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International Journal for Modern Trends in Science and Technology, 7(04): 47-54, 2021

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0704008
Available online at: http://www.ijmtst.com/vol7issue04.html

Earthquake Analysis of Multistoried Residential Building – A Case Study using ETABS

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To Cite this Article
Dandu Sivaramaraju and Dr. Dumpa Venkateswarlu, "Earthquake Analysis of Multistoried Residential Building – A Case Study using ETABS", *International Journal for Modern Trends in Science and Technology*, Vol. 07, Issue 04, April 2021, pp.:47-54.

Article Info
Received on 25-February-2021, Revised on 24-March-2021, Accepted on 29-March-2021, Published on 03-April-2021.

ABSTRACT

The country's development is made in determined by means of the infrastructural development of the country, which includes the construction of the roads, multi storied structures, industries etc.,. Also, the construction of the multi storied buildings have been started in the early 1990's of the decade considering the seismic loads as per the then code provisions. But with the upgradation of the seismic codes in the present day practice, there were some important consideration to be taken for all the structures that are going to be constructed.

In the present study, an attempt has been made by taking a buildings with shear wall is a typical feature in the modern multi-storey construction in urban India. Such features are highly undesirable in building built in seismically active areas. This study highlights the importance of explicitly recognizing the presence of the shear wall in the analysis of building. Design of RCC elements will also be perform as per IS- 456 : 2000 for the building with shear wall . A numerical study will perform using ETABS Software will be used for 3D multi storey frames with and without shear wall to study the responses of the structure under different earthquake zones. Shear force, Bending moment,Axial force, inter storey drift, base shear, storey shear,storey moment will be computed for both the buildings with and without shear wall and comparing the results. It was identified that, with the increasing zone number, the resultant shear forces, base shear, and the moments of the structures are increasing and they can be countered by means of shear wall construction at appropriate locations.

KEYWORDS: *Shear wall, earth quake, base shear, ETABS, buildings.*

I. INTRODUCTION

From a long time it has been the constant effort of structural engineers to improve their concepts of analysis and design so that an economical structure is obtained consistent with safety and serviceability. The introduction of various grades of steels helped in achieving considerable economy in the use of scarce minerals and in reducing the cost of construction.

A complete knowledge of the behavior of structures is essential for design and such knowledge as mainly obtained though organized research in laboratories. Ultimately such knowledge finds acceptance in the "codes of practice" in various countries. These research and development programs are very costly to be afforded by any one country. These research developments have become truly international and this is particularly true in the field of "Limit state design of R.C.C.Structures". The theory of elasticity itself is accurate and scientific the loads acting on a structure and the limiting stress of materials used in that structures cannot be accurately predicted. By specifying low values for working stress engineers thought they could ensure safety of structure.The working stress has failed to meet the challenges of constructing the voiding economically and at the same time ensuring safety and serviceability in a rational manner.After many researches the load carrying capacities of various structural members such as columns, beams etc. have been found in bending, shear, etc., individually and in various combinations. This lead to the assessment of ultimate loads the structures can carry bat failure. Now the assessment of load carrying capacities of various structures can be carried out with a mathematical precision that is slowly tending to match the capabilities of elastic structural analysis. At this stage, we can dispense with elastic analysis and working stress, Design on the basis of direct estimation of various types of structures. The chance over form the concept of stresses to concept of "strength of structure" is after a prolonged effort.

The limit state design adopts characteristic values for strength of steel and concrete. The term characteristic strength means "values of the strength of material below which not more than 5% of the test results are expected to fall". Further in structural design account taken out on the dead, live and wind load, creep, temperature etc. wherever possible. The term characteristic load means "values of which has a 95% probability of not being exceeded during the life time of the structure". In this method we aim at semi-probabilistic design concepts. Where by we acknowledge that in the real world nothing is deterministic.

The characteristic values allow for inherent variations on the loads and material strength. There are additional factors such as overloads, under strength of materials, unknowns in analysis and design and loss of life due to failure of a structural element, which are to be considered in ensuring adequate safety factor by reducing state method, design these various factors have been separated and designed as partial safety of structures. These were originally dumped into a single safety factors by reducing state method design these various factors have been separated and assigned as partial safety factors. The recommended values of partial safety factors for concrete are 1.5 and for steel is 1.15.

Methods of design

Structures and structural elements may be designed by any of the following

- Working Stress Method
- Ultimate load method
- Limit State Method.

The limit state method of design is used in the design of various components of the structure.

Need of study

Reinforced concrete framed sections is the best type of construction systems to resist both the lateral and the gravity loads anticipating on the structures. But with the increased height and stories of the structure, the structural elements like beams and column sections will be increased as a result of which there will be lot of congestion at the intersections of the beam column joints. Because of which the concrete is not able to take the vibrations caused by the earthquake shaking of the seismic activity and the joints will be subjected to distress. So in order to counter this problem, the concept of shear walls has been developed and they cater problem very effectively by a uniformly distributed sections in the shear wall. Besides many structural advances, the adoption of shear walls will require a lot of economy. So the construction of shear wall is recommended depending upon the severity of the seismic activities or the wind loads and the importance of the buildings.

II. METHOD OF ANALYSIS

Equivalent Static Analysis:

It is one of the method for calculating the seismic loads. The high rise structures are not considered for the design simple static method. In practical as it does not take into account all the factors that are the importance of the foundation condition. The equivalent static analysis is used to design only for the small structures. In this method only one mode is considered for each direction. The earthquake resistant designing for the low rise structures the equivalent static method is enough. Tall structures are needed more than two modes and mass weight of each story to design earthquake resistant loads. This is not suitable to design those structures and dynamic analysis method to be used for high rise structures.

Response Spectrum Analysis:

The seismic forces strikes the foundation of a structure will move with the ground motion. It shows that structure movement is generally more than the ground motion. The movement of the structure as compared to the ground is refused as the dynamic amplification. It depends on the natural frequency of vibration, damping, type of foundation, method of detailing of the structure.

The response "design acceleration spectrum" which refers to the max acceleration called spectral acceleration coefficient Sa/g, as a function of the structure for a specified damping ratio for earthquake excitation at the base for a single degree freedom system.

The revised IS 1893-2002 uses the dynamic analysis by response spectrum. In this method takes into account all the five important engineering properties of the structures.

i.The fundamental natural period of vibration of the building (T in seconds)
ii. The damping properties of the structure
iii. Type of foundation provided for the building
iv. Imp0ortance factor of the building
v. The ductility of the structure represented by response reduction factor.

III. NUMERICAL STUDIES

Basic Dimensions:

Length - 41.52m.
Breadth - 23.78m. Height – 25m.
No of stories: G+7.
Storey height: Base floor ht- 4m
Remaining floor ht- 3.5m

2D Plan:

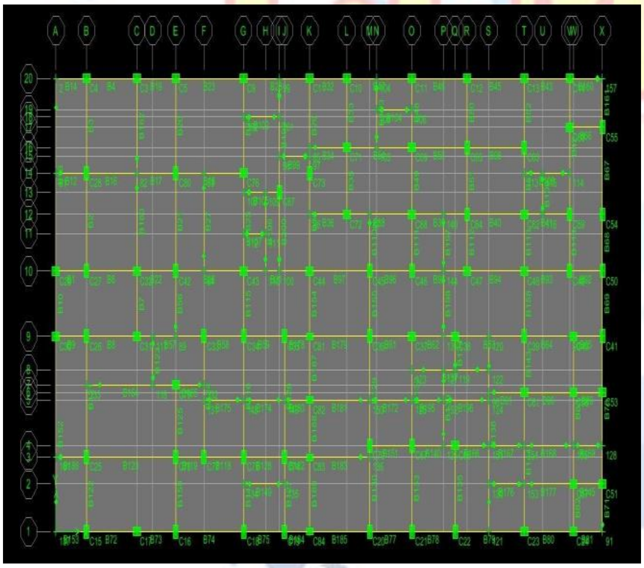


Figure 2D plan

3DView:

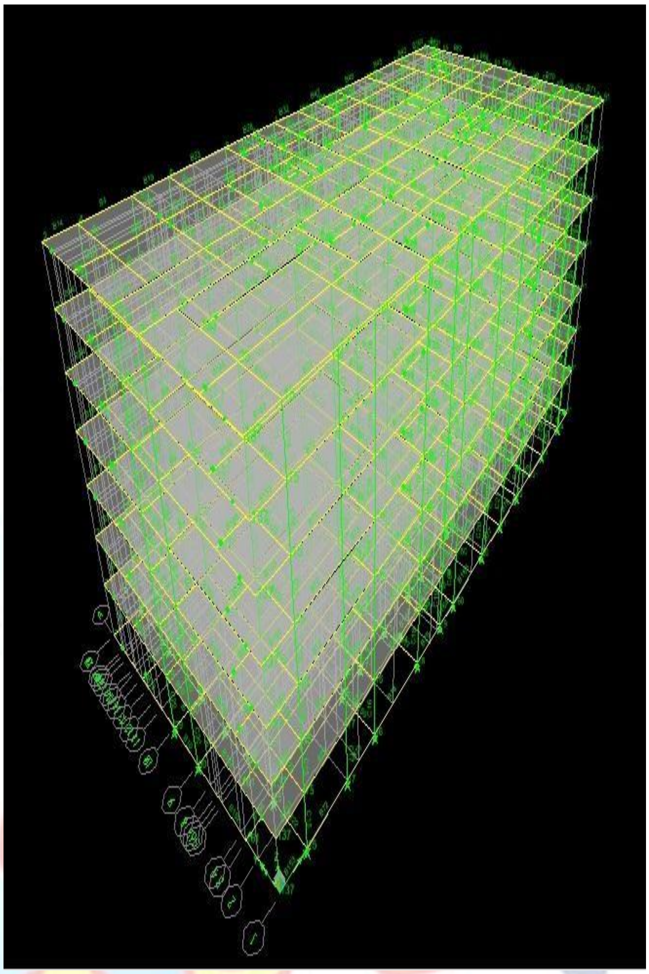


Figure 3D Plan

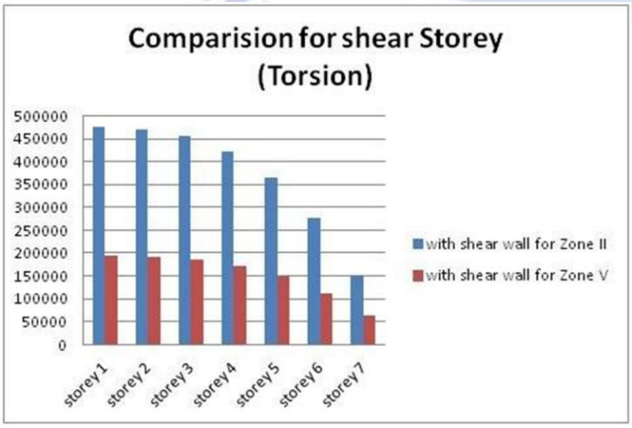
S.no	Loads	Calculations	References
	Dead Load		
	a)Slab	0.15x25=3.75KN/m²	IS875(part-1)-1987
	b)Floor finishing	1 KN/ m²	IS875(part-1)-1987
	c)OuterWall	0.23x19x3.5=15.3KN/ m²	IS875(part-1)-1987
	d)InnerWall	0.115x19x3.5=7.64KN / m²	IS875(part-1)-1987
2.	**Liveloads**		
	a)Corridor	4KN/ m²	IS1893(part-1) - 2002
	b)Deeds& Indexing	2.5KN/ m²	IS1893(part-1) - 2002
	c)Administration Office	3.5KN/ m²	IS1893(part-1) - 2002
	d)Washroom & toilets	2KN/m²	IS1893(part-1) - 2002
	e)ElectricalRoom	3.5KN/ m²	3(part-1)-2002

	f)WaitingRoom	3KN/ m²	IS1893(part-1) - 2002
	g)MailRoom	5KN/ m²	IS1893(part-1) - 2002
	h)Employees Office	3KN/ m²	IS1893(part-1) - 2002
	I)CourtManager	3KN/ m²	IS1893(part-1) - 2002
	J)IT&Telecom	3.5KN/ m²	IS1893(part-1) - 2002
	K)Archive	2.5KN/ m²	IS1893(part-1) - 2002
	L)Monitoring& Control Room	3.5KN/ m²	IS1893(part-1) - 2002
	M) PrayHall	5KN/ m²	IS1893(part-1) - 2002
	N)Transferable Department	5KN/ m²	IS1893(part-1) - 2002

Tables'1-12 shows difference between Torsion, ShearinX-Direction and Shear inY-Direction of Shear Stories for different Zones.

Torsion		
	WithShearWallforZoneII	**With ShearWallforZoneV**
Storey1	474672	193071
Storey2	470289	191288
Storey3	455084	185103
Storey4	422372	171798
Storey5	365530	148678
Storey6	277936	113049
Storey7	152965	62218

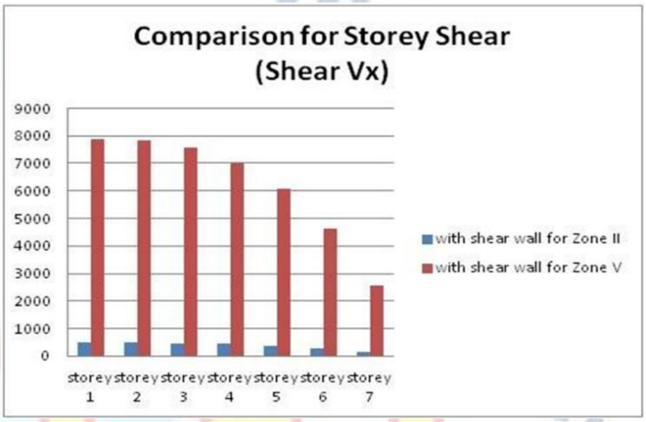
Table1



Fromtheabovefigureitshowsthatstoreyshearfortorsi onismoreforzoneIIascomparedto zoneV

Table2

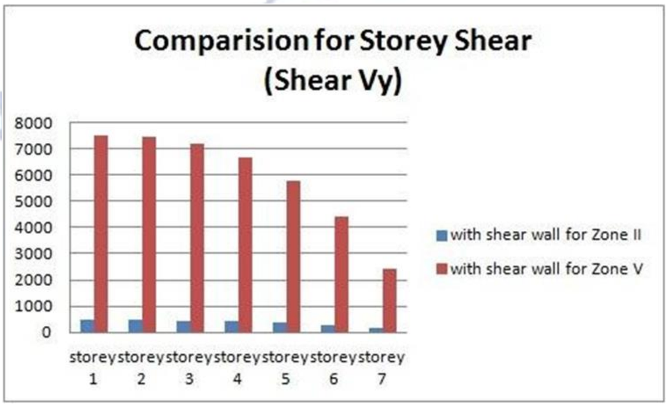
ShearVx		
	WithShearWallforZoneII	**WithShearWallforZoneV**
Storey1	492	7885
Storey2	488	7813
Storey3	472	7561
Storey4	438	7019
Storey5	380	6076
Storey6	289	4624
Storey7	160	2552



FromtheabovefigureitshowsthatstoreyshearV$_x$ismoreforzoneVascomparedtozoneII

Table3

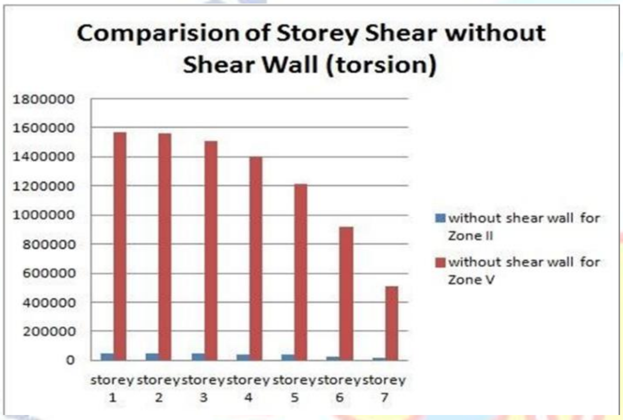
ShearVy		
	WithShearWallforZoneII	**WithShearWallforZoneV**
Storey1	469	7503
Storey2	464	7434
Storey3	449	7194
Storey4	417	6678
Storey5	361	5781
Storey6	275	4399
Storey7	152	2428



FromtheabovefigureitshowsthatstoreyshearVyismo reforZoneVascomparetoZoneII

Table4

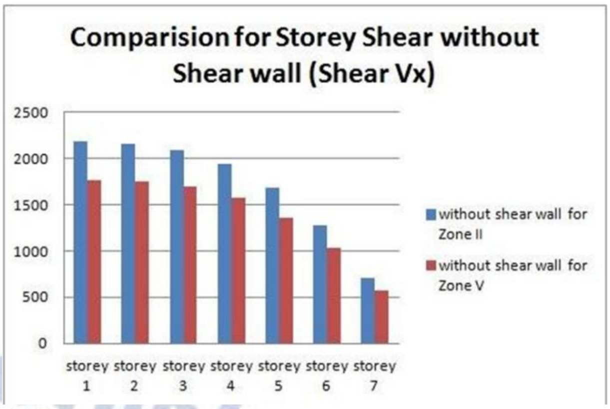
Torsion		
	WithoutShearWallforZoneII	**WithoutShearWallforZoneV**
Storey1	49343	1572211
Storey2	48888	1557709
Storey3	47309	1507390
Storey4	43911	1399128
Storey5	38007	1211012
Storey6	28909	921120
Storey7	15929	507531



FromtheabovefigureitshowsthatstoreyshearfortorsionismoreforzoneVascomparedto zoneII

Table 5:

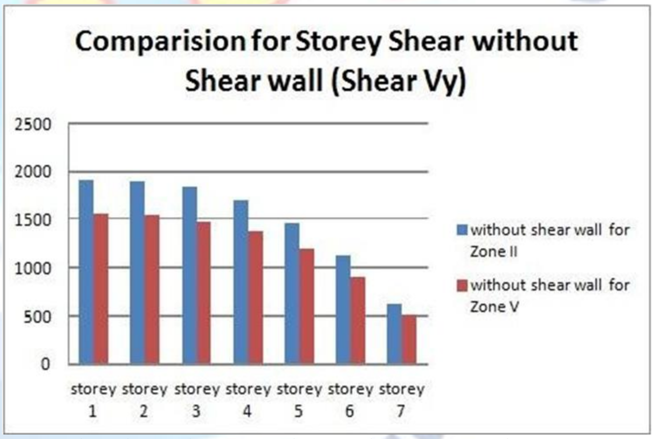
Shear Vx		
	WithoutShearWallforZoneII	**WithoutShearWallforZoneV**
Storey1	2175	1760
Storey2	2155	1744
Storey3	2085	1688
Storey4	1936	1567
Storey5	1676	1356
Storey6	1276	1033
Storey7	705	571



Fromtheabovefigureitshowsthatstoreyshear$V_x$ismo reforzoneIIascomparedto zoneV

Table6

ShearVy		
	WithoutShearWallforZoneII	**WithoutShear WallforZoneV**
Storey1	1916	1551
Storey2	1899	1537
Storey3	1838	1487
Storey4	1706	1381
Storey5	1477	1195
Storey6	1125	910
Storey7	621	503



FromtheabovefigureitshowsthatstoreyshearV$_y$ismo reforzoneIIascomparedto zoneV

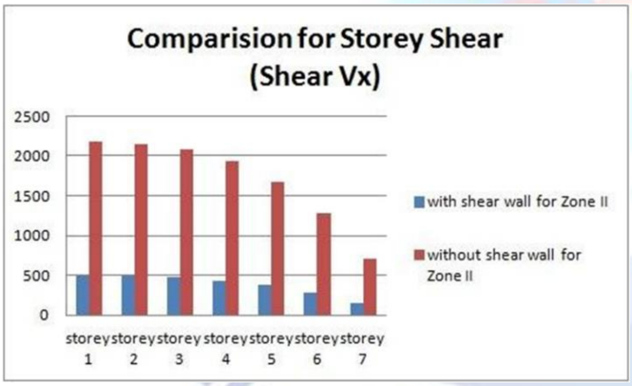
Table7

Torsion		
	WithShearWallforZoneII	**WithoutShearWallforZoneII**
Storey1	474672	49343
Storey2	470289	48888
Storey3	455084	47309
Storey4	422372	43911
Storey5	365530	38007
Storey6	277936	28909
Storey7	152965	15929

Fromtheabovefigureitshowsthatstoreyshearfortorsionismoreforzonellwithshearwall as compared to zonellwithout shear wall

Table8

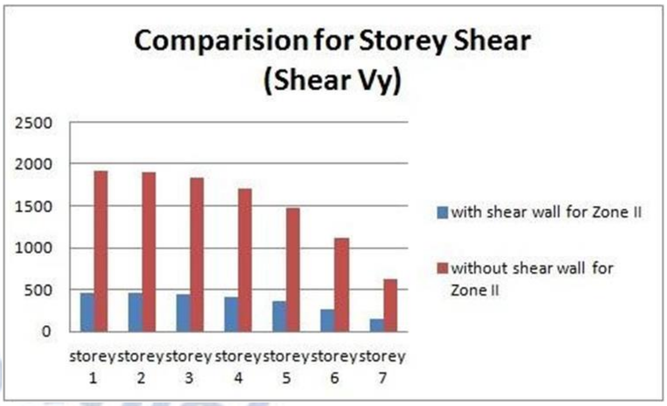
ShearVx		
	WithShearWallforZoneII	WithoutShearWallforZoneII
Storey1	492	2175
Storey2	488	2155
Storey3	472	2085
Storey4	438	1936
Storey5	380	1676
Storey6	289	1276
Storey7	160	705



Fromtheabovefigureitshowsthatstoreyshear$V_x$islessforzoneII withshearwallascompared to zoneIIwithout shear wall.

Table9

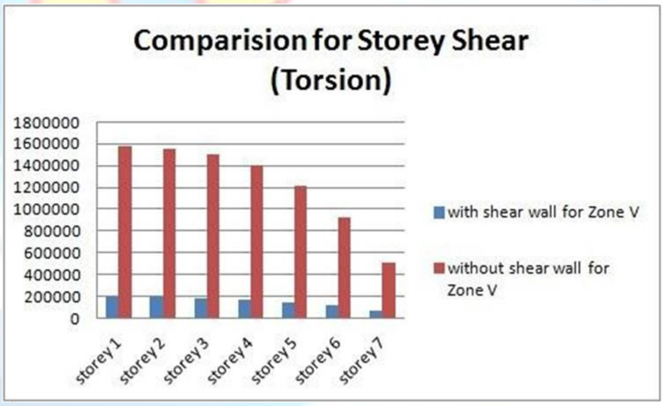
ShearVy		
	WithShearWallforZoneII	WithoutShearWallforZoneII
Storey1	469	1916
Storey2	464	1899
Storey3	449	1838
Storey4	417	1706
Storey5	361	1477
Storey6	275	1125
Storey7	152	621



Fromtheabovefigureitshowsthatstoreyshear$V_y$ismoreforzoneIIwithshearwallas compared to zoneIIwithout shear wall.

Table10

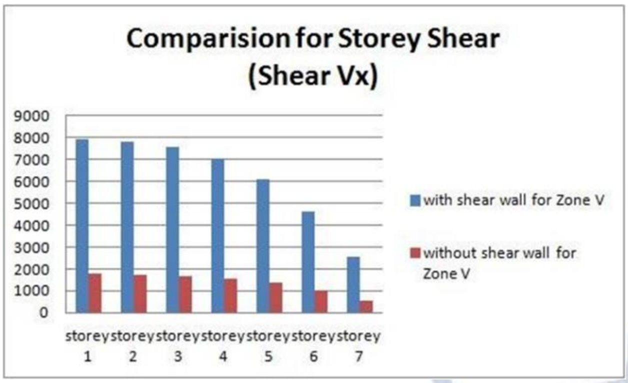
Torsion		
	WithShearWallforZoneV	WithoutShear WallforZoneV
Storey1	193071	1572211
Storey2	191288	1557709
Storey3	185103	1507390
Storey4	171798	1399128
Storey5	148678	1211012
Storey6	113049	921120
Storey7	62218	507531



Fromtheabovefigureitshowsthatstoreyshearfortorsionismoreforzone Vwithshearwall as compared to zoneV withoutshearwall.

Table11

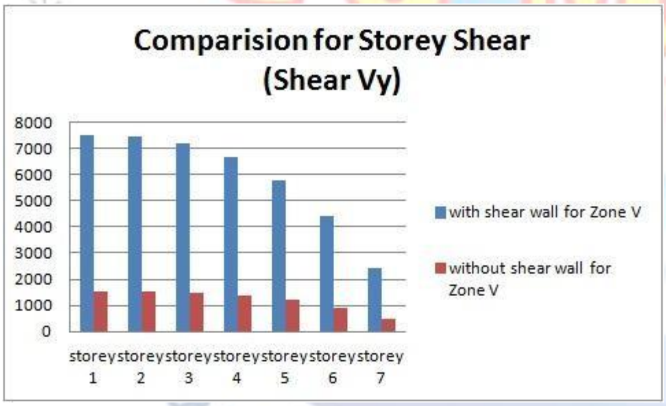
ShearVx		
	WithShearWallfor ZoneV	WithoutShearWallfor ZoneV
Storey1	7885	1760
Storey2	7813	1744
Storey3	7561	1688
Storey4	7019	1567
Storey5	6076	1356
Storey6	4624	1033
Storey7	2552	571



FromtheabovefigureitshowsthatstoreyshearV$_x$ismo reforzoneVwithshearwallas compared to zoneV withoutshear wall.

Table12

ShearVy		
	WithShearWallfor ZoneV	WithoutShearWallforZoneV
Storey1	7503	1551
Storey2	7434	1537
Storey3	7194	1487
Storey4	6678	1381
Storey5	5781	1195
Storey6	4399	910
Storey7	2428	503



FromtheabovefigureitshowsthatstoreyshearV$_y$ismo reforzoneVwithshearwallas compared to zoneV withoutshear wall.

V. CONCLUSION

The behaviour of multi-storey building with and without shear wall is studiedunder different earthquake excitation. The Seismic coefficient method has been used. The structural model has been developed to study the behaviour of multi-story frameusing ETABS software. Design of RCC Elements as per IS 456 Detailing of Structural elements as per SP-34 is adopted throughout the study. The results obtained are presented in the form of tables andgraphs. The analysis of frame is studied by varying the Zone factor.

- The inclusion of shear wall in the structure is very much beneficial to the structure in order to increase the lateral stiffness of the structure.
- The location, shape, symmetry of the shear wall will also determine the resistance of the structure against the earthquake excitation.
- It is concluded thatwith increase in Zone factors ,the storey shear , Columns forces without shear wallareincreasesas comparedto thebuildingColumns with shear wall.

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