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Analysis of Different Parameter of Wall Belt Support in Multistorey Building With Higher Importance Factor

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ABSTRACT

Rapid growth of infrastructure to accommodate modern civilization is demanding tall structures in cities. As the buildings are becoming taller the problem of their lateral stability and sway has to be tackled by engineering judgment. Structural system development has evolved continuously to overcome the problems related to lateral stability and sway, one such structural system is outrigger and belt truss structural system.The outrigger and belt truss structural system has proved to be most promising structural system in resisting problem related to lateral stability and sway. The present study is conducted for 10 storied high rise building with Importance factor. High rise building with floor plan in addition with core shear wall of is considered. Seismic analysis is carried out to study parameter's maximum storey displacement, inter storey drift and base shear to compare building with application of concrete and steel outrigger at various positions varying with the importance factor and the software used for this analysis is staad Pro.

Keywords— Importance Factor, Outrigger, Perception review, Seismic analysis, Wall belt supported system.

Introduction

Outriggers are rigid horizontal structure i.e. truss or beam which connect core wall and outer column of building to improve building strength and overturning stiffness. Outriggers have been used in tall building for nearly half century, but innovative design principle has been improving its efficiency. Mankind is always fascinated for Tall building. In Early era the symbol of economic power and leadership is the skyscraper. There has been a demonstrated competitiveness that exists in present mankind to proclaim to have the tallest building in the world. The design of tall and slender structures is controlled by three governing factors, strength (material capacity), stiffness (drift) and serviceability (motion perception and accelerations), produced by the action of lateral loading, such as wind. Outrigger system is one type of structural system which is formed from a cantilever shaped horizontal member connected to structures inner core and outer columns. Through the connection, the moment arm of the core will be increased which lead to higher lateral stiffness of the system. Central core in a building act as cantilever, outriggers are provided to reduce overturning moment in core and to transfer moment from core to outer column by connecting the core and column. The outrigger systems can be produced in any combination of steel, concrete and composite construction. Outrigger may be extended to both side of central core or core may be located at one side of building with outrigger extending to other side column. Belt wall connects outer perimeter column of a building and offer a wider perimeter to resist lateral deflection of building. Behaviour of outrigger with belt wall proven to be more effective when compare to the outrigger without belt wall. The exterior columns and belt wall system resist the rotation of central shear core and decrease the lateral deformation as well as bending moment at base of the structure. The belt truss tied the peripheral column of building while the outriggers engage them with main or central shear wall. Therefore; exterior columns restrained the core wall from free rotation through outrigger arms. Outrigger structural system encompass of a central core wall either shear wall or braced frames with outrigger truss connecting between core and the peripheral columns. These are the horizontal members designed to control overturning moment and stiffens the building by fastening the core to the exterior column through stiff horizontal members referred as a outrigger member, where as core acts a single-redundant cantilever beam for lateral forces and hence battle the rotation at the top by

stretching and shortening action results in tensile and compressive action consequentially restoring couple by combating twisting of core thus cap truss be positioned as a restraining spring at the apex which considerable reduces the lateral deflection and base moments. Effectiveness of outrigger and belt wall can be affected by the various factors like position of outrigger and belt wall, number of outrigger, geometry of building, types of core i.e. concrete or steel and floor to floor height.[5][9]

Importance Factor (I)

It is a factor used to obtain the design seismic force depending on the functional use of the structure, characterized by hazardous consequences of its failure, its post-earthquake functional need, historic value, or economic importance.

When a change of occupancy results in a structure being re-classified to a higher importance factor, the structure shall conform to the seismic requirements for a new structure with the higher importance factor.

Table 1: List of buildings framed with assigned abbreviation

S. No.	Buildings framed for analysis	Abbreviation
1	Wall Belt Not Provided with G+10 Configuration	WB1
2	Wall Belt Provided at foundation with G+10 Configuration	WB2
3	Wall Belt Provided at 1st floor with G+10 Configuration	WB3
4	Wall Belt Provided at 3rd floor with G+10 Configuration	WB4
5	Wall Belt Provided at 5th floor with G+10 Configuration	WB5
6	Wall Belt Provided at 7th floor with G+10 Configuration	WB6
7	Wall Belt Provided at 9th floor with G+10 Configuration	WB7

Table 2: Input details for Multistory Building for all cases

Building configuration	G+10
Height of building	47.92m
Concrete and Steel Grade	M 30 & FE 550

Literature Review:

Minu Mathew and Manjusha Mathew (2017),

Concluded in their paper that he reviewed approach for the design and development of tall building using outrigger and belt wall is useful to provide a potential solution. Recently, outrigger and belt wall system is widely used to reduce lateral drift. [1]

Prajyot A. Kakde, Ravindra Desai (2017),

Concluded in their paper that he outrigger and belt truss structural system has proved to be most promising structural system in resisting problem related to lateral stability and sway. The present study is conducted for 70 storied high rise building with core shear wall. [2]

LekshmiSoman, SreedeviLekshmi(2017),

Concluded in their paper that Outrigger braced structures is an efficient structural form in which the central core is connected to the outer columns. [3]

Roslida Abd. Samat et al. (2018),

Concluded in their paper that along-wind responses are determined by employing the procedures from the ASCE 7-16 while the across-wind responses of the buildings are calculated based on the procedures and wind tunnel data available in a database of aerodynamic load. [4]

Neeraj Patel , Sagar Jamle(2019),

Concluded in their paper that his study outrigger system is take en for analysis due the fact that is found the most optimal system for high rise buildings and skyscrapers.[5]

C. Bhargav Krishna and V. Rangarao (2019),

Concluded in their paper that Tall building development has been rapidly increasing worldwide introducing new challenges that need to be met through engineering judgment.[6]

ArchitDangi and Sagar Jamle (2019),

Concluded in their paper that he, shear core outrigger and belt supported system is used on G+10 multistory residential building located at seismic zone IV. General structure compared with both wall belt and truss belt supported system using optimum location suggested by Taranath method. [7]

Jateen M. Kachchhi, Snehal V. Mevada and Vishal B. Patel (2019),

Concluded in their paper that he study mainly focuses on determining the most effective and economical system which can resist lateral load such as wind load and seismic load. [8]

Mohammad Bilal Rasheed and Sagar Jamle (2020),

Concluded in their paper that he study can also be useful for low as well as high seismic prone areas as well. The software analysis also been referred for the analysis in the research field.[9]

Donny Morris (2020),

Concluded in their paper that this research use 4 models building (A-BC-D) with 62 floors of tower and 6 floors of podium, has dual system portal combination with particular concrete shear-wall and located in the City of Jakarta which soft soil categorize. [10]

Durgesh Kumar Upadhyay and Sagar Jamle (2020),

Concluded in their paper that he introduction of wall belt supported system makes an additional effort to make the structures stiffer than before. The lateral displacement again a major parameter, obtained as less as compared without usage of the same The tall structures are preferred due to less consumption of the land area for living purpose.[11]

Chirag Singh and Mayur Singi(2020),

Concluded in their paper that hehave used the outrigger system and erected as discussed in graphical representations in discussion part. In conclusion, parametric result comparison noted down. Overall it is observed that the Case TLA is very efficient among all the cases. Also, we have enhanced the property of worst case TLC which is found by our result and discussion by implementing the outrigger system. [12]

Tae‑Sung Eom, HiubaltMurmu and Weijian Yi (2019),

Concluded in their paper that he the force transfer mechanism and performance of the distributed belt walls, acting as virtual outriggers under lateral load, are investigated. For the reinforcement of the belt walls subjected to high shear demand, a reinforcing method using high-strength prestressing strands (i.e. PSC belt wall) is suggested, and the shear strength of the PSC belt walls is estimated based on the compression field theory.[13]

Pankaj Patel and Prof. Rahul Sharma (2021),

Concluded in their paper that In this project a G+10 Storey structure has analyzed using seven different cases named as RA1 to RA7-OTB. 1 to 7 indicates single outrigger system, shear core outrigger system truss belt support system with optimized trusses, at various locations under seismic zone III. The built up area used for various case as 315 sq. m. [14]

Objectives

To find the most efficient for use of wall system in multistoried building with highest importance factor Multistory Building: -

1) Nodal displacement
2) Story drift
3) Base shear
4) Axial force

RESULTS AND DISCUSSION

As per the objectives, the Response Spectrum Analysis has performed on different building models consist of building having G+10 storied structures with usage of wall belt RCC elements. The analysis results obtained using Staad pro software is shown in tabular form along with various graphs with various parameters as follows

Table 3: Maximum Displacement in X direction for all wall belt cases

Case	**Maximum Displacement (mm)**
	For X Direction
WB1	**147.657**
WB2	**139.437**
WB3	**125.261**
WB4	**125.900**
WB5	**122.446**
WB6	**119.763**
WB7	**125.915**

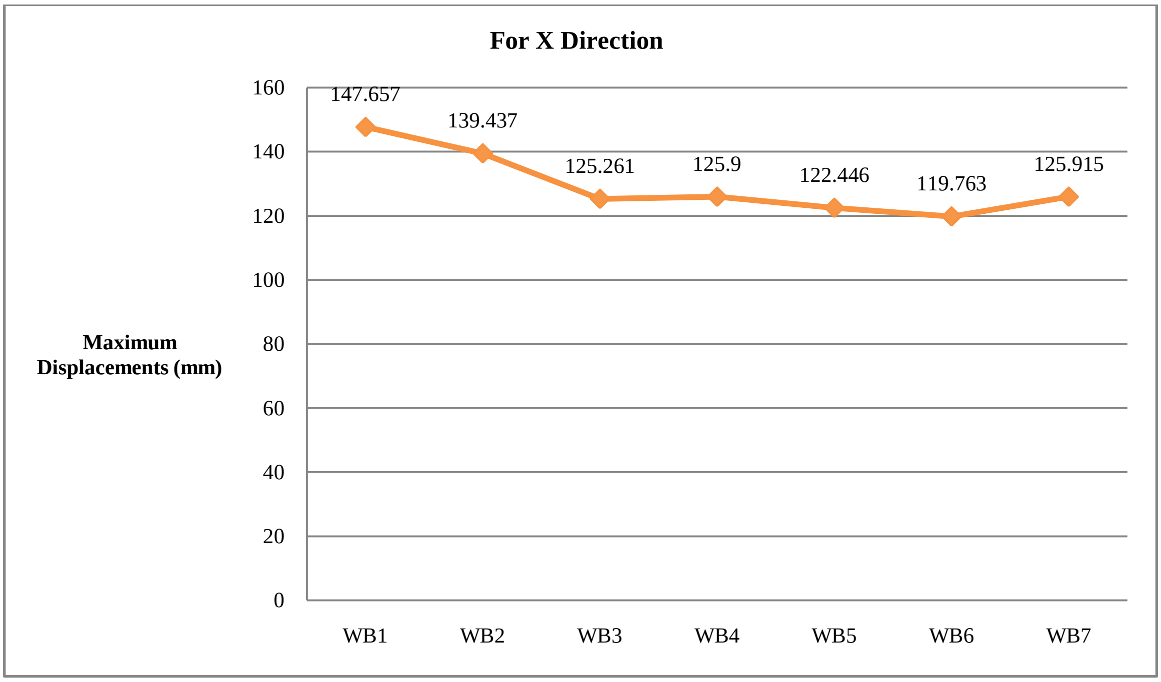

Fig. 5.1: Maximum Displacement in X direction for all wall belt cases

Table 4: Maximum Displacement in Z direction for all wall belt cases

Case	Maximum Displacement (mm) For Z Direction
WB1	**186.232**
WB2	**172.667**
WB3	**161.750**
WB4	**158.252**
WB5	**153.362**
WB6	**154.414**
WB7	**164.847**

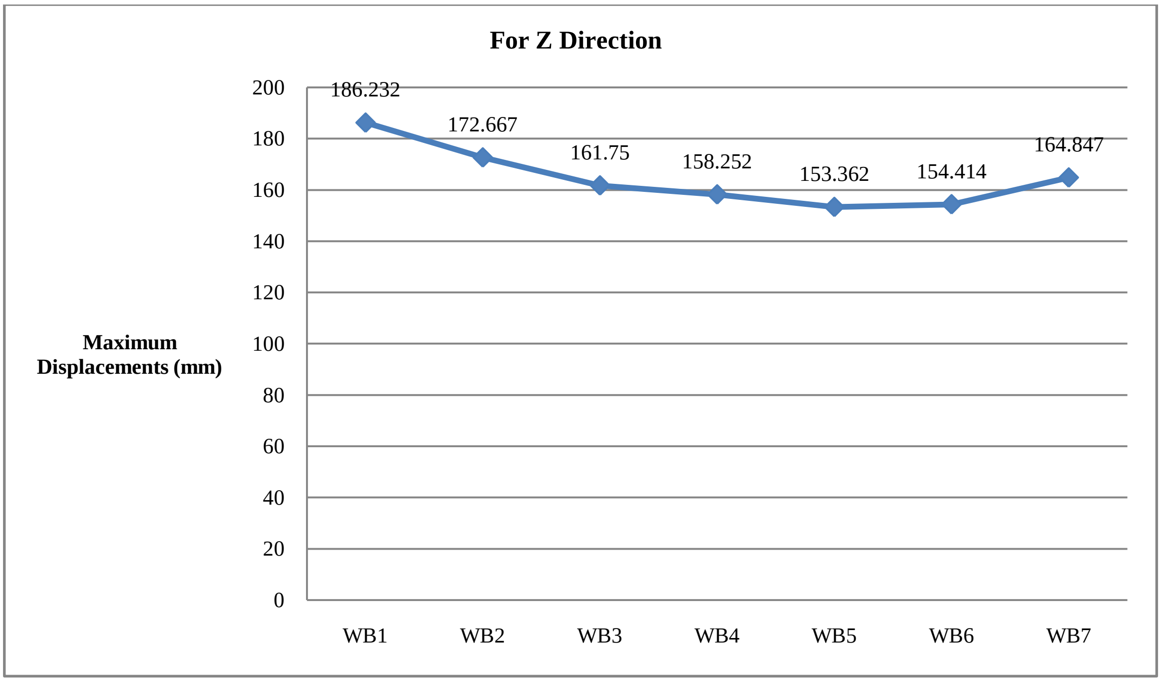

Fig. 5.2: Maximum Displacement in Z direction for all wall belt cases

Table 5: Storey Drift in X direction for all wall belt cases

S. No.	Height (m)	Storey Drift (cm) For X Direction						
		WB1	**WB2**	**WB3**	**WB4**	**WB5**	**WB6**	**WB7**
1	0	0	0	0	0	0	0	0
2	4	0.3633	0.0928	0.3386	0.3309	0.3408	0.3488	0.3547
3	7.66	0.6154	0.5435	0.4752	0.5343	0.5551	0.5755	0.5906
4	11.32	0.7828	0.7710	0.2264	0.6618	0.6789	0.7133	0.7388
5	14.98	0.9132	0.8640	0.7240	0.6684	0.7619	0.8089	0.8466
6	18.64	1.0105	0.9948	0.9068	0.3015	0.8201	0.8646	0.9169
7	22.3	1.0640	1.0521	0.9660	0.7871	0.7732	0.853	0.9415
8	25.96	1.2388	1.2299	1.1463	1.0398	0.3407	0.9828	1.0550
9	29.62	1.3243	1.3178	1.2433	1.1277	0.9387	0.9176	1.0718
10	33.28	1.3168	1.3116	1.2464	1.1412	1.0234	0.3534	1.0111
11	36.94	1.2592	1.2326	1.1964	1.1030	0.9717	0.8070	0.8694
12	40.60	1.3202	1.2929	1.2474	1.1535	1.0195	0.8876	0.3212
13	44.26	1.2257	1.1636	1.1081	1.0235	0.9040	0.7594	0.7090
14	47.92	1.3168	1.2169	1.1499	1.0437	0.8969	0.7419	0.6497

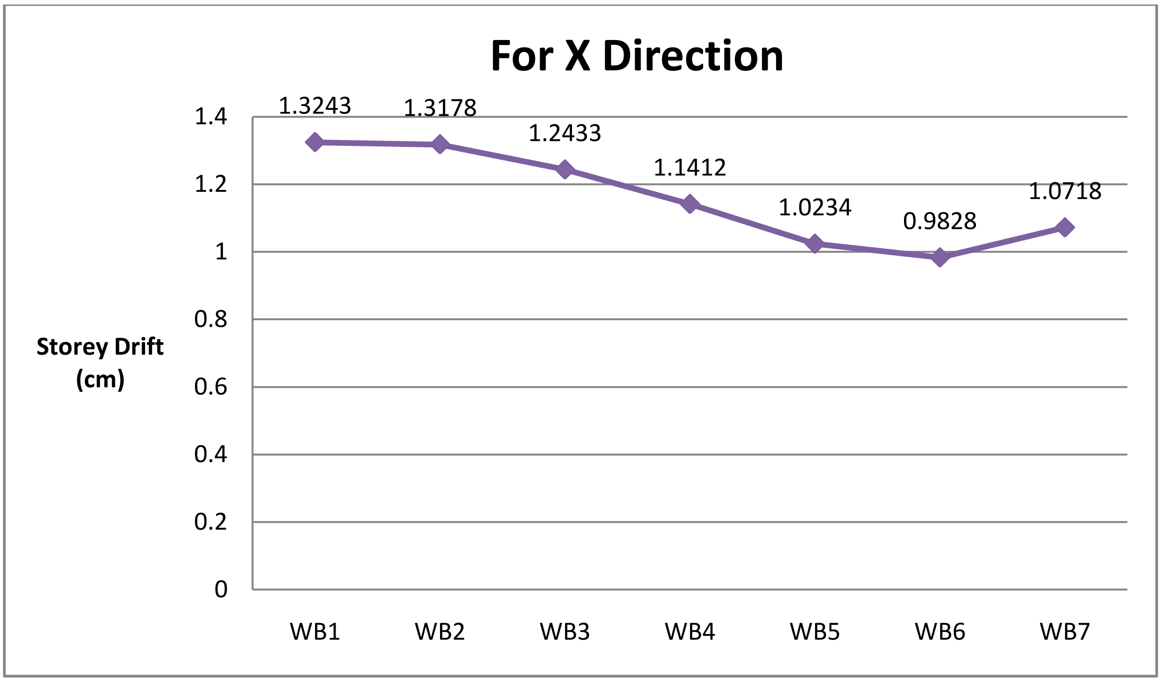

Fig. 5.3: Storey Drift in X direction for all wall belt cases

Table 6: Storey Drift in Z direction for all wall belt cases

S. No.	**Height (m)**	**Storey Drift (cm)**						
		For Z Direction						
		WB1	**WB2**	**WB3**	**WB4**	**WB5**	**WB6**	**WB7**
1	0	0	0	0	0	0	0	0
2	4	0.5209	0.0586	0.4772	0.5021	0.5121	0.5169	0.5198
3	7.66	0.7860	0.5968	0.5514	0.7353	0.7590	0.7712	0.7784
4	11.32	0.9012	0.8542	0.1271	0.8018	0.8494	0.8718	0.8848
5	14.98	0.9708	0.9456	0.6978	0.6787	0.8862	0.9231	0.9440
6	18.64	1. 106	0.9950	0.9107	0.1587	0.8792	0.9393	0.9714
7	22.3	1.0232	1.0135	0.9575	0.7090	0.7280	0.9231	0.9705
8	25.96	1.2815	1.2760	1.2268	1.1250	0.1665	1.0999	1.1955
9	29.62	1.3820	1.3793	1.3379	1.2588	0.9202	0.9364	1.2531
10	33.28	1.3012	1.2993	1.2650	1.2026	1.0758	0.1668	1.1206
11	36.94	1.1537	1.1515	1.1220	1.0714	0.9786	0.7007	0.8349
12	40.60	1.2352	1.2332	1.2025	1.1520	1.0651	0.9334	0.1353
13	44.26	1.2186	0.9131	0.8860	0.8428	0.7761	0.6794	0.5597
14	47.92	1.3012	1.0418	0.9816	1.1356	1.1176	1.2013	1.5060

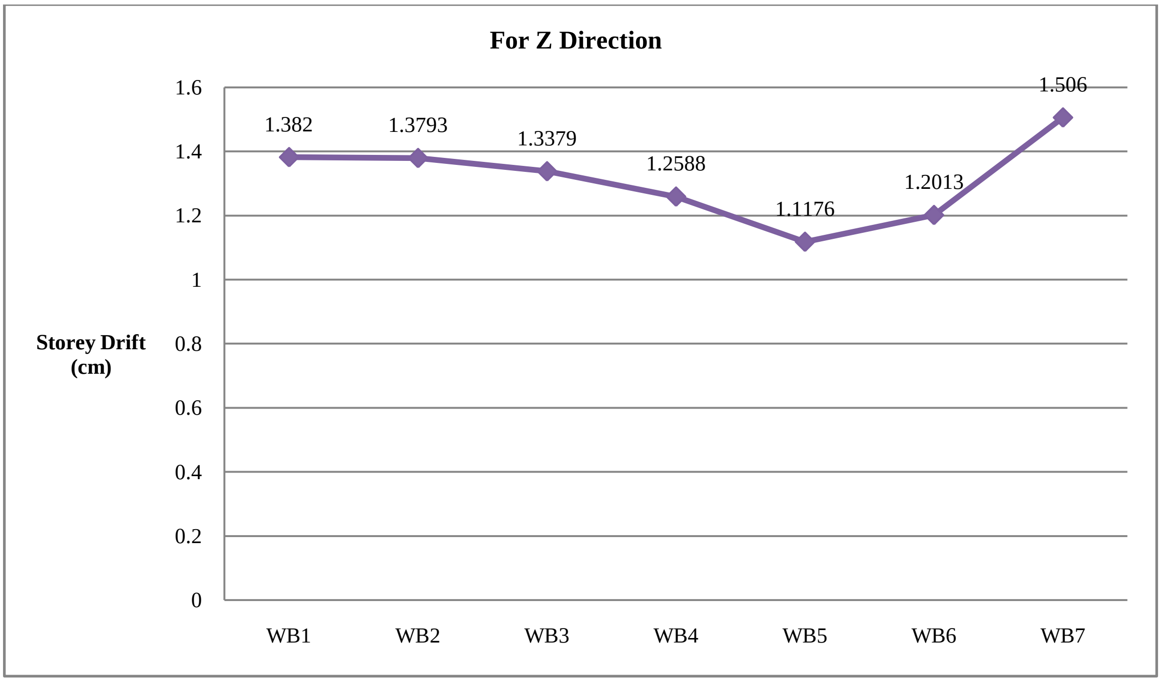

Fig. 5.4: Storey Drift in Z direction for all wall belt cases

Table 7: Base Shear in X and Z directions for all wall belt cases

Case	**Base Shear (KN)**	
	X direction	**Z direction**
WB1	8259.03	9947.29
WB2	8211.60	10074.86
WB3	8959.38	10746.63
WB4	9474.69	11572.91
WB5	9052.93	11215.68
WB6	8686.07	10515.54
WB7	8627.77	10598.53

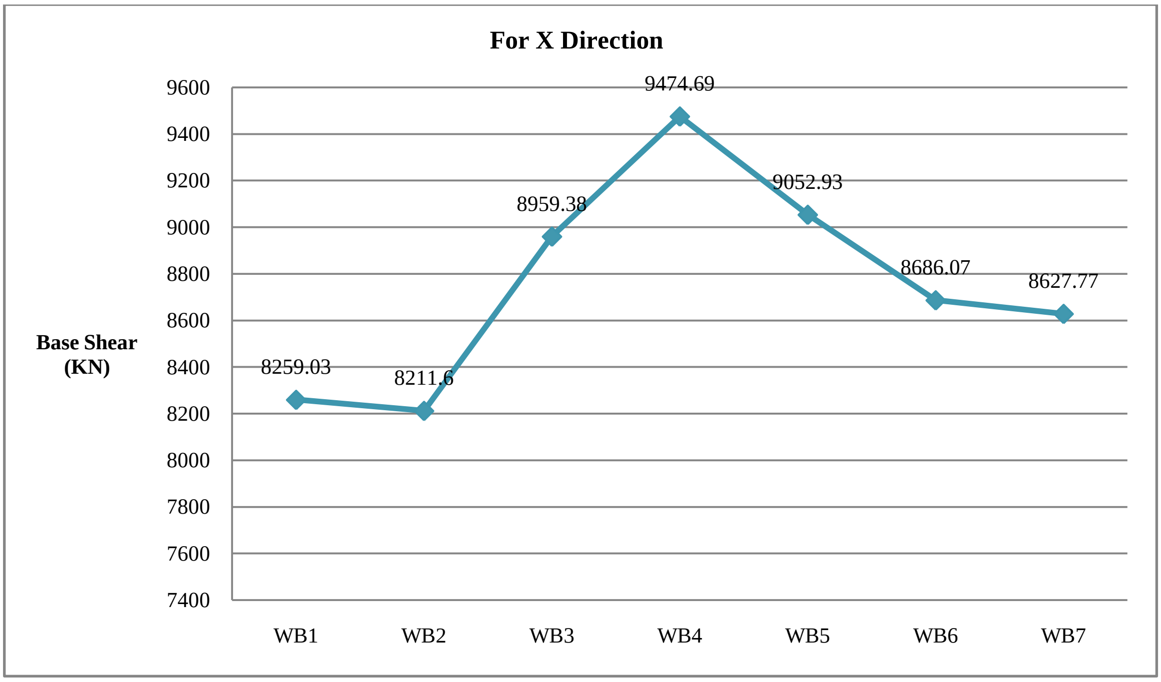

Fig. 5.5: Base Shear in X direction for all wall belt cases

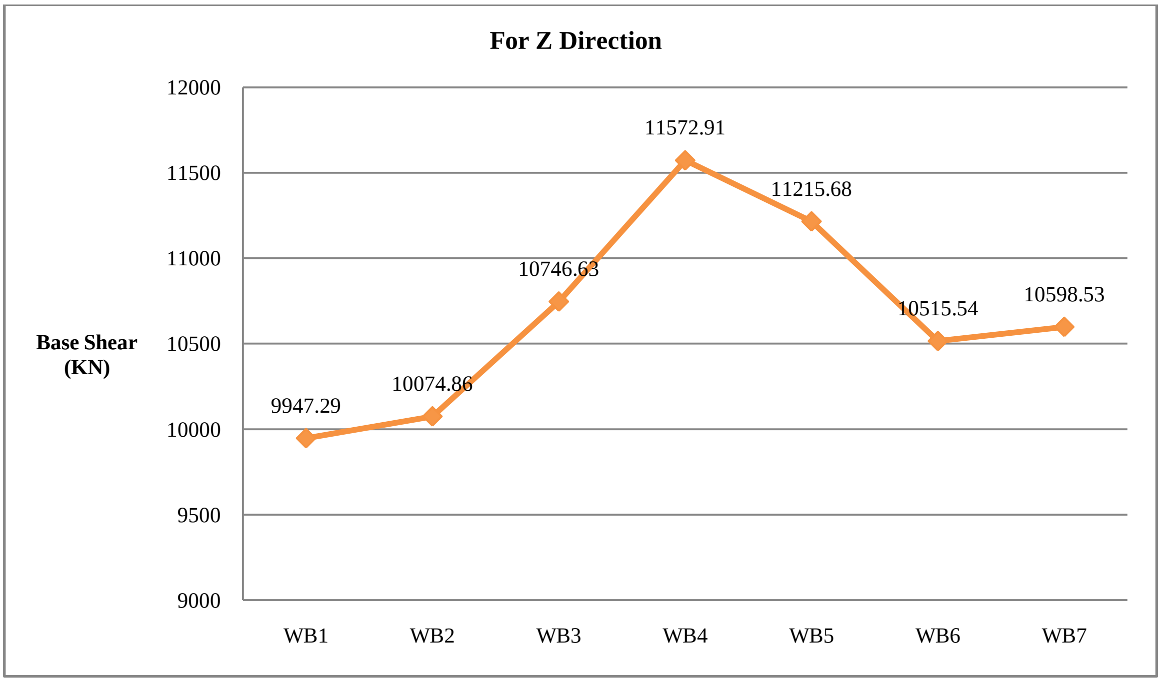

Fig. 5.6: Base Shear in Z direction for all wall belt cases

Table 8: Maximum Axial Forces in Column for all wall belt cases

Case	Column Axial Force (KN)
WB1	13279.375
WB2	11932.481
WB3	10582.834
WB4	11582.834
WB5	11963.821
WB6	12724.740
WB7	13056.893

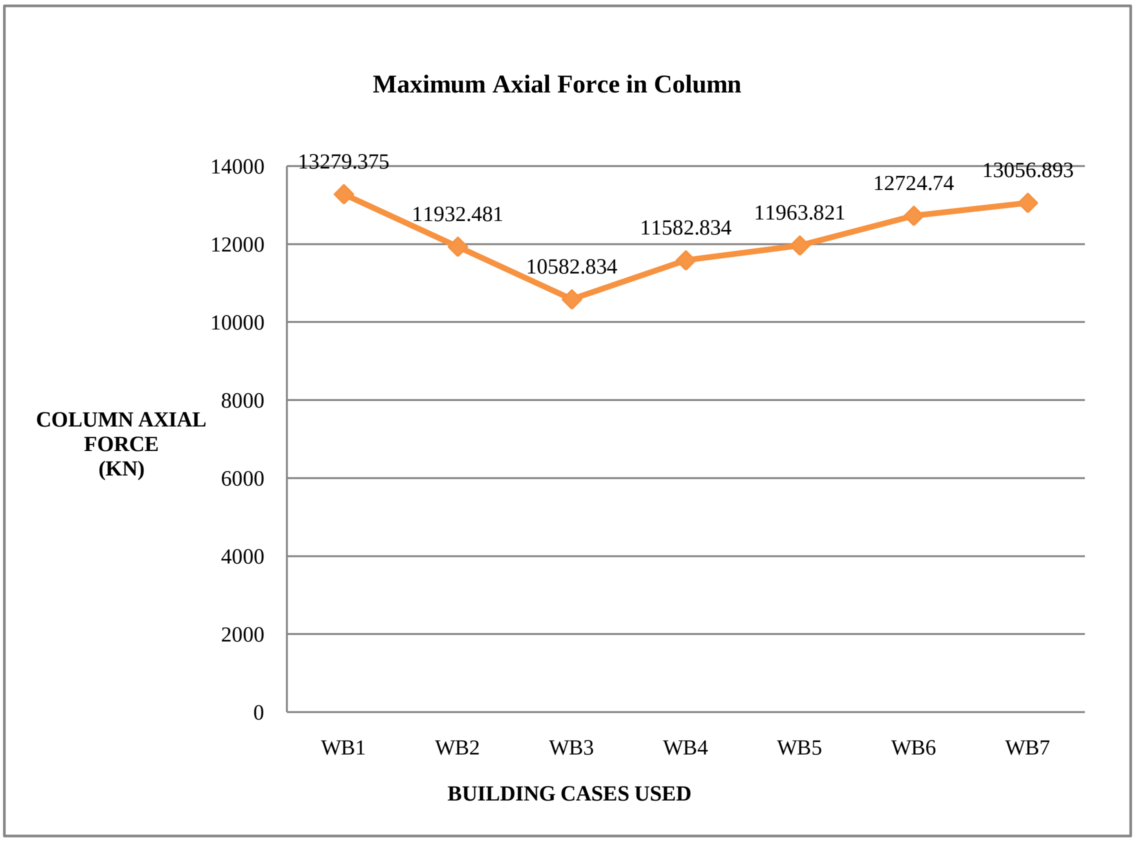

Fig. 5.10: Maximum Axial Forces in Column for all wall belt cases

CONCLUSION

As we analysis about seven diverse cases of Use of wall belt supported system in multistoried building with highest importance factor which gives them a variety of outcome regarding the structure. In term of mentioned cases subsequent outcome are obtained from this comparative analysis.

The conclusions can be pointed out are as follows: -

1. On comparing it has been concluded that the maximum displacement in X direction obtained for case WB6.
2. On comparing it has been concluded that the maximum displacement in Z direction obtained for WB5.
3. As per comparative results in axial force, case WB3 is very effective than other cases.

4. As per comparative results, WB6 case for story drift in X direction values are efficient among all cases
5. As per comparative results, WB5 case for story drift in Z direction values are efficient among all cases
6. As per comparative results, WB2 case for base shear forces in X direction values are efficient among all cases.
7. As per comparative results, WB1 case for base shear forces in Z direction values are efficient among all cases.

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