PUSHOVER ANALYSIS OF EARTHQUAKE RESISTANCE RCC STRUCTURE USING STAAD.PRO SOFTWARE

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Abstract –

RCC structure has become crucial to the construction industry in recent decades. A structure must be designed with strong seismic performance in mind. A multi-story reinforced concrete building's seismic performance is planned in compliance with the current Indian code (IS 456 -2000). The study of each structural members performance is conducted using nonlinear static analysis. This paper study about a popular method to ascertain the performance level of a building is through pushover analysis, which yields results that indicate whether collapse occurs at the member or structure level. Performance-based design is used to evaluate the performance level of buildings subjected to earthquakes. Various approaches in nonlinear static analysis were developed to study the performance of a building. This assessment has taken into account a non-existing solid Rcc structure that is assumed to be located in Zone IV, as defined by IS 1893:2000, a classification of seismic zones in India. During the entire inquiry, brick work infills have been considered to be non-structural individuals. Systems for inelastic static static study include the Secant Method, the Displacement Coefficient Method, and the Capacity Spectrum Method. Pushover Analysis, a non-direct static approach, was used to examine the structure's weak points, building on static testing. The structure was recreated in SeismoStruct Version 5.2.2 using M20 cement and Fe415 steel support, as predicted in STAAD Pro v8i. After that, the research is carried out for 150% of the predetermined objective displacing for the structure to track individual yielding and the sufficiency of the core quality. The degree of damage suffered by the structure during the objective displacing is thought to represent the damage the structure would experience under configuration level ground shaking.

***Key Words*:** Pushover analysis, RCC structure, Pushover curve, drift velocity, STAAD.PRO, Earthquake structure.

1.INTRODUCTION

Any sort of seismic event that produces seismic waves, regardless of whether they be natural or human-caused, can be referred to as a tremor. Although breaks in geographical limitations are typically the source of tremors, other events such as volcanic movement, mining hits, avalanches, and atomic testing can also trigger tremors. An earthquake, sometimes known as a tremor, is caused by the sudden emergence of life in the outermost layer of the Earth, which generates seismic waves. The seismicity of a region is determined by the frequency, kind, and magnitude of earthquakes that occur there over time. Seismometer measurements are used to quantify earthquakes. Several structures with fundamental structural components fail to meet current earthquake requirements and sustain significant damage during an earthquake. The Jalgaon structures were designed by essential. Many buildings have a fundamental construction but don't satisfy the current earthquake requirements, therefore they sustain significant damage in an earthquake. The reason the structures at Jalgaon were designed using essential auxiliary framework is that, according to the Earthquake Zoning Map of IS: 1893-2002, Jalgaon is located in Zone III of the Seismic Zone Map of 2002, meaning it is the location least likely to experience earth tremors. The structure under investigation is a four-story building that was designed without taking IS: 1893–2002 plan components into account.

The methods for evaluating structures that are seismically weak or damaged by earthquakes are still being developed. When a severe ground movement occurs, buildings that don't meet the requirements of an earthquake plan could sustain significant damage or collapse. For future usage, an earthquake assessment reflects the earthquake limit of tremor-powerless structures. Based on earthquakes, India is divided into four zones, per the Seismic Zoning Map of IS: 1893-2002. Zone II, Zone III, Zone IV, and Zone V are these.

India is the country where research on earthquake assessment has lately emerged. There are two approaches qualitative and analytical to assess structure seismicity. Qualitative approaches collect data on design, visual inspection reports, and the structure's state upon collapse. The analytical method is a thorough investigation of dynamic analysis that takes the structure's ductility and strength under earthquake loads into account. One of the widely used techniques for evaluating a structure's earthquake risk is pushover analysis. Under both vertical and lateral loading systems, it is a static nonlinear static analysis. The lateral loads correspond to equivalent static earthquake forces, while the vertical loads should be constant loads like gravity loads.

Pushover analysis is a method of creating a building's capacity curve by performing a series of incremental static analyses. In order to monitor the progressive yielding of the structural component, this technique requires the execution of a nonlinear static analysis of the structure. The structure is vulnerable to a lateral load. The building is loaded to the specified displacement till it reaches it. When the building is exposed to design level ground stimulation, this target displacement is calculated to represent the top displacement. Pushover analysis gives details about a structure's early failure and weak points in relation to the plot between a structure's base shear and roof top displacement. This method involves gradually applying force or displacement to the structure until it reaches its limit state. The identification of hinge development and degradation of structural stiffness occurs when a force or displacement is applied.

A pushover curve, also known as a capacity curve, is created using pushover analysis and shows the relationship between base shear (V) and roof displacement (Δ). The Pushover curve depicts how the structure responds beyond the elastic limit and is dependent on the strength and deformation capacity of the structure.

The intricacy of the ground motion parameters and structural characteristics makes it impossible to anticipate with any degree of accuracy how the structure will react to ground motion during an earthquake. A set of lateral displacement is employed directly as a design condition in pushover analysis. The displacement represents the structure's maximum anticipated response to ground motion.

2. LITERATURE REVIEW

X.-K. Zou et al. (2005) proposed an effective technique for automating the Pushover drift performance design of reinforced concrete buildings by combining Pushover Analysis with numerical optimization procedures. In order to meet code requirements, PBD uses nonlinear pushover analysis, a highly iterative process that typically requires a lot of computational work.

Mehmet et al. (2006) clarified that pushover analysis, a nonlinear static procedure, has been used by the structural engineering profession because of its ease of use. Based on the FEMA-356 and ATC-40 guidelines, pushover analysis is performed for various nonlinear hinge properties available in some programs. He noted that Plastic hinge length (Lp) has a significant impact on the displacement capacity of the frames. The default-hinge properties cannot adequately account for the columns' orientation and axial load level.

Cimellaro et al. suggested bidirectional pushover analysis for models with uneven shape. When the results of the expanded N2 approach and the proposed bidirectional pushover analysis were compared to the findings of the nonlinear response history analysis (NRHA) in terms of interstory drift and floor rotations, they were found to be acceptable. In the first analysis example, the classical N2 approach was used. In the second analysis scenario, the N2 method is used individually in the X and Y directions with load factors 1 and 0.6, and the findings are combined in an SRSS combination. By simultaneously applying bidirectional seismograms in both directions, the same process is used as bidirectional pushover analysis. The ITACA website provides seismograms with a peak ground acceleration of 0.15g.

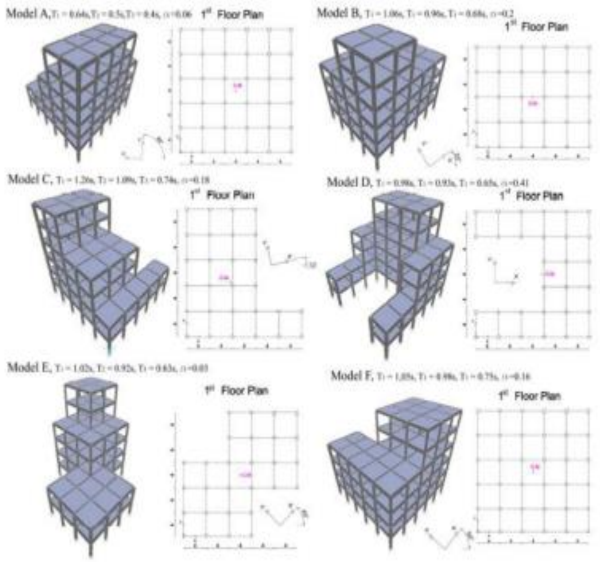

Fig -1: Different setbacks considered by cimellaro et al

Girgin et al. (2007) state that pushover analysis, due to its conceptual simplicity and ease of computation, has been the recommended method for seismic performance evaluation of structures by the major rehabilitation guidelines and codes. Pushover analysis makes it possible to follow the progression of the structure's overall capacity curve as well as the sequence of yielding and failure at the member and structural levels.

3. METHODOLOGY

3.1 Building description

The four-story, RC building that was employed for the analysis is a non-existent construction with 3 meters between floors. Seismic zone 4 is thought to be where the building is situated. The structure has a frame model with infill considered as non-structural member and constrained areas defined for the columns supporting the ground floor. Below are the building details and design data.

Building Details

- Number of bays along X- axis: 8
- Number of bays along Y- axis: 4
- Spacing along X axis: 4 m
- Spacing along Y axis: 3 m
- Size of column: 400 x 400 mm
- Size of beam: 450 x 600 mm
- Thickness of slab: 120 mm
- Grade of concrete: M20
- Grade of steel: Fe500

Design Details

- Dead Load: As per software
- Live Load:1.5kN/m2 on roof
- Live Load1: 3kN/m2 on other floors
- Earthquake Load: As per IS 1893(Part 1):20024
- Type of soil site: Medium
- Seismic zone: 4

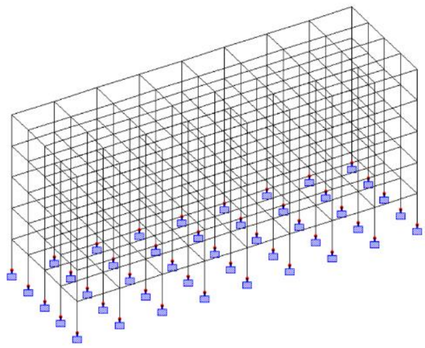

Fig 2: 3D rendering of structure in staadpro

3.2 Pushover Analysis

The definition of pushover analysis is an analysis in which a mathematical model that directly includes the nonlinear load-deformation characteristics of individual building components and elements is subjected to gradually increasing lateral loads that represent the inertia forces in the event of an earthquake until a "target displacement" is exceeded. The greatest building displacement at the roof that is anticipated under specific earthquake ground motion is known as the target displacement. Using a nonlinear static analysis algorithm, the structural pushover analysis estimates the force and deformation capacity as well as seismic demand in order to evaluate performance.

Pushover analysis can be completed as displacement control or force controlled, based on what is expected of the structure and the physical characteristics of the load. When the amount of load is known and the structure is assumed to be able to support it, the force-controlled option can be helpful. The displacement-controlled approach needs to be used in situations when the structure will likely lose strength or become unstable, or when specific drifts are needed, and the applied load's amount is unknown beforehand. Essentially, a displacement-controlled pushover analysis consists of the subsequent steps:

1. A two- or three-dimensional model is made to represent the general behavior of the structure.
2. Every significant element whose lateral reaction is impacted by bilinear or trilinear load-deformation diagrams has been identified.
3. The structural model is first subjected to gravity loads, which are made up of dead loads and a certain percentage of live loads.
4. Next, a predetermined lateral load pattern that is dispersed over the building height is used.
5. Lateral loads are increased until the combined forces of gravity and lateral loads cause some member or members to yield.
6. At initial giving, base shear and roof displacement are noted.
7. The structural model is adjusted to take the surrendered member decreased stiffness into consideration.
8. In order to make additional member yield, gravity loads are eliminated and a new lateral load increment is added to the altered structural model. It should be noted that the redesigned structural model undergoes a separate analysis for each incremental lateral load, with zero beginning conditions. Consequently, member forces are calculated by adding the forces from the present analysis to the total of the forces from the preceding increments at the conclusion of an incremental lateral load analysis. Stated differently, the outcomes of every incremental lateral load study are layered upon one another.
9. To get the cumulative values of the base shear and roof displacement, the lateral load increment and the roof displacement increment are added to the corresponding preceding total values.
10. Until the roof displacement reaches a predetermined degree of distortion or the structure becomes unstable, steps 7, 8, and 9 are repeated.
11. The pushover curve of the structure is obtained by plotting the roof displacement against the base shear.

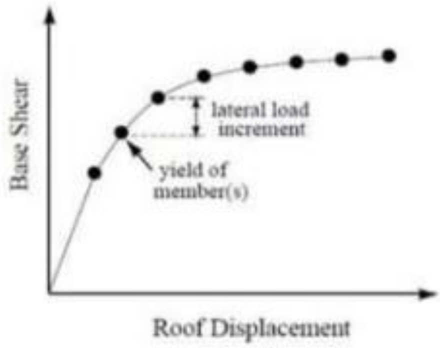

Fig 3: Pushover curve of structure

4. RESULTS AND GRAPHS

FOR X- AXIS LOADING
Loading on structure on X axis 3D rendering view

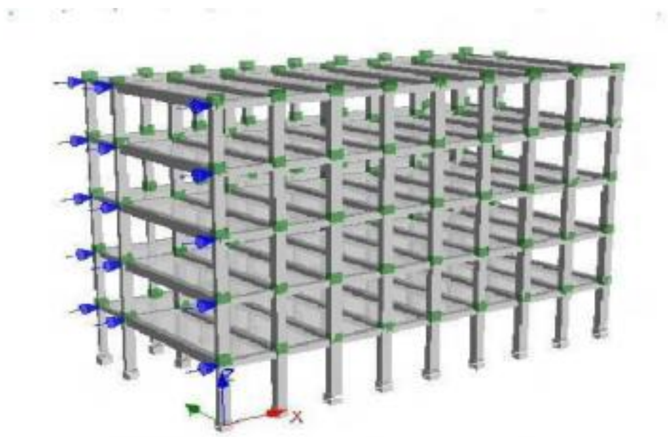

Fig 4: 3-D rendering for x-axis loading

Graph of Base shear versus Roof Displacement

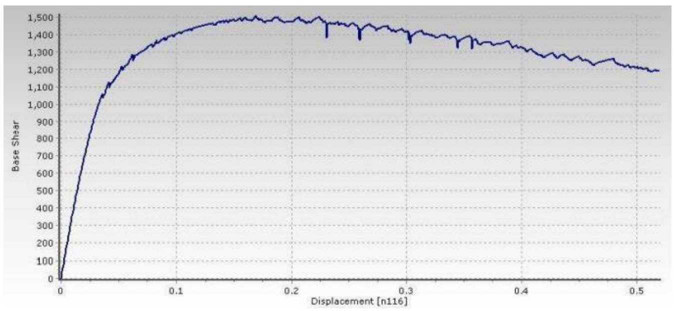

Fig 5: Capacity curve generated upon x-axis loading

Inter-story Drift versus Base Shear graph

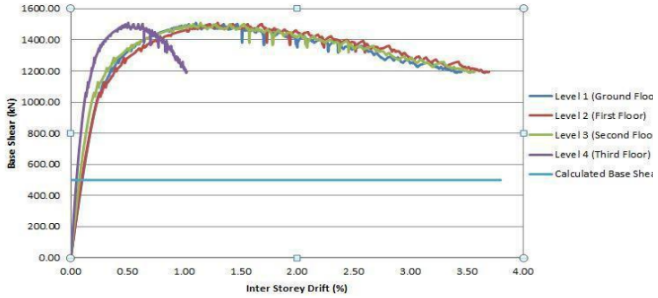

Fig 6: Inter-story Drift versus Base Shear Plot upon x-axis loading

FOR Y- AXIS LOADING
Loading on structure on Y axis 3D rendering view

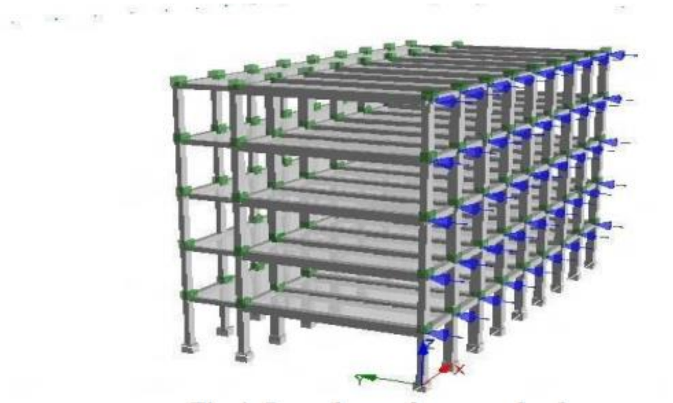

Fig.7: 3-D rendering for y-axis loading

Graph of Base shear versus Roof Displacement

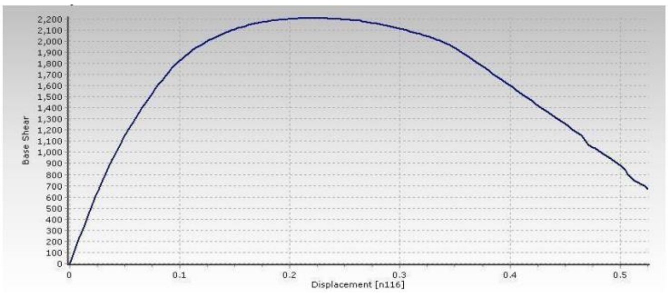

Fig.8: Capacity curve generated upon y-axis loading

Inter-story Drift versus Base Shear graph

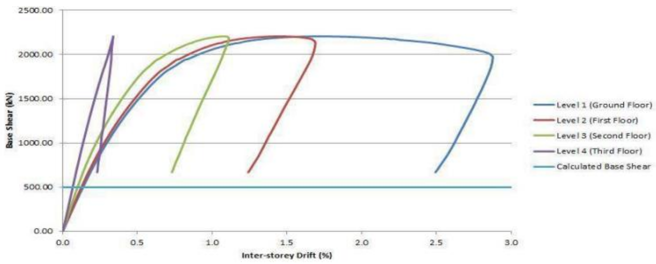

Fig.9: Inter-story Drift versus Base Shear Plot upon y-axis loading

SeismoStruct Version 5.2.2 computes the target displacement for both x- and y-axis loading, resulting in pushover curves that depict the behavior of the structure. Pushover curves for calculated Target Displacements:

- ✓ The maximum top node displacement for x-axis loading given is 8.48765mm.
- ✓ The maximum top node displacement for y-axis loading given is 18.34mm

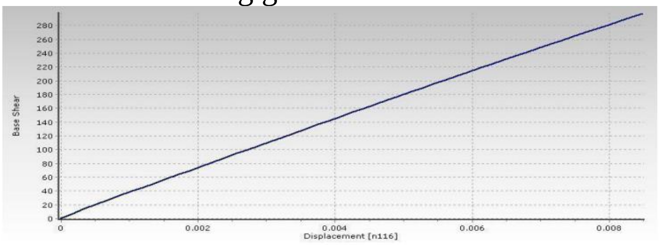

Fig.10: Pushover Curve for y-axis loading up to target displacement

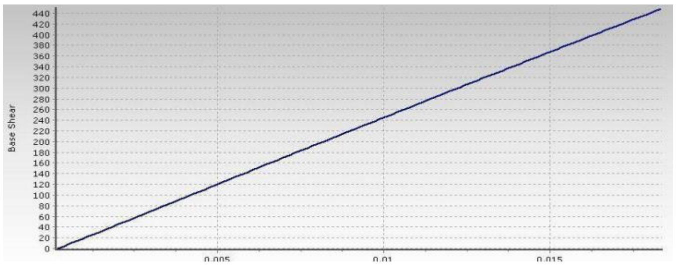

Fig.11: Pushover Curve for y axis loading up to target displacement

5. CONCLUSIONS AND DISCUSSION

Pushover analysis was a great technique for examining the structure's nonlinear behavior, evaluating the inelastic strength and deformation needs, and identifying design flaws. Concrete (M20) and steel (Fe 415) were the components that were expected. The simulation's material met the following performance requirements: yield strain limit of steel was set at 0.0025; fracture strain limit of steel was set at 0.060; crushing strain limit of unconfined concrete was set at 0.0035; and crushing strain limit of confined concrete was set at 0.008.

An idealized force-displacement plot was created from the pushover curve that was discovered when the structure was loaded to the point of collapse. The displacement coefficient technique is used to compute the target displacement. There has been no failure in the structure examined up to the intended displacement limit. Thus, this analysis concludes that the structure is totally secure.

Pushover analysis is an effective instrument for identifying plan difficulties and surveying inelastic quality and disfigurement requests. A generally easy way to look into the non-direct conduct of a structure is the pushover analysis.

SeismoStruct Version 5.2.2 is used to obtain a pushover curve after the pushover analysis is carried out by putting the structure to the calculated base shear for limiting displacement. After that, the structure is pushed to a state of complete collapse.

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