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Optimized Design of Lightning Protection using Rolling Sphere Method

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Abstract: ***This Article is going to furnish information about all lightning protection schemes that has to be provided for some types of buildings in order to provide a rigid protection against lightning strikes. International Standard IEC 62305 recommends to use three methods of lightning protection systems, either mesh, protection angle or rolling sphere. A summary of a case study conducted at Canada for one of the AIS Substation will be discussed. The substation initially designed to use lightning protection system, and thenafter some decades the same was upgraded to rolling sphere method. Comparison will be made to show how the optimum selection of lightning protection scheme saves time, cost and has direct impact on the environment, in terms of reducing the number of main components utilized for a building.***

Keywords: lighting strikes, IEC 62305, Mesh, protection angle, rolling sphere

1. Introduction

World wide news annually broadcast that lightning strikes is posing catastrophic damages to assets and threaten human lives. For precaution sake, during construction of some types of building, it is very essential to consider Lightning Protection System (LPS), which has to be designed according to certain set of regulations, especially if the building contains valuable equipment located at power stations/ substations or there are flammable substances stored inside/outside the buildings. LPS is a system designed to provide a dedicated path for lightning to discharge to earth, without creating any harm to personals or electrical equipment. It consists of many items, mainly air terminals to surge the lightning and other auxiliary metallic accessories. In line with lightning protection international standard, IEC 62305, there are different schemes of lightning protection system, Mesh, Protection Angle and rolling spheres. Each method will be introduced briefly.

2. Abbreviations

- Lightning Protection System: LPS
- Rolling Sphere Method: RSM
- Minimum Time Between Failure: MTBF
- Heating Ventilation & air conditioning: HVAC
- Photovoltaic: PV

3. Different Schemes of Lightning Protection Systems

3.1 Mesh Protection System

Mesh design method is the simplest form of LPS, because it is undependable on the height of the building, and used for simple architectures like domestic households, mainly for perfectly square or rectangular buildings. It consists of an auxiliary mesh made of flat conductive materials joints together at defined interval (i. e. copper). The mesh can be installed only on Flat on sloped structure, not curved (Refer to Figure - 1). For Medium to large - scale buildings (i. e. Substations, Industry plants), mesh can be implemented, but due to its limitations, it does not come alone. It has to be merge with other types of LPS, either protection angle or rolling sphere, subject to the suitable class number of each type. According to IEC 62305, mesh conductor size differs based on the selected class, and that is totally dependable on user requirements (Refer to Table - 1).

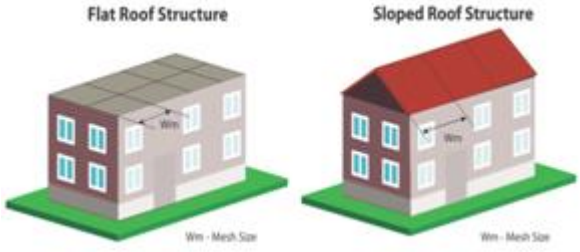

Figure 1: Typical Example of Mesh Scheme Application
Reference: https://axis-india.com/mesh-method-for-lightning-protection/

Table 1: Mesh Protection conductor size based on selected class. Reference: IEC 62305

Sr. No.	Class of LPS	Mesh Size
1	Class I	5 × 5
2	Class II	10×10
3	Class II	15×15
4	Class IV	20× 20

3.2 Protection Angle System

Protection Angle method is wider in applications comparted tomesh method, because it can be installed at gable roofs (not smooth/not flat), refer to figure - 2. In addition, protection angle is recommended in case there are metallic equipment installed at roof like HVAC units or PV panels. This type of protection scheme uses number of air terminals placed at the highest points on top of buildings/structures at different locations. Each air terminal covers a certain angle of protection, figure - 3showsthe class numbers that can be selected during Engineering of a particular building. The degree of protection can be selected based on the height of terminal from base to tip, complication of the architecture and height of the building. For example, if class I is selected, this means that the angle of protection is 70 degree, considering 2 meters height of the terminal. (Simple design).

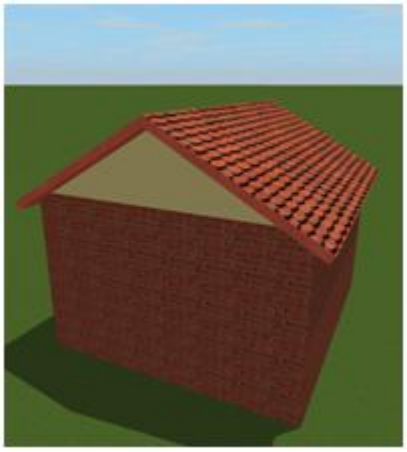

Figure 2: Structure with Gable roof. Reference: https://www.livehome3d.com/support/lh3d-win-help/en/working-with-roofs-modifying-the-style-of-a-roof

In case of installing PV panels at roof, sufficient distance among the modules and air terminals shall be considered to avoid sparking, as well as selecting the appropriate protection angle. The designer has to conduct risk assessment and evaluation for the plot, accordingly the class of air terminals and number shall be selected. The risk shall consider the type of building and the likelihood of experiencing lightning strikes.

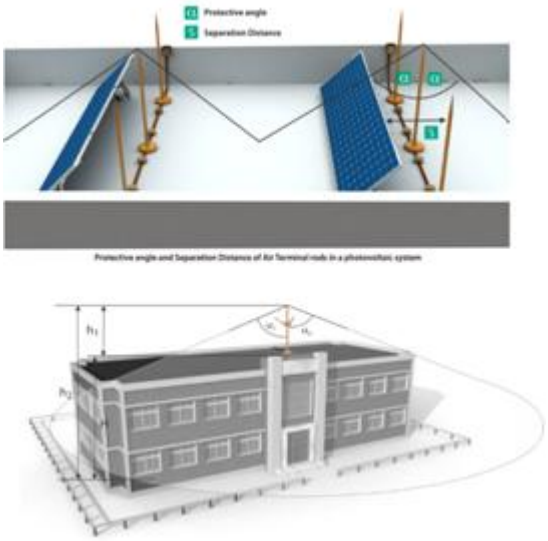

Figure 3: Protection angle, based on selected class. Reference: IEC 62305

3.3 Rolling Sphere

Rolling Sphere method (RSM) is a geometric modeling used to aid in selecting the area of lightning protection zone that cover a particular building. This method is more accurate and complex compared to other lightning protection schemes, because it specifies the exact number of spikes needed for each building and considers the worst case scenarios, in which a lightning strike hits the side of the building. The module simulates an imaginary sphere rolling covering/shading the area that want to be protected from strikes. The area of protection covered depends on the radius of the imaginary sphere, and the geometry of the structure. Table - 2 shows the radius of sphere according to the class number. This is totally depends on customer requirement as more radius indicates more protection coverage.

Table 2: Protection class based on sphere radius
Reference: IEC 62305

Sr. No.	Class of LPS	Radius
1	Class I	20 m
2	Class II	30 m
3	Class II	45 m
4	Class IV	60 m

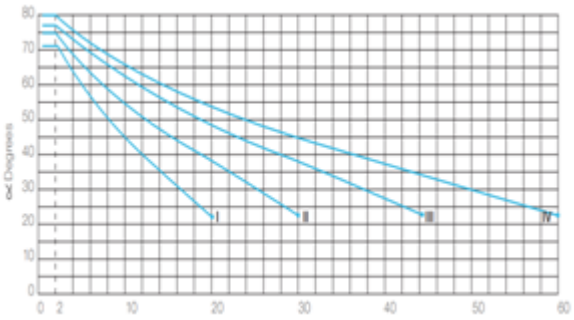

Figure 4: Examples of protection angle implementation Reference: https://axis-india.com/protective-angle-method-for-lightning/

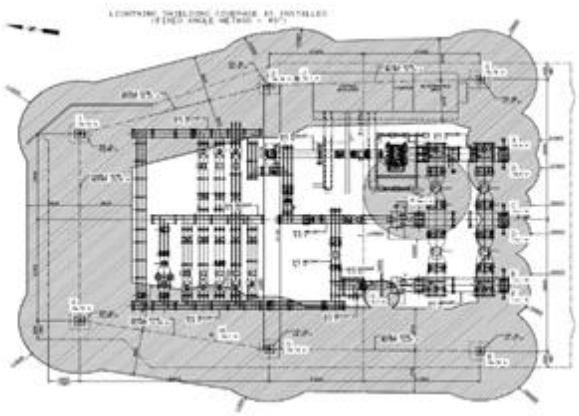

Figure 5: Examples of rolling sphere implementation Reference: https://axis-india.com/rolling-sphere-method/

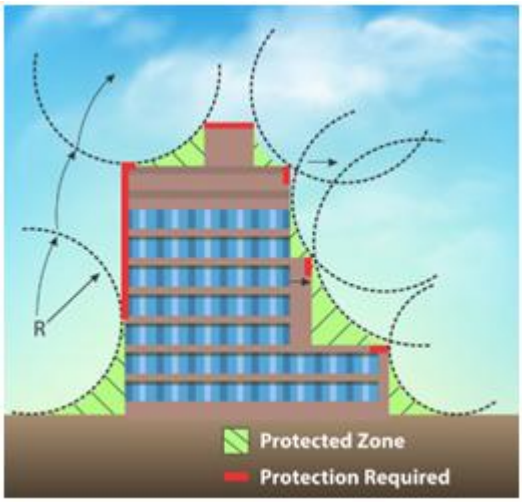

Figure 6: Substation plan view with protection angle lightning protection scheme.
Reference: Case Study [1]

4. Case Study and Comparison

Referring to a case study made by Professor. “Stephen Chuang”, Canada, for one of the out yard AIS substations. Risk evaluation and comparison made among protection angle (selected angle 45 degree) and rolling sphere methods. From the detail calculations, it is found that the failure rate of protection angle was 0.2%. Accordingly, the calculated Minimum Time Between Failures (MTBF) is4, 266, 211 years from one flash that may strike the equipment to another flash. However, the failure rate of rolling sphere was 0.05%, which reflects MTBF of17, 064, 846years between one severe flash to another. This conclude that rolling sphere method has safer margin and more rigid to withstand compared to protection angle.

The substation commissioned in 1964 with protection angle lighting method. Six spikes were utilized at the roof, along with other earthing and lighting accessories. The protection coverage /zone is as shown below in figure (6). It is not covering the entire plot of the substation, thus not protecting all the equipment exposed to sky. After few decades, lightning protection scheme upgraded to rolling sphere. Although the same number of terminals/spikes used, the protection zone is increased, refer to figure (7). Likewise, a complete protection zone can be achieved by protection angle, in case of increasing the number of air terminals. Obviously rolling sphere method is achieving much more protection zone with also six number of spikes (no change).

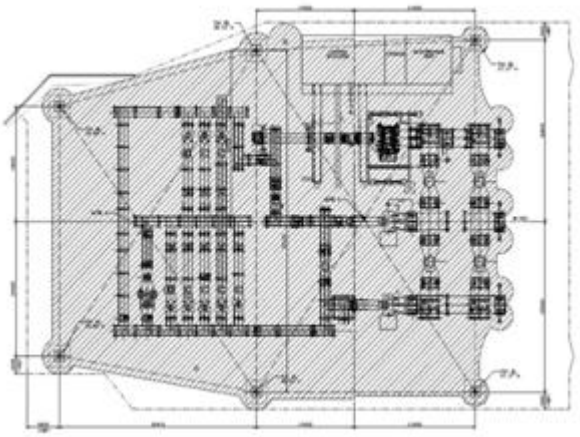

Figure 7: Substation plan view with rolling sphere lightning protection scheme.
Reference: Case Study [1]

5. Conclusion

As responsible consumers living on this earth, it is important to consider the environmental effects during planning and engineering stages of any building has to be constructed. Besides choosing the optimal sorts of civil materials, earthing and lightning materials shall be considered too, as it was the focal point of discussion in this article. It is clearly shown that rolling sphere is the best selection for lighting protection scheme, because it saves the quantity of earthing and lightning materials, thus reduce the installation time, less labor and machines utilized during project life cycle, without compromising the safety and quality of the system. Eventually that is linked to reducing the carbon footprint, thus saving the environment.

References

[1] A Case Study for Substation Lightning Strike Risk Evaluation, by Stephen Chuang, 111 Dunsmuir Street #400, Vancouver, BC V6B 5W3, 604 - 6644123.
[2] IEC International Standard, Reference - IEC 62305. (2010).
[3] Lightning Protection Guide - 3rd Edition. (2015). Retrieved from www.dehn - international. com: https: //www.dehn - international. com/sites/default/files/media/files/lpg - 2015 - e - complete. pdf
[4] Mesh Method for Lightning Protection Design as per IEC 62305. (2020, Augest 18). Retrieved from www.axis - india. com: https: //axis - india. com/mesh - method - for - lightning - protection/
[5] Modifying the Style of a Roof. (n. d.). Retrieved from Live Home 3D: https: //www.livehome3d. com/support/lh3d - win - help/en/working - with - roofs - modifying - the - style - of - a - roof
[6] Protective Angle Method for Lightning Protection Design. (2020, July 14). Retrieved from www.axis - india. com: https: //axis - india. com/protective - angle - method - for - lightning/
[7] Rolling Sphere Method for Lightning Protection. (2020, Augest 4). Retrieved from www.axis - india. com: https: //axis - india. com/rolling - sphere - method/

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