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# Design and Analysis of Monolithic dome Structures using STAAD.Pro v8i Software

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**ABSTRACT:** These times due to modernity and need in recent construction. The monolithic dome is being very much in demand because it needs no interior support for variety of floor plans. This project includes analysis of monolithic dome structures using STAAD. Pro v8i SS6 software. In this study by applying point loads over the nodal joints, analysis and design of concrete dome structure will be done using STAAD.Pro v8i SS6 software. In the present research, the efforts are made to study the behavior of monolithic dome structure and four models are analysed. The analysis is carried out for four models using STAAD.Pro V8i software by equivalent static method. The analysis is performed for medium seismic zone and medium soil type. The results of analysis in terms of nodal displacement, axial force, shear force, bending moment and maximum absolute plate stress are obtained.

**KEYWORDS:** Dome, STAAD.Pro V8i, Equivalent static method, Analysis, Reinforcement design, Nodal displacement, Shear force, Axial force, Bending moment, Maximum absolute Plate stress.

## I. INTRODUCTION

Domes have a longer history in the built environment and has been included the variety of architectural styles around the world. They are prominent in Persian, Roma, Islamic, Byzantine and Italian Renaissance architecture. During the A.D times, monolithic dome construction were created and built to get lot of volume out of the structure dome construction that are monolithic. In 1970s, monolithic dome buildings were developed across Europe and America as well as in Canada, Mexico, Asia, Africa and Australia.

Dome structures can be designed to meet any architecture style, including residences, cabins, churches, schools, arenas, gymnasiums, stadium mass, landlord dwelling, auditorium and other private and public constructions. They are cost effective, environmentally friendly, extremely durable, and simple to use. Monolithic dome operate well in any climate, including those that are extremely hot or cold. They can also be built using cement stabilised earth blocks (CEBs) or reinforced concrete construction (RCC). When completed, domes are earthquake, hurricane and tornado resistant. For example, since its construction, a residential house in Pensacola beach, Florida, known as the monolithic “Dome of a home”, has been subjected to multiple hurricanes. In the United States, some communities have elected to build new schools using monolithic dome technology.

These times due to modernity and need in recent construction. Monolithic domes are greatly in demand because it doesn't need any interior support for variety of floor plans. The study employs STAAD. Pro V8i SS6 software to analyse four models of monolithic domes structures by equivalent static method under various loading scenarios using dead as well as live loads applied towards nodal joints. Ability of a dome construction to handle a longer span with minimal interference makes it distinctive. The outcomes of analysis in relation of nodal displacement, axial force, shear force, bending moment and maximum absolute plate stress are compared.

Types of domes

- Monolithic domes
- Beehive/Corbel dome
- Crossed Arched dome
- Cloister dome
- Geodesic domes
- Oval domes
- Onion dome
- Braced dome



## II. LITERATURE REVIEW

**1. Numerical Study of Concrete Dome Structure using ANSYS 17.0-** Bincy Baby, Lakshmy G. Das - Dome structures are space structures which engulf large area with smallest surface. It is a doubly curved shell structure. Dome is durable, firm and sturdy than the other singly curved shell structure, which may be applicable to several engineering structures like auditorium, exhibition area, industrial structures top covering of circular water tank etc. Study of this paper deals with numerical analysis of dome structure prepared from four different geometries where finite element analysis is administered out using ANSYS 17.0 software. Structural analysis of Algeciras Market dome shapes is feasibly the foremost common solicitation of the finite element method. We can accomplish differing types of structural analysis. Such as Static Analysis, dynamic analysis etc. Here Static structural analysis and Topology Optimization were administered. In this study the analysis determines deflection, maximum principle stress and crack pattern the various models created. Findings: Doubly- curved shell, Semi-spherical dome, Torispherical dome, Elliptical dome, ANSYS.

**2. Analysis and design of spherical dome structure by using STAAD.Pro-** R.Madhukumar, U. Manivasan, V.S.Satheesh and S. Suresh Babu -International Journal of Modern trends in engineering and research ISSN: 2455-0876. The optimised values of the parameters for structural designing are proposed for segments and column divisions in substructure on definitive PGA and yielding PGA. Findings - Seismic response, Failure mechanism, Single layer latticed domes, and Low cycle fatigue IDA.

**3. Design and analysis of geodesic tunnel dome for an auditorium** - Arya Abhishek, Phadtare Shubham, Patil Pratik, Tipare Harshal, Reetika Sharan- International Research Journal of Engineering and Technology (IRJET). The results of the static analysis and design of a geodesic tunnel dome are presented in this paper. The length of an auditorium is 40 metres, the breadth of the internal side is 20 metres, and elevation of the summit is 10.63 metres, according to the writers. They created the model that was needed for this job. They similarly computed the forces performing (i.e. Wind load, Dead load, Live Load &, etc.) on every panel of erections for designing purposes; assigned loads are repelled through two hinged arches that are then passed to RCC column, which is then transferred to the soil layers via the foundation. Wind intensity is according to ( IS875-1987 Part-3 ) is 44m/s. Findings: Geodesic Tunnel Dome, Heavy Wind Load, Arch Truss, Aesthetic View, Energy Efficient, Economical, Steel tubes.

**4. Reinforced cement concrete (RCC) dome design-** Shaik Tahaseen, International Journal of Civil and Structural Engineering, They have designed RCC dome roof structures utilising manual methods in this article, which provide detailed proposal of RCC domes. The technique for creating RCC domes stayed undoubtedly discussed, and ring beam reinforcement were obtained from the analysis and design.

## III. OBJECTIVE

- To understand the behaviour of dome structure by analysis.
- To investigate the analysis and compare the obtained results of monolithic dome structure under various loading conditions.
- To determine safe and reliable monolithic dome structure against various loading cases.
- To determine nodal displacement, axial force, shear force, bending moment and maximum absolute plate stress for monolithic dome structures.

## IV. METHODOLOGY

In this project, a comparison analysis of four monolithic dome models of different rise and plate thickness are conducted to investigate structure behaviour by applying point loads over the nodal joints analysis and design of concrete dome structure will be done using STAAD.Pro v8i SS6 software. The analysis is performed for medium seismic zone and medium soil type.

The following are two cases prepared for the analysis in the project

Case1: Dome models with different rise

1. Model 1: Base diameter=15m, Rise=3m(Span/5), Plate thickness=0.1m
2. Model 2: Base diameter=15m, Rise=2.5m(Span/6), Plate thickness=0.1m
3. Model 3: Base diameter=15m, Rise=2.14m(Span/7), Plate thickness=0.1m
4. Model 4: Base diameter=15m, Rise=1.87m(Span/8), Plate thickness=0.1m



Case2: Dome models with different Plate thickness

1. Model 1: Base diameter=15m, Rise=3m, Plate thickness=0.1m.
2. Model 2: Base diameter=15m, Rise=3m, Plate thickness=0.15m.
3. Model 3: Base diameter=15m, Rise=3m, Plate thickness=0.20m.
4. Model 4: Base diameter=15m, Rise=3m, Plate thickness=0.25m.

Table 1: Structural details of monolithic dome models considered for study

Sr. No.	Details	Monolithic dome
1	Staging level	2
2	Height of staging	3.5m
3	Size of Bottom beam	380x230mm
4	Diameter of column	450mm
5	Length of column	7m
6	Number of column	16
7	Roof slab thickness	250 mm
8	Wall thickness	300 mm
9	Type of soil	Medium Soil
10	Unit weight of R.C.C	25KN/M3
11	Material properties	M25 Grade Concrete & Fe415

### V. LOADS CONSIDERATION

STAAD. Pro software was used to analyse the chosen model. The analysis takes into account dead load in relation to self-weight for the study, with a plate pressure of 6KN/m. According to IS 875(Part 2), the live load is 7KN/m<sup>2</sup>. In the table given below, the gravity loads are shown. In line with table 8 of IS 1893 (Part 1): 2002, seismic weight is defined as total dead load along with 50 percentage of live load.

Table 2: According to IS 875(Part 2) the gravity loads assigned to RC buildings.

Gravity loads	Value of loads
Dead Load(DL)	3KN/ M2
Live Load(LL)	3.5KN/M2

#### ➤ Seismic and wind load details

As the height of a building structure rises, it becomes more vulnerable to horizontal loads, making it more flexible and susceptible to damage. As a result, earthquake and wind loads accounts for the majority of lateral load for which the structure must be analysed.

Table 3: Earthquake and Wind loads as per IS 1893(Part 1): 2016.

Earthquake Zone	III
Zone Factor-Z	0.16
Importance Factor-I	1
Response Reduction Factor-R	3
Damping Ratio	0.05
Soil Type	Medium
Basic Wind Speed-Vb	39m/ sec
Design Wind Pressure-Pz	0.960KN/m <sup>2</sup>

#### ➤ Combination of loads

The chosen model are investigated using appropriate proportions of applied dead loads, live loads, and seismic loads. IS 1893 (Part 1)-2016 specifies the load combinations, which are based on existing Table 5.4. ELX and ELZ should be addressed because the earthquake loads will be distributed in both the X-Horizontal direction and Z-Vertical directions for the structure.

The given below shows various combinations of loads.

1. 1.5DL+1.5LL
2. 1.2DL+1.2LL+1.2WLX+
3. 1.2DL+1.2LL+1.2WLX-
4. 1.2DL+1.2LL+1.2WLZ+
5. 1.2DL+1.2LL+1.2WLZ-
6. 1.2DL+1.2LL+1.2SLX+
7. 1.2DL+1.2LL+1.2SLX-
8. 1.2DL+1.2LL+1.2SLZ+
9. 1.2DL+1.2LL+1.2SLZ-
10. 0.9DL+0.9LL+WLX+
11. 0.9DL+0.9LL+WLX-
12. 0.9DL+0.9LL+WLZ+
13. 0.9DL+0.9LL+WLZ-
14. 0.9DL+0.9LL+SLX+
15. 0.9DL+0.9LL+SLX-
16. 0.9DL+0.9LL+SLZ+
17. 0.9DL+0.9LL+SLZ-

➤ **Details of monolithic dome**

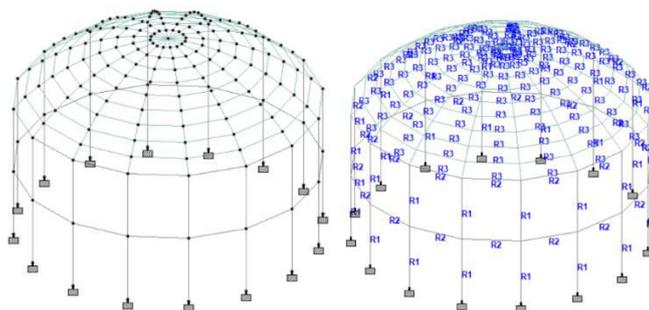


Fig 1: Monolithic dome structure geometry

➤ **Beam and column reinforcement details**

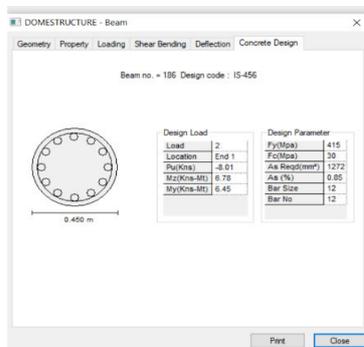


Fig 2: Concrete circular column reinforcement

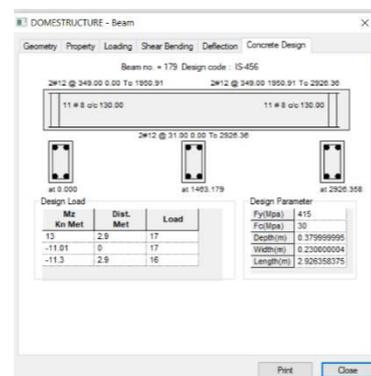


Fig 3: Concrete rectangular beam reinforcement



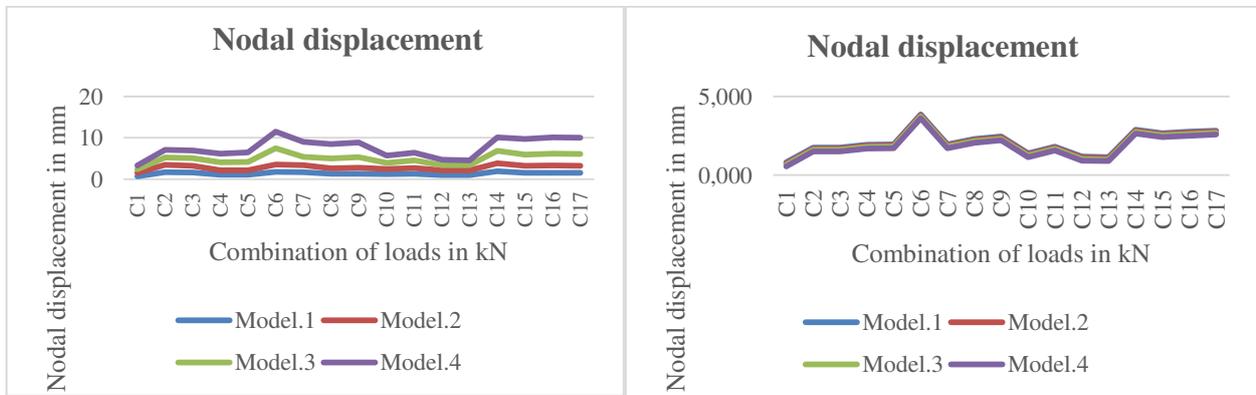
The monolithic concrete dome was designed in accordance with IS-456. In a monolithic concrete dome, rectangular beams and circular columns are considered. As illustrated in fig 2&3 reinforcement was designed in STAAD. Pro programme.

**VI. EXPERIMENTAL RESULTS**

The research is admitted out using STAAD. Pro v8i software and following results are obtained in respect to nodal-displacement, Axial force, Shear force, Bending moment and Maximum absolute plate stress.

➤ **Nodal displacement**

The displacement is considered in this section to study the behaviour of monolithic dome. Node displacements are the global displacements for every node in X, Y and Z direction as per the global coordinate system. The fig4 shows nodal-displacement for all the four dome models considered for study.



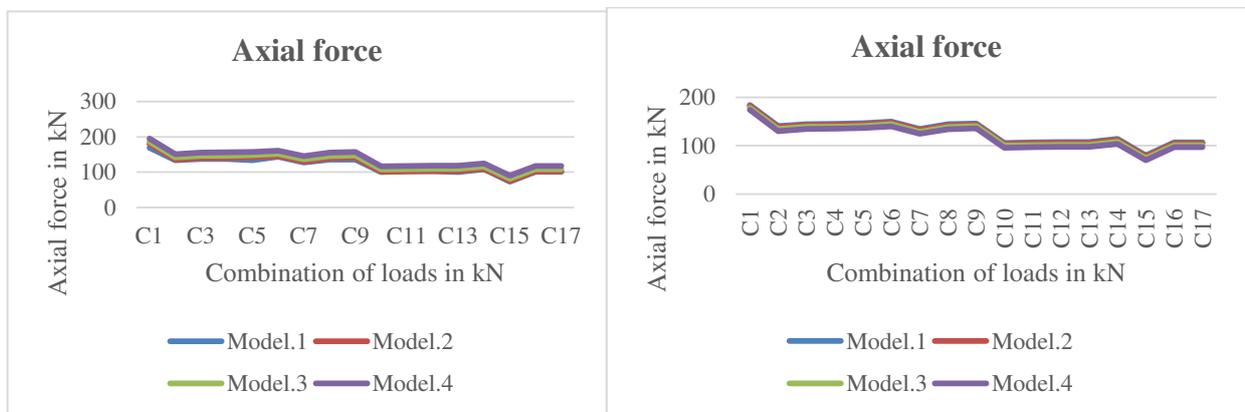
For Case 1:

For Case 2:

Fig 4:Chart showing nodal displacement of monolithic domes

➤ **Axial force**

The axial force is considered in this section to study the behaviour of monolithic dome.



For Case 1:

For Case 2:

Fig 5:Chart showing axial force of monolithic dome models



➤ **Shear force**

Shear force is been considered in this project to study behaviour of monolithic dome models.



Fig 6:Chart showing shear force of monolithic dome models

➤ **Bending moment**

Bending moment is been considered in this project to study behaviour of monolithic dome models.

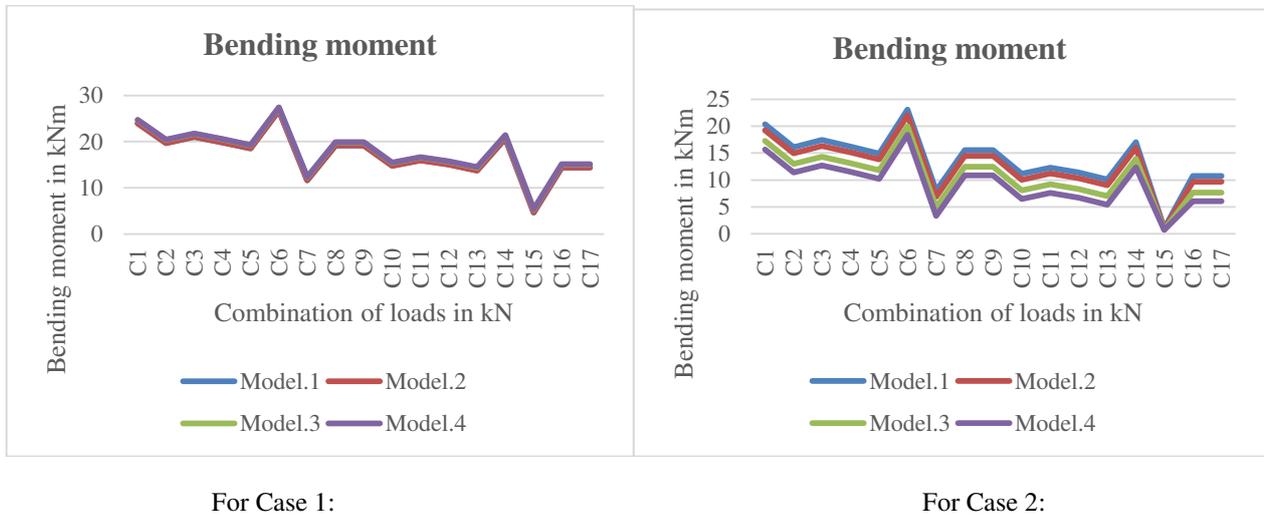
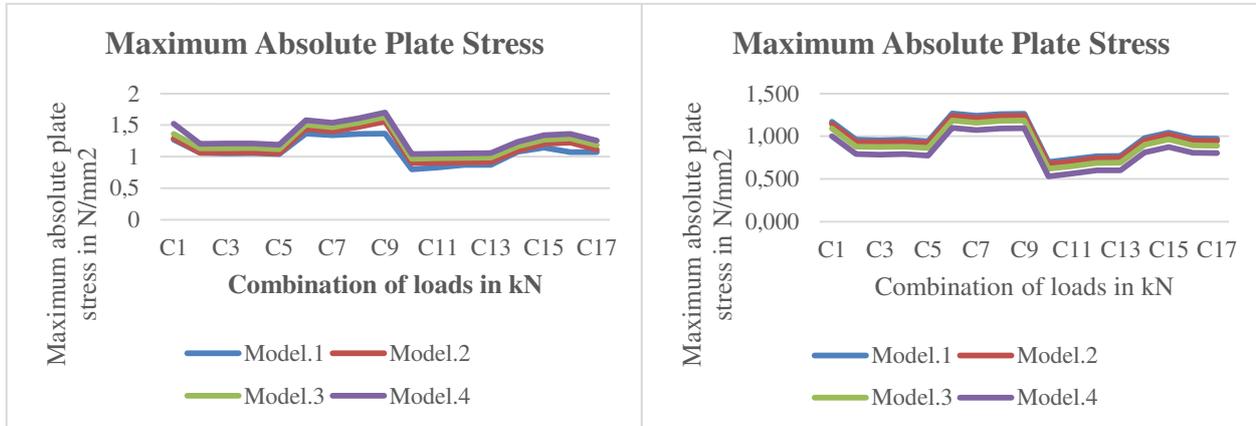


Fig 7:Chart showing Bending moment of monolithic dome models

➤ **Maximum absolute plate stress**

Maximum absolute plate stress is considered to all monolithic dome models and are given below.



For Case 1:

For Case 2:

Fig 8: Chart showing maximum absolute plate stress of monolithic dome models

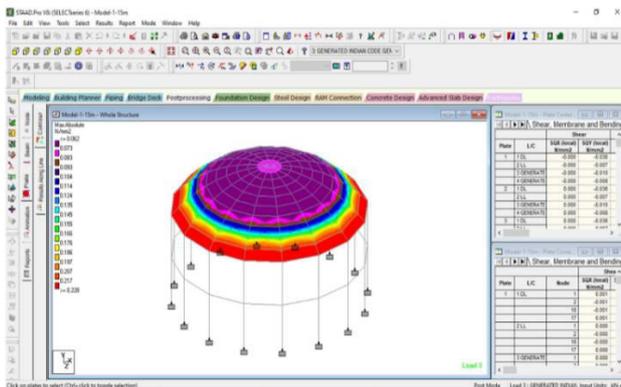


Fig 9: Maximum absolute plate stress of model no.1

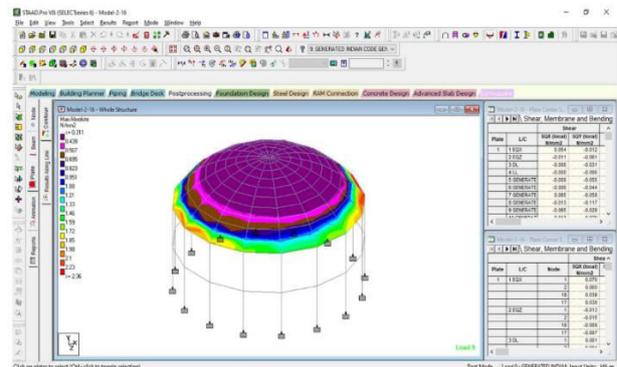


Fig 10: Maximum absolute plate stress of model no.2

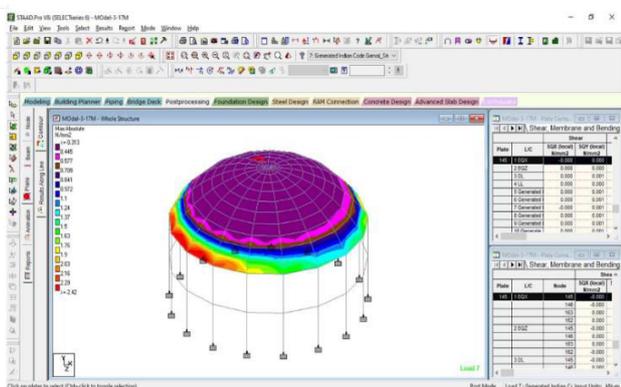


Fig 11: Maximum absolute plate stress of model no.3

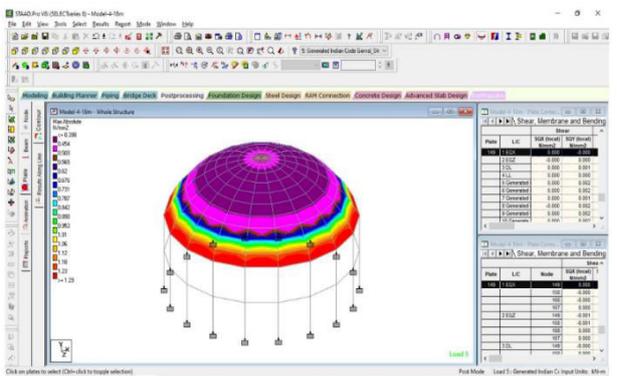


Fig 12: Maximum absolute plate stress of model no.4



## VII. CONCLUSION

The following are findings of the investigation

- In this examine, we have analysed different monolithic concrete dome models. The structure was designed based on mentioned standards. The design was completed in accordance with the Reinforced concrete design codal provisions.
- STAAD. Pro v8i software was used to assess the structural behaviour of the RC dome.
- This is an attempt to enhance the aesthetical efficiency of the roof system.
- In case 1: model 1 was found out to be safe and reliable one and the fourth model was found out to be critical.
- Stresses are inversely proportional to rise of the dome structure.
- Higher rise gives lower stress and will be safe against buckling.
- In case 2: Model 4 was found out to be safe and reliable one and the first model was found out to be critical.
- Stresses decreases with increase in plate thickness of the dome structure.
- The maximum absolute plate stress, nodal displacement, axial force, Bending moment and shear force are presented for all the models.
- According to this project a dome model of 3m rise with 0.25m plate thickness is more efficient to withstand stresses than others dome models considered for analysis.

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