COMPARATIVE STUDY OF INDUSTRIAL BUILDING SHEDS MADE OF STEEL AND CONCRETE

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ABSTRACT

The seismic vibrations cause random ground motions, in all possible directions emanating from the epicentre. The ground motions in vertical directions are rare, but an earthquake is always accompanied with horizontal ground shaking. The vibration of the ground causes the structures to vibrate, developing inertial forces. As the earthquake changes directions, it can cause reversal of stresses in the structural components, that is, tension may change to compression and compression ma change to tension. Earthquake can cause generation of high stresses, which can lead to yielding of structures and large deformations, rendering the structure non-functional and unserviceable. The large storey drifts can make a building unsafe for the occupants to continue living. The most commonly adopted buildings construction practices in India are the Reinforced Concrete Frames. With growing economy, the need for construction of industries and factories is increasing day by day. With industrial structures, not only the building has to take up gravity loads, but as well as lateral forces. Many important Indian cities fall under high risk seismic zones, hence strengthening of industrial buildings for lateral forces is a prerequisite. In this study the aim is to analyse the seismic response of an Industrial structure to ground motion using Response Spectrum Analysis. This analysis is performed in various codal provisions (namely Indian, American, and European codes) in Staad Pro. And change in the time period, base shear, maximum deflection, maximum axial force, maximum Bending moments of columns in Y & Z directions, percentage mass participation factors, mode shapes and Sa/g vs Time period graphs are observed and compared. The earth quake parameters, codal provisions & site conditions are different in different countries, but the structural analysis concept of Response spectrum analysis has to be same. So, if a structure fails in codal provisions of one code, then using the same theory prescribed by other code (of course, empherical values may change), we may pass the structure. This is the purpose of the comparison & to know which code is superior to other in terms of response spectrum analysis.

1.0 INTRODUCTION

Earthquake causes random ground motions, in all possible directions emanating from the epicentre. Vertical ground motions are rare, but an earthquake is always accompanied with horizontal ground shaking. The ground vibration causes the structures resting on the ground to vibrate, developing inertial forces in the structure. As the earthquake changes directions, it can cause reversal of stresses in the structural components, that is, tension may change to compression and compression ma change to tension. Earthquake can cause generation of high stresses, which can lead to yielding of structures and large deformations, rendering the structure non-functional and unserviceable. There can be large storey drift in the building, making the building unsafe for the occupants to continue living there.

Reinforced Concrete Frames are the most commonly adopted buildings construction practices in India. With growing economy, the need for construction of industries and factories is increasing day by day. With industrial structures, not only the building has to take up gravity loads, but as well as lateral forces. Many important Indian cities fall under high risk seismic zones, hence strengthening of industrial buildings for lateral forces is a prerequisite.

OBJECTIVES:

The objective of this study is to investigate the effects of the selection and scaling of seismic excitations of the response of reinforced concrete framed buildings and compare the response spectrum analysis results with various codes. The response parameters used here are the maximum interstorey drifts and storey shears. The following are the list of tasks conducted and described in this thesis, in order to achieve this objective:

- Review of relevant literature
- Modelling and design of the building used in the analysis,
- Selection and scaling of seismic motions,
- Response spectrum analysis of the building.

SCOPE OF WORK

The scope of this project is limited to the Response Spectrum analysis of substation building using STAAD PRO software. The Response Spectrum analysis is performed in 3 different codes namely, Indian code, American code and Euro code. The results of the Response Spectrum analysis are compared with respect to above three mentioned codes. An RCC framed G +3 industrial substation building is being analysed in this project.

2.0 LITERATURE REVIEW

Various research works and experiments have been carried out since a long time over the globe to understand or to evaluate the effect of seismic forces on the Industrial RCC buildings in high seismic zones. The concept of modelling and analysis techniques used for this purpose has also been getting improved with advancement of engineering and technology as well as with past experience.

Lukas Moschen, 2016, paper represented method of response spectrum for peak floor response of any structure. The analysis is done by modal which is prepared under complete quadratic combination. He also explained the concept of stochastic base excitation for various high-rise building. Method has been tested multi-storeyed structures at various planes but with particular ground motion Technique embraced both flexible and inelastic structures all the while.

Chandurkar, Pajgade (2013) evaluated the response of a 10-storey building with seismic shear wall using ETAB v 9.5. The comparison of the change in response by changing the location of shear wall in the multi-storey building was the main focus in this review. Four models were studied-one being a bare frame structural system and the rest three were dual type structural system.

Jaime Landingin, 2012, looked at the seismic arrangements of the three seismic outline codes, specifically the Philippine code NSCP2010 (National Structural Code of the Philippines), the European code (Eurocode 8), and International Building Code IBC 2009 to the most common ordinary residential building of standard occupancy. The NSCP 2010 response spectrum function was considered for the horizontal load action with various combinations of loads.

Praval Priyaranjan (2012) attempted to evaluate an existing building located in Guwahati (Seismic zone -V) using equivalent static analysis. Indian Standard IS-1893:2002 (Part-1) has been followed for the Equivalent Static analysis method. Building was modelled in commercial software STAAD Pro. Seismic force demand for each individual member has been calculated for the design base shear as required by Indian Standard code IS-1893:2002.

Savitha et al. (2009) studied performance based seismic evaluation of building seismic vulnerability of building was assessed by carrying out nonlinear static pushover analysis at immediate occupancy, life safety and collapse prevention performance levels. Comparative study of two retrofit techniques was made by comparing the values of natural period, base shear, lateral displacement, storey drift, ductility and also performance of buildings were checked at their respective failure modes and target displacement levels.

S.D. Charkha, Latesh (2014) discussed the effects of scaling of earthquake excitations on the dynamic response of reinforced concrete framed buildings were investigated by analysing the nonlinear dynamic responses of three reinforced concrete framed buildings. The responses of the building resulting from the artificial accelerograms compatible with the design spectrum, and from the scaled real records were found to be quite similar.

3.0 NUMERICAL MODELLING

The industrial building chosen for this project is a substation building (electrical room). A substation building is a building dedicated to electrical equipment. Its size is usually proportional to the size of the building.

Electrical rooms typically house the following equipment:

- Electric switchboards
- Distribution boards
- Circuit breakers and disconnects

Constructional Features

The construction features of an electrical substation building vary depending on the type of the equipment to be installed. To support heavy transformers and switchgears, heavy mass concrete supporting structures have to be constructed. A heavy cable tray system or busbar shall be supported to Walls and ceilings. As the electrical equipment gives off heat and the temperature must not rise beyond the permissible limits of equipment, additional ventilation or air conditioning may be required. For maintenance of large equipment, the installation of double doors may be required.

MODELLING

In this project, a reinforced concrete framed building (G + 3), which includes a concrete floor with complete panel arrangement at +3.2m level has been modelled as per the conceptual drawings or the initial architectural drawings shown below.

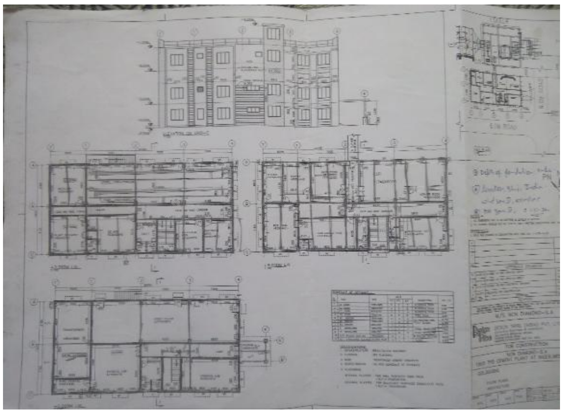

Figure: Substation Building General arrangement drawings

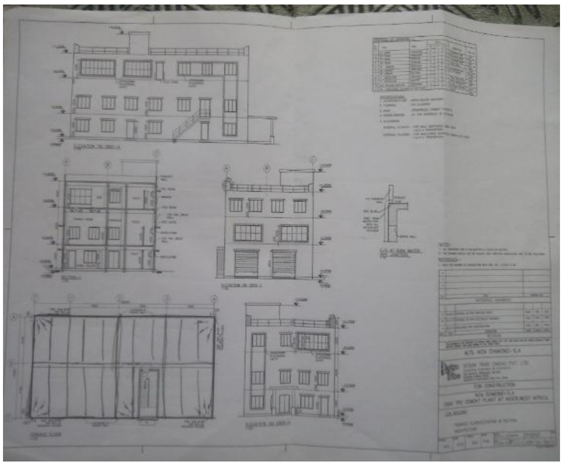

Figure: Substation Building General arrangement drawings

The panel load considered here is 500 kg/m and 700 kg/m along the beam. The model is analysed in Numerical Computer Software STAAD.Pro V8i. There are there floors in the building with floor levels +3.2 m level, +8.2 m level and +11.7 m level respectively.

RESPONSE SPECTRUM METHOD

In order to perform the seismic analysis and design of a structure to be built at a particular location, the actual time history record is required. However, it is not possible to have such records at each and every location. Further, the seismic analysis of structures cannot be carried out simply based on the peak value of the ground acceleration as the response of the structure depend upon the frequency content of ground motion and its own dynamic properties. To overcome the above difficulties, earthquake response spectrum is the most popular tool in the seismic analysis of structures. There are computational advantages in using the response spectrum method of seismic analysis for prediction of displacements and member forces in structural systems. The method involves the calculation of only the maximum values of the displacements and member forces in each mode of vibration using smooth design spectra that are the average of several earthquake motions.

RESPONSE SPECTRUM ANALYSIS:

In order to perform response spectrum analysis of an industrial building, a 3D model is modelled in STAAD PRO, as per the inputs provided in section 3.2 of this document. The snapshot of the 3D model is shown below:

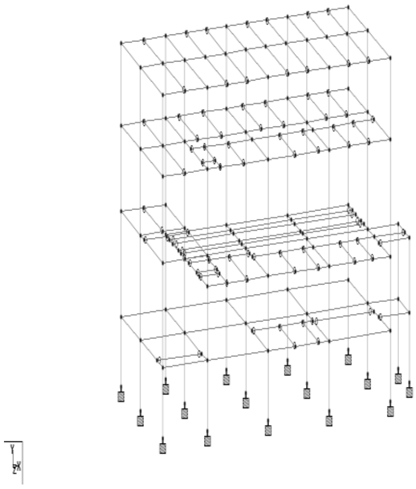

Figure: 3D Model of Substation Building

Loads Considered

The following are the list of loads considered upon the building as per Indian code:

- *Dead Load*: The dead load consists of self-weight of the building, wall load, slab load and staircase load.
- *Live Load*: A live load of 500 kg/m^2 is imposed on all slabs as per clauses provided in IS: 800 (Part 2).
- *Wind Load*: The wind load is applied as per clauses provided in IS: 800 (Part 3).
- *Seismic Load*: The seismic load application and generation of response spectrum analysis for a building is done by the following approach:

All these loads are imposed on the building in the STAAD pro analysis.

Methodology for Seismic load application

The design lateral shear force at each floor in each mode (Qik) is computed by STAAD in accordance with the IS: 1893 Part 1: 2002 (equation 7.8.4.5c and 7.8.4.5d)

$$Qik = A_k * \varphi_{ik} * P_k * W_i$$

where

A_k = design horizontal spectrum for different modes

φ_{ik} = mode shape coefficient at i^{th} floor in mode k

P_k = modal participation factor of k^{th} mode

W_i = seismic weight of the structure

A_k & W_i has to be defined by the user and φ_{ik}, P_k are calculated by the system. User provides value for (Z/2 * I/R) as factor for input spectrum.

4.0 RESULTS AND DISCUSSIONS

BASE SHEAR IN X- DIRECTION

Table: Base Shear in X- direction

Parameter	Indian Code	American Code	Euro Code
Base Shear in X-Direction (kN)	279	930	1581

RESPONSE SPECTRUM RESULTS

Table: IS 1893 -2002: Response Spectrum Results

	Seismic acceleration (Sa/g)	Time period (T)
INDIAN CODE	2.416	0.563
	2.500	0.435
	2.500	0.399
	2.500	0.303
	2.500	0.274
	2.500	0.269

COMPARISON OF RESULTS

The following are the list of parameters that are being compared between Indian, American and Euro codes after the response spectrum analysis:

- Base shear
- Maximum Displacement
- Maximum Axial load
- Maximum Moments in Y and Z direction for selected columns
- Percentage Mass participation factor
- Mode shape Vs Horizontal Seismic acceleration (Sa/g)
- Horizontal Seismic acceleration (Sa/g) Vs Time Period (T)

Response Spectrum Graph as per IS 1893 2002 code

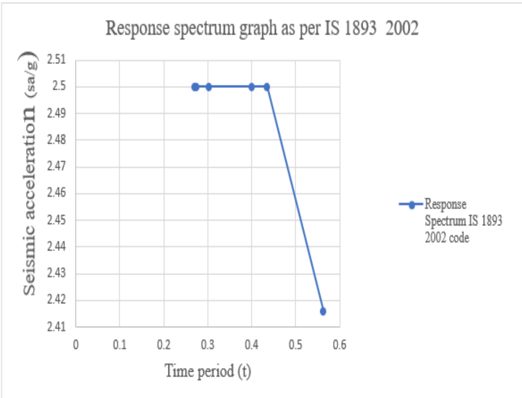

Figure: Response Spectrum Graph as per IS 1893 2002 code

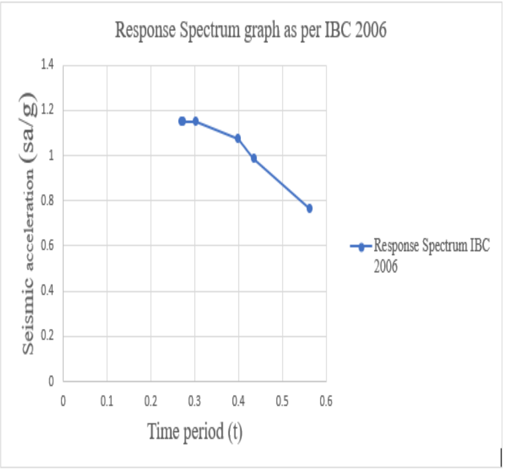

Figure: Response Spectrum Graph as per IBC 2006 code

CONCLUSION:

- The Base shear in X direction, compared to Euro code shows an average value of 62 % higher base shear than Indian code and IBC.
- The Base shear in Z direction, compared to Euro code shows an average value of 71 % higher base shear than Indian code and IBC.
- Maximum Displacement of columns as per Euro code shows an average value of 82 % higher values than Indian code and IBC.
- Maximum Bending Moment of columns, in X direction as per Euro code shows an average value of 52 % higher values than Indian code and IBC.
- Maximum Bending Moment of columns, in Z direction as per Euro code shows an average value of 90 % higher values than Indian code and IBC.
- The percentage mass participation factor of the structure is the same, when analysed with respect to the above mentioned three codes.

Finally, IBC code is superior to all the three codes followed by Indian code and Euro code in terms of Response spectrum analysis of an industrial building.

SCOPE FOR FUTURE STUDY

Further studies can be conducted on high rise buildings (sky – scrapers) as the current project is limited to building height of only 15m. Dynamic analysis of the structures can be performed by using more advanced softwares like SAP, FEA etc. This investigation can also be done on sloping RCC buildings constructed on hill stations where land is undulated and the ground parameters are unpredictable. Studies can also be conducted by modelling the structures having base isolation system.

References:

[1] Lukas Moschen, 2016, a technical paper representing the method of response spectrum for peak floor response of any structure. The analysis is done by modal which is prepared under complete quadratic combination which explains the concept of stochastic base excitation for various high-rise building.

[2] Chandurkar, Pajgade (2013) evaluated the response of a 10-storey building with seismic shear wall using ETAB v 9.5. The comparison of the change in response by changing the location of shear wall in the multi-storey building was the main focus in this review.

[3] Praval Priyaranjan (2012) A technical paper presented by Nove discussed the effects of scaling of earthquake excitations on the dynamic response of reinforced concrete framed buildings were investigated by analysing the nonlinear dynamic responses of three reinforced concrete framed buildings.

[4] Savitha et al. (2009) Samruddhi S. Thawari (IJRASET) Volume 4 Issue VII, Analysis of an Industrial Building

[5] S.D. Charkha, Latesh, S. Sanklecha International Journal of Research in Civil Engineering, Architecture & Design Volume 2, Issue 2,April-June, 2014 Economizing Steel Building using Pre-engineered Steel Sections.

[6] Miss. Kavita K. Ghogare (IJRASET) Volume 2 Issue XI, November 2014 ISSN: 2321-9653 Seismic Analysis & Design of Multistorey Steel Building