Effect of Timber Members on Structures under Seismic Loading

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***Abstract*— The sustainability of Reinforced Cement Concrete material and its structures will play predominant role in creating environmental impacts. The alternative material for construction of multi-story structures is the need of hour. The substitute material should be compatible for construction as well as should sustained the seismic forces during earthquake. The substitute material taken is Timber, being an orthogonal in nature, behaves differently from RCC with respect to elastic and physical properties. Here, G+9 RCC structure and G+4 timber strucure are considered to find the seismic compatibility of structure. G+4 timber model, RCC- timber model, steel- timber model are considering for the dynamic loading analysis. The building modeled in ETABS software using different material properties. The high self-weight and brittleness of concrete is not favorable to seismic prone structures whereas steel structures are 60% lesser in weight through they can withstand earthquake more effectively than the concrete structures.**

Keywords—Steel frame; RCC frame; Timber frame; Seismic Analysis; ETABS2016

I. INTRODUCTION

Concrete is a material that literally holds different places together. From row houses and apartment buildings to bridges, viaducts and sidewalks, this inescapable grey material's importance to modern urban life is undeniable. Despite of its undeniable importance in day-to-day construction purpose, many research scholars, environmentalists and construction engineers are seeking for a complete alternate material to RCC, due to increasing amount of severe harmful environmental impact of material. There are however a number of alternative green building materials that offer alternatives to concrete, and a lower environmental impact. And one of those alternative material is Wood or Timber. Timber still retains many advantages over more industrial building materials like concrete or steel.

In India most of the people approached towards the concrete structure instead of steel as they find concrete as convenient and cost effective in nature. But as India is becoming worlds second most populous country and the area is just limited then vertical hike is in the building construction is very necessary. So, for construction of this multistoried building steel can be a truly effective material in all engineering aspect. The use of steel as a core construction material is not yet become prevalent in India as it is in other developing where maximum construction both commercial and residential high rise structures are being built of steel. It is very stiff and they possesses high strength to weight ratio which shows great integrity against the seismic loading.

II.LITERATURE REVIEW

Anuj Domale, L.G.Kalurkar (2018) presented a paper on Seismic Analysis of RCC and Steel Frame Structure by Using ETABS. The study an attempt has been made to analyze the seismic behavior of RCC and steel frames using Etabs 2015.The high self-weight and brittleness of concrete is not favorable to seismic prone structures whereas steel structures are 60% lesser in weight through they can withstand earthquake more effectively than the concrete structures. Aim of the study to compare the seismic performance of G+6 and G+9 frames for both steel and RCC. For current study all frames are analyzed under equivalent static method.

Shubham Bhutada, P.D. Pachpor, A.K. Sharma (2019) presented a paper on research on RCC and Timber Multi-Storey Structures using Response Spectrum Search. In this study two geometrically identical multi-story structures are compared to find the seismic compatibility of timber structure as compared to RCC structure. Both the buildings were modelled in ETABS software using different material properties, RCC and Timber, and were analysed using Response Spectrum Analysis. Different parameters were studied and compared for both the buildings like, shear force, bending moment, lateral story displacement and story shear. After analysis, it was concluded that timber structures can be built with lighter sections as that of RCC. And due to much more flexibility of Timber Structures, proper design of connections and their adequate strength is required to increase the stiffness of timber structures.

Zheng Li , , Minjuan He , Xijun Wang , Minghao Li (2018) presented a paper on Seismic performance assessment of steel frame infilled with prefabricated wood shear walls. Steel-timber hybrid structural systems offer a modern solution for building multi-story structures with more environmentally-friendly features. This paper presents a comprehensive seismic performance assessment for a kind of multi-story steel-timber hybrid structure. In such a hybrid structure, steel moment resisting frames are infilled with prefabricated light wood frame shear walls to serve as the lateral load resisting system (LLRS). In this paper, drift-based performance objectives under various seismic hazard levels were proposed based on experimental observations. Then, a numerical model of the hybrid structure considering damage accumulation an stiffness degradation was developed and verified by experimental results, and nonlinear time-history analyses were conducted to establish a database of seismic responses.

Prof. S. S. Charantimath, Prof. Swapnil B.Cholekar, Manjunath M. Birje (2014)) presented a paper on Comparative Study on Structural Parameter of R.C.C and Steel Building. This paper shows research on composite column, composite beam and deck slab in which structural steel section are encased in concrete have been carried out. However, for medium to high-rise buildings R.C.C structure is no longer economic because of increased dead load, less stiffness, span restriction and hazardous formwork. The results of this work show that the Composite structures are the best solution for high rise structure as compared to R.C.C structure.

III.FRAME DETAILS

In the present study G+9 of RCC structure in zone IV are being analyzed by equivalent static method by using ETABS2016 software. In case of RCC structure, all structural members are considered as per IS 456:2000.The basic planning and loading for the RCC structure is kept similar for the study. The load pattern, details of RCC frame structure are as shown below:-

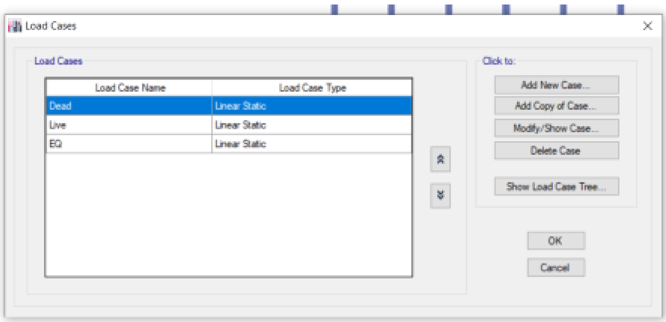

Fig. 1 Types of loading.

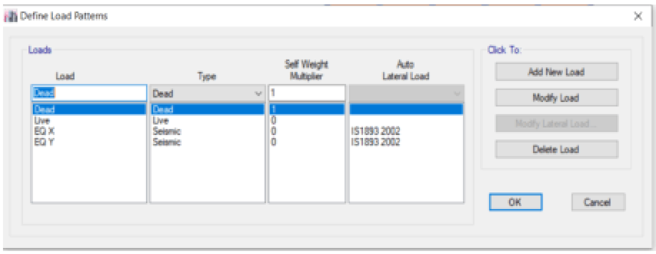

Fig. 2:- Load patterns.

TABLE 1 Structural Member Details

PARTICULARS	RCC
NO OF STORY	G+9
TOTALSTORYHEIGHT	30m
BEAM SIZE	400X600mm
COLUMN SIZE	500x700mm
SLAB/DECK	150mm

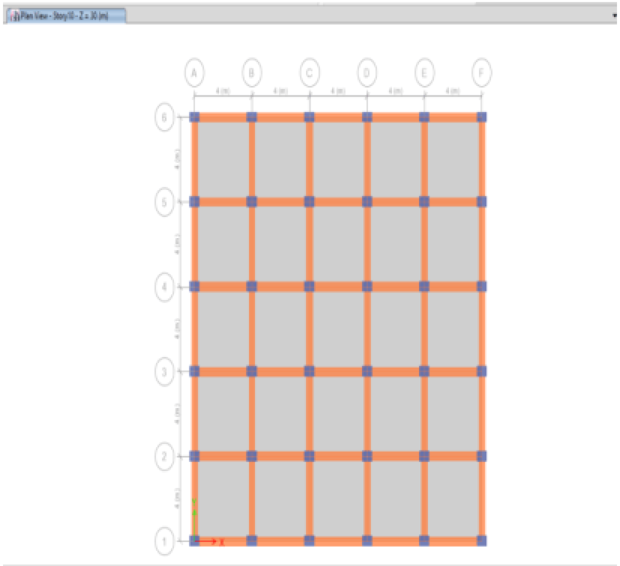

Fig.3 Plan of RCC Structure

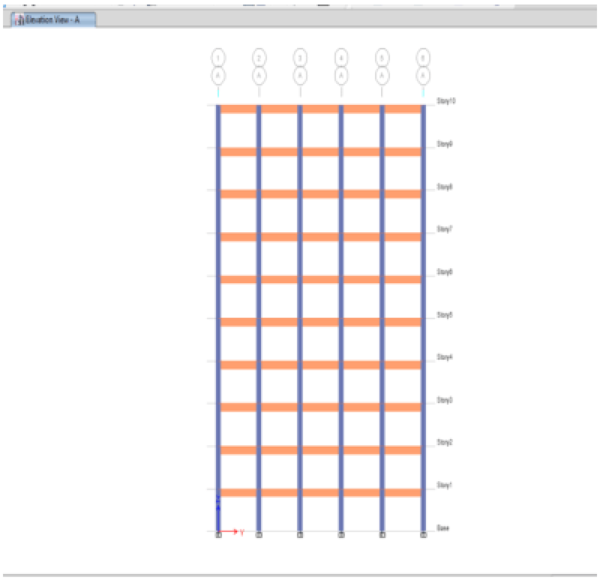

Fig. 4 Elevation of RCC Structur

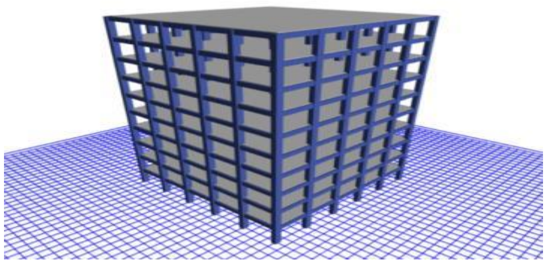

Fig. 5 3D view of RCC structure

IV.METHODOLOGY

The present study deals with equivalent static method for seismic analysis of G+9 frame structure for RCC. The analysis of the building model is run in software ETABS2016. For the analysis the parameters like, Time Period, Base Shear, Lateral forces are studied significantly for the loading.

Analysing the result and considering a G+4 timber structure model , RCC- timber model, and steel-timber model. Here RCC structural members are replacing with steel and timber members and analysing the models with linear dynamic loading. Seismic code varies with the every region across the country. In India standard criteria for earthquake resistant design of structures IS 1893(PART-1):2002 is the main code which gives the idea about the seismic design force according to the various zones. Finally to prove that steel buildings are safe in seismic prone zones.

V. RESULT

a. After calculating time period of RCC structure, the value of highest time period for RCC structure of G+9 is 1.126 sec.

Modal Periods and Frequencies

Case	Mode	Period sec	Frequency cyc/sec	Circular Frequency	Eigenvalue rad²/sec²
Modal	1	1.126	0.888	5.5784	31.1189
Modal	2	1.012	0.988	6.2086	38.5468
Modal	3	0.946	1.057	6.6414	44.1085
Modal	4	0.369	2.711	17.0351	290.1948
Modal	5	0.327	3.06	19.2281	369.7198
Modal	6	0.309	3.239	20.3515	414.1854
Modal	7	0.213	4.686	29.4419	866.8252
Modal	8	0.185	5.415	34.0246	1157.6708
Modal	9	0.178	5.615	35.2811	1244.7565
Modal	10	0.147	6.795	42.6969	1823.0277
Modal	11	0.124	8.076	50.7445	2575.0023
Modal	12	0.121	8.239	51.7658	2679.6999

Fig. 6:- Time period from validation of RCC Structure

b. From the obtained result Base Shear for RCC frame

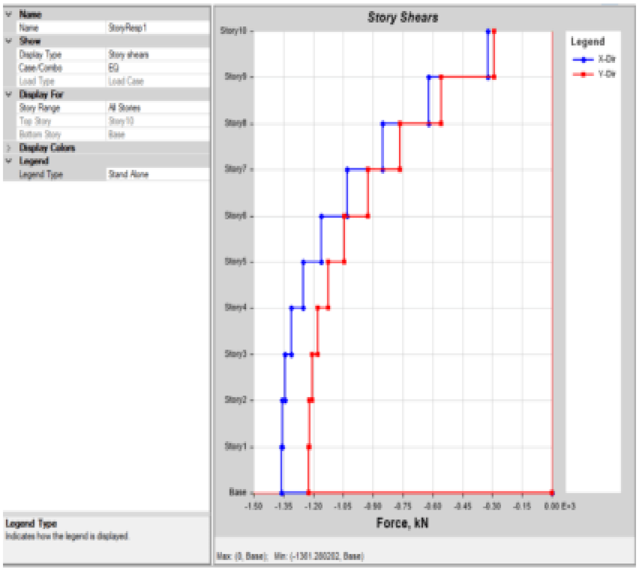

Fig. 7 Base shear from validation of RCC Structure.

structure is 1361.28 KN. Seismic weight of RCC frame structure is more structure because of its greater dense cross-section of structural member.

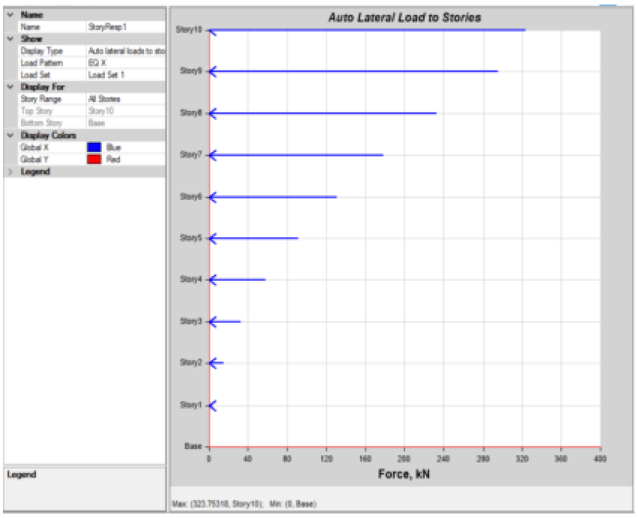

Fig. 8:- Lateral force effect from validation of RCC Structure

c. Graph shows lateral forces acting on RCC under seismic loading. The lateral forces can produce critical stresses in the structure, induce undesirable vibrations or cause excessive lateral sway of the structure. Seismic weight of RCC frame structure is more structure because of its greater dense cross-section of structural member.

Table shows the result obtained after validation of G+9 RCC structure under seismic loading.

TABLE 2 Result obtained after validation.

Parameters	**Journels**	**ETABS**	**% Error**
BASE SHEAR	1360 KN	1361.28 KN	0.09
LATERAL LOAD	325 KN	323.75 KN	0.38
TIME PERIOD	1.14 sec	1.126 sec	1.20

- The value of base shear obtained is 1361.28KN.
- The value of time period obtained 1.126 sec.
- The value of lateral load obtained is 323.75 KN.
- The value of base shear, time period, lateral load obtained from analysis of G+9 RCC structure in ETabs is approximately valid while comparing with journal(Seismic Analysis of RCC and Steel Frame Structure By Using ETABS).

A. RESPONSE SPECTRUM ANALYSIS OF G+4 TIMBER STRUCTURE

Considering G+4 timber structure for analysis of parameters. Property, load cases, load pattern details of timber frame structure are as shown below:-

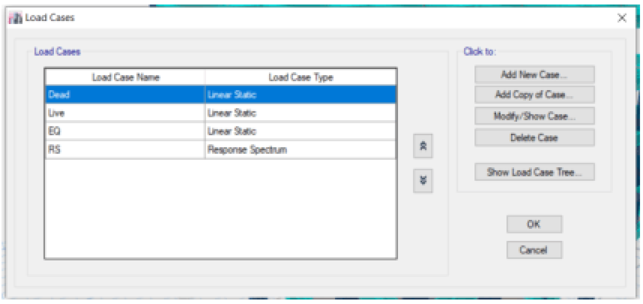

Fig. 9 Types of loading

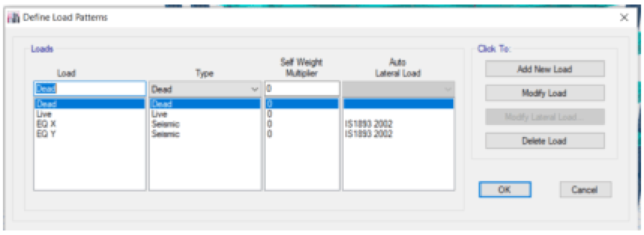

Fig.10 Load patterns.

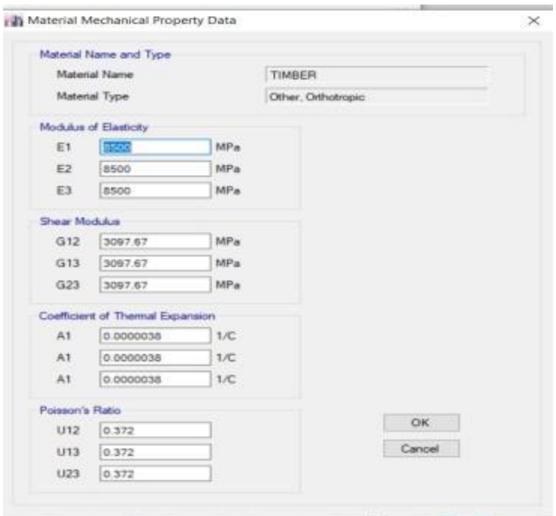

Fig. 11 Material property

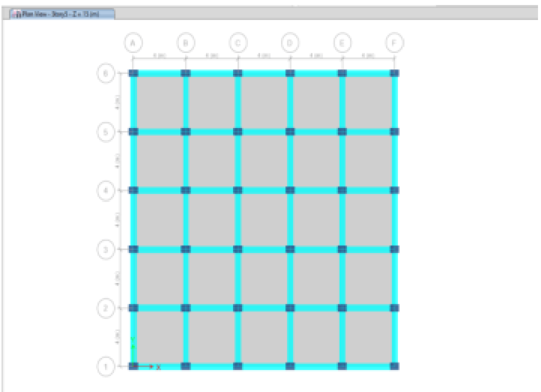

Fig. 12 Plan of timber Structure

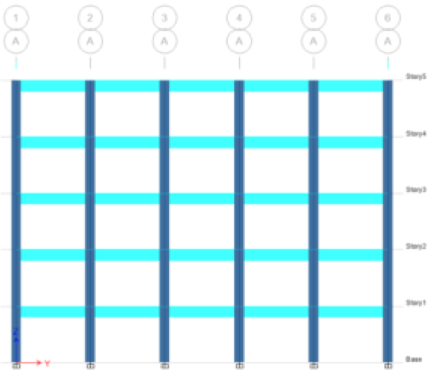

Fig. 13 Elevation of timber Structure

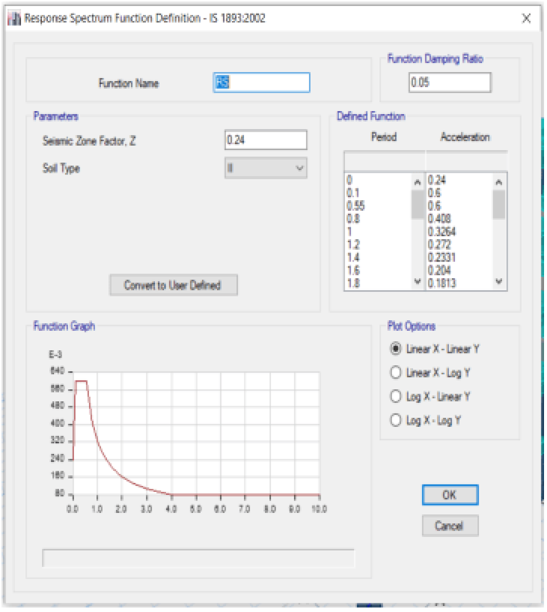

Fig. 14 Response spectrum function

VI. RESULT

The result obtained by the Response spectrum analysis of G+4 timber structure are:-

1. After calculating story displacement of timber structure,the value of highest story displacement for timber structure of G+4 is 4.52 mm.

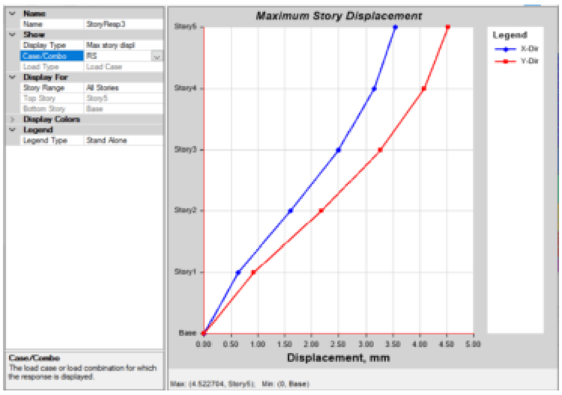

Fig. 15 story displacement using Response spectrum Analysis of timber structure

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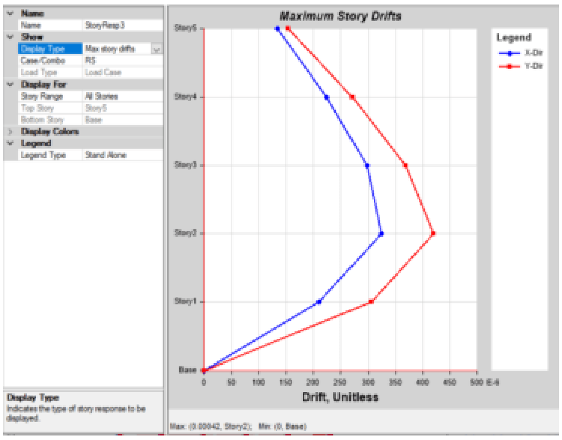


Fig. 16 Story drift using Response spectrum
Analysis of timber structure

2. From the obtained result story shear for timber frame structure is 349.9 KN.

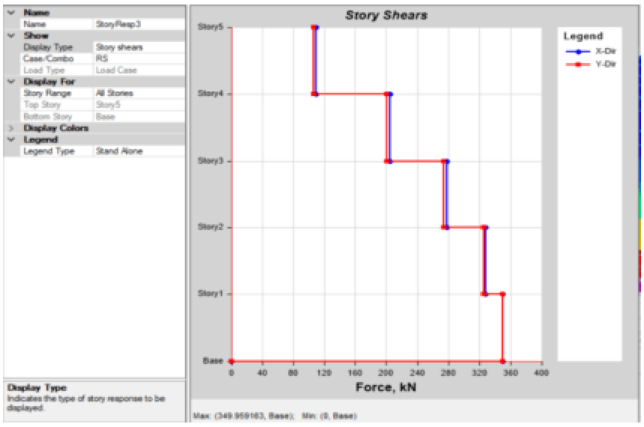
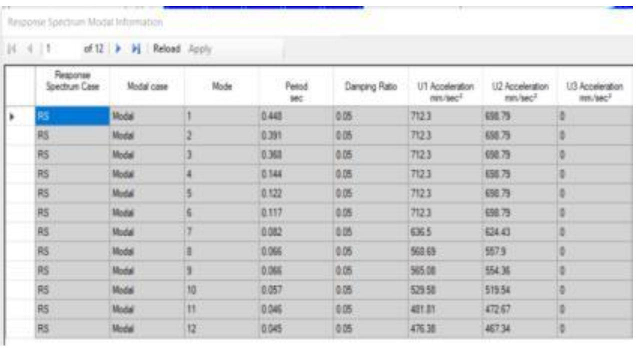


Fig. 4 story shear using Response spectrum
Analysis of timber structure

3. After calculating time period of timber structure, the value of highest time period for timber structure of G+4 is .448 sec



Response Spectrum Case	Modal case	Mode	Period sec	Damping Ratio	U1 Acceleration mm/sec²	U2 Acceleration mm/sec²	U3 Acceleration mm/sec²
RS	Modal	1	0.448	0.05	712.3	698.79	0
RS	Modal	2	0.391	0.05	712.3	698.79	0
RS	Modal	3	0.368	0.05	712.3	698.79	0
RS	Modal	4	0.144	0.05	712.3	698.79	0
RS	Modal	5	0.122	0.05	712.3	698.79	0
RS	Modal	6	0.117	0.05	712.3	698.79	0
RS	Modal	7	0.082	0.05	636.5	624.43	0
RS	Modal	8	0.066	0.05	568.69	557.9	0
RS	Modal	9	0.066	0.05	565.08	554.36	0
RS	Modal	10	0.057	0.05	529.58	519.54	0
RS	Modal	11	0.046	0.05	481.81	472.67	0
RS	Modal	12	0.045	0.05	476.38	467.34	0

Fig. 4 Time period using Response spectrum
Analysis of timber structure

VII. CONCLUSION

The major conclusions drawn from present study are as follows:-

1. Time period for RCC frame structure is more as compared timber structure due higher mass of RCC frame Structure.
2. The Base shear found in RCC framed structure is more as compared to Steel frame structure.
3. Value of base shear obtained for RCC and timber frame structures are 1361.28KN and 349.9 KN respectively.
4. Seismic weight of RCC frame structure is more than Steel Frame structure because of its greater dense cross-section of structural member.
5. From the study it is concluded that RCC and timber combined design, make it a safe choice in seismic zone for greater performance of structure.

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