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DYNAMIC ANALYSIS OF MULTI STOREY STRUCTURE WITH STEEL ENCASED CONCRETE COLUMNS AND RCCCOLUMNS

[1]Savula Harish[2]Shaik.Bajamma

[1] PG scholar, Department of civil, ST.Mary's Group of institutions
[2] Assistant professor, Department of civil, ST.Mary's Group of institutions

ABSTRACT:
An extensive study has been carried out on the behavior of composite column in a structure. In composite column construction steel and concrete are united in such a manner that the advantages of the materials are employed in an efficient manner. By bonding and friction between steel and composite material these materials will accept the external loading in composite columns.

In this study comparison of composite and conventional structure is carried out. Just varying the design of column i.e., by using composite and conventional column and keeping all other structural members same for both the structures. Composite column design is carried out according to Euro code 4 and conventional column design is by IS 456-2000. The buildings are taken to be true to be placed in III seismic zone. Seismic design is followed by IS 1893-2002. There are many different types of composite column from those we have taken concrete encased composite column for our analysis. Concrete encasement would increase the load resistance of steel column. During seismic activity the response of structure is also influenced by the material property which depends on the materials and also its configuration in the structural system. The base of the structure is assumed to be fixed. The building height is 30 m which comes under low rise building. Modeling and analysis has been carried in ETABS software. The results are obtained of various parameters such as time period, mode shapes, storey displacements, storey drifts, storey shears and storey stiffness, thus by obtaining those results graphs have been plotted. And comparison of two different type of structure has been done. Thus, we found that the composite structure is more efficient and can resist more earthquake load than the conventional RCC structure

1 INTRODUCTION

1.1 General

In India most of the building structures fall under the category of low rise buildings. So, for these structures reinforced concrete members are used widely because the construction becomes quite convenient and economical in nature. But since the population in cities is growing exponentially and the land is limited, there is a need of vertical growth of buildings in these cities. So, for the fulfillment of this purpose a large number of medium to high rise buildings are coming up these days. For these high rise buildings it has been found out that use of composite members in construction is more effective and economic than using reinforced concrete members. The popularity of steel-concrete composite construction in cities can be owed to its advantage over the conventional reinforced concrete construction. Reinforced concretes frames are used in low rise buildings because loading is nominal. But in medium and high rise buildings, the conventional reinforced concrete construction cannot be adopted as there is increased dead load along with span restrictions, less stiffness and framework which is quite vulnerable to hazards.

1.2 Columns

A column can be defined as a vertical structural member designed to transmit a compressive load. It might transfer loads from a ceiling, floor slab, roof slab, or from a beam, to a floor or foundations. Commonly, columns also carry bending moments about one or both of the cross-section axes. Hence it should be realized that the failure of a column results in the collapse of the entire structure. The design of a column should therefore receive importance.

In the modern construction industry, Columns are mostly constructed by concrete; apart from that materials such as Wood, Steel, Fiber-reinforced polymer, Cellular PVC, and Aluminium too are been used. The type of material is been decided on the scale, coast and application of the construction.

There are several types of columns which are used in different parts of structures.Columns are classified based on the several conditions which include:

1.3 Buckling

In engineering, buckling is the sudden change in shape of a structural component under load such as the bowing of a column under compression or

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the wrinkling of a plate under shear. If a structure is subjected to a gradually increasing load, when the load reaches a critical level, a member may suddenly change shape and the structure and component is said to have buckled.

Buckling may occur even though the stresses that develop in the structure are well below those needed to cause failure in the material of which the structure is composed. Further loading may cause significant and somewhat unpredictable deformations, possibly leading to complete loss of the member's load-carrying capacity. However, if the deformations that occur after buckling do not cause the complete collapse of that member, the member will continue to support the load that caused it to buckle. If the buckled member is part of a larger assemblage of components such as a building, any load applied to the buckled part of the structure beyond that which caused the member to buckle will be redistributed within the structure. Some aircraft are designed for thin skin panels to continue carrying load even in the buckled state.

1.4 Euler's Theory of Column Buckling

The Euler's theory states that the stress in the column due to direct loads is small compared to the stress due to buckling failure. Based on this statement, a formula derived to compute the critical buckling load of column. So, the equation is based on bending stress and neglects direct stress due to direct loads on the column.

Euler's theory of column buckling is used to estimate the critical buckling load of column since the stress in the column remains elastic. The critical buckling load is the maximum load that a column can withstand when it is on the verge of buckling. The buckling failure occurs when the length of the column is greater when compared with its cross-section.

1.5Composite Structures

Composite Steel-Concrete Structures are used widely in modern bridge and building construction. A composite member is formed when a steel component, such as I beam, is attached to a concrete component, such as a floor slab or bridge deck. In such a composite T-Beam the comparatively high strength of the concrete in compression complements the high strength of the steel in tension. The fact that each material is used to the fullest advantage makes composite Steel-Concrete construction very efficient and economical. However, the real attraction of such construction is based on having an efficient connection of the Steel to the Concrete, and it is this connection that allows a transfer of forces and gives composite members their unique behavior.

1.6Need of Steel - Concrete Composite Section

Steel concrete composite construction combines the compressive strength of concrete with the tensile strength of steel to evolve an effective and economic structural system. Over the years, this specialized field of construction has become more and more popular in the western world and developed into a multifaceted design and construction technique. Apart from composite beam, slab and column, options like composite truss, slim-floor etc., are also being explored in the field of composite construction.

1.7Outline of the project

The aim of the present study is to compare seismic performance between (G+10) story RCC and composite building frame situated in earthquake zone III.

- In the first stage, three dimensional models will be developed and gravity design check will be carried out using ETABS software.
- In the second stage, modal analysis and response spectrum analysis will be carried out for both the structures.
- In the third stage, seismic analysis of the composite and RCC structure will carryout. Followed by discussion on comparisons of results obtained.

II LITERATURE REVIEW

2.1 Introduction

A detailed examination of the related literature in the form of journals and official documents was performed to study the pattern of migration and retention of employees in the construction industry. Steel-concrete composite systems have become quite popular in recent times because of their advantages against conventional construction. Composite construction combines the better properties of the both i.e. concrete in compression and steel in tension, they have almost the same thermal expansion and results in speedy construction.

2.2 Review of the Literature

Several studies were conducted regarding the analysis of composite and RCC structure. The following authors are described some studies on composite and RCC multistoried buildings.

Asha B.R, Mrs. Sowjanya G.V (2015)

In their research on "Comparison of Seismic Behaviour of a Typical Multi-Storey Structure with Composite Columns and Steel Columns" There work seeks to investigate the seismic

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behaviour of a typical ordinary moment resisting framed structure with composite columns and conventional Steel columns and examine the key design issues involved. The present study deals with seismic behaviour of a typical (G+12) storied framed structure assessed through equivalent static method of analysis as per IS: 1893-2002 for moderate seismic zone III using ETABS software package. The analyses are performed on a suite of 2 types of ordinary moment resisting framed 3D space models with different column types – Steel, and CFST. The analysis is carried out and the results are compared in terms of critical earthquake response parameters such as base shear, storey drifts, roof displacements, and storey overturning moments.Thus, all the parameters demonstrate higher order of both global and local stability indicating that the composite columns are stiffer than conventional Steel columns.

Kumawat and Kalurkar (2014)

In their research on "Analysis and Design of Multi storied Building Using Composite Structure", they have concluded that Steel concrete composite construction means the concrete slab is connected to the steel beam with the help of shear connectors, so that they act as a single unit. In the present work steel concrete composite with RCC options are considered for comparative study of G+9 story commercial building which is situated in earthquake zone-III and for earthquake loading, the provisions of IS: 1893 (Part1)-2002 is considered. A three dimensional modeling and analysis of the structure are carried out with the help of SAP 2000 software. Equivalent Static Method of Analysis and Response spectrum analysis method are used for the analysis of both Composite and RCC structures. The results are compared and found that composite structure more economical.

2.3 Conclusion on Literature Review

From the literature review the cost comparison reveals that steel-concrete composite design structure is more costly than RCC structure. But few researchers have proven RCC structures are costly than composite structures when scale of the construction changes. The dead weight of composite structure is found to be 15% to 20% less than RCC structure and hence the seismic forces are reduced by 15% to 20%.And in comparison with RCC structure, steel structure saves 18.66% and composite structure saves 32.02% in construction time. But there is no literature on seismic comparison of comparison structures for Indian zone, Hence the present work is aimed to compare results of response of the structure and displacement of composite and RCC structure.

III COMPOSITE AND RCC MULTISTORIED BUILDING

3.1 Introduction

Composite multistoried building consists of composite beams and composite columns. Composite beams are mainly subjected to bending, it means steel beams are connected to deck slab with shear connections, and the RCC structure consists of RCC beams and columns. Modeling of multistoried Steel-Concrete Composite and RCC 3-dimensional commercial building considering tostudy various components of composite elements and RCC elements.

3.1.1 Shear Connectors

Shear connections are essential for steel concrete construction as they integrate the compression capacity of supported concrete slab with supporting steel beams / girders to improve the load carrying capacity as well as overall rigidity. The beams support a uniformly distributed load of w/unit length. For theoretical explanation, two extreme cases of no interaction and 100% (full) interaction are analyzed.

No Interaction Case

It first assumed that there is no shear connection between the beams, so that they are just seated on one another but act independently. The moment in inertia (I) of each beam is given by $bh^3/12$. The load carried by each beam is w/2 per unit length, with mid span moment of $wl^2/16$ and vertical compressive stress of w/2b at the interface.

Full (100%) interaction case

Let us now assume that the beams are joined together by infinitely stiff shear connection along the face. As slip strain are now zero everywhere, this case is called "full interaction". Inthis case, the depth of the composite beam is two h with a breadth b, so that $I=2bh^3/3$. The mid-span moment is $wl^2/8$.

3.2 Elements of RCC Building

Concrete is one of the most popular materials for buildings because it has high compressive strength, flexibility in its form and it is widely available. The history of concrete usage dates back for over a thousand years. Contemporary cement concrete has been used since the early

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nineteenth century with the development of Portland cement. Despite the high compressive strength, concrete has limited tensile strength, only about ten percent of its compressive strength and zero strength after cracks develop.

3.3 Summary

In this chapter the Elements of composite and RCC structures has been explained. Elements of composite multistoried building like types of composite encased columns, types of shear connectors, advantages of profiled deck and composite Beam. Elements of RCC structure building like different types of columns and types of beams.

IV METHODOLOGY

4.1 ETABS Software

ETABS is an engineering software product that caters to multi-story building analysis and design. Modeling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid-like geometry unique to this class of structure. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS. For a sophisticated assessment of seismic performance, modal and direct-integration time-history analyses may couple with P-Delta and Large Displacement effects. Nonlinear links and concentrated PMM or fiber hinges may capture material nonlinearity under monotonic or hysteretic behavior. Intuitive and integrated features make applications of any complexity practical to implement. Interoperability with a series of design and documentation platforms makes ETABS a coordinated and productive tool for designs which range from simple 2D frames to elaborate modern high-rises.

The step wise procedure that is followed in ETABS Software is

- Modeling of structural elements
- Loading, analysis and design
- Output

ETABS also features interoperability with related software products, providing for the import of architectural models from various technical drawing software, or export to various platforms and file formats. SAFE, the floor and foundation slab design software with post-tensioning (PT) capability, is one such option for export. CSI coordinated SAFE to be used in conjunction with ETABS such that engineers could more thoroughly detail, analyze, and design the individual levels of an ETABS model. While ETABS features a variety of sophisticated capabilities, the software is equally useful for designing basic systems. ETABS is the practical choice for all grid-like applications ranging from simple 2D frames to the most complex high rises.

4.2 Linear static analysis

This method of finding lateral force is also known as the static method or equivalent static method or seismic coefficient method. The static method is the simplest one and it required less computational effort and it is based on formula given in the code of practice IS 1893:2002 (part-1). The design against seismic loads must consider the equivalent linear static methods. It is to be done with an estimation of base shear load and its distribution on each story calculated by using formula given in the code.

4.3 Linear dynamic analysis

Response spectrum method is the linear dynamic analysis method. In that method the peak response of structure during an earthquake is obtained directly from the earthquake response, but this is quite accurate for structural design applications.

In **linear time history analysis** overcomes all the disadvantages of modal responsespectrum analysis, provide non-linear behavior is not involved, the support points of the model are oscillated back and forth in accordance to a recoded ground motion of an actually occurred earthquake (as recorded by a seismograph and available in tabular form of time vs acceleration).

4.4 Non-linear static analysis

It is practical method in which analysis is carried out under permanent vertical loads and gradually increasing lateral loads to estimate deformation and damage pattern of structure. Non-linear static analysis is the method of seismic analysis in which behavior of the structure ischaracterized by capacity curve that represents the relation between the base shear force and thedisplacement of the roof. It is also known as Pushover Analysis.

4.5 Non-linear dynamic analysis

It is known as Non-Linear Time history analysis. It is an important technique forstructural seismic analysis especially when the evaluated structural response is nonlinear. Toperform such an analysis, a representative earthquake time history is required for a structure being evaluated. Time history analysis is a step-by-step analysis of the dynamic response of a structure to a specified loading that may vary with time. Time history analysis is used to determine the seismic response of a structure under dynamic loading of

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representative earthquake.

V MODELING AND ANALYSIS

5.1 Modeling of RCC Structure

The RCC structure is consist of columns, beams and slab. The distance between the columns to column is 5m in x-direction and 5m in y-direction. The overall dimensions of the structure are 30m*15m. Column dimensions are 900*600mm, beam dimensions are 500*300mm and thickness of slab is 125mm.

5.1.1 Plan of Asymmetry RCC Structure

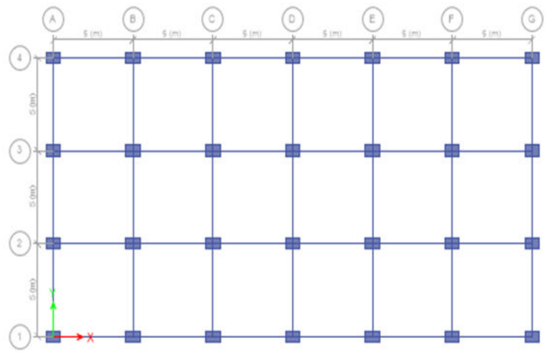

Figure 5.1: Plan of RCC Structure

5.1.2 Building Details

The building considered here is commercial building having G + 10 storied located in seismic zone III and for earthquake loading, the provisions of the IS: 1893(Part1)2002 is considered. The plan of building is shown in above figure 5.1. The building is planned to facilitate the basic requirements of commercial building. The plan dimension of the building is 30 x 15 m. Height of each storey for composite and RCC is 3m. The floor plans were divided into three by six bays in such a way that center to center distance between two grids is 5 meters by 5 meters respectively. The study is carried out on the same building plan for RCC and composite construction with some basic assumptions made for deciding preliminary sections of both the structures. The basic loading on both types of structures are kept same, other relevant data is tabulated in Table 5.1.

Table.5.1: RCC structure properties

Section properties	30m*15m
Beam dimensions	500*300 mm
Column dimensions	900*600 mm
Thickness of slab	125 mm
Grade of concrete	M30
Grade of reinforcement	Fe415
Live load	3 KN/m^2
Dead load	3 KN/m^2
Floor finishes	1 KN/m^2
Seismic zone	III
Importance factor	1
Zone factor	0.16
Density of concrete	25 KN/m^3

5.1.3 RCC Column Modeling

In the below Figure 5.2 shows that the RCC column modeling by using E-tabs software. Here the modeling of RCC column is a rectangular column.Columns support primarily axial loadbut usually also some bending moments. The combination of axial load and bending moment defines the characteristic of column and calculation method.

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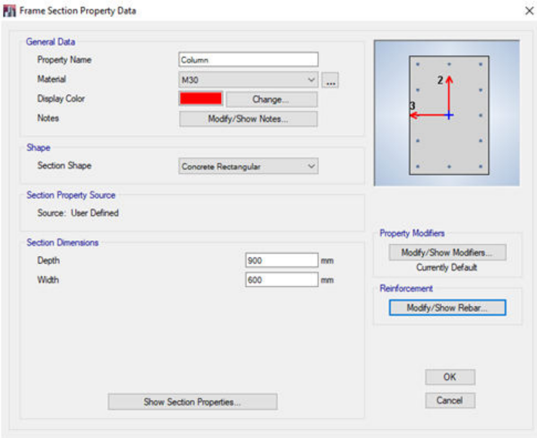

Figure 5.2 RCC Column details

5.1.4 RCC Beam Modeling

Figure 5.3 show that the RCC beams modeling by using E-tabs software. Here the modeling of RCC beam is a rectangular beam. Beams can be described as members that are mainly subjected to flexure and it is essential to focus on the analysis of bending moment, shear, and deflection.

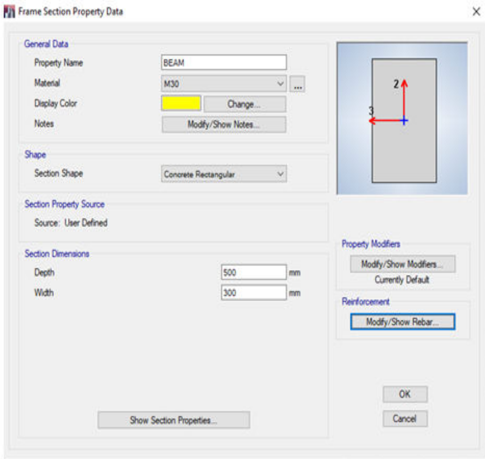

Figure 5.3: RCC beam details

5.2 Modeling of Composite structure

The composite structure is consisting of composite columns, composite beams and deck slab. The distance between the columns to column is 5m in x-direction and 5m in y-direction. The overall dimensions of the structure are 30m*15m.Column dimensions are 900*600mm, beam is 600*300mm and thickness of slab is 125mm.

5.2.1 Plan of Asymmetry Composite Structure

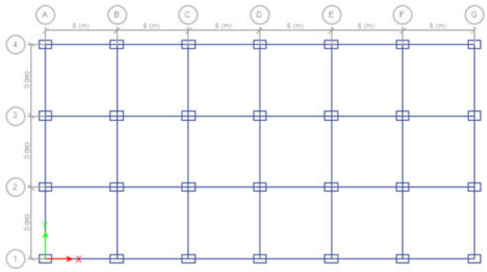

Figure 5.5: Plan of Composite Structure

5.2.2 Building Details

The building considered here is commercial building having G + 10 storied located in seismic zone III and for earthquake loading, the provisions of the IS:1893(Part1)2002 is considered. The plan of building is shown in fig. 5.5.The building is planned to facilitate the basic requirements of commercial building. The plan dimension of the building is 30 x 15 m. Height of each storey for composite and RCC is 3m. The floor plans were divided into three by six bays in such a way that center to center distance between two grids is 5 meters by 5 meters respectively. The study is carried out on the same building plan for RCC and composite construction with some basic assumptions made for deciding preliminary sections of both the structures.The basic loading on both types of structures are kept same, other relevant data is tabulated in table 5.2.

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Table 5.2: Composite structure properties

Section properties	30 m*15 m
Beam dimensions	600*300 mm
Column dimensions	900*600 mm
Thickness of slab	125 mm
Grade of concrete	M 30
Grade of steel	Fe 250
Live load	3 KN/m^2
dead load	3 KN/m^2
Floor finishes	1 KN/m^2
Seismic zone	III
Importance factor	1
Zone factor	0.16
Density of concrete	25 KN/m^3

VI RESULTS AND DISCUSSION

6.1Mode shapes

A mode shape is a specific pattern of vibration executed by a mechanical system at a specific frequency. Different mode shapes will be associated with different frequencies. The experimental technique of modal analysis discovers these mode shapes and the frequencies. The following below Figures 6.1 and 6.2 shows the mode shapes of RCC symmetry and composite symmetry structures respectively and Figures 6.3 and 6.4 shows the mode shapes of RCC and Composite Asymmetry structures.

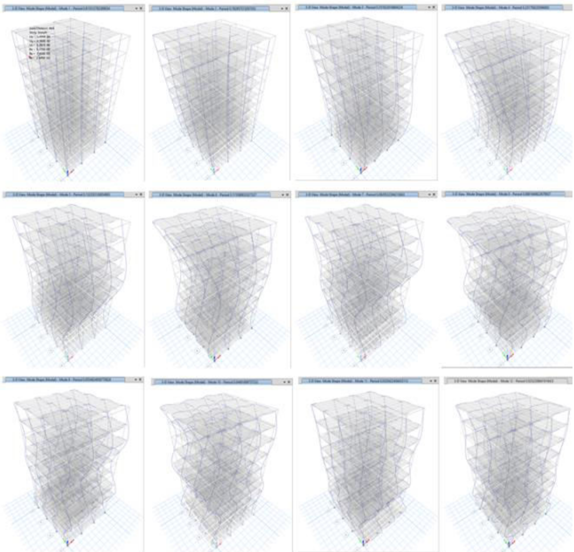

Figure 6.2: Mode Shapes of Symmetry Composite structure

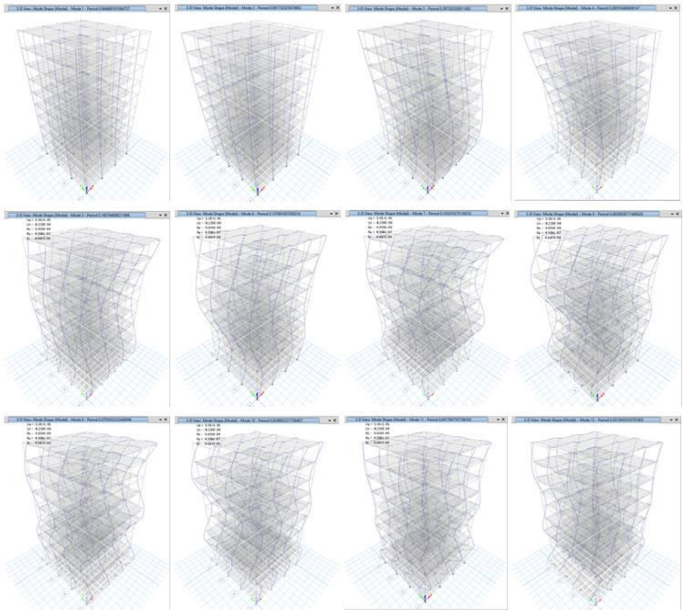

Figure 6.1: Mode shapes of symmetry RCC structure

6.2Summary

In this chapter results of response spectrum analysis of G+10 structures are presented. From this it is observed that the Bending Moment and Shear force are less in the composite structure as compared to RCC structure. The displacement drifts and shears of composite structure is less as compared to RCC structure. The time period is less in the composite structure as compared to RCC structure.

VII CONCLUSION

7.1 Summary

In this project three dimensional composite and RCC structure models are developed. In analysis storey responses are considered and compared between both the structures.

7.2 Conclusions

In this study, the comparative study of RCC and Composite multistoried building (G+10) is presented. Parameter considered are, beam deflection, maximum shear force, and maximum bending moment, time period and displacement.

- The displacement of composite structuresis lesser than the RCC structures.
- The storey drifts, shears and stiffness values of composite structure are lesser than the RCC structure in both asymmetry and symmetry cases.
- The asymmetry structure is more stiffer than symmetry structure in both RCC and composite structures.
- The time period of composite structure is also less than the RCC structure.
- The composite structure will perform well in earthquake condition than the RCC structure this will be decided by the comparative of displacement for both the structures i.e. composite structure and RCC structure.
- Base shear is less in composite building compared to RCC building.

The data mentioned above is clearly said that composite section is always a better choice against R.C.C. structures. Composite Structure provides efficient and better performance against earthquake loads than R.C.C. structures.

7.3 Future Scope

- The use of fully and partially encased steel sections in reinforced concrete is particularly beneficial for earthquake-resistant design. A further study on the suitability of other types of composite structural systems for earthquake-resistant design is highly recommended.
- The wind analysis of multi-storied composite structure can be carried out and charts can be prepared for various wind pressure.
- Non-linear dynamic analysis can be carried out of various types of composite and RCC structures.

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