# Reliability Analysis on Shear Strength of RC Beams and Sensitivity Analysis

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**Abstract -** *Shear failure in reinforced concrete member is a highly random process and very hazardous. For last ten year, experiments have been done to analyze this phenomenon, in order to solve the riddle that shear is. Researchers turn out to be more knowledgeable about the shear and the factors responsible for the same. The present work involved collecting the test data of concrete beams of different depths and consequently different shear span ratio(a/d) and relating the test results to four shear resistance formulas for (beams without shear reinforcement) given by different codes. ACI-318, BS8110, IS-456, and the formula given by the Bazant Zdenek.P and Yu [2] considering size effect in the beam (ASCE 2011 Paper). An attempt is made to establish the probability distribution to describe the inherent randomness in shear resistance of RC beams. IS 456-2000 adopted the concept of characteristic value for material strength and load. 6 series of beam data from the literatures are collected and the test results are compared with the results obtained from the four empirical formulas. The findings are that, i) Bazant size effect formula gives very conservative results, since it is consider the size effect in the beam. ii) IS-456 and ACI-318 gives reasonable estimates at shear strength at the failure of section but not for shear resistance at the appearance of first shear crack in the beam in some situation. An attempt has been made to establish the probability of failure or margin of safety of R.C.C beam subjected to shear force in various limit states, and to propose the LRFD design format. As the basic variables in the design of a R.C.C beam have inherent probabilistic variations, the probability of failure can be accessed through reliability analysis. Conducted a sensitivity analysis to establish the statistical influence played by each basic variable on the shear resistance predicted using the different building codes.*

***Key Words***: *Shear strength, Size effect, Building codes, IS-456, BS8110, ACI-318, Probability of failure, Sensitivity.*

## 1. INTRODUCTION

Four different shear design methods in different codes are taken to compare the shear strength test results of the beam with the predicted shear force from these building codes namely IS 456-2000, ACI 318-2008, BS8110-1997, and shear strength equation given by the Bazant considering size effect in ASCE 2011 paper. The beams selected are off without shear reinforcement.

### 1.1 Shear resistant formulas as per standard building codes:

#### 1.1.1 ACI 318-2008:

According to the American Concrete institute the shear resistance of the beam without shear reinforcement (ACI 318-2008) is given by;

$$vc = 2 * \lambda * \sqrt{f'c} * b * d \; in(lbf)$$
$$Vc = \left(\lambda * \frac{\sqrt{f'c}}{6} * b * d\right) in(kN)$$

#### 1.1.2 BS 8110-1997:

The equation is mentioned in the ACI code, In ACI code this equation mentioned as equation number (11-3). This equation holds good for the beam subjected to shear and flexure only.

Where; λ = 1 for the normal concrete.

$$\tau c = 0.79 * \left(\frac{fcu}{25}\right)^{\frac{1}{3}} * (Pt)^{\frac{1}{3}} * \left(\frac{400}{d}\right)^{\frac{1}{4}} \; in\left(\frac{N}{mm^2}\right)$$
$$Vc = \tau c * b * d \; in\,(kN)$$

#### 1.1.3 IS 456-2000:

The amount of the nominal shear strength $\tau_c$ be determined by on various factors like grade of concrete (fck) also the proportion of longitudinal steel ($P_t$=100*Ast/(b*d). The value for $\tau_c$ is given in code (Table 19 of IS 456). That is based on empirical formula given below.

$$\tau c = \left(0.85 * \sqrt{0.8 * fck} * \sqrt{\frac{1 + 5\beta}{6 * \beta}}\right) in \left(\frac{N}{mm^2}\right)$$

$$Where;\ \beta = \frac{0.8 * fck}{6.89 * Pt}$$

0.85 = Reduction factor.
0.8*$f_{ck}$ = Cylindrical strength in terms of cube strength.

$$Vc = \tau c * b * d \; in\,(kN)$$

**1.1.4 Shear Force equation Proposed to ACI code considering size effect:**

Rendering to the classical principles of elastic or plastic structures prepared from a material with no-random strength ($f_t$), the nominal strength ($\sigma_N$) of a structure is independent of the structure size (D) when geometrically like structures are considered. Any deviation from this property is named as the size effect.

**Bazant's Size effect law:**

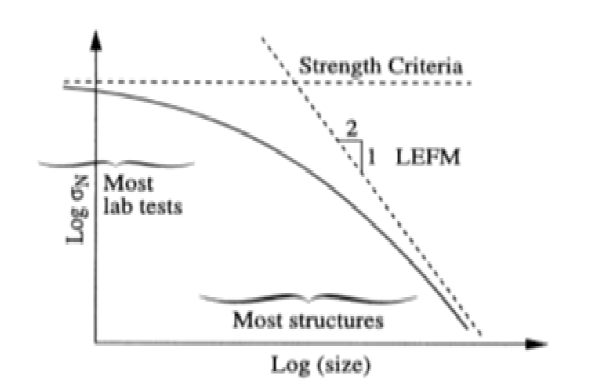



**Figure.1.1 Asymptotic property of size effect**

From the Bazant's size effect law, the equation used for the shear strength considering size effect is given by;

$$vc = \left(\frac{Vo}{\left(\frac{1+d}{do}\right)}\right)\ in\ (psi)$$

Where;

$$do = k * (f')^{\frac{-2}{3}}\ in\ (inch)$$

$$Vo = (f'c)^{\frac{1}{2}} * (Pt)^{\frac{3}{8}} * \left(k1 + \frac{d}{a}\right)\ in\ (psi)$$

Shear span ratio = $\frac{a}{d}$

$Vc = Vo * b * d\ in\ (lbf)$

## 2. CHARACTERIZATION OF RANDOMNESS:

The beams subjected to shear force have inherent random variation. An attempt has been made to characterise the randomness in terms of a probability distribution. For analysing the characteristic randomness in limit state and at working loads, method of shear strength for RC Beam without shear reinforcement, 6 rectangular beams of different a/d ratio and longitudinal steel reinforcement are selected from the literature.

**Table -1:** Beam data collected from literatures

| Beam Designation | Length (mm) | Breadth, b(mm) | Overall Depth, D(mm) | Effective Depth,d(mm) | a/d ratio | fy (N/mm²) | fck (N/mm²) | Pt (%) |
|---|---|---|---|---|---|---|---|---|
| BV-335 | 1250 | 200 | 335 | 307 | 1.14 | 530 | 28.18 | 1.31 |
| BV-236 | 1250 | 200 | 236 | 210 | 1.86 | 520.5 | 28.18 | 1.35 |
| BV-189 | 1250 | 200 | 189 | 163 | 2.39 | 520.5 | 28.18 | 1.39 |
| BV-164 | 1250 | 200 | 164 | 139 | 2.81 | 547 | 28.18 | 1.41 |
| BV-131 | 1250 | 200 | 131 | 106 | 3.68 | 547 | 28.18 | 1.48 |
| BV-105 | 1250 | 200 | 105 | 81 | 4.81 | 512 | 28.18 | 1.55 |

**Table -2:** Test results of the RC beams subjected to two Point load test given below.

| Sl.no | Beam Designation | Shea at first crack, mean (kN) | Standard deviation (σ) | Shear force at failure, mean(kN) | Standard deviation (σ) |
|---|---|---|---|---|---|
| 1 | BV-335 | 86 | 1.732 | 168.6 | 26.340 |
| 2 | BV-236 | 61.2 | 1.607 | 64.6 | 4.923 |
| 3 | BV-189 | 45.6 | 0.813 | 48.5 | 3.137 |
| 4 | BV-164 | 39.4 | 1.419 | 47 | 8.845 |
| 5 | BV-131 | 35.1 | 1.950 | 35.1 | 1.950 |
| 6 | BV-105 | 25.8 | 0.75 | 26 | 0.52 |

## 2.1 Characteristic or normal value:

The word characteristic strength refers that value of strength of the material below which not more than 5% of the fallouts are expected to fall. The term characteristic load means that cost of load, which has a 95% possibility of not being overdone for the duration of the life of the building.

**Table -3:** Characteristic Value for the Tested series of beam data generated for 1000 values using Monte-Corlo simulation (MCS):

| Sl.no | Beam Designation | Mean Value(μ) (Vc)test | Standard deviation(σ) (Vc)test | Co-efficient of variation (%) | Characteristic value (Vc)cha=μ-1.645σ |
|---|---|---|---|---|---|
| 1 | BV 335 | 168.387 | 25.928 | 15.47 | 125.74 |
| 2 | BV 236 | 64.36 | 4.909 | 7.63 | 56.28 |
| 3 | BV 189 | 48.426 | 3.193 | 6.59 | 43.17 |
| 4 | BV 164 | 47.17 | 8.875 | 18.82 | 16.21 |
| 5 | BV 131 | 35.104 | 1.92 | 5.47 | 31.94 |
| 6 | BV 105 | 26.08 | 0.514 | 2 | 25.23 |

## 3. Histograms and Curve fitting:

Histograms and curve fitting is done using MATLAB, for the 1000 values of simulated data using MCS method. And distribution of the variations are analysed. Mean and standard deviation are determined.

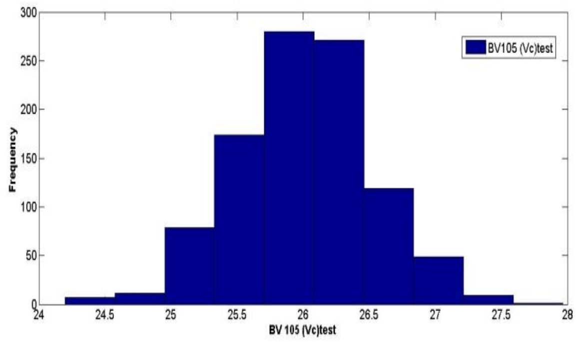



**Figure-1:** Histogram for the Beam BV105

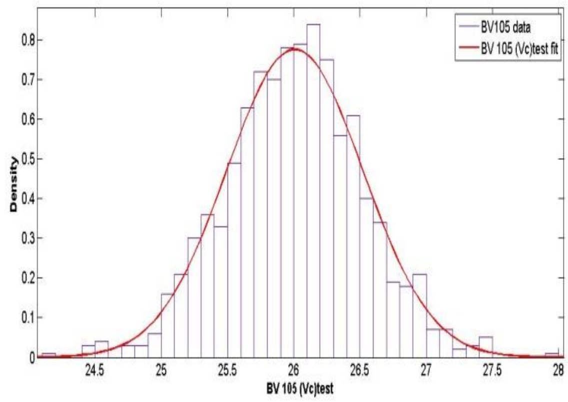



**Figure-2:** Curve fitting for BV 105

## 4. COMPARATIVE STUDIES:

### 4.1 Comparison of RC beam test data with different building codes:

The comparison of the shear strength obtained for RC beam data series with shear resistance obtained using different codes, like ACI 318-2008, BS 8110-1997, IS 456-2000, And Bazant's size effect formula has been done in this section. Comparison is made for both in the working state and limit state of failure. That is the comparison done between the shear strength at the first crack appeared on the beam with the shear resistance obtained from different building codes and the shear strength at the failure of the beam and the with the shear resistance obtained from different building codes are analysed in this section. An analysis of the comparative values of shear strength at first crack and at failure as obtained from test data and as predicted by the different code and Bazant's size effect formula has been made in this chapter.

### 4.2 The mean values of (Vc)test (the tested data series) are compared with the (Vc)pred (shear resistance predicted from different Building code).

#### 4.2.1 ACI 318-2008:

**Table 4.1:** The mean values of tested data series and shear resistance predicted from ACI 318 are given below;

| Beam Designation | First Shear crack noticed, **(Vc)1stcra** (kN) | Shear force at failure, **(Vc)fail** (kN) | Mean value Predicted from **ACI 318 code (Vc)pred (kN)** | **(Vc)1st cra/(Vc)pred** | **(Vc)fail/(Vc)pred** |
|---|---|---|---|---|---|
| BV 335 | 86 | 168.39 | 64 | 1.343 | 2.634 |
| BV 236 | 61.2 | 64.36 | 43 | 1.423 | 1.502 |
| BV 189 | 45.6 | 48.42 | 34 | 1.341 | 1.426 |
| BV 164 | 39.4 | 47.17 | 29 | 1.358 | 1.621 |
| BV 131 | 35.1 | 35.10 | 22 | 1.5956 | 1.5956 |
| BV 105 | 25.8 | 26 | 16.6 | 1.55 | 1.57 |

#### 4.2.2 BS 8110-1997:

**Table 4.2:** The mean values of tested data series and shear resistance predicted from BS 8110 are given below;

| Beam Designation | First Shear crack noticed, **(Vc)1stcra** (kN) | Shear at failure, **(Vc)fail** (kN) | Mean value Predicted form **BS 8100 code (Vc)pred (kN)** | **(Vc)1stcra /(Vc)pred** | **(Vc)fail /(Vc)pred** |
|---|---|---|---|---|---|
| BV 335 | 86 | 168.6 | 64 | 1.344 | 2.634 |
| BV 236 | 61.2 | 64.6 | 39 | 1.5692 | 1.6564 |
| BV 189 | 45.6 | 48.5 | 27 | 1.6888 | 1.7963 |
| BV 164 | 39.4 | 47 | 24 | 1.6416 | 1.9583 |
| BV 131 | 35.1 | 35.1 | 24 | 1.4625 | 1.4625 |
| BV 105 | 25.8 | 26 | 20 | 1.29 | 1.3 |

#### 4.2.3 IS 456-2000:

**Table 4.3:** The mean values of tested data series and shear resistance predicted from IS 456 are given below;

| Beam Designation | First shear crack noticed, **(Vc)1stcra** (kN) | Shear at failure, **(Vc)fail** (kN) | Mean value Predicted from **IS 456 code (Vc)pred (kN)** | **(Vc)1stcra/(Vc)pred** | **(Vc)fail /(Vc)pred** |
|---|---|---|---|---|---|
| BV 335 | 86 | 168.6 | 42 | 2.047 | 4.014 |
| BV 236 | 61.2 | 64.6 | 33 | 1.855 | 1.957 |
| BV 189 | 45.6 | 48.5 | 26 | 1.754 | 1.865 |
| BV 164 | 39.4 | 47 | 21.69 | 1.817 | 2.167 |
| BV 131 | 35.1 | 35.1 | 23 | 1.53 | 1.53 |
| BV 105 | 25.8 | 26 | 15 | 1.72 | 1.73 |

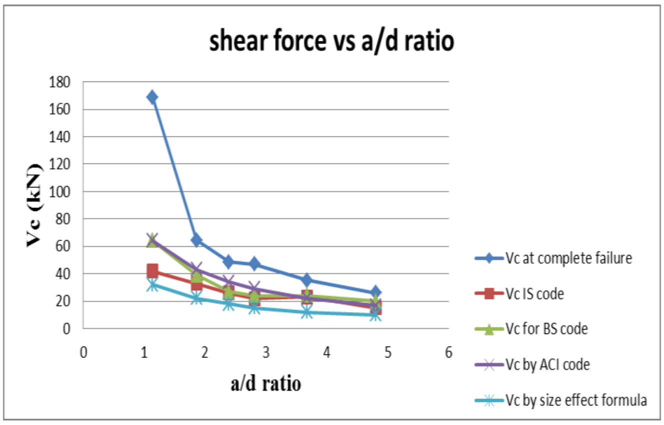
### 4.2.4 Bazant's size effect formula (ASCE 2005)

**Table 4.4:** The mean values of tested data series and shear resistance predicted from IS 456 are given below;

| Beam Designation | First Shear crack noticed, **(Vc)1stcra** (kN) | Shear at failure, **(Vc)fail** (kN) | Mean value Predicted from **size effect formula (Vc)pred (kN)** | **(Vc)1stcra /(Vc)pred** | **(Vc)fail /(Vc)pred** |
|---|---|---|---|---|---|
| BV 335 | 86 | 168.6 | 32 | 2.687 | 5.269 |
| BV 236 | 61.2 | 64.6 | 22 | 2.782 | 2.936 |
| BV 189 | 45.6 | 48.5 | 18 | 2.533 | 2.694 |
| BV 164 | 39.4 | 47 | 15 | 2.627 | 3.133 |
| BV 131 | 35.1 | 35.1 | 12 | 2.925 | 2.925 |
| BV 105 | 25.8 | 26 | 10 | 2.58 | 2.6 |

### 4.3 Comparison of shear strength of beam data series with the shear resistance obtained according to different building codes:

The shear forces are predicted by using different shear prediction formula given by the building codes are predicted according to the beam properties. The experimental shear forces are compared with the shear forces predicted using different building codes. And the variations are analysed. The mean values of predicted shear forces are used to plot the graph, and mean values are found for the thousand (1000) random values using the MCS method.




**Graph 4.1:** Variation of shear strength at complete failure with a/d ratio.

### The observations from the Figure 4.1 are given below:

1. The predicted values from the ACI 318-2008 and BS 8110-1997 are almost matching with each other. In the entire range of a/d considered.

2. The size effect formula gives very conservative results. The failure curve is lower than all the other curves.

3. The difference between test values and predicted values is more for lower a/d ratios as compared the difference for higher a/d ratios. For a/d beyond about 4, the difference is not significant.

### 5. PROBABILITY OF FAILURE:

### 5.1 Computation of reliability index (β):

A traditional concept of the safety limit is connected with the ultimate limit states. For example, a beam fails if shear force due to loads exceeds the shear force carrying capacity. Let R characterize Shear force of the beam obtained by testing (shear force carrying capacity) and S represents the shear resistance obtained by formulas, given in different building codes.

Formerly the corresponding limit state function, g, can be transcribed;

g = R – S.

If both R and S are independent (in the statistical sense), normal random variables, then the reliability index is,

$$\beta = \left(\frac{\mu R - \mu S}{\sqrt{(\sigma R)^2 + (\sigma S)^2}}\right)$$

Here μR and μS are the mean values of tested data series collected and the predicted mean values using different formulas of building codes respectively.

And σR and σS are the standard deviation of tested data series and the predicted standard deviations of the predicted values using different formulas from building codes respectively.

### 5.2 Computation of probability of failure ($P_f$):

The safety margin is expressed as $M = \mu_R - \mu_S$, the probability failure of the beam is determined using the formula, $P_f = \varphi(-\beta)$. The percentage of probability is calculated multiplying 100 with the probability of failure.

After finding the probability of failure, Reliability of the beam under shear can be calculated using the formula; Reliability=1-probability

### 5.3 Probability of limit state of failure:

The Shear force at beam failure and the predicted value of shear resistance by using formulas given by different codes are used to determine the likelihood of failure.

**Table 5.1:** The reliability of the beam BV 335, for beam shear force at failure of the beam and the shear resistance calculated from the different codes are analyzed in this table given below;

| Building codes | Mean value of test series **(μR)** | Mean value from codes **(μS)** | Standard deviation test series **(σR)** | Standard deviation from formulas **(σS)** | Reliability index **(β)** | Probability of failure **Pf=φ(-β)** | Reliability **(1-Pf)*100** |
|---|---|---|---|---|---|---|---|
| ACI 318-2008 | 168.39 | 64 | 25.928 | 10.34 | -3.74 | 0.00009201 | 99.990799 |
| BS 8110 - 1997 | 168.39 | 64 | 25.928 | 7.86 | -3.85 | 0.00005906 | 99.995095 |
| IS 456-2000 | 168.39 | 42 | 25.928 | 4.79 | -4.79 | 8.3489 *$(10)^{-7}$ | 99.999916 |
| Bazant's Size effect formula | 168.39 | 32 | 25.928 | 3.01 | -5.22 | 8.9462 *$10^{-8}$ | 99.999991 |

## 5.4 Working stress method to calculate probability of failure:

The shear resistance on the beam when first shear crack appeared and the predicted value of shear force by using formulas given by different codes are used to calculate the probability of failure, so it's a working stress method.

**Table 5.2**: The reliability of the beam **BV 335**, beam at first shear crack and the shear resistance calculated from the different codes are analysed in this table given below;

| Building codes | Mean value of test series **(μR)** | Mean value from codes **(μS)** | Standard deviation test series **(σR)** | Standard deviation from formulas **(σS)** | Reliability index **(β)** | Probability of failure **Pf=φ(-β)** | Reliability **(1-Pf)*100** |
|---|---|---|---|---|---|---|---|
| ACI 318-2008 | 86 | 64 | 1.732 | 10.34 | -2.098 | 0.02222 | 97.778 |
| BS 8110-1997 | 86 | 64 | 1.732 | 7.856 | -2.73 | 0.00317 | 99.683 |
| IS 456-2000 | 86 | 42 | 1.732 | 4.79 | -8.63 | 2.81*$10^{-18}$ | 100 |
| Bazant's Size effect formula | 86 | 32 | 1.732 | 3.01 | -15.56 | 0 | 100 |

## 6. SENSITIVITY ANALYSIS:

### 6.1 General

The variation of a dependent variable will contribute towards the variation of the shear strength. For example from BS 8110-1997 the formula for shear resistance is given by;

$$Vc = \tau c * b * d \ in\ (kN)$$

$$\tau c = 0.79 * \left(\frac{fcu}{25}\right)^{\frac{1}{3}} * (Pt)^{\frac{1}{3}} * \left(\frac{400}{d}\right)^{\frac{1}{4}} \ in\ \left(\frac{N}{mm^2}\right)$$

Where Vc is a function of; Vc= f(fcu,Pt,b,d) and variables are basic variables.

Hence, fcu= material strength.
Pt,b,d= sectional dimensions.

Hence the shear resistance is depends on;

1. Material strength
2. Sectional Dimensions.

These variables are called basic design variables; any variation in the basic design variables will cause a random variation in the design shear resistance (Vc).

The variation of Vc has to be considered in the design;
Vc=(Vc)mean±(∆Vc).

The reduction in Vc is much concern with the structural design; That is (Vc)mean-(∆Vc) is the reduction in shear resistance Vc.

If 'S' is the action and 'R' is the resistance the worst case of design situation is given by;
R-∆R≥S+∆S

### 6.2 Sensitivity Analysis:

The variables in the formula for shear resistance will contribute towards the variation in the shear resistance (Vc). The variable which contributes maximum variation will be the most sensitive parameter. And the variable which contributes the minimum variation in the shear strength will be the least sensitive parameter.

For example if 'fy' contributes maximum variation in the shear strength ($V_c$), then the care should be taken in the field to minimize its variation.

If the parameter 'fy' is most sensitive we can minimize its variation by;

1. If we are using Fe-500 steel, use the same grade of steel consistently throughout the project.

2. Use the same company steel or the steel from the same source.
3. Do not combine the Fe-500 steel with Fe-415 steel or with TMT bars.

**Table 6.1:** Sensitivity analysis for ACI 318-2008:

| Beam Designation | Mean Value(kN) (Vc)μ | Co-efficient of variation (%) | Parameters which causes the variation in shear strength (Vc) | | |
|---|---|---|---|---|---|
| | | | f'c (%) | b (%) | d (%) |
| BV 335 | 64 | 16.16 | 64.09 | 21.74 | 14.17 |
| BV 236 | 43 | 15.97 | 60.18 | 20.39 | 19.43 |
| BV 189 | 34 | 15.67 | 56.98 | 19.32 | 23.70 |
| BV 164 | 29 | 15.65 | 54.74 | 18.55 | 26.69 |
| BV 131 | 22 | 15.99 | 50.54 | 17.13 | 32.32 |
| BV 105 | 16.6 | 16.20 | 45.95 | 15.57 | 38.46 |

Here; Characteristic compressive strength (f'c) is most sensitive parameter, so the major variation in the shear strength (Vc) is due to the variation in characteristic compressive strength.

**Table 6.2:** Sensitivity analysis for BS 8110-1997:

| Beam Designation | Mean Value(kN) (Vc)μ | Co-efficient of variation (%) | Parameters which causes the variation in shear strength (Vc) | | | |
|---|---|---|---|---|---|---|
| | | | fcu (%) | Pt (%) | b (%) | d (%) |
| BV 335 | 64 | 12.275 | 3.94 | 93.37 | 1.79 | 0.87 |
| BV 236 | 39 | 12.426 | 4.04 | 92.80 | 1.84 | 1.32 |
| BV 189 | 27 | 12.733 | 4.13 | 92.24 | 1.88 | 1.74 |
| BV 164 | 24 | 12.713 | 4.18 | 91.86 | 1.90 | 2.05 |
| BV 131 | 24 | 12.588 | 4.34 | 90.88 | 1.97 | 2.80 |
| BV 105 | 20 | 13 | 4.48 | 89.68 | 2.04 | 3.78 |

Here Percentage of longitudinal reinforcement ($P_t$) is the most sensitive parameter, so the major variation in the shear strength (Vc) is due to the parameter, percentage of longitudinal steel reinforcement.

**Table 6.3:** Sensitivity analysis for IS 456-2000:

| Beam Designation | Mean Value(kN) (Vc)μ | Co-efficient of variation (%) | Parameters which causes the variation in shear strength (Vc) | | | |
|---|---|---|---|---|---|---|
| | | | fck (%) | Pt (%) | b (%) | d (%) |
| BV 335 | 42 | 11.405 | 82.86 | 16.64 | 0.3 | 0.2 |
| BV 236 | 33 | 10.606 | 83.31 | 16.10 | 0.3 | 0.28 |
| BV 189 | 26 | 10.962 | 83.75 | 15.58 | 0.3 | 0.36 |
| BV 164 | 21.6 | 12.309 | 83.94 | 15.33 | 0.3 | 0.43 |
| BV 131 | 23 | 11.30 | 84.63 | 14.50 | 0.3 | 0.56 |
| BV 105 | 15 | 11.33 | 85.21 | 13.74 | 0.3 | 0.74 |

Here Characteristic compressive strength (fck) is the most sensitive parameter, so the major variation in the shear strength (Vc) is due to the parameter, ie characteristic compressive strength.

**Table 6.4:** Sensitivity analysis for size effect formula:

| Beam Designation | Mean Value(kN) (Vc)μ | Co-efficient of variation (%) | Parameters which causes the variation in shear strength (Vc) | | | | |
|---|---|---|---|---|---|---|---|
| | | | f'c (%) | Pt (%) | $(a/d)^{-1}$ (%) | b (%) | d (%) |
| BV 335 | 32 | 9.4 | 0.010 | 27.88 | 51.88 | 12.00 | 8.22 |
| BV 236 | 22 | 10.33 | 0.0082 | 23.67 | 55.39 | 10.54 | 10.38 |
| BV 189 | 18 | 10.53 | 0.0077 | 21.49 | 56.19 | 9.86 | 12.44 |
| BV 164 | 15 | 11.733 | 0.0074 | 20.30 | 56.29 | 9.46 | 13.93 |
| BV 131 | 12 | 12.467 | 0.0069 | 18.07 | 56.08 | 8.84 | 16.99 |
| BV 105 | 10 | 12.3 | 0.0065 | 16.07 | 55.02 | 8.25 | 20.65 |

Here Shear span ratio (a/d) is the most sensitive parameter, so the major variation in the shear strength (Vc) is due to the parameter, ie due to shear span ratio.

## 7. CONCLUSIONS

In the present work the following few conclusions are drawn.

1. An attempt is made to establish the probability distribution to describe the inherent randomness in shear resistance of a RC beam. The effort is towards developing the concept of characteristic value of shear resistance of RC elements, as it is well established that the shear resistance is a random variable.
2. The Monte Carlo simulation is castoff to produce random values of shear resistance. The statistical analysis and probability modelling are presented. It is shown that the shear resistance follows a normal distribution and hence characteristic shear resistance can be predicted at a required level of probability of exceedence.
3. In Section-5 all the predicted values of shear resistance from different building codes give safer values compare to the experimental results at first shear crack and the failure in shear of the beam. But Bazant's size effect formula gives safest results. And all the predicted values more compare to the first shear crack appears on the beam, except by the size effect formula, compare with test results.

4. In Section-5 for the lesser a/d ratios, (that is beam with more depth) the predicted values shear resistance are very less compare to the beams with more a/d ratios.
5. In Section-5 the reliability index and probability of the failure of predicted shear resistance using different building codes are analysed, the reliability of the beam for shear is 100% for all 6 beams if we used a size effect formula to predict the shear resistance.
6. In Section-6 sensitivity analysis is done and the statistical influence of different parameters on the shear resistance predicted using different building codes are discussed.

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