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Progressive Collapse Analysis of Circular and Elliptical Structures

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Abstract— *when one of the structural members fails, which in turn triggers the failure of subsequent structural sections, a progressive collapse will take place. Because of this, the structure will either completely or partially collapse as a result of its current state. Failure of a vertical structural part is the most common cause of progressive collapse in structures, and it almost always occurs at the top of the structure. There is a risk that explosive charges, accidents, or even deliberate damage could cause the column to fail and fall. In order to carry out the analysis, first the columns at each of the various places are removed one at a time in line with the criteria set by the General Service Administration (GSA), and then the values of the radius and the column DCR are calculated. According to the data, it was concluded that the column that was situated further away from the center had a greater risk of suffering from a slow and steady collapse.*

Keywords: Progressive collapse, DCR, GSA.

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I. INTRODUCTION

The first design phase for a building is followed by the design phase for the maximum forces or tension. However, if the load that is applied to the whole structure or to one structural element is more than this service load or stress limit value, then the structure will fail or the structural element will fail. The building or any element, such as beams and columns, can fail when the load exceeds the service loads, which then leads to the failure of neighboring elements and the failure of the entire structure. The term for this type of situation is "progressive collapse" or "progressive failure." When an abnormal load is placed on a structure, it is possible that one of the structural parts, such as a column, beam, or slab, will sustain more damage than the others. Damage to a horizontal member like a beam is less concerning than failure of a vertical member or structural member like a column. When an impact from an impulsive load causes damage to a vertical member such as a column, the loads are transferred to other components of the member that are adjacent to or in close proximity to the damaged component. If the injured element's nearby parts are able to withstand the increased load, then the damaged element itself will be able to withstand the load; if they are unable to, then it will not. In the event that one of the neighboring structural elements fails a second time, the load-bearing capacity of the surrounding elements must be sufficient. If it is not, the failure will gradually get worse, which could result in many failures that will harm the structure.

Figure1.1: Ronan Point building after 16 May 1968 collapse

A structure, R.C.C., is made up of several components, including columns, beams, slabs, foundations, and so on.

These structural components are also referred to as the structure's sustaining elements. Although there are primarily two categories of loads that might effect on a structure, these categories are known as continuous loads (DL) and dynamic loads (LL). Both self-loading and active load, which includes the weight of moving people, furniture, and other objects, as well as wind load and seismic load, are factors that influence the structure. Self-loading refers to the weight of permanent structural elements like a column. Active load includes all other loads.

The phenomenon known as collapse phenomena occurs when an interior load-bearing section of a structure fails owing to some cause, such as an explosion or a vehicle accident, which renders the structure or component unable to retain its structural integrity.

In order to prevent the system's collapse due to the failure of a single component, these efforts often focused on enhancing redundancy and alternate load paths. In actuality, though, redundancy is merely one method for lessening a system's susceptibility to disproportionate collapse. It's feasible that in many situations, improved continuity and connectedness across the structure (which can improve both redundancy and local resistance) together with stronger local resistance for critical components will be more advantageous than increased redundancy. By using the right mix of increased redundancy, local resistance, and connectedness, it should be possible to significantly reduce the likelihood that structures will have a disproportionate collapse.

Aim

"To study how column removal time and modeling affect progressive collapse determine internal force redistribution and dynamic effect of unexpected structural element loss on moment resisting frame construction".

Problem Statement

To provide techniques for increasing structural integrity under abnormal loading conditions, it is necessary to analyze the behavior of simple connections under the progressive collapse scenario.

Objectives

- Modeling of spherical and elliptical building.
- Progressive collapse analysis of spherical structure.
- Progressive collapse analysis of elliptical structure.

II. Methodology

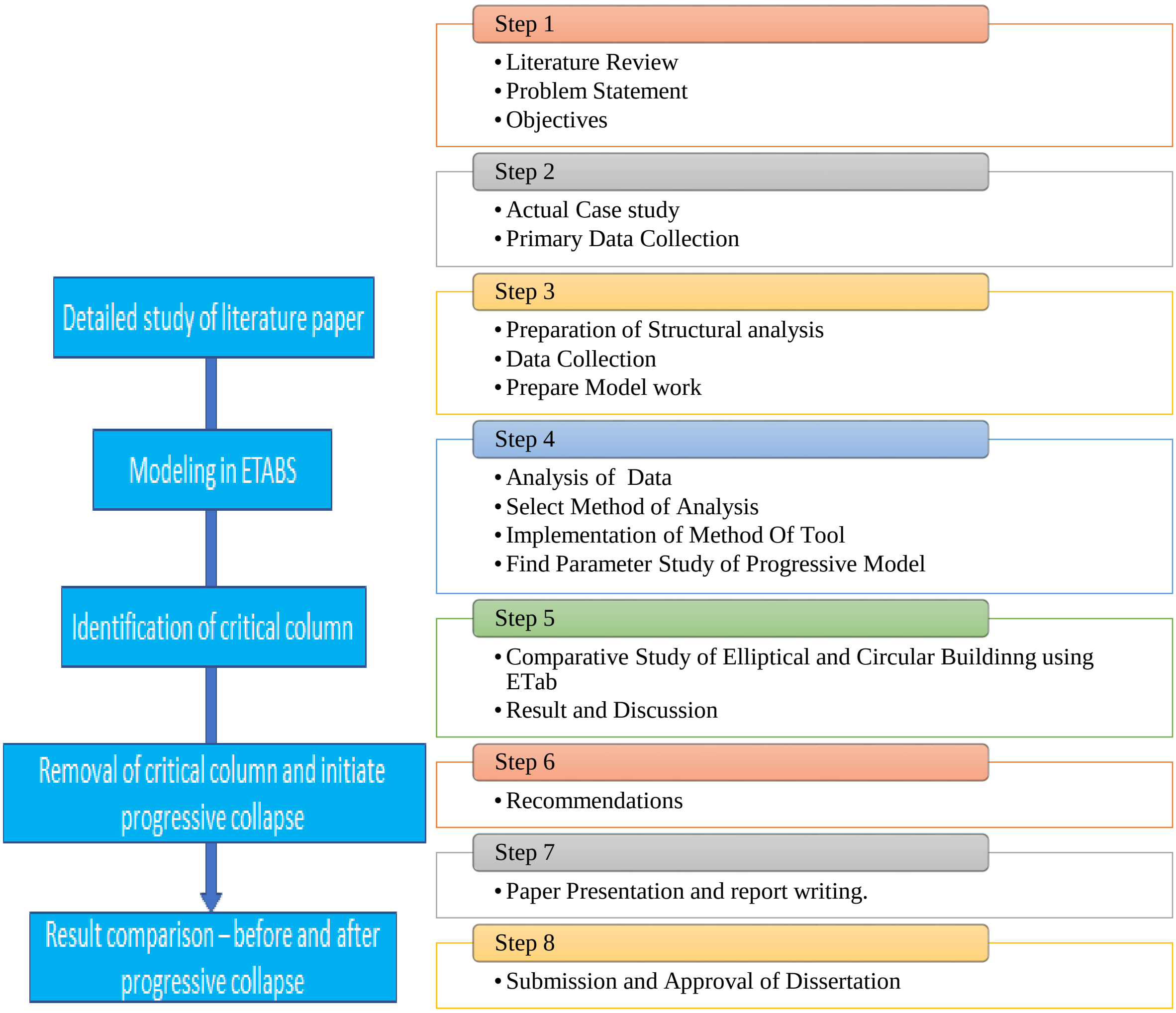


Figure1.2: Methodology Flow

Localized structure damage causes progressive collapse. Most studies on structures collapses due to explosion, car impact, fire, or other man-made risks, not earthquakes. This study weakened a corner-column to cause early damage. Push over analysis is performed on the three-dimensional building model to examine structure deformations, frame energy absorption, and collapse pattern.

DESIGN AND MODELLING

Design of Circular Progressive Model

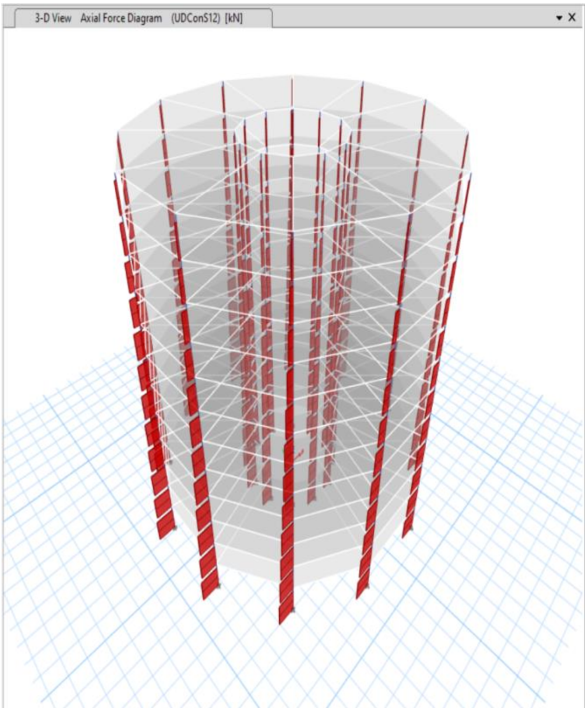


Figure1.3: Model of Circular Building

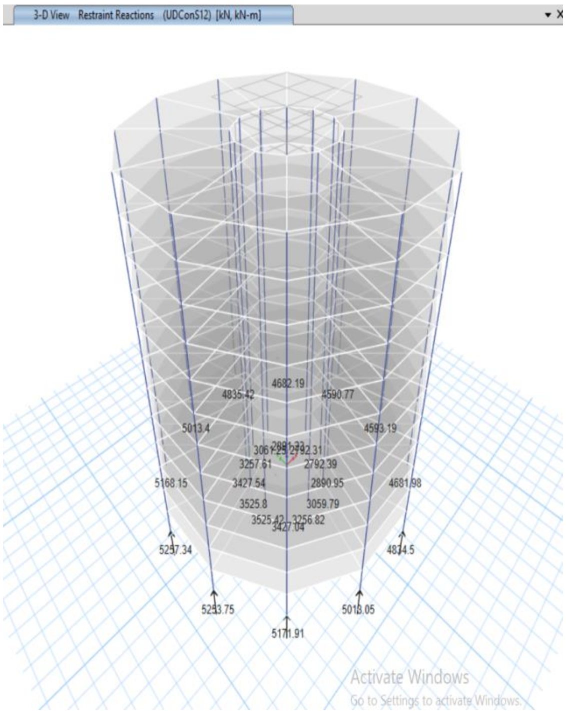


Figure1.4: Circular Model of Base Reaction

Circular Model of Bending Moment Direction

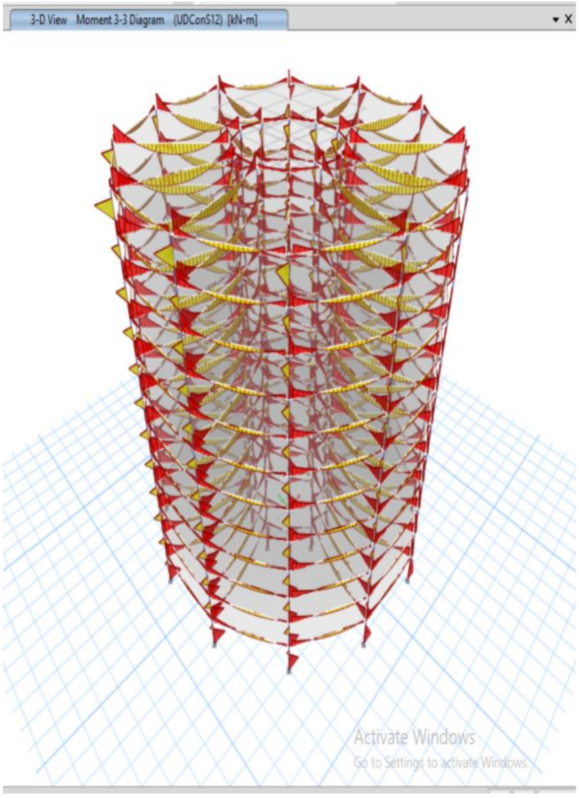


Figure1.5: Circular Model of Bending Moment Direction

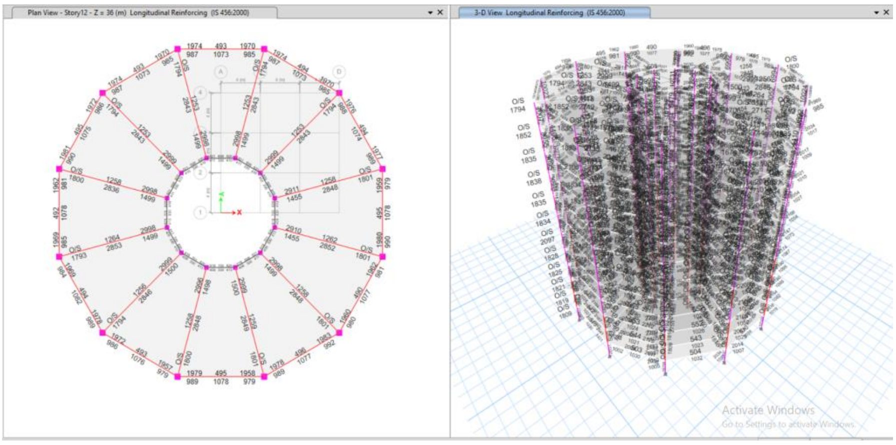


Figure1.6: Column & Beam Fail Details of Building

3D Plan View of Building

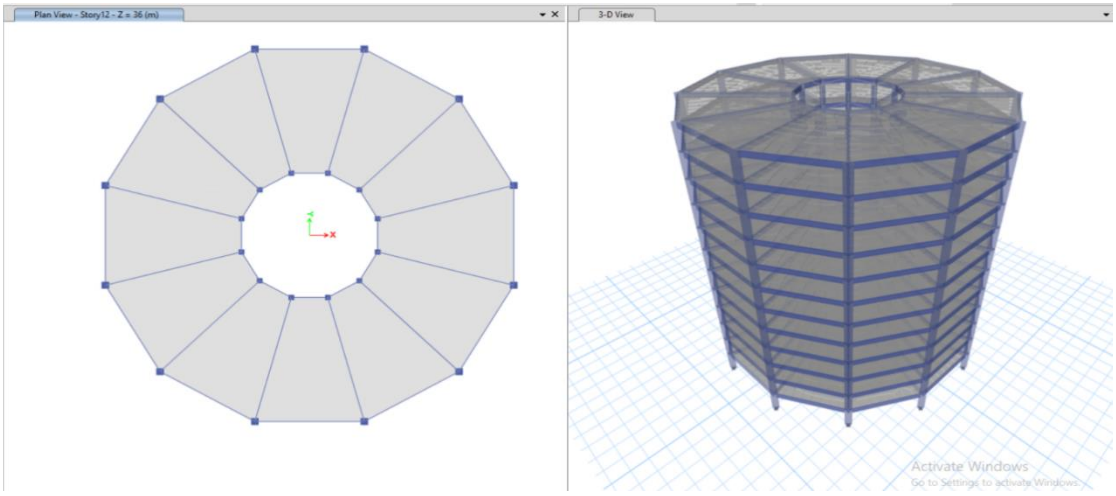


Figure1.7: 3D Plan View

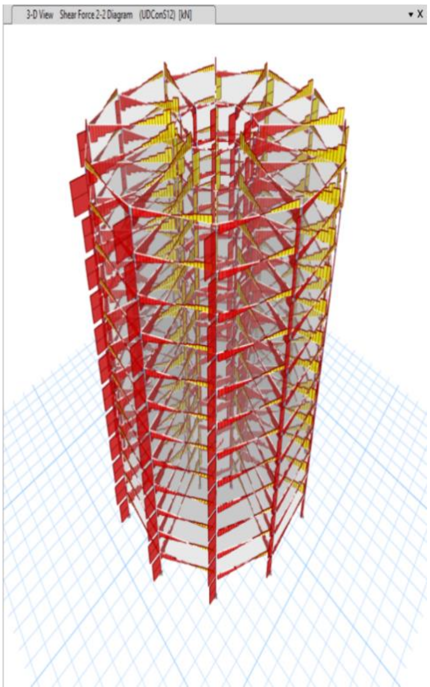


Figure1.8: Shear Force of Circular Building

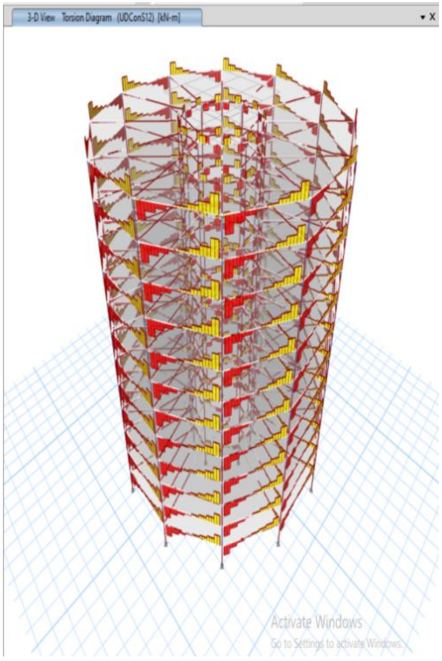


Figure1.9: Torsion of Circular Building

Elliptical model Design

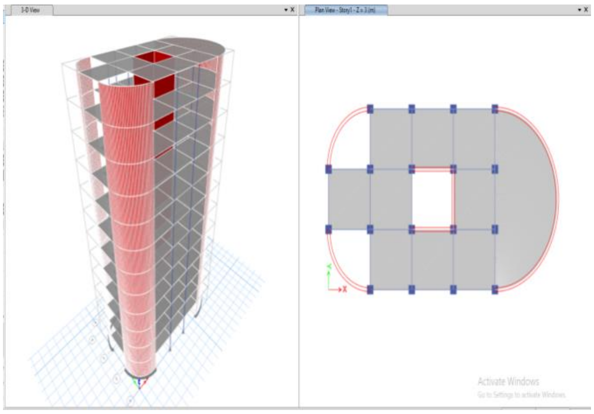


Figure1.10: 3D Plan View of Elliptical Model

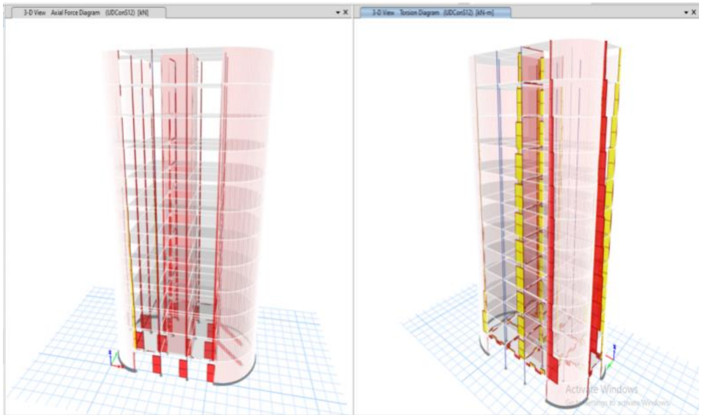


Figure1.11: Shear Force and Torsion Moment of Elliptical Model

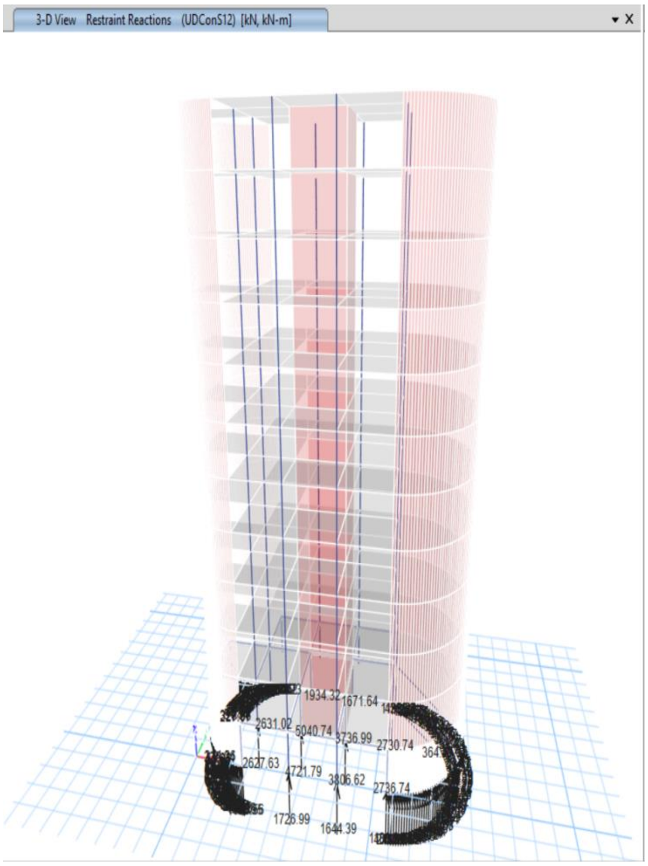


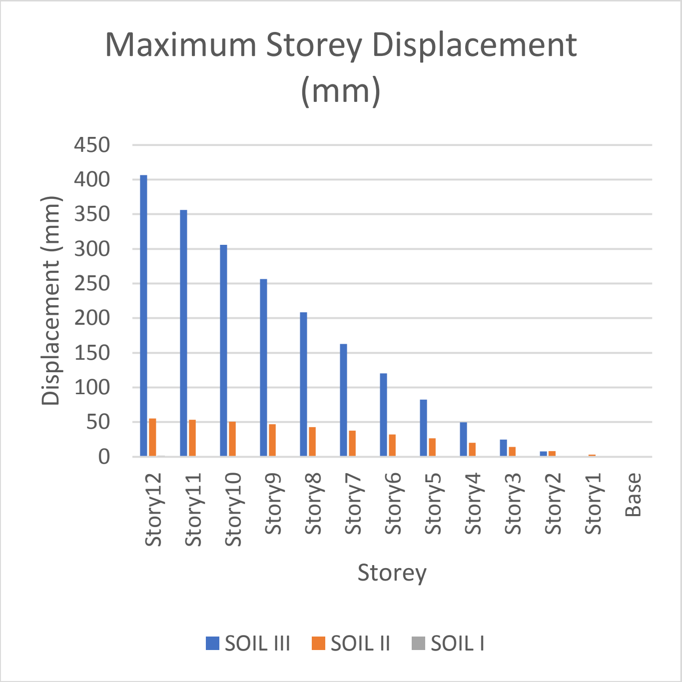
Figure1.12: Support Reaction of Elliptical Model

III. RESULT AND DISCUSSION

Maximum Storey Displacement (mm)

Table1.1: Maximum Storey Displacement (mm)

Maximum Storey Displacement (mm)		
Storey	**Elliptical Shape**	**Circular Shape**
Story12	406.296	55.029
Story11	356.012	53.254
Story10	305.945	50.553
Story9	256.549	46.947
Story8	208.516	42.573
Story7	162.734	37.586
Story6	120.242	32.13
Story5	82.2	26.336
Story4	49.853	20.325
Story3	24.507	14.222
Story2	7.506	8.23
Story1	0.274	2.879
Base	0	0

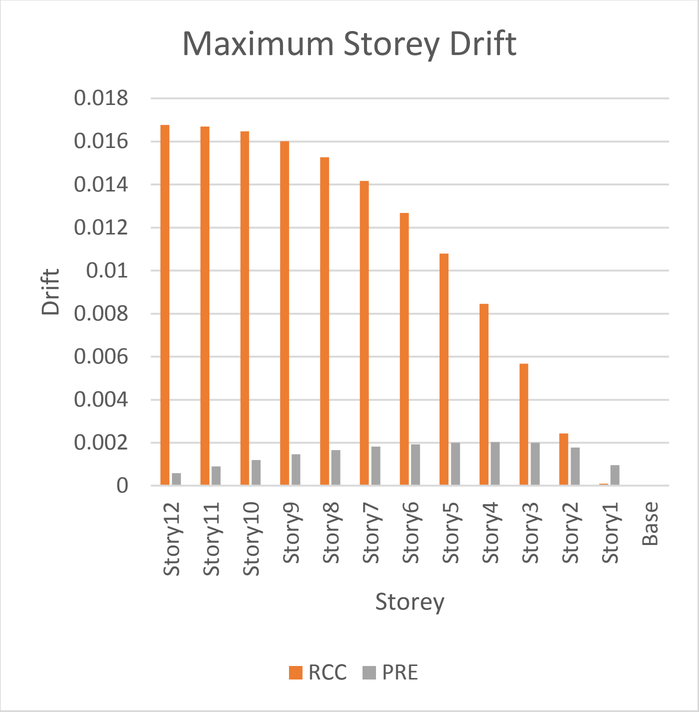


Graph1.1: Maximum Storey Displacement (mm)

Maximum Storey Drift

Table1.2: Maximum Storey Drift

Maximum Storey Drift		
Storey	**Elliptical Shape**	**Circular Shape**
Story12	0.016761	0.000592
Story11	0.016689	0.0009
Story10	0.016465	0.001202
Story9	0.016011	0.001458
Story8	0.015261	0.001663
Story7	0.014164	0.001819
Story6	0.012681	0.001931
Story5	0.010782	0.002004
Story4	0.008449	0.002034
Story3	0.005667	0.001997
Story2	0.00243	0.001783
Story1	9.10E-05	0.00096
Base	0	0

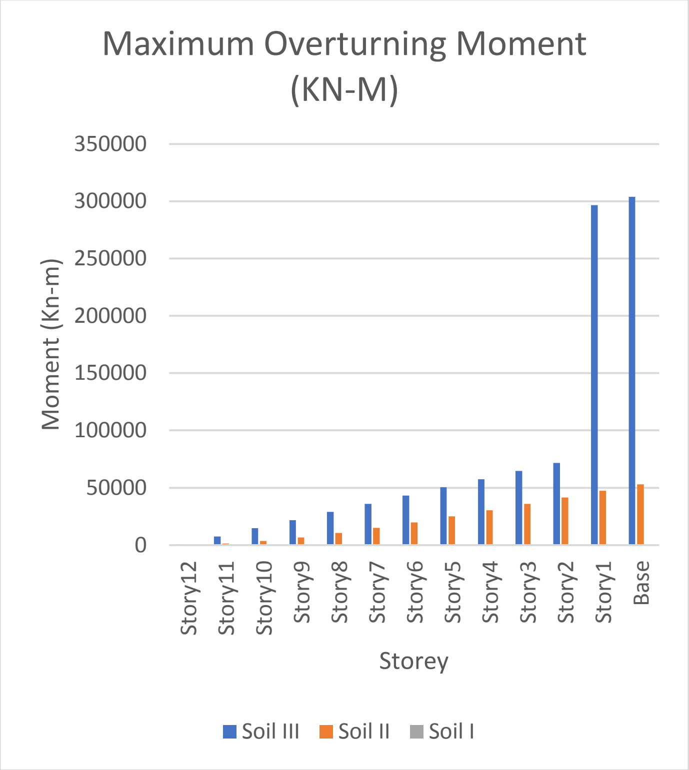


Graph1.2: Maximum Storey Drift

5.3 Maximum Overturning Moment

Table1.3: Maximum Overturning Moment

Maximum Overturning Moment (KN-M)		
Storey	**Elliptical**	**Circular**
Story12	366.7439	0
Story11	7500.17	1228.9591
Story10	14633.6	3518.6694
Story9	21767.02	6685.0336
Story8	28900.45	10561.4874
Story7	36033.88	14998.9997
Story6	43167.3	19866.0723
Story5	50300.73	25048.7403
Story4	57434.16	30450.5718
Story3	64567.58	35992.668
Story2	71701.01	41613.6629
Story1	296656.7	47269.7241
Base	303909.2	52934.5517

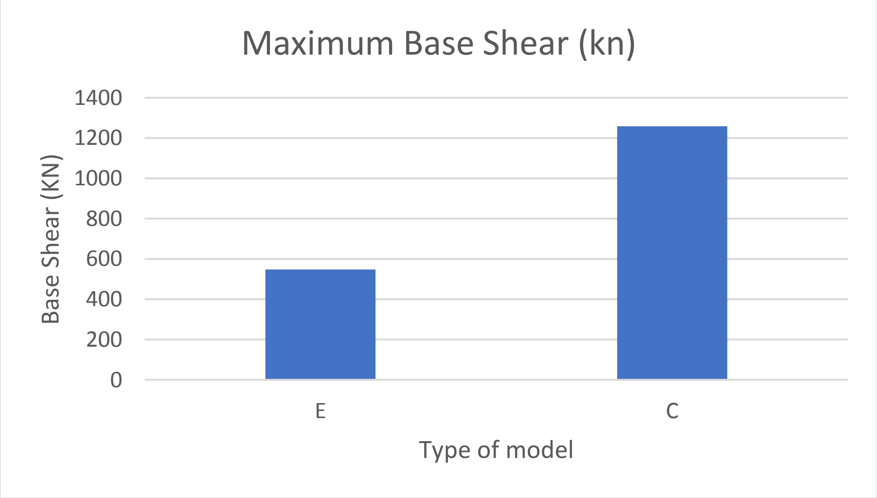


Graph1.3: Maximum Overturning Moment

Maximum base Shear

Table1.4 Maximum base Shear

Maximum Base Shear (Kn)		
TYPE	**Base Shear (Kn)**	
Elliptical	548.53	
Circular	1258.46	

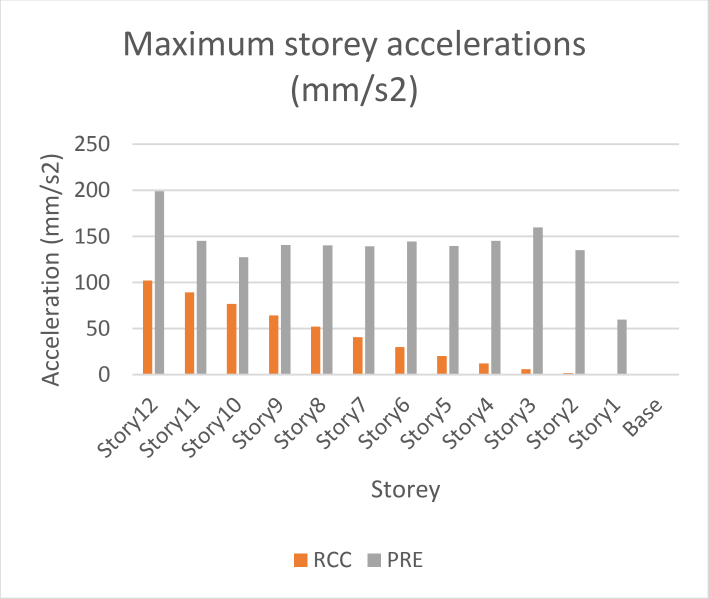


Graph1.4 Maximum base Shear

Maximum storey accelerations (mm/s2)

Table1.5: Maximum storey accelerations (mm/s2)

Maximum storey accelerations (mm/s2)		
Storey	**Elliptical**	**Circular**
Story12	102.04	199.01
Story11	89.37	145.14
Story10	76.74	127.41
Story9	64.28	140.65
Story8	52.16	140.21
Story7	40.61	139.31
Story6	29.88	144.29
Story5	20.29	139.68
Story4	12.17	145.09
Story3	5.89	159.6
Story2	1.73	134.9
Story1	0.01	59.88
Base	0	0



Graph1.5: Maximum storey accelerations (mm/s2)

IV. CONCLUSION

In this study, analyze the progressive collapse process of a shell and elliptical shell structure large-span single-layer latticed shell structure. The mid-span zone on the left side of the structure is the weak zone of the structure, where the first failure members of the structure and the nodes of maximum displacement are located, according to an analysis of dynamic response processes such as the vertical displacement of the nodes and the failure sequence of the members. Here is where there is a significant change in the reticulated shell structure's curvature. Starting from the position of the first member to fail, the failure sequence of members is primarily separated into two orientations.

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