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STRESSES IN A STUPA DOME WITH NON-HOMOGENEOUS MATERIALS

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Ancient Stupas in Sri Lanka are solid structures, mostly made of bricks, and some of them reached colossal proportions. The Jetavana Stupa built by King Mahasena (276-303 AD), reached a height of 122 m, making it the third tallest structure in the world at one time, and it is still the largest brick structure in the world.

With the passage of time, and due to the exposure to elements and the neglect, ancient stupas underwent decay, and were restored from time to time. Presently the Central Cultural Fund is carrying out restoration/conservation of ancient stupas, and this should be carried out with care and sensitivity. One of the requirements for this is the knowledge of stresses in the stupa, and the identification of critical zones.

In connection with the conservation of Jetavana stupa, stress analyses have been done previously, assuming the stupa material to be homogeneous. However, excavations have shown that the dome of the stupa, its largest structural component, have four different zones made of bricks of different sizes, and earth; the outermost zone consisting of large strong bricks and the inner core consisting of earth filling.

This paper presents some results of a study of stresses in the dome of the Jetavana stupa, taking into account the non-homogeneity of its material. Analyses were done using the finite element package SAP2000. The dome, which is a truncated ellipsoid of height 52.2 m, and base diameter 105.4 m, was modelled as an axisymmetric solid of linear elastic material having different values for Young's modulus (E) and Poisson's ratio (υ). The loading considered was that due to gravity.

The results show that the vertical stresses are moderately sensitive to material properties, the sensitivity being more to Young's modulus than to Poisson's ratio. The vertical stresses are compressive throughout the dome, and they reach a maximum of 823 kPa at the centre of the base when $E = 4.5$ GPa throughout, and this value starts to decrease as E at the core is reduced beyond 2.5 GPa, and reaches 594 kPa at the centre of the base when E is made very small. On the other hand, radial and hoop stresses are very sensitive to material properties, especially to Poisson's ratio. They also remain compressive all over the dome, except when E is made very low at the core.

The mild dependency of the vertical stresses on the material properties is to be expected, as the vertical stress essentially takes up the self weight. The strong dependency of horizontal stresses (hoop & radial) on Poisson's ratio is also to be expected, as Poisson's effect is the main factor causing them. In all cases, stresses found were well below the strengths of the ancient bricks.