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A Comparative Analysis of Different Bracing Types for RCC Building in Diverse Seismic Zones

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ABSTRACT

In earthquake design, buildings endure inertia forces causing stresses due to ground motion. India, seismic-prone, faces significant damage from earthquakes, requiring resistance to minor, moderate, and severe shaking. Deformations occur in the load-bearing system during earthquakes, influencing displacement demand. Strengthening methods aim to keep displacement demand below capacity through reducing expected demand or enhancing capacity. Key factors include stiffness, mass, and displacement capacity. Reinforcement size, placement, and detailing affect building behavior. Special mechanisms improve lateral stability, including various bracing systems like X, V, inverted V, K, and diagonal bracing. Bracing configurations such as diagonal, cross (X), chevron, and V-bracing have distinct merits and demerits. High-rise buildings primarily transfer gravity loads, including dead and live loads, while withstanding lateral loads from earthquakes, blasting, and wind based on terrain.

Keywords: Inertia forces, seismic resistance, displacement demand, strengthening methods, stiffness, mass, reinforcement, lateral stability, bracing systems, high-rise buildings, gravity loads, lateral loads.

INTRODUCTION

In earthquake-resistant design, buildings must withstand varying levels of seismic activity, from minor to severe shaking. During earthquakes, structures experience deformations and internal forces due to ground motion, leading to displacement. Buildings with higher stiffness and lower mass tend to have smaller displacement demands, while each building has a specific displacement capacity. Strengthening methods aim to keep displacement demands below this capacity by reducing expected displacement or enhancing the structure's capacity. Reinforcement placement and detailing significantly influence a building's behavior during earthquakes, necessitating special mechanisms like bracing systems (e.g., X-bracing, V- bracing) to improve lateral stability. Different bracing configurations (e.g., diagonal, cross, chevron) offer varying advantages and disadvantages. High-rise buildings must also safely transfer gravity loads, including dead and live loads, while withstanding lateral loads from earthquakes, blasts, and wind based on terrain category.

In this paper seismic analysis of G+8 BUILDING which lies in zone 2, zone 3, zone 4 and zone 5 has been described and response of building is shown in the form of story drift, story displacement and base shear. The analysis has been done using STAAD Pro.

OBJECTIVE

- To perform seismic analysis in different zones
- To obtain the result of base shear, story displacement and story drift.
- To study the role of bracing system in RCC structure.
- To understand behavior of the structure under the action of seismic on different zones.
- To evaluate the response of braced and unbraced structure subjected to seismic load andto identify for resisting the seismic load efficiently.

Types Of Bracing

X Bracing The design of bracing involves the strategic placement of diagonal braces in the shape of an 'X' within a building's frame. These diagonal members typically connect nonadjacent horizontal elements, such as beams or girders, creating a distinctive crosspattern. One of the primary objectives of X-bracing is to resist excessive lateral sway thatmay lead to structural instability or damage. The system operates by transferring these horizontal forces diagonally through the braces, ultimately directing them to the building's foundation. The advantages of X-bracing are noteworthy. This bracing configuration is effective in bothtension and compression, providing versatility in its ability to counter lateral forces from various directions' ductility of X-bracing contributes to its effectiveness in earthquake-resistant design.

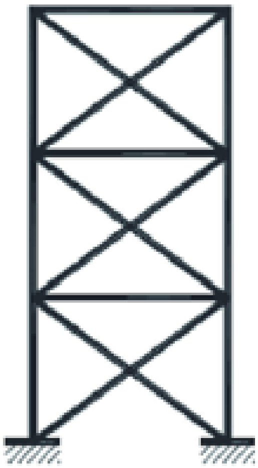


Fig 1.1 X bracing system

Inverted V Bracing Inverted V-bracing is a structural bracing system employed inbuilding design to enhance the lateral stability and earthquake resistance of structures. This bracing configuration involves diagonal members arranged in an inverted V shape, connecting two nonadjacent horizontal members within a building's frame. The braces aretypically oriented in a manner that resembles an upsides-down letter "V," converging at a central point. One of the key purpose of inverted V-bracing is to mitigate the effects of horizontal loads, such as those generated by earthquakes. The diagonal members act as tension and compression elements, effectively transferring lateral forces to the foundation and minimizing building sway. The advantages of inverted V-bracing include its ability toprovide stability in multiple directions. The configuration of the braces allows for efficient resistance against lateral loads from various angles, contributing to the overall seismic performance of the building.

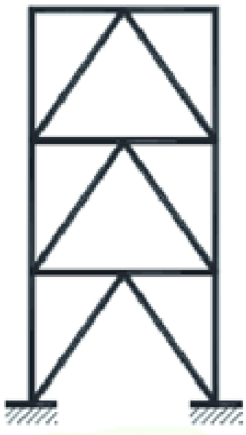


Fig 1.2 Inverted V bracing system

Diagonal bracing Ductile shear walls (more appropriately called flexural walls), which form part of the lateral load resisting system, are vertical members cantilevering vertically from the foundation, designed to resist lateral forces in its own plane, and are subjected to bending moment, shear and axial load. Unlike a beam, a wall is relatively thin and deep, and is subjected to substantial axial forces. The wall must be designed as an axially loaded beam, capable of forming reversible plastic hinges (usually at the base)with sufficient rotation capacity.

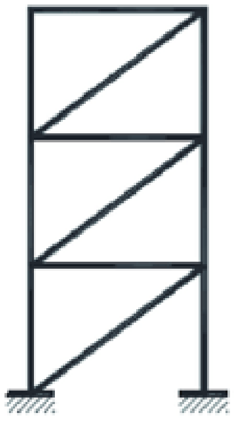


Fig 1.3 Diagonal bracing system

K bracing K-bracing is a structural bracing system utilized in building design to enhance lateral stability and mitigate the impact of horizontal forces, particularly during seismic events. This system involves diagonal braces arranged in the shape of the letter "K," connecting a column to a beam or a beam to a girder. The braces are inclined at an angle, and their positioning forms a distinctive k-pattern within the structural frame. The primary purpose of K-bracing is its effectiveness in preventing buckling and increasing the lateral load- carrying capacity of the structure. The braces help maintain the stability of columns and beams, reducing the risk of structural failure during seismic event.

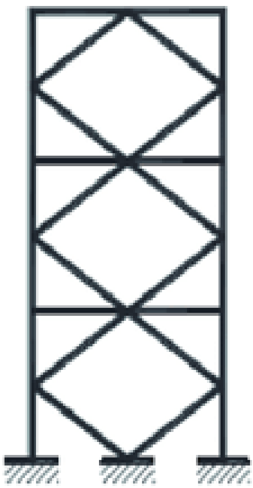


Fig 1.4 K-bracing system

METHODS OF ANALYSIS

Equivalent Static Method

All design against earthquake effects must consider the dynamic nature of the load. But,for simple regular structures analysis by equivalent linear static methods is sufficient. This is allowed in most codes of practice for regular, low-to medium rise buildings. Inthis method of analyzing multi storey buildings recommended in the code, the structure is treated as discrete system having concentrated masses at floor levels which include that weight of columns and walls in any storey should be equally distributed to the floors above and below the storey. In addition, the appropriate amount of imposed load at the floor is also lumped with it. Initially, design base shear is computed for the whole building, and then it is distributed along the height of the building. The lateral forces at each floor thus obtained are distributed to individual lateral load resisting elements. It assumes that the building responds in its fundamental mode. For this to be true, the building must be low-rise and must not twist significantly when the around moves. The response is read from a design response spectrum, given the natural frequency of the building either calculated or defined by the building code. Then Linear Static Procedure ignores the non-linearity of the structureand the dynamic effect.

ANALYSIS OF G+8 BUILDING IN DIVERSE SEISMIC ZONE

Earthquakes are uncontrollable natural disasters. To minimize damage, we analyze buildings using software like STAAD.Pro to simulate seismic loads and understand their effects. This helps engineers design structures that can better withstand earthquakes.

GEOMETRICAL DATA

Table 2.1: Geometrical data

No of stories	G + 8
No of bay in X direction	5
No of bay in Y direction	5
Type of building used	business
Plan dimensions	20 x 20 m
Typical storey height	4 m
Bottom storey	4 m
Height of structure	36 m
Live load	4 KN/m^2

MEMBER PROPERTIES

Table 2.2 Member properties

Thickness of slab	180 mm
Column size	600 x 600 mm
Beam size	450 x 450 mm
Bracing size	100 100 x 12 mm

SEISMIC LOAD

Table 2.3 Seismic load

Zone	IV	V
Zone factor	0.24	0.36
Response Reduction factor	5	5
Importance factor	1.2	1.2
Structure type	SMRF	SMRF
Soil condition	Medium	Medium
Building	RCC	RCC

PLAN OF STRUCTURE

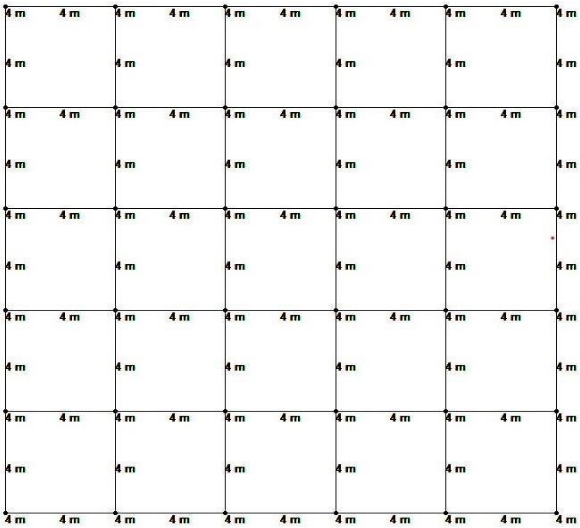
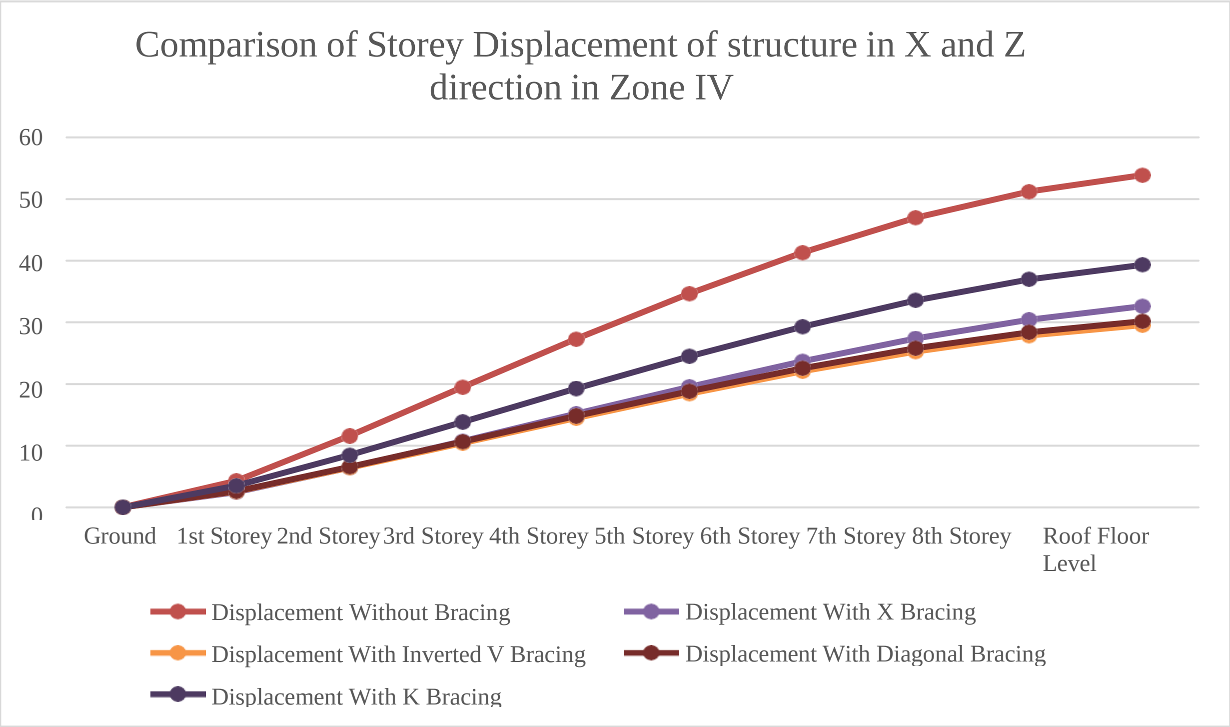


Fig 3.3.1 Plan of Model

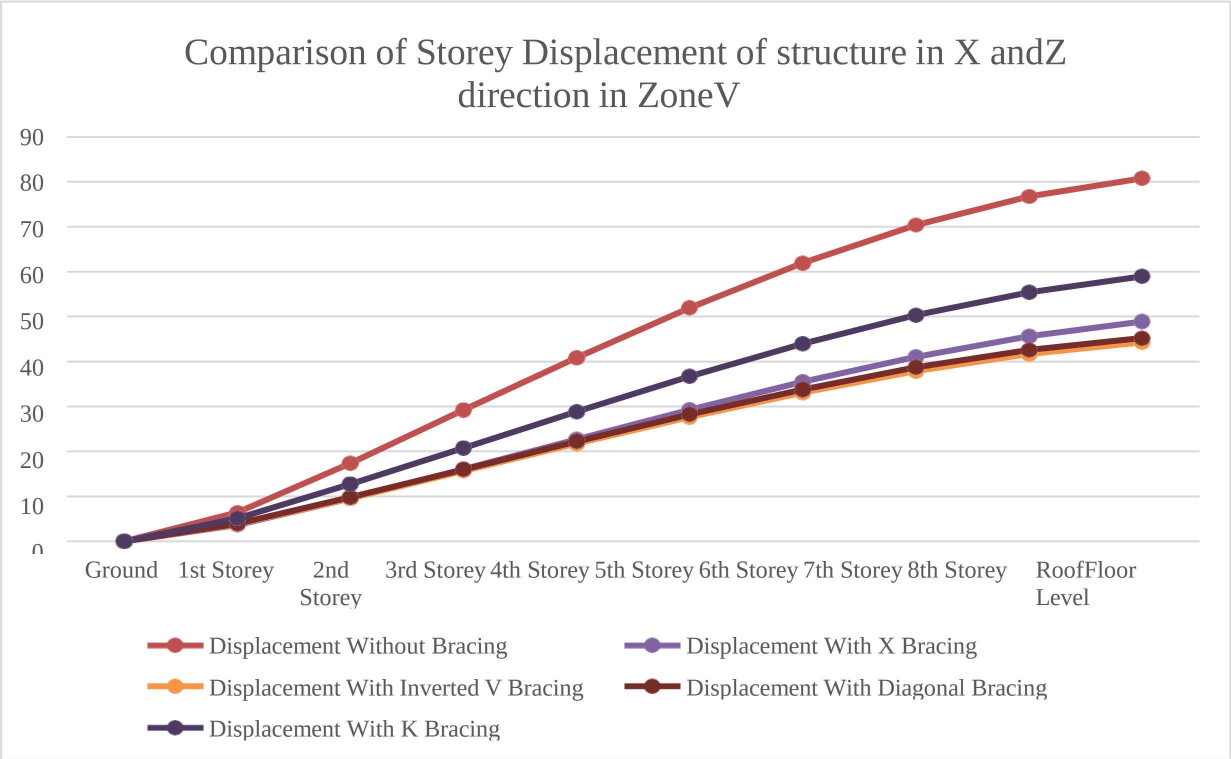
RESULT

The seismic analysis of an eight-story building was conducted using the equivalent static method as per IS 1893 standards. The analysis results provide insights into how the building responds to seismic forces. This information is crucial for designing the structure to withstand earthquakes effectively.

STORY DISPLACEMENT



Graph 3.1: Comparison graph of Storey Displacement in X and Z direction in Zone IV



Graph 3.2: Comparison graph of Storey Displacement in X and Z direction in Zone V.

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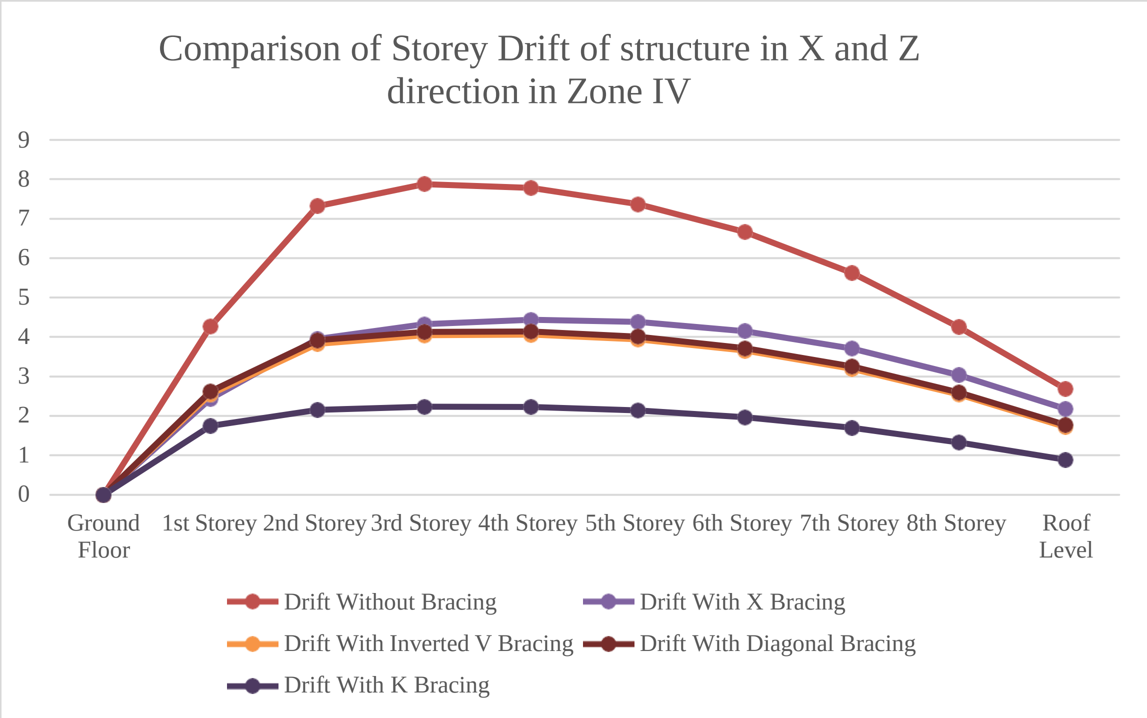
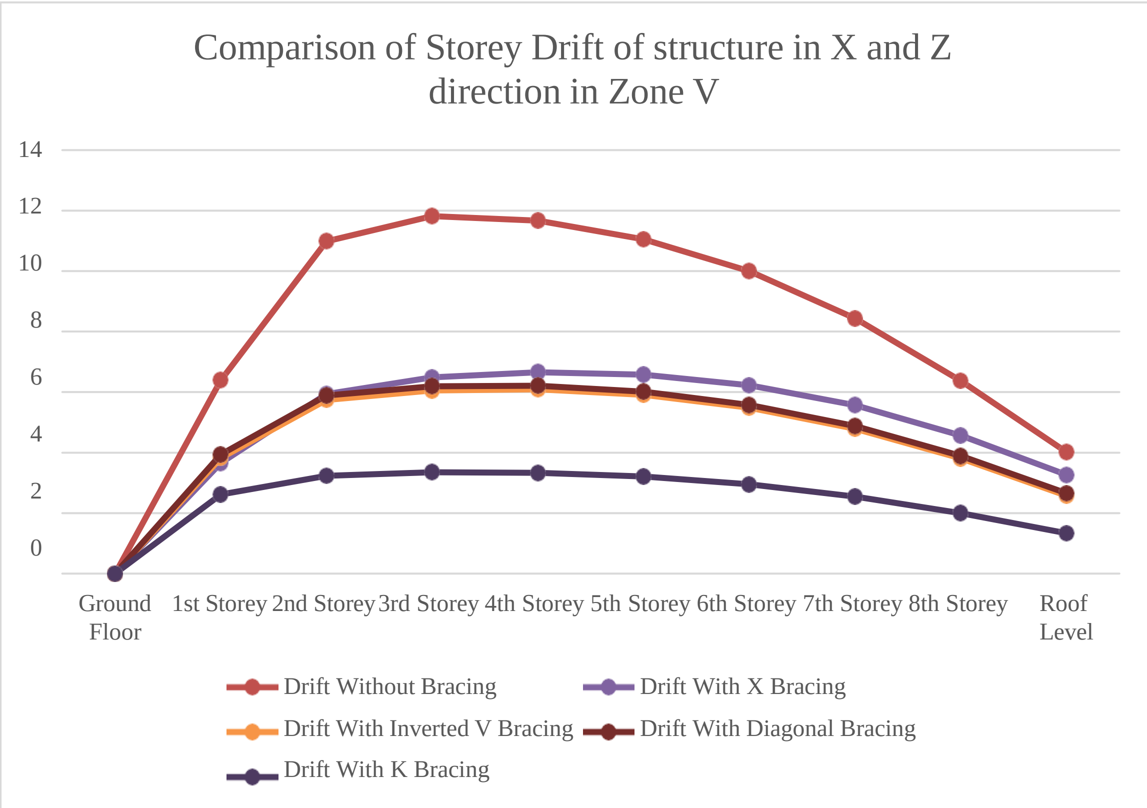
STORY DRIFT



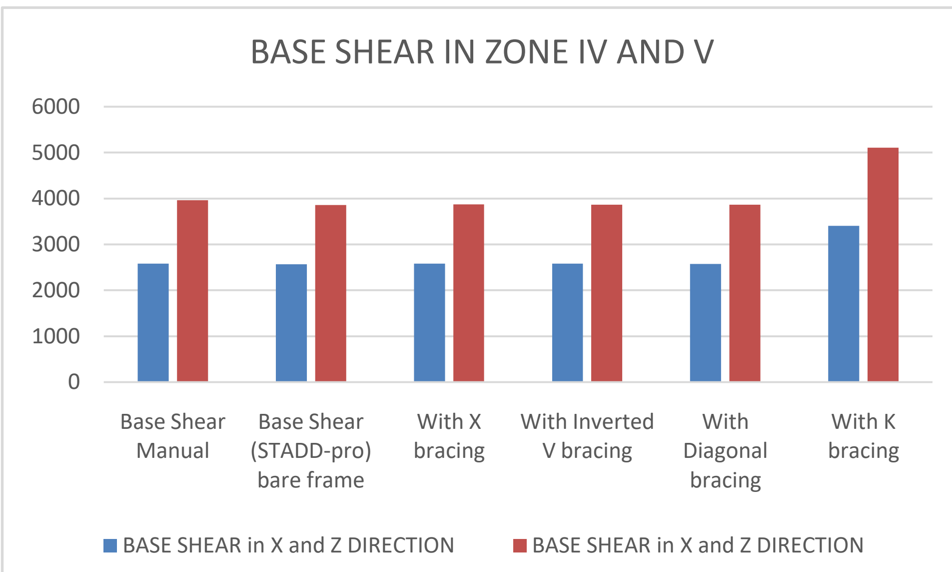
Graph 3.3: Comparison graph of Storey Drift in X and Z direction in Zone IV.



Graph 3.4 Comparison graph of Storey Drift in X and Z direction in Zone V

BASE SHEAR

TYPE OF STRUCTURE	BASE SHEAR in X and Z DIRECTION (IN KN)	
ZONE	**IV**	**V**
Base Shear Manual	2580.24	3959.77
Base Shear (STADD-pro) bare frame	2569.87	3854.81
With X bracing	2581.35	3872.02
With Inverted V bracing	2578.95	3868.42
With Diagonal bracing	2575.61	3863.42
With K bracing	3404.93	5107.4



CONCLUSION

- The base shear is increase after the application of bracings. The maximum base shear occurs in K-Bracing as compare to the bare frame for zone IV and V.
- The storey displacement reduce in frame with bracing are provided. The maximum reduction of storey displacement occurs in frame with INVERTED V -bracing for zone IV and V with **45.18%.**
- The storey drift also reduces in frame with bracing provided. The maximum reduction of storey drift occur in frame with K-Bracing for zone IV and V with **59.54%.**
- From result it is observed that the after application of bracing both Storey Displacement and Storey Drift get reduces. And maximum reduction for Storey Displacement is in INVERTED V -Bracing and maximum reduction for Storey Drift is in K-Bracing.
- It is found that the Base Shear, Storey Displacement and Storey Drift is goes on increasing as goes for higher zone i.e. Zone IV to Zone V for all models that is Structure without Bracings and Structure with Bracings.

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