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Comparative Study on Behaviour of High Rise R.C.C Structure with Shear Wall and High Rise R.C.C. Composite Structure with Consideration of Non-Linear P-Delta Analysis

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Abstract: ***The P-Delta effect are the second order effects which increase lateral displacement(The lateral displacements can be caused by wind or seismically induced inertial forces) in the high rise structure. The increase in number of storey in the structure directly proportion to the delta effect in the structure. The present work concerned with the Comparative Study On Behaviour of High Rise R.C.C Structure With Shear Wall and High Rise R.C.C. Composite Structure With consideration of Non-linear P-Delta Analysis. The present study give overview of different research works to be done in high rise structure for the P-Delta analysis.***

Keywords: High rise RC.C. structure with shear wall, High rise R.C.C. composite structure, non-linear P-Delta analysis, Drift, Displacement, ETABS

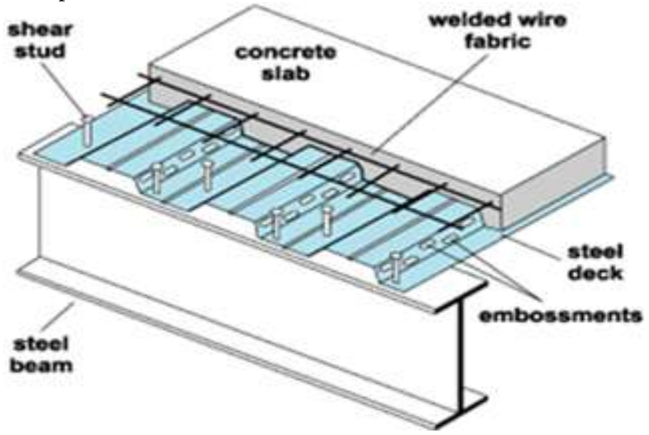
1.Introduction and Objectives

In Recent decades, shear walls and tube structures are the most appropriate structural forms, which have caused the height of concrete buildings to be soared. So, recent RC tall Buildings would have more complicated structural behaviour than before. Therefore, studying the structural systems and associated behaviour of these types of structures would be very interesting. The lateral load resisting structure consist shear wall, composite columns, composite beams and deck slab are mostly used. Shear walls have high in-plane stiffness thus it resists the lateral loads and control the deflection more efficiently. A composite high-rise building structural system with steel reinforced concrete column, steel beam and reinforced concrete core tube has been adopted in the recent construction activity. The main benefits from the use of high rise composite R.C.C. structures construction are in terms of construction time and cost. Composite construction combines the better properties of both concrete and steel construction. In the present work included Comparative study of R.C.C. shear wall and composite (G+32 STORY) building. In the comparative study includes deflections of the structure, size and material consumption of members in composite with respect to R.C.C. shear wall, seismic forces and behaviour of the building under seismic condition in composite with respect to R.C.C. shear wall structure, foundation requirements and type of foundation can be selected for Composite structure with respect to R.C.C. shear wall structure and total weight of the building.

2. High Rise Composite R.C.C Structure

Formally the multi-story buildings in India were constructed with R.C.C framed structure or Steel framed structure but recently the trend of going towards composite structure has started and growing .A steel-concrete composite column is a compression member, comprising either a concrete encased hot-rolled steel section or a concrete filled tubular section of hot-rolled steel and is generally used as a load-bearing member in a composite framed structure. increased strength for a given cross sectional dimension. In composite construction the two different materials are tied together by the use of shear studs at their interface having lesser depth which saves the material cost considerably. Thermal expansion (coefficient of thermal expansion) of both, concrete and steel being nearly the same. Therefore, there is no induction of different thermal stresses in the section under variation of temperature. x increased stiffness, leading to reduced slenderness and increased buckling resistance. X good fire resistance in the case of concrete encased columns. x corrosion protection in encased columns. formwork is not required for concrete filled tubular sections. I-beams (or I-sections), as the name states are manufactured in the shape of a capital "I". The core of the I-beam, better known as the web, will ensure that resistance against shear forces is provided. Except for the web, the I-beam also consist of flanges, taper or parallel flange, on either side of the web and at both ends. The flanges provide resistance to bending moments. The best advantage of a webbed and flanged beam (I section) is that the material is present where it should be and in the right quantities. This makes the beam more economical and lighter and in turn again making it even more economical. A beam primarily resists bending, shear and torsion. Shear is resisted by the web and you just put in enough thickness of web that the shear is taken care of. A deck slab are use in high rise building structures and bridge or road bed is the roadway, or the pedestrian walkway, surface of a bridge, slab of the buildings, and is one structural element of the superstructure of a bridge. The deck may be constructed of concrete, steel, open grating, or wood.

Sometimes the deck is covered with asphalt concrete or other pavement.



(FIG 00: Details of Deck Slab)

3. Project Details

1) **Architectural details**

Following are the some parameters are considered for the analysis of the G+32 storey structure with shear wall and composite frame.

-Dimension of the building : 24 m x 27 m.
(As shown in fig 01)
-Total Height of the building : 98.3 m
-Floor to Floor Height : 2.9 m

Figure 1: Plan of the Building

2) Codes used for analysis of the structure:-

-R.C.C. design : IS 456: 2000
-Earthquake design : IS1893: 2016
-Code for Dead load : IS875: Part 1
-Code for Live load : IS875: Part 2
-Code for Wind load : IS875: Part 3
-Composite design : AISC 360-05

3) The basic parameters considered for the Analysis and design:-

- Slab depth: 125 mm thick : Assumed
- Live load in office area: 3 kN/sq. m : As per IS 875 Part 2
- Live load in Balcony area: 3 kN/sq. m : As per IS 875 Part 2
- Live load in passage area: 3 kN/sq. m : As per IS 875 Part 2
- Live load in urinals: 2 kN/sq. m : As per IS 875 Part 2
- Floor finish load: 1.5 KN/ sq. m : As per IS 875 Part 1
- Wall thickness: 230 mm thick wall : Assumed
- Stair case loading: 3 kN/sq. m : As per IS 875 Part 2
- Lift shaft: 300 mm thick shear wall : Assumed

The sizes of the members in different model have been taken as per strength as well as displacement requirements. For all the models the sizes are curtailed at every 10 story to achieve economy and reduce dead weight of the structure. Here is the summary of the final sizes achieved and designed.

-Column/Shear Wall Size Details

Table 1

PARTICULAR	RCC SHEAR WALL	COMPOSITE (COLUMN)	Embedded Section of Steel
Foundation to Ground	400 mm thick Shear wall	600X600	W18X65
Ground to 10th floor	350 mm thick shear wall	600X600	W18X65
10th to 20th floor	300 mm thick shear wall	600X600	W18X65
20th to 32 floor	300 mm thick shear wall	600X600	W18X65

-Beams Size Details

	RCC FRAM	Composite Frame
Foundation to Ground	300X700 MM	300X700
Ground to 10th floor	300X650 MM	W24X76
10th to 20th floor	300X600 MM	W14X74
20th to 32 floor	300X600MM	W14X68

Modelling with ETABS

3-D model is being prepared for the frame static analysis and dynamic analysis with shear wall Of the building in ETABS version 16.0.2

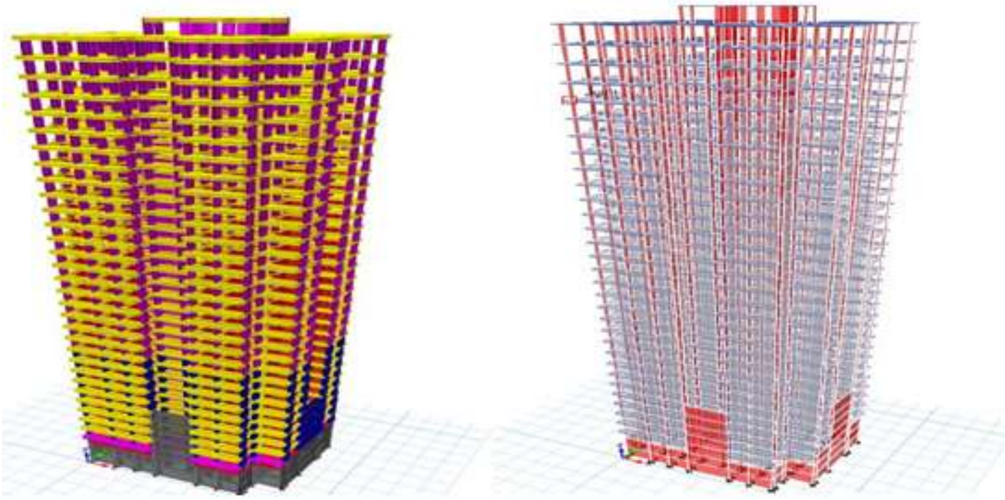


Figure 2: Skeleton Model and 3D View of the Structure

4. Analysis and Design Parameters Considered

A) Earthquake parameters considered:-
- Zone : I (Mumbai)
- Soil type : Hard soil
- Importance factor : 1
- Time period : Base on IS 1893

B) Wind parameters consider
- Wind speed : 44 M/S
- Terrain categorise : 4
- Class : C
- Diaphragm details: Semi rigid diaphragm

Post Design Details for G+32 Storey Structure
Table no.2

Serial No.	Particular	Details	
1	Foundation depth	9 M Below Ground Level	No Basement Provided
2	Foundation type	Raft foundation	Shear wall fixed at raft
3	No of storey	32	2.9 m storey height
4	Walls	9" Thick	For all walls
5	Lift	Central Shaft	Machine room at top
6	Water tank	At terrace level	

5. Results

Comparison Factors
a) Time Periods
b) Base Shear
c) Displacements
d) Drift
e) Total Weight
f) Storey Stiffness
g) Graphs

(A) Time Period of the Structure Under Static and Dynamic Load Consideration
(For Shear Wall Rcc Structure& Composite Structure)
1) Static Fundamental time period (for RCC and Composite Structure)

Table 3

Case	Time Period In Sec
EX	1.8
EY	1.7

2) Modal time period(for Rcc and composite structure with and without p-delta effect.)

Table 4

Case	Mode	RCC Frame Without P- Delta	RCC Frame With P-Delta	Composite Frame Without P-Delta	Composite Frame With P-Delta
		Time Period in Second	Time Period in Second	Time Period in Second	Time Period in Second
Mode	1	4.1	4.35	6.5	7.71
Mode	2	3.18	3.28	6.05	6.9
Mode	3	2.86	2.95	5.5	6.48

(B) Base Shear Details

Table 5

Particular	RCC Frame (Without P-Delta)	RCC Frame (With P-Delta)	Composite Frame Without P-Delta	Composite Frame With P-Delta	Fig No
BASE SHEARFOR STATIC EQX	4196.96 KN	4196.96 KN	3624.99	3624.99	01
BASE SHEAR FOR STATIC EQY	4443.84KN	4443.84KN	3838.23	3838.23	02
BASE SHEAR FOR DYNAMIC SPECX	1091.68KN 4196.96 KN After Scaling	1091.68KN 4196.96 KN After Scaling	3826.49 3625.00 KN After Scaling	3826.49 3625.00 KN After Scaling	03
BASE SHEAR FOR DYNAMIC SPECY	1376.19KN 4443.84 KN After Scaling	1376.19KN 4443.84 KN After Scaling	3954.25 3838.23 KN After Scaling	3954.25 3838.23 KN After Scaling	04

(C) Displacement Details

Table 6

Directions	RCC Frame (Without P-Delta	RCC Frame (With P-Delta)	Composite Frame Without P-Delta	Composite Frame With P-Delta
Max storey displacement for EQX	0.145 M	0.161 M	0.341	0.457
Max storey displacement for EQy	0.105M	0.111M	0.498	0.682
Max storey displacement for SPEC X	0.026M 0.096 M After Scaling	0.026M 0.106 M After Scaling	0.233	0.331
Max storey displacement for SPEC Y	0.0239M 0.077 After Scaling	0.0239M 0.080 After Scaling	0.374	0.505
Max storey displacement for Wind In X direction	0.074 M	0.083 M	0.244	0.332
Max storey displacement for Wind In Y direction	0.0508M	0.053M	0.309	0.427
GRAPH	01	02	03	04

(D) Drift Details

Table 7

Directions	RCC Frame (Without P-Delta	RCC Frame (With P-Delta)	Composite Frame Without P-Delta	Composite Frame With P-Delta
Max storey Drift for EQX	0.0022	0.0025	0.005	0.007
Max storey Drift for EQy	0.0015	0.0016	0.008	0.006
Max storey Drift for SPEC X	0.00045 0.0015 After Scaling	0.00045 0.0017 After Scaling	0.0036	0.005
Max storey Drift for SPEC Y	0.00037 0.0012 After Scaling	0.00037 0.0012A After Scaling	0.006	0.007
Max storey Drift for Wind In X direction	0.0012	0.0014	0.0038	0.005
Max storey Drift for Wind In Y direction	0.00072	0.0007	0.0050	0.007
GRAPH	05	06	07	08

(E) Total Dead WT of the Structure

Table 8

	RCC FRAM	Composite Frame
LOAD IN KN	305544.02	278120.83

(F) Storey Stiffness

1) For RCC Frame (Without P-Delta Effect)

Table 9

Story	Load Case	Stiffness X	Load Case	Stiffness Y
OHT/LMR	Spec x	76114.1	spec y	79471.49
T F	Spec x	337213.2	spec y	291805.4
30	Spec x	448855	spec y	452191.3
20TH	Spec x	549115.8	spec y	729789
10TH	Spec x	704693.5	spec y	1838631
GF	Spec x	28823389	spec y	26596905
PLINTH	Spec x	58711051	Spec y	44348859

2) For RCC Frame With P-Delta Effect:

Table 10

Story	Load Case	Stiffness X	Load Case	Stiffness Y
OHT/LMR	Spec x	71326.35	spec y	77598.51
T F	Spec x	321257.5	spec y	284592.7
30	Spec x	428207.3	spec y	437736.1
20TH	Spec x	500599.8	spec y	694793.3
10TH	Spec x	616961.6	spec y	1766009
GF	Spec x	28113304	spec y	26362839
PLINTH	Spec x	57929910	Spec y	44050609

3) For Composite Frame (Without P-Delta Effect)

Table 11

Story	Load Case	Stiffness X	Load Case	Stiffness Y
OHT/LMR	Spec x	29373.47	spec y	18474.89
T F	Spec x	91684.68	spec y	63857.03
30	Spec x	134470	spec y	88259.61
20TH	Spec x	194618.4	spec y	122490.1
10TH	Spec x	282205.7	spec y	472887.5
GF	Spec x	25618196	spec y	15903536
PLINTH	Spec x	56755251	Spec y	40474118

4) For Composite Frame (With P-Delta Effect)

Table 12

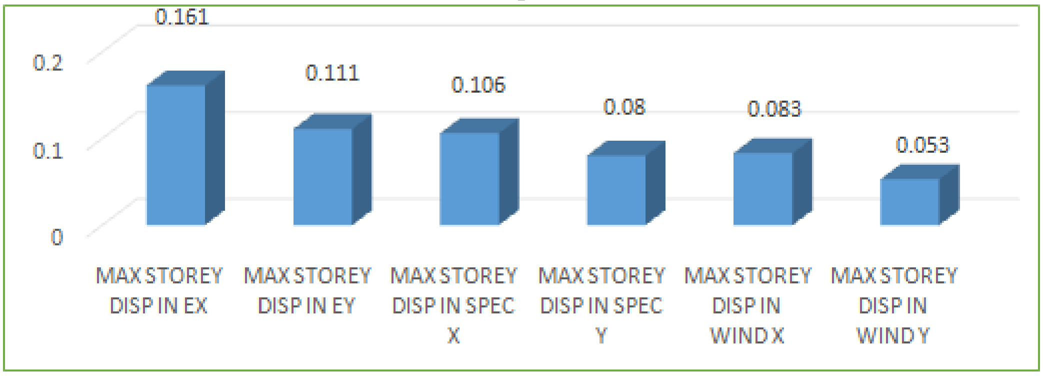
Story	Load Case	Stiffness X	Load Case	Stiffness Y
OHT/LMR	Spec x	23816.65	spec y	18474.89
T F	Spec x	73647.89	spec y	63857.03
30	Spec x	107705	spec y	88259.61
20TH	Spec x	141005.9	spec y	122490.1
10TH	Spec x	208339.5	spec y	472887.5
GF	Spec x	24789160	spec y	15903536
PLINTH	Spec x	55760179	Spec y	40474118

(G) Graph

DISPLACEMENT OF RCC SHEAR WALL STRUCTURE WITHOUT P-DELTA EFFECT

X -AXIS DISPLACEMENTS & Y-AXIS IN M

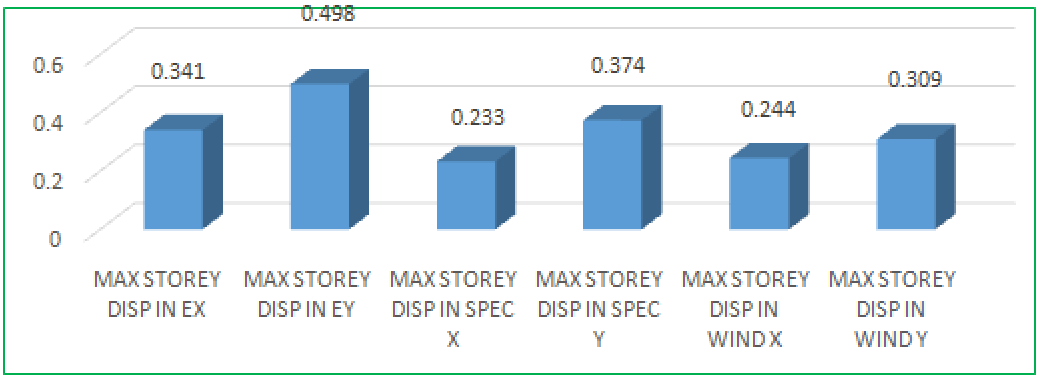
Graph 1



DISPLACEMENT OF RCC SHEAR WALL STRUCTURE WITH P-DELTA EFFECT

X -AXIS DISPLACEMENTS & Y-AXIS IN M

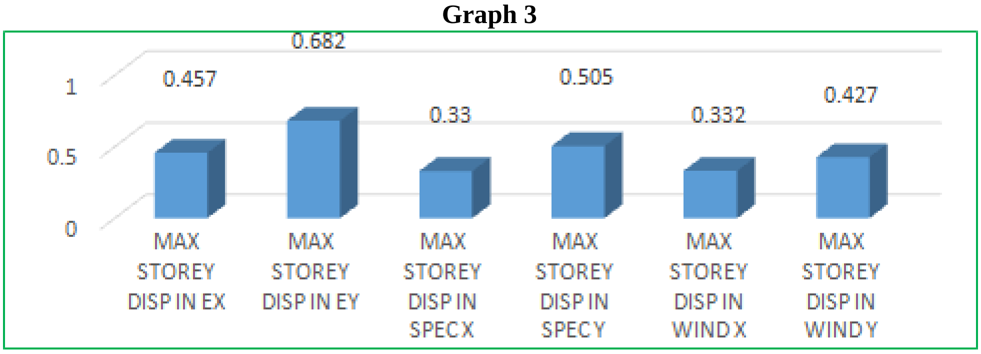
Graph 2



DISPLACEMENT OF COMPOSITE STRUCTURE WITHOUT P-DELTA EFFECT

X -AXIS DISPLACEMENTS & Y-AXIS IN M

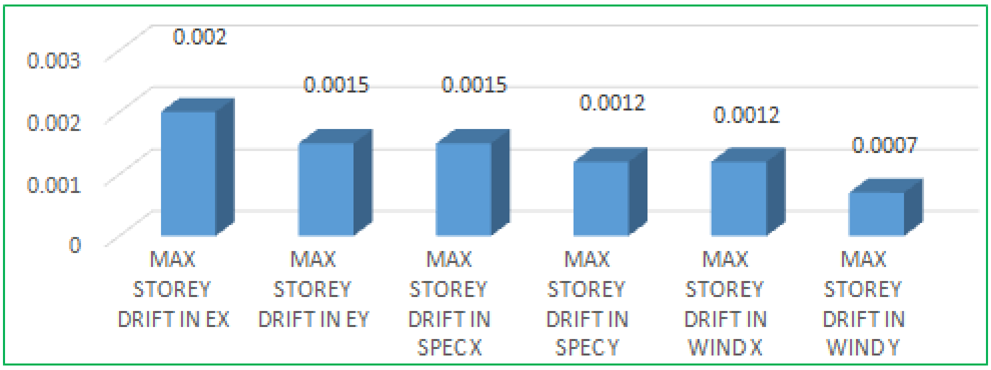
Graph 3



DISPLACEMENT OF COMPOSITE STRUCTURE WITH P-DELTA EFFECT

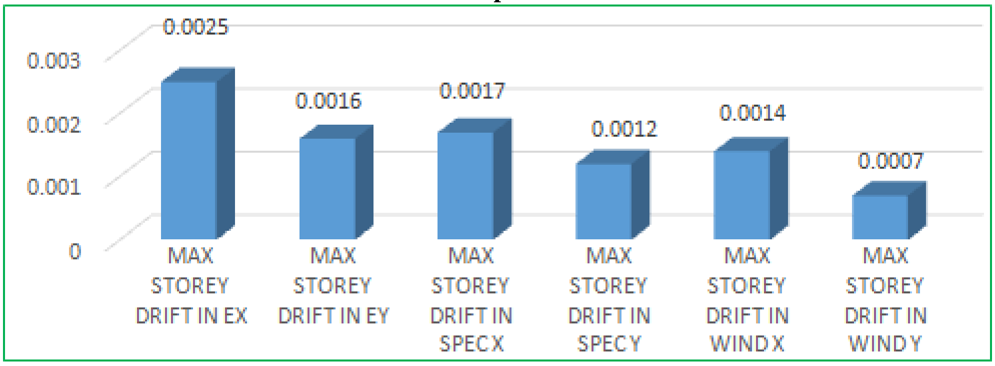
X -AXIS DISPLACEMENTS & Y-AXIS IN M

Graph 4



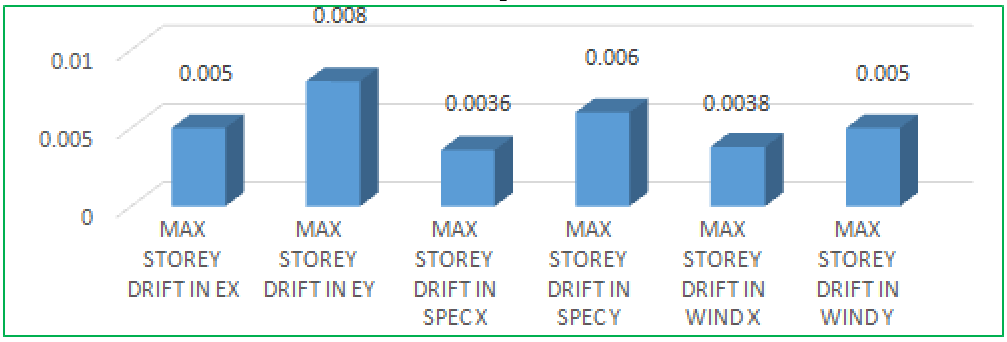
DRIFT OF RCC SHEAR WALL STRUCTURE WITHOUT
P-DELTA EFFECT
X -AXIS DRIFT DIRECTION & Y-AXIS DRIFT VALUES

Graph 5



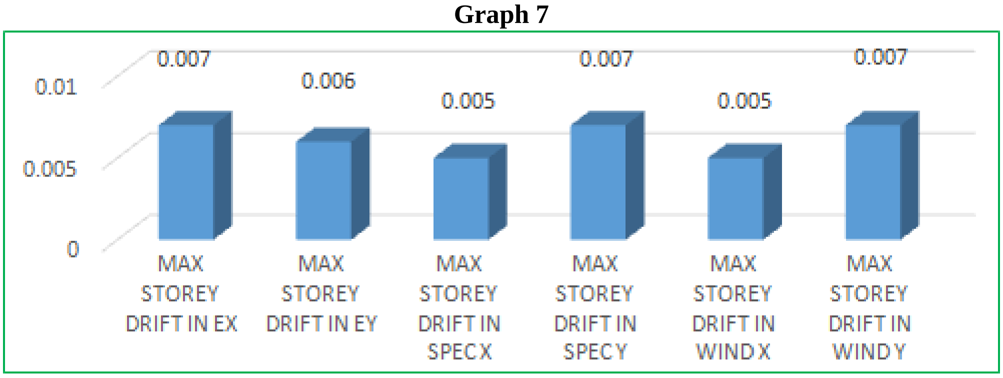
DRIFT OF RCC SHEAR WALL STRUCTURE WITH
P-DELTA EFFECT
X -AXIS DRIFT DIRECTION & Y-AXIS DRIFT VALUES

Graph 6



DRIFT OF COMPOSITE STRUCTURE WITHOUT
P-DELTA EFFECT
X -AXIS DRIFT DIRECTION & Y-AXIS DRIFT VALUES

Graph 7



DRIFT OF COMPOSITE STRUCTURE WITH
P-DELTA EFFECT
X -AXIS DRIFT DIRECTION & Y-AXIS DRIFT VALUES

Graph 8

6. Conclusion

As per storey stiffness results the R.C.C structure with shear wall having better stiffness results when compared with column Because shear wall capture in plane as well as out of plane stiffness. When non-linear P-delta effect will be considered in the both R.C.C structure with shear wall and composite structure the effect of P-delta will compensate the results as where the additional displacement occurs at that area it will increase the additional moments. The results shows that the composite structure is having more drift and displacement values when compared with R.C.C structure with shear wall, because the composite structure is more ductile than R.C.C shear wall structure As shown in graph 1,2,3,4,5,6,7,8. The weight of the R.C.C structure with shear wall is 10% greater than composite structure. The composite structure is better in case of handling and Execution and completion of the work. Also it will save time when compared with R.C.C structure with shear wall.

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