Trusty and Seismic Analysis of an Existing Building

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Abstract-**To designate the building safety by seismic analysis for various intensities of seismic activities and other factors like Seismic zone, nearby faults, History of earthquakes at a particular zone and based on its surrounding areas. Seismic analysis is a subset of structural analysis and is the calculation of the response of a building structure to earthquakes. A building in the premises of Kumaraguru College of Technology, Coimbatore was opted for the response calculation and the structural data were collected. The building frames were analyzed for the six earthquake demands namely IS: 1893-2002 equivalent static method IS: 1893-2002 response spectrum method and Bhuj earthquake (2001, M6.9), Chamoli (1999, M6.8), Uttarkashi (1991, M6.8), El-Centro (1940, M6.9) using time history method. The analysis of the building frames were carried out analytically and by using ETABS software as per the recommendations of IS:1893-2002. Base shear, Storey drift and maximum displacements were compared for the earthquake demands.**

Keywords- **RCC frame, Structural analysis, Equivalent Static method, Response Spectrum method, Time history method, Story drift, Maximum Displacement, Base Shear.**

I. INTRODUCTION

The principal of all genre of structural systems used in the structural building is to transfer gravity loads persuasively. The most common vertical loads resulting in the effects due to gravity are dead load, live load and snow load, etc. Besides, buildings are also subjected to lateral loads caused by wind, blasting or earthquake. Lateral loads can develop high stresses, produce strong influence or cause quivering. For that reason, it is very substantial for the structure to have enough stamina against vertical loads together with tolerable rigidity to resist flanking power.

Southern peninsular of India was once considered as a stable land mass while compared to the northern parts of India. Tamil Nadu is not an active seismic state because of earthquakes happened in the past at bearable level. Even though, several faults have been diagnosed in this region, shows that movement of shiver happened during the Holocene period. It had been a long felt obligation to deliberate the earthquake resistant design and construction of structures infectious into account seismic data from learning of these earthquakes. Response of the building will count on the seismic intensity of earthquake; it bargains with the study of the brewing earthquake ground motions on the existing building.

The structure will be confirmed whether it was constructed as per design procedures or not, by conducting Non-Destructive Tests (NDT). The name "Nondestructive" allows for careful and thorough materials evaluation without the need for deconstruction or damage. Non-Destructive Testing plays an important role in assuring that structural and mechanical components carry out their job in a safe, righteous, and cost-effective aspect. NDT technicians accomplish the necessary tests to detect the indicators and discontinuities that may cause defeats or shut downs in the systems [1-3]. These tests are performed

in a manner that does not affect the future usefulness of the members of the structures [9-11]. For seismic analysis, the floor system in all the configurations is modeled as rigid frames diaphragm; beam and column members modeled as two node beam elements. The foundation in all the models is assumed to be fixed support system.The aim of the vulnerability evaluation is to find the deficiencies in structure before taking appropriate rehabilitations to upgrade the system. Several methodologies have been developed to estimate the vulnerability of Existing buildings and to evaluate the damage of structures; time by time these methodologies have been improved. The use of damage probability matrices for the probabilistic prediction of damage to buildings from Earthquakes were first developed in 1974 [4]. Seismic performance and damage evaluation of a low rise (3 storied) RC building, designed under gravity load as per Indian code IS 456-2000 is considered [8]. The torsion effects and accidental eccentricity is considered in the analysis as per recommendations of Indian code IS: 1893 (Part 1) - 2002 [12]. Non linear static analysis is carried out using available computer program ETABS (V 9.15) [5]. The dead loads confirming IS: 875 (Part-1)-1987 and imposed loads confirming IS 875 (Part 2)-1987 of the RC buildings are taken [13-14]. To realize the response of the structure for various demands the structure was analyzed by various methods the results are compared. The results showed that it is possible to get a good accuracy in measuring the highest load an RC frame could withstand through the above analysis. So, in this study, analyses have been performed using ETABS which is a general purpose structural analysis program for static and dynamic analyses of structures [6-7].

II. STRUCTURAL DETAILS

A laboratory which was used by the physics and chemistry department, situated in Saravanampatti, Coimbatore is selected as a model. It is a RCC framed structure of G+1 and each having the area of 428.64 m^2.The details are shown in Figure 1-3.

a. Model

Fig 1.Elevation

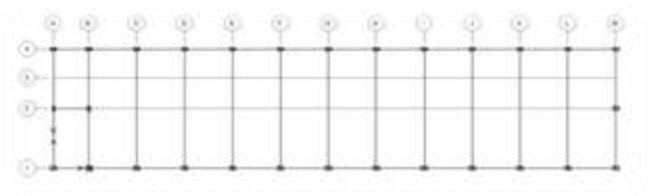

Fig 2.Beams & Columns

b. Building plan

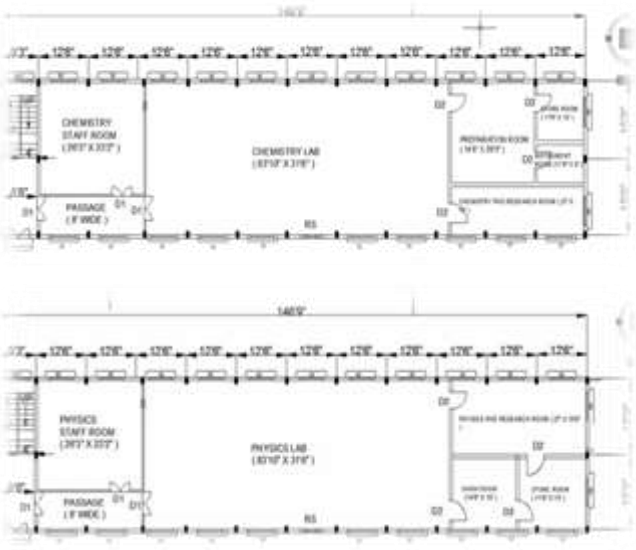

Fig 3.Plan

III. STRUCTURAL DATA COLLECTION

a. Need of non-destructive testing

It is often necessary to test concrete structures after the concrete has hardened, to determine whether the structure is suitable for its designed use. In some cases it is also possible to check the quality of workmanship and structural integrity by the ability to detect voids, cracking and delamination.

b. Rebound hammer

Rebound hammer test is wrought to ascertain the compressive strength of concrete as per IS: 13311

(Part 2) – 1992. The test was conducted on three levels of the members at certain equal distance and at levells three readings were takened. As the conclusion of rebound hammer test, most of the beams and columns had the below design strength. As such the estimation of strength of concrete by rebound hammer method cannot be considered as very accurate and probability of accuracy of prediction of concrete strength in a structure is ± 25 percent. So the structural members are considered as having the design strength.

c. Ultrasonic pulse velocity test

This test is wrought to ascertain the quality of concrete by ultrasonic pulse velocity method as per IS: 13311 (Part 1) – 1992. These test readings (Table 1) also taken by alike as the rebound hammer test.

TABLE 1 UPV TEST

MEMBER	PATH LENGTH (Km)	TRAVEL TIME (Sec)	VELOCITY (Km/Sec)
BEAM	0.0003	56.90	5.2
COLUMN	0.0003	67.80	4.4
SLAB	0.001	233	4.3
STAIRCASE	0.001	222	4.5

c. Rebar locator test

Rebar indicator is one of the NDT, which are used to indicate the steel bar entrenched in concrete earlier drilling and earlier taking core test. Its ability is up-to a maximum depth of 180 mm. As a conclusion of this test the reinforcement details of structural members were drawn (Figure 4 and 5).

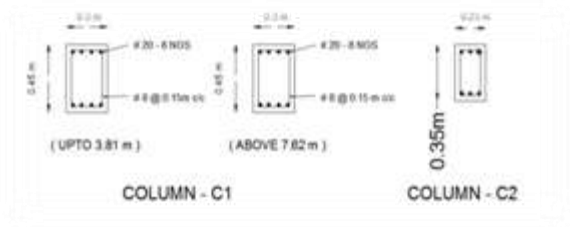

Fig 4.C/S of the Column

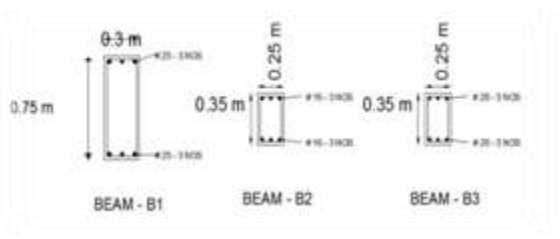

Fig 5.C/S of the Beam

IV. STRUCTURAL ANALYSIS

a. *Equivalent static method*

As per IS 1893 (Part 1): 2002 Indian Standard Criteria for Earthquake Resistant Design of Structures: Part 1 General Provision and Buildings (Fifth Revision). It needs the carrying out a task of nonlinear static analysis of structure that allows monitoring liberal yielding of the structural component. The building is subjected to a lateral load (Table 2) which magnitude boosted until the building reaches target displacement. This goal of displacement is determined to represent the top displacement when the building is subjected to design level ground excitation.

Table 2 Static load

FLOOR	D.L (kN/m^2)	L.L (kN/m^2)	SEISMIC LOAD (kN)
ROOF	3531.85	1285.92	4818
FIRST	4246.22	1285.92	5532
TOTAL LOAD (kN)			10350

Design of Base Shear V_B= 0.1 X 10350 = 1035 kN

b. Response spectrum method

Response spectrum analysis is exact valuable for analyzing the accomplishment of structures under earthquake.

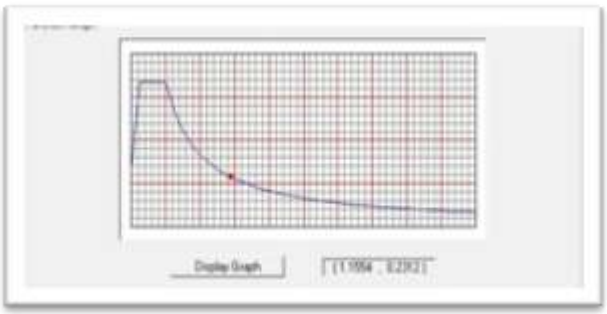

Fig 6. Response Spectra

From the response spectrum analysis of the existing building, the base shear is calculated using response spectra curve (Figure 6).

c. Time history analysis method

Time history data are very less for Indian earthquakes. Because in early stage there is no awareness about earthquakes in India but now India has experienced the effects of earthquake. The required time history data's were taken as per the requirement [15]. While these dada put into the ETABS software the following results were obtained (Figure 7 - 10).

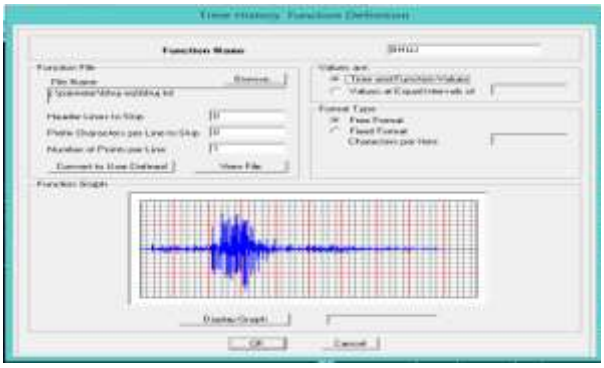

Fig.7 Bhuj

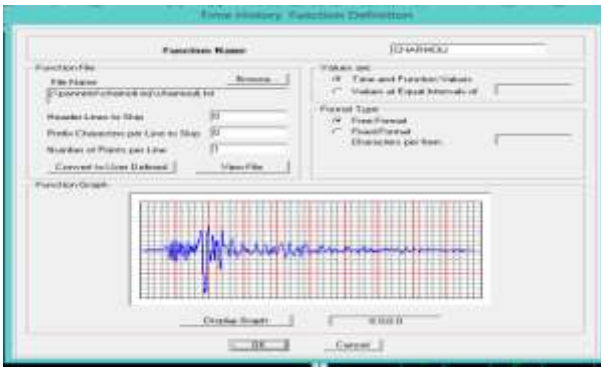

Fig 8 Chamoli

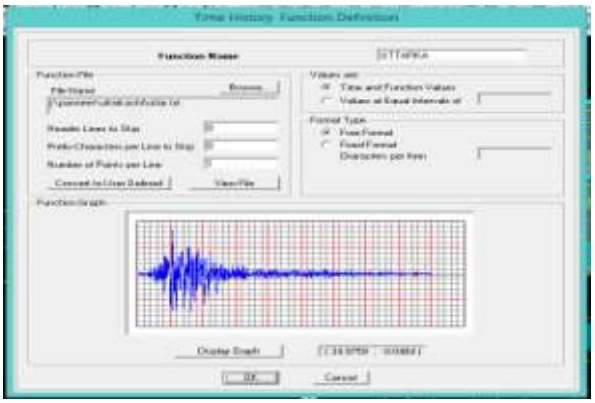

Fig 9 Uttarkashi

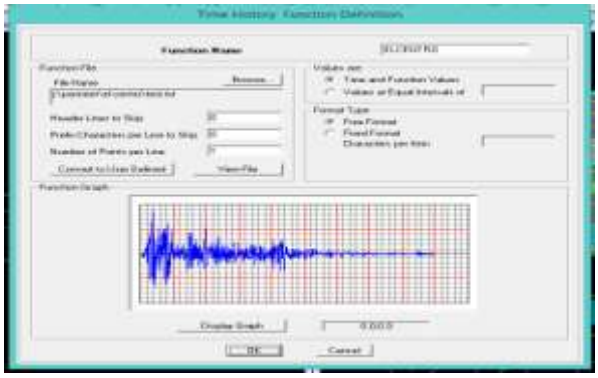

Fig.10 El-Centro

By using the above input values the structure was analyzed. As a result of Base shear, Max.Displacement, Storey drift for the structure was obtained.

V. RESULTS AND DISCUSSION

Results of the equivalent static method, response spectrum method and time history analysis methods are compared and discussed in this chapter.

a. Storey drift

While compare the storey drift results which drawn from various methods (Figure 11) & (Table 3-4), for ground floor equivalent static method gives maximum values and for first floor El-Centro EQ gives maximum values.

TABLE 3 COMPARISON OF STOREY DRIFT

		Time history analysis method			
		Elcento EQ	Bhuj EQ	Chamoli EQ	Uttarkashi EQ
Storey drift (mm)	G	2.20	1.70	1.70	1.70
	G+1	2.20	2.10	2.10	2.10

TABLE 4 COMPARISON OF STORY DRIFT

		Static Method	Response spectrum
Storey drift (mm)	G	0.30	1.50
	G+1	4.70	1.90

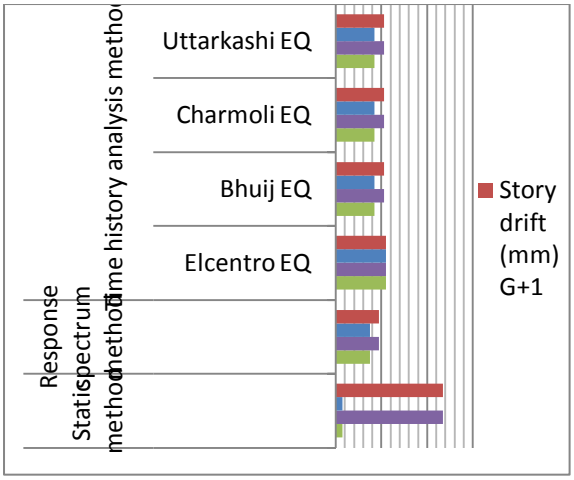

Fig 11.comparison of storey Drift

b. Maximum displacement

While comparing the maximum displacement results which drawn from various methods equivalent static method gives maximum value (Figure 12) & (Table 5-6).

Fig 12 Comparison of Max.Displacement

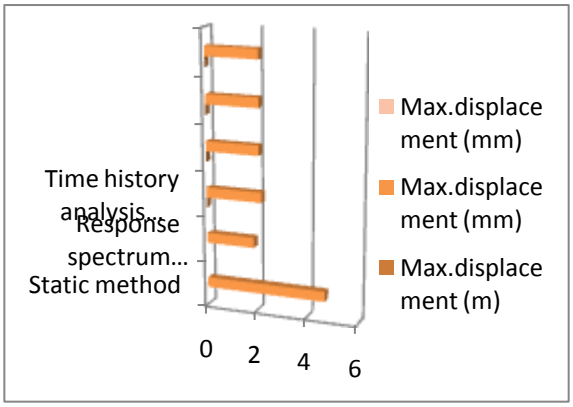

TABLE 5 COMPARISON OF MAX.DISPLACEMENT

	Static Method	**Response spectrum**
Max.displacement (mm)	**4.70**	**1.90**

TABLE 6 COMPARISON OF MAX.DISPLACEMENT

	Time history analysis method			
	Elcentro EQ	Bhuj EQ	Chamoli EQ	Uttarkashi EQ
Max.displ (mm)	2.20	2.10	2.10	2.10

c. Base shear

While comparing the base shear results which drawn from various methods response spectrum method gives maximum value. (Figure 13) & (Table7-8).

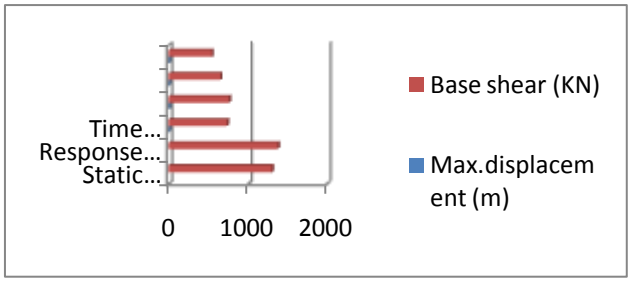

Fig 13 Comparison of Base shear

TABLE 7 COMPARISON OF BASE SHEAR

	Static Method	**Response spectrum Method**
Base shear (kN)	**1305**	**1379**

TABLE 8 COMPARISON OF BASE SHEAR

	Time History Analysis Method			
	Elcentro EQ	**Bhuj EQ**	**Chamoli EQ**	**Uttarkashi EQ**
Base shear (kN)	**739**	**763**	**654**	**545**

VI. CONCLUSION

Based on the Rebound hammer test, Ultrasonic pulse velocity test and Rebar locator test concluded that existing building was constructed as per design procedure and design norms, and it is still functioning as intended without any loss in structural demands. Subsurface soil is considered as hard and rocky based on the test on soil and IS: 1893-2002 code norms. By using the ETABS software the structure was analyzed using three methods namely equivalent static method, response spectrum method and time history analysis method the following results are obtained.

- ✓ Storey drift of the three method results are within the limit (0.004x3810 = 15.24 mm) as per clause no 7.11.1 of IS-1893 (Part-1):2002.
- ✓ Design base shear (V_b) is less than the result of the dynamic analysis (V_b) as per clause no 7.8.2 of IS-1893 (Part-1):2002.

From analysis of the structure for various earthquake demands Equivalent Static Method gives the most reliable result among the three types of analysis.

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