RELIABILITY ANALYSIS OF STATIC RESPONSE OF STRUCTURES WITH IRREGULARITIES

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Abstract - *Reliability analysis of static response of structures helps us to acquire more accurate storey shear values acting on the structure, which results in more economical design of the structure. The reduction in quantity of concrete is not as economical as reduction in quantity of steel. This can be achieved by performing static analysis through reliability method. We have adopted Monte-Carlo simulation to perform the analysis. The total forces acting on the structure is reduced by performing reliability analysis, which leads to more economical design of the structure. The base shear values obtained by performing equivalent static analysis according to IS1893 (Part1)-2002 is more as compared to the static analysis performed in Etabs 2013. This is because the software takes clear distances than centre-centre. If the same concept is adopted for reliability analysis, the base shear values can be decreased further. The base shear values are found out by all the 3 methods as mentioned above. To show the use of reduction in base shear values, the amount of steel required for the critical column in the structure is found and comments have been made on them.*

Effort is done to reduces the quantity of steel required which results in economical design.

Key Words: Reliability analysis, Static response, base shear, Monte-Carlo simulation.

1. INTRODUCTION

Earthquake is the vibration of the earth's surface as a result of a release of energy in the earth's crust. Seismic forces are the most devastating and complex forces that analysts come through. Earthquake is a naturally occurring process which cannot be avoided but the undesirable effects due to this can be minimized. The complicated nature of seismic forces to the structural response can be attributed to many factors that influence them. Nature of seismic forces and structures response to these forces are highly unpredictable. This unpredictable nature of these forces and the structural response can be attributed to many factors that influence it.

There is Indian Standard Codal Provisions (IS 1893:2002) to construct earthquake resistant structures.

There are different methods of analysis, which provide different degree of accuracy. The analysis process can be categorized on the basis of three factors: the type of externally applied loads, the behaviour of structure / structural materials, and the type of structural model selected. Based on the type of externally applied load and behaviour of structure the seismic methods of analysis can be classified as

a) Linear Static Analysis,
b) Linear Dynamic Analysis,
c) Non-Linear Static Analysis
d) Non-Linear Dynamic Analysis

To carry out this work linear static analysis method is adopted.

Reliability analysis is defined as the consistent evaluation of design risk using probability theory. Reliability analysis provides more accurate results as it performs 'n' number of iterations.

2. LINEAR STATIC ANALYSIS

Linear static analysis can be performed by equivalent static lateral force method. This method can be applied for regular structure with limited height i.e. for low and medium height buildings.

The horizontal seismic coefficient and total seismic weight of the structure is determined and hence base shear is found.

3. MONTE-CARLO SIMULATION

The number of iterations (n) to be performed is assumed. Higher the number 'n', higher is the accuracy of the result obtained. 'n' random variables are generated. Multiplying coefficients U_1 and U_2 are calculated. Each parameter is varied 'n' number of times and the results are obtained from appropriate formulas.

4. IRREGULARITIES IN BUILDINGS

Structural plans can be either regular or irregular. Irregularities are mainly of two types viz.

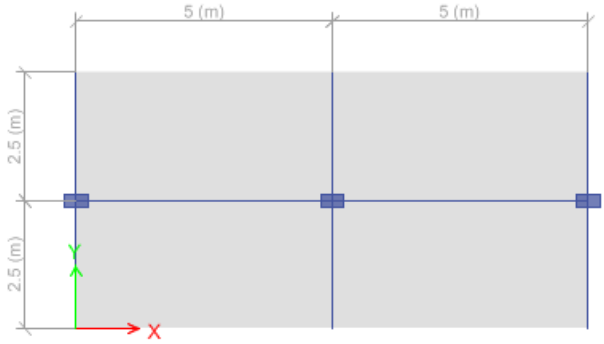
1. Horizontal Irregularities
2. Vertical Irregularities.

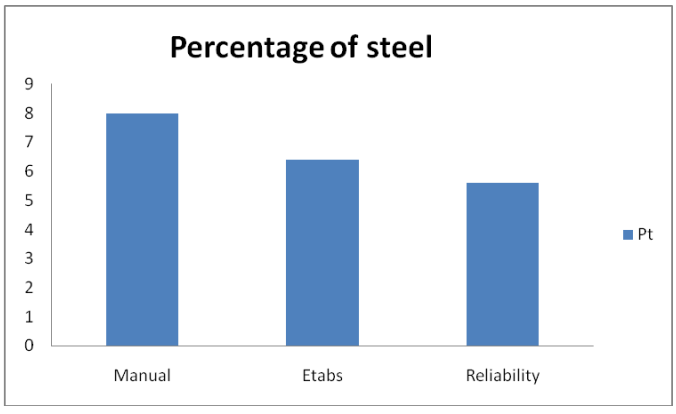
They can be subdivided into various irregularities. Few of them are considered in this study.

5. PRESENT STUDY

In the present, an attempt is made to reduce the amount of forces acting on the structure through reliability analysis of static response of structure as compared to the static analysis of the structure. Following examples have been taken for this study.

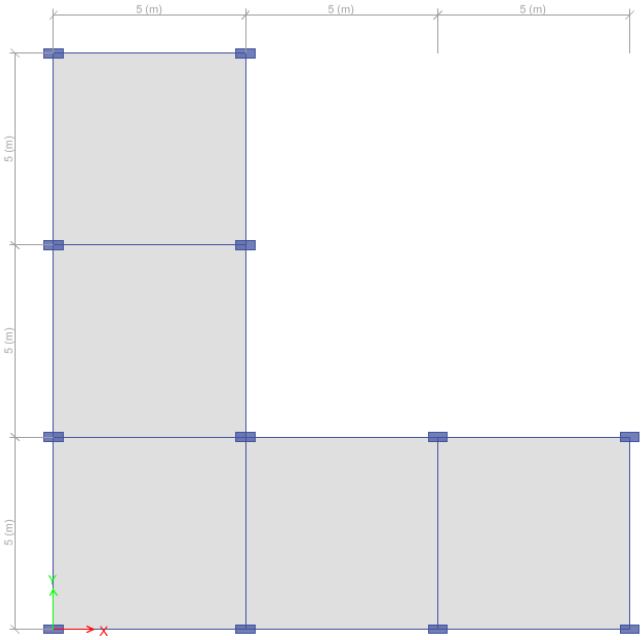
Example 1: Symmetrical Plan

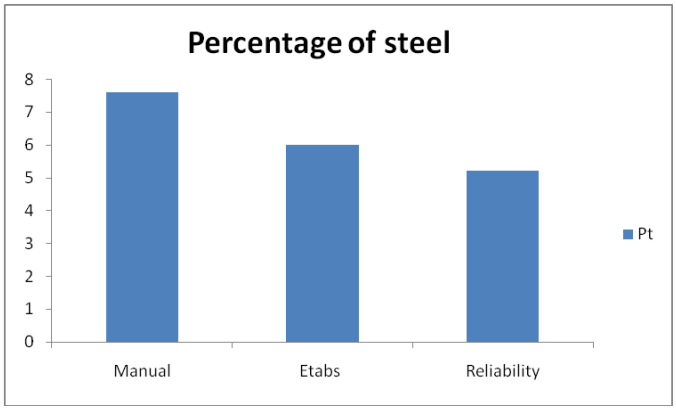




After obtaining the storey shear values from manual, Etabs and Reliability analysis, the structural analysis using these forces is performed and the moments of the critical columns was noted and design was performed to obtain the percentage of steel required. A comparitive graph of Pt is given above. The amount of steel saved as compared to manual and Etabs calculation is 20% whereas a further more of 17.85% of steel can be saved from reliability analysis. This percentage of savings is only for a single column in the structure.

Example 2 : Plan Irregular structure

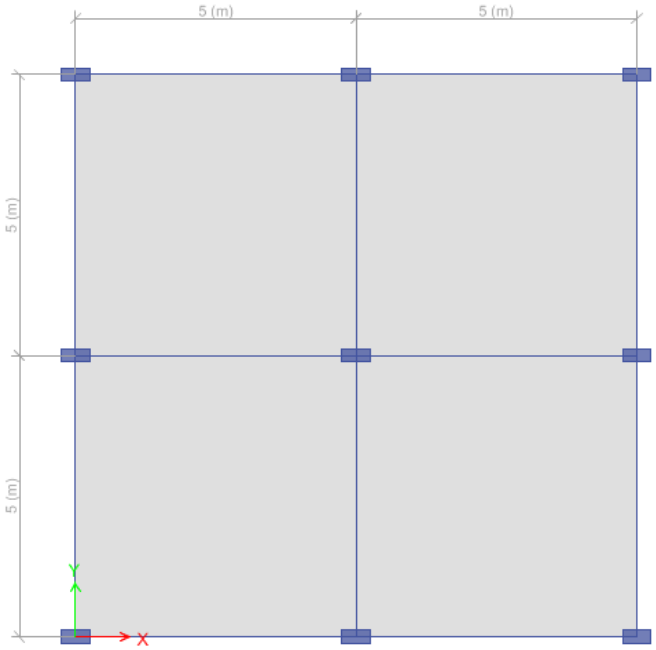


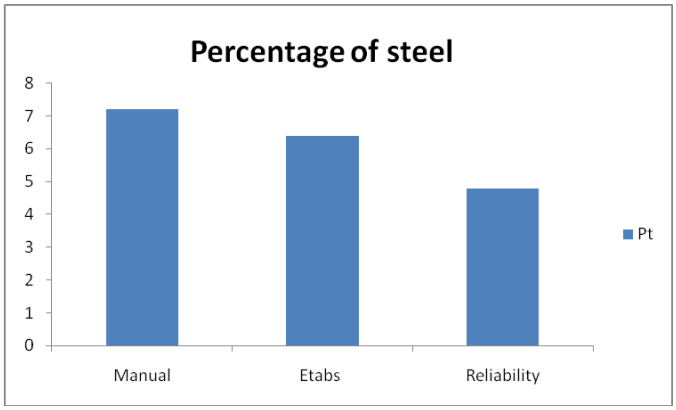


The above procedure is repeated and the graph is plotted as explained.

The amount of steel saved as compared to manual and Etabs calculation is 21.05% whereas a further more of 13.33% of steel can be saved from reliability analysis. This percentage of savings is only for a single column in the structure.

Example 3 : Stiffness Irregular structure

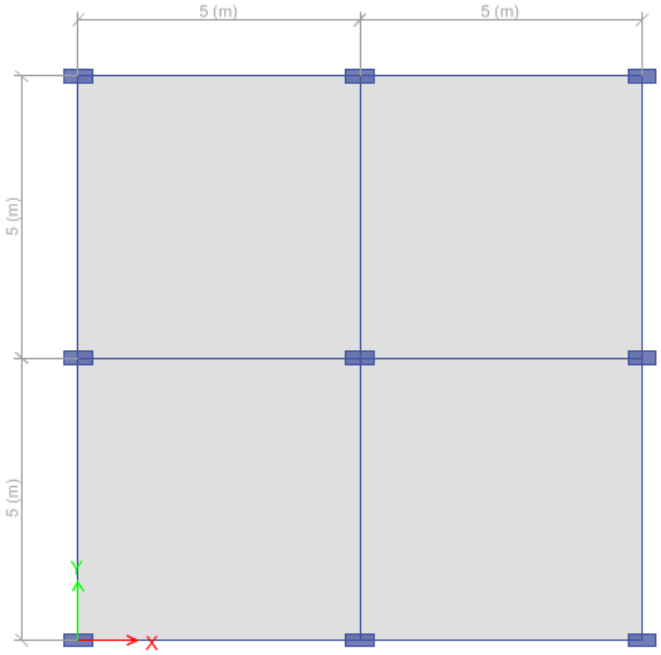


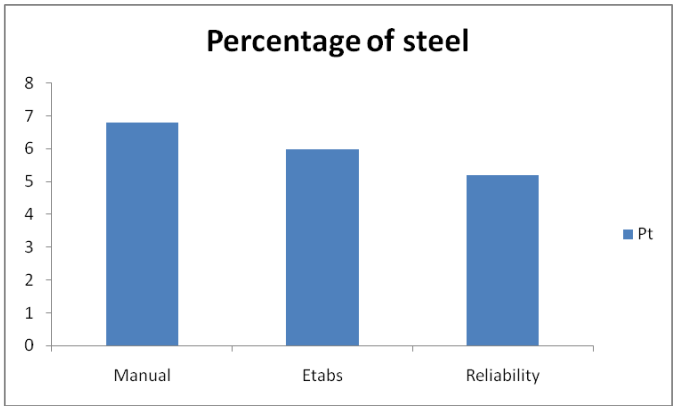


The elevation of the structure remains same except in the ground floor and hence the stiffness irregularity.

The amount of steel saved as compared to manual and Etabs calculation is 11.11% whereas a further more of 25% of steel can be saved from reliability analysis. This percentage of savings is only for a single column in the structure.

Example 4 : Mass Irregular structure

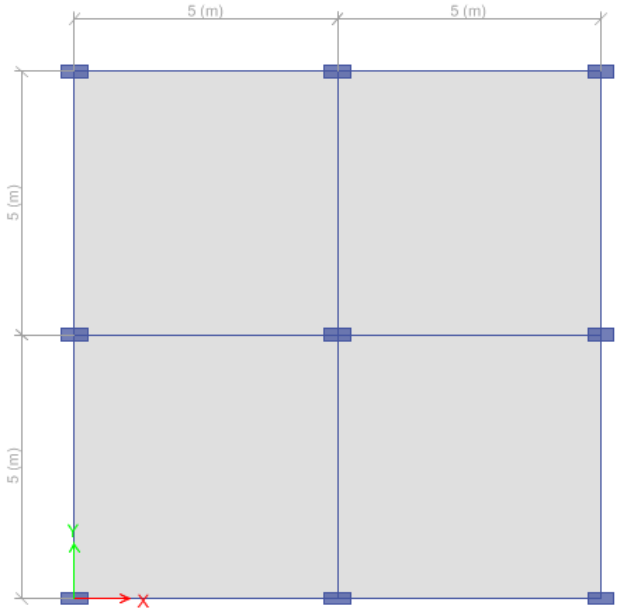




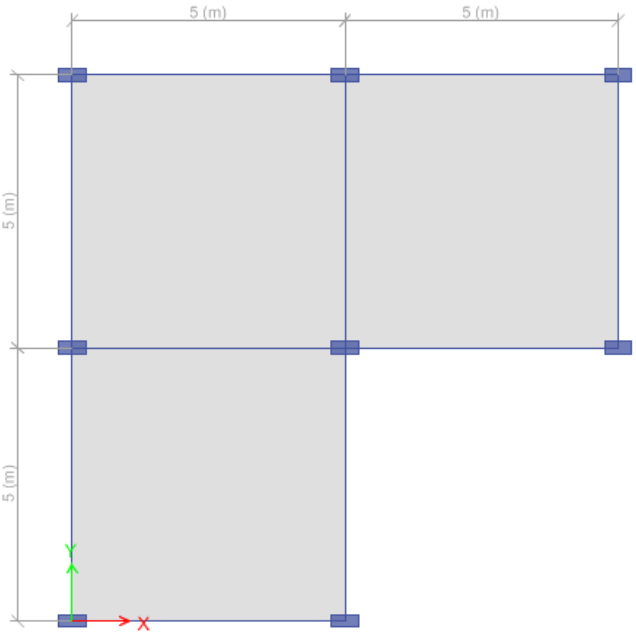
The imposed load on the structure in floor 2 is increased as per IS 875 (Part 2)-1987 and hence the mass irregularity.

The amount of steel saved as compared to manual and Etabs calculation is 11.76% whereas a further more of 13.33% of steel can be saved from reliability analysis. This percentage of savings is only for a single column in the structure.

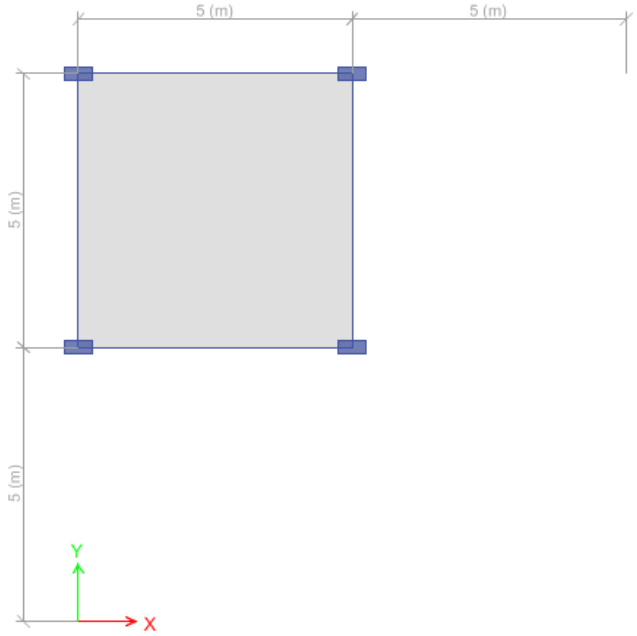
Example 5 : Elevation Irregular structure



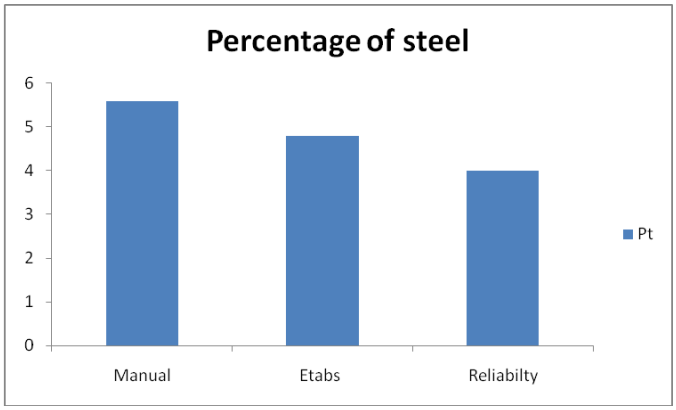
Floor 1 and 2



Floor 3



Floor 4



As the paln clearly shows the irregularity in elevation.

The amount of steel saved as compared to manual and Etabs calculation is 14.29% whereas a further more of 16.67% of steel can be saved from reliability analysis. This percentage of savings is only for a single column in the structure.

6. CONCLUSIONS

As it is clearly seen that a further more of savings in percentage of steel varying from 13.33% to 25% can be made by finding more accurate value of storey shear values just for a single column in a structure as compared in various types of irregularities. Since the cost multiplication factor is just a number which is constant same percentage of saving is achieved even when amount is considered.

If reliability analysis is applied for all the components of the structure, the percentage saving would be very high as the size of the structure increases. In buildings with greater dimensions of concrete, the savings achieved through reliability analysis would be significantly high. Hence reliability analysis is a very strong tool for the design of structures.

