IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 17, Issue 5 Ser. IV (Sep. – Oct. 2020), PP 16-20
www.iosrjournals.org

A Study on Probability Failure of RC Beam in Single Bay Portal Frame for Varying Live Load

R. J. Fernandes[1], Amit Sunkad[2]
[1]*Assistant Professor, Civil Engineering, SDMCET Dharwad, Karnataka, India*
[2]*M.Tech Student, Civil Engineering, SDMCET Dharwad, Karnataka, India*

Abstract
In conventional deterministic design techniques, all parameters are not subjected to probabilistic variations. It is well known that loads coming on the structure are random. Similarly, the material and the geometrical parameters are also subjected to statistical variations. Given that load and strength both are random variables, therefore, structural safety is a statistical variable. With this in mind, an attempt is being made to measure the safety levels for RC beams in a single bay frame assured by the design as per current practise code IS 456-2000. Digital simulation on a R.C frame for a specific beam considering statistics and probability distribution forshear force and bending moments are carried using Software SAP2000v22 using a MATLAB-supported programme. Statistics on resistance are developed using the related equations given in IS 456-2000. Several design situations are considered for 20 %, 40 %, 60 % live load, corresponding to different material grades. Monte Carlo Simulation measures the probability of failure, which determines the safety margin statistics M = R-S.

Key Words: *Probability, Reliability, Beam Failure, SAP2000, MATLAB*

Date of Submission: 10-10-2020 Date of Acceptance: 26-10-2020

I. Introduction

Many random variables such as densities, member geometry, applied loads etc. are involved in structural engineering problems. The presence of several parameters substantially affects the action of the structural elements, therefore large numbers of data such as shear forces, maximum bending moment, deflections at critical points etc. are needed to analysed. For practical analysis, it is important to take into account random input parameters for expected values and variances of the structural response.The structural safety depends on the Structural resistance (R) and the Structural action (S). The structural behaviour is the function of loads which is a random variable. The resistance depends on the probabilistic physical properties of the materials used and the geometrical properties of the structure. Forgiven random design variables determining the degree of safety within the probabilistic design situation is far more relevant.In the past years, numerous approaches for probabilistic structural analyses have been reviewed. Monte-Carlo simulation(MCS) method is the easiest way to accomplish the probabilistic studies, in fact this method is statically consistent.The structural response of RC beam in a portal frame is considered in this study in particular as flexure and shear. Flexure and shear generally depend on different parameters such as geometry and materials. Most of these parameters are random in nature, and therefore there is uncertainty about the intensity in the RC members' response.

Objective

To study the probability of RC beam failure in the portal frame integrating various uncertainties by Monte-Carlo simulation process.

II. Methodology

The methodology to achieve the above-mentioned objective is as follows:

- Modelling the single bay RCC frame in SAP2000 software.
- Validation of the modelling by deterministic approach.
- Validation of the modelling by probabilistic approach using Monte-Carlo simulation technique.
- Fitting of probabilistic distribution responses for different variables.
- Comparing the results of deterministic and probabilistic methods and computing probability of failure

Deterministic Design of Beam

An RCC single bay frame with the below details is considered

- Column height = 4.0 m

- Beam lengths = 6.0 m
- Live load on Beam = 20 kN/m
- Grade of concrete = M25
- Grade of Steel = fe500
- Column Size = 300 x 450 mm
- Beam Size = 300 x 450 mm

Frame analysis is performed in SAP2000, and these results used for deterministic design. Bending moment and shear force is used to check the beam safety. Under various design constraints as per the provision of IS: 456-2000 the section is found to be safe. If the section fails it must be revised in the deterministic design.

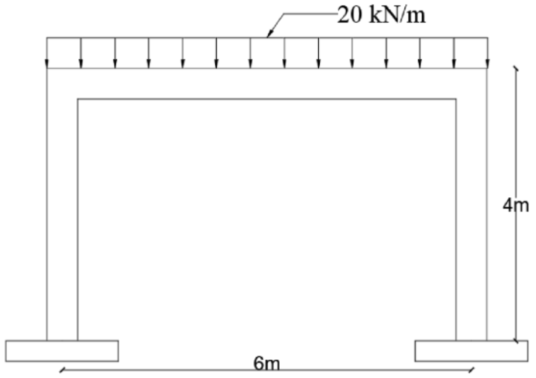

Fig.1: Loading and geometric details of case study frame

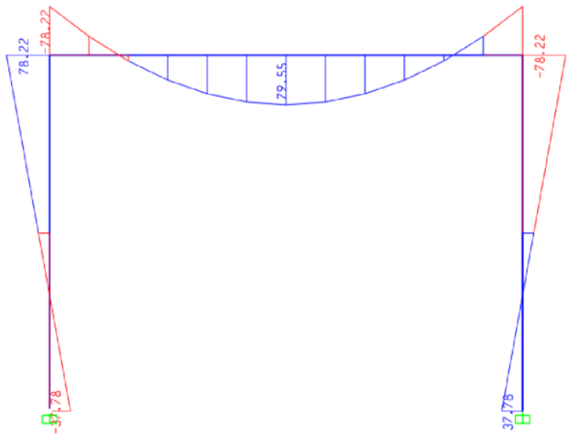

Fig.2: Bending Moment

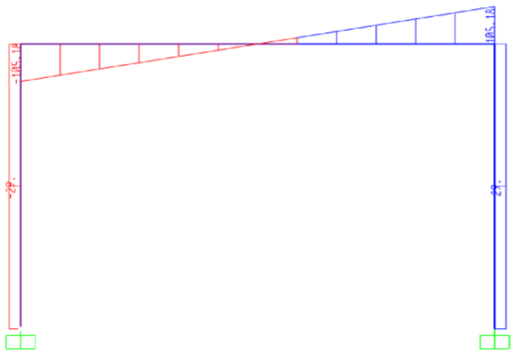

Fig.3: Shear Force

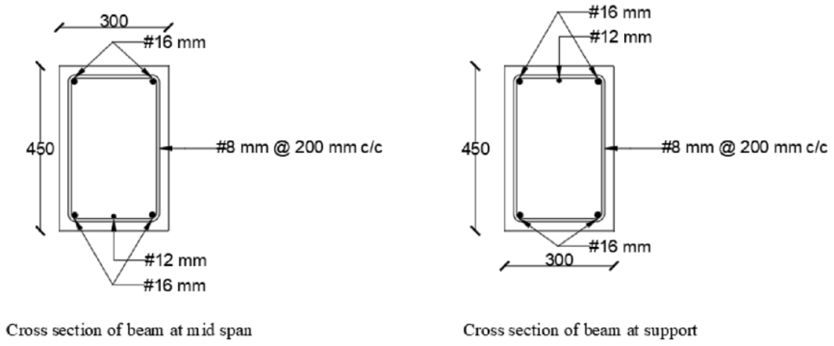

Fig.4: Cross section of beam at different location

Monte Carlo Simulation

It is a powerful engineering tool that enables one to perform a statistical analysis of structural engineering uncertainty problems. This method is used for complex problems where numerous random variables are related in an experiment which is performed by computer rather than in a structural engineering laboratory.Various methods have been developed for the generation of uniform pseudo-random numbers. Subroutines for this purpose are readily available. Built-in programmes are generally available in computer software like MATLAB to generate uniform random numbers.The Box and Muller technique is used to generate normal variants for normal distribution.Standard normal deviations are obtained here by producing two uniform random numbers v1 and v2 (with a uniform density range between 0 and 1) at a time. Then the desired standard normal variates are given by

$$u1=[2\ln(1/v1)]^{0.5}\cos(2\pi v2)$$

$$u2=[2\ln(1/v1)]^{0.5}\sin(2\pi v2)$$

Further we generate Standard normal variates with respect to mean and standard deviation which is given by

$$y1=\mu+\sigma*u1$$

$$y2=\mu+\sigma*u2$$

Load And Resistance Data Generation

For the probabilistic design mean and standard deviation value for distribution of parameters are required. Standard deviation for each parameter is calculated by coefficient of variables. Geometric dimensions, Properties of material and Loads on structure are considered as design variables. The coefficient of variables is given below table

Table.1: Coefficient of Variables for different design variables

	Variables	Coefficient of Variables
Geometric Property	Breadth	0.03
	Depth	0.04
Material Property	f_{ck}	0.15
	f_y	0.1
Load	20% Live Load	0.2
	40% Live Load	0.4
	60% Live Load	0.6

**Ref. Dr. K. Manjunath and MeghanaBharadwaj,(2016)"Reliability analysis of Flanged RC Beams in Limit State of Cracking*

Probabilistic Design of Beam

In probabilistic design method all design parameters are considered to be random in nature. The design random variables are loads on structure i.e.live loads on the floors, wind loads, ocean waves, earthquakes, etc. Similarly, structural strength i.e. concrete strength, steel strength, etc. and geometric parameters like section size,height, width, weight, etc. are subject to statistical variations. Therefore, in order to make a reasonable estimate of structural safety it is necessary to consider the random variations of essential parameters. Due to the random variables of load, strength and geometric properties, the structural safety is also a statistical variable. In view of uncertainty about strength and load, the aim of the structural reliability analysis is to evaluate the structural safety. The structural performance is assessed with physical and empirical data supported models. The structural reliability theory is based on probabilistic modelling of these uncertainties and which provide methodology for calculating the likelihood that structures fulfil the performance criteria in MATLAB software.

All the following steps are performed for the probabilistic model; the standard normal deviations are calculated by producing two uniform irregular numbers v1 and v2 with a uniform range of 0 and 1. After that it calculates the normal standard variants u1 and u2. The variations are applied in this study for beam depth, and beam width, characteristic of concrete strength, characteristic of steel strength, and live load. For 100 values of standard normal variations above parameters are applied, and SAP2000v22 performs 100 frame analytics numbers. Similarly, all parameters vary, the moment and shear force is obtained for 20 %, 40% and 60% variation in live load. Probability failure is obtained and the variation in live load is compared with 20 percent, 40 percent and 60 percent. Simulate resistance using a beam equation that is subjected to the IS 456-2000 gravity charge.

III. Histogram and Probability Distribution

Histogram provides the most frequently occurring values for the data range, and the degree to which they are dispersed. The observation is made and it is noted as they occur. Therefore, the collected sample data is in an unorganised pattern. That unorganised data gets arranged properly. These values are ranked in ascending order. The ordered values are then divided into intervals, and the number of observations at each interval is plotted as a bar chart. The histogram and probability distribution curve of the sample generated is plotted for maximum moment capacity and maximum capacity of beam shear. Suitability of probabilistic model to fit the data following tests are conducted in MATLAB

a) Chi-square Test.

b) Kolmogorove-Smirnov (K S) Test.

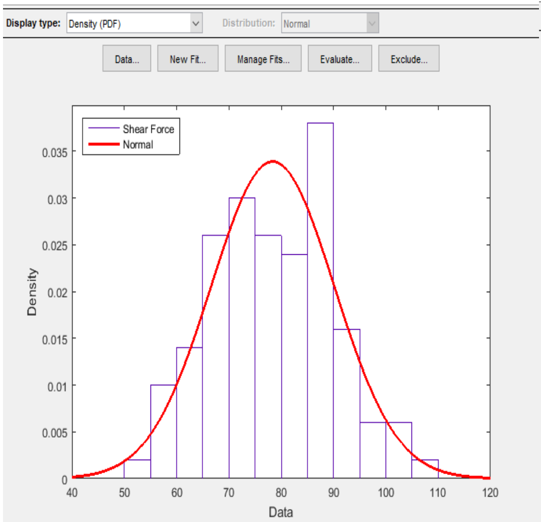

Fig.5 Probability distribution curve for SF

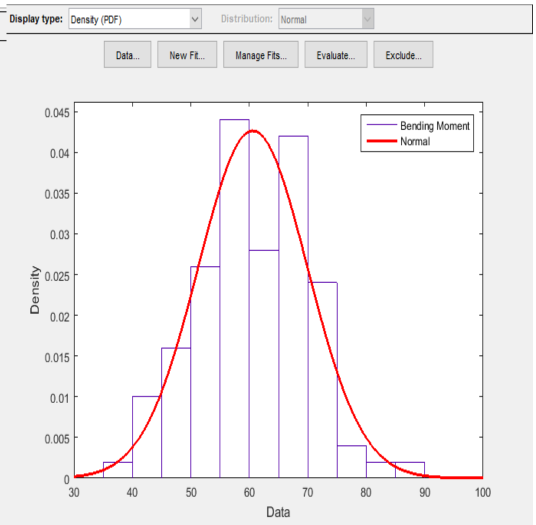

Fig.6 Probability distribution curve for BM

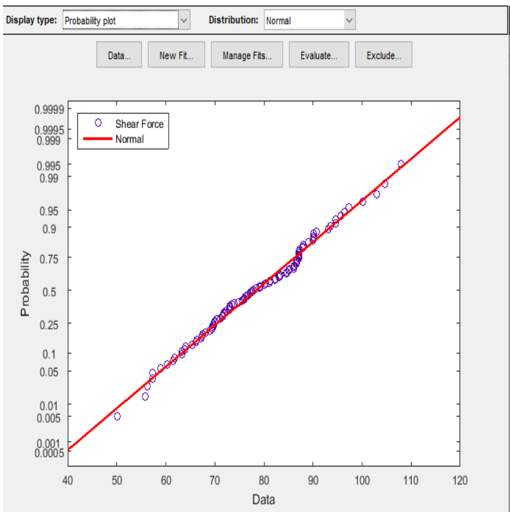

Fig.7 Probability Plot for SF

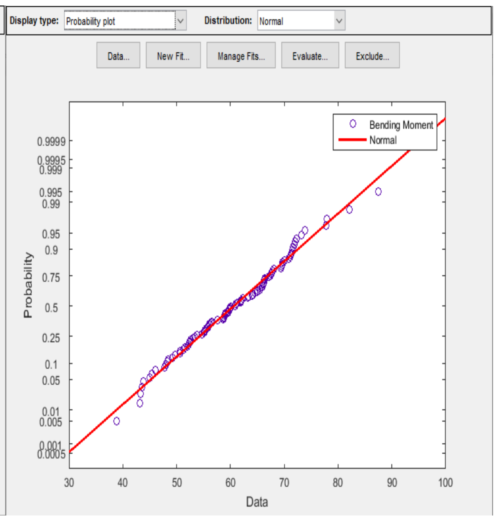

Fig.8 Probability Plot for BM

IV. Results and Conclusion

The probability Failure of Beam in Shear is as follows

Live Load	20%	40%	60%
p_f	0	0.02	0.12
Reliability	1	0.98	0.88

The probability Failure of Beam in Flexure is as follows

Live Load	20%	40%	60%
p_f	0.01	0.12	0.33
Reliability	0.99	0.88	0.67

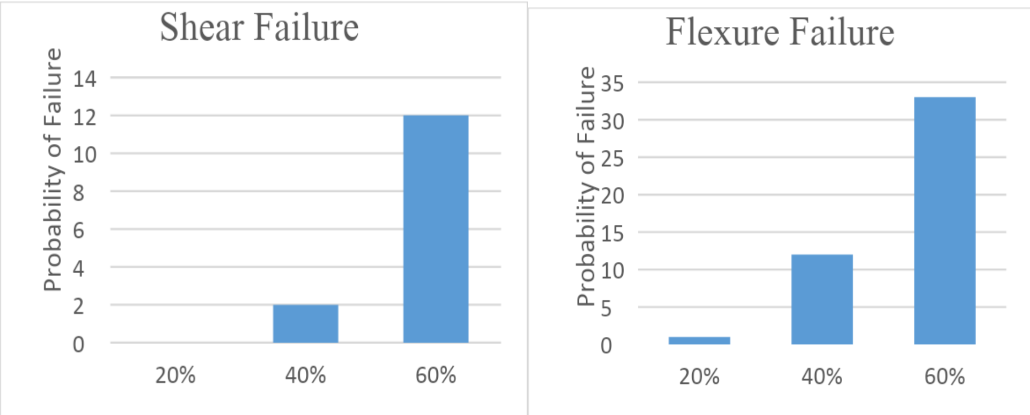

Fig.9 Bar chart showing probability of failure in shear and flexure

In this study, an attempt is made to quantify the safety levels in a single bay portal frame in terms of probability failure of a reinforced concrete beam by treating as basic design variables as random and literature is used to collect their statistics. The RC frame is analysed using SAP2000v22 software and designed according to the provision of IS 456-2000 using a deterministic approach. If the sections fail, the deterministic design must be redesigned. The probabilistic approach design data set varied randomly with the use of Monte-Carlo simulation technique as a function of statistical model for thedifferent variables involved. With the aid of MATLAB software, the RC frame is analysed and repeated 100 times for various live load cases in SAP2000v22 software. Distribution of probability is tried as a Normal function. It is observed that both the moment and shear follows normal distribution which is tested by Chi-Square and K-S test for a given distribution of probability to a generate data. Using the generated values of the design variables as input beams is designed for a probabilistic model (S) according to the design guidelines given by IS-456 and is compared with deterministic model (R). The probability of the beam failure is determined by the ratio between the number failures and the total number of simulations. We calculate the reliability as Ro = 1-Pf. It is observed that the failure rate of the beam section in the shear is approximately 0 percent or a failure of probability is 0 (20 percent live load), 2 percent or a failure of probability is 0.02 (40 percent live load), 12 percent or a failure of probability is 0.12 (60 percent live load) and a failure of the beam section in flexure is approximately 1 percent, or a failure of probability is 0.01 (20 percent live load), 12 percent live load. Probability failure for 20 per cent live load is very low. While designing the structures designer do not know the explicit safety levels as per provisions given in IS 456-2000, therefore, Probability of failure has to be kept very low. The reliability based design is intended to formulate the design procedure for a known level reliability.

References

[1]. VidyaSagar J, Manjunath G S, Probability of failure of column and beam in steel structure due to plan irregularities,International Research Journal of Engineering and Technology. 2017; 4(08): 1022-1028

[2]. Manjunath J, Dr. K Manjunath, Naveen Kumar S, Sunil Kumar M S, Astudy on probability failure of a column in RC frame by varying live load,International Research Journal of Engineering and Technology. 2015; 2(05): 48-53

[3]. Amy KirkeHong Hao, Estimation of failure probabilities of RC frame structures in Singapore to the simulated largest credible ground motion,2004; 26(1):139-150

[4]. IS 456-2000 Indian standard code of practice for plain and reinforced concrete, fourth edition, Bureau of Indian Standards

R. J. Fernandes, et. al. “A Study on Probability Failure of RC Beam in Single Bay Portal Frame for Varying Live Load.” *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 17(5), 2020, pp. 16-20.