

Analysis of Ancient and Present Lightning Protection Systems of Large Heritage Stupas in Sri Lanka

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Abstract : Protection of heritage monuments against lightning has become extremely important as far as their historical values are concerned. When such structures are large and tall, the risk of lightning initiated from both cloud and ground can be high. This paper presents a lightning risk analysis of three giant stupas in Anuradhapura era (fourth century BC onwards) in Sri Lanka. The three stupas are Jethawaaramaya (269-296 AD), Abayagiriya (88-76 BC) and Ruwanweliseya (161-137 BC), the third, fifth and seventh largest ancient structures in the world. These stupas are solid brick structures consisting of a base, a near hemispherical dome and a conical spire on the top. The ancient stupas constructed with a dielectric crystal on the top and connected to the ground through a conducting material, was considered as the hypothesis for their original lightning protection technique. However, at present, all three stupas are protected with Franklin rod type air termination systems located on top of the spire. First, a risk analysis was carried out according to IEC 62305 by considering the isokeraunic level of the area and the height of the stupas. Then the standard protective angle method and rolling sphere method were used to locate the possible touching points on the surface of the stupas. The study was extended to estimate the critical current which could strike on the unprotected areas of the stupas. The equations proposed by (Uman 2001) and (Cooray2007) were used to find the striking distances. A modified version of rolling sphere method was also applied to see the effects of upward leaders. All these studies were carried out for two scenarios: with original (i.e. ancient) lightning protection system and with present (i.e. new) air termination system. The field distribution on the surface of the stupa in the presence of a downward leader was obtained using finite element based commercial software COMSOL Multiphysics for further investigations of lightning risks. The obtained results were analyzed and compared each other to evaluate the performance of ancient and new lightning protection methods and identify suitable methods to design lightning protection systems for stupas. According to IEC standards, all three stupas with new and ancient lightning protection system has Level IV protection as per protection angle method. However according to rolling sphere method applied with Uman's equation protection level is III. The same method applied with Cooray's equation always shows a high risk with respect to Uman's equation. It was found that there is a risk of lightning strikes on the dome and square chamber of the stupa, and the corresponding critical current values were different with respect to the equations used in the rolling sphere method and modified rolling sphere method.

Keywords : Stupa, heritage, lightning protection, rolling sphere method, protection level

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