An Appraisal on Shear Strength of Concrete for Different Codes

Ch. Manjula[1*], Sumanth Kumar B[2], D Rama Seshu[3]
[1, 2] Research Scholar, Department of Civil Engineering, National Institute of Technology, Warangal, India
[3] Professor, Department of Civil Engineering, National Institute of Technology, Warangal, India
*reddy.daughter319@gmail.com

Introduction

The shear in Reinforced concrete (RC) members has been recognized as most significant actions from the point of structural safety. Despite significant progress in the understanding and modeling of shear, it is regarded as one of the least understood but most important problems in reinforced concrete. The shear resistance of RC without any web reinforcement is generally attributed to three main mechanisms: the shear resistance of concrete in the un-cracked compression zone, the aggregate interlock at the cracked interface, and the dowel action of the longitudinal reinforcement. The magnitudes of these three mechanisms vary throughout the loading process and depend on cracking pattern and deformation. As the applied shear force is increased, the dowel action is the first to reach its capacity, after which a large shear is transferred to aggregate interlock. The failure of aggregate interlock necessitates a rapid transfer of shear to the concrete in the compression zone. The sudden transfer of shear to the concrete compression zone results in brittle failures. There is sometimes little warning before failure occurs and this makes shear failures in RC particularly objectionable.

Review of Codal Provisions

Numerous empirical and analytical models have been proposed to calculate the shear resistance of concrete in RC beams without shear reinforcement. In most of the codes of practice the shear strength of concrete is expressed through empirical equations resulting from experimental test outcomes. The factors considered to be influencing the shear resistance of concrete in most of the codes include: i) Strength of concrete ii) Longitudinal steel ratio iii) Shear span to effective depth ratio and iv) Size of aggregate. The codes of practice such as IS 456, BS 8110, ACI 318 and Euro code 2 consider into interpretation the effect of reinforcement ratio, effective depth and concrete compressive strength whereas Canadian code studies the shear strength to be a function of concrete compressive strength only. Model code 2010 reflects the shear strength of beams as a function of longitudinal strain in the web and size of aggregate. In most specific codes, shear strength of a reinforced concrete (RC) beam is the sum of the shear potential of the concrete component and the steel component is taken. This interpretation is for suitability only, even though the resistances offered by concrete and steel form parts of complex interactions. Though ample studies carried out on shear failure of concrete beam still it is debatable regarding the precise shear behaviour of reinforced cement concrete structure elements. In order to understand the effect of different parameters on the shear resistance of concrete it is necessary to carry out a comparative study of the models presented in different codes of practice regarding shear strength.

In view of the above an attempt is made in this paper to present an appraisal of shear strength of concrete beams with no shear reinforcement. The codes of practice considered in the study are IS 456-2000, BS 8110, Euro code 2 (EN 1992), Canadian code (CSA A23.3), ACI code 318 and Model code (FIB) 2010. Only the simplified methods specified in each of the codes have been used in this comparative study.

Review of different codes has been carried out and the shear stress of concrete has been calculated for beams without shear reinforcement. The corresponding variation of shear stress of concrete has been shown in Fig 1. The variation of concrete shear strength for different percentage of steel shown in Fig.2 is for a typical M25 grade of concrete and effective depth of 300mm.

Table 1 shows the comparison for IS 456 shear capacities, which indicates that the shear strength of concrete established by IS 456 is very much under estimated than other codes for constant % of reinforcement steel. Table 2 summarises that the FIB model 2010 is lower to other codes.

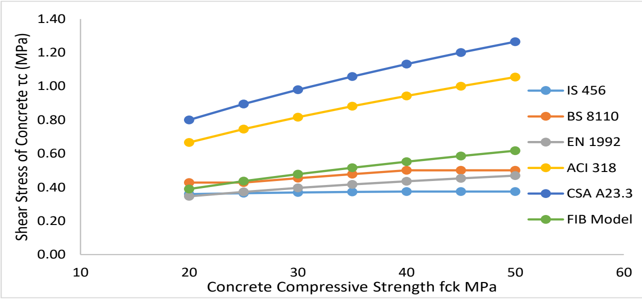

Figure 1. Variation of Concrete Shear Stress to Concrete Compressive Strength

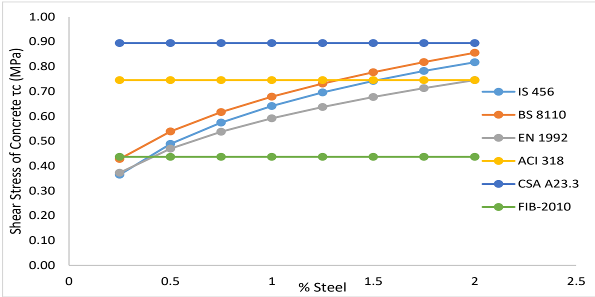

Figure 2. Variation of Shear Stress of concrete to % of Reinforcement Steel

Table 1. Comparison of Shear stress of IS 456 with different codes (Constant % of Reinforcement Steel)

S. No	Concrete Compressive Strength f_{ck} MPa	τc_{BS} / τc_{IS} BS 8110 - 1997	τc_{EN} / τc_{IS} EN 1992-1-1:2004	τc_{ACI} / τc_{IS} ACI 318 - 2014	τc_{CSA} / τc_{IS} CSA A23.3 - 2004	τc_{FIB} / τc_{IS} FIB Model - 2010
1	20	1.191	0.963	1.856	2.227	1.087
2	25	1.173	1.022	2.043	2.452	1.196
3	30	1.232	1.074	2.213	2.656	1.296
4	35	1.286	1.120	2.370	2.843	1.387
5	40	1.335	1.163	2.515	3.018	1.473
6	45	1.335	1.210	2.668	3.201	1.562
7	50	1.335	1.253	2.812	3.374	1.646
	Avg	**1.270**	**1.115**	**2.354**	**2.825**	**1.378**

Table 2. Comparison of Shear stress of IS 456 with different codes (Constant Grade of Concrete)

S. No	% of Reinforcement Steel	τc_{BS} / τc_{IS} BS 8110 - 1997	τc_{EN} / τc_{IS} EN 1992-1-1:2004	τc_{ACI} / τc_{IS} ACI 318 - 2014	τc_{CSA} / τc_{IS} CSA A23.3 - 2004	τc_{FIB} / τc_{IS} FIB Model - 2010
1	0.25	1.173	1.022	2.043	2.452	1.196
2	0.5	1.103	0.961	1.525	1.830	0.893
3	0.75	1.074	0.935	1.297	1.556	0.759
4	1	1.059	0.922	1.162	1.394	0.680
5	1.25	1.051	0.916	1.071	1.285	0.627
6	1.5	1.047	0.912	1.004	1.205	0.588
7	1.75	1.046	0.911	0.953	1.143	0.558
8	2	1.046	0.912	0.911	1.094	0.534
	Avg	**1.075**	**0.936**	**1.246**	**1.495**	**0.729**

Results and Concluding Remarks

An appraisal of shear strength of concrete without web reinforcement indicated that there is no consistent mechanical model for estimating the shear strength of concrete without shear reinforcement. The evaluation of the shear strength of concrete using different existing codes of practice showed that Indian standard code is highly underestimating the shear strength of concrete. The study further indicates that the available approaches for shear design of concrete members without stirrups have still a great uncertainty and requires further research particularly in the context of increased use of new concretes.

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