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BEHAVIOR OF CONNECTIONS AGAINST PROGRESSIVE COLLAPSE OF STEEL STRUCTURES

[1]B. SRAVAN KUMAR,[2]VIKAR MALEEK
[1]M.Tech Student, [2]Assistant Professor
DEPARTMENT OF CIVIL ENGINEERING
PRASAD ENGINEERING COLLEGE, JANGAON, WARANGAL,T.S.

Abstract:

This project deals with the importance of connections to resist progressive collapse. Progressive collapse event can be defined as "The spread of an initial local failure from element to element, eventually resulting in the collapse of the entire structure or a disproportionately large part of it". During sudden column removal, plastic hinges will be formed at the center and at the two ends of the beam. The beam which was resisting loads by flexural action will suddenly change its behavior to tensile catenary action in order to resist the progressive collapse. But the connections are not designed for such axial loads and the structure fails due to failure of the connections. Hence, to resist progressive collapse, it is necessary to design connections for such high moments and axial forces. The findings show how design for seismic resistance and design to resist progressive collapse do not necessarily align and highlight which structural properties are the most important to consider in each frame type, therefore encouraging the use of the proposed redesigning methodology, which is capable of effectively remediating robustness by efficiently addressing localised weaknesses.

I. Introduction:

Progressive collapse occurs, when any one of the major structural load carrying members is removed suddenly from a building due to any unfavorable situation or condition and if the remaining structural elements are not capable of supporting the whole weight of the building. For example,if a column is damaged due to ire, manmade or natural hazards, the whole weight of the building (gravity load) inclusive of imposed loads are displaced to adjacent columns of the structure. If these adjacent columns are also not that much strong and stif to carry the additional loads, they would have also been failed. As a consequence, the vertical load carrying elements may loose their strength and thus the massive collapse of the structure occurs. his failure usually occurs in a domino effect and precedes to a progressive collapse of the structure. he progressive collapse behaviour of steel-frame buildings under ire load has been studied by lot of researchers for the past two decades. the General Services Administration (GSA) guidelines suggested some general expressions and conditions to predict the members which may be prone to the progressive collapse. These guidelines also recommended Demand Capacity Ratio (DCR) values to evaluate the intensity of damage of individual members of the structure due to progressive collapse. he progressive collapse of an existing Hotel located in San Diego, California was examined both experimentally and analytically. he strain occurred due to the removal of the exterior columns from the building was measured experimentally with the help of strain gauges. From the Cardington full-scale ire tests, dissimilarity has been observed between the real behavior under ire and the experimental behavior through standard furnace tests for the structural elements.

Progressive and disproportionate collapse:

Progressive or disproportionate collapse is described as "collapse to an extent disproportionate to the cause" and is usually triggered by unforeseen extreme events Its effects range from human losses and great financial damage to public psychological shock due to the dramatic extent of the catastrophe. Examples of the potential abnormal loads that can trigger progressive collapse include: aircraft impact, design/construction error, fire, gas explosions, accidental overload, hazardous materials, vehicular collision, bomb explosions etc. The robustness of a building is defined by its ability to resist damage disproportionate to the original cause, rather than prevention of total failure, due to fact that the triggering event assumes structural damage has already taken place. The difference between the two terms is subtle: progressive collapse occurs when the cause leads to the collapse of additional structural elements apart from those initially damaged; it is not immediate, like, for example, damage from a huge blast. Another definition of progressive collapse "Progressive collapse is a situation where local failure of a primary structural component leads to the collapse of adjoining members which, in turn, leads to additional collapse. Hence, the total damage is disproportionate to the original cause." Thus, while both terms describe the same thing, it is possible to claim that disproportionate collapse focuses on the damage assessment of the building while progressive collapse focuses more on the structural mechanism involved. Although the issue did not initially receive extensive attention from structural engineers, a number of high profile disasters brought it into consideration. Nevertheless, designing buildings to resist progressive collapse requires a very different approach compared to designing for other loading cases such as earthquake or wind In fact, the complex nature of the phenomenon, which includes gross deformations, large strains, inelastic material behaviour, change of geometry effects, dynamic effects and the varying propagating actions (separation of structural members, impact of failed components etc.) requires not only a comprehensive understanding of the main physical features but also a well-thought analysis methodology for evaluating and comparing the performance of different building designs. Gradually, requirements for avoiding such scenarios have been incorporated in building regulations throughout the world and an effort to put these into practice was carried out by the introduction of provisions in the respective material-specific design codes.

Composite Structures:

At the point when a steel part, similar to an I-area shaft, is joined to a solid segment with the end goal that there is an exchange of powers and minutes between them, for example, an extension or a story piece, at that point a composite part is shaped. In such a composite T-bar, as appeared in Figure similarly high quality of the solid in pressure supplements the high quality of the steel in strain. Here it is essential to take note of that both the materials are utilized to fullest of their capacities and give an effective and practical development which is an additional preferred position.

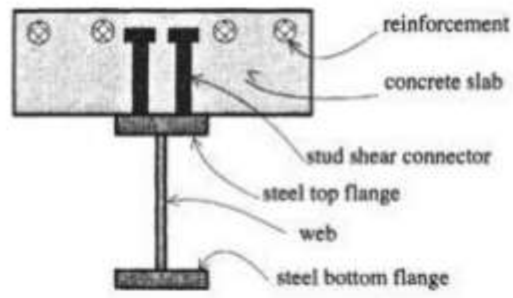

Figure: 1. Composite Steel-Concrete beam

A concrete beam is shaped when a solid piece which is casted in-situ conditions is set over an I-area or steel shaft. Affected by stacking both these components will in general carry on in an autonomous manner and there is a relative slippage between them. In the event that there is a legitimate association to such an extent that there is no relative slip between them, at that point an I-area steel shaft with a solid section will carry on like a solid bar. The figure is appeared in the figure 1.2. In our present examination, the bar is composite of cement and steel and carries on like a solid pillar. Cement is frail in pressure and moderately more grounded in strain though steel is inclined to clasping affected by pressure. Henceforth, them two are given in a composite such they utilize their credits furthering their greatest potential benefit. A composite pillar can likewise be made by making associations between a steel I-area with a precast fortified solid section. Keeping the heap and the range of the pillar consistent, we get an increasingly monetary cross area for the composite shaft than for the non-composite convention bar. Composite shafts have lesser estimations of diversion than the steel bars attributable to its bigger estimation of solidness. In addition, steel pillar segments are likewise utilized in structures inclined to fire as they increment protection from flame and consumption.

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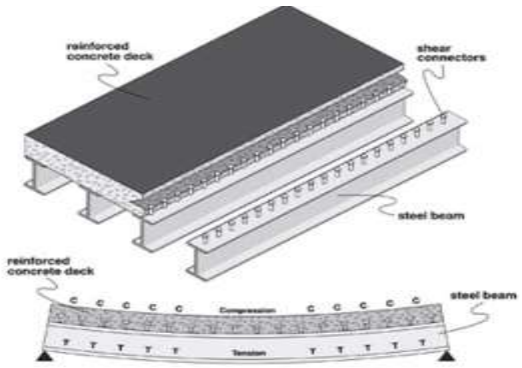

Figure:2. Composite beam

Steel-Concrete Composite Columns:-

A steel-concrete composite segment is a pressure part involving a solid filled rounded segment of hot-moved steel or a solid encased hot-moved steel area. cement filled and cement encased segment areas individually. In a composite segment, both the solid and the steel connect together by rubbing and bond. In this manner, they oppose outer stacking. By and large, in the composite development, the underlying development burdens are beared and upheld by exposed steel sections. Cement is filled on later inside the rounded steel areas or is later casted around the I segment. The mix of both steel and cement is so that both of the materials utilize their characteristics in the best way. Because of the lighter weight and higher quality of steel, littler and lighter establishments can be utilized. The solid which is casted around the steel areas at later stages in development helps in restricting endlessly the sidelong avoidances, influence and kicking of the section. It is extremely advantageous and productive to raise exceptionally tall structures on the off chance that we use steel-solid composite casings alongside composite decks and pillars. The time taken for erection is likewise less because of which rapid development is accomplished along better outcomes.

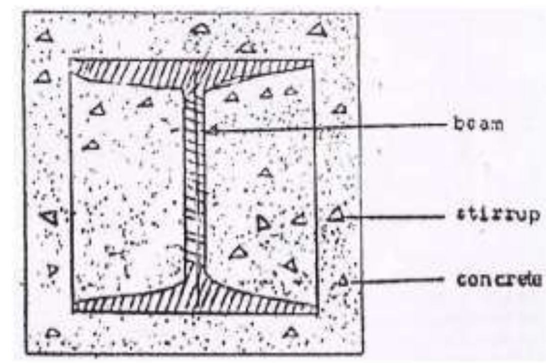

Figure: 3.Concrete encased steel column

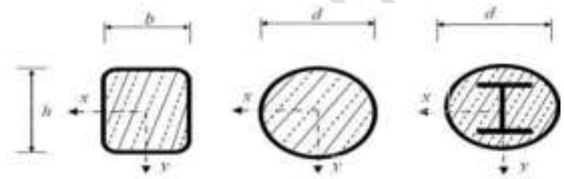

Figure:4. Steel encased concrete column sections

Objectives:

- If design provisions are to advance from tying capacity, more evidence is needed on the contribution of different mechanisms towards the resistance to progressive collapse for composite and bare steel frames.
- Towards that direction, additional case studies will help evaluate the contribution of alternative mechanisms that might also be necessary to take into account. In fact, it appears that there is more than a single solution for improving resistance to progressive collapse, though most are limited by their cost and their compatibility with common construction practices. Thus, it is vital to concentrate on determining the most efficient way to enhance robustness of a building for certain given design configurations.
- Buildings designed against special loading cases have different design configurations and may or may not perform better in the case of a progressive collapse scenario. A very common example is structures with seismic reinforcement and sway frames designed for seismic regions, which form an important

fraction of the world's buildings. However, it is still unclear whether seismic provisions are an effective and efficient way of enhancing resistance against progressive collapse.

II. LITERATURE REVIEW

.G. Bhatia [1] in his paper clarified the Improvement in assembling innovation has furnished machines of higher evaluations with better resistances and controlled conduct .These machines offer ascent to extensively higher unique powers and along these lines higher anxieties and, consequently, request improved execution and wellbeing ruling out disappointments. This paper features requirement for a superior communication between establishment planner and machine maker to guarantee improved machine execution. The paper additionally depicts the structure helps/procedures for establishment plan. Different issues identified with scientific displaying and translations of results are talked about finally. Complexities of structuring vibration separation framework for hard core machines are likewise examined. Impacts of dynamic attributes of establishment components viz., pillars, sections, and platforms and so forth on the reaction of machine, alongside some contextual analyses, are likewise displayed. The paper likewise addresses the impacts of seismic tremors on machines just as on their establishments. Utilization of monetarily accessible limited component bundles, for examination and structure of the establishment, is firmly suggested, yet with alert

M. Mallikarjun, Dr P V Surya Prakash [2] Carried study on examination and plan of a multi-storied private structure of ung-2+G+10 by utilizing most practical section strategy and the dead burden and live burden was connected on the different basic segment like chunks, bars and found that as the investigation is conveyed utilizing most efficient segment technique this was accomplished by decreasing the size of segments at highest floors as burden was more at the base floor. The conserving was finished by methods for section direction in longer range in longer heading as it will decrease the measure of bowing and the region of steel was additionally diminished

III. METHODOLOGY

The prominent role of connections in defining the behaviour and controlling the performance of a frame is widely acknowledged. Developing accurate models is a continuously challenging task because of the need to allow for complex loading conditions and component interaction. However, incorporating connection design in modern building codes requires a consistent, quantitative and widely accepted method, able to take into account the contribution of each individual component and its influence on overall connection behaviour. It represents a major technical improvement because it is practical to apply and can facilitate the calculation of the internal distribution of forces, realistic moment-rotation response, rotational capacity based on component deformation and global connection properties under varying loading conditions. In the extreme event of progressive or disproportionate collapse, local damage is not arrested locally but propagates to the rest of the building. Its main features are gross deformations, dynamic effects and inelastic material behaviour. As mentioned in the previous chapter, the ICL Method proposes a multi-level structural idealisation, which allows for the response at higher levels to be deduced from the responses at lower levels. As ultimate capacity and ductility depend strongly on connection strength, stiffness and rotational capacity, connection modelling is considered a priority. This is a necessary prerequisite for conducting rapid parametric studies that will allow the relative merits of alternative connection designs to be compared. For a welded moment resisting beam to column connection in a frame subject to column removal, substantial axial forces will develop as the system passes through the compressive membrane, tensile and, eventually, catenary stage; existing models do not cover this loading regime Unless extended to incorporate the connection bending moment – axial load interaction, analytical models are unfit for progressive collapse analysis.

Geometry of the model:

A beam column joint that was considered for experimental tests is shown in figure. The load was applied on the extreme end of the beam. The specimen consisted of a steel beam and a steel column connected

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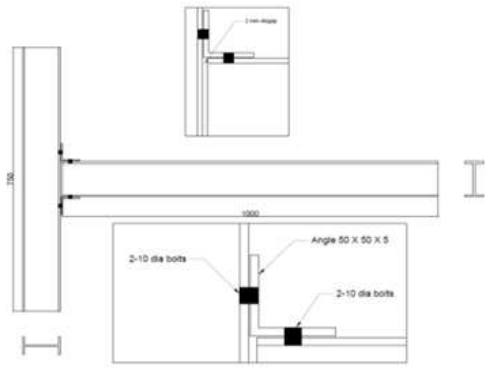
with each other using two angles of size 50 x 50 x 5. This model was prepared to validate FEM model in ANSYS. The steel beam and column both are made up of ISMB 100.



Geometry of the model

Discretization of the model

The mesh is chosen in such a way that, accurate results would be available in a reasonable analysis time. As shown in Figure, finer mesh has been used in areas of high stresses i.e. at the contact zones of the joint.

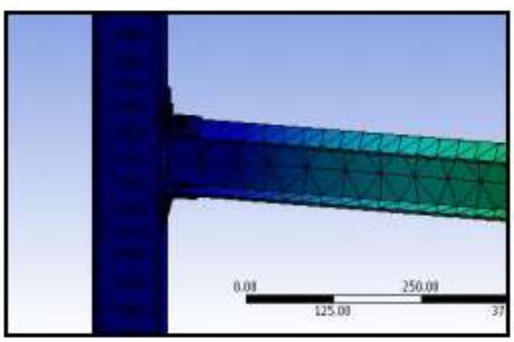


Figure:5. Discretization of the model

In order to achieve simplicity, the bolts are not modeled with a hexagonal head but are assumed to have a circular head and the nut is bonded with the bolt in such a way that the nut is assumed to have a permanent connection with the bolt. Slipping of the nut from the bolt is also not considered. All the contact surfaces in the connection were assumed to be frictional with a frictional co-efficient of 0.15. The tangential contact between the bolt hole and bolt shank was considered frictionless.

Figure:6.A vertical load was applied at the end of the beam

Behaviour in progressive collapse:

Research on the behaviour of moment resisting frames has mainly focused on modelling entire or parts of a structure in order to identify the possible alternative load paths and observe the general behaviour. Although moment resisting connections have been extensively studied in earthquake loading, behaviour under the loading and deformation conditions of progressive collapse has only relatively recently been examined more closely. The study also warned that moment connections prequalified for rotational capacity due to bending alone might not perform equally under combined bending moment and axial loading. Failure for the WUF-B connection was brittle and it was observed at the compressive beam flange; after that, the flexural demand in the connection interface had to be resisted by the beam's bolted web, which in turn quickly deteriorated. The side plate connection was able to maintain stability under much higher loading and failure in the system was observed in the beam instead of the connection. Results identified deep rolled wide-flange steel sections as a cost-effective solution for enhancing progressive collapse resistance because of their ductility.

STRUCTURAL STEEL:

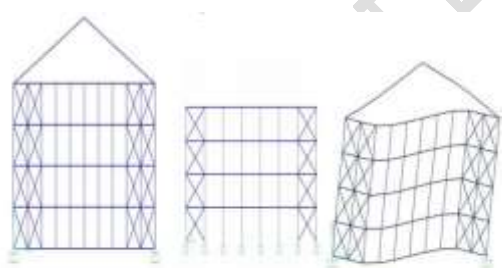
- High number of design options
- Skeletal framework often complex
- Loads carried by beams
- Structure is covered by cladding

- Large use of glass, polycarbonate and plastic
- Large shopping centres, sports centres and multi-storey offices.

Seismic dampers:

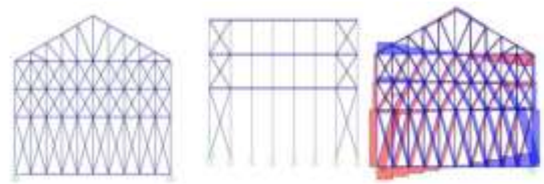
Another methodology for controlling seismic harm in structures and improving their seismic presentation is by introducing seismic dampers instead of auxiliary components, for example, slanting props. These dampers demonstration like the pressure driven safeguards in vehicles a great part of the unexpected bastards are invested in the water powered liquids and just little is transmitted above to the body of the vehicle. At the point when seismic vitality is transmitted through them, dampers retain some portion of it, and hence moist the movement of the structure. Dampers were utilized to secure tall structures against wind impacts. Be that as it may, it was just that they were utilized to secure structures against seismic tremor impacts. Regularly utilized sorts of seismic dampers incorporate thick dampers (vitality is consumed by silicone-based liquid going between cylinder chamber course of action), erosion dampers (vitality is consumed by surfaces with grating between them scouring against one another), and yielding.

Un braced steel structure (Gable portal frame):-



In above fig showing the gable portal frame or unbraced steel structure in XZ plane similarly in fig shown YZ plane and fig showing the deformed shape of Ist mode configuration. During such deformation mode the time history analysis is getting t=0.834

Howe type of roof truss with different bracing configuration:-



In above diagrams fig showing the Howe type of roof truss with CDB in XZ plane similarly fig showing Howe truss with CDB in YZ plane and fig exhibit axial force diagram in Howe type of roof truss.

IV. **RESULTS**

This part will give you a concise review of structural steel. Basic steel is utilized as the system for some, steel structures, for example, modern and business structures, propelled base structures, and extensions. A wide range of pieces go into manufacturing and raising the system for a steel structure, and as a Seabee Steelworker, you should have an exhaustive information of the different basic individuals. We will examine the most widely recognized names of the steel individuals just as how to affix and tie down the individuals to one another and to the solid establishment they are based upon. We will likewise talk about where and how in the structure the steel individuals are utilized. Before any basic steel is manufactured or raised, a strategy and grouping of occasions, or erection, should be set up. The plans, successions, and required materials are foreordained by the building area and drawn up as a lot of plans. This part portrays the nuts and bolts of auxiliary steel: the wording, utilization of the individuals, techniques for association, and essential arrangement of occasions during erection.

Industrial building is the structure and development of structures serving industry. Such structures rose I n significance with the mechanical unrest, and were a portion of the spearheading structures of current engineering. Paper secured two kinds of modern structure, for example, ordinary and pre-designed structure. Pre Engineered Building (PEB) idea is another origination of single story mechanical structure development. This system is adaptable not just because of its quality pre-structuring and

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construction, yet in addition because of its light weight and practical development.

A modern structure is any structure that is utilized to store crude materials, house an assembling procedure, or store the outfitted merchandise from an assembling procedure. Modern structures can go from the least difficult stockroom type structure to very advanced structures incorporated with an assembling framework. These structures are low ascent steel structures portrayed by low stature, absence of inside floor, dividers, and allotments. The material framework for such a structure is a bracket with rooftop covering. Plan of fundamental components of the structure (Roof deck, Purlins, Girders, Columns and Girts) isn't troublesome, yet joining them into practical and savvy framework is a perplexing undertaking. In Industrial structure structures, the dividers can be framed of steel sections with cladding which might be of profiled or plain sheets, GI sheets, precast cement, or brick work. The divider must be enough solid to oppose the parallel power because of wind or tremor The below figure represents the isometric line diagram of the hanger The support hanger provided are hinged

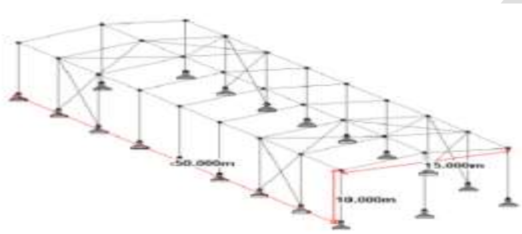

Figure:7. Isometric line diagram of hanger

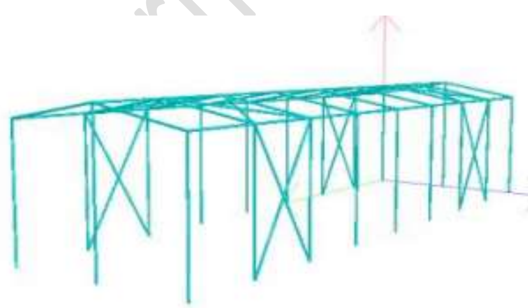

Figure: 8. 3D View of the hanger with material

The above figure represents the isometric view of the hanger with the application of the material. The material applied is steel and it follows the Indian code of practice.

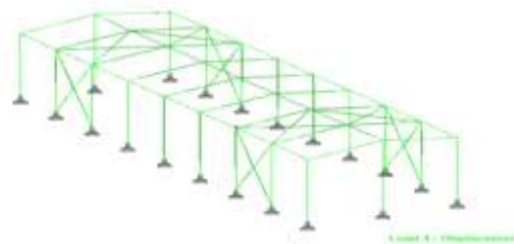

Figure:9. Displacement for Dead Load

The above figure represents the displacement diagram for the dead load and the imposed load into the structure. The displacement produced due to this load combination is very little.

Figure:10.Bending moment towards Z direction due to minimum Load

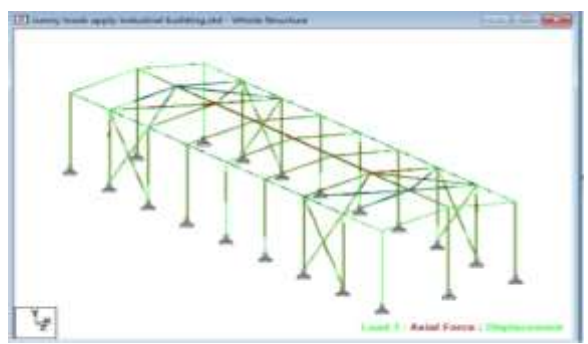

Figure:11.Axial force due to D.L and L.L combination

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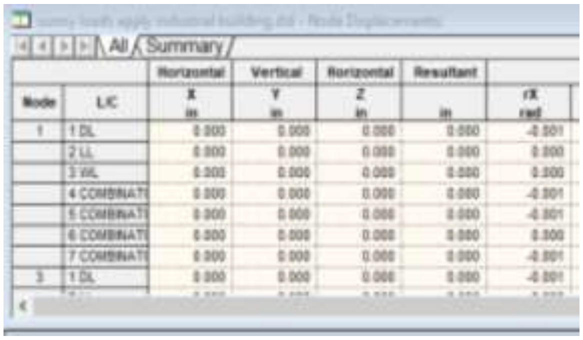


		Horizontal	Vertical	Horizontal	Resultant	
Node	L/C	X in	Y in	Z in	in	rX rad
1	1 DL	0.000	0.000	0.000	0.000	-0.001
	2 LL	0.000	0.000	0.000	0.000	0.000
	3 WL	0.000	0.000	0.000	0.000	0.000
	4 COMBINATI	0.000	0.000	0.000	0.000	-0.001
	5 COMBINATI	0.000	0.000	0.000	0.000	-0.001
	6 COMBINATI	0.000	0.000	0.000	0.000	0.000
	7 COMBINATI	0.000	0.000	0.000	0.000	-0.001
3	1 DL	0.000	0.000	0.000	0.000	-0.001

Figure: 12.Industrial building Load displacement

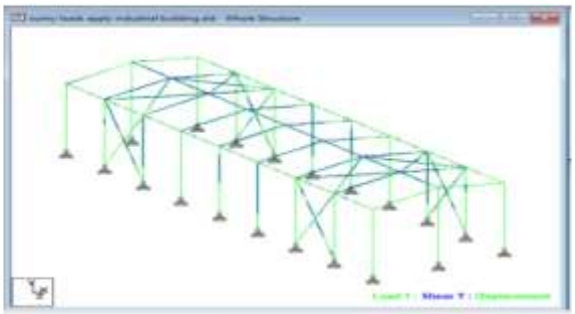
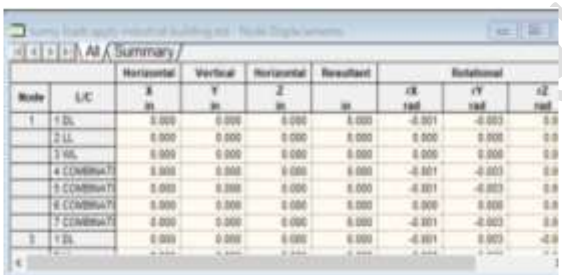


Figure:13. Shear force at Y direction due to D.L and L.L combination



		Horizontal	Vertical	Horizontal	Resultant	Rotational		
Node	L/C	X in	Y in	Z in	in	rX rad	rY rad	rZ rad
1	1 DL	0.000	0.000	0.000	0.000	-0.001	-0.003	0.0
	2 LL	0.000	0.000	0.000	0.000	0.000	0.000	0.0
	3 WL	0.000	0.000	0.000	0.000	0.000	0.000	0.0
	4 COMBINATI	0.000	0.000	0.000	0.000	-0.001	-0.003	0.0
	5 COMBINATI	0.000	0.000	0.000	0.000	-0.001	-0.003	0.0
	6 COMBINATI	0.000	0.000	0.000	0.000	0.000	0.000	0.0
	7 COMBINATI	0.000	0.000	0.000	0.000	-0.001	-0.003	0.0
3	1 DL	0.000	0.000	0.000	0.000	-0.001	0.003	-0.0

Figure:14. Industrial building Load displacement

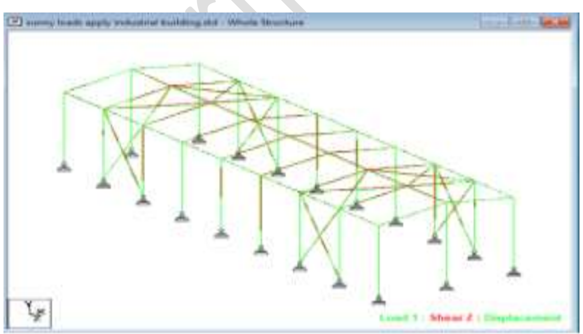


Figure:15. Shear force at Z direction due to D.L and L.L combinations

Seismic Coefficients:

Coefficients	VALUES
Response reduction factor R	5
Importance factor I	1
Zone factor Z	0.36
Time period T	0.568

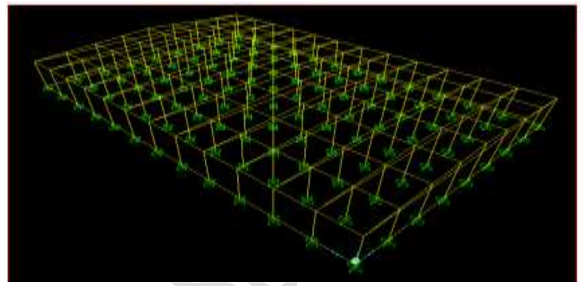


Figure:16. bay fixed modal

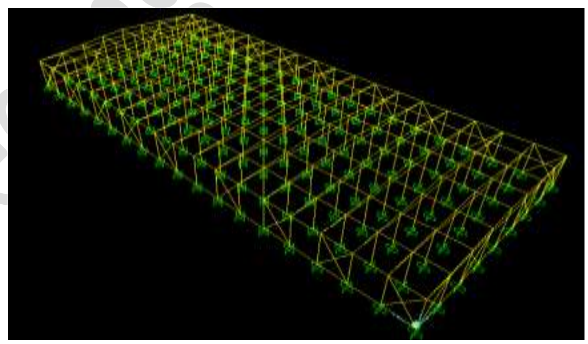


Figure: 17.bay x bracing modal

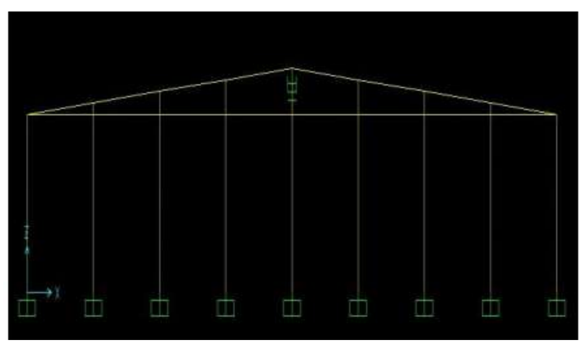


Figure:18. model with damper

The forces and displacements created in every one of the individual from a structure are acquired from the examination. These outcomes got from the investigation have been examined in detail in this part. Further these outcomes have been utilized for the comprehension of conduct of the structure between the steel structure with supporting and dampers under the impacts of horizontal burdens.

Variation of natural time period:

The variation of natural time period is studied for model with and without bracing , and with and without dampers. The values of natural time period (mode 1, mode 2 and mode 3

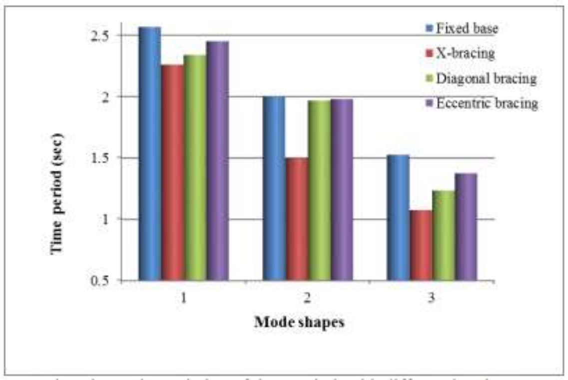


Fig :19. shows the variation of time period with different bracings.

From the above figure it can be seen that there is decrease in time period with the implementation of bracings and x bracing is found out to be more effective in reducing time period than other bracings.

Variation of base shear:

The variation of base shear is studied for model with and without bracing, with and without dampers The values of base shear of the member

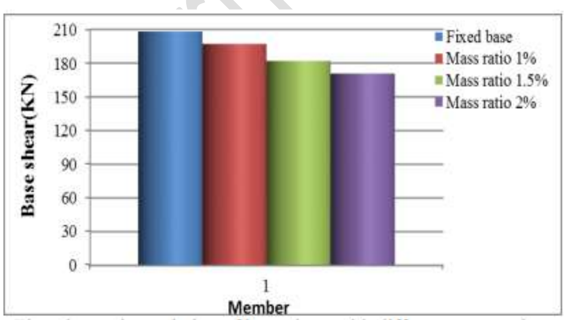


Fig:20. shows the variation of base shear with different mass ratio.

From the above figure it can be seen that there is decrease in base shear with the implementation of dampers and damper with mass ratio 2% is found out to be more effective in reducing base shear than other dampers with mass ratio (1%,1.5%).

COMPARISION OF LATERAL DISPLACEMENT:

The variation of lateral displacement is studied for a steel structure with different number of bays(12,14,18,24) implemented with different bracings and dampers is compared with fixed base modal. the values of lateral displacement of a (12,14,18,24) bay modal with and without bracings and dampers.

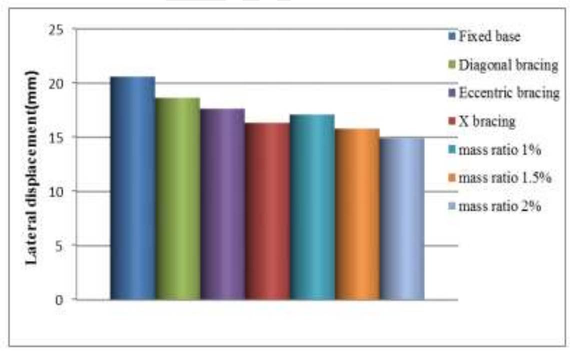


Figure:21. shows the variation of lateral displacement with different mass ratio and bracings.

From the above figure it can be seen that there is decrease in lateral displacement with the implementation of dampers and bracings.

Time history analysis:

Analysis of structure, applying information over augmentation time venture as capacity of quickening, power, minute or removal Quake ground speeding up records in particular NW bhuj segments of bhuj seismic tremor records have been chosen the records are characterized for the quickening focuses. as for a period interim of 0.05secs,time history examination has been completed for the modals with fixed base and various bracings and damper with various mass proportion (1%,1.5%,2%).

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The variety of base shear is contemplated for a steel structure with various number of bayous (12,14,18,24) actualized with various bracings is contrasted and fixed base modular and it is exposed to bhuj quake information. The estimations of base shear of a (12,14,18,24) sound modular with and without bracings are appeared in beneath charts

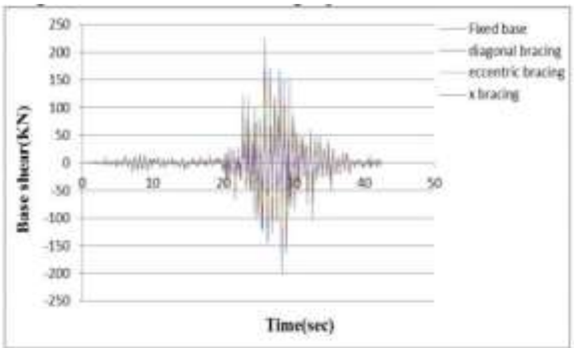

Figure:22. shows the variation of base shear with different bracings.

From the above figure it can be seen that there is decrease in base shear with the implementation of bracings and x bracing is found out to be more effective in reducing base shear than other bracings.

V. CONCLUSION:

In order to improve the progressive collapse resistance of structures in buildings and reduce the DCR values there are two possible options. One option is t The moment curvature curve shows that web cleat connection behaves in a ductile manner during progressive collapse. Stiffeners can be provided at the column connection junction where there are high deformations. Web cleat connections can resist very high axial loads and hence can easily initiate catenary action which will resist progressive collapse o use larger steel cross sections and the other option is to use more bracing. These two suggestions may lead to higher steel weight and may also cause more deformation after the columns affected by ire load.

an the calculated allowable deflection. Thus, the structure is safe against deflection.

- Working stress method is simple to use but does not give consistent values of a factor of safety. That is the reason Limit states methods were developed.
- The limit states provide a checklist of the basic structural requirements for which design calculations may be required. Limit states design, by providing consistent safety and serviceability, ensures an economical use of materials and a wide range of applications.

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