Wind Analysis of Tall Building Consists of Different Framing Systems over the Height

Rahul M[1] Dr.G.Narayana[2] Sajeet.S.B[3]
[1]PG Student [2]Professor & Head [3]Structural Engineer
[1,2,3]Department of Civil Engineering
[1,2]S.J.C.I.T, Chickballapur, Karnataka, India [3]Bangalore, Karnataka, India

Abstract— In the present days, reinforced concrete and steel structures are mostly used since, these two have been the most convenient and economic system for a low rise buildings. However, for a medium to high rise buildings this kind of structures are hazardous and is no longer economic due to reduced stiffness, increase in dead load and span limitation. So it has been a challenging task for the structural engineers in striving for the most economic and effective design solution. So the composite material usage is of particular interest, due to its capability in improving the overall performance of structure. In India, many structural engineers are unwilling to accept the usage of composite steel-concrete structure because of complication in its analysis and design. But the literature describes that with proper configuration, the composite system can afford an exceptionally effective structural system with high strength and better wind performance characteristics. The present study discusses the wind response of regular and vertical irregular tall building by using different framing systems over the height of the building. So, among all these frame types concrete will be the better option but in addition to this we have an another option that is the Combined model which is preferable in places where the wind response is more on buildings. So to optimize this wind response, a Combined model of RCC, Steel and Composite frames as combination has been developed and is analyzed using ETABS software, and there by the combined model has proven to be the better option.

Key words: Wind, Tall Building, RCC Structure, Vertical Irregular Building

I. INTRODUCTION

In general, the wind blows towards a ground surface at a high wind speeds in the horizontal direction. The air that flows in a large scale is said to be global atmospheric circulations and the strong winds that generates is nearly related to these kind of circulations and in addition to a temperature differences of smaller scale.

In the structural engineers point of view the wind may be defined as the lateral load which likely to cause an increase in forces and the larger moments over the tall buildings. The cities in many developing countries around the world are developing very rapidly, with a growth in vertical buildings are primarily to common feature. This is because the expansion in horizontal has almost reached the saturation point. In addition to this there is an adequacy of a land in many metropolitan cities, so there by it is must and should to know about the tall buildings and their wind load effects over the building. It has been an immense confront for the engineers in order to diminish the wind load on the tall structures.

In the present days, because of rapid growth in population, a special attention has been given in construction of tall buildings at many places. It is essential to consider the consequence of wind with its intend as the building becomes tall over the height.

II. OBJECTIVES

The main objectives of this present study is listed as follows

1) To study the wind response of regular and vertical irregular tall building by using different framing systems like RCC, Steel and Composite individually.
2) To study the wind response of regular and vertical irregular tall building by combining the different framing systems such as RCC, Steel and Composite over the 1/ 3rd height of the building.
3) To compare the above two cases.

III. PRESENT STUDY

In the present study, the different framing systems like RCC, Steel and Composite over the height of building are used. In these framing systems the each system may varies with their properties like density. The maximum density based on these three materials is steel and the minimum is RCC. Whereas, the density of composite material lies in between RCC and steel.

Based on this one can say that the response of steel framing system will be more than the other framing systems. Hence in the present study discusses the combination of different framing systems over the height, this combination reduces the wind response drastically.

IV. MODELING AND ANALYSIS

This study includes the modeling and analysis of different models using ETABS 9.7.4 software. Equivalent static wind analysis is carried out on models.

A. Modeling Details of Regular Building

The structural details of regular buildings which is adopted in the study is as follows
Plan**:** 30m x 14m
Number of Stories**:** 20
The storey height (Floor to Floor height)**:** 3.2m
Number of bays**:** In (X and Y direction) = (5 & 3)

It has a uniformly distributed mass over the height of building. The structural plan is as shown in figure 1.

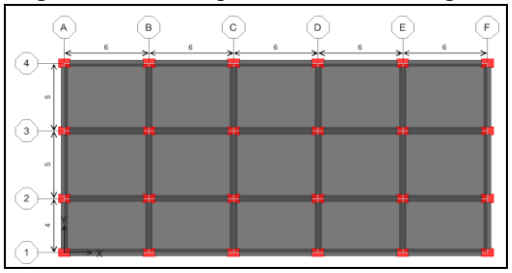

Fig. 1: Structural plan

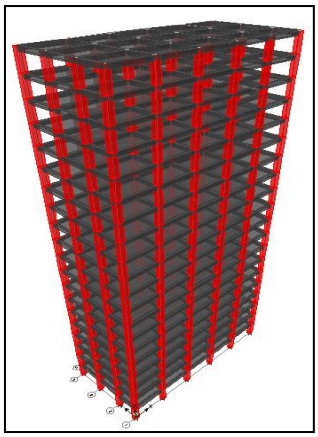

Fig. 2: 3D View of Regular building

B. Vertical Irregular Building

In the vertical irregular building, the building plan will be symmetrical that is the dimensional plan will be of 30m x 14m from ground floor to 7th floor as shown in figure 3. Then from 8th floor to top floor the building plan will be unsymmetrical that is the dimensional plan will be of 12m x 14m over the height of building as shown in figure 4. The entire building which appears to be in 'L' shape. The structural model will have the same storey height of 3.2m.

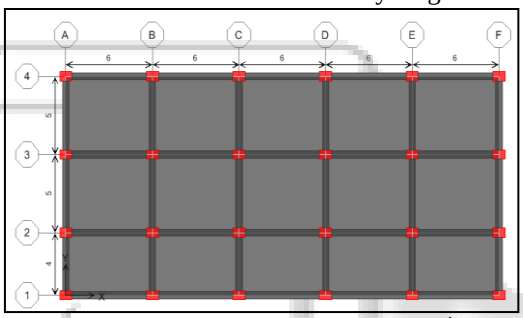

Fig. 3: Plan view from Ground Floor to 7th Floor

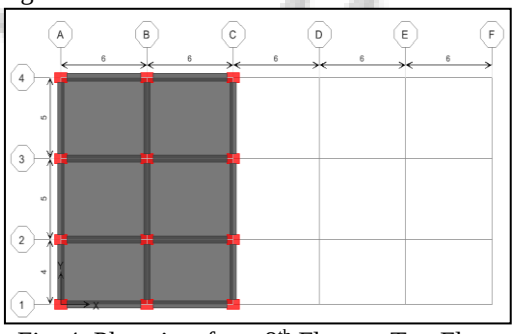

Fig. 4: Plan view from 8th Floor to Top Floor

C. Models Considered for the Analysis

The models considered for the analysis of regular and vertical irregular building is as follows.

- MD 1: Regular RCC Model.
- MD 2: Regular Steel Model.
- MD 3: Regular Composite Model.
- MD 4: Regular Combined model.
- MD 5: Vertical irregular RCC model.
- MD 6: Vertical irregular Steel model.
- MD 7: Vertical irregular Composite model.
- MD 7: Vertical irregular Combined model.

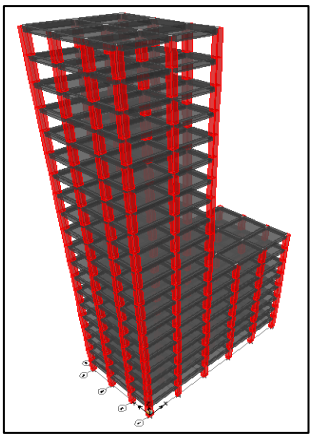

Fig. 5: 3D View of Vertical irregular Building

D. Material Properties and Structural Details

Grade of concrete	M30 for Slab and Beam
Grade of concrete	M 35 for Column
Grade of Steel	Fe 500 HYSD Bars
Density of Concrete	25 KN/m^3
Density of Steel	78.5 KN/m^3
Floor to Floor height	3.2m
Slab Thickness	150 mm
Wall Thickness	230 mm
Restraints	Fixed at Base
Diaphragm	Rigid type
Live load on floor	4 KN/m^2
Live load on roof	1.5 KN/m^2
Wind speed	33 m/s
Terrain Category	II
Building Class	C

Table 1: Building Details

Model Type	Column (Mm)	Beam (Mm)	Slab (Mm)
Type 1(RCC)	600X850	450X600	150
Type 2(Steel)	2ISMB600	ISMB550	150
Type3 (Composite)	600X850 + 2ISMB600	ISMB550	150
Type4 (Combined)	GF to 6F – 600X850	450X600	150
	7F to 13F – 600X850 + 2ISMB600	ISMB550	150
	14F to TF – 2ISMB600	ISMB550	150

Table 2: Structural Section Details

V. RESULTS AND DISCUSSIONS

A. Regular Building

1) Time Period (sec)

The value of Time Period (T), usually depends on flexibility of building and the mass, if greater the flexibility, the longer will the time period and if more the mass, longer will be the time period.

The figure 6 shows that, with increase in number of modes the time period has decreased consistently. Also It has been observed that the time period of MD2 (Steel model) is maximum and minimum is in MD4(Combined model) and MD1(RCC model). With this we can say that in

Combined and RCC model the flexibility and mass is less when compared to Composite and Steel model.

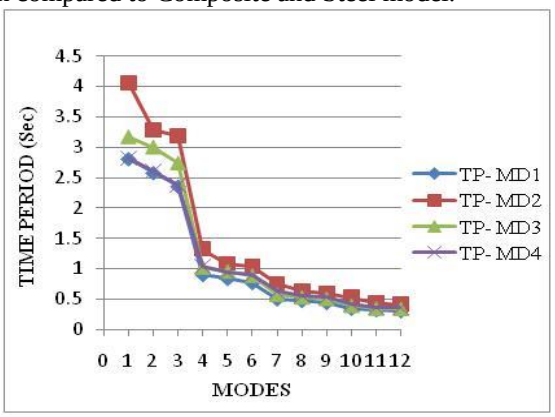

Fig. 6: Time Period Vs Modes

2) Frequency (Hz)

The frequency may generally be defined as the number of Cycles per unit time.

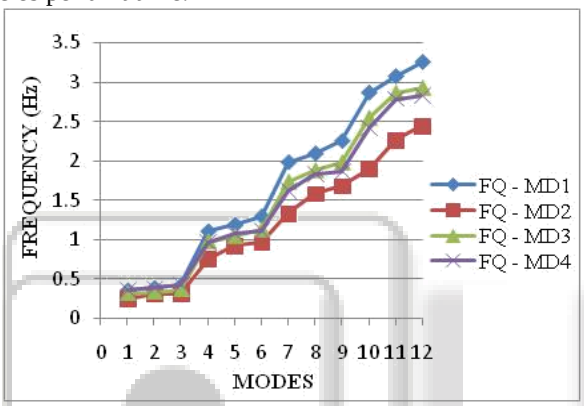

Fig. 7: Frequency Vs Modes

The figure 7 shows that, with increase in number of modes the frequency has also increased consistently. Also it has been observed that the frequency of MD1(RCC model) and MD4(Combined model) is maximum and minimum is in MD2(Steel model).

3) Displacement (mm)

The displacement of structure has reduced due to increase in the stiffness of structure.

From figure 8 and figure 9 it is observed that, the maximum displacement among all four models is in MD2 (Steel model) and minimum is in MD1 (RCC model) and the MD4 (Combined model) which also shows considerably less displacement when compared to Steel and Composite model. Further it is observed that the displacement of stories has increased steadily over the height of building.

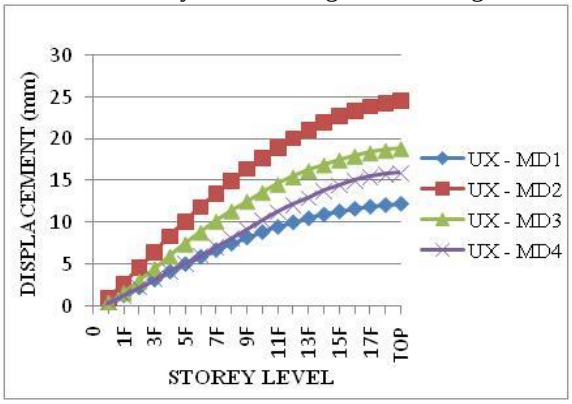

Fig. 8: Displacement - X Vs Storey Level

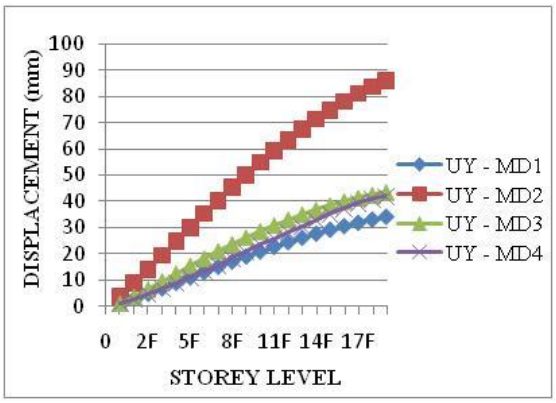

Fig. 9: Displacement - Y Vs Storey Level

4) Storey Drift

The storey drift is the displacement of an one level in relation with other level may be above or below.

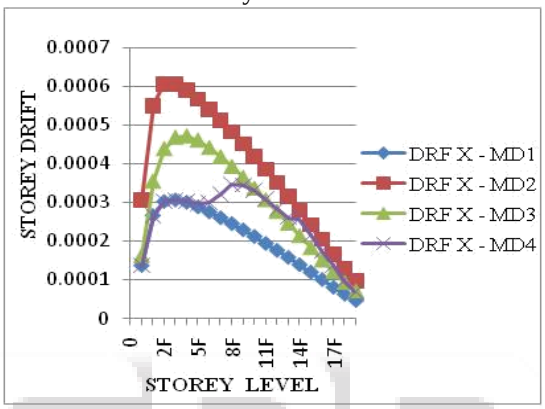

Fig. 10: Storey Drift - X Vs Storey Level

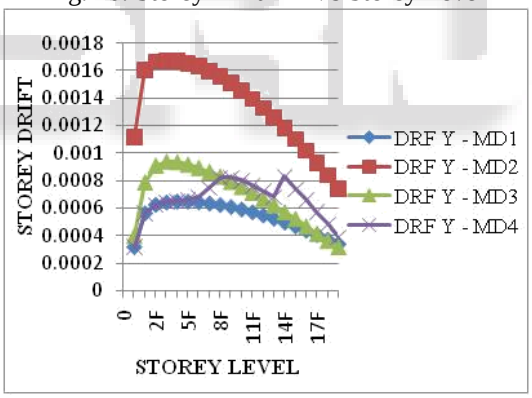

Fig. 11: Storey Drift - Y Vs Storey Level

The above figure 10 and figure 11 shows that the storey drift increases from bottom to middle stories and finally decreases towards the top stories.

5) Storey Shear (KN)

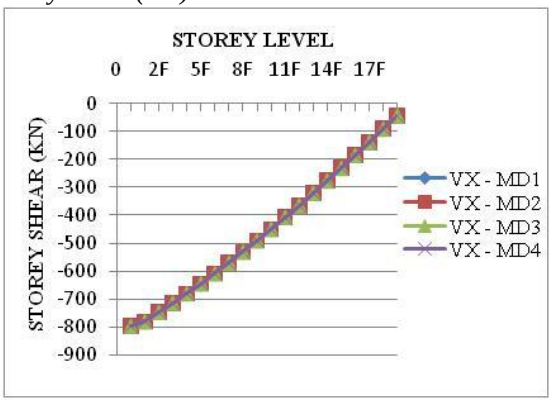

Fig. 12: Storey Shear – X Vs Storey Level

It is referred as the summation of design lateral forces considerably at levels above the storey under suitable consideration.

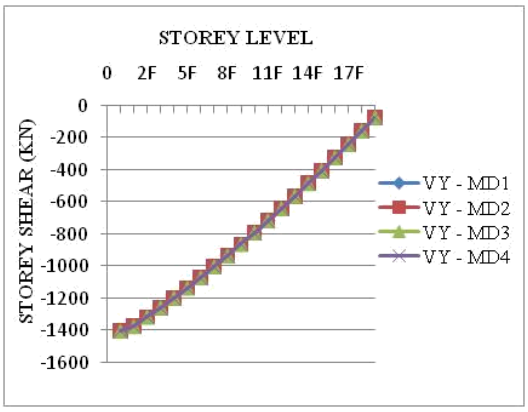

Fig. 13: Storey Shear -Y Vs Storey Level

The figure 12 and figure 13 shows that all four models have similar storey shear values and it is observed that the storey shear has decreased consistently from bottom to upper stories.

B. Vertical Irregular Building

1) Time Period (sec)

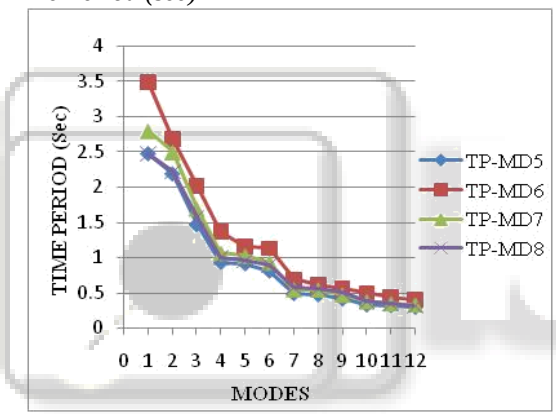

Fig. 14: Time Period Vs Modes

From figure 14 it has been observed that the time period of MD6 (Steel model) is maximum and minimum is in MD5 (RCC model) and MD8 (Combined model).

2) Frequency (Hz)

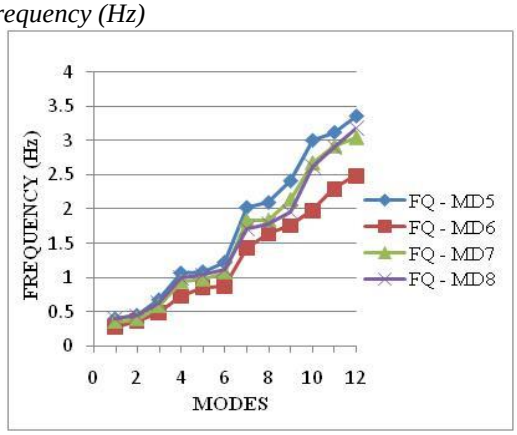

Fig. 15: Frequency Vs Modes

From figure 15 it has been observed that the Frequency of MD5 (RCC model) and MD8 (Combined model) is maximum and minimum is in MD6 (Steel model). The value of frequency usually depends on time period.

3) Displacement (mm)

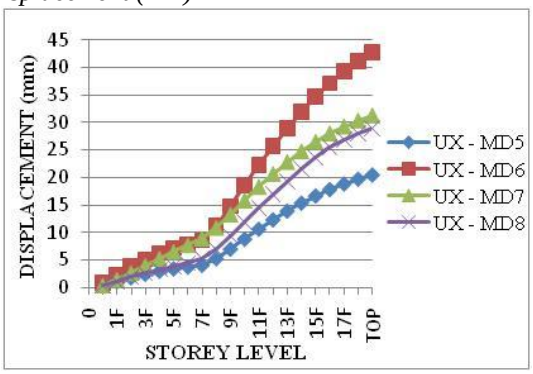

Fig. 16: Displacement – X Vs Storey Level

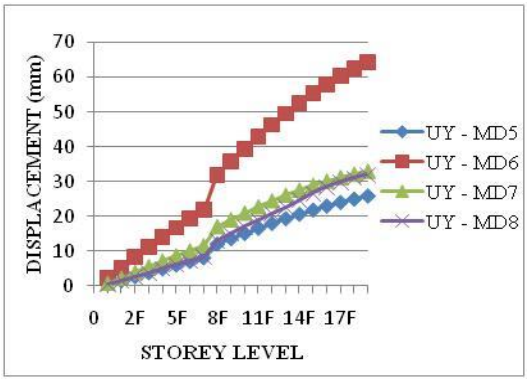

Fig. 17: Displacement – Y Vs Storey Level

The figure 16 and figure 17 shows that the maximum displacement is in MD6 model and minimum is in MD5 and MD8 model also shows less displacement when compared to MD6 and MD7 model.

4) Storey Drift

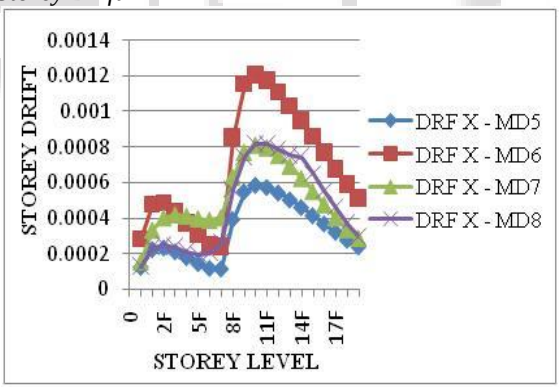

Fig. 18: Storey Drift – X Vs Storey Level

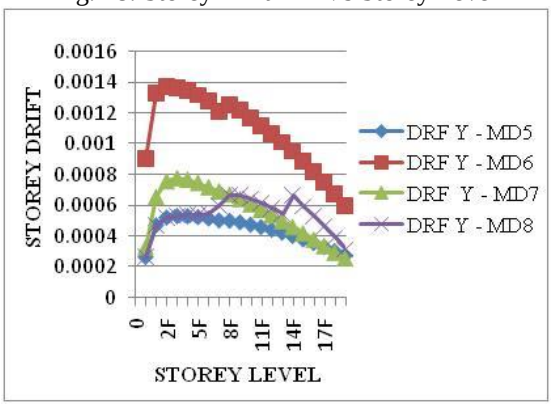

Fig. 19: Storey Drift - Y Vs Storey Level

5) Storey Shear (KN)

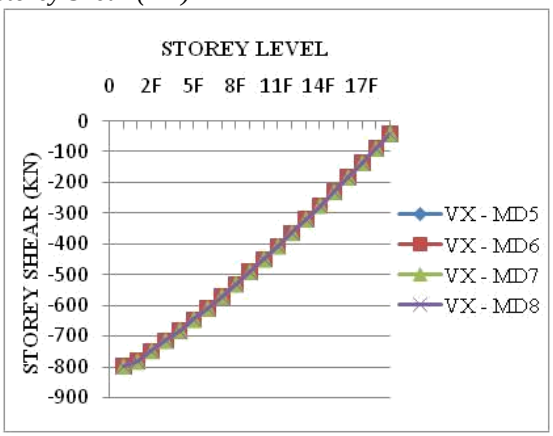

Fig. 20: Storey Shear – X Vs Storey Level

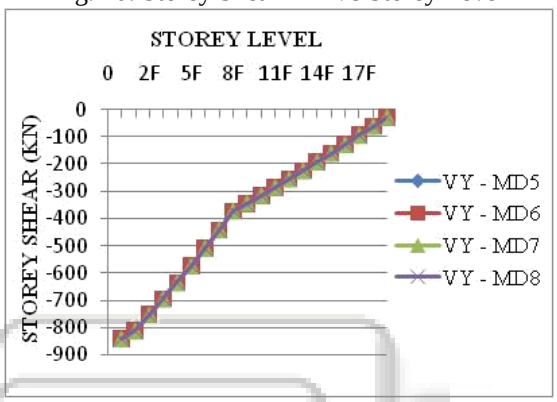

Fig. 21: Storey Shear -Y Vs Storey Level

VI. CONCLUSIONS

From the above study on regular and vertical irregular tall buildings it is to be concluded that.

1) The study has come across the variable effects of wind with reference to different frames. Also it comparatively differentiates the wind effects over the height of the building.
2) The wind analysis has given an idea about the behavior of combined model with the effect of wind on it.
3) The study has come across that response of wind is more on Steel frame when compared to other frame types such as RCC, Composite and Combined model.
4) The time period at the 1st mode in the Combined and the RCC model is less when compared with Steel and Composite model.
5) The frequency at the 1st mode in the Combined and RCC model is merely more than in Composite model and is less in Steel model when compared with all three models.
6) The displacement in Combined model is predominantly less than in Steel and Composite model. And is almost less in RCC model when compared with above three models.
7) The displacement in the Combined model has reduced by 35% to 55% when compared with Steel model and by 15% to 32% when compared with Composite model in 'X' direction. Similarly, in 'Y' direction it has reduced by 51% to 72% when compared with Steel model and by 3% to 29% when compared with Composite model.
8) The storey drift in Combined and RCC model is less at the bottom and middle stories than in Steel and Composite model.
9) The wind response of the vertical irregular building is same as regular building but with different values. And even in this case the combined irregular model is comparably better than Steel and Composite model.
10) The displacement in combined model has reduced by 32% to 55% when compared with Steel model and by 8% to 43% when compared with Composite model in 'X' direction. Similarly in 'Y' direction it has reduced by 50% to 72% when compared with Steel model and also by 2% to 29% when compared with Composite model.
11) From the above study it is to be concluded that Combined and RCC model is proven to be the best option for the region were the wind response is more on building.
12) In present days, the RCC structures have been the most widely used structural system as it is most convenient and effective system. But in addition to this we have an another better option of Combined structure which is innovative and trendy to the present market and has also proven to be the effective system from the above study.

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