Indian J.Sci.Res. 17(2): 406 - 411, 2018

ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

PUSHOVER ANALYSIS OF SOFT STOREY STRUCTURE WITH BRACING AND SHEARWALL

[1]Sangeetha Reddy, [2]Sairam Neridu, [3]Dr Archanaa Dongre
[1,2,3]Department of Civil Engineering Vidya Jyothi Institute of Technology, Aziz Nagar, Hyderabad

Abstract - The recent increase in population and urbanization are bringing changes in the field of construction. The less availability of land in urban areas are the major reasons for choosing soft storey structures. These types of buildings are not desirable in seismically active areas because various vertical irregularities are induced in such buildings which have performed consistently poor during disasters. The recent experiences gained from the disasters say that the structures are deficient to meet requirement of codes. The majority of buildings that failed during the disasters were of the open ground storey. So a performance based modern technique nonlinear static analysis is chosen. Most used method to find out the performance of structure is nonlinear static analysis using PUSHOVER ANALYSIS. The Pushover Analysis process involves applying loads by using a programing software (SAP20000) (version19).

The present study involves Three different types of buildings located in Zone 2 analyzed in (SAP 2000) with various aspects related to the performance of structures with soft Storied, with bracing and with shear wall. Initially RC open frame is considered to understand its behavior. Later R.C. Building with soft storey and R.C. Building with shear wall with bracing is considered and the results are compared. The actual performance of the structure is obtained.

Keywords - Soft storey building, cross steel Bracings, Response spectrum, Push over Analysis, SAP 2000

I. Introduction

A soft story building is one which is a multi-storey building with large openings, wide spaces at the ground level which generally requires a shear wall for increasing the capacity of the building. Due to the urbanization generally, the constructors are opting for soft storey structures where large openings are used as parking slots. Now a day since they provide parking area which is most required. This kind of building shows tendency to collapse during disaster because of the soft storey effect. The soft storey structures are less resistant and have less stiffness during the time of disaster. In a structure if a floor has stiffness less than 70% then such structures are called generally soft storey structures. The large spaces present in a structure are located in ground storey and they are used for commercial spaces like shops or for parking areas. So in such cases if damage occurs to the ground storey there is a chance for collapse of the entire structure. So shear walls are generally used during the construction of medium and high rise buildings. They prevent buckling of walls. The construction of soft storey structures requires much care during their designing.

Extreme Soft Storey

An extreme soft storey is the one in which the lateral stiffness is less than 60percent of that in the storey above or less than 70percent of the average stiffness of the three storeys above.

There has been increase in the population from past many years. The increase of population has created many problems in urban areas. Shortage of land has been the main problem in urban areas. This led to the problem of parking in main metropolitan cities. The availability of space has become less for parking so it has led to the construction of soft storey structure. The soft storey is one in which there are openings in the ground floor. The strength of the columns in such structures is less as floor increases. If the column in that floor is less strong it may cause deflections that effect the total strength of the structure. The presence of walls in the upper floor makes the structure stronger than an open structure. Due to such kind of provisions, the lateral displacements of whole structure is governed mostly by the deformation at the lower stories. Therefore, it is important to analyze the demand of force and deformation of the members at different parts of structure.

Fig 1: Showing Softstorey Structure

[1]Corresponding Author

Soft Storey Failure

The failure of soft storey is because of the demand of strength of the column in the first storey which is high when compared to other floors, in top floor the column forces are decreased due to the presence of brick walls that share the forces and the upper floors are stiff and strong when compared to first soft story. So the lateral displacement of the structure is present mostly at the first storey of the structure. Thus when the lateral force acting has less stiffness it may affect the whole structure and the structure may fail.

Fig 2: Failure of Soft Storey Structure during Marina EarthQuake1989

Rc Shear Wall

Reinforced concrete (RC) buildings with RC walls are called as Shear Walls in addition to slabs, beams and columns. These walls generally start from the foundation level and are continuous throughout the building height. Shear walls provide more strength and stiffness to buildings that reduces the sway and displacements of the building and reduces damage to structure and its contents. Since the shear walls carry large earthquake forces, the overturning effects on them are large. Shear walls in buildings are symmetrically located in plan to reduce ill-effects of twist in buildings. They could be placed symmetrically along one or both directions in plan.

Cross Bracings

Cross bracings are usually placed with two diagonal member in an X shaped manner. Cross bracings help the structure to reduce displacements and make the structure strong during disasters. The cross bracings help the structure to give strength because the open ground floor of soft storey structure has no walls that effect the structure. So they are added to the structure to increase their strength and to reduce the displacements. When compared to shear wall they have less capacity but also bracings help the structure to build up strength and resist the damage.

Static Analysis:

Static analysis is again divided into:

- Linear static and
- Non-linear static analysis

A performance based new modern technique Nonlinear static analysis is chosen which involves

II. Pushover Analysis

The structural engineering's have recently developed a new design that takes in to account a performance based structure and are going away from simplified linear elastic methods towards a more non-linear technique.Pushover analysis is an analysis method in which the structure is subjected to increasing lateral forces with an height-wise distribution until a target displacement is reached. Basically, a pushover analysis is a series of incremental static analysis carried out to develop a capacity curve for the building. Based on the capacity curve, a target displacement which is an estimate of the displacement thatthedesignearthquake will produce on the building is determined.The extent of damage experienced by the structure at this target displacement is considered representative of the damage experienced by the building when subjected to design level ground shaking. Many methods were presented to apply the nonlinear static pushover (NSP) to structures.

Objective

To study the performance and behaviour of different structures such as open storey, soft storey, structurewith shear wall and bracing.

Study Area

The accurate analysis of the soft storey structures requires the modelling of open structure with Shear wall and Bracings for its stiffness and strength. There are many changes considering Shear wall and Bracings in the OGS buildings but our aims for the case study or the area of our concern are stated below:

a) The project illustrates a simple computer-based analysis technique called PUSHOVER ANALYSIS for performance-based design of building frameworks subjected to earthquake loading.

b) This technique is commonly performance based technique which is nonlinear static analysis using incrementally increasing lateral loads.

III. Description of Pushover Analysis

In Pushover analysis method the structure is subjected to lateral incresaing load until a target displacement is obtained. A two or three dimensional model is taken load deformation diagrams is first created and gravity loads are applied initially. Load patterns are added and lateral forces are increased. The process is continued until a displacement at top of building reaches a certain level of displacement or until the structure becomes unstable. The displacement v/s baseshear is plotted to get global capacity curve.

Pushover analysis can be performed as Force controlled or Displacement controlled. In force controlled pushover procedure full load combination is applied i.e; this procedure can be used when the load is known(gravity loading)

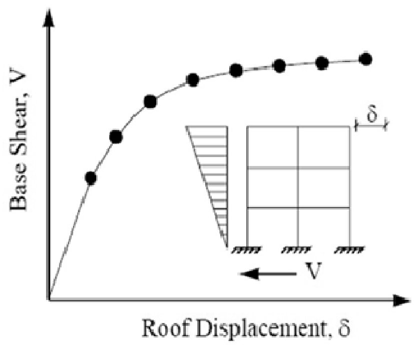

Fig 3: Global Capacity (Pushover) Curve Of A Structure

In Displacement controlled procedure the magnitude of applied load is not known in advance. The load combination is increased or decreased as necessary until the control displacement reaches a specific value. Generally, roof displacement at center of mass of structure is chosen as the control displacement. The internal forces and the deformations obtained at the displacement are used as estimates of inelastic strength.

Performance Based Plastic Design

Pushover analysis is performed by displacement coefficient method or capacity spectrum method. The Capacity Spectrum Method (CSM) is a performance based analysis used for variety of purposes for large buildings, design check of newly constructed building, evaluation of existing structure for identification of damaged portions. The procedure compares the capacity of the structure (form of pushover curve) with demand on the structure.

The main objective of Displacement Coefficient Method (DCM) is to find the target displacement which is the maximum displacement that the structure is likely to be experienced during the design earthquake. It provides a process for estimating the displacement demand on the structure by using bilinear representation of capacity curve to calculate a target displacement.

There are five different levels of structural response depending on amount of damage occurred on structure when pushover analysis is done. They are:

1. Operational (O) level
2. Immediate occupancy (IO) level
3. Live safety (LS) level
4. Collapse prevention (CP) level
5. Collapsed (c) level

Operational level

The following facts can occur in structure in this operational level, In the Operational level, the following facts can occur in the structure;

i. Negligible structural and nonstructural damage
ii. Occupants are safe during event
iii. Utilities are available
iv. Facility is available for immediate re-use
v. Losses less than 5% of replacement value

Immediate occupancy level

In the Immediate Occupancy level, the following facts can occur in the structure;

(1) Negligible structural damage
(2) Occupants are safe during event
(3) Minor nonstructural damage
(4) Building is safe to occupy but may not function
(5) Limited interruption of operations
(6) Losses less than 15%

Live safety level

In this level, the following fact can occur in the structure;

(1) significant structural damage
(2) Some injuries may occur
(3) Extensive nonstructural damage
(4) Building not safe for re-occupancy until repaired
(5) Losses less than 30%

Collapse Prevention (CP) level

In this level, the following fact can occur in the structure;

(1) Significant structural damage
(2) Some injuries may occur
(3) Extensive nonstructural damage

(4) Building not safe for re-occupancy until repaired

(5) Losses less than 30%

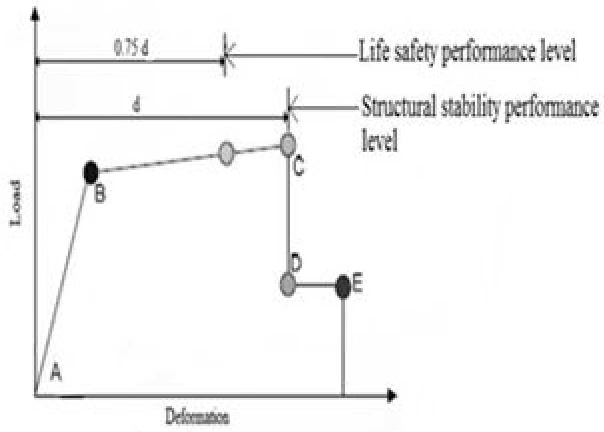

Fig 4: Performance Level of Structure

Where, IO = Intermediate Occupancy

LS = Life Safety
CP = Collapse Prevention
D = Damage Level
E = Emergency Level

Modal Analysis

MATERIAL AND SECTION PROPERTIES

SECTION PROPERTY	4STOREY	5STOREY	6STOREY
Beam Dimension	230mmx230mm	230mmx230mm	300mmx300mm
Column Dimension	230mmx230mm	230mmx230mm	300mmx300mm
Wall Thickness	Thickness of wall is taken as 0.23m		
ShearWallThickness	Thickness of shear wall taken as 0.23m		

MATERIAL PROPERTY	
GRADE OF CONCRETE FOR BEAM	M25
GRADE OF CONCRETE FOR COLUMN	M30
REBAR	HYSD GRADE 415

Yield line theory:

Calculating loads in 2-d:

By using yield line theory for square slab WLx/3

The parameters in this study are: Width =3m

Length =4m

Wlx/3= 3x4/3 =4KN/m^2

Therefore, live load in 2-D= 4Kn/m^2

Based on concrete grade: slab dead wt. = density of concrete x volume

= 25 x 4 x 4 x 0.15/4

= 15KN/m^2

Therefore, slab dead weight=15KN/m^2

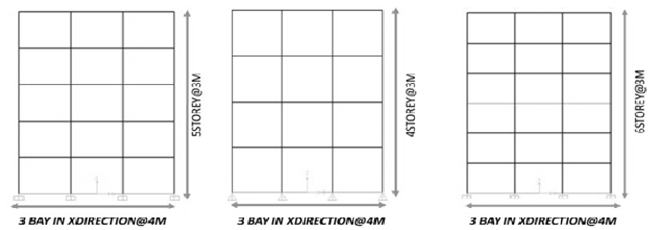

Fig 5: Elevation of Structures with Uniform Baywidth

Two Dimensions Frame Structure

Modal Analysis of RCC structures of 4 Storey, 5 Storey and 6 Storey of 2D frame with defined material and section property. The resultant graphs are obtained

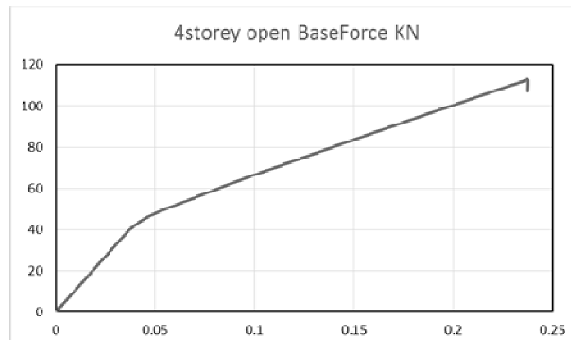

Fig 6: Graph Showing 4 Storey Open Structure

Modal Analysis of RCC structures of 4 Storey, 5 Storey and 6 Storey of 2D frame with defined material and section property. Mode shapes of RCC structures are considered.

Comparison between 4, 5, 6 Open Story Structures

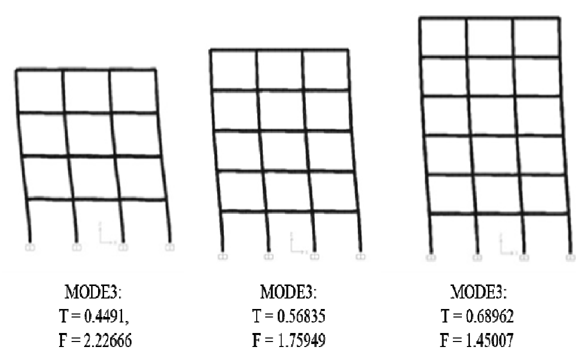

Fig 7: Timeperiod and Frequency of Open Storey Structure

Table 1: Timeperiod and Frequency of Open Storey Structure

Storey number Cyc/sec	Time period (t) in sec	Frequency (f) in cyc/sec
4STOREY	0.4491	2.22666
5 STOREY	0.56835	1.75949
6 STOREY	0.68962	1.45007

Comparison between 4, 5, 6 Story Structures with infill above ground floor

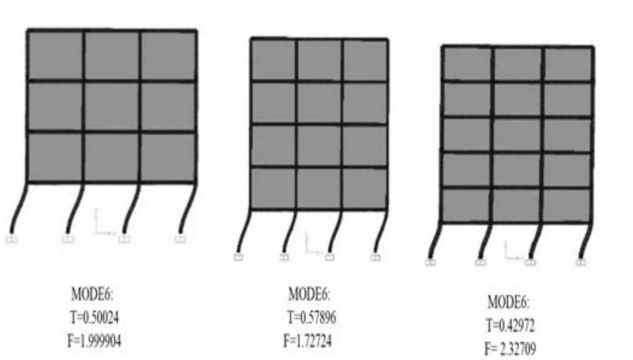

Fig 8: Timeperiod and Frequency of Structure with infill above ground floor

Table 2: Timeperiod and Frequency of Structure with infill above ground floor

Storeynumber cyc/sec	Time period (t) in sec	Frequency (f) in cyc/sec
4 STOREY	0.50024	1.999904
5 STOREY	0.57896	1.72724
6 STOREY	0.42972	2.32709

Comparison between 4, 5, 6 Story Structures with Bracings

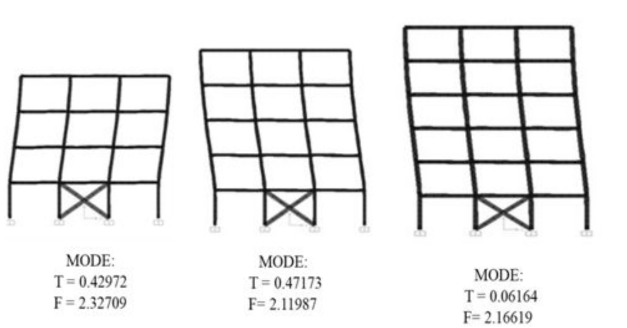

Fig 9: Timeperiod and Frequency of Structure with Brasings

Table 2: Timeperiod and Frequency of Structure with Brasings

Storey number Cyc/sec	Time period (t) in sec	Frequency (f) in cyc/sec
4STOREY	0.42972	2.32709
5STOREY	0.47173	2.11987
6STOREY	0.06164	2.16619

Comparison between 4, 5, 6 Story Structures with Shearwalls

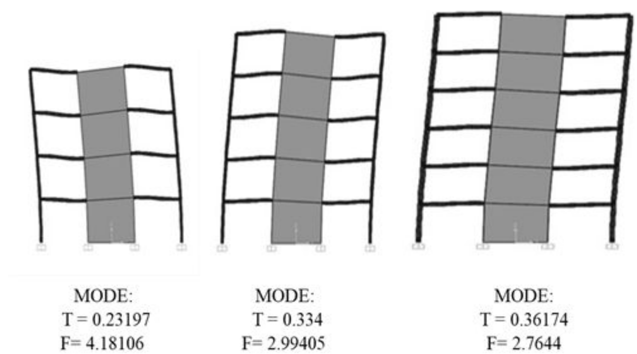

Fig 10: *Timeperiod and Frequency of Structure with Shearwalls*

Table 3: *Timeperiod and Frequency of Structure with Shearwalls*

STOREY NUMBER CYC/SEC	TIMEPERIOD (T) IN SEC	FREQUENCY (F) IN CYC/SEC
4STOREY	0.23197	4.18106
5STOREY	0.334	2.99405
6STOREY	0.36174	2.7644

IV Conclusions

Pushover analysis has been carried out for 4,5and 6 storey reinforced concrete structures by using SAP2000 (version 19). Only two-dimensional numerical modeling has been carried out for proper understanding the behavior of the structure.

The considered structures depict medium and tall storey behavior, as these structures are becoming common in urban areas. Static linear, static non-linear and dynamic analysis are carried using SAP2000.

1. Structural performance is affected and changed by different infill's like soft storey, shear wall, bracings

2. Shear wall is an ultimate load bearing structure which increased the resistance capacity.
3. Considering a shear wall it is better option for all lateral loads.
4. By the study we can say that bracings also give good support for the structure.
5. The open or soft storey structures are more effected during disasters.
6. It was observed that hinges are developed at ground floor of soft storey building that effect the strength of structure.
7. The lateral forces does not change with increase with height of building but the one that changes is displacement.

References

[1] Amin.M.R, Hasan.P, Islam.B.K.M.A, (2011), "Effect of soft storey on multistoried reinforced concrete building frame

[2] Haroon Rasheed Tamboli, Umesh.N.Karadi, (2012) Seismic Analysis of RC Frame Structure with and without Masonry Infill Walls

[3] IS 1893 (Part 1)-2002, Criteria for Earthquake Resistant Design Of Structures

[4] Karwar1.D.B, Londhe. R.S, (2014), a performance of RC framed structure using pushover analysis

[5] Lamb.P.B, R.S.Londhe (2012), Seismic behavior of soft first storey

[6] Munde P.K, Magarpatil H.R, (2012), Seismic Response of RC Framed Masonry InfilledBuildings with Soft First Storey

[7] Priyanka Hanamantrao Jagadale, SuchitraHirde, (2015) Seismic Performance of Multi- storied Reinforced Concrete Building with Soft Story (2015)