Investigation of International Standard, International Electrotechnical Commission, IEC 62305 and Indian Standard IS 2309 in positioning the Air Terminals (ATs)

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Abstract—**From 18th Century onwards, many scientists and researchers across the globe have conducted experiments and researches related to the subject called Lightning and as a result they have acquired success in protecting the structures against lightning strokes to a great extent. However, the science behind lightning has not been completely discovered and therefore any design of lightning protection scheme can't be certified as cent percent safe.**
Here in this paper, a cuboid equivalent to a rectangular industrial building has been taken into consideration. Lightning Protection Scheme for the same has been designed in two ways: i) based on the Protective Angle Method and Rolling Sphere Method as per International Standard IEC 62305 and ii) based on the Protective Angle Method as per Indian Standard IS 2309. This paper mainly focuses on the comparison of those two designs which ultimately discloses the difference in safety level that we are having by adopting a particular standard.

***Index Terms*—Lightning, Protective Angle, Rolling Sphere, Air Terminal**

I. Introduction

The function of the air-termination systems of a lightning protection system is to prevent direct lightning strikes from damaging the volume to be protected. They must be designed to prevent uncontrolled lightning strikes to the structure to be protected. By correct dimensioning of the air-termination systems, the effects of a lightning strike to a structure can be reduced in a controlled way. There are three methods based on which air termination system can be designed, which are as follows: i) Protective angle method, ii) Mesh method and iii) Rolling sphere method. All these methods are explained in the International Standard, IEC 62305. Whereas on the other hand, Rolling Sphere Method is not discussed in the Indian Standard, IS 2309. However, Mesh method is described nearly in the same manner in both the standards. Therefore, for simplicity and for the purpose of comparison, here we will consider only the first and last method.

II. Design based on the Rolling Sphere Method:

Applying the rolling sphere method, the positioning of the air termination system is adequate if no point of the structure to be protected comes into the contact of the sphere with radius, r, depending on the class of Lightning Protection System (LPS), rolling around and on top of the structure in all possible directions.
For the design purpose, a rectangular building having the following dimension has been taken into the consideration:
Length = 54 meter
Width = 27 meter
Height = 15 meter
Assuming Class IV of Lightning Protection System (LPS), we get the radius of the rolling sphere to be 60 meter, according to the Table 2 given in IEC 62305-3 as shown below:

Table 1: Rolling Sphere Radius for different classes

Class	I	II	III	IV
Radius of Rolling Sphere	20	30	45	60

As per the design six Air Terminals (ATs) are placed on the top of the building as shown in the below figure:

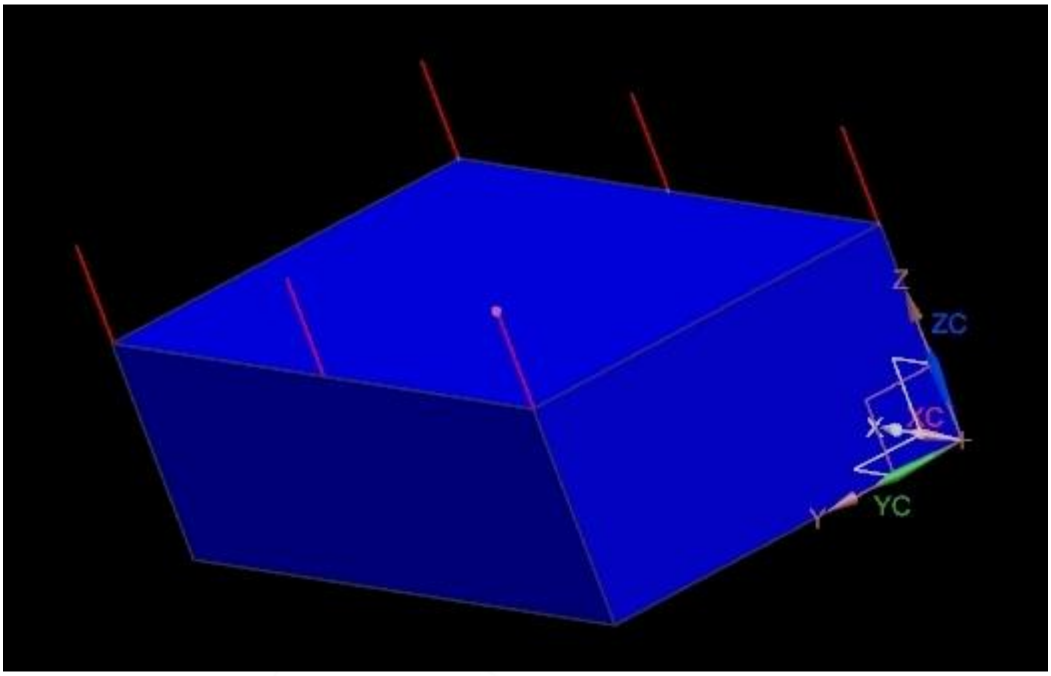

Figure 1: Cuboid with ATs on the top of it

On all the structures, higher than the rolling sphere radius r, flashes to the side of structure may occur. Each lateral point of the structure touched by the rolling sphere is a possible point of strike. However, here we can neglect this aspect of side flashes as the height of the building considered is 15 meter and the probability for flashes to the sides is generally negligible for structures lower than 60 meter, as per the standard.

Now keeping the height of these ATs as much as 5 meter, no point of the building comes in contact with the sphere when rolled around and on the top of the building. Therefore it can be considered that the design of the lightning protection system is safe as whole of the protection zone comes under the volume protected by the designed ATs.

III. Design based on the Protective Angle Method according to IS 2309:

The protective angle depends upon the severity of the stroke and the presence within the protective zone of conducting objects providing independent paths to earth. For the practical purpose of providing an acceptable degree of protection for an ordinary structure, the protective angle of any single component part of an air termination network, namely either one vertical or one horizontal conductor is considered to be 45°. Between three or more vertical conductors, spaced at a distance not exceeding twice their height, the equivalent protective angle may, as an exception, be taken as 60° to the vertical conductor.

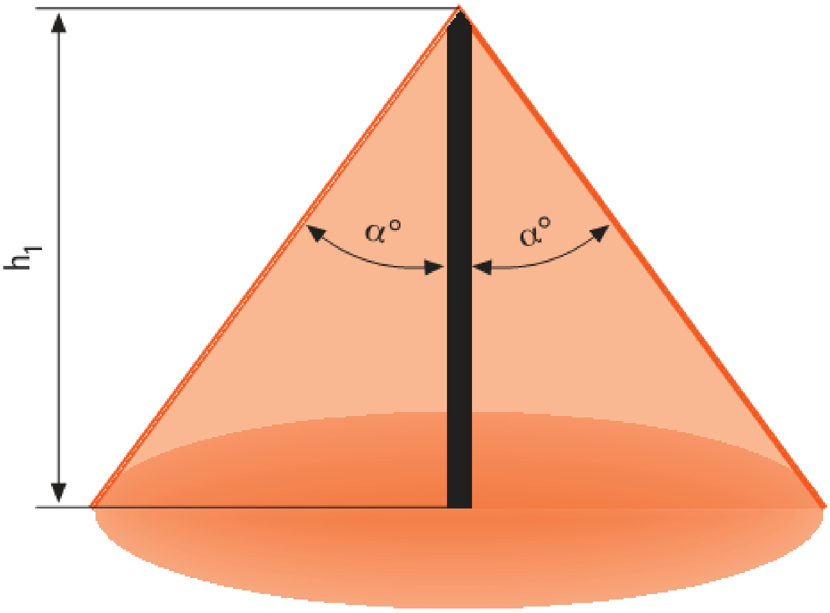

Figure 2: Cone of Protection

In the above design based on the rolling sphere method, the distance between any two ATs is equal to or more than 27 meter, which is quite more than twice the height of ATs. Therefore, the protection angle of 45° has to be considered and accordingly if we draw the cone of protection as shown in the above figure, then it does not cover the entire protection zone. Therefore, it can be observed that as many of the edges do not come under the volume protected by the cone of protection, the above design is not safe as per IS 2309.

IV. DESIGN BASED ON THE PROTECTIVE ANGLE METHOD ACCORDING TO IEC 62305:

The volume protected by a vertical rod is assumed to have the shape of a right circular cone with the vertex placed on the air termination axis, semi-apex angle α, depending on the class of LPS, and on the height of the air termination system as given in Table 2 of IEC 62305-3.

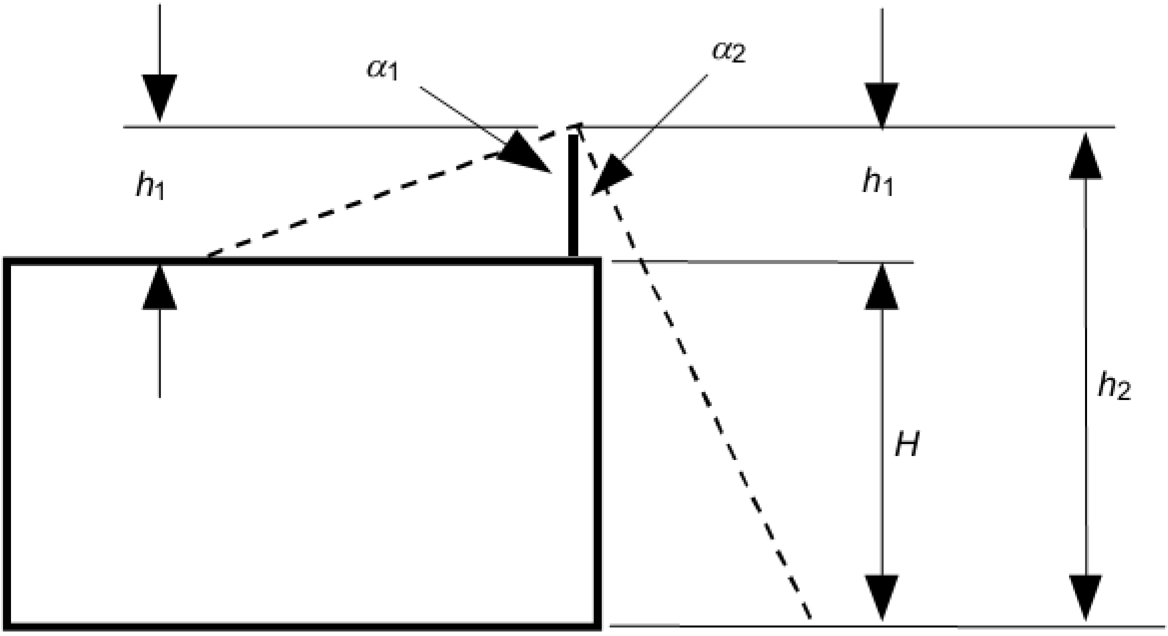

Figure 3: Volume protected by a vertical air-termination rod

Here h_1 is the physical height (5 meter in our case) of the air termination rod. The protection angle α_1 corresponds to the air termination height h_1, being the height above the roof surface to be protected; the protection angle α_2 corresponds to the height h_2=h_1+H, the ground being the reference plane.

For the above design, as the height of air termination rod is 5 meter, the corresponding α_1 will be 72°. As a result the distance covered on the roof from the bottom of the air terminal will be equal to 15.39 (i.e. 5*tan72°).

However, keeping the number of ATs fixed, the height of the ATs is not adequate enough to cover the entire protection zone.

CONCLUSION

It has been considered that the rolling sphere method mentioned in IEC 62305, is the best method for positioning the air termination rod compared to the other methods of lightning protection scheme. However, from the above example it can be concluded that the rolling sphere method is not the best suited method in all the cases. Sometimes this method fails to design the best protection scheme because of the large difference in the radii between the different lightning protection levels. In this case, the design was safe as per the rolling sphere method mentioned in IEC 62305. However, the same design was proved to be unsafe according to the protective angle method mentioned in IEC 62305 as well as IS 2309.

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