

The effect of displacement induced loading on ancient stupas of different shapes

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The ancient stupas are the oldest gravity structures in Sri Lanka. These stupas have been made of bricks in lime mortar. Huge granite solid rocks were also used for the foundation. The main components of a stupa are: a square platform (salapathalamaluwa), basal rings (pesa-valalu), a solid dome (garbhaya) a square chamber (hataraskotuwa), a cylindrical member (devatakotuwa), a conical member (kothkerella) and kotha at the top of the conical member. Generally according to its shape, these can be classified into six categories, but in this country there is evidence of four types of structures. These are bubble shaped (like a hemisphere), bell shaped (like a bell), paddy-heap shaped (like a heap of paddy) and a pot shaped (like an inverted pot). Due to several decades of neglect of these stupas and enemy attacks, some remain to be in ruins. In some stupas, there was evidence of apparent fractures. But the rulers at that time had taken great efforts from time to time to restore them. Here all efforts to restore the structures have been made within a framework of environmentally friendly techniques and materials. Some of these monuments have changed in shape due to various rehabilitation processes including expansions at the base. Other efforts include plastering with new coatings to the outer surface.

Present finite element analysis recognises self weight of the dome and settlements at the base of the dome. Literature provided by the Jetavana Project Office describes the limited tests conducted on the materials on samples cut from ancient bricks, and hence it is assumed that the material used for other stupas have similar properties.

In this study, the four common domes are analysed for force and displacement induced loading. The element utilised is axi-symmetric solid (ASOLID) of SAP90. For each model 4-node quadrilateral and 3-node triangular elements have been utilised. Load case 1 is only the self weight of the dome where the base is fully restrained. Load case 2 is the loading due to the applied displacements at some points of the base. But in the actual situation, these two cases occur together. Element stresses are determined by using geometric centre of the finite element. Results reveal that actual vertical element stress has more influence on the fracture of these stupas. The analyses reveal that largest tensile stresses developed in the circumferential direction is maximum in the bubble shaped type. This is followed by the paddy-heaped, pot shaped and bell shaped.

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