Capacity Spectrum Analysis of R.C.C Structure with & without Shear wall

1: Introduction

Amongst the natural hazards, earthquakes have the potential for causing the greatestdamages. Since earthquake forces are random in nature & unpredictable, the engineeringtools needs to be sharpened for analyzing structures under the action of these forces. Inrecent times, world has some severe earthquake, which suggest that the level of groundacceleration is increased as compared to past. Therefore there is need to assess the capacityof the structure and take the necessary measure to improve the capacity of them as and whenrequired. Although an elastic analysis provides a good estimation of the elastic capacity ofstructure and indicates where first yielding will occur, it cannot predict failure mechanism and account for redistribution off orcas during progressive yielding. In elastic procedure help demonstrate how building really behave by identifying mode so failure and the potential for progressive collapse. Since structure will respond to the earthquake induced groundmotion in an inelastic manner, the linear elastic equivalent lateral procedures do not providea direct method to assess the resulting maximum displacement and true failure modes.Capacity Spectrum Method is gaining a new dimension in the non-linear static analysiswherein pushover analysis and response spectra is to be considered. The Capacity SpectrumMethod (CSM) was first introduced in the 1970s as a rapid evaluation procedure in a pilotproject for assessing seismic vulnerability of buildings at the Puget Sound Naval Ship yard(Freeman et al., 1975). In the 1980s, it was used as a procedure to find a correlation between earth quake ground motion and building performance (ATC, 1982). The method was also developed into a design verification procedure for the Triservices (Army, Navy, and Air Force) "Seismic Design Guidelines for Essential Buildings" manual (Freeman et al., 1984; Army, 1986). CapacitySpectrumMethodisseismicAnalysisphilosophywhereinpushoveranalysis and response spectra are to be considered. The procedure compares the capacity of the structure (in the form of a push over curve) with the demands on the structure (in the form of response spectra). The graphical intersection of the two curves approximates theresponse of the structure. In this context capacity spectrum analysis which is an iterativeprocedureshallbe lookeduponas analternativefortheorthodoxanalysisprocedures.

This study focuses on pushover analysis (Capacity spectrum) & Response spectrum(Demand spectrum) of multi-storey RC framed buildings .To develop pushover analysis thebuilding subjecting them to monotonically increasing lateral forces with an invariant heightwisedistributionuntilthepresetperformancelevel(targetdisplacement)isreached.Pushover analysis is a static, nonlinear procedure in which the magnitude of the structuralloading is incrementally increased in accordance with a certain predefined pattern. With the increase in the magnitude of the loading, weak links and failure modes of the structure areidentified. Static pushover analysis is an attempt by the structural engineering profession toevaluate the real strength of the structure and it promises to be a useful and effective tool forperformance based design. In the capacity spectrum method, the multi-story buildings areconvertedinto the equivalent single degree offreedom (1-DOF) systems based ontheoutputsofpushoveranalysis.Andthestructuralperformanceofbuildingsisrepresentedbya base shear versus horizontal displacement relationship of the equivalent 1-DOF systems.Therelationship is referred to asthecapacityspectrum.

In order to use the Capacity Spectrum Method, it is necessary to convert the capacitycurve obtained from pushover analysis in terms of base shear V_b and roof displacement $\Delta_{roof}$to the capacity spectrum. Capacity spectrum is the representation of the capacity curve inADRS (Acceleration Deformation Response spectra) format. To get the demand spectrumResponse spectrum is converted from the standard S_a vs. T into ADRS format. After gettingthe Capacity spectrum and Demand spectrum curve they are superimpose with each other to get the performance point. The performance point gives the behavior of structure to earth quake.

SeismicAnalysisMethod:

- LinearMethods
  - -LinearStatic
  - -LinearDynamic
- NonlinearMethods
  - -NonlinearStatic
  - -NonlinearDynamic

Remark:

Although an elastic analysis gives a good indication of the elastic capacity ofstructure and indicates where first yielding will occur, it cannot predict failure mechanismand account for redistribution of forces during progressive yielding. Inelastic procedures help demonstrate show buildings really work by identifying modes of failure and the potential for progressive collapse. The use of inelastic procedures for design and evaluationis an attempt to help engineer better understand how structure will behave when subjected tomajorearthquake, when itis assumed thatthe capacityof thestructure will beexceeded.

In this study we are going to learn, the capacity spectrum method, a nonlinear staticprocedure that provides a graphical representation of the global force- displacement capacitycurveofthestructureandcomparesittotheresponsespectrarepresentationsoftheearthquake demands, is a very useful toolin the evaluation and retrofit design of existingconcretebuildings.Thegraphicalrepresentationprovidesaclearpictureofhowabuildingis going to respond to earthquake ground motion and it provides an immediate and clear picture of how various retrofit strategies, such as adding stiffness or

strength, will impact the building's response to earth quake demands.

2. LITERATUREREVIEW:

In literature review we will study the research papers which are related to capacityspectrum method for R.C.C. building to determine the performance level of structuresubjectedto earthquake.

1. N. Lingeshwarana, at el (2018)**"Comparative Analysis On Asymmetrical and Symmetrical Structures Subjected to Seismic Load"**

The Objective Of Study Is To study the performance of different structures on application of loads. Analysis of buildings in ETABS software for storey drift, displacement of symmetric and asymmetric structures. Comparing storey displacement and storey drift. Here the study is carried out with different shapes for G + 9 building behavior. For the modelling general software ETABS wasused. More user-friendly and versatile program offering a wide range of features such as static and dynamic analysis, non-linear dynamic analysis and non-linear static pushover analysis, etc.The Conclusion O fthe Study Was Symmetrical building perform better than asymmetrical buildings. As per results shown above T shaped building is more susceptible to seismic load compared to symmetrical building. The storey displacement at the first floor is relatively lower when compared to that of the top floor. L shaped and H shaped buildings are showing similar displacement under seismic load. Displacement is less for symmetric building than asymmetric building.

2. Sigmund A. Freeman at ISET (2004)**"Review of The Development of The Capacity spectrum Method"**

By means of a graphical procedure; in this paper the general procedure of capacity spectrummethod i.e. it compares the capacity of the structure with the demands of earthquake groundmotion on the structure is explained. The capacity of the structure is represented by anonlinear force-displacement curve, sometimes referred to as a pushover curve. The baseshear forces and roof displacements are converted to equivalent spectral accelerations andspectral displacements, respectively, by means of coefficients that represent effective modalmasses and modal participation factors. These spectral values define the capacity spectrum.The demands of the earthquake ground motion are represented by response spectra. Thegraphical construction that includes both Capacity spectrum curve and Demand spectrumcurve results in an intersection of these two curves that estimates the performance of thestructure.

3. **Tatsuya 1 AZUHATA1** at WCEE 2000"**Seismic Performance Estimation of Asymmetric Buildings Based on The Capacity Spectrum Method"**

Which includes the procedure for seismic performance estimation ofasymmetricbuildingsbasedonaconceptofthecapacity spectrummethod.Inordertoevaluatethetorsionaleffectduetoplanasymmetrytoinelasticseismicresponsesofasymmetric buildings, the strength modification factor and the deformation amplification factor are introduced? The strength modification factor is used to quantify the decrease of strength capacitiesto horizontal seismic forces of asymmetric-plan stories, considering strength eccentricities and to signal strength capacities. The deformation amplification factor is used to quantify the amplification of story drifts in the damage-predicted sides of asymmetric-plan stories, based on linear and staticthree-dimensionalanalysis.Theproposedprocedureusingthesefactorsisverifiedbyparametric studies for inelastic responses of Three-story asymmetric building's models with some types of asymmetric-plan stories using a step by step time integration method .From the results, it was cleared that the torsional effect can be evaluated by using thetwo introduced factors, and the story drifts at the perimeters in the damage-predicted sides ofasymmetric-plan stories can be predicted conservatively and approximately by the proposedprocedure.

4. **Kaspar PETER1** at WCEE 2000 **"Application of the Capacity Spectrum Method to R.CC. BuildingsWith Bearing Walls "**

Present results of a research project investigating theseismic evaluation of reinforced concrete structures with bearing walls. The investigation isbased on the analysis of nonlinear structural models with the capacity spectrum method, anapproximate nonlinear static analysis procedure, and time history analyses. The latter serve asreference.Effortsfocusontherealisticmodellingofreinforcedconcretebuildingswithbearing walls and on the determination of the application limits of the capacity spectrummethod.In this paper a study on the response of one example building named KJA is carriedout.It's a residential building with 9 stories above ground and one basement. The KJAbuilding was seismically evaluated for an earthquake loading according EC8, for 0.16g peakacceleration and soft soil class C. To apply the CSM, the capacity spectrum and the responsespectrum are to intersect. Therefore, a NLDA with the EC8-acceleration time history wasexecuted. The NLDA yielded a spectral target displacement of S_d = 33 mm (45 mm roofdisplacement) and conclusion is that a good estimation for the equivalent damping is 10%.Fortheapplication ofdisplacement based analysis methods such asthe CSM.

5, *Mrugesh D. Shah at*NCRTET (2011)**"Performance Based Analysis of R.C.C Frames"**

. It is limit states design extended to cover complex range of issues faced by earthquakeengineers.

Two typical new R.C.C. buildings were taken for analysis: G+4 and G+10 to cover thebroader spectrum of low rise & high rise building construction. Different modelling issueswere incorporated through nine model for G+4 building and G+10 building were; bare frame(without infill), having infill as membrane, replacing infill as a equivalent strut in previousmodel. All three conditions for 2×2, 3×3, 4×4 bays. Comparative study made for bare frame (with out in fill), having in fill as membrane, replacing

in fill as an equivalent strut. From the results for G+4 and G+ 10 stories in bare frame without infill have lesser later al load capacity (Performance point value) compare to bare frame within fill as membrane and bare frame with infill having lesser lateral load capacity compare to bare framewith Equivalentstrut.

1. Nitin Choudhary1 at IOSR (2014)**"Pushover Analysis Of R.C.C Framed Structure With Shear Wall"**

In this paper the description of pushover analysis FEMA, ATC 40 are given. Also different methods of pushover analysis such as inelastic component behavior, Capacity spectrum method, Time history method are explained. Analysis in done for given building and conclusions are Provision of shear wall results in a huge decrease in base shear and roof displacement both symmetrical building and un-symmetrical building. In L-shaped building when shear wall is provided on the larger side of the building results in a decrease of 4.3% in base shear and 58.15% in roof displacement and when provided on smaller side results in a decrease of 7.97% in base shear and 55.43% in roof displacement. Hence in unsymmetrical buildings shear wall must be provided on smaller side of building. The performance based seismic design obtained by above procedure satisfies the acceptance criteria for immediate occupancy and life safety limit states for various intensities of earthquakes. Performance based seismic design obtained leads to a small reduction in steel reinforcement when compared to code based seismic design (IS 1893:2002) obtained by STAAD.Pro.

2. Ms. Priyanka Soni1*, at IJETT (2016) **"Structural Analysis of Multistory Building ofDifferentShear Walls Location and Heights"**

In this paper the different purposes of providing the shear wall in explained. The stiffness of the shear wall, just like its strength, depends on the combined stiffness of its three components: lumber, sheathing and fasteners. The size and grade of end stud(s), thickness and grade of sheathing, and the sheathing fastener diameter determine how flexible a wood shear wall will be. When present, hold own devices also contribute to the overall stiffness of the shear wall. If hold own devices stretch or slip, the top of the shear wall will move horizontally. This horizontal movement adds to the movement allowed by the lumber, sheathing and fasteners. Any additional movement from the hold own will reduce the effective stiffness of the shear wall. In this chapter a multistory building has been modelled and analyze with considering all loads like Dead load, Live load, Wind Load as per as Is standard and Seismic load as per as IS standard. With Deferent Position Of Shear wall In this project it is concluded that the G+10 structure shear wall is generated less value of von-misses stress and deformation on structure at location 1 as compare to location 2.

8.Shruthi Indaragi1, at IRJET (2019)**"Response Spectrum Analysis of Symmetric and Asymmetric Structures in Seismic Zones"** by

In this paper the different irregularities if structure is listed like plan irregularity and vertical irregularity. The objective of the study is To study the response spectrum method for Analysis of symmetric and asymmetric building structures and to study the effect of plan irregularity on the fundamental natural period of the building, its effects on performance of the structure during earthquake for different building models. Analyzing the regular and irregular structure and comparing the response parameters for both structures. The various conclusions are Story shear has maximum values in all cases in irregular building as compared to regular structure due to earthquake forces in seismic zones. Displacement in X and Y direction increases withIncrease in height of the structure in both buildings. Displacement is more in asymmetric structures as compared to symmetric structures in all zones. Storey drifts are Maximum in symmetric structures G+12 and G+15 and increases with increase in height of the structure in both zones. Overturning moment has maximum values in symmetric structures for G+15 at zone3 due to maximum number of storeys. Moment has maximum values in asymmetric structure or G+12 at zones 3&4 and for G+15at zone4 respectively. From results and graphs observed that maximum displacement, storey drifts, storey shear, and moments occurs in asymmetric structures not in regular building due to earthquake forces and irregularity of structures.

2.1OutcomesfromLiteratureReview

From the available literature it was observed that most of the studies are not on theCapacity Spectrum method for Different Positon of Shear Wall with Plan Symmetry and Asymmetry. Only a limited number of published works on multi-story R.C.C Building For mentioned Objective to find out the performance level buildings. Thus, after reviewing theexisting literature it was felt that a comparative study on multi-story buildings With Different Position of Shear Wall IN Plan symmetry and asymmetry bycapacityspectrum method analysis is required.

3...Objectives:-

The Objective of this Study is to carry out seismic analysis using capacity spectrummethod for RCC multi-story building with shear wall and plan symmetry &Todeterminetheperformancelevelofbuildingbyconsideringstructural capacity obtained from pushover analysis and earthquake demand obtained from response spectra (IS 1893-2002)is intended.

Following will be the objectives of the study.

1) To study the effect of providing shear walls, in RC framed building, using pushover analysis.
2) To compare the seismic response of building in terms of base shear, storey drifts,
Storey displacements with and without shear wall.
3) Determination of performance point of building with and without shear wall.

4. Scopeof work:

Seismic analysis (Performance level) would be carried out for a RCC multi-story(G+10) building for thefollowing various cases with the helpof Etabs Software.

1) R.C.C building with Shear Wall Plan Symmetry.

2) R.C.CBuilding without Shear Wall Plan Symmetry.

3) R.C.C Building with Shear Wall Plan Asymmetry.

4) R.C.C Building without Shear Wall Plan Asymmetry.

5. Proposedmethodology:

One of the most widespread procedures for the assessment of building performance,duetoearthquake,istheCapacitySpectrumMethod(CSM).TheCapacitySpectrumMethod(CSM),by mean so fagraphicalrepresentation,comparesthecapacity ofthestructure with the demands of earthquake ground motion on the structure. The capacity ofthe structure is represented by a nonlinear force-displacement curve, referred as a pushovercurve. The base shear forces and roof displacements are converted to equivalent spectral accelerations and spectral displacements, respectively, by means of coefficients that represent effective modal masses and modal participation factors. These spectral values define the capacity spectrum. The demands of the earthquake ground motion are representedby response spectra. The capacity spectrum method (CSM) is a nonlinear static analysismethod, which compares the global force-displacement capacity curve of a structure with anearthquake response spectrum in a graphical shape (Freeman, 1998),(Badoux,1998). For this, both the capacity curve and there sponse spectra have to convert in to a spectral acceleration (S_a)spectral displacement(S_d)graph. Due to this transformation, the global building will be reduced to an equivalentSODF structure. By using a trial and error procedure one can estimate the performance point, which describe the spectral displacement of the building due to the given earth quake. A graphical construction that includes both capacity curve and demand curve resultsin an intersection of the two curves that estimates the performance of the structure to theearthquake.

Following methodology will be carrying out

- Study of seismic zones.
- Literature study (searching codes, methods and techniques).
- Defining objectives of the study.
- Referring IS Codes for loads applications.
- Model generation using Etabs.
- Applying loads and seismic parameters as assumed for this study.
- Analysis (Push Over) of building models to obtain the results (Performance Point, Drift, Base Shear, and Displacement).
- Comparison of the results and concluding the work with conclusion.

References:

1. Seismic performance estimation of asymmetric buildings based on the capacity spectrum method by tatsuya azuhata1 at WCEE (2000).
2. seismic analysis of structures using capacity spectrum method by soyabaslam momin1 at IRJET (2020).
3. application of the capacity spectrum method to r.c. buildings with bearing walls by kaspar peter1 WCEE (2000).
4. Review of the development of the capacity spectru. Method by sigmund a. Freeman. At ISET (2004).
5. R.C frames analysis by using pushover analysis considering bay width variation by prof. Deosarkarmanoj u.1 at IJARSE (2016).
6. Seismic performance assessment of reinforced concrete buildings using pushover analysisby M.Mouzzoun1 at IOSR (2013).
7. Pushover Analysis of R.C. Frame Building with Shear Wall by Nitin Choudhary1 at IOSR (2014)
8. Performance based analysis of r.c.c. frames by mrugesh d. Shah at NCRTET (2011)
9. Seismic Performance based Design of Reinforced Concrete Buildings using Nonlinear Pushover Analysis by Dimpleben P. Sonwane1 at IJERT (2015)
10. Literature Review on the Seismic Performance of Multi-Storey Building with Different Locations of Shear Wall and Diagridby S. P. Sharma1, at IJSR (2015).
11. Elastic overstrength of reinforced concrete shear wall buildings in chileby d. Ugalde(1), at 16WCEE (2017).
12. Behavior of reinforced concrete shear wall buildings subjected to large earthquakes by David Ugaldeat EL (2017).
13. Structural Analysis of Multistory Building Of Differentshear Walls Location and Heights by Ms. Priyanka Soni1 at IJETI (2016).
14. Pushover Analysis of R.C. Frame Building with Shear Wall: A Reviewby Dr. RakeshkumarPandeya. At IJCRT (2020).
15. Response spectrum analysis of symmetric and asymmetric structures in seismic zonesby shruthi indaragi1 at IRJET (2019).

16. Comparative analysis on asymmetrical and symmetrical structuresSubjected to seismic loadby N. Lingeshwarana, at EL (2018).
17. Effect of shear wall on seismic performance of RC frame buildingsby TulayAksu at EL (2019).
18. Fundamental principles of the reinforced concrete design code changes in Chile following the Mw 8.8 earthquake in 2010by Leonardo M. Massone⇑at EL (2019).