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PERFORMANCE BASED STUDY ON R.C FRAMED STRUCTURE BY CONSIDERING STIFFNESS OF SLAB SUBJECTED TO SEISMIC LOAD

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ABSTRACT: R.C structure with considering stiffness of slab Skeleton framing system, composed of only reinforced concrete columns, beams and slabs, have been adopted in analysis for many framed buildings. Generally, flexural stiffness of slabs is ignored and the floor load is transferred as uniformly distributed load on to the supporting beams in the conventional analysis of bare frame structures. However, in reality, the floor slabs may have some influence on the lateral response of the structures. Consequently, if the flexural stiffness of slabs in a frame system structure is totally ignored, the lateral stiffness of the framing may be underestimated. So, to study on the behavior of R.C structure with considering stiffness of slab is very essential. The research was already done on linear analysis. Therefore the objective of the present investigation is to study the nonlinear behavior of the R.C structure with considering the effect of increased stiffness due to slab elements in R.C space frames, subjected to seismic loading, on the parameter like displacement etc. By comparing the two models of frame such has Skeleton framed structure (SFS), Skeleton framed Structure with considering stiffness of slab (SFWS), the effect of increased stiffness on the above parameters studied and also the increased capacity of framed system studied.

Key Words: R.C structure, Seismic behavior, stiffness

1.INTRODUCTION

The Buildings, which appeared to be strong enough, may crumble like hours of cards during earthquake and deficiencies may be exposed. Experience gain from the recent earthquake of Bhuj, 21 demonstrates that the most of buildings collapsed were found deficient to meet out the requirements of the present day codes. In last decade, four devastating earthquakes of world have been occurred in India, and low to mold intensities earthquake of world frequently. Due to wrong construction practices and ignorance for earthquake resistant design of buildings in our country, most of the existing buildings are vulnerable to future earthquakes. In the simplest case, seismic design can be viewed as a row-step process. The first, and usually most important one, is the conception of an effective structural system that needs to be configured with due regards to all important seismic performance objectives, ranging from serviceability consideration to life safety and collapse prevention. This step comprises the art of seismic engineering, since no rigid rules can, or should, be imposed on the engineer's creativity to devise a system that not only fulfils seismic performance objectives, but also pays tribute to functional and economic constraints imposed by the owner, the architect, and other professionals involved in the design and construction of a building. By default, this process of creation is based on judgment, experience, and understanding of seismic behavior, rather than rigorous mathematical formulations. Rules of thumb for strength and stiffness targets, based on the fundamental knowledge of ground motion and elastic and inelastic dynamic response characteristics, should involve a demand/capacity evaluation at all important performance level, which requires identification of important capacity evaluation at all important performance level, which requires identification of important capacity parameters and prescription of acceptable values of these parameters, as well as the prediction of the demands imposed by ground motions. Suitable capacity parameters and their acceptable values, as well as suitable methods for demands prediction will depend on the performance level to be evaluated. In light of these facts, it is imperative to seismically evaluate the existing building with the Present day Knowledge to avoid the major destruction in the future earthquakes. The Buildings found to be seismically deficient should be retrofitted or strengthened.

1.2 Necessity of Non-Linear Static Pushover Analysis:

The existing building can become seismically deficient since seismic design code requirements are constantly upgraded and advancement in engineering knowledge. Further, Indian buildings built over past two decades are seismically deficient because of lack of awareness regarding seismic behavior of structures. The widespread damage especially to RC buildings during earthquakes exposed the construction practices being adopted around the world, and generated a great demand for seismic evaluation and retrofitting of existing building stocks.

1.3 Pushover Analysis:

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 The second step consists o 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.

1.4 Purpose of Non-linear Static Pushover Analysis:

The purpose of pushover analysis is to evaluate the expected performance of structural systems by estimating performance of a structural system by estimating its strength and deformation demands in design earthquakes by means of static inelastic analysis, and comparing these demands to available capacities at the performance levels of interest. The evaluation is based on an assessment of important performance parameters, including global drift, inter story drift, inelastic element deformations (either absolute or normalized with respect to a yield value), deformations between elements, and element connection forces (for elements and connections that cannot sustain inelastic deformations), The inelastic static pushover analysis can be viewed as a method for predicting seismic force and deformation demands, which accounts in an approximate manner for the redistribution of internal forces that no longer can be resisted within the elastic range of structural behavior.

The pushover is expected to provide information on many response characteristics that cannot be obtained from an elastic static or dynamic analysis. The following are the examples of such response characteristics**:**

The realistic force demands on potentially brittle elements, such as axial force demands on columns, force demands on brace connections, moment demands on beam to column connections, shear force demands in deep reinforced concrete spandrel beams, shear force demands in unreinforced masonry wall piers, etc.

- ❖ Estimates of the deformations demands for elements that have to form in elastically in order to dissipate the energy imparted to the structure.

- Consequences of the strength deterioration of individual elements on behavior of structural system.
- Consequences of the strength determination of the individual elements on the behavior of the structural system.
- Identification of the critical regions in which the deformation demands are expected to be high and that have to become the focus through detailing.
- Identification of the strength discontinuities in plan elevation that will lead to changes in the dynamic characteristics in elastic range.
- Estimates of the understory drifts that account for strength or stiffness discontinuities and that may be used to control the damages and to evaluate P-Delta effects.
- Verification of the completeness and adequacy of load path, considering all the elements of the structural system, all the connections, the stiff nonstructural elements of significant strength, and the foundation system.

1.5 Limitations of Pushover Analysis:

Although pushover analysis has advantages over elastic analysis procedures, underlying assumptions, the accuracy of pushover predictions and limitations of current pushover procedures must be identified. The estimate of target displacement, selection of lateral load patterns and identification of failure mechanisms due to higher modes of vibration are important issues that affect the accuracy of pushover results. Target displacement is the global displacement expected in a design earthquake. The roof displacement at mass centre of the structure is used as target displacement. The accurate estimation of target displacement associated with specific performance objective affect the accuracy of seismic demand predictions of pushover analysis. However, in pushover analysis, generally an invariant lateral load pattern is used that the distribution of inertia forces is assumed to be constant during earthquake and the deformed configuration of structure under the action of invariant lateral load pattern is expected to be similar to that experienced in design earthquake. As the response of structure, thus the capacity curve is very sensitive to the choice of lateral load distribution, selection of lateral load pattern is more critical than the accurate estimation of target displacement. The lateral load patterns used in pushover analysis are proportional to product of story mass and displacement associated with a shape vector at the story under consideration. Commonly used lateral force patterns are uniform, elastic first mode, "code" distributions and a single concentrated horizontal force at the top of structure. Multi-modal load pattern derived from Square Root of Sum of Squares **(SRSS)** story shears is also used to consider at least elastic higher mode effects for long period structures. These loading patterns

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usually favor certain deformation modes that are triggered by the load pattern and miss others that are initiated and propagated by the ground motion and inelastic dynamic response characteristics of the structure. Moreover, invariant lateral load patterns could not predict potential failure modes due to middle or upper story mechanisms caused by higher mode effects. Invariant load patterns can provide adequate predictions if the structural response is not severely affected by 4 higher modes and the structure has only a single load yielding mechanism that can be captured by an invariant load pattern.

FEMA-273 recommends utilizing at least two fixed load patterns that form upper and lower bounds for inertia force distributions to predict likely variations on overall structural behavior and local demands. The first pattern should be uniform load distribution and the other should be "code" profile or multi-modal load pattern. The 'Code' lateral load pattern is allowed if more than 75% of the total mass participates in the fundamental load. The invariant load patterns cannot account for the redistribution of inertia forces due to progressive yielding and resulting changes in dynamic properties of the structure. Also, fixed load patterns have limited capability to predict higher mode effects in post-elastic range. These limitations have led many researchers to propose adaptive load patterns which consider the changes in inertia forces with the level of inelasticity. The underlying approach of this technique is to redistribute the lateral load shape with the extent of inelastic deformations. Although some improved predictions have been obtained from adaptive load patterns, they make pushover analysis computationally demanding and conceptually complicated. The scale of improvement has been a subject of discussion that simple invariant load patterns are widely preferred at the expense of accuracy. Whether lateral loading is invariant or adaptive, it is applied to the structure statically that a static loading cannot represent inelastic dynamic response with a large degree of accuracy.

1.6 Non-Linear analysis Method:

1.6.1 General:

In order to investigate the nonlinear behavior of the building structures having soft stories, nonlinear static pushover and nonlinear time history analysis are performed on the analytical models. In this project, the nonlinear material properties used in this study and the underlying principles on the nonlinear static pushover time history analysis methods is explained.

1.6.2 Nonlinear Behavior of Structural Elements:

The nonlinear behavior of building structure of a building structure depends on the nonlinear response of the elements that are used in the lateral force resisting system. Therefore, before applying any nonlinear analysis method on a building structure, the nonlinear behavior of such elements must be clearly described and evaluated. In FEMA-

273, the generalized load deformation relation of a structural member while exhibiting nonlinear behavior is shown in figure. After the member yields (When applied load/yield load proportion (Q/Q_y) is equal to 1), the subsequent strain hardening accommodation the strain hardening in the load-deformation relation as the member deforms towards the expected strength.

1.7 Element Description of Etabs 9.4:

In ETABS, a frame element is modeled as a line element having linearly elastic properties and nonlinear force-displacement characteristics of individual frame elements are modeled as hinges represented by a series of straight line segments. A generalized force-displacement characteristic of a non-degrading frame element (or hinge properties) in ETABS

1.8 **Description of Pushover Analysis:**

Pushover analysis is an approximate analysis method in which the structure is subjected to monotonically increasing lateral forces with an invariant height-wise distribution until a target displacement is reached. Pushover analysis consists of a series of sequential elastic analyses, super imposed to approximate a force-displacement curve of the overall structure. A two or three Dimensional model which includes bilinear or trilinear load-deformation diagrams of all lateral force resisting elements is first created and gravity loads are applied initially. A predefined lateral load pattern which is distributed along the building height is then applied. The lateral forces are increased until some members yield. The structural model is modified to account for the reduced stiffness of yielded members and lateral forces are again increased until additional members yield. The process is continued until a control displacement at the top of building reaches a certain level of deformation or structure becomes unstable. The roof displacement is plotted with base shear to get the global capacity curve. Pushover analysis can be performed as force-controlled or displacement controlled. In force-controlled pushover procedure, full load combination is applied as specified, i.e., force-controlled procedure should be used when the load is known (such as gravity loading). Also, in force-controlled pushover procedure some numerical problems that affect the accuracy of results occur since target displacement may be associated with a very small positive or even a negative lateral stiffness because of the development of mechanisms and P-delta effects. Generally, pushover analysis is performed as displacement-controlled proposed by Allahabad to overcome these problems. In displacement-controlled procedure, specified drifts are sought (as in seismic loading) where the magnitude of applied load is not known in advance. The magnitude of load combination is increased or decreased as necessary until the control displacement reaches a specified value. Generally, roof displacement at the centre of mass of structure is chosen as the control displacement. The internal forces and deformations computed at the target displacement are used as estimates of inelastic strength and deformation demands that have to be compared with available capacities for a performance check.

2.METHODOLOGY

This software is able to predict the geometric nonlinear behavior of space frames under static or dynamic loadings, taking into account both geometric nonlinearity and material under static or dynamic loadings, taking into account both geometric nonlinearity and material inelasticity. This software accepts static loads (either forces or displacements) as well as dynamic actions and has the ability to perform Eigen values, nonlinear static pushover and nonlinear dynamic analysis.

Material Properties:

The material used for construction is Reinforced concrete with M-25 grade concrete and fe-415 grade reinforcing steel. The Stress-Strain relationship used is as per I.S.456:2 . The basic material properties used are as follows:

Modulus of Elasticity of steel, Es = 2.1x1 ^{5} MPa

Modulus of Elasticity of concrete, E_C = 2.5x1 ^{4} MPa

Characteristic strength of concrete, f_{ck} = 25 MPa

Yield stress for steel, f_y = 415 MPa

Ultimate strain in bending, ε_{cu} = . 35

3.7.1 Model Geometry:

The structure analyzed is a four-storied, one bay along X-direction and two bays along Y-direction moment-resisting frame of reinforced concrete with properties as specified above. The concrete floors are modeled as rigid. The details of the model are given as:

Number of stories = 6

Number of bays along X-direction = 3

Number of bays along Y-direction = 3

Storey height = 3 m

Bay width along X-direction = 5. m

Bay width along Y-direction = 5. M

Earth Quake load parameters:

Parameters	Values
seismic zone factor, Z	.1, .16, .24& .36
Importance factor, I	1.
Response reduction factor ,R	3.
Percentage damping	5%
Fundamental time period, T	.433
Soil type	Type-III(soft soil)
Average response acc.coeff.,(Sa/g)	2.5

3D-View of Building:

The Figure 1 shows the 3D-View of the structure. The storey heights, column Lines, description of slabs etc. can be seen in this picture.

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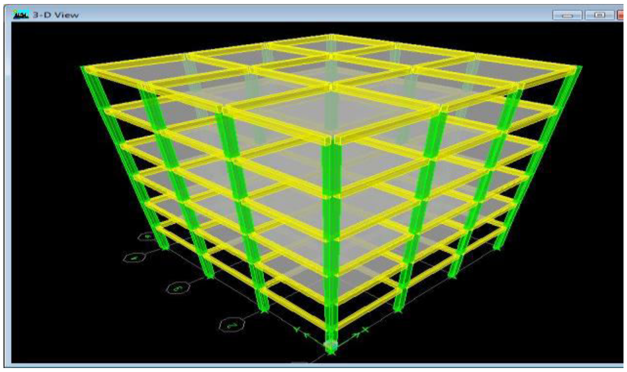

Fig 1 -3D View of building

3. Results and Discussions

Comparison -1:The R.C Framed Structure with and without considering Stiffness of slab (SFWS & SFS) for seismic zone-II:

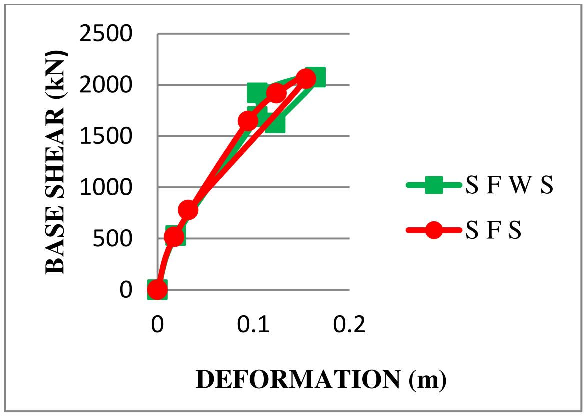

Fig.2 Comparison of capacity curve for SFS & SFWS at seismic zone –II

Comparison -2 the R.C Framed Structure with and without considering Stiffness Of slab (SFWS & SFS) for seismic zone-III:

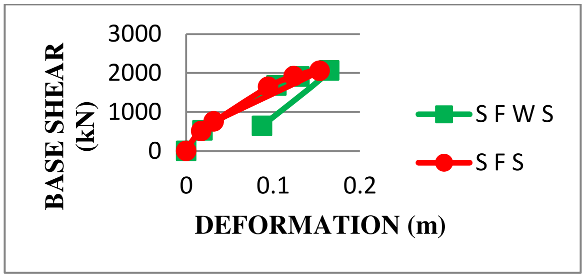

Fig.3 Comparison of capacity curve for SFS & SFWS at seismic zone –III

Comparison - 3:The R.C Framed Structure with and without considering Stiffness Of slab (SFWS & SFS) for seismic zone-IV:

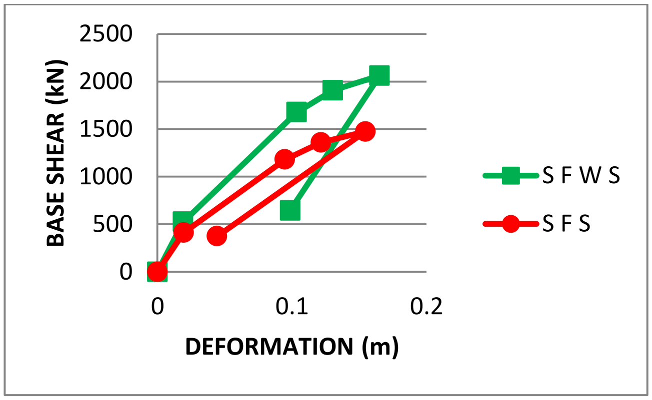

Fig.4 Comparison of capacity curve for SFS & SFWS at seismic zone –IV

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Comparison -4:The R.C Framed Structure with and without considering Stiffness Of slab (SFWS & SFS) to seismic zone-V

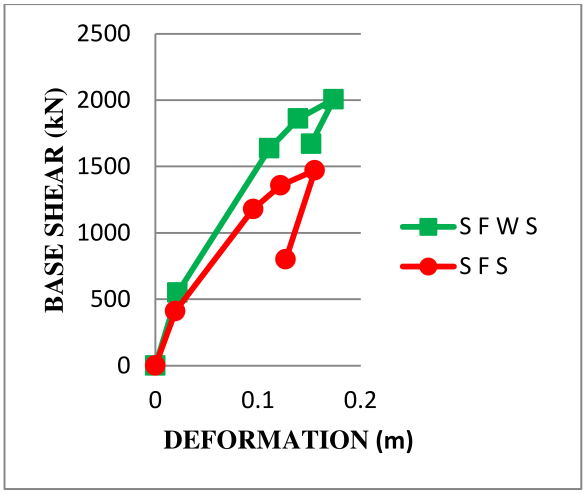

Fig.5 Comparison of capacity curve for SFS & SFWS at seismic zone –V

4. CONCLUSIONS

The performance R.C frame with & without considering stiffness of slab (SFS & SFWS) was investigated using the pushover analysis. Following were the major conclusions drawn from the Study.

Zone – II:

a) Comparing with SFS and SFWS, The SFS Base Shear is 7.2% less than SFWS.
b) Comparing with SFS and SFWS, The SFS Displacement is 6.53% less than SFWS.

Zone – III:

a) Comparing with SFS and SFWS, The SFS Base Shear is .1% less than SFWS.
b) Comparing with SFS and SFWS, The SFS Displacement is 7.2% less than SFWS.

Zone – IV:

a) Comparing with SFS and SFWS, The SFS Base Shear is 3.9% less than SFWS.
b) Comparing with SFS and SFWS, The SFS Displacement is 6.7% less than SFWS.

Zone – V:

a) Comparing with SFS and SFWS, The SFS Base Shear is 3.6% less than SFWS.
b) Comparing with SFS and SFWS, The SFS Displacement is 11% less than SFWS.

1. In the comparison of performance based study on R.C. framed structure with and without considering Stiffness of slab (SFWS & SFS) to seismic load at different zones-II, III, IV, V, the capacity curve based on with considering stiffness of slab (SFWS) can with stand for more deformation and base shear than without considering stiffness of slab (SFS).
2. From the pilot study, non-linear analysis of R.C structures with considering stiffness of slab (SFWS) to seismic load can resist for more deformation than Skelton framing system (SFS).

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