

ANALYTICAL STUDY OF STEEL MULTI-STORIED BUILDING WITH VARYING DIAPHRAGM POSITIONS

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Abstract:

The main causes of structural failure are imperfect designs that haven't determined the factual loading conditions on the structural rudiments. Damages from earthquake generally begin at locations of structural weaknesses in multi-storied framed structures. Structures with openings in slabs are prone to damages due to the action of side loads. These days, openings in the floors is common for numerous reasons like stair cases, lighting architectural etc., these openings in diaphragm causes stresses at discontinues joints with structure rudiments. Discontinuous diaphragms are designed without stress computations and are allowed about to be acceptable ignoring any gap goods. A Diaphragm is structural element that transmits side loads to the perpendicular resisting rudiments of a structure. The diaphragm forces tend to be transferred to the perpendicular resisting element primarily through in shear stress. The most common side loads to be defied are those performing from wind and earthquake conduct, but other side loads similar as side earth pressure or hydrostatic pressure can also be resisted by diaphragm action. The diaphragm of a structure frequently does double duty as the bottom system or roof system in a structure or the deck of the ground, which simultaneously supports gravity loads. Hence, the main aim of the present study is to do seismic analysis by the method of push- over analysis of steel multi-storied structure with varying diaphragm positions. In this work, openings in slabs are provided at various locations and with structures having different shaped columns are used. This entire project is done in ETABS Software.

Keywords :- Diaphragm, Steel multi-storied building, Seismic analysis, Push-over analysis .

I. INTRODUCTION

1.1 Background

In multi-storey framed structure, damages from earthquake generally initiates at locales of structural sins present in the side Cargo defying frames. This best of multi-storey framed structures during strong earthquake movements depends on the distribution of mass, stiffness, strength in both the vertical and perpendicular air planes of structures. In many cases, these sins may be created by discontinuities in stiffness, strength or mass along the diaphragm. similar discontinuities between diaphragms are frequently associated with unforeseen variations in the frame figure along the length of the structure.

Structural masterminds have developed confidence in the design of structures in which the distributions of mass, stiffness and strength are more or less invariant.

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There's a lower confidence about the design of structures having irregular geometrical configurations(diaphragm discontinuities). In the present thesis, the effect of diaphragm discontinuity on the seismic response of a named multi storey structure is studied.

1.2 Diaphragm

In structural engineering, a diaphragm is a

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structural element that transmits side loads to the perpendicular resisting rudiments of a structure(similar as shear walls or frames). Diaphragms are generally vertical, but can be leaned similar as in a gable roof on a wood structure or concrete ramp in a parking garage. The diaphragm forces tend to be transferred to the perpendicular resisting rudiments primarily through in- plane shear stress. The most common side loads to be defied are those performing from wind and earthquake conduct, but other side loads similar as side earth pressure or hydrostatic pressure can also be defied by diaphragm action. The diaphragm of a structure frequently does double duty as the bottom system or roof system in a structure, or the sundeck of a ground, which contemporaneously supports graveness loads. Diaphragms are generally constructed of plywood or acquainted beachfront board in timber construction; essence sundeck or compound essence sundeck in sword construction; or a concrete arbor in concrete construction. The two primary types of diaphragm are flexible and rigid. Flexible diaphragms repel side forces depending on the tributary area, irrespective of the inflexibility of the members that they're transferring force to. On the other hand, rigid diaphragms transfer cargo to frames or shear walls depending on their inflexibility and their position in the structure. The inflexibility of a diaphragm affects the distribution of side forces to the perpendicular factors of the side force defying rudiments in a structure.

Parts of a Diaphragm include

- The membrane, used as a shear panel to carry in- in-plane shear.
- The drag strut member, used to transfer the load to the shear walls or frames.
- The chord, used to repel the pressure and contraction forces that develop in the diaphragm, since the membrane is generally unable of handling these loads alone.

For illustration, looking at the plan view of a simple structure the wind and seismic load is represented as a distributed load into the diaphragm. This structure has three shear walls to repel the lateral forces.

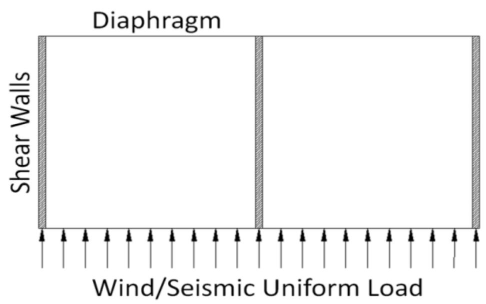

Fig 1.2.1 Diaphragm

1.3 Diaphragm Discontinuity

A horizontal system acting to transmit side forces to vertical- defying rudiments. The bottoms and roof of a structure, in addition to defying staidness loads, are also generally designed to act as diaphragms. In this respect, they're demanded both to distribute seismic forces to the main rudiments of vertical resistance, similar as frames and shear walls, and also to tie the structure together so that it acts as a single reality during an earthquake. The robustness and redundancy of a structure is largely dependent on the performance of the diaphragms. In a ductile structure, diaphragms will nearly always be demanded to remain elastic, so that they can sustain their function of transferring forces to the main side- defying structure, and tying the structure together.

Diaphragms should in principle thus have the strength to sustain the maximum forces that may be convinced in them by the chosen yielding medium

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within the rest of the structure. Euro- code 8 deals with this rather simply by specifying that diaphragms should be designed for1.3 times the shear forces attained directly from the analysis. generally, the seismic analysis of structures is carried out on the supposition that diversions in the diaphragms are so small compared with those in the main side weight defying structure that the diaphragms can be treated as rigid. In utmost cases, this is fairly satisfactory, because generally diaphragm harshness affects neither overall structural stiffness nor the distribution of forces within a structure. also, during a major earthquake, in ductile structures where the diaphragms are designed to remain basically elastic, the superstructure diversions are likely to include large plastic distortions, adding the difference still further.

1.4 TYPES OF DIAPHRAGM:

a. Rigid Diaphragms :-

A diaphragm may be considered rigid when its midpoint relegation, under side cargo, is lower than twice the average deportations at its ends. Rigid diaphragm distributes the vertical forces to the perpendicular resisting rudiments in direct proportion to the relative rigor. It's grounded on the supposition that the diaphragm doesn't distort itself and will beget each perpendicular element to redirect the same quantum. Rigid diaphragms able of transferring torsional and shear diversions and forces are also grounded on the supposition that the diaphragm and shear walls suffer rigid body gyration and this produces fresh shear forces in the shear wall. Rigid diaphragms correspond of corroborated concrete diaphragms, precast concrete diaphragms, and compound sword sundeck. In discrepancy to the Flexible diaphragm, some diaphragms are veritably stiff compared to the stiffness of the frames; the in-plane distortion of the diaphragm is veritably small compared to the vertical diversions of the frames. Due to the lack of capacity and capabilities in early computers it came common to simplify the logical model by assuming that the diaphragm is infinitely rigid. This is what's known as the Rigid diaphragm.

The size of the computational model is reduced drastically when this supposition is made (which was necessary when computers had much lower processing power). The Rigid diaphragm can rotate and restate, but it cannot distort. In such a model, the side forces will be distributed (and redistributed at posterior situations) grounded upon the relative bones of all the members defying side loads. Because concrete bottoms and bottoms of concrete filler on essence sundeck are generally veritably stiff, the Rigid diaphragm is frequently a suitable representation. It provides a accessible logical tool for tying the frames together and distributing the story forces to the various frames. It's intriguing to note that hand styles that were used, before computers were readily available, to attempt to distribute the loads to the frames grounded on the relative bones of the frames were grounded on an implicit supposition that the diaphragms were Rigid.

The Rigid Diaphragm is considered completely rigid along the entire plane and internally the program connects all bumps at that position together strictly. As the side loads are applied to the Rigid diaphragm, they're distributed to the side walls grounded on the stiffness of the walls.

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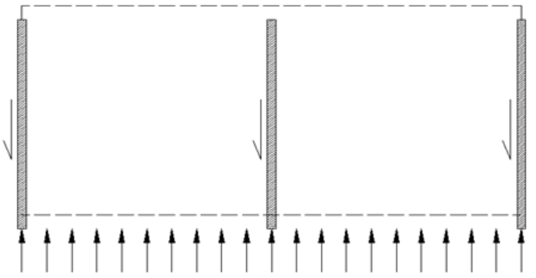

Fig 1.3.1 Rigid Diaphragm

b. Flexible Diaphragms :-

A diaphragm is considered flexible, when the midpoint displacement, under side cargo, exceeds twice the average displacement of the end supports. When the side stiffness of the frames is veritably large compared to the in- plane stiffness of the diaphragm, the diaphragm has veritably little influence on the distribution of side forces. Such a diaphragm is classified as Flexible. It's assumed then that the relative stiffness of these non-yielding end supports is veritably great compared to that of the diaphragm. Thus, diaphragms are frequently designed as simple shafts between end supports, and distribution of the side forces to the perpendicular resisting rudiments on a influent range, rather than relative stiffness. Flexible diaphragm isn't considered to be able of distributing torsional and rotational forces.

Flexible diaphragms correspond of transversely sheated wood diaphragms, faced diaphragms etc. It lacks the capacity to redistribute forces between frames. In the extreme, vertical braces are occasionally needed to give the cargo paths to the frames. Frequently with the help of drags and passions it's able of distributing the side loads to the frames simply grounded on influent exposure(for wind) or tributary area(for seismic). This is common for essence roof balconies. These diaphragms aren't represented in the logical model in any way; the side model consists only of the frame members. There's no medium analytically to transfer the side forces to the frames, and so the loads must be explicitly assigned as nodal loads by the mastermind. This modelling is closest to the way that analysis was done before 3D programs came available.

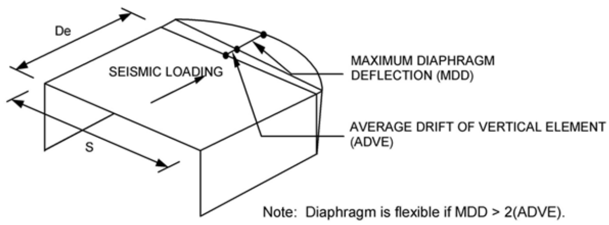

Fig 1.3.2 Flexible Diaphragm

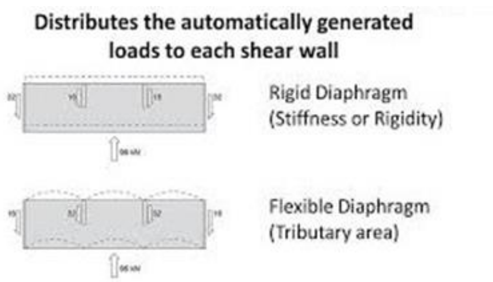

Fig 1.3.3 load distribution in rigid and flexible diaphragm

c). Semi-rigid Diaphragms :-

Numerous diaphragms don't qualify as either Flexible or Rigid. The in- plane distortions of the diaphragm have significant influence on the distribution of side forces to the frames. similar diaphragms are appertained to as Semi-rigid. To adequately capture these goods the diaphragm must be modelled and included explicitly in the analysis. This requires that the diaphragm stiffness parcels be specified and the diaphragm enmeshed into shell or plate rudiments. This dramatically increases the size of the logical model and the time that it takes to dissect. Historically this wasn't doable due to the limited memory and capacity of computers, but that's no longer the case.

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The Rigid diaphragm supposition is still useful and can be adequately valid in numerous cases, but an over-reliance on the use of the Rigid diaphragm supposition has led to further and more strict conditions in Building Canons specifying when the diaphragms must be modelled as Semi-rigid. The Semi-Rigid diaphragm is sub-meshed into a Finite Element Analysis (FEA) with plates that represent the stiffness of the diaphragm. As the loads are applied into a Semi-Rigid diaphragm the inflow of the diaphragm deflects as shown below. This will frequently produce a more realistic distribution of the forces to the side resisting rudiments.

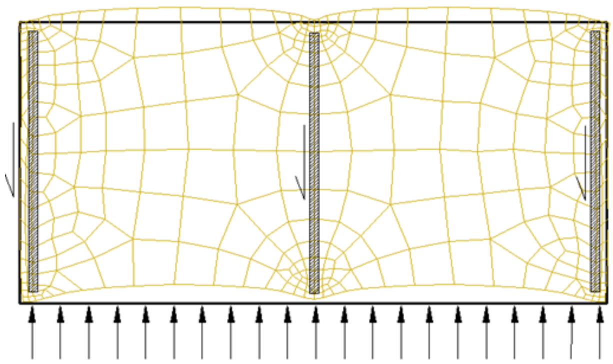

Fig 1.3.4 Semi-rigid diaphragm

1.5 Defining Loads on a Diaphragm

The last step is to define the loads on the diaphragm. Because thesemi-rigid diaphragm is less stiff than a rigid diaphragm, the analysis is likely to indicate a longer fundamental structure period for the model with thesemi-rigid diaphragm than the rigid diaphragm; the longer period may affect in a lower base shear for seismic loads. This is applicable. The rigid diaphragm analysis may give shorter structure ages and, hence, larger base shears, which are conservative. In utmost cases, still, the difference is anticipated to be minor.

Diaphragm displacements and story drifts given by the semi-rigid diaphragm analysis will differ kindly from a rigid diaphragm analysis due to the locally lesser(or lower) diversions that affect from not being constrained by the rigid diaphragm supposition. In regions of the diaphragm not incontinently conterminous to the side frame members, these differences may be particularly lesser; the validity of those values reported by the semi-rigid analysis should be questioned because although the parcels of the arbor or sundeck are more directly defined, the diaphragm deportations at locales down from the side frames may be exaggerated without consideration of the constraining goods of the graveness framing, which typically isn't included in the side analysis for simplicity.

It's delicate to perform independent verification computations other than some simplified approximations. Like wise, the affair is more complicated and substantial. For illustration, rather of simply reporting the relegation and gyration of the diaphragm, the affair includes the deportations of all of the mesh bumps. This can be less burdensome if the software has the applicable visualization and reporting tools. For illustration, RAM Structural System has a command that reports the deviation, drift, and drift rate for any unequivocal position on the diaphragm named by the stoner; the stoner needs to simply elect the position, rather than digging through line after line of mesh node deviation values.

1.6 OBJECTIVES

The main ideal of this study is

1. To do Push- Over analysis of steel multi-storied structure by furnishing various diaphragm positions.

2. The diaphragms are handed at various locations in the structural element and the analysis is carried out.

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3. To estimate the effect of diaphragm discontinuity in the steel structure and locations provided in it.

1.7 SCOPE OF THE PRESENT STUDY

In the present study, a typical multi story steel building is analysed using ETABS 2016 Software for nonlinear static (pushover) and seismic analysis. All the analysis has to be carried out considering the diaphragm discontinuity and the results are to be checked. This study is done for steel framed multi-story building.

II.LITERATURE REVIEW

Analysis of Buildings with Varying Percentages of Diaphragm Openings

Arya V Manmathan1 from Sree Buddha College of Engineering has done ANALYSIS OF BUILDINGS WITH VARYING PERCENTAGES OF DIAPHRAGM OPENINGS. In this work, openings in slabs are handed at various locations similar as centre, at corners and at fringe with structures having various shaped columns. The goods of size of openings in slabs were delved. The seismic performance of multi-storey regular structure is determined by Response Diapason analysis in ETABS software. The structure with three different column shapes is analysed by Response diapason analysis for slab openings handed at centre, corner and periphery. From Maximum Storey drift and Base shear view, slab openings at centre is set up to be more effective in defying side forces. As the chance of slab opening increases, base shear also increases.

Effect of Diaphragm Openings in Multi-storeyed RC framed buildings using Pushover analysis

P.P. Vinod Kumar, Dr.V.D. Gundakalle done trial on INFLUENCE OF STIFFNESS DISCONTINUOUS DIAPHRAGM CHARACTERISTICS ON THE SEISMIC BEHAVIOR OF RC STRUCTURE. This study is conducted to estimate problems in structural behavior of structures during earthquake. An supposition is made in the seismic analysis that all the structures bear linearly elastic during seismic excitations which intern doesn't clear the non-linearity of the structure. So in order to understand better the non-linear response of the structures this study would be useful. In the mentioned seismic analysis, the structure will be analyzed for direct static, direct dynamic and non-linear static styles. The influence of diaphragm openings on the seismic response of multi-storeyed structures played a major part in reducing the base shear, hence attracting lower seismic forces.

Influence of Stiffness Discontinuous Diaphragm Characteristics on the Seismic Behavior of RC Structure

Vinod V, Pramod Kumar H V, Assistant Professor Department of Civil Engineering C.B.I.T, Kolar, Karnataka, India had done trial on INFLUENCE OF STIFFNESS DISCONTINUOUS DIAPHRAGM CHARACTERISTICS ON THE SEISMIC behavior OF RC STRUCTURE. In this paper an action is made on the seismic behavior of the multi-story structure by using diaphragm and there discontinuities. On the intention a regular four story and eight story structure have analyzed and modelled by response diapason analysis using ETABS 2015. side load analysis as per the seismic law IS 1893(Part 1)- 2002 is carried out for regular structure with rigid diaphragm by varying heights and indeed for the spastic diaphragm latterly an trouble is made to study the effect of seismic loads and relative study between the response diapason

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analysis for both X and Y direction. Optimum 20 opening or Discontinuity of stiffness diaphragm can be used in the seismic prone RC multi-story structure, indeed the number of story height increases the same comparison results of 20 openings can be employed. Discontinuity in diaphragm shows that optimum chance of openings will with stand the seismic forces in earthquake areas.

III.METHODOLOGY

• A thorough literature review has been done for the application of the diaphragm discontinuity and analysis on it.

• Design the steel building as per prevailing Indian Standard for dead load, live load, and earthquake load.

• Apply the diaphragm discontinuity for the steel building.

• Analyze the building using push-over analysis method.

• Analyze the results and arrive at conclusions.

3.1 DETAILS OF SELECTED BUILDING

Here, the building of 22-storeys is taken into consideration and the earthquake zone is taken as II.

Table 1- Details of the Building

Building Parameters	Details
Plan size	30m*24m
Usage	Residential
Building height	(G+22)
Grade of Steel	Fe250
Grade of Concrete	M25
Seismic Zone	Zone II
Column section	ISMB 350
Beam section	ISMB 300 & ISMB 350
Slab thickness	120mm
Live load	3 KN

Model 1,2,3	Beam ISMB 350 & Column ISMB 350
Model 4,5,6	Beam ISMB 350 & Column ISMB 300

Table 2- Properties {from steel table}

For ISMB350		**For ISMB300**	
width of flange	140mm	width of flange	140mm
Thickness of Flange	14.2mm	Thickness of Flange	12.4mm
Depth of Section	350mm	Depth of Section	300mm
Thickness of Web	8.1mm	Thickness of Web	7.5mm
Radius	7mm	Radius	7mm

3.2 MODELS OF THE BUILDING

Model 1- Normal Building with diaphragm with same column and beam size of ISMB 350

Model 2 – Building with central opening with diaphragm with same column and beam size of ISMB 350

Model 3 – Model with Corner opening with diaphragm with same column and beam size of ISMB 350

Model 4 – Model with different column and beam size of ISMB 350 and ISMB 300 respectively with diaphragm

Model 5- Model with central opening and diaphragm with different column and beam size of ISMB 350 and ISMB 300 respectively with diaphragm

Model 6- Model with corner opening and diaphragm different column and beam size of ISMB 350 and ISMB 300 respectively with diaphragm

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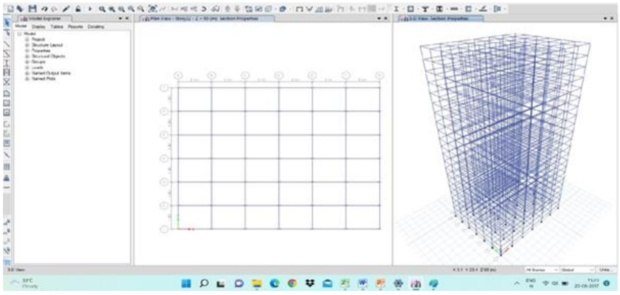

Fig 3.1 Model 1- Plan of the Building with same column and beam size of ISMB 350

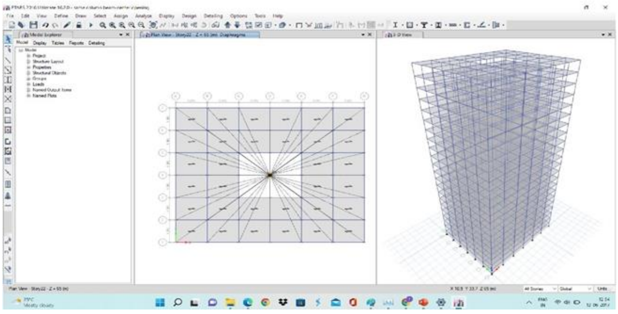

Fig 3.2 Model 2 - Building with central opening with diaphragm with same column and beam size of ISMB 350

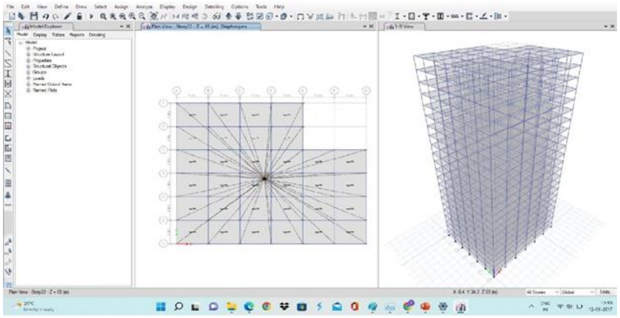

Fig 3.3 Model 3 – Model with Corner opening with diaphragm with same column and beam size of ISMB 350

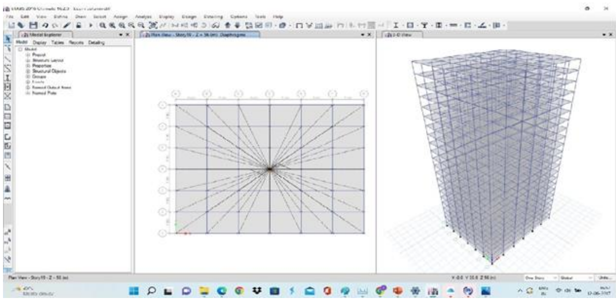

Fig 3.4 Model 4 – Model with different column and beam size of ISMB 350 and ISMB 300 respectively with diaphragm

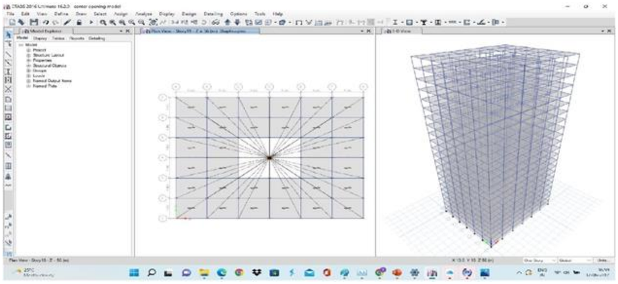

Fig 3.5 Model 5- Model with central opening and diaphragm with different column and beam size of ISMB 350 and ISMB 300 respectively with diaphragm

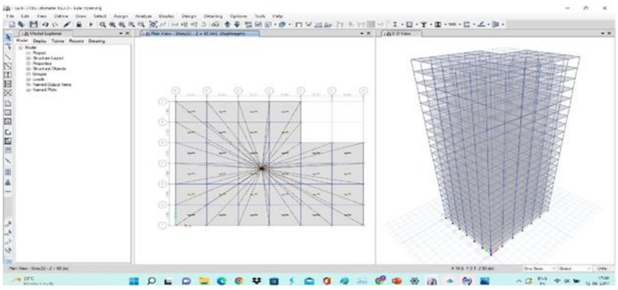

Fig 3.6 Model 6- Model with corner opening and diaphragm different column and beam size of ISMB 350 and ISMB 300 respectively with diaphragm

IV.ANALYSIS

4.1 INTRODUCTION

Seismic system of analysis is done in order to ascertain the various responses of structures during earthquake and also to borrow the retrofitting of structures. It's an important tool for earthquake prone areas like Japan, North- East of India, Nepal, Philippines, and numerous further. This system of analysis is also important for design of elements of RCC structures like beam, column, slab which are designed in accordance to IS 139202016. The seismic forces are dynamic in nature and these forces are tested for load carrying capacity, rigidity, dampness, stiffness and mass. IS 1893:2016 is used to carry out

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seismic analysis ofmulti-storey structure.

4.2 TYPES OF SESIMIC ANALYSIS

This method is divided into five categories.

1. Equivalent Static Analysis

In this analysis, an array of forces is used to represent the consequence of earthquake ground motion. It follows the assumption that the structure is responsive in its abecedarian mode. This is applicable for low rise structure and the structure which don't rotate significantly about its axis. Further inquiries have been made to increase its operation to high rise structures and low position of gyration about its axis.

The equivalent static lateral force system is a simplified technique to substitute the effect of dynamic lading of an anticipated earthquake by a static force distributed laterally on a structure for design purposes. The total applied seismic force V is generally estimated in two horizontal directions parallel to the main axes of the structure. It assumes that the structure responds in its fundamental lateral mode. For this to be true, the structure must be low rise and must be fairly symmetric to avoid torsional movement under ground movements. The structure must be suitable to resist goods caused by seismic forces in either direction, but not in both directions simultaneously.

2. Response Spectrum of Analysis

A response spectrum is a function of frequency or period, showing the peak response of a simple harmonious oscillator that's subordinated to a flash event. The response spectrum is a function of the natural frequency of the oscillator and of its damping. therefore, it isn't a direct representation of the frequency content of the excitation(as in a Fourier transfigure), but rather of the effect that the signal has on a supposed system with a single degree of freedom(SDOF).

This analysis is carried out when modes other than the abecedarian one significantly affect the response of the structure. Then, the response of Multiple- Degree- of- Freedom System(MDOF) is represented as the superposition of modal response where each modal response is determined from the spectral analysis of Single- Degree- of- Freedom-System(SDOF). All these are also composite to calculate the total response.

3. Linear Dynamic Analysis

In circumstances where structures are moreover too irregular or too high, the response spectrum analysis is no longer applicable and more complex analysis is frequently needed, similar as non-linear static analysis or dynamic analysis. This analysis can be performed either by mode superposition system or response spectrum system and elastic history time system. This analysis generates advanced vibration modes and actual distribution of forces in the elastic range in a good way. The difference between Linear Static Analysis and Dynamic Static analysis is the force distribution along the height of the structure and the position of force. Apart from this, the response of the structure to base stir is calculated in the sphere of time, and hence all phase information is maintained.

4. Non-Linear Static Analysis

It's an improvement of direct static or dynamic analysis as it allows the inelastic behaviour of the structure. But one thing is unchanged as it assumes a set of static incremental side cargo over the height of the structure. This analysis is also known as "pushover" analysis. A pattern of forces is applied to a structural model including non-linear parcels and the total force is plotted with reference to displacement to depict a capacity wind. This can also be combined with a demand wind (generally in the form of an Acceleration- Displacement Response Spectrum (ADRS)) hence reducing the problem to an SDOF System. Also, this analysis is simpler, gives information on strength, deformation, rigidity and the distribution of demands. Along with advantages it has some limitation like it neglects the variation in loading patterns and also the effect of resonance and advanced modes impact on structures.

5. Non-Linear Dynamic Analysis

This analysis is based on the direct numerical integration of the stir dis-criminational equations by taking into consideration the elasto-plastic distortion of the structure element. Its advantage involves producing results with low query as well as analysis grounded on time domain. Also, this system considers the modification due to resonance, changes in deportations at various situations of structures and increase of motion duration.

In this, the non-linear static analysis that is 'Pushover Analysis' is used.

4.3 PUSHOVER ANALYSIS

4.3.1 Introduction

Pushover analysis is a static procedure that uses a simplified nonlinear technique to estimate seismic structural deformations. Structures re-design themselves during earthquakes. As individual factors of a structure yield or fail, the dynamic forces on the structure are shifted to other factors. A pushover analysis simulates this miracle by applying loads until the weak link in the structure is set up and also revising the model to incorporate the changes in the structure caused by the weak link. A alternate replication indicates how the loads are redistributed. The structure is " pushed " again until the alternate weak link is discovered. This process continues until a yield pattern for the whole structure under seismic lading is linked.

Pushover analysis is generally used to estimate the seismic capacity of being structures and appears in several recent guidelines for build seismic design. It can also be useful for performance- grounded design of new structures that calculate on rigidity or redundancies to repel earthquake forces. This approach was developed to permit analysis of being structures and to study the effectiveness of schemes for strengthening these structures and giving them lesser rigidity. The being structure begins to lose resistance fleetly once its peak resistance is exceeded, and it would probably collapse during a very strong shaking. The strengthened structure exhibits some rigidity that will make collapse much less likely.

Pushover analysis is now also used constantly to estimate the anticipated performance of designs for new structures. However, in pushover analysis, generally an steady side load pattern is employed that the distribution of the inertia forces is assumed to be not changing during earthquake and deformed configuration of the structure under the action of invariant side cargo pattern is likely to be similar to that which is endured in the design earthquake. As response of the structure, thus the capacity wind is largely sensitive to the side cargo distribution selected choice of side load pattern is more critical as compared to the accurate estimation of the target displacement.

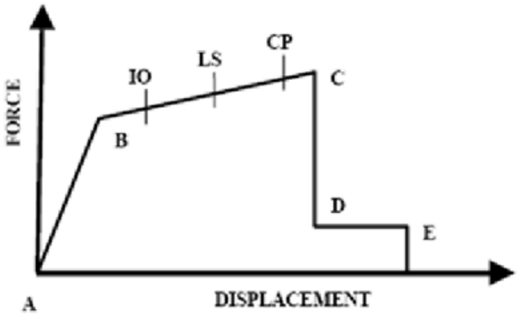

Fig 4.1 Pushover Graph

In order to gain performance points as well as the position of hinges in different stages, we can use the pushover wind. In this wind, the range AB the elastic range, B to IO the range of instant residency, IO to LS the range of life safety and LS to CP the range of collapse prevention. When a hinge touches point C on its force- relegation wind also that depend must start to drop load. The manner in which the load is released from a hinge that has reached point C is that the pushover force or the base shear is reduced till the force in that hinge is steady with the force at point D. As the force is released, all the elements discharge and also relegation is dropped. After the yielded hinge touches the point D force position, the magnitude of pushover force is again amplified and the relegation starts to increase again. If all the hinges are within the given CP limit also the structure is supposed to be safe. Though, the hinge after IO range may also be needed to be retrofitted depending on the significance of the structure.

a) Immediate residency – Achieves elastic behavior by limiting structural damage(e.g., yielding of sword, significant cracking of concrete, and non-structural damage.)

b) Life Safety- Limit damage of structural and non-structural factors to minimize the threat of injury or casualties and to keep essential rotation routes accessible.

c) Collapse Prevention – insure a small threat of partial or complete structure collapse by limiting structural distortions and forces to the onset of strength and stiffness declination.

4.3.2 The Hinges

Hinges are points on a structure where one expects cracking and yielding to do in fairly advanced intensity so that they show high flexural (or shear) displacement, as it approaches its ultimate strength under cyclic loading. These are locations where one expects to see cross diagonal cracks in an factual structure structure after a seismic mayhem, and they're set up to be at the either ends of beams and columns, the 'cross' of the cracks being at a small distance from the joint – that's where one is anticipated to fit the hinges in the beams and columns of the corresponding computer analysis model.

Hinges are of various types – namely, flexural hinges, shear hinges and axial hinges. The first two are inserted into the ends of beams and columns. Since the presence of masonry in fills have significant influence on the seismic behaviour of the structure, modelling them using original diagonal struts is common in PA, unlike in the conventional analysis, where its inclusion is a rarity. The axial hinges are fitted at either ends of the slant struts therefore modelled, to pretend cracking of in fills during analysis.

Principally a hinge represents localised force-displacement relation of a member through its elastic and inelastic phases under seismic loads. For illustration, a flexural hinge represents the moment-gyration relation of a ray of which a typical bone is as

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represented in Fig. 1. AB represents the direct elastic range from unloaded state A to its effective yield B, followed by an inelastic but direct response of reduced (ductile) stiffness from B to C. CD shows a sudden reduction in load resistance, followed by a reduced resistance from D to E, and eventually a total loss of resistance from E to F. Hinges are fitted in the structural members of a framed structure generally. These hinges have non-linear countries defined as 'Immediate residency' (IO), ' Life Safety '(LS) and ' Collapse Prevention '(CP) within its ductile range. This is generally done by dividing B- C into four corridor and denoting IO, LS and CP, which are countries of each individual hinges(in spite of the fact that the structure as a whole too have these countries defined by drift limits). There are different criteria for dividing the member BC. The main result of a pushover analysis, consists of the "capacity wind" representing the displacement of a named control point, generally assumed coincident with the centre of mass of the top bottom of the structure, versus the base shear measure(Cb).

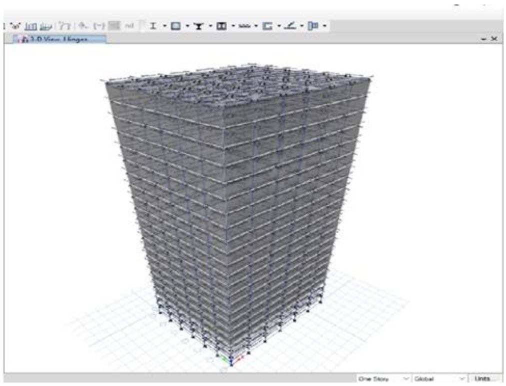

Fig 4.3.6 Assigning of Hinges in the building

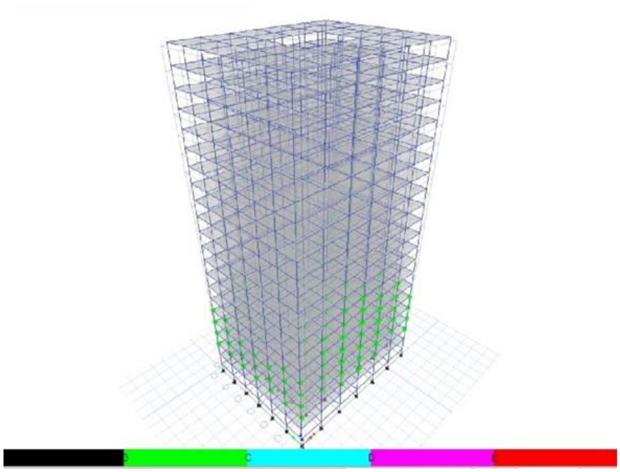

Fig 4.4.1 Hinges in the building

Calculations

1. Calculation of displacement value to measure the percentage differences among the models :

Displacement = H/100 (from IS 1893:2002)

= 69/100 (H = 69m)

Displacement = 0.69 m

Therefore, Displacement = 690 mm

V.RESULTS AND DISCUSSIONS

5.1 Earthquake Analysis Results

Storey Displacement Results

Table 3- Earthquake displacement values (mm)

Storey	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Storey22	432.685	454.572	435.964	487.456	430.158	491.05
Storey21	426.621	448.194	429.25	480.617	423.855	483.479
Storey20	417.985	439.113	420.051	470.879	415.037	473.108
Storey19	406.791	427.346	408.347	458.26	403.71	459.916
Storey18	393.265	413.124	394.356	443.01	390.095	444.146
Storey17	377.65	396.705	378.316	425.403	374.427	426.066
Storey16	360.179	378.338	360.461	405.707	356.938	405.943

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Storey15	341.083	358.263	341.018	384.18	337.853	384.032
Storey14	320.578	336.708	320.204	361.066	317.388	360.577
Storey13	298.866	313.888	298.222	336.595	295.743	335.808
Storey12	276.141	290.004	275.266	310.984	273.111	309.942
Storey11	252.583	265.246	251.517	284.435	249.67	283.182
Storey10	228.359	239.79	227.144	257.137	225.588	255.72
Storey 9	203.623	213.798	202.302	229.265	201.018	227.732
Storey 8	178.518	187.419	177.137	200.978	176.105	199.38
Storey 7	153.174	160.79	151.781	172.423	150.976	170.815
Storey 6	127.709	134.034	126.355	143.731	125.751	142.171
Storey 5	102.227	107.263	100.97	115.023	100.538	113.572
Storey 4	76.835	80.587	75.736	86.417	75.445	85.144
Storey 3	51.693	54.177	50.822	58.095	50.64	57.189
Storey 2	27.32	28.583	26.875	30.645	26.651	30.194
Storey 1	6.449	6.506	6.325	6.971	6.046	6.876
Base	0	0	0	0	0	0

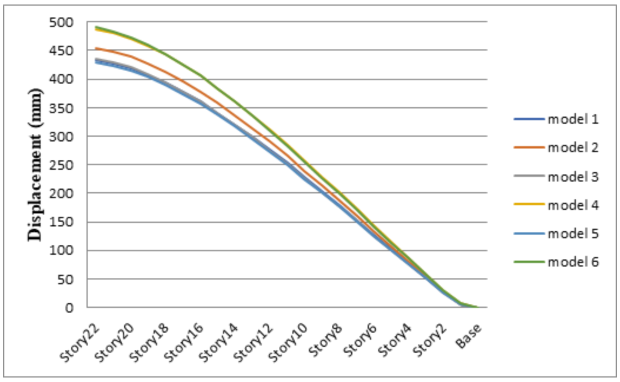

Fig 5.1 Earthquake Analysis Graph

• Among six Models, Model 5 that is with different column- beam size and with centre opening has less displacement value compared with other five models.

5.2 PUSH-OVER ANALYSIS RESULTS

The pushover analysis is carried out for 6 models. The pushover curves for six models in X-direction and Y-direction are shown below. A brief comparison of results are tabulated. Base shear for different models are shown.

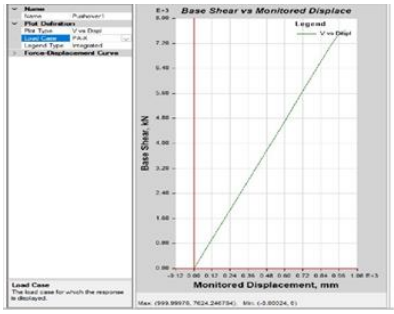

Fig 5.2.1 Model 1- Pushover curve in X-axis

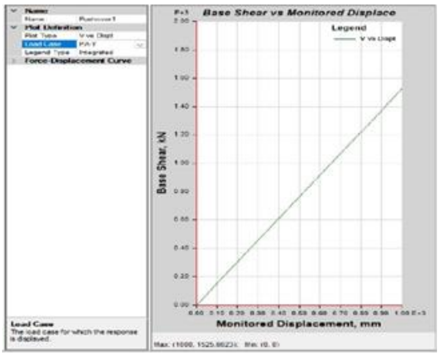

Fig 5.2.2 Model 1- Pushover curve in Y-axis

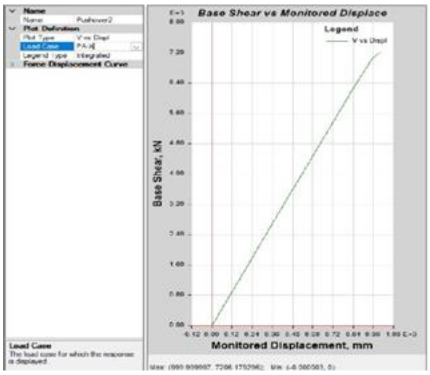

Fig 5.2.3 Model 2- Pushover curve in X-axis

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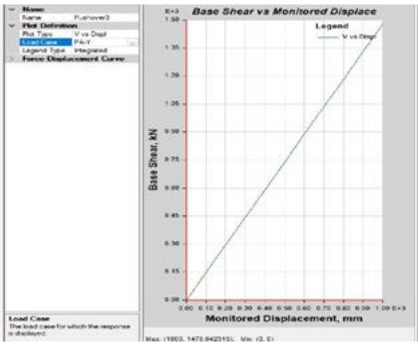

Fig 5.2.4 Model 2- Pushover curve in Y-axis

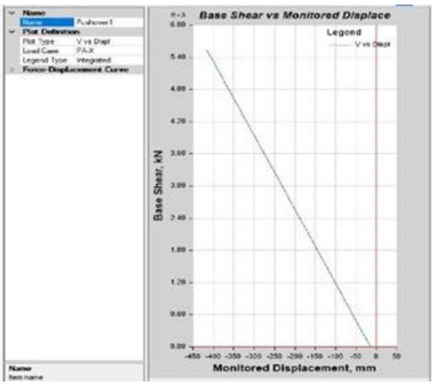

Fig 5.2.5 Model 3 - Pushover curve in X-axis

Models Base Shear Results from ETABS

Table 4- Model Base Shear values

Model	**Base Shear in X –direction (kN)**	**Base Shear in Y –direction (kN)**
1	7624.2468	1525.6623
2	7206.1793	1478.0423
3	5530.0167	6838.6653
4	4811.4234	8434.7358
5	4852.3424	7362.8395
6	4289.7377	6126.8833

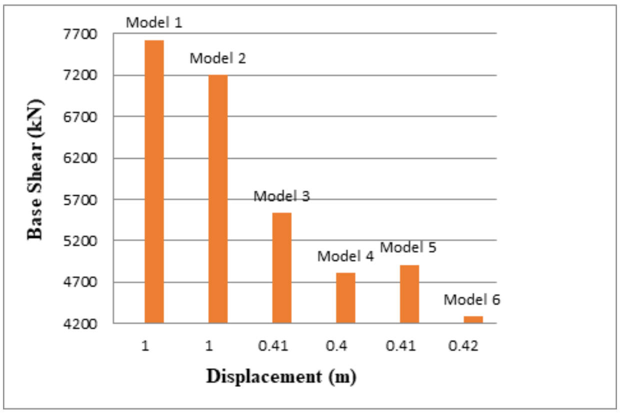

Fig 5.3.3 Push curve in X-direction

VI.CONCLUSION

From the results obtained,

- Among 6 Models, Model 5 has less displacement value compared with other five models.
- For the model 5, the displacement is 62.34 % less compared with models 1,2,3,4,6 .
- For model 6 that is with different column-beam section with side opening has 71.16% more displacement compared with models 1,2,3,4,5.
- For model 1, the base force taken in X-direction is 2.47 % more than other models. Similarly the base force taken in Y-direction is 0.49% more than other models.
- For the model 2, the base force taken in X-direction is 2.34 % more than other models. Similarly the base force taken in Y-direction is 0.48 % more than other models.
- For model 4, the base force taken in X-direction is 1.56 % more than other models. Similarly the base force taken in Y-direction is 2.74% more than other models.
- For model 5, the base force taken in X-

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direction is 1.57 % more than other models. Similarly the base force taken in Y-direction is 2.39% more than other models.

- Among 6 models, model 1,2,3 has the highest base shear value in X-direction i.e of 7624.24 kN.
- For the same column beam section models, the base shear is maximum in X-direction compared with different column beam sections. As the base shear values in 'X' direction are more than in 'Y' direction, building is stronger in 'X' direction.

Hence the beam-columns having same sectional properties are preferable.

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