EFFECT ON THE RESPONSE OF A TYPICAL BUILDING DUE TO THE PRESENCE OF VARIOUS STRUCTURAL ELEMENTS IN THE STRUCTURE/BUILDING

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Abstract:-The aim of present work is to study the response of a structure/building due to presence of various structural components like walls, staircase, floors, beams etc. The response of various models/cases is studied by using non-linear static/pushover analysis. The purpose of the pushover analysis is to assess the structural performance by estimating strength and deformation capacities using static non-linear analysis & comparing these capacities with the demands at the corresponding performance levels. A six storey frame building is designed based on prevailing Indian Codes, non-linear static/pushover analysis are performed on these structures and results are prepared and a conclusion is made of various responses like structural displacement, base shear and hinge pattern of building frames.

Objectives:

The present study is aimed at Assessment of response of a building to using non-linear static/ pushover analysis. The aim of the present study is achieved by considering the following objectives:

First the building is designed for external loads and earthquake loads are given as per IS-1893 (Part-1), then various building response parameters are determined and compared to each other by using pushover analysis.

To do a detailed parametric study involving following parameters such as to find displacement/deformations, base shear, hinge patterns by incorporating

(a) An infill brick wall at periphery.
(b) A stair case
(c) Floor beams at each floor

Keywords: ***Non-linear static/pushover analysis, Response, Earthquake, Stiffness, Inelastic behavior, Base shear, lateral load.***

1. Introduction

Construction of structures is the important need of mankind in the current day world. The group of people involved in constructing the building facilities, including owner, architect, structural engineer, contractor and local authorities, contribute to the overall planning, selection of structural system and to its configuration. This may lead to building structures with irregular distributions in their mass, stiffness and strength along the height of building. When such buildings are located in a high seismic zone, the structural engineer's role becomes more challenging. Therefore the structural engineer needs to have a thorough understanding of the response of a structure to these external loadings.

Many buildings in the present day scenario have irregular configurations in the both plan and elevation. Buildings with asymmetrical distribution of stiffness, mass and strength suffer severe damage during earthquakes. This has been observed in the previous earthquakes. Such buildings undergo torsional motions. An ideal multi-storey building designed to resist lateral loads due to earthquake would consist of only symmetric distribution of mass and stiffness in plan at every storey and a uniform distribution along height of the building. Such a building would respond only laterally and is considered as torsionally balanced (TB) building. But it is very difficult to achieve such a condition because of restrictions such as architectural requirement and functional needs.

It is very important for a structural engineer to have ample knowledge about the response of a structure he/she is going to construct or an already existing structure. The response of the structure/building is very important aspect or consideration for a structural engineer which lets him decide the type of structural system to be employed in the structure in order to enable the structure to perform well for any given loading system without letting the structure to undergo excessive deformations and keeping the stresses within permissible limits. In addition to the external loading system the response of the structure is governed by the structural system or structural form employed in the structure. In low rise structures we can employ the bare frame structural form but in high rise structures this bare frame structural form may not perform well due to large magnitude of lateral loads so other structural forms like introducing the braces or shear walls which have higher lateral stiffness compared to bare frames may be employed in order to perform well for the lateral loads coming on the structure. The response of the structure thus varies by introducing various structural components in the original framed structure in order to increase the stiffness of the structure. The location of these different structural components also affects the response of the structure. This statement may be explained as, if shear walls are introduced in any structure, the unsymmetrical location or position of these shear walls will lead the structure to undergo torsion as the centre of mass and centre of stiffness may not lie at the same point but are at some distance from each other. Therefore the introduction of different structural components not only affects the response of a structure but the location or position of the structural component also affects the response to a large extent. Thus a structural engineer or the designer should have thorough knowledge about the response or behavior of the structure due to various structural elements which may be employed in the structure in order to decrease the flexibility of the structure to various loads which are coming on the structure. The aim of the research is to study the response of the structure by introducing different structural elements into the bare frame model.

2. Models Studied:

The different models of the building that have been studied:

Model-01 (Csae 01):

6-storeyed bare frame building with beams, columns and slab with ground storey height as 4.1m and rest storey heights as 5m each.

Model-02 (Case 02):

6-storeyed frame building with infill brick walls(230mm thick) only at the periphery. There are no walls in the interior of the building.

Model-03 (Case 03):

6-storeyed frame building with infill brick wall at periphery and a staircase.

Model-04 (Case 04):

6-storeyed frame building with infill brick wall at periphery, a staircase and with two floor beams under each slab panel.

2.1 Building Geometry and Properties :

The building under study has six storeys with height of ground storey as 4.1m and the height of rest storeys as 5m. the plan of the building is square with 3 bays in each direction and the centre to centre distance of columns is 7.5m. the plan and elevation of the building are shown as below.

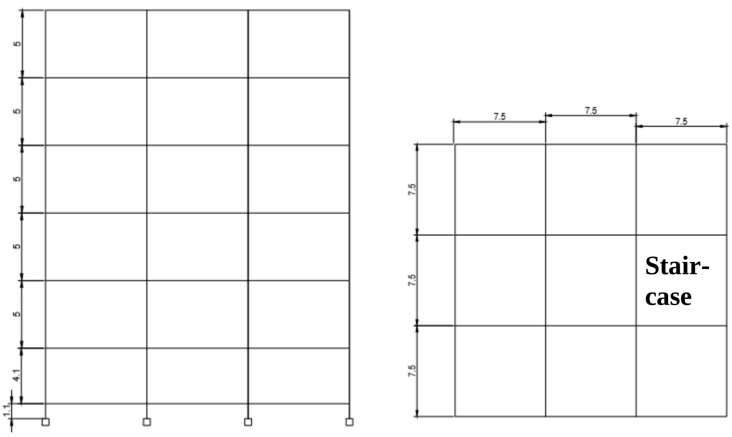

Figure 1 Building Elevation and Plan

3. Analysis Methodology:

Non-linear static/pushover analysis method is employed for the analysis of the structure. The pushover analysis of a structure is a static non-linear analysis under permanent vertical loads and gradually increasing lateral loads. The equivalent static lateral loads approximately represent earthquake induced forces. A plot of the total base shear versus top displacement in a structure is obtained by this analysis that would indicate any premature failure or weakness. The analysis is carried out up to failure, thus it enables determination of collapse load and ductility capacity. On a building frame, and plastic rotation is monitored, and lateral inelastic forces versus displacement response for the complete structure is analytically computed. This type of analysis enables weakness in the structure to be identified. The decision to retrofit can be taken in such studies.

The seismic design can be viewed as a two-step process. The first, and usually most important one, is the conception of an effective structural system that needs to be configured with due regard to all important seismic performance objectives, ranging from serviceability considerations. This step comprises the art of seismic engineering. The rules of thumb for the strength and stiffness targets, based on fundamental knowledge of ground motion and elastic and inelastic dynamic response characteristics, should suffice to configure and rough-size an effective structural system.

Elaborate mathematical/physical models can only be built once a structural system has been created. Such models are needed to evaluate seismic performance of an existing system and to modify component behaviour characteristics (strength, stiffness, deformation capacity) to better suit the specified performance criteria.

The second step consists of the design process that involves demand/capacity evaluation at all important capacity parameters, as well as the prediction of demands imposed by ground motions. Suitable capacity parameters and their acceptable values, as well as suitable methods for demand prediction will depend on the performance level to be evaluated.

The implementation of this solution requires the availability of as set of ground motion records (each with three components) that account for the uncertainties and differences in severity, frequency characteristics, and duration due rapture characteristics distances of the various faults that may cause motions at the site. It requires further the capability to model adequately the cyclic load-deformation characteristics of all important elements of the three dimensional soil foundation structure system, and the availability of efficient tools to implement the solution process within the time and financial constraints on an engineering problem.

4. Results and Discussions:

Note: All the loads may be considered in kN, the displacements in metres.

4.1 Lateral Displacement

The lateral displacements of structure along the height of the building in all the four cases/models are shown in the following figures from 2 to 5

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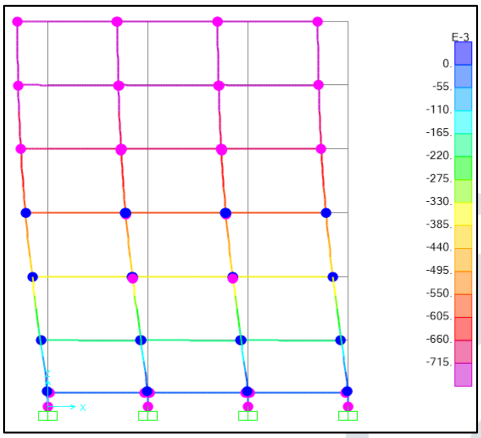

Figure 2 : Case 1

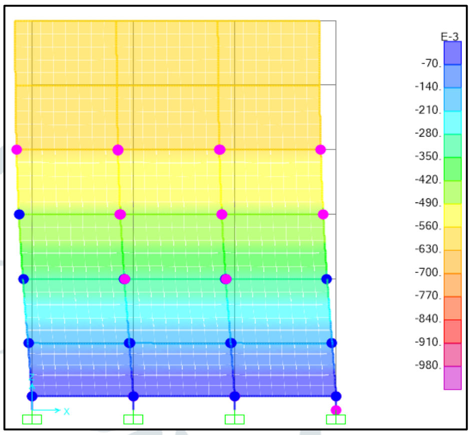

Figure 3: Case 2

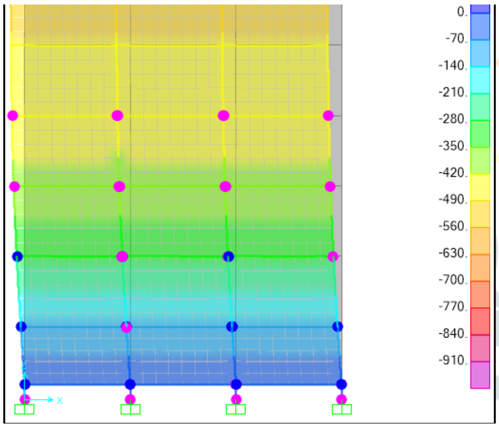

Figure 4 : Case 3

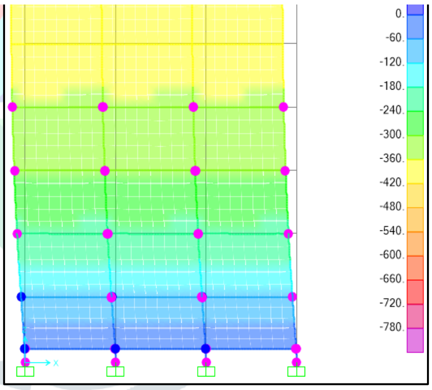

Figure 5: Case 4

4.2 Hinging Pattern:

The hinging pattern of a particular plane frame in the XZ plane at Y=0 in all the four cases is shown in figures 6 to 9.

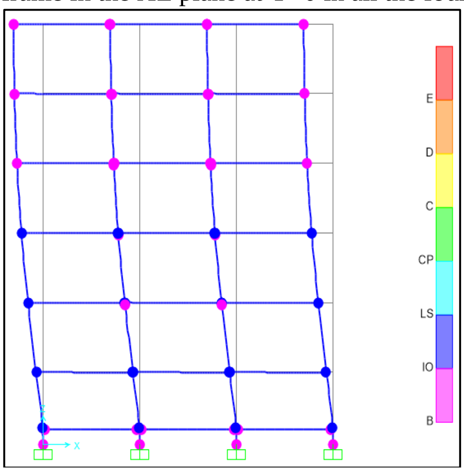

Figure 6 : Case 1

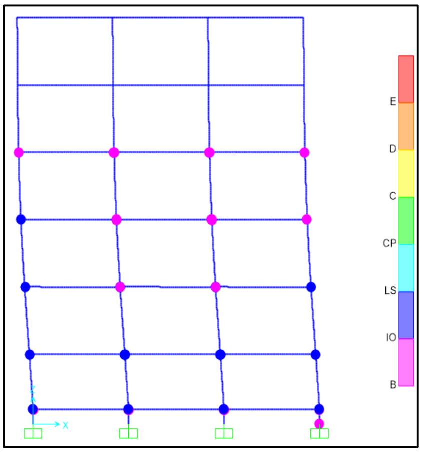

Figure 7: Case 2

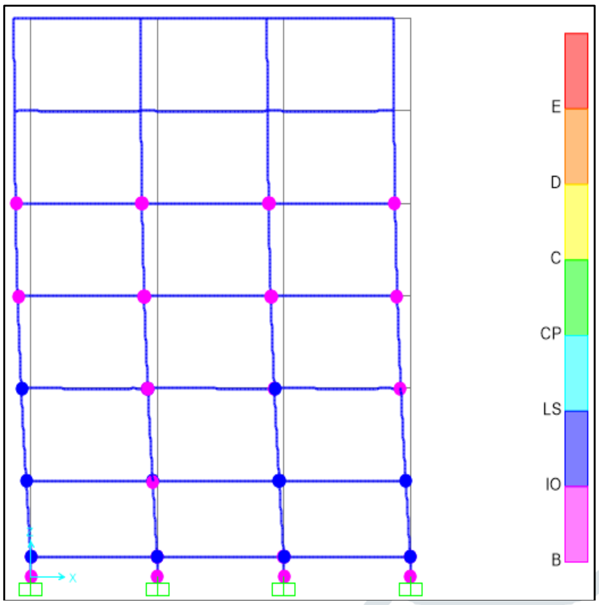

Figure 8 : Case 3

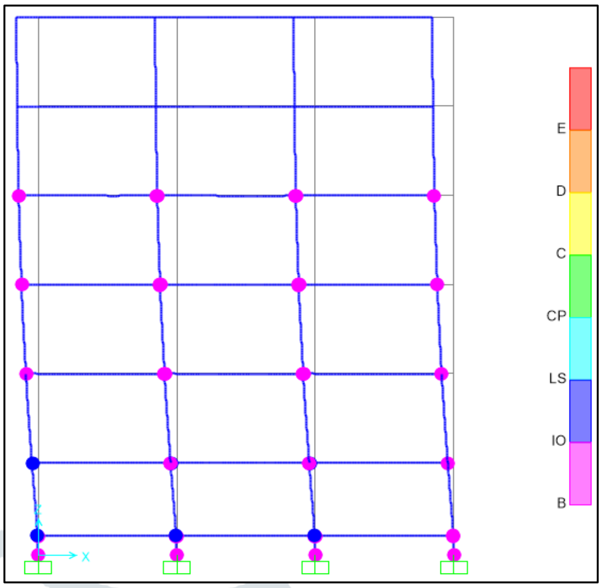

Figure 9: Case 4

4.3 Resultant Base Shear Vs Monitered Displacement

The Resultant Base Shear vs Monitored Displacement plot of all the four cases is shown in figures 10 to 13.

Figure 10: Case 1

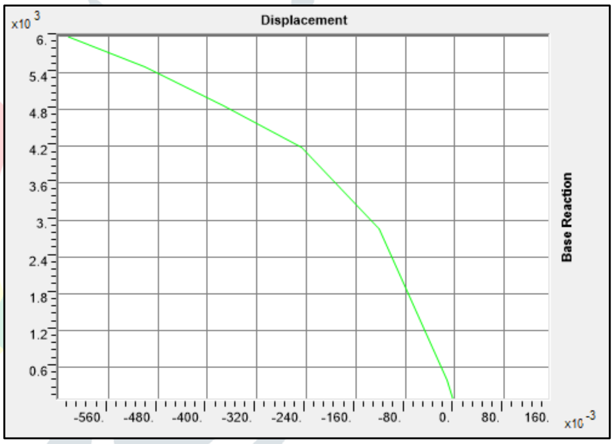

Figure 11: Case 2

Figure 12: Case 3

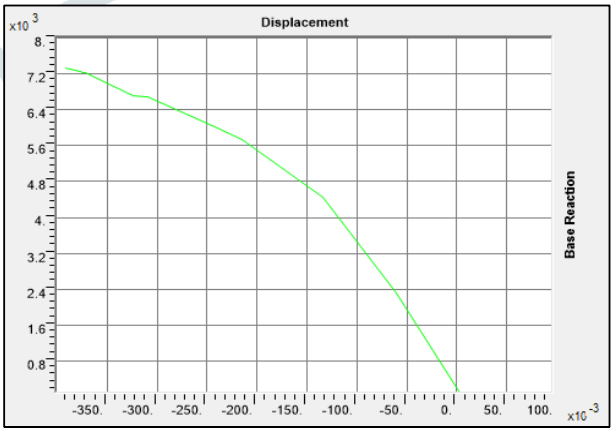

Figure 13: Case 4

4.4 Joint Displacements

The joint displacement of a particular joint (Joint 1) in the top storey of all the four cases is shown in table below.

Table Joint Displacements of Joint 1									
Joint	**OutputCase**	**CaseType**	**StepType**	**U1**	**U2**	**U3**	**R1**	**R2**	**R3**
Text	Text	Text	Text	M	m	M	Radians	Radians	Radians
Case 1									
1	PUSHx1	NonStatic	Max	-1.75E-07	0.000054	-0.000074	0.000259	0.00001	0.000048
1	PUSHx1	NonStatic	Min	-0.011987	-0.000129	-0.000152	-0.000063	-0.012261	-3.00E-07
Case 2									
1	PUSHx1	NonStatic	Max	-1.75E-07	0.000054	-0.000074	0.000259	0.00001	0.000048
1	PUSHx1	NonStatic	Min	-0.011987	-0.000129	-0.000152	-0.000063	-0.012261	-3.00E-07
Case 3									
1	PUSHx	NonStatic	Max	0.000025	0.000047	-0.000174	-0.000046	0.000074	0.000197
1	PUSHx	NonStatic	Min	-0.004234	7.895E-06	-0.000259	-0.00013	-0.005198	-1.21E-07
Case 4									
1	PUSHx	NonStatic	Max	0.000024	0.000046	-0.000179	-0.000039	0.000072	0.000143
1	PUSHx	NonStatic	Min	-0.010702	4.836E-06	-0.000298	-0.000125	-0.011141	-4.05E-08

CONCLUSION:

On comparing the pushover curves, hinging pattern, lateral displacements, and storey shears of all the building models, following points may thus be concluded:

1. Results of pushover analysis of these models indicate that the plastic hinge formation of all the members is not sudden, the plastic hinges are formed in sequence, starting from lower members of the bottom storey. In some frames no plastic hinges were observed in the upper storeys. Therefore it is suggested to take higher partial factor of safety for lower storey and lower partial factor of safety for higher storey so as to obtain more uniform plastification and better structural design.
2. Overall lateral displacements of the structure are reduced by introduction of infill walls. This is due to increase in the lateral stiffness of the bare frame structure by infill walls.
3. Base shear vs monitored displacement plots show that there are lesser displacements at particular magnitude of base shear when the lateral stiffness of structure is increased by the introduction of infill walls.
4. The presence of stair case (asymmetric position) however results in lesser lateral displacements but more rotational deformations (torsion).
5. The floor beams reduce the lateral and slab deformations and thus adds to economy also by reducing the slab thickness.

REFERENCES

- M.Mouzzoun, O.Moustachi, A.Taleb, S.Jalal, "*Seismic performance assessment of reinforced concrete buildings using pushover analysis*" ISSN: 2278-1684 Volume 5, Issue 1 (Jan. - Feb. 2013).
- Kadid and A. Boumrkik, *"Pushover analysis of reinforced concrete frame Structures" Asian journal of civil engineering"* (BUILDING AND HOUSING) VOL. 9, NO. 1 (2008).
- Nivedita N. Raut & Ms. Swati D. Ambadkar, *"Pushover Analysis of Multistoried Building"*, Global Journal of Researches in Engineering Civil and Structural Engineering Volume 13 Issue 4 Version 1.0 Year 2013.
- R. Shahrin & T.R. Hossain, *"Seismic performance evaluation of residential buildings in Dhaka city by using pushover analysis Dhaka, Bangladesh"* ISBN: 978-984-33-4363-5 December 22-24, 2011.
- Applied Technology Council, *"Seismic Evaluation and Retrofit of Concrete Building, ATC-40"*, Volume 1and 2, Report NO.SSC 96-01, Seismic Safety Commission, Redwood City, 1996.
- Federal Emergency Management Agency, *"NEHRP Guidelines for the Seismic Rehabilitation of Buildings"*, FEMA356, Washington, D.C., 2000.
- Anil K. Chopra and R.K Goel "*A modal pushover analysis procedures to estimate seismic demand for buildings".*
- IS-1893 (part 1) 2002*"Indian Standard criteria for Earthquake Resistant Design of Structures".*
- IS 875 part 1, 2, 3and 4 (1987) "*Indian Standard code of practice for Design loads for buildings and structures"*. Beareu of Indian Standards, New Delhi.
- SAP 2000 (Version 19.0). *Integrated software for structural analysis and Design. Computers and Structures*, Inc., Berkeley, California.