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Comparative Analysis of Stone Masonry and RCC PAGODA

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Abstract. ***Pagoda is a dome shaped structure in which openings like doors and windows are in dome itself. Pagoda is mainly used for meditation purpose and preservation of relics of the Gautam BUDDHA and their students. The main objective of this study is to compare Stone masonry pagoda with R.C.C. Pagoda in terms of displacement, cost, moment and forces. Wind load is taken from IS-875 part-III. Comparison of R.C.C. Pagoda and Stone masonry pagoda was done using Staad Pro Software. It was found that Stone masonry pagoda is stronger than R.C.C. pagoda in all manners, but cost of construction of Stone masonry pagoda is higher as compared to R.C.C. pagoda. Cost of construction of stone masonry pagoda (global vipassana pagoda) is more due to transportation, dressing and cutting of stone at site and the cost of construction of R.C.C. Pagoda is low as compared to stone masonry pagoda; if we use locally available stone then the cost of construction of stone masonry pagoda will reduce.***

Keywords: pagoda, Staad pro, RCC pagoda, stone pagoda, node displacement, wind load, axial force.

I. INTRODUCTION

A dome may be defined as a thin shell generated by the revolution of a regular curve about one of its axes. The shape of the dome depends up on the type of the curve and direction of the axis of revolution. The roof is curved and used to cover large storey buildings. The shell roof is useful when inside of the building is open and does not contain walls or pillars. Domes are used in variety of structures such as roof of circular areas, circular tanks, exhibition halls, auditoriums etc. Domes may be constructed of masonry, steel, timber and reinforced cement concrete. In this paper we design RCC dome roof structure by using manual methods which gives detail design of RCC domes. The procedure of designing RCC domes was clearly explained and from the Analysis and design we get the Meridional Reinforcement, hoop Reinforcement of a dome and ring beam Reinforcement.

II. RELATED WORK

Richard L. Wood et.al (2017) investigates the effect of April 2015 M 7.8 Gorkha Earthquake and aftershocks caused extensive damage to numerous heritage sites throughout Nepal. The five-tiered Nyatapola Temple experienced extensive cracks within the unreinforced masonry. They collected detailed assessment to characterize its state in the aftermath of the 2015 earthquake to inform potential rehabilitation solutions.

E. Perriaet.al (2017) the main aim of their project is the developing of a structural model to understand the load-carrying capacity of Laves Balken's system from the laser-scanning model. For this reason the, extensive surveys and photo documentation was collected on three areas of the roof construction, characterized by three peculiar usage of Laves Balken's system. Their work presents the survey of the pagoda-roof that covers the tower of the castle, and problems that can be encountered during the survey of very complex timber constructions. For correct output, some particular considerations have to be done before and during the survey on the field.

Young Hoon Jo and Chan Hee Lee (2017) studied forces on 3D digital documentation and displacement analysis to evaluate the structural stability of 5-story pagoda in Geugolsan Mountain, Jindo, and using terrestrial laser scanning. The result of their study were analyzed to determine horizontal, central, and plane displacements due to deterioration pressure on the pagoda and conduct an evaluation of the architectural heritage. They conducted displacement analysis through three-dimensional reverse-engineering and digital restoration using terrestrial laser scanning was also conducted

SHAIK Tahaseenet (2016) the objective of their research analysis and design R.C.C. dome. The minimum thickness they take 125mm for R.C.C dome. Dead load and live load as per IS 456-2000 are considered. This study helps the long span construction of RCC domes the key objective of R.C.C. domes is to build a strong and safe roof structure.

Jianli Yuah et.al (2016) research investigates the damage situation of Ying-Xian Timber Pagoda is evaluated, advantages and disadvantages of historical restoration schemes are analyses, and a new restoration scheme is proposed. Their new scheme, tensioning-restoration and supporting-safeguard for torsion and inclined deformation of the wooden pagoda, will utilize the repairing scaffolds as the loading platforms to operate the external tensions for deformation correction of the pagoda, use the adjustable-height steel frames as the internal supports for structural safety of the pagoda during the restoration, and the tensioning-restoration shall be carried out under the non-disassembly situation of the timber structure.

Yujiao Zhou et.al (2015) discussed kiwarihou a well-known traditional architectural design method for Japanese wooden building design. They investigated the architectural design of a traditional Japanese wooden pagoda (3-storied pagoda in Joruriji temple) from the perspective of kiwarihou. Based on extensive survey on the size of this pagoda, they explored the probable content of the kiwarihou architectural design method. Their investigative result showed that the size of nearly every aspect of this pagoda are either multiples or factions of a specific length (the module).

Luko TSUWA et. al (2015) they focused on the seismic evaluation method of five-storied pagodas. A previous research pointed the effect of the bending deformation of a whole building on the vibration characteristics of a pagoda. They developed a three dimensional analytical model of five-storied pagoda including the vertical stiffness of Kumimono and truss roof as a factor of rocking motion. In addition, they conducted earthquake response analysis with the analysis model. Their analysis results almost agreed with experimental ones on the time history of horizontal displacement in each floor. But the largest deformation upper the 4th floor of this analysis model was smaller than experimental results

Renbin Zhan et. al (2015) studied, three dimensional pagoda network structure of the upper Ordovician Pagoda Formation in South China were interpreted in a special type of nodular limestone of unusual scale and morphology, formed in a relatively deeper and quiet-water substrate during a long episode (about 5 million years) of sea-level high stand. They studied corroborates recent paleo geographic reconstructions that position the South China paleoplate on the Equator during the Late Ordovician sign.

M. Shakyaet. et.al (2014) they discussed the Nepal is located in one of the most severe earthquake prone area of the world. Conservation and restoration of ancient monument and particularly temples in Nepal is the major concern in order to preserve their built heritage, transferring it to the future generation. Based on the numerical parametric analysis, structural weakness or fragilities of pagoda topology were associating to the traditional building and structural detailing of temples.

Humberto varumet .al (2013) they were devoted to outline particular building characteristics of the UNESCO classified Nepalese pagoda temple and the common structural fragilities, which may affect their seismic performance. Moreover, based on a parametric sensitivity analysis, structural weaknesses/fragilities of pagoda temple were identified associated to the local and traditional construction techniques, detailing and common damages.

Chayanon Hansapinyo et al (2013) their research is aimed to perform seismic evaluation of esteemed brick masonry in inverted bell-shaped chedi at Phrathat Doi Suthep temple, Chiangmai, Thailand by using the finite element analysis. The validated finite element model has been made through the full-scale ambient vibration test (presented in the accompanied paper) they were selected past twenty years earthquake records and matching of the records to the seismic response spectrum was mad for equation the local seismic conditions. Then the matched seismic wave record used for the input of time history analyses.

H-J. Parket.al (2013) they studied potential amplifications of hazard maps and provides primary data on seismic risk assessment of each cultural heritage sites in Gyeongin, the capital of Korea's ancient Silla Kingdom. An extensive geotechnical survey including a series of in situ tests are is presented, and they provided pertinent soil profiles for site response analyses on thirty cultural heritage sites.

III. THE PROPOSED WORK

The following data were collected for the analysis and design of RCC and stone masonry pagoda from Global vipassana pagoda Mumbai.

Table1 Pagoda Building Description

S. NO.	Pagoda building Description	
1.	Plan Area	6098.30m^2
2.	X-Y Directional Grid spacing	88.117mx83.34m
3.	Storey Height	83.34m
4.	Number of storey	3

5.	Beam Dimension	500mmx 550mm
6.	Plate thickness of first dome	1000mm
7.	Plate thickness of second dome	800mm
8.	Plate thickness of third dome	500mm
9.	Bottom Support Condition	Fixed
10.	Thickness of surface meshing	500mm

Table 2 Material Specification

S. No.	Material specification	
1.	Grade of Concrete, M-25	F_{CK}= 25 N/mm^2
2.	Density of Concrete	Y'$_c$ =25 KN/m^3
3.	Density of Stone	0.0237 KN/m^3
4.	Cost of stone	As per SOR 7300Rs per cubic meter
5.	Cost of RCC	As per SOR 4500Rs per cubic meter

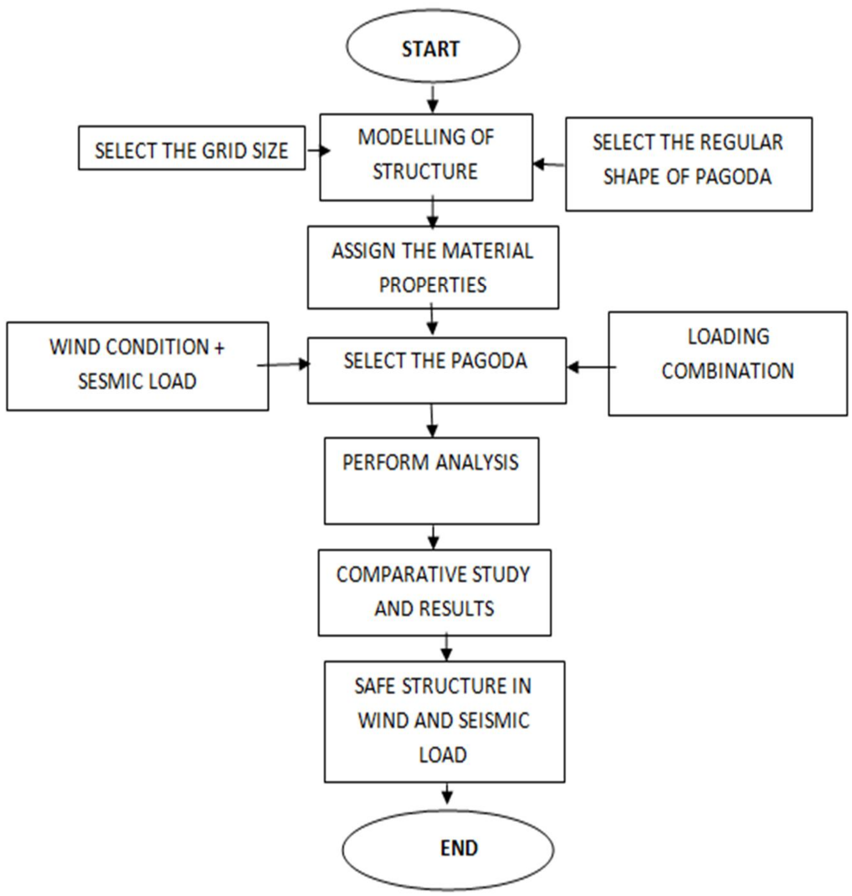

Figure1. Flow Chart showing process of analysis and design of structure

IV. CASES

A. CASE-I Following loads are adopted for analysis (concrete pagoda)-

1) Calculation for seismic load for RCC Pagoda

Dead load calculation = Load of plaster + Load of floor finish

2) *Self weight of RCC Pagoda* - It comprises of weight of beams and RCC plate in the structure.= 4 KN/m^2

Dead load calculation = External wall load + Load of plaster + Load of floor finish

LUMP WEIGHT = DEAD LOAD + 0.5 LIVE LOAD

3) Dead load on concrete pagoda- it is calculated as per IS-875 (part I): 1987

a) Self weight- It comprises of weight of beams and RCC plates in the structure.

b) Load of plaster = External wall thickness + Internal wall thickness thickness of plaster X density of plaster + thickness of Plaster X density of plaster

4) Wind load- It is calculated as per IS-875 (part III): 1987.

Design wind pressure **(P_Z).**

$$\mathbf{P_Z = 0.6\, V_Z^2} \text{(N/m}^2\text{)}$$

V_Z= design wind velocity in m/s at height z.
P_Z= design wind pressure in N/m2 at height z.
V_Z = hourly mean wind speed in m/s at height z.
V_b = regional basic wind speed in m/s (Bombay=44).
K_1= probability factor.
K_2 = terrain and height factor.
K_3 = topography factor.

$V_Z = V_b\, K_1\, K_2\, K_3$
=44 x 1 x 1.2 x 1
=52.8 m/s

B. Case-Ii Following Loads Are Adopted For Analysis (Stone Masonry Pagoda Dome)-

1) Calculation of seismic load for stone masonry pagoda.

a) Self weight of stone masonry = It comprises of weight of beams and stone plate in the structure.

b) Load of floor finish= thickness floor finish X density of floor finish.(Minimum thickness of floor finish = 50mm to 100mm

c) Live load for commercial = 4 KN/m^2

LUMP LOAD = DEAD LOAD + 0.5 LIVE LOAD

V. COMPARATIVE ANALYSIS

Table5 Comparison results of stone masonry and RCC pagoda.

S. NO.	Forces, Moments and node displacement	STONE MASONRY PAGODA	R.C.C. PAGODA	STONE MASONRY PAGODA/R.C.C PAGODA in times
1.	Maximum Bending Moment in Z-Direction(KN-m)	37.052	61.553	0.60
2.	Maximum Bending moment in Y-Direction(KN-m)	8.879	135.734	0.0654
3.	Axial force (KN)	38.079	599.626	0.0633
4.	Shear Force in Y-Direction(KN)	66.09	207.875	0.317
5.	Shear Force in Z-Direction(KN)	24.462	375.228	0.065
6.	Node Displacement(mm)	1.46	75.185	0.019
7.	Torsion(KN-m)	1.545	452.316	3.4×10^{-3}

In this table, we calculate the measures for RCC and stone masonry pagoda. The maximum bending moment in y & z direction, axial force, shear forces in y & z direction, node displacement and torsion in stone masonry pagoda are less as compare to RCC Pagoda

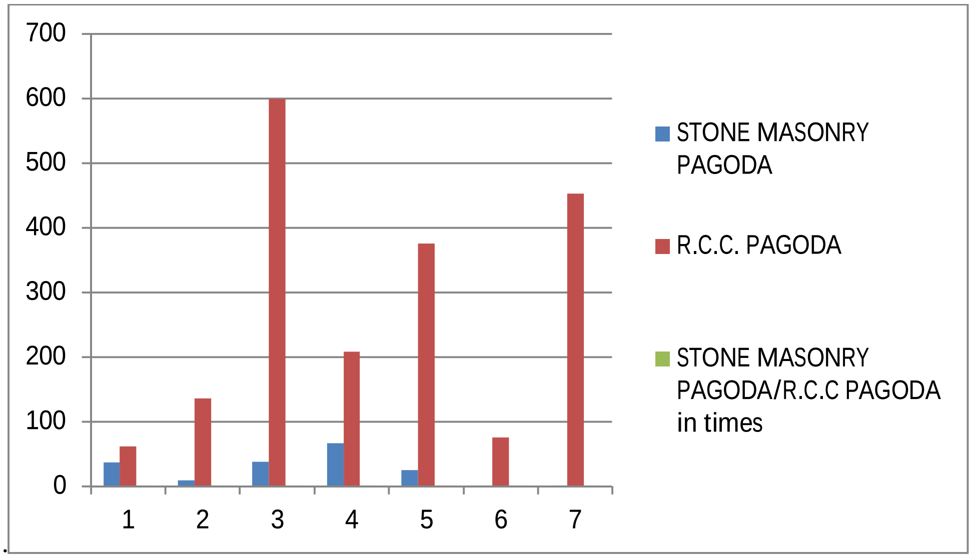

Figure2. Comparison results of stone masonry and RCC pagoda

VI. CONCLUSION AND FUTURE SCOPE

In this paper a framework for comparative analysis of RCC and stone masonry pagoda have been presented in terms of axial force, node displacement, torsion, maximum bending moment in y & z direction and shear forces in y & z direction. We have also presented results in cost. The construction cost of stone masonry pagoda is more than RCC pagoda due to transportation, dressing and cutting of stone. If we use locally available stone than the cost of construction of stone pagoda will reduce.

We compared RCC and Stone masonry pagoda by using Staad prov8i. Axial force, node displacement, torsion, maximum bending moment in y & z direction and shear forces in y & z direction are more in RCC pagoda as compare to stone masonry pagoda. The research proposals made out of this thesis have opened several challenging research direction, which can be further investigated. Echo sound effect problem is the major problem inside the Global vipassana pagoda. In further study other monuments of stone can be consider. In our study dome structure is considered whereas in future it can be extended to other shape structures.

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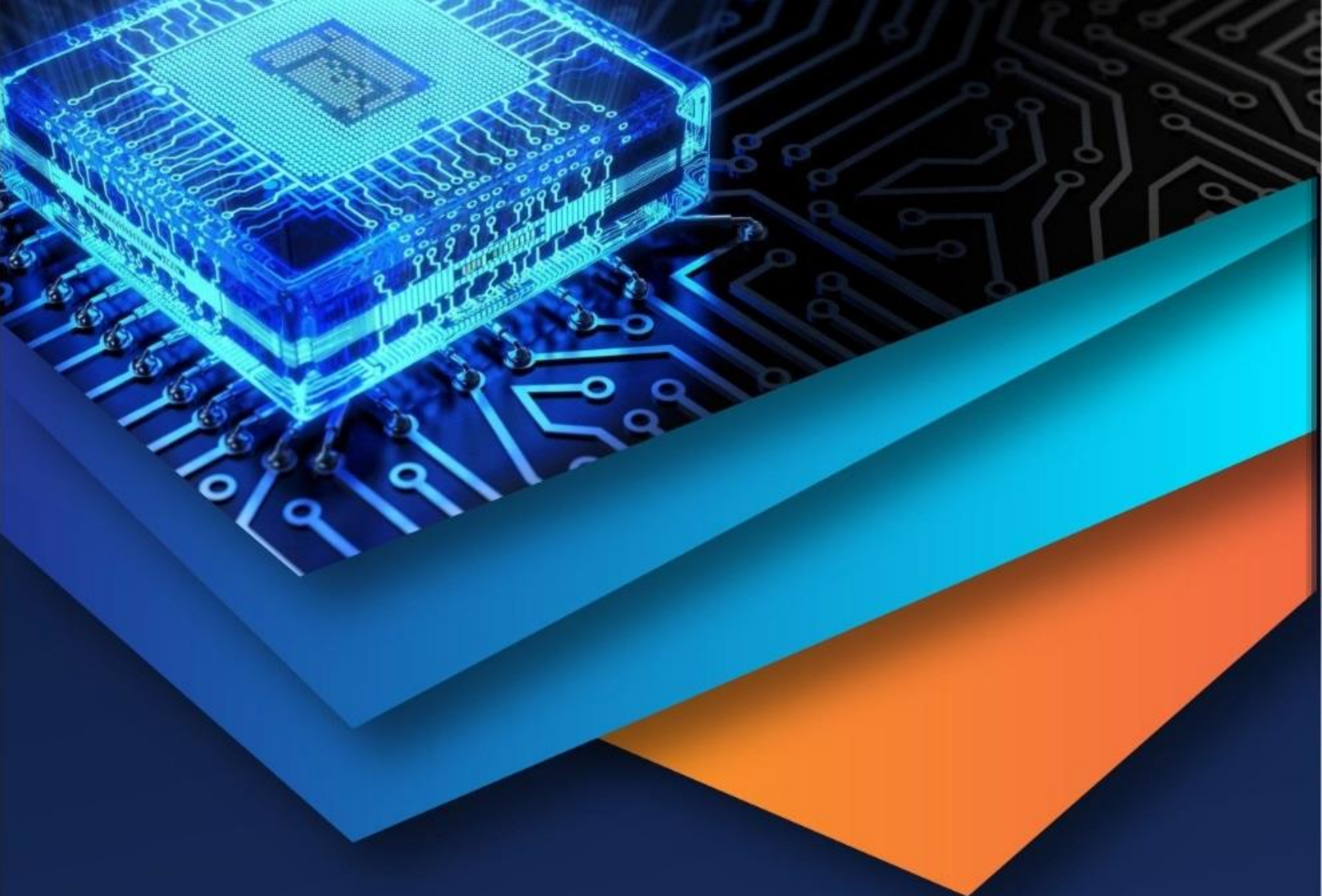

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