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Seismic Assessment of a Historical Masonry Structure using Analysis Tool

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ABSTRACT

As India is a place of historical divine, here structure of 18th century also exist in a safe and static condition without much failure in there stability. In this study we are selecting a historical monumental (mahal) building, collecting its dimensional data, material property, sectional details and strength to model the same structure of same aspects in Sap2000 and to Assign Non linear static analysis to check stability criteria and resistivity of an old structure. In this study, I will analyze a historical building located at islam nagar Bhopal M.P. to determine the critical section of the monument after determining its strength, applying pushover analysis method using analysis tool SAP2000 considering seismic data of Bhopal region. In this study it is concluded that in the analysis of historical monument using analysis tool SAP2000 and assigning pushover method we concluded that brick masonary section is critical one and need to be retrofitted to resist any natural calamity.

Keywords : Dimensional Data, Material Property, Restoration, FEMA

I. INTRODUCTION

The historical backdrop of engineering is inseparably associated with the historical backdrop of development. The modelers' concept of room and shape can't be appeared however through the development of a structure. Improvement of basic ideas, and not the changing of mold in beautifying shapes, is the main impetus of the historical backdrop of engineering. In the pre-modern, traditionalist social orders, the by and large embraced ideas of engineering, thought about both as a spatial workmanship and as a method of building, were additionally a component of the distinguishing proof of the general public's conventional qualities. Obviously, just the compositional ideas that legitimized and demonstrated their structura] rationale by a straightforward actuality of existing for anextensive stretch of time.

Fig 1: Islamnagar Fort

Pushover analysis

Pushover analysis is an expected analysis strategy where the structure is subjected to various monotonically expanding parallel powers, with a dispersion which is stature insightful invariant, until the point that the objective removal is contacted. Pushover analysis involves a progression of progressive versatile analysis, superimposed to gauge a power uprooting bend of general structure.

Pushover analysis can be executed as power controlled or relocation controlled. In compel controlled pushover method, full load blend is connected as determined, i.e, drive controlled methodology ought to be utilized when the heap is referred to, (for example, gravity stacking). Likewise, in constrain controlled pushover methodology some numerical issues that influence the exactness of results happen since target relocation might be related with a little positive or even a negative parallel solidness on account of the advancement of components and P-delta impacts. Pushover analysis has been the favored technique for seismic execution assessment of structures by the real restoration rules and codes since it is reasonably and Page 6 computationally straightforward. Pushover analysis permits following the grouping of yielding and disappointment on part and basic level and additionally the advance of general limit bend of the structure.

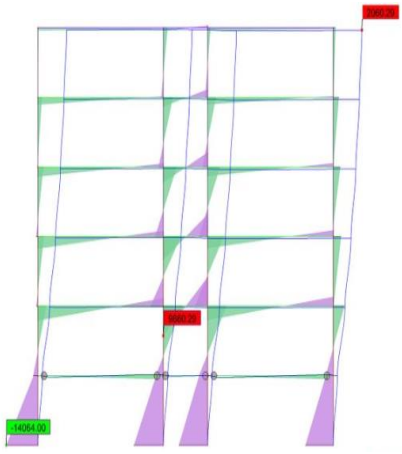

Fig 2 : Analysis in SAP2000

K. Venkatarao (2016) contemplated the seismic conduct of customary RC surrounded building, level section with drop and without drop working in every single seismic zone of India. Diverse parameters like parallel float, base shear, day and age and pivotal power are thought about. It was reasoned that parallel dislodging of ordinary RC outline is less when contrasted with level piece without drop building.

Durgesh Neve (2016) Investigation of Flat Slab Resting on Shear Walls by utilizing ETABS-13,In this examination, a building model is thought about in various perspectives, for example, story float, story removal and so on for level piece with segments and level chunk laying on shear dividers. He watched that Flat chunk with shear divider is profitable idea to be utilized as a part of a tall structure as shear dividers are demonstrate as indicated by arrange for which builds the cover zone, and furthermore horizontal story relocations and story float are diminished by utilized the shear divider.

Pradeep et. al (2016) contemplated the framework to slaughter parallel powers following up on a building format by acquainting unbendable stomach with the structure likewise take a gander at the three conditions of resolute stomach, semi firm stomach and with no locale, to appreciate which one is more profitable and induced that use of tenacious stomach is more ground-breaking than other condition concerning section and fragment controls and dislodging.

Problem Identification

The following outcomes of literature review are as follows:

- SAP2000 is advance analysis tool working on FEMA standards for structural analysis.
- Researchers determined that pushover analysis as per FEMA 365 provide nonlinear results accurately.
- Researchers observed that monumental buildings without seismic criterias are working well.

Objectives

The main aim of this dissertation work is at doing seismic evaluation for the historical building located at Islamnagar, using nonlinear static analysis method(pushover). The fort is currently used as a tourist place. However, since it was constructed in 18th century earlier, it wasn't designed to withstand earthquakes.

- Analyze the seismic performance of the existing structure with more degree of accuracy by using Non-linear Static Analysis Method.
- Analyze the critical section for historical monument built up of masonary structure.
- Find the target displacement of the structure by using Idealized Force-Displacement Curve and Displacement Coefficient Method in accordance with FEMA.
- Studying the behavior of the structure when subjected to the Pushover Analysis by limiting the maximum displacement of the top node to the calculated target displacement.

II. Methodology

In preparing modelling and designing of the structure with its actual strength and properties following steps are followed:

Step-1 first step of our study is to collect data and measurement from site. To prepare its correct modelling in SAP2000.

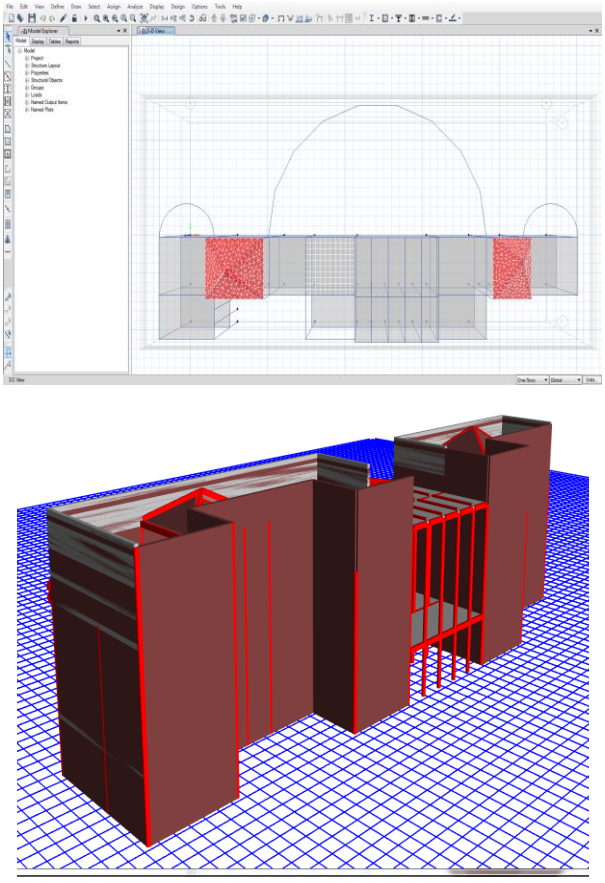

Fig 3 : Modelling of plan in SAP2000

Step-2 Second step is to assign material property and sections on different members of the structure such as walls, column, dome etc.

Step-3 To assign loadings as per linear statics method in X & Z direction with deal and live load.

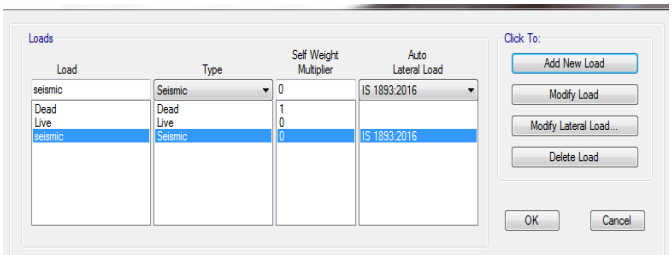

Fig 4 : Load Calculation

Step-4 Analyze the building frame for linear static analysis to determine its results and design

Step-5 Apply plastic hinges to the joints of beam and column. The maximum moments caused by the earthquake occur near the ends of the beams and columns, the plastic hinges are likely to form there and most ductility requirements apply to section near the junction.

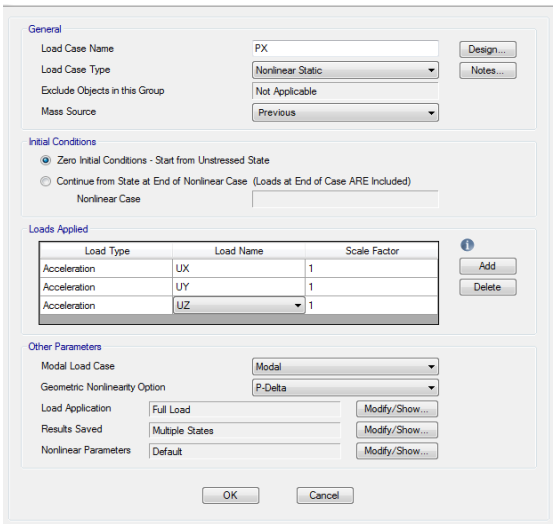

Fig 5 : Pushover Analysis

Step-6 Apply pushover load on these hinges.

Federal Emergency Management Agency (FEMA) and Applied Technical Council (ATC) are the two agencies which formulated and suggested the Non-linear Static Analysis or Pushover Analysis under seismic rehabilitation programs and guidelines.

Step-7 Analysis to determine the most critical section and monument strength.

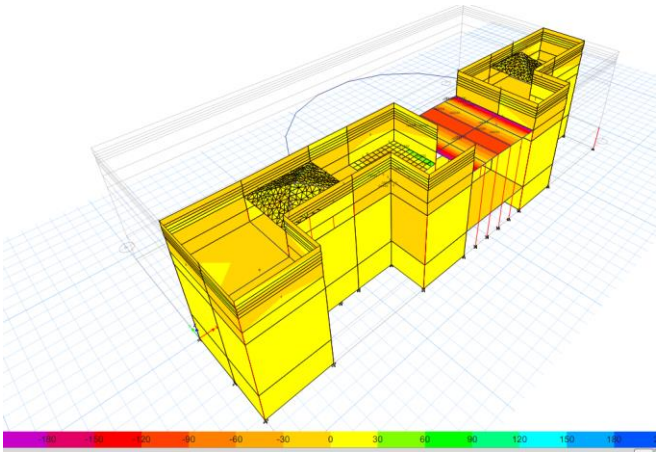

Fig 6 : Load analYsis

Loading Conditions:

- **Dead Load: As per I.S. 875-I**

  Self weight – Vertical direction (gravitational)

  Dead load consist of the self-weight of the building, which depends on material density.

  In sap2000 self-weight is automatically generated, thus no need of assigning.

- **Loads which are assigned:**

  Brick Masonary load: walls which are made up of brick masonary are assigned with following loading condition:

  Density- 18.5 kN/m³, thickness- 0.25 m, height – 3.5 m.

  (0.25 m) x (3.5 m) x (18.5 kN/m³) = **16.18 kN/m.**

  Stone Masonary load:

  Density- 26.5 kN/m², Thickness - 0.32 m, Height – 4.5 m.

  (0.32 m) x (4.5 m) x (26.5 kN/m³) = **38.16 kN/m.**

- **Live Load: As per 875-II**

  Live load of the building is considered as -4 kN/m² load as per 875-II (monumental structure).

- **Seismic Load: As per 1893 –I :2016.**

  All frames are analyzed for (II) earthquake zone. The seismic load calculation is as per IS: 1893(part-1)-2016.

Geometrical details:

In present work we are analyzing an old monumental structure located at Islam nagar, Bhopal. As this structure was built in 18th century, thus seismic provisions are not considered hence in this study we are analyzing the monumental structure with its actual dimensions collected from the site is modelled and checked for pushover analysis results. For this study material strength is tested at site using rebound hammer and applied in a analysis tool SAP2000 to determine its critical setion.

Table 1 : Geometrical Details

Design data of building	**Dimension**
Plan dimension	9.41 x 60.7 meter
No. of bay in X direction	14
No. of bay in Y direction	2
Typical height	3.5, 4.5 meter
Column size	400 x 300 mm
Beam size	ISMB 150
Thickness of slab	100 mm
Stone Wall thickness	320 mm for external wall
Brick wall thickness	250 mm

III. Analysis Result

Brick masonry section:

Table 2 : Drift in Brick Masonry

Drift		
height	X-dir.	Y-dir.
4.5	0	0
4	0	0
3.5	0	0
3	0	0
2.5	0	0
2	1.00E-06	2.00E-06
1.5	2.20E-05	8.70E-05
1	3.35E-07	2.00E-06
0.5	3.09E-08	1.00E-06
0	0	0

Displacement (mm):

Table 3: Displacement in wall masonry

Max. Displacement in mm		
Height	X direction mm	Y direction mm
4.5	2.151	0.928
4	1.861	1.9
3.5	1.701	1.442
3	1.536	2
2.5	1.366	1.992
2	1.184	0.122
1.5	0.017	0.041
1	0.023	0.126
0.5	9.26E-05	0.002
0	0	0

Stone masonry wall:

Table 4: Drift in Stone masonry wall

height	Drift	
	X-dir	Y-dir
4.5	2.60E-05	0.000377
4	2.60E-05	0.000383
3.5	2.60E-05	0.000395
3	2.60E-05	0.000411
2.5	2.90E-05	0.000436
2	2.90E-05	0.000146
1.5	2.30E-05	0.000135
1	1.00E-06	3.86E-07
0.5	1.00E-06	8.93E-08
0	0	0

Displacement:

Table 5: Displacement in Stone masonry

Height	Max. displacement in mm	
	X direction mm	Y direction mm
4.5	41259.165	450.004
4	60046.555	855.222
3.5	55583.495	1267.206
3	38977.15	619.407
2.5	17078.455	328.098
2	0.072	0.024
1.5	0.035	0.163
1	2.177	1.069
0.5	0.002	0.0002678
0	0	0

Comparative results:

Torsion:

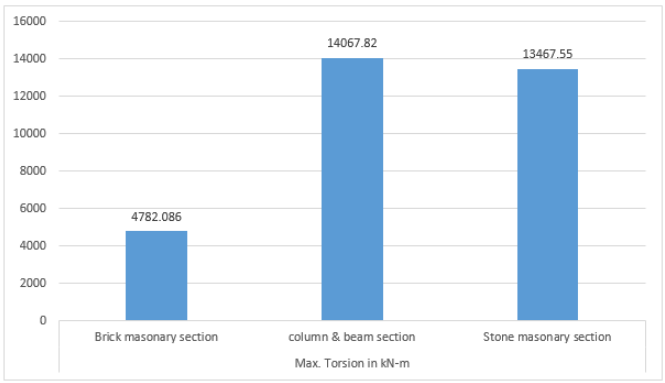

Fig 7 : Torsion

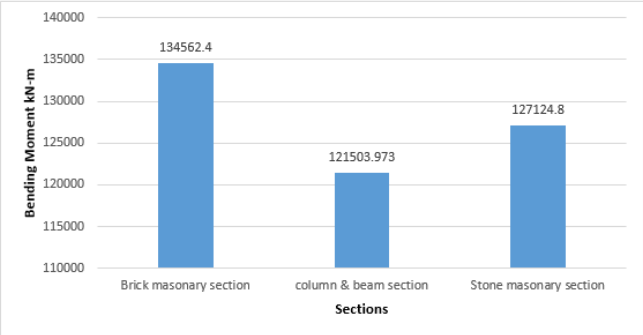

Fig 7 : Bending Moment

IV.CONCLUSION

1) Story displacements are generally reduced by the provision of sectional stability the reason behind this is the sectional stability increases the stiffness and lateral strength of the structure.

2) On comparison of story displacements values of different cases along the longitudinal and transverse directions using the ESA methodbrick masonary section showed highest value of story displacements due weak stability and strength.

3) Story drift values are within the limits recommended by the code IS: 1893:2016 (Part 1)

4) Story drift has significantly influenced by the age of structure. In the case of column beam section story drift values are decreased due to the presence of strengthening sections.

5) Strength and material properties have significant influence in the time period. From the SAP2000 v16 analysis beam column section showed minimum time period in time period compared to the other cases due to the presence of steel beam which is resisting and distributing load evenly.

6) The value of torsion is minimum on brick masonry case, due to absence of strengthening material and the value of torsion is maximum on beam column section, due to presence of strengthening sections and material.

8) The value of Moment is minimum on beam column section,whereas maximum in brick masonary case which results in higher reinforcement requirement in retrofitting of this area.

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