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Finite Element Analysis of Ancient Thousand Pillar Temple in Southern India

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Introduction:

- Kakatiyas said to have ruled for more than 300 years during which they have built several stone temples with beautiful architecture spread across Hanumakonda, Warangal, Pillalmarri. Some of the prominent examples of Kakatiyan architecture are Thousand pillar temple, Ramappa Temple, Warangal Fort, Kakatiya Kala Thoranam, and Ghanpur temple [1].

- In this paper, an attempt is made to develop a three-dimensional model of the complicated structure "Thousand Pillar Temple" of the Kakatiyan Era constructed during 1175–1324 CE with a special focus on the geometrical detailing.

- Thousand pillar temple (Veyisthambala Gudi) is one of the fine and earliest available examples of Kakatiya art, architecture and sculpture built in 1163 AD using grey granite as seen in fig-1. This site is recognized as a world heritage site by UNESCO (5889) [2].

- Structural foundation is said to be constructed using sandbox technique which can resist horizontal loads especially earthquakes.

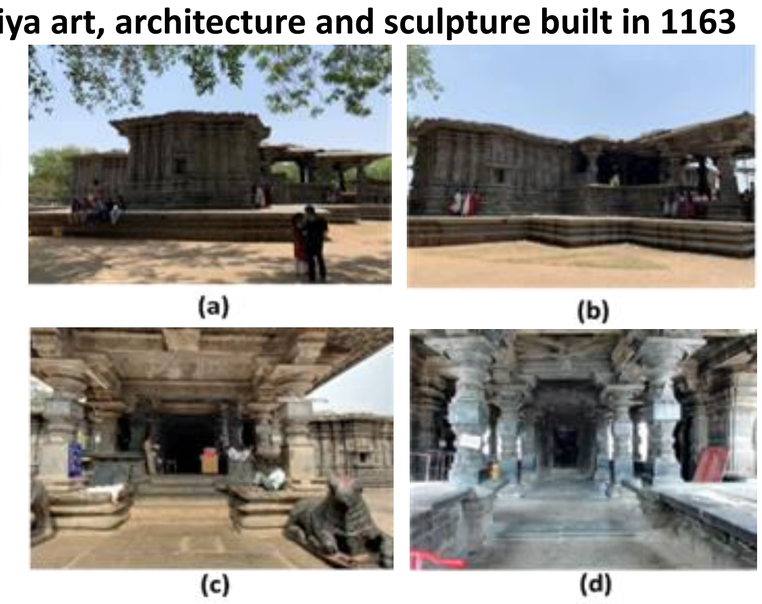

Fig.1. External and internal views of the thousand pillar temple with its plan

Numerical Modelling

- The authors have visited the temple and column dimensions have been measured at the site manually and all other dimensions have been interpolated using photogrammetry techniques as given in fig-2.

- Fig-2 (a) shows a original column with segregation marking of different geometrical components with roman numbers, and the respective components have been modelled carefully as seen in fig-2 (b) so that all the geometrical aspects are considered for the numerical analysis.

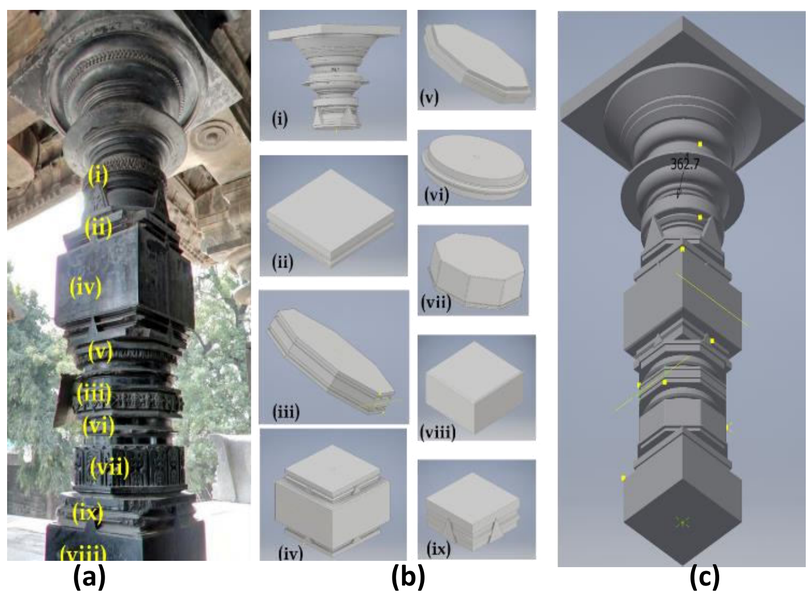

Fig.2. (a) Column with numerical Geometrical segregation (b) Individual component modelling (c) Concatenation of all the individual components

- Once all the sections of the column are developed, they are combined to form a column as shown in fig-2(c). Fig-3 shows the other two types of pillars, beam modelling and beam-pillar joint. Complete modeling is shown in fig-4.

Fig.3. Columns with developed three-dimensional models

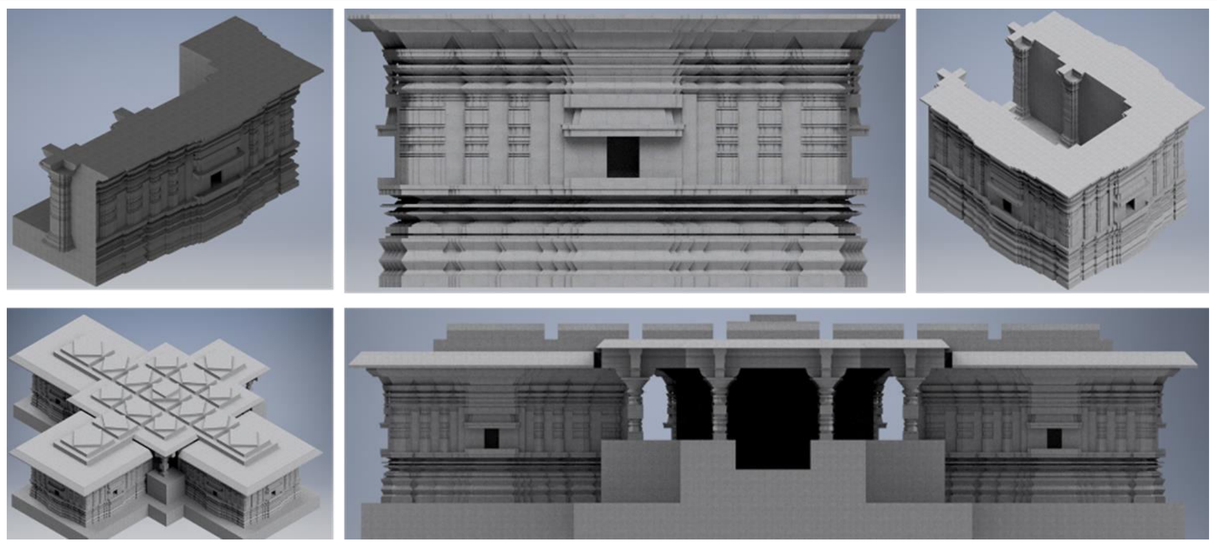

Fig.4. Wall, sectional views of Sanctum, complete three-dimensional model with a perspective view and side view

Analysis and Results:

- Physical properties of the Granite stone are, Youngs Modulus-55000 MPa, Poisson's Ratio-0.25, Shear Modulus-27000 MPa, and Density-2700 kg/m3.

- Fig-5 shows four images regarding the CAD model, Meshing, Von-misses stress and displacement modelled in Autodesk Inventor and Table-1 shows the column type, its height, mesh details, and max stresses.

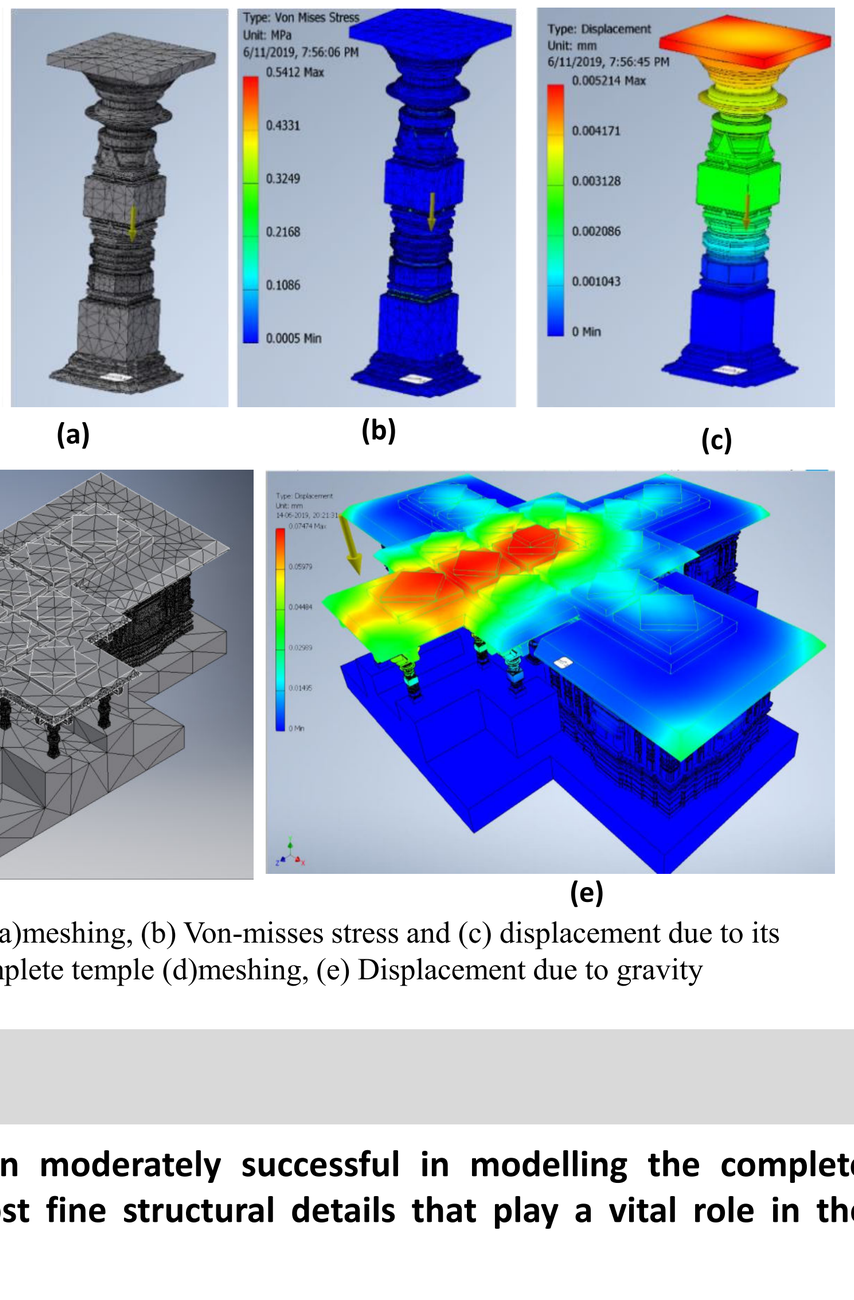

Fig.5. Column type-1 (a)meshing, (b) Von-misses stress and (c) displacement due to its self-weight. Complete temple (d)meshing, (e) Displacement due to gravity

Conclusions:

- This study has been moderately successful in modelling the complete structure with almost fine structural details that play a vital role in the gravity analysis.

- Another conclusion from the study is that columns cannot be assumed similar or uniformly modelled in the numerical modelling. The fine geometrical considerations of the columns will increase the understanding of the structural response, structural stability, and load transfer for both gravity and lateral loads.

Important References:

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