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# Comparative Study of R.C.C. and Composite Structures Under Different Soil Conditions

Tushar Patidar[1], Dr. Savita Maru[2]
[1, 2]*Department of Civil Engineering, Ujjain Engineering College, Ujjain, (M.P.), India*

***Abstract:*** ***The need for multi-storey buildings arises from a fact that it offers vertical expansion, making them an ideal choice for maximizing available urban space without influencing valuable land resources. A thorough literature review has conducted for comparative study of RCC and Composite buildings and its various advancements conducted before. This paper is based on regular and irregular plan area under different soil conditions. Total 18 cases have taken for consideration (6- square shape, 6 – L shape and 6 – T shape plan) with 3 cases each of RCC and 3 cases for Composite building and method selected - Response Spectrum Method. Results for Square shape plan shows that SCPH case i.e. Square plan with Composite structure over hard soil performs well in most of the output parameters. Results for L shape plan shows that LCPH case i.e. L shape plan with Composite structure over hard soil performs well in most of the output parameters while in case of story displacement and drift LRCCH i.e. L shape plan with RCC structure over hard soil performs better but the values of LCPH are also within the limits of IS codes. Results for T shape plan shows that in case of story displacement and drift TRCCH i.e. T shape plan with RCC structure over hard soil performs better because of the higher stiffness of RCC structure while in all other output parameters TCPH i.e. T shape plan with composite structure over hard soil performs well. Concluding the research work, use of composite structure performs well and can be used with building stability techniques so that the displacement factors can be minimized for composite structures.***

***Keywords: Composite frame, Shears connectors, Grade of Concrete, RCC frame, Deck slab.***

## I. INTRODUCTION

The demand for multistorey buildings generated from various factors with respect to urban populations growing rapidly, innovative solutions are needed to offer housing and commercial areas without consuming precious land. Multistorey structures address this by constructing it vertically. Additionally, economic factors come into play as land costs rise. Multistorey buildings provide cost-effective ways to optimize space, making them an attractive choice for developers and city planners.

### *A. RCC and Composite Structures*

Both the Reinforced Concrete (RCC) and Composite building systems possess distinct qualities and benefits that align with the changing demands of urban infrastructure. This article examines the attributes and uses of both RCC and Composite buildings, offering valuable perspectives on how they each contribute to modern construction methodologies. **RCC structures** are architectural and engineering constructions that utilize reinforced concrete, combining the compressive strength of concrete and the tensile strength of steel reinforcement to create durable and load-bearing elements.

Here are some key features:

- Strength and Durability
- Flexibility in Design
- Fire and Corrosion Resistance
- Load-bearing Capacity
- Low Maintenance
- Seismic Performance

Composite structures are engineered systems that integrate different components, combining lightweight components with a matrix to achieve enhanced mechanical properties and functional advantages. Here are some aspects to consider:

- High Strength to Weight Ratio
- Reduced Maintenance
- Fatigue Resistance
- Seismic Performance
- Insulation Properties
- Aesthetic Possibilities

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## II. RESEARCH OBJECTIVES

On keeping in mind the above problem statement outline for new research work is proposed in the form of conclusive outcomes given below :-

1) To create and study various cases of different plan area over soft, medium and hard soil and comparing them by using Response Spectrum Method of dynamic analysis using ETABS software tool.
2) To calculate modal participation factor for square shape, L shape and T shape plan area for both normal and composite structure.
3) To determine and compare maximum displacement in X and Y direction for square shape, L shape and T shape plan area for both normal and composite structure.
4) To evaluate and relate storey drift in X and Y direction for square shape, L shape and T shape plan area for both normal and composite structure.
5) To determine maximum Overturning Moment for various cases.
6) To study the variation in base shear in both X and Y direction.
7) To compare different parametric values and mark the economic one in percent and at last, provide the recommendations and remedies for the uneconomic to create a feasible construction reference.

The main and foremost objective is to compare the conventional RCC framed building with advanced composite structure on regular and irregular plan areas on different soil conditions with comparison of various result parameters

## III. PROCEDURE AND 3D MODELING OF THE STRUCTURE

Seismic analysis is carried out on a G+16 storey building by using a software approach. The seismic data is taken as per the IS 1893(PART1):2016. The response spectrum analysis method is adopted for analysis of buildings. Input details and model descriptions are mentioned below:-

Table 1: General data used for the analysis of the structure

| Constraint | Data used for all buildings |
|---|---|
| Floors configuration | G + 16, 4m @ 6 bays in X direction and 6m @ 4 bays for Square, L, T shape |
| Overall height, Floor to floor height and Depth of foundation | 57.6 m, 3m and 3.6m respectively |
| RCC Beam size | 600 mm X 400 mm |
| RCC Column sizes | 600 X 550 mm, 850 X 800 mm, 950 X 950 mm |
| Slab and Shear wall thickness | 150 mm and 180 mm |
| Material properties | M 30 Concrete, Fe 500 grade steel |
| Composite Steel Beam | ISMB 300 (Fe 345 grade) |
| Composite Steel Column | 450 X 400 mm, 550 X 500 mm, 650 X 650 mm with ISMB 350 (Fe 345 grade) |
| Soil type | Soft, Medium and Hard |
| Seismic zone, RF, I, mode shapes, damping ratios | III, 4, 1.2, 6, 5% |
| Fundamental natural period of vibration ($T_a$) | Approximate, RCC = $0.075\ h^{0.75}$ and Composite = $0.080\ h^{0.75}$ |
| FF load, water proofing load, external & Internal wall load, parapet wall load | 2 KN/ sq. m, 0.508 KN/ sq. m, 14.04 KN/m & 7.02 KN/m, 2.58 KN/m |
| Live load on floors, roof and staircase | 3 KN/ sq. m, 1.5 KN/ sq. m and 3 KN/ sq. m |

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Table 2: Model Description

| S. No. | Abbreviation | Description of structure |
|---|---|---|
| 1. | SRCCS | Square plan RCC structure over soft soil |
| 2. | SRCCM | Square plan RCC structure over medium soil |
| 3. | SRCCH | Square plan RCC structure over hard soil |
| 4. | SCPS | Square plan Composite structure over soft soil |
| 5. | SCPM | Square plan Composite structure over medium soil |
| 6. | SCPH | Square plan Composite structure over hard soil |
| 7. | LRCCS | L shape plan RCC structure over soft soil |
| 8. | LRCCM | L shape plan RCC structure over medium soil |
| 9. | LRCCH | L shape plan RCC structure over hard soil |
| 10. | LCPS | L shape plan Composite structure over soft soil |
| 11. | LCPM | L shape plan Composite structure over medium soil |
| 12. | LCPH | L shape plan Composite structure over hard soil |
| 13. | TRCCS | T shape plan RCC structure over soft soil |
| 14. | TRCCM | T shape plan RCC structure over medium soil |
| 15. | TRCCH | T shape plan RCC structure over hard soil |
| 16. | TCPS | T shape plan Composite structure over soft soil |
| 17. | TCPM | T shape plan Composite structure over medium soil |
| 18. | TCPH | T shape plan Composite structure over hard soil |

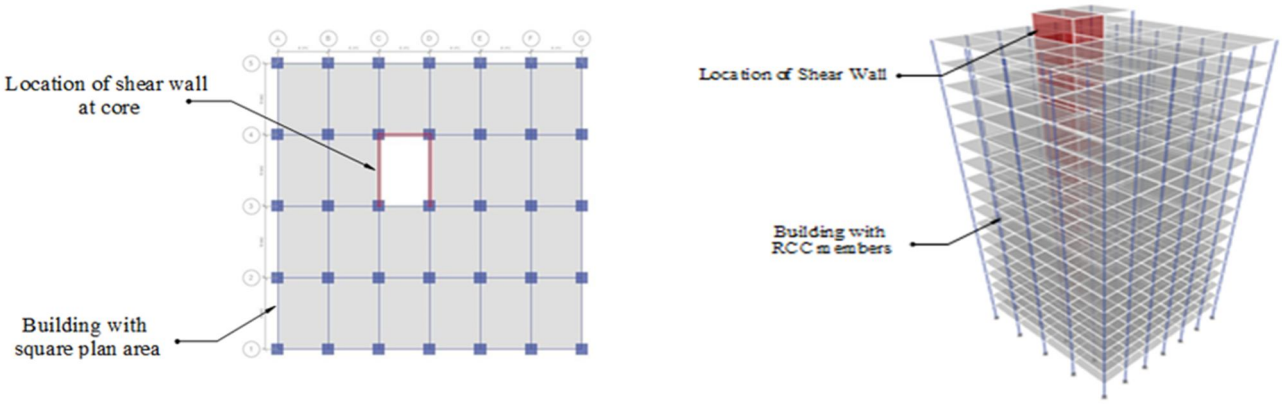



Fig. 1: Square shape plan and 3D view of RCC and Composite structure over all 3 soil conditions

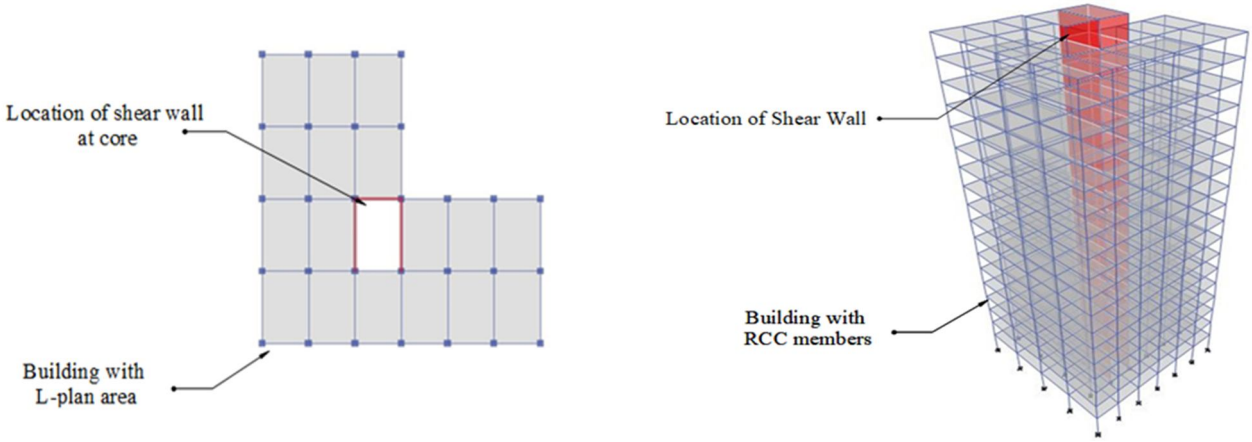



Fig. 2: L shape plan and 3D view of RCC and Composite structure over all 3 soil conditions

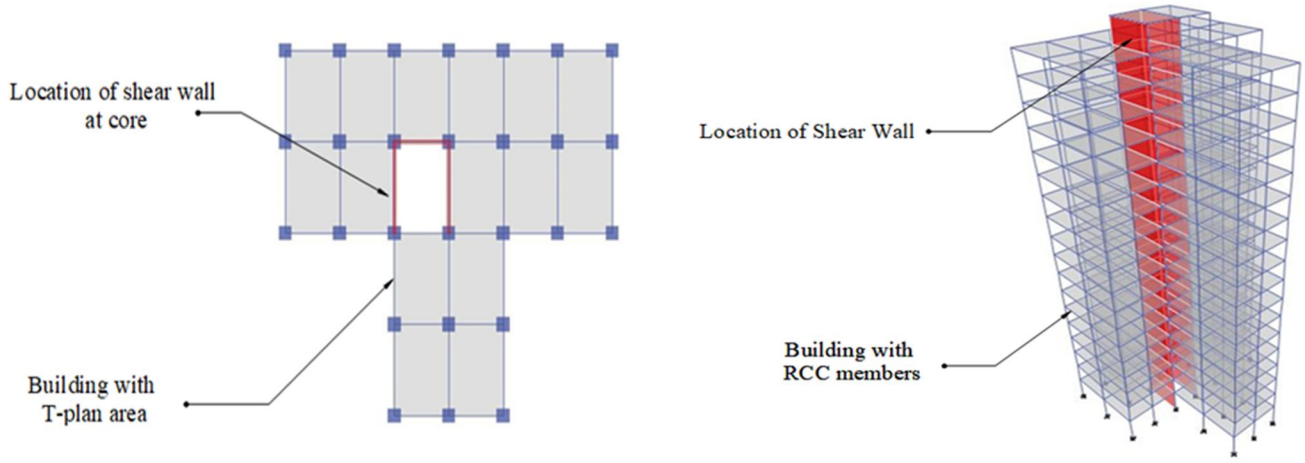



Fig. 3: T shape plan and 3D view of RCC and Composite structure over all 3 soil conditions

## IV. RESULT AND DISCUSSION

As shown by the result that is mentioned below, the composite structure has a lower stiffness than the RCC structure. This is because the steel that is used in the composite structure has more flexibility than the concrete that is used in the RCC structure. This difference in flexibility influences how the composite structure behaves when it is subjected to loading. It causes the composite structure to have a longer duration of oscillation, a higher amount of displacement and a larger degree of storey drift. On the other hand, the RCC structure has a higher base shear and overturning moment under the same loading conditions.

The composite structure has a better performance than the RCC structure when it comes to earthquake considerations. This is because the steel possesses some inherent characteristics that make it more resilient to seismic forces, such as ductility, energy absorption and self-centring. These characteristics enable the steel to deform and recover without losing its strength and stability. Therefore, the composite structure provides more advantages than the conventional RCC structure when it comes to coping with earthquakes.

Result of each parameter has discussed with its representation in graphical form below:-

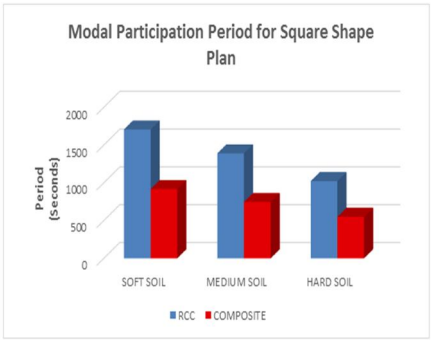



Fig. 4: Modal Time Period for Square plan

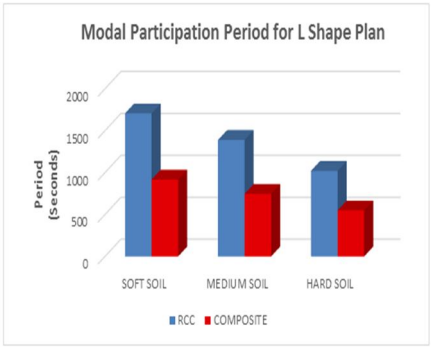



Fig. 5: Modal Time Period for L shape plan

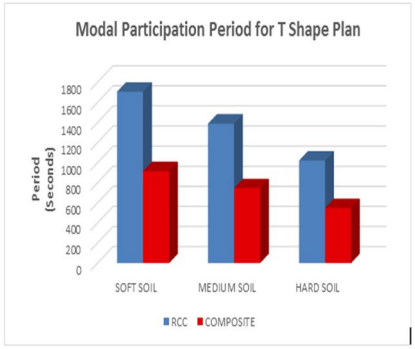



Fig. 6: Modal Time Period for T shape plan

As shown in fig 4, fig 5 and fig 6 the time period results show that observed values for square shape plan, L shape plan and T shape plan are 2.492 sec. for (SRCCS), 1.194 sec for (LRCCS) and 2.466 sec for (TRCCS) its values increase upto 0.079 sec for (SCPS), 1.212 sec for (LCPS) and 0.686 sec for (TCPS) when using composite structure over soft soil. 2.511 sec. for (SRCCM), 1.194 sec for (LRCCM) and 2.466 sec for (TRCCM) its values increase upto 0.06 sec for (SCPM), 1.208 sec for (LCPM) and 0.686 sec for (TCPM) when using composite structure over medium soil. 2.511 sec. for (SRCCH), 1.194 sec for (LRCCH) and 2.466 sec for (TRCCH) its values increase upto 0.006 sec for (SCPH), 1.212 sec for (LCPH) and 0.686 sec for (TCPH) when using composite structure over hard soil. The reason is given in commencement of result and discussion section above. The time period increases due to more flexibility of composite structure.

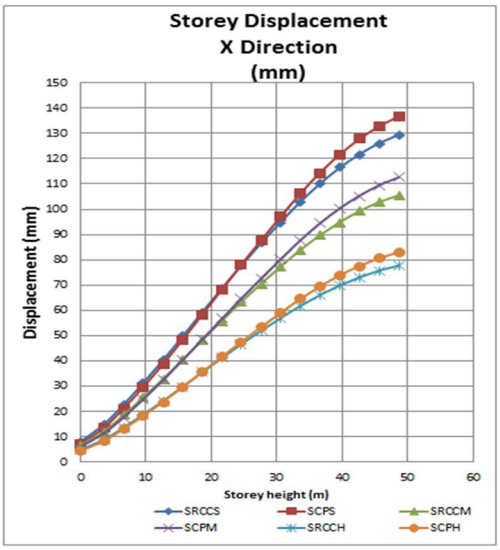



Fig. 7: Storey Displacement in X direction for Square plan

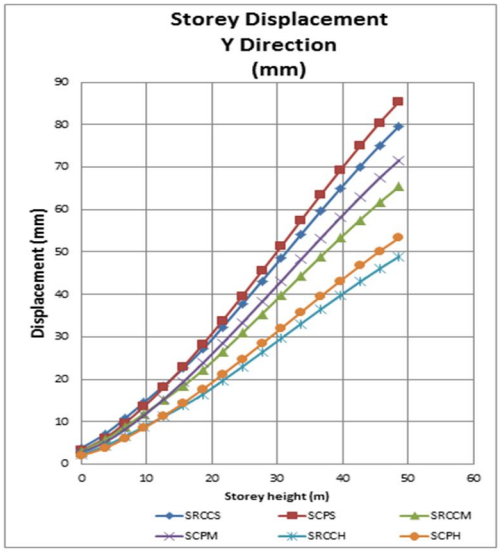



Fig. 8: Storey Displacement in Y direction for Square plan

As shown in fig 7 and fig 8 the storey displacement results show that observed values for square shape plan in X and Y direction are 129.430mm and 79.666 mm respectively for (SRCCS), its values increase upto 7.253mm for X direction and 5.78 mm for Y direction when using composite structure (SCPS) over soft soil. 105.508mm and 65.446 mm respectively for (SRCCM), its values increase upto 7.143mm for X direction and 6.174 mm for Y direction when using composite structure (SCPM) over medium soil. 77.728mm and 48.933 mm respectively for (SRCCH), its values increase upto 5.225mm for X direction and 4.391 mm for Y direction when using composite structure (SCPH) over hard soil. The reason is given in commencement of result and discussion section above. The story displacement increases due to more flexibility of composite structure.

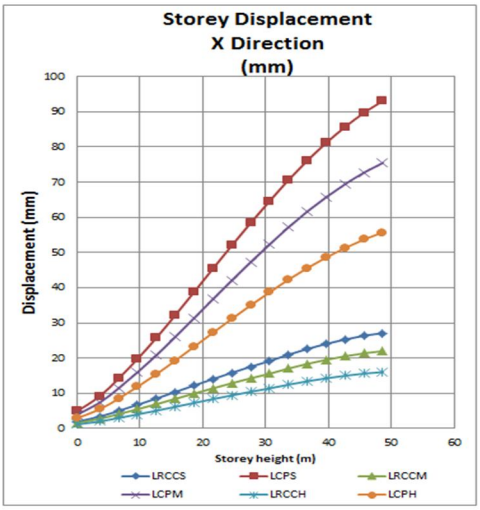



Fig. 9: Storey Displacement in X direction for L shape plan

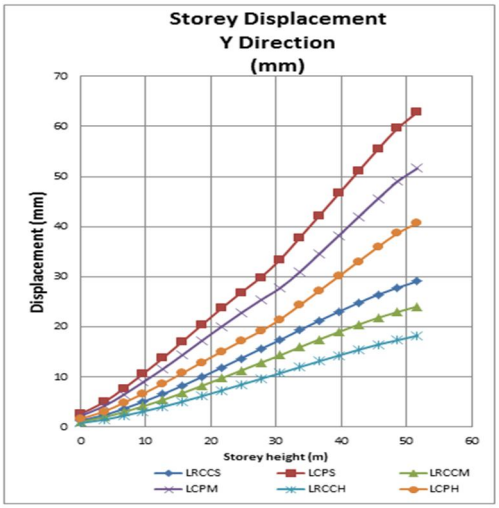



Fig. 10: Storey Displacement in Y direction for L shape plan

As shown in fig 9 and fig 10 the storey displacement results show that observed values for L shape plan in X and Y direction are 27.132 mm and 27.872 mm respectively for (LRCCS), its values increase upto 65.964 mm for X direction and 31.794 mm for Y direction when using composite structure (LCPS) over soft soil. 22.008 mm and 22.984 mm respectively for (LRCCM), its values increase upto 53.478 mm for X direction and 26.043 mm for Y direction when using composite structure (LCPM) over medium soil. 16.058 mm and 17.36 mm respectively for (LRCCH), its values increase upto 39.675mm for X direction and 21.329 mm for Y direction when using composite structure (LCPH) over hard soil. The reason is given in commencement of result and discussion section above. The story displacement increases due to more flexibility of composite structure.

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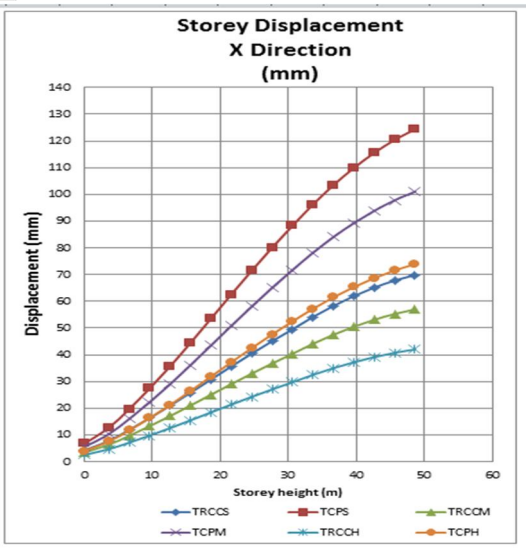



Fig. 11: Storey Displacement in X direction for T shape plan

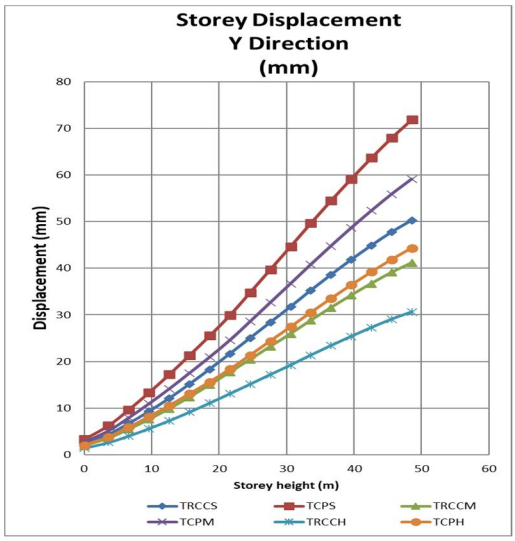



Fig. 12: Storey Displacement in Y direction for T shape plan

As shown in fig 11 and fig 12 the storey displacement results show that observed values for T shape plan in X and Y direction are 69.862 mm and 50.249 mm respectively for (TRCCS), its values increase upto 54.53 mm for X direction and 21.611 mm for Y direction when using composite structure (TCPS) over soft soil. 56.99 mm and 41.166 mm respectively for (TRCCM), its values increase upto 44.061mm for X direction and 17.955 mm for Y direction when using composite structure (TCPM) over medium soil. 42.041mm and 30.619 mm respectively for (TRCCH), its values increase upto 31.905 mm for X direction and 13.709 mm for Y direction when using composite structure (TCPH) over hard soil. The reason is given in commencement of result and discussion section above. The story displacement increases due to more flexibility of composite structure.

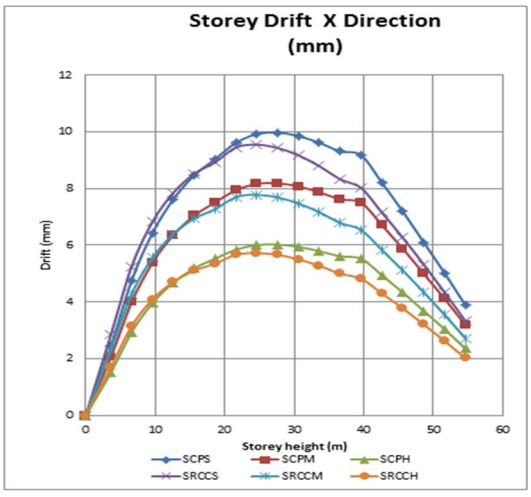



Fig. 13: Storey Drift in X direction for Square shape plan

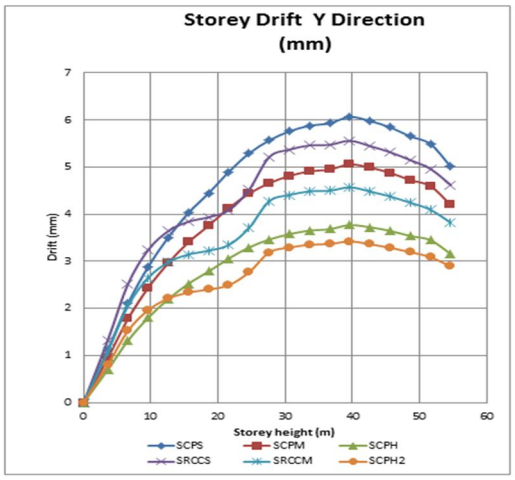



Fig. 14: Storey Drift in Y direction for Square shape plan

As shown in fig 13 and fig 14 the storey drift results show that observed values for square shape plan in X and Y direction are 4.347 mm and 4.962 mm respectively for (SRCCS), its values increase upto 0.678mm for X direction and 0.528 mm for Y direction when using composite structure (SCPS) over soft soil. 3.552 mm and 4.094 mm respectively for (SRCCM), its values increase upto 0.566 mm for X direction and 0.502 mm for Y direction when using composite structure (SCPM) over medium soil. 2.629 mm and 3.087 mm respectively for (SRCCH), its values increase upto 0.413 mm for X direction and 0.362 mm for Y direction when using composite structure (SCPH) over hard soil. The reason is given in commencement of result and discussion section above. The story drift increases due to more flexibility of composite structure.

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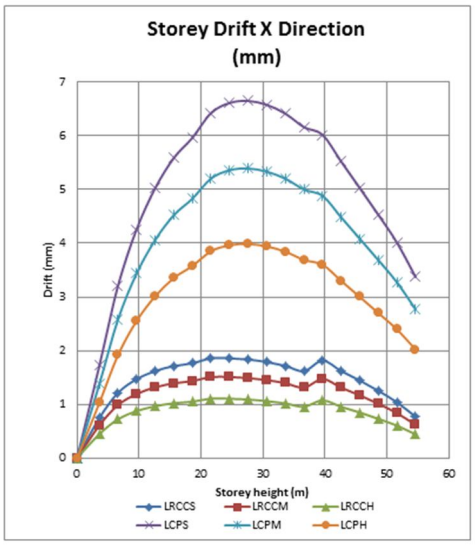



Fig. 15: Storey Drift in X direction for L shape plan

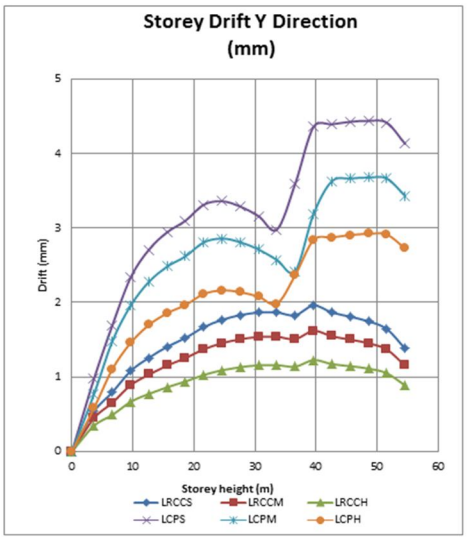



Fig. 16: Storey Drift in Y direction for L shape plan

As shown in fig 15 and fig 16 the storey drift results show that observed values for L shape plan in X and Y direction are 1.037 mm and 1.644 mm respectively for (LRCCS), its values increase upto 2.974 mm for X direction and 2.773 mm for Y direction when using composite structure (LCPS) over soft soil. 0.836 mm and 1.369 mm respectively for (LRCCM), its values increase upto 2.435 mm for X direction and 2.298 mm for Y direction when using composite structure (LCPM) over medium soil. 0.603 mm and 1.05 mm respectively for (LRCCH), its values increase upto 1.791 mm for X direction and 1.864 mm for Y direction when using composite structure (LCPH) over hard soil. The reason is given in commencement of result and discussion section above. The story drift increases due to more flexibility of composite structure.

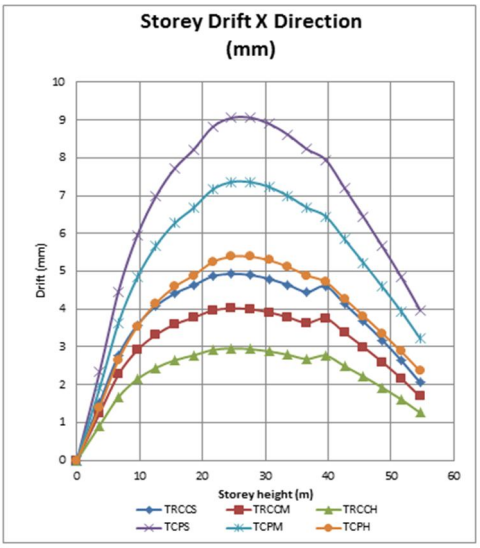



Fig. 17: Storey Drift in X direction for T shape plan

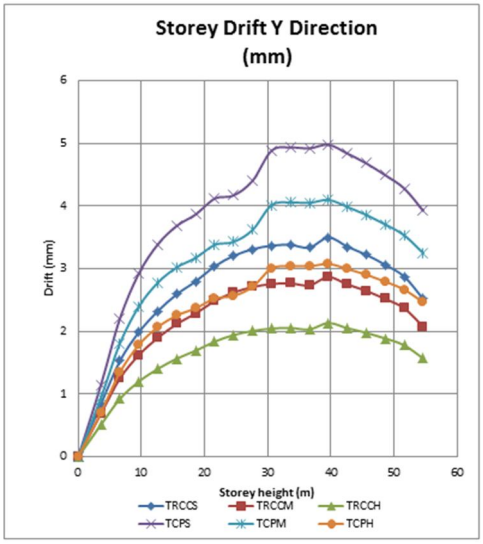



Fig. 18: Storey Drift in Y direction for T shape plan

As shown in fig 17 and fig 18 the storey drift results show that observed values for T shape plan in X and Y direction are 2.644 mm and 2.875 mm respectively for (TRCCS), its values increase upto 2.209 mm for X direction and 1.406 mm for Y direction when using composite structure (TCPS) over soft soil. 2.166 mm and 2.368 mm respectively for (TRCCM), its values increase upto 1.774 mm for X direction and 1.166 mm for Y direction when using composite structure (TCPM) over medium soil. 1.611mm and 1.779 mm respectively for (TRCCH), its values increase upto 1.268 mm for X direction and 0.888 mm for Y direction when using composite structure (TCPH) over hard soil. The reason is given in commencement of result and discussion section above. The story drift increases due to more flexibility of composite structure.

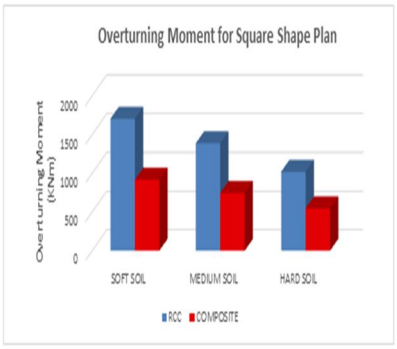



Fig. 19: Overturning moment for Square plan

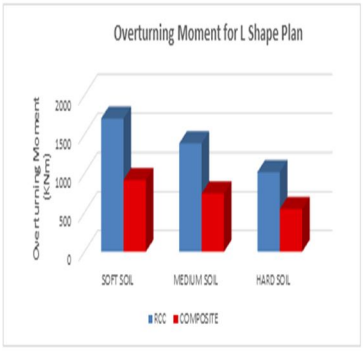



Fig. 20: Overturning moment for L shape plan

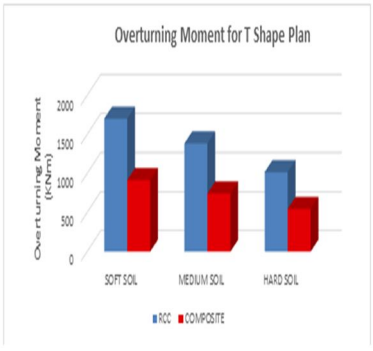



Fig. 21: Overturning moment for T shape plan

As shown in fig 19, fig 20 and fig 21 the overturning moment results show that observed values for square shape plan, L shape plan and T shape plan are 2272967 KNm for (SRCCS,SRCCM and SRCCH), 3486612.16 KNm for (LRCCS, LRCCM and LRCCH ) and 3708718.9546 KNm for (TRCCS, TRCCM and TRCCH) its values decrease upto 796455.9114 KNm for (SCPS, SCPM and SCPH), 1031278.0907 KNm for (LCPS, LCPM and LCPH) and 1164440.3458 for (TCPS, TCPM and TCPH) when using composite structure over soft, medium and hard soil. The reason is given in commencement of result and discussion section above. The overturning moment decreases due to more flexibility of composite structure.

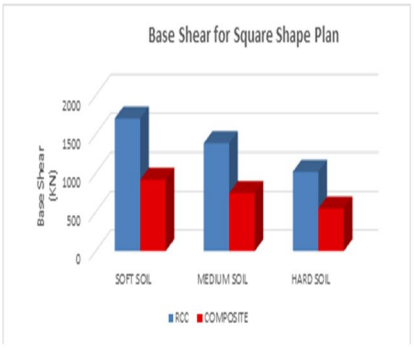



Fig. 22: Base Shear for Square shape plan

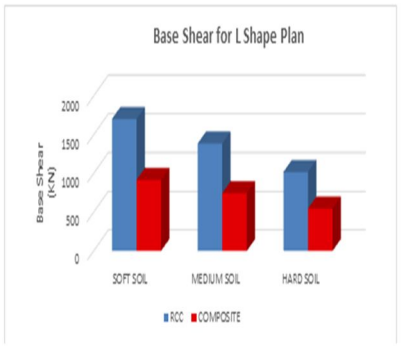



Fig. 23: Base Shear for L shape plan

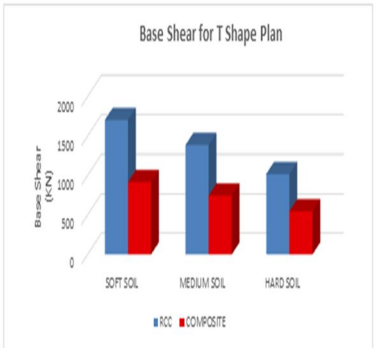



Fig. 24: Base Shear for T shape plan

As shown in fig 22, fig 23 and fig 24 the base shear results show that observed values for square shape plan, L shape plan and T shape plan are 2486.5 KN for (SRCCS), 1835.79 KN for (LRCCS) and 1705.46 KN for (TRCCS) its values decrease upto 1193.969 KN for (SCPS), 827.0219 for (LCPS) and 789.4546 KN for (TCPS) when using composite structure over soft soil. 2024.94 KN for (SRCCM), 1495.01 KN for (LRCCM) and 1388.87 KN for (TRCCM) its values decrease upto 972.3366 KN for (SCPM), 669.02 KN for (LCPM) and 642.9092 KN for (TCPM) when using composite structure over medium soil. 1488.93 KN for (SRCCH), 1099.28 KN for (LRCCH) and 1021.23 KN for (TRCCH) its values decrease upto 714.9534 KN for (SCPH), 495.2227KN for (LCPH) and 472.7273 KN for (TCPH) when using composite structure over hard soil. The reason is given in commencement of result and discussion section above. The base shear decreases due to more flexibility of composite structure.

## V. CONCLUSION

Based on the methodology adopted and analysis of various cases, the results have been evaluated and discussed thoroughly and have reached a conclusion that can be pointed out are as follows:-

*A. Conclusion for Square Shape Plan*

*1)* On comparing all 6 model cases, the time period keeps on decreasing upto 82.30% from every mode shapes and observed minor difference in each case.

*2)* Displacement in X and Y direction shows decreasing values of 43.13% and 42.732% respectively and hence **SCPH** shows efficient case in square shape plan.

3) The storey drift values in X and Y directions shows minimum values in **SCPH** case with decreasing values of 62.671% and 43.575% respectively in square shaped plan.
4) When comparing the overturning moment for square shaped plan, the values trend keeps on decreasing with values upto 35.04 %, and observed least value in SPCS, SCPM and SCPH due to composite structures are lighter in weight and imposed less overturning moment than that of RCC structure.
5) The base shear values on comparing shows same values in both X and Y direction since plan area is symmetrical in both directions. The least values observed in **SCPH** i.e. composite structure on hard soil with decreasing values upto 68.873 %.

*B. Conclusion for L Shape Plan*

1) On comparing all 6 model cases, the time period keeps on decreasing upto 74.28% from every mode shapes and observed least time period for RCC in medium and hard soil.
2) Displacement in X and Y direction shows decreasing values of 82.751% and 70.882 % respectively and hence LRCCH shows efficient case in L shape plan.
3) The storey drift values in X and Y directions shows minimum values in LRCCH case with decreasing values of 83.614% and 72.393% respectively in L shaped plan.
4) When comparing the overturning moment for L shaped plan, the values trend keeps on decreasing with values upto 29.57 %, and observed least value in LPCS, LCPM and LCPH due to composite structures are lighter in weight and imposed less overturning moment than that of RCC structure.
5) The base shear values on comparing shows same values in both X and Y direction since plan area is symmetrical in both directions. The least values observed in LCPH i.e. composite structure on hard soil with decreasing values upto 67.095%.

*C. Conclusion for T Shape Plan*

1) On comparing all 6 model cases, the time period keeps on decreasing upto 81.123% from every mode shapes and observed least time period for RCC in medium and hard soil.
2) Displacement in X and Y direction shows decreasing values of 66.202% and 57.390 % respectively and hence **TRCCH** shows efficient case in T shape plan.
3) The storey drift values in X and Y directions shows minimum values in **TRCCH** case with decreasing values of 47.68% and 57.14% respectively in T shaped plan.
4) When comparing the overturning moment for L shaped plan, the values trend keeps on decreasing with values upto 31.39 %, and observed least value in TPCS, TCPM and TCPH due to composite structures are lighter in weight and imposed less overturning moment than that of RCC structure.
5) The base shear values on comparing shows same values in both X and Y direction since plan area is symmetrical in both directions. The least values observed in **TCPH** i.e. composite structure on hard soil with decreasing values upto 67.838 %.

This project concluded that when comparing all the result parameters, in different plan areas, in case of story displacement and drift, SRCCH, LRCCH and TRCCH values shows lesser values since the stiffness of RCC members are more than composite structure. In all other output result parameters, composite values seems efficient values and hence should be recommended that when this type of construction procedure adopted, use of composite structure performs well and can be used with building stability techniques, the displacement factors can be minimized for composite structures.

## VI. FUTURE SCOPE

1) This project concluded that when using composite structure the parameters that affect building stability increases. This work can be further extended to usage of different types of composite materials.
2) Different software's can be used for further research for comparative analysis.
3) This project can further be extended with analysis over actual soil conditions with geotechnical investigation report of an actual area.
4) This work can be extended for different cities, so that the recommendations of the usage of light weight concrete can be predicted for the selected city.
5) This project worked out on square shape, L shape and T shape plan area. The work can also be extended for different plan areas especially for vertical irregularities

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## VII. ACKNOWLEDGEMENTS

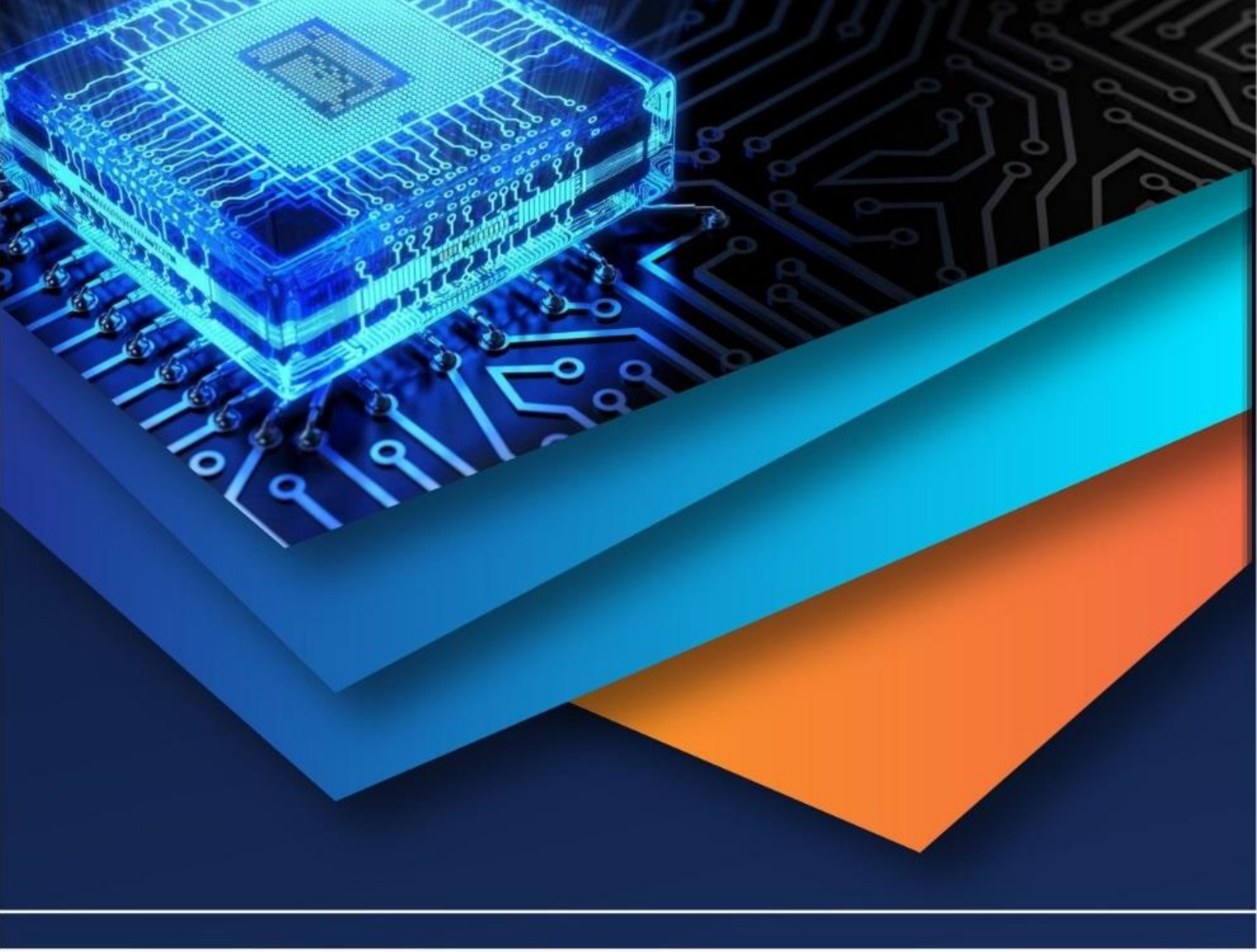
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