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Analysis of Wind Response on Different Shapes of High Rise Mivan Wall Buildings by Using Gust Factor Method

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Abstract - *In addition to gravity loads, high rise buildings are susceptible to wind loads hence the magnitude and nature of these wind loads has to be determined and the structure has to be analyzed for the wind loads to understand its behavior. This work focuses on the wind produced response of the high rise building by taking G+20 Storey building .The structure under study is a Mivan structure where in which the slab wall system is adopted in place of moment resting frame for the building. This study concentrates on the horizontal irregularities by considering different shapes in plan of the structure. Magnitudes of wind loads are dependent on the area of exposure of the building, hence the shape of the building has to be studied with due importance as the area of exposure is dependent on shape. Different shaped building will have different responses to the applied lateral loads. Hence in this study an attempt has been made to predict the effect of different shapes of building for wind loads.In this work wind forces are calculated based on Gust effectiveness factor method. Gust effectiveness factor method is known for rational and realistic way of calculating dynamic wind loads. The wind loads so calculated by this method are applied for various shapes of the building models and are analyzed. The results obtained for different models are correlated to predict the better performance against the wind loads amongst the different shapes considered.*

Key Words: Mivan Technology, Gust Factor Method, Horizontal Irregularities, Wind Responses, Dynamic wind.

1. INTRODUCTION

Growing population, race towards new heights, new architecture and growing economy around the globe has intensified the urbanization .This phenomenon has led to grow vertical, as the horizontal growths have reached an extent of saturation. Hence High rise buildings have become more prevalent in most of the cities, replacing vast areas of small houses. The race towards the new heights and architecture is associated with many challenges. In high rise buildings, Lateral loads will be of primary concern rather than just gravity loads. Lateral loads induce heavy moments and forces on the high rise buildings. Presence of asymmetry in plan of the high rise building adds complexity to the building as it introduces torsional effects. Hence the study of responses of different types of structural elements used and the different shapes of building adopted is of immense important to choose the perfect combination of structural element and the shape of a building which minimize the lateral displacement.

In general, it is very much necessary that both wind as well as earthquake loads should be considered for the design of tall buildings. Governing criteria for carrying out dynamic analysis of high rise buildings for wind loads are different from earthquake loads. The present study is on the dynamic wind effects on high rise buildings and describes about response of the structures for the various wind actions to choose better shape of structure among C, H, L and T. The structural system considered is a structural wall system which is widely adopted due to its ample of advantages, in the construction of high rise buildings in recent days.

1.1 Mivan Technology

Construction sector is one of the major sectors which contributes more to Indian economy and is an integral part of the development. Increased rate of population growth has led to increased demand for housing.

There is a growing realization today that speed of construction needs to be given greater importance especially for large housing projects for achieving the national objective of creating a large stock to overcome shortest possible time. Fortunately, one such technology catering to faster speed of construction is Mivan technology.

Mivan is an Aluminum formwork system which has empowered and motivated the mass construction projects throughout the world. Mivan technology has got wide range of advantages like fast long-lasting, economical, and adaptive and produces excellent quality work which reduces cost of maintenance. Mivan technology is best suited for the developing countries like India since fully cast in situ concrete structures can be erected easily with the help of aluminum form work.

A Malaysian based company called Mivan Company Ltd. Got an innovative idea of Mivan Technology. It initially introduced and produced this alumina form work in early 1990's hence the name Mivan Technology. In the later stages a Construction company in Europe developed this Mivan technology to larger extent. Currently more than thirty thousand square meters of form work uses this aluminum form work system in various parts of the globe. In India especially in Mumbai, many buildings have been built with the help of Mivan technology. This aluminum form work system is proved to be most suited kind of form work for a kind of construction environment in India.

Mivan technology is widely used in Asia, Europe, Gulf countries and in other parts of the globe also. Adoption of steam curing allows the premature removal of moulds hence adds to the rate of construction, about two flats for a day. Every activity is arranged in assembly line manner. Thus, this system produces well controlled and more precise and superior production at optimal cost in shorter time period. The forms are finished tough and care is taken that the finished forms are fabricated with high precision. Concrete is manufactured in ready concrete mix plants under firm caliber control and transported to site with transit mixers. Before concreting, the frames for doors, windows, and ducts are placed in the form for service. Staircase, chejjas also different pre-fabricated things are consolidated under that structure. This may be a boss preference when contrasted with different current development systems.

1.2 Horizontal Irregularities

An irregular structure is one which exceeds the limits prescribed by different design codes. Horizontal irregularity limits and vertical irregularity limits have been discussed in the relevant codes. The structure may have two types of irregularities namely Horizontal irregularities and vertical irregularities. The present study concentrates on the Horizontal irregularities in the tall structures. A horizontal irregularity occurs if center of mass and the center of stiffness of the structure do not coincide, which may result in eccentricities in the structure finally giving rise to the torsion in the structure. As for as possible the irregularities should be minimized for the better performance of the buildings but now a days it is unavoidable that the structure is designed for the irregularities.

2. OBJECTIVES

The objectives of this study can be listed as follows

- To study the Dynamic Wind response of high rise irregular Mivan wall building by Gust factor method of wind analysis.
- To correlate the Gust Wind response of different shapes of High rise irregular Mivan wall building.

3. METHODOLOGY

General Steps followed

- In ETABS software Modeling of C-shaped, H-shaped L-shaped and T shaped buildings.
- Gust factored Wind load calculations by using the formulae specified in IS-875 (part –III) -1987 in Excel spread sheets.
- Importing the wind loads calculated in excel sheets to the ETABS and applying the same to the respective building models.
- Analyzing all the models in ETABS.
- Comparing the results of C, H, L, and T shaped buildings.

3.1 Structural Models

G+20 storied tall Mivan wall C-shaped, I-shaped, L-shaped and T-shaped building models are considered as a part irregularity for modeling. 700 Square.m is the Plan Area of each model. Depth of foundation is restricted to 2m from the natural ground level and storey height of the building including ground storey is kept 3.5m for all type of buildings. ETABS 9.7.0 version software is used for structural modeling and analysis. Different material parameters and sectional parameters used while modeling are listed in the tables below.

The behaviour of the building against wind loads varies with the area of exposure of the building so, at most care should be taken while arriving at different shapes in plan. Buildings shape in plan is chosen in such a way that total area in plan of all the buildings is same so that value of dead and live load remains almost same. For convenient arrangement of different shapes, the plan area is divided into grid of size 5mX5m.

As this work focuses on the behavioural examination of Mivan wall system or structural Slab Wall System the structural components are modeled by using Slab and wall elements only.

Table -1: Section Properties

Structural Element	Material property	Thickness	Type
Wall	M40	160 mm	Shell
Slab	M25	150 mm	Membrane

Dimensional details of buildings used for modeling

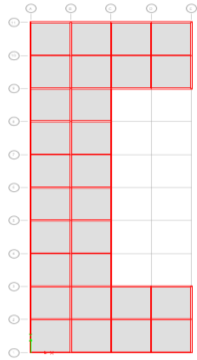
- Building height : 73.5m
- Storey height : 3.5m

3.2 Types of Models

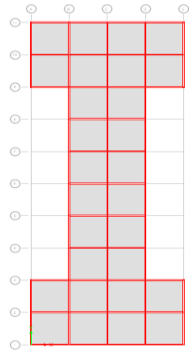
Before knowing the best shape among the C-shape, H-shape, L-shape and T-shape it is a prime thing to choose the better plan arrangement that is nothing but better lateral length ratio for which all the shapes experience minimum wind load. To arrive at this, each shape is modeled and analysed for 2 lateral length ratios. Hence there are 2 types of C, H, L and T shapes under study.

Models with lateral length ratio greater than one are labelled as TYPE-1 models. Under this type-1 model C-shape and H-shape models are with lateral length ratio 2.5 and L-shape and T-shape models are with lateral ratio 1.67 and models with lateral length ratio equal to one are labelled as

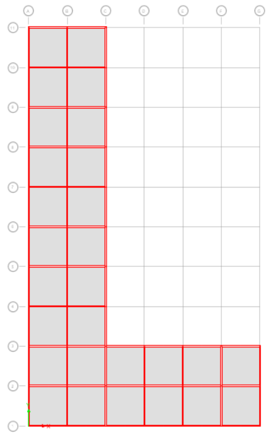
TYPE-2 models. Among the TYPE-1 and TYPE-2 models better resisted type will be chosen for further study to know better shape among C, H, L and T shape.



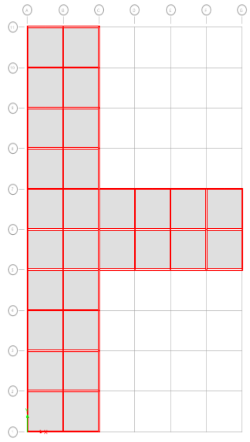
C-shape Plan(C1)



I-shape Plan(I1)

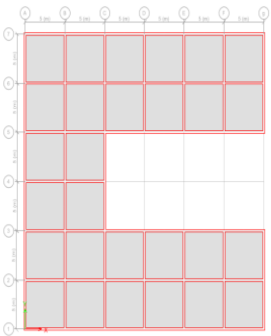


L-shape Plan(L1)

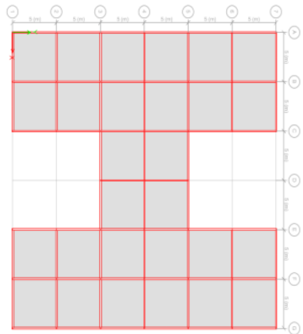


T-shape Plan(T1)

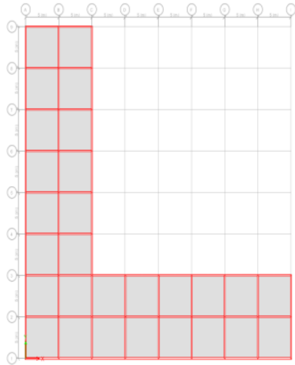
Fig. 1 Plan of Type 1 Models



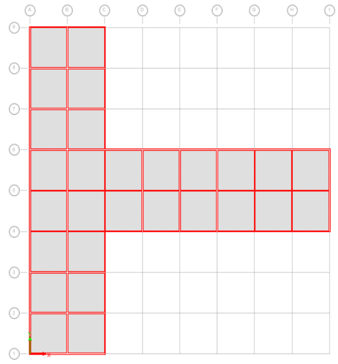
C-shape Plan(C2)



I-shape Plan(I2)



L-shape Plan(L2)



T-shape Plan(T2)

Fig. 2 Plan of Type 2 Models

3.3 Parameters Considered for Wind load Calculation

The wind load is dependent on various parameters and are to be given due importance while selecting particular parameter. IS 875 (Part III) -1987 has given detailed information about the parameters which are to be considered in the calculation of wind loads. They are

- Life of the Structure
- Terrain Category
- Topography
- Location

These parameters are further divided in to subcategories and are accounted in the load calculation in the form of coefficients. The coefficients k1(risk factor), k2 (terrain factor) and k3(topography factor) which are used in the calculation of design hourly mean wind speed are selected based on life of the structure, terrain category and topography respectively. The basic wind speed is dependent on the location of the structure, as per IS-875 (Part III) 1987 our country is divided in to 6 zones based on the basic wind speeds in each zone.The following are the parameters which are considered for present study

- Life of the Structure : 50 years
- Terrain category : Category 2
- Topography : Flat
- Location : Madras
- Basic wind speed : 50 m/s
- Building height : 73.5 m
- Storey Height : 3.5 m

3.3.1 Gust Factor wind load calculation

Gust factored wind load calculation has been done as per section no.8 of IS-875 PART-3-1987 for all building models and are tabulated below. Wind load on building depends on the area that is prone to wind pressure. If areas of exposure are same and other parameters controlling the wind loads are constant then the wind loads acting on the building models will also be same. In this study, C matches with H and L matches with T in area of exposures.

Table -2: Gust Wind loads along 0 degree and 180 degree for C1 and H1 shape building.

STOREY	HEIGHT m	K2'	Vz m/s	Pz kN/m²	Fo CYCLES/SEC	S	foL(h)/Vh	E	G	FORCE kN
GSTORY	3.5	0.670	33.50	0.6734	17.7995	0.0366	32.2894	0.0557	1.9545	299.410
STORY1	7	0.670	33.50	0.6734	17.7995	0.0366	32.2894	0.0557	1.9545	299.410
STORY2	10.5	0.675	33.75	0.6834	17.6677	0.0370	32.0502	0.0562	1.9559	304.102
STORY3	14	0.710	35.50	0.7562	16.7968	0.0393	30.4703	0.0591	1.9654	338.101
STORY4	17.5	0.735	36.75	0.8103	16.2254	0.0409	29.4339	0.0608	1.9720	363.545
STORY5	21	0.754	37.70	0.8528	15.8166	0.0422	28.6922	0.0619	1.9768	383.513
STORY6	24.5	0.768	38.40	0.8847	15.5282	0.0431	28.1692	0.0627	1.9804	398.609
STORY7	28	0.782	39.10	0.9173	15.2503	0.0440	27.6649	0.0636	1.9840	414.033
STORY8	31.5	0.795	39.73	0.9468	15.0103	0.0449	27.2296	0.0643	1.9873	428.082
STORY9	35	0.805	40.25	0.9720	14.8145	0.0456	26.8744	0.0649	1.9901	440.087
STORY10	38.5	0.816	40.78	0.9976	14.6238	0.0463	26.5284	0.0655	1.9929	452.280
STORY11	42	0.826	41.30	1.0234	14.4379	0.0470	26.1912	0.0661	1.9957	464.661
STORY12	45.5	0.837	41.83	1.0496	14.2567	0.0477	25.8624	0.0667	1.9986	477.233
STORY13	49	0.847	42.35	1.0761	14.0799	0.0484	25.5418	0.0673	2.0015	489.994
STORY14	52.5	0.854	42.68	1.0927	13.9727	0.0489	25.3473	0.0676	2.0033	497.990
STORY15	56	0.858	42.92	1.1053	13.8929	0.0492	25.2026	0.0679	2.0046	504.067
STORY16	59.5	0.863	43.17	1.1179	13.8141	0.0495	25.0596	0.0682	2.0060	510.185
STORY17	63	0.868	43.41	1.1307	13.7361	0.0499	24.9181	0.0684	2.0074	516.345
STORY18	66.5	0.873	43.66	1.1435	13.6590	0.0502	24.7783	0.0687	2.0087	522.548
STORY19	70	0.878	43.90	1.1563	13.5828	0.0505	24.6400	0.0690	2.0101	528.793
STORY20	73.5	0.883	44.15	1.1693	13.5074	0.0509	24.5032	0.0693	2.0115	496.860

Table -3: Gust Wind loads along 90 degree and 270 degree for C1 and H1 shape building.

STOREY	HEIGHT m	K2'	Vz	Pz kN/m²	Fo CYCLES/SEC	S	foL(h)/Vh	E	G	FORCE kN
GSTORY	3.5	0.670	33.50	0.6734	28.1436	0.0347	51.0541	0.0387	1.9990	108.354
STORY1	7	0.670	33.50	0.6734	28.1436	0.0347	51.0541	0.0387	1.9990	108.354
STORY2	10.5	0.675	33.75	0.6834	27.9351	0.0350	50.6759	0.0389	1.9998	110.020
STORY3	14	0.710	35.50	0.7562	26.5580	0.0377	48.1778	0.0401	2.0055	122.073
STORY4	17.5	0.735	36.75	0.8103	25.6547	0.0397	46.5391	0.0410	2.0097	131.099
STORY5	21	0.754	37.70	0.8528	25.0082	0.0412	45.3663	0.0416	2.0131	138.193
STORY6	24.5	0.768	38.40	0.8847	24.5523	0.0423	44.5394	0.0421	2.0156	143.550
STORY7	28	0.782	39.10	0.9173	24.1128	0.0435	43.7420	0.0426	2.0181	149.019
STORY8	31.5	0.795	39.73	0.9468	23.7334	0.0445	43.0538	0.0430	2.0204	153.998
STORY9	35	0.805	40.25	0.9720	23.4238	0.0454	42.4922	0.0433	2.0224	158.249
STORY10	38.5	0.816	40.78	0.9976	23.1222	0.0462	41.9451	0.0437	2.0244	162.564
STORY11	42	0.826	41.30	1.0234	22.8283	0.0471	41.4119	0.0440	2.0264	166.943
STORY12	45.5	0.837	41.83	1.0496	22.5418	0.0480	40.8921	0.0444	2.0284	171.386
STORY13	49	0.847	42.35	1.0761	22.2623	0.0489	40.3852	0.0447	2.0305	175.895
STORY14	52.5	0.854	42.68	1.0927	22.0928	0.0494	40.0776	0.0449	2.0318	178.718
STORY15	56	0.858	42.92	1.1053	21.9667	0.0498	39.8488	0.0452	2.0329	180.874
STORY16	59.5	0.863	43.17	1.1179	21.8420	0.0503	39.6226	0.0454	2.0340	183.049
STORY17	63	0.868	43.41	1.1307	21.7187	0.0507	39.3990	0.0457	2.0352	185.240
STORY18	66.5	0.873	43.66	1.1435	21.5968	0.0511	39.1779	0.0459	2.0364	187.445
STORY19	70	0.878	43.90	1.1563	21.4763	0.0515	38.9593	0.0462	2.0376	189.666
STORY20	73.5	0.883	44.15	1.1693	21.3571	0.0519	38.7430	0.0465	2.0388	178.194

Table -4: Gust Wind loads along 0 degree and 180 degree for L1 and T1 shape building

STOREY	HEIGHT m	K2'	Vz	Pz kN/m^2	Fo CYCLES/SEC	S	$foL(h)/V_h$	E	G	FORCE kN
GSTORY	3.5	0.670	33.50	0.6734	21.7999	0.0267	39.5463	0.0455	1.9212	**305.619**
STORY1	7	0.670	33.50	0.6734	21.7999	0.0267	39.5463	0.0455	1.9212	**305.619**
STORY2	10.5	0.675	33.75	0.6834	21.6384	0.0271	39.2534	0.0459	1.9223	**310.383**
STORY3	14	0.710	35.50	0.7562	20.5717	0.0301	37.3183	0.0482	1.9308	**344.924**
STORY4	17.5	0.735	36.75	0.8103	19.8720	0.0321	36.0490	0.0499	1.9370	**370.832**
STORY5	21	0.754	37.70	0.8528	19.3713	0.0331	35.1406	0.0512	1.9408	**391.000**
STORY6	24.5	0.768	38.40	0.8847	19.0181	0.0339	34.5000	0.0522	1.9436	**406.240**
STORY7	28	0.782	39.10	0.9173	18.6777	0.0346	33.8824	0.0531	1.9464	**421.804**
STORY8	31.5	0.795	39.73	0.9468	18.3838	0.0353	33.3493	0.0540	1.9490	**435.976**
STORY9	35	0.805	40.25	0.9720	18.1440	0.0358	32.9143	0.0547	1.9512	**448.083**
STORY10	38.5	0.816	40.78	0.9976	17.9104	0.0364	32.4905	0.0554	1.9534	**460.376**
STORY11	42	0.826	41.30	1.0234	17.6827	0.0369	32.0775	0.0561	1.9557	**472.855**
STORY12	45.5	0.837	41.83	1.0496	17.4608	0.0375	31.6749	0.0568	1.9580	**485.523**
STORY13	49	0.847	42.35	1.0761	17.2443	0.0381	31.2822	0.0575	1.9603	**498.380**
STORY14	52.5	0.854	42.68	1.0927	17.1130	0.0384	31.0440	0.0580	1.9618	**506.434**
STORY15	56	0.858	42.92	1.1053	17.0153	0.0387	30.8668	0.0583	1.9629	**512.553**
STORY16	59.5	0.863	43.17	1.1179	16.9187	0.0389	30.6916	0.0586	1.9640	**518.715**
STORY17	63	0.868	43.41	1.1307	16.8232	0.0392	30.5183	0.0590	1.9651	**524.918**
STORY18	66.5	0.873	43.66	1.1435	16.7288	0.0394	30.3471	0.0593	1.9662	**531.163**
STORY19	70	0.878	43.90	1.1563	16.6355	0.0397	30.1777	0.0596	1.9674	**537.449**
STORY20	73.5	0.883	44.15	1.1693	16.5431	0.0400	30.0102	0.0600	1.9685	**504.937**

Table -5: Gust Wind loads along 90 degree and 270 degree for L1 and T1 shape building.

STOREY	HEIGHT m	K2'	Vz	Pz kN/m^2	Fo CYCLES/SEC	S	$foL(h)/V_h$	E	G	FORCE kN
GSTORY	3.5	0.670	33.50	0.6734	28.1436	0.0262	51.0541	0.0387	1.9570	**152.197**
STORY1	7	0.670	33.50	0.6734	28.1436	0.0262	51.0541	0.0387	1.9570	**152.197**
STORY2	10.5	0.675	33.75	0.6834	27.9351	0.0266	50.6759	0.0389	1.9577	**154.531**
STORY3	14	0.710	35.50	0.7562	26.5580	0.0289	48.1778	0.0401	1.9627	**171.411**
STORY4	17.5	0.735	36.75	0.8103	25.6547	0.0307	46.5391	0.0410	1.9665	**184.048**
STORY5	21	0.754	37.70	0.8528	25.0082	0.0320	45.3663	0.0416	1.9694	**193.979**
STORY6	24.5	0.768	38.40	0.8847	24.5523	0.0330	44.5394	0.0421	1.9717	**201.479**
STORY7	28	0.782	39.10	0.9173	24.1128	0.0340	43.7420	0.0426	1.9740	**209.135**
STORY8	31.5	0.795	39.73	0.9468	23.7334	0.0350	43.0538	0.0430	1.9761	**216.103**
STORY9	35	0.805	40.25	0.9720	23.4238	0.0357	42.4922	0.0433	1.9778	**222.054**
STORY10	38.5	0.816	40.78	0.9976	23.1222	0.0365	41.9451	0.0437	1.9797	**228.093**
STORY11	42	0.826	41.30	1.0234	22.8283	0.0373	41.4119	0.0440	1.9815	**234.222**
STORY12	45.5	0.837	41.83	1.0496	22.5418	0.0381	40.8921	0.0444	1.9834	**240.442**
STORY13	49	0.847	42.35	1.0761	22.2623	0.0389	40.3852	0.0447	1.9853	**246.751**
STORY14	52.5	0.854	42.68	1.0927	22.0928	0.0394	40.0776	0.0449	1.9865	**250.703**
STORY15	56	0.858	42.92	1.1053	21.9667	0.0398	39.8488	0.0452	1.9875	**253.718**
STORY16	59.5	0.863	43.17	1.1179	21.8420	0.0402	39.6226	0.0454	1.9885	**256.759**
STORY17	63	0.868	43.41	1.1307	21.7187	0.0406	39.3990	0.0457	1.9896	**259.822**
STORY18	66.5	0.873	43.66	1.1435	21.5968	0.0410	39.1779	0.0459	1.9907	**262.906**
STORY19	70	0.878	43.90	1.1563	21.4763	0.0414	38.9593	0.0462	1.9918	**266.010**
STORY20	73.5	0.883	44.15	1.1693	21.3571	0.0418	38.7430	0.0465	1.9929	**249.911**

Table -6: Gust Wind loads along 0,90,180 and 270 degree for C2 and H2 shape building

STOREY	HEIGHT m	K2'	Vz	Pz kN/m²	Fo CYCLES/SEC	S	foL(h)/V_h	E	G	FORCE kN
GSTORY	3.5	0.670	33.50	0.6734	21.7999	0.0403	39.5463	0.0455	1.9889	**189.833**
STORY1	7	0.670	33.50	0.6734	21.7999	0.0403	39.5463	0.0455	1.9889	**189.833**
STORY2	10.5	0.675	33.75	0.6834	21.6384	0.0409	39.2534	0.0459	1.9903	**192.814**
STORY3	14	0.710	35.50	0.7562	20.5717	0.0445	37.3183	0.0482	2.0006	**214.437**
STORY4	17.5	0.735	36.75	0.8103	19.8720	0.0471	36.0490	0.0499	2.0084	**230.697**
STORY5	21	0.754	37.70	0.8528	19.3713	0.0490	35.1406	0.0512	2.0143	**243.486**
STORY6	24.5	0.768	38.40	0.8847	19.0181	0.0504	34.5000	0.0522	2.0187	**253.168**
STORY7	28	0.782	39.10	0.9173	18.6777	0.0518	33.8824	0.0531	2.0232	**263.073**
STORY8	31.5	0.795	39.73	0.9468	18.3838	0.0530	33.3493	0.0540	2.0274	**272.107**
STORY9	35	0.805	40.25	0.9720	18.1440	0.0541	32.9143	0.0547	2.0309	**279.836**
STORY10	38.5	0.816	40.78	0.9976	17.9104	0.0552	32.4905	0.0554	2.0345	**287.693**
STORY11	42	0.826	41.30	1.0234	17.6827	0.0563	32.0775	0.0561	2.0382	**295.681**
STORY12	45.5	0.837	41.83	1.0496	17.4608	0.0574	31.6749	0.0568	2.0419	**303.800**
STORY13	49	0.847	42.35	1.0761	17.2443	0.0585	31.2822	0.0575	2.0457	**312.051**
STORY14	52.5	0.854	42.68	1.0927	17.1130	0.0592	31.0440	0.0580	2.0481	**317.226**
STORY15	56	0.858	42.92	1.1053	17.0153	0.0597	30.8668	0.0583	2.0499	**321.161**
STORY16	59.5	0.863	43.17	1.1179	16.9187	0.0602	30.6916	0.0586	2.0517	**325.126**
STORY17	63	0.868	43.41	1.1307	16.8232	0.0607	30.5183	0.0590	2.0535	**329.120**
STORY18	66.5	0.873	43.66	1.1435	16.7288	0.0613	30.3471	0.0593	2.0554	**333.143**
STORY19	70	0.878	43.90	1.1563	16.6355	0.0618	30.1777	0.0596	2.0572	**337.196**
STORY20	73.5	0.883	44.15	1.1693	16.5431	0.0623	30.0102	0.0600	2.0591	**316.903**

Table -7: Gust Wind loads along 0,90,180 and 270 degree for L2 and T2 shape building

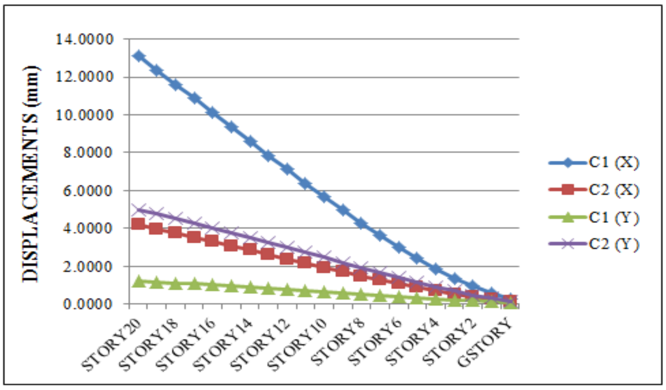
STOREY	HEIGHT m	K2'	Vz	Pz kN/m2	Fo CYCLES/SEC	S	foL(h)/Vh	E	G	FORCE kN
GSTORY	3.5	0.670	33.50	0.6734	25.1724	0.0246	45.6641	0.0415	1.9285	**218.161**
STORY1	7	0.670	33.50	0.6734	25.1724	0.0246	45.6641	0.0415	1.9285	**218.161**
STORY2	10.5	0.675	33.75	0.6834	24.9859	0.0249	45.3259	0.0416	1.9293	**221.519**
STORY3	14	0.710	35.50	0.7562	23.7542	0.0274	43.0915	0.0430	1.9350	**245.814**
STORY4	17.5	0.735	36.75	0.8103	22.9462	0.0293	41.6258	0.0439	1.9394	**264.020**
STORY5	21	0.754	37.70	0.8528	22.3680	0.0308	40.5769	0.0446	1.9428	**278.339**
STORY6	24.5	0.768	38.40	0.8847	21.9603	0.0318	39.8372	0.0452	1.9455	**289.172**
STORY7	28	0.782	39.10	0.9173	21.5671	0.0330	39.1240	0.0460	1.9486	**300.288**
STORY8	31.5	0.795	39.73	0.9468	21.2278	0.0340	38.5085	0.0467	1.9514	**310.417**
STORY9	35	0.805	40.25	0.9720	20.9509	0.0348	38.0062	0.0474	1.9539	**319.075**
STORY10	38.5	0.816	40.78	0.9976	20.6812	0.0357	37.5168	0.0480	1.9564	**327.873**
STORY11	42	0.826	41.30	1.0234	20.4183	0.0366	37.0399	0.0486	1.9590	**336.810**
STORY12	45.5	0.837	41.83	1.0496	20.1620	0.0375	36.5750	0.0492	1.9616	**345.888**
STORY13	49	0.847	42.35	1.0761	19.9120	0.0383	36.1216	0.0498	1.9641	**355.092**
STORY14	52.5	0.854	42.68	1.0927	19.7604	0.0388	35.8465	0.0502	1.9657	**360.840**
STORY15	56	0.858	42.92	1.1053	19.6476	0.0392	35.6419	0.0505	1.9668	**365.209**
STORY16	59.5	0.863	43.17	1.1179	19.5361	0.0395	35.4396	0.0508	1.9680	**369.608**
STORY17	63	0.868	43.41	1.1307	19.4258	0.0399	35.2395	0.0511	1.9691	**374.038**
STORY18	66.5	0.873	43.66	1.1435	19.3168	0.0402	35.0418	0.0514	1.9703	**378.498**
STORY19	70	0.878	43.90	1.1563	19.2090	0.0406	34.8462	0.0517	1.9715	**382.989**
STORY20	73.5	0.883	44.15	1.1693	19.1024	0.0410	34.6528	0.0519	1.9727	**359.831**

4. RESULTS AND DISCUSSIONS

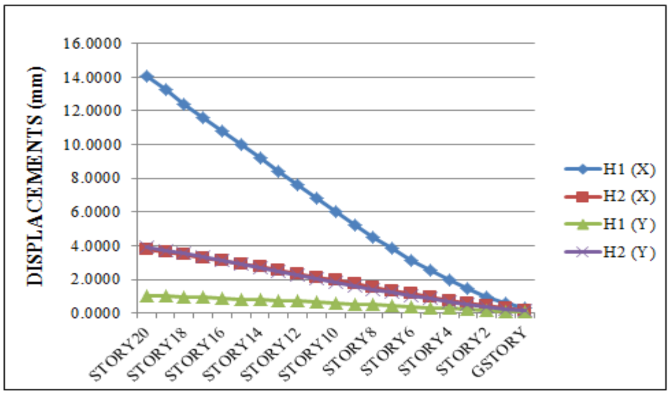
A comparative behavioural study of high rise irregular Mivan-wall structures has been done, with the aim of response optimization of the building against the wind loads and to verify more adoptable arrangements of the shapes, so that the building is exposed to minimum wind pressure. All the C, H, L and T shapes are analysed for 2 different arrangements i.e. for 2 lateral length ratios.

Behaviour of the structures is also studied for three different load application types that is, for Diaphragm loads, for joint loads and for Pressure loads. Then different shaped building models are compared with the help of results obtained from the analysis to arrive at the best shaped building model among C-shape, H-shape, L-shape and T-shapes. To assess the best shape among the models, the buildings are studied for storey displacements, inter storey drifts and storey shears.

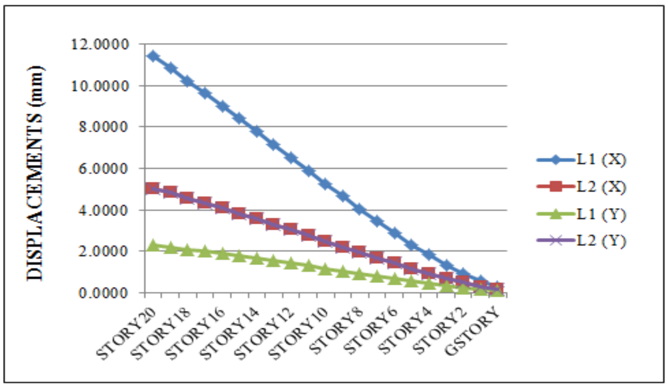
4.1 Comparison of Results Different Arrangements



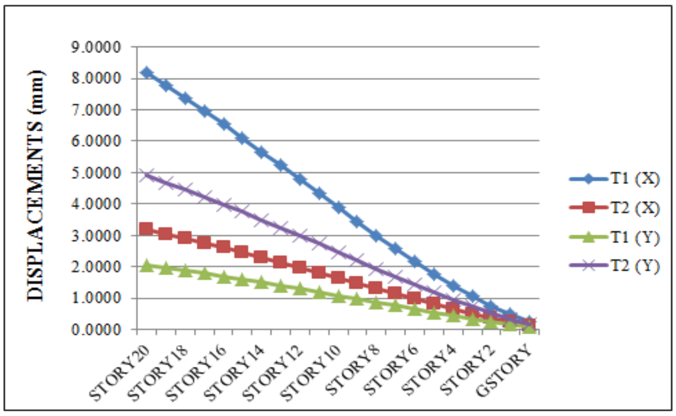
Graph -1: Storey displacements (Along X and Y direction) of C shaped models.



Graph -2: Storey displacements (Along X and Y direction) of H shaped models.



Graph -3: Storey displacements (Along X and Y direction) of L shaped models.



Graph -4: Storey displacements (Along X and Y direction) of T shaped models.

4.1.1 Discussions

By going through the graphs shown above, it can be clearly stated that the displacements are more in case of type-1 models and are comparatively less in type-2 models.Slenderness and large area of exposure to wind load are the two prime reasons, which have made type-1 models to undergo more displacements. Area of exposure is less in case of type 2 models hence displacements underwent by type-2 models are also less comparatively.Since displacements are minimum in type-2 models which are having lateral length ratio of the plan dimensions equal to unity (L1/L2 = 1) can be considered for the further analysis.

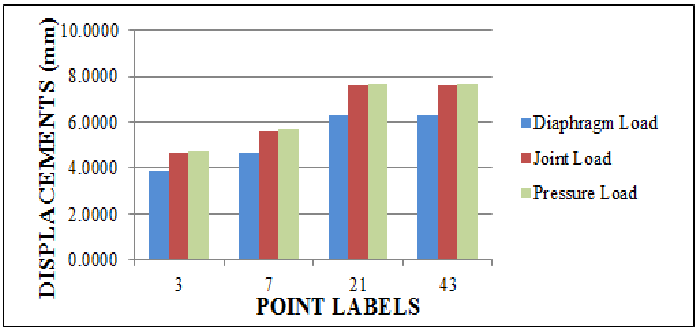
4.2 Comparison of Results for Different Types of Load Application

Behaviour of all the building models are checked for different types of load applications to know under which type of load application the models undergo more displacements.Methods of application of loads are

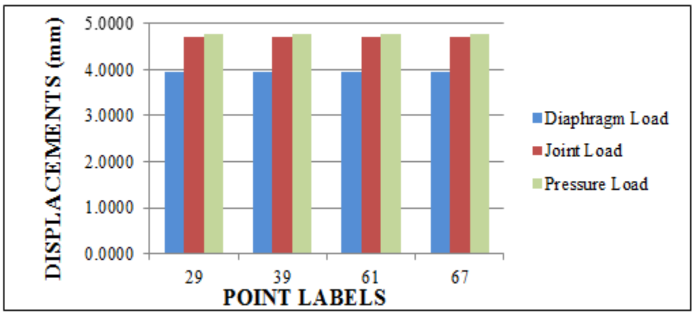
- Applied in the form of Diaphragm loads
- Applied in the form of Joint loads

• Applied in the form of Pressure loads

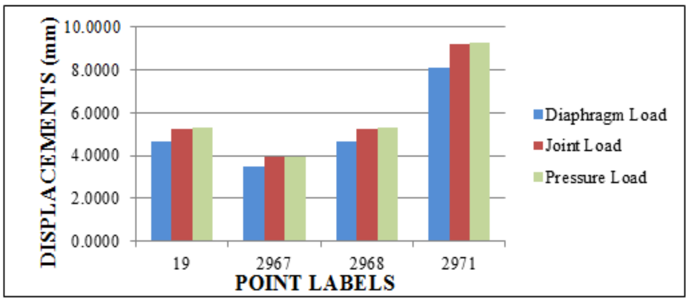
In each building model certain critical nodes are chosen and the displacements of those chosen nodes are compared for all the load application types.



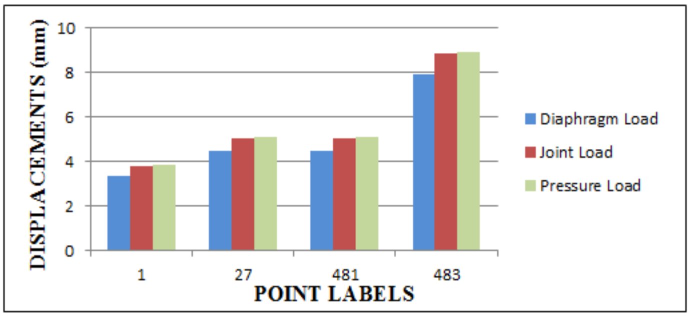
Graph -5: Different Point displacements of C shaped models.



Graph -6: Different Point displacements of H shaped models.



Graph -7: Different Point displacements of L shaped models.



Graph -8: Different Point displacements of T shaped models.

4.2.1 Discussions

The displacement values corresponding to diaphragm load type application are comparatively less.The displacement values corresponding to equivalent joint loads as well as pressure loads are almost same.The difference in displacement values produced by diaphragm loads and pressure loads are found to be around 1-2 mm.Since the pressure loads will have more realistic way of application of wind loads on the high rise buildings, building models with pressure load application type are considered for further studies.

4.3 Comparison of Results of Different Shaped Models

From the graphs which are compared against type of load application, it was found that the wind loads applied in the form of pressure will experience the wind loads in a more realistic way to cause more displacement in building models compared to other methods of load application. Hence the building models with pressure load application type are considered for further studies.To assess the best shape among the models, the buildings are studied for storey displacements, inter-storey drifts and storey shears. These storey displacements, inter storey drifts and storey shears of different model shapes are tabulated against the wind forces acting in four different directions.

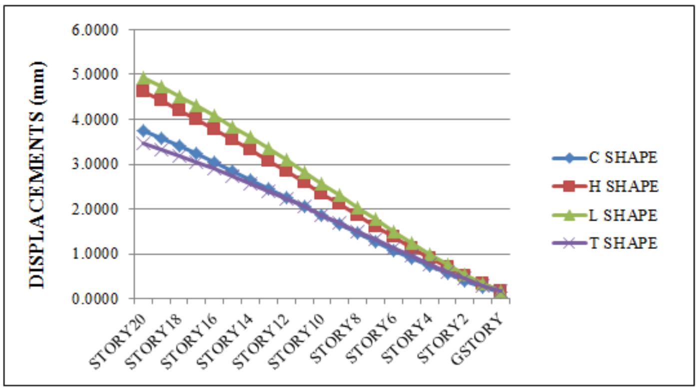
Four along wind directions considered for study are

- Along Positive X direction i.e. 0 degree
- Along Positive Y direction i.e. 90 degree
- Along Negative X direction i.e. 180 degree
- Along Negative Y direction i.e. 270 degree

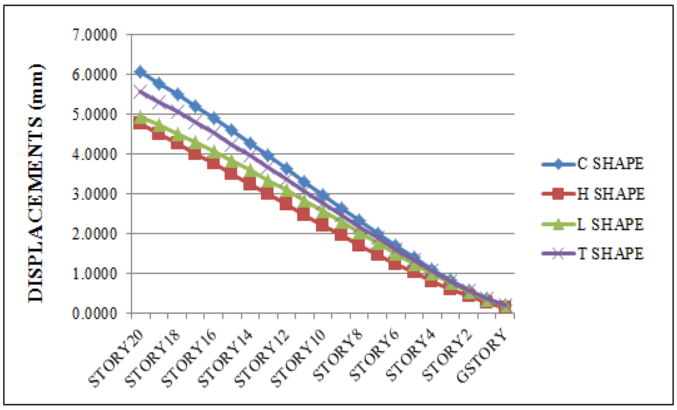
Load combinations are considered as per IS 456: 2000 and are

- DCON3 i.e. 1.2 (D.L+ L.L+ SIDL+ DWIND 0)
- DCON5 i.e. 1.2 (D.L+L.L+SIDL+ DWIND 90)
- DCON7 i.e. 1.2 (D.L+L.L+SIDL+ DWIND 180)
- DCON9 i.e. 1.2 (D.L+L.L+SIDL+ DWIND 270)

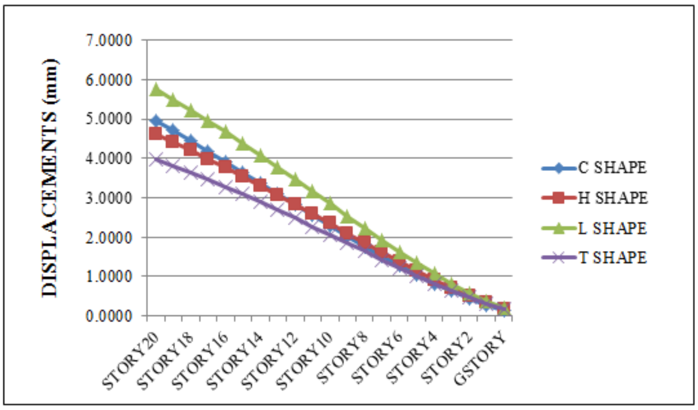
4.3.1 Storey Displacements



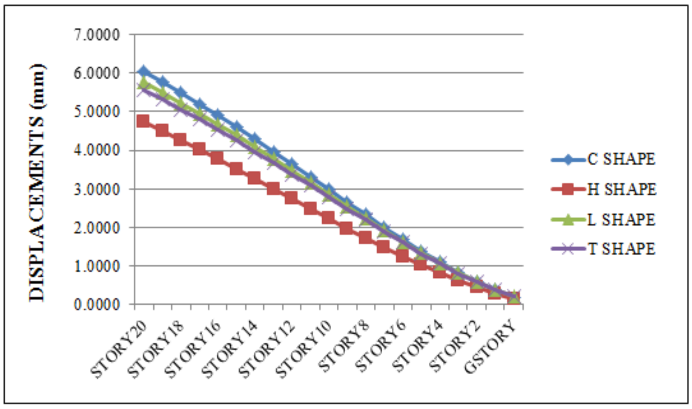
Graph -9: Storey displacements for different shaped models for load case DCON3.



Graph -10: Storey displacements for different shaped models for load case DCON5.



Graph -11: Storey displacements for different shaped models for load case DCON7.



Graph -12: Storey displacements for different shaped models for load case DCON9.

4.3.1.1 Discussions

For DCON3 i.e. for factored Wind load which is incident at zero degree angle

- Among C, H, L and T models, L shaped model has undergone maximum Storey displacement whereas T shaped model is having minimum Storey displacement.
- H shape and C shaped models have intermediate Storey displacement values of L and T shapes.
- Graph-9 tells us that for the wind incident angle zero degree the performance of T shape model is better.

For DCON 5 i.e. for factored Wind load which is incident at 90 degree angle

- Among C, H, L and T models, C shaped model has undergone maximum Storey displacement whereas H shaped model is having minimum Storey displacement.
- L shape and T shaped models have intermediate Storey displacement values of C and H shapes.
- Graph-10 tells us that for the wind incident angle 90 degree the performance of H shape model is better.

For DCON 7 i.e. for factored Wind load which is incident at 180 degree angle

- Among C, H, L and T models, L shaped model has undergone maximum Storey displacement whereas T shaped model is having minimum Storey displacement.
- C shape and H shaped models have intermediate Storey displacement values between L and T shapes.
- Graph-11 tells us that for the wind incident angle 180 degree the performance of T shape model is better

For DCON 9 i.e. for factored Wind load which is incident at 270 degree angle

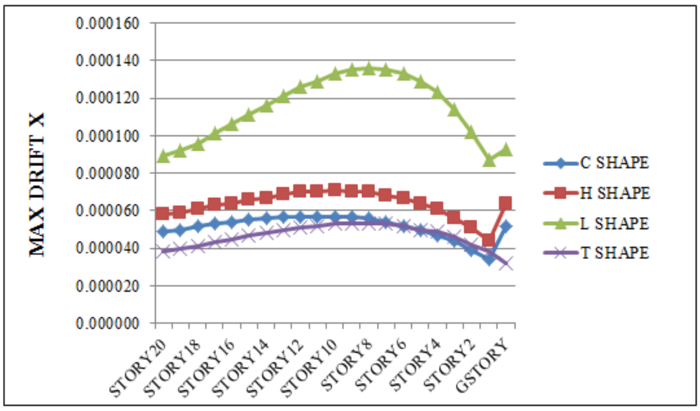
- Among C, H, L and T models, C shaped model has undergone maximum Storey displacement whereas H shaped model is having minimum Storey displacement.
- L shape and T shaped models have intermediate Storey displacement values of C and H shapes.
- Graph-12 tells us that for the wind incident angle 270 degree the performance of H shape model is better.

Irrespective of the wind incident angle, maximum storey displacement that was found in each model in this study are listed below.

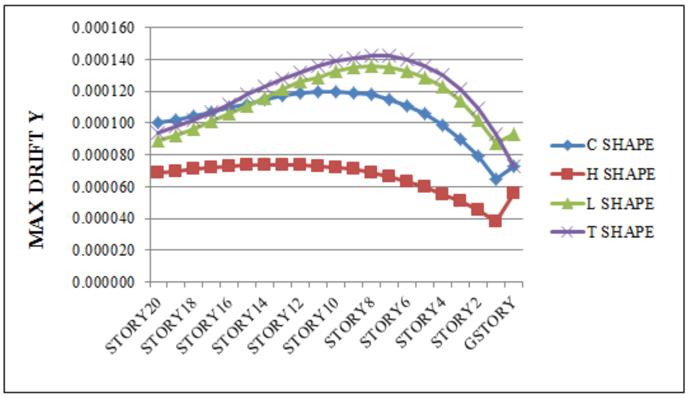
- 6.0562 mm for C shaped model
- 4.6135 mm for H shaped model
- 5.7649 mm for L shaped model
- 5.5626 mm for T shaped model

Out of all the above listed values of maximum displacements, maximum displacement is minimum for H shaped model and maximum for C shaped model.

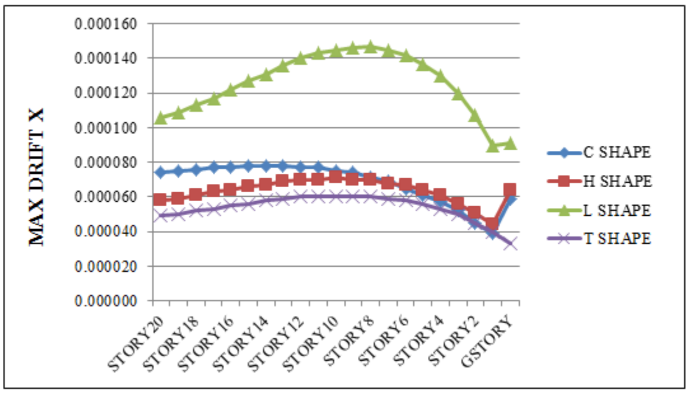
4.3.2 Storey Drift ratio



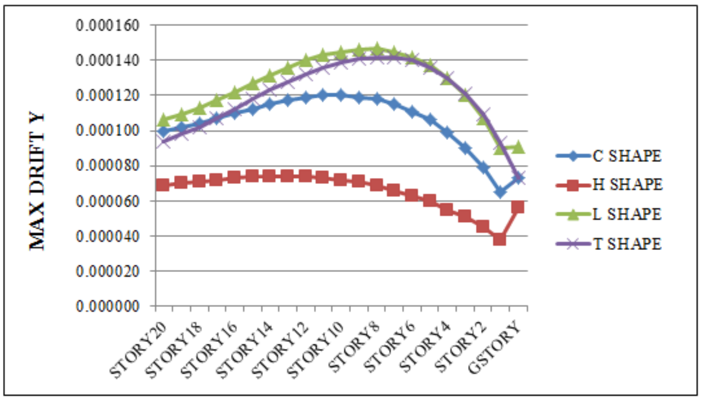
Graph -13: Max storey drift ratios for different shaped models for load case DCON3.



Graph -14: Max storey drift ratios for different shaped models for load case DCON5.



Graph -15: Max storey drift ratios for different shaped models for load case DCON7.



Graph -16: Max storey drift ratios for different shaped models for load case DCON9.

4.3.2.1 Discussions

For DCON3 i.e. for factored Wind load which is incident at zero degree angle

- Among C, H, L and T models, L shaped model has got maximum Storey drift ratios whereas T shaped model is having minimum Storey drift ratios.
- H shape and C shaped models have intermediate Storey drift ratio values between L and T shapes.
- Graph-13 tells us that for the wind incident angle zero degree the performance of T shape model is better.

For DCON 5 i.e. for factored Wind load which is incident at 90 degree angle

- Among C, H, L and T models, T shaped model has got maximum Storey drift ratios whereas H shaped model is having minimum Storey drift ratios.
- L shape and C shaped models have intermediate Storey drift ratio values between T and H shapes.
- Graph-14 tells us that for the wind incident angle 90 degree the performance of H shape model is better.

For DCON 7 i.e. for factored Wind load which is incident at 180 degree angle

- Among C, H, L and T models, L shaped model has got maximum Storey drift ratios whereas T shaped model is having minimum Storey drift ratios.
- C shape and H shaped models have intermediate Storey drift ratio values between L and T shapes.
- Graph-15 tells us that for the wind incident angle 180 degree the performance of T shape model is better

For DCON 9 i.e. for factored Wind load which is incident at 270 degree angle

- Among C, H, L and T models, L shaped model has got maximum Storey drift ratios whereas H shaped model is having minimum Storey drift ratios.

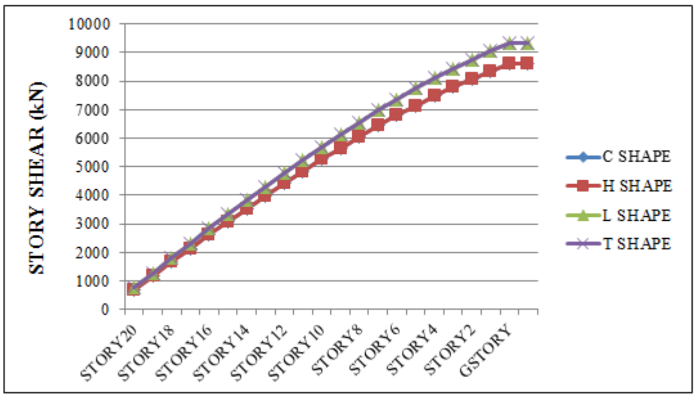
- C shape and T shaped models have intermediate Storey drift ratio values between L and H shapes.
- Graph-16 tells us that for the wind incident angle 270 degree the performance of H shape model is better.

Irrespective of the wind incident angle, maximum Storey drift ratio that were found in each model is listed below.

- 0.000120 for C shaped model
- 0.000074 for H shaped model
- 0.000147 for L shaped model
- 0.000142 for T shaped model

Out of all the above listed values of maximum Storey drift ratios, maximum Storey drift ratio is minimum for H shaped model and maximum for L shaped model.

4.3.3 Storey Shears



Graph -17: Storey shears for different shaped models

4.3.3.1 Discussions

- The storey shear is maximum for L shape and T shaped models and minimum for C and H shaped models.
- Thus for the same plan area the C and H shaped models has lesser storey shears compared to L and T shapes.

5. CONCLUSIONS

The following conclusions are drawn based on the results of the analysis.

- Since lateral dimensions ratio is more than unity for Type-1 models, the area of exposure that is prone to wind loads is more in Type-1 models. Hence Type-1 building models exhibit more displacements compared to Type-2 building models. Therefore we can conclude that Type-2 building models have better performances in comparison with the Type-1 building models.
- Building models with wind loads applied in the form of pressures have exhibited more displacements compared to those building models with wind loads applied in the form of diaphragm loads and joint loads.
- C-shape, L-shape, T-shape building models have more displacement in comparison with H-shape models.
- H-shape model has less values of storey displacement, storey drift and storey shear compared to C-shape, L-shape and T-shape building models. This implies that H shape models have better behaviour against wind loads.
- Even though, T-shaped building model has less values of displacements and storey drifts for comparison of results under consideration of wind flow in certain individual direction. As a whole H shape model has least value for both maximum storey displacement and maximum storey drift for wind loads.

6. SCOPE FOR FUTURE WORK1

- Work can be extended to study on across wind responses of irregular buildings.
- As a part of extension of this work the effect of internal wind pressures can also be studied by considering openings in external walls.
- For more accuracy as a part of extension of the work Computational Fluid Dynamics method can be used to compute wind loads.

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