mechanics can be utilized as a valuable knowledge to analyse the shear failure problems of reinforced concrete members without stirrups.

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