

Lightning Effect on Scaled Protected and Un-Protected Building Structures and the Air Terminal Bypasses

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ABSTRACT

Lightning strikes affect the building structures by producing high electric field on the surface and around the building structure. Lightning air terminal is a traditional enemy of the thunder storm as it captures the lightning flashes. Effect of lightning flash on the building structure when the lightning air terminal was not installed and when it was installed on different building structure was studied in this paper. Similarly most of the time Lightning Air Terminal (LAT) bypasses take place on different building structures and thus a lot of building structures get damage. The phenomenon of bypasses was also studied in this paper. When thunder storm strikes a building the electric field effect is propagated throughout the building surface and it damages the entire building. When the air terminal is placed on the corners/edges it captures the lightning flashes on certain points and discharges it into the ground and the building remains safe. This phenomenon was studied in detail in this paper and it was proved that by installing the air terminal the remaining building structure was safe and the electric field intensity was concentrated on the installed air terminal rather than the whole roof top and the rest of the building.

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1. INTRODUCTION

Lightning protection can be divided into two main aspects which are (1) building protection by minimizing the magnetic and electric field and (2) by reducing the effect of high voltage and high current [1]. Building protection from lightning was proposed by standard documents in 1978 and now many standard documents given much more information about building protection [2]. Lightning flashes initiation takes place around 5 km for a cloud to ground flashes. When the flashes approach to the surface of the ground it produces electric field on the building structures or the trees and other grounded objects when the distance is around 100 m above the ground [3]. Lightning Air Terminals (LATs) can be divided into different types which are standard sharp pointed, blunt, concave, flat and conical which are given in Figure 1 [4].

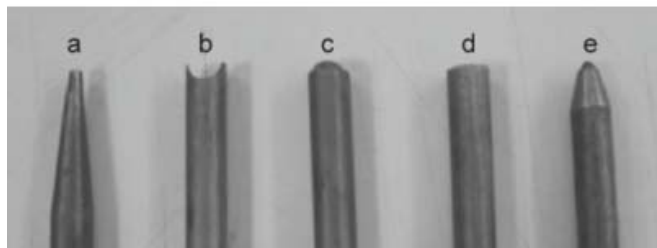


Figure 1. Different Types of LATs. (a) Standard Sharp Pointed (b) Concave (c) Blunt (d) Flat (e) Conical

In this paper the standard LAT was used as all the standards still recommend and easy to installed on the roof tops of the building structures.

2. ELECTRIC FIELD AND BUILDING STRUCTURE

During a thunderstorm the cloud is electrically charge by positive and negative charge the process of ionization takes place as a result of which lightning stroke is formed which produces the electric field on the grounded structures [5]. Lightning flash attracted by any grounded object is a complex phenomenon. When a downward leader exists and the leader channel develops from its tip it produces the upward from the tip when it interfere the down ward leader channel [6]. The electric field value at the ground level in normal weather condition is 130V/m while as the thunderstorm effect increases its effect becomes more and reaches up to a level of 1 kV/m [7]. The harmful effect of lightning is directly related with the thunder storm activities. 70% of lightning densities are not harmful however it effect is sever when it hit anything on the ground. Therefore standards have been introduced to take the protective measures against lightning [8]. During the breakdown process when the lightning flashes take place the electric field started. The electric field at the tip of rod becomes higher and it remains constant at the tip of the rod. As a result of this the upward streamer initialization are formed from the tip of the rod placed at the tip of the rod [9]. In the first negative cloud to ground flashes the return stroke is initiated by the lightning flash which approaches toward the ground. AT certain level the electric field gained such intensity that it connects with the down coming leader and as a result the return stroke at the tip of the rod or any building structure takes place [10].

3. PERFORMANCE OF FRANKLIN ROD

Franklin rod is the major device which, is installed on building for the lightning protection purpose. For more than 250 year franklin rod is used as a protection device [11]. For the protection of any structure lightning rod geometry is an essential element. When rods of height of 6.4m above the ground with the same distance from each other it has been shown that the rods with blunt tips are good receptor of lightning stroke [12].

Bypass phenomenon of lightning air terminal (LAT) is now a days an issue of interest. LAT acts as lightning attraction device which then produce an electric field around and can therefore, the LAT is bypassed. Due to this the lightning can produce side flashes which can damage the building. To study this phenomenon few surveys and the lightning flash damages been studying on different buildings when then buildings been installed with lightning protection system (LPS) [13].

4. METHODOLOGY

This paper presents lightning effect for protected and non -protected building structures. The electric field effect is studied on the scaled model of different geometrical structures. The building structures were scaled down in order to test during indoor testing process. The heights of all the structures were same as 10 cm. Similarly the height of the LAT was also 1 cm which was similar for all the tested models. The LATs were directly connected to the ground for all the shapes. The voltage is applied according to the air breakdown per centimeter. The air break down for a tropical area is 30 k V/cm, depends on the humidity. The voltage is applied for 3 cm air gape which means that the lightning impact is studied for short air gap. For the all the shapes the applied voltage and air gape is kept the same. The building structures are considered the grounded isolated and conducting building structures. The effect of field intensity is studied when the buildings are installed with Franklin rod and when there is no rod installed.

5. RESULTS AND DISCUSSION

In this paper the electric field is simulated for three different scaled geometrical shapes which include square, circular and triangular shapes. The electric field plot for every shape is given below.

5.1. Electric Filed on Circular Shape with and without LAT

When the high voltage is applied on the circular shape without the LAT the electric field is observed throughout the roof top and the electric field is propagated along the roof top and the electric field effect the whole roof top. While, with the installation of LAT the electric field effect is concentrated on the installed LAT only. The electric field effect is higher on the tip of the LAT and its intensity becomes lower to the sides. Similarly when LAT is installed it can reduce the electric field intensity. The electric field effect is seen in figure 2.

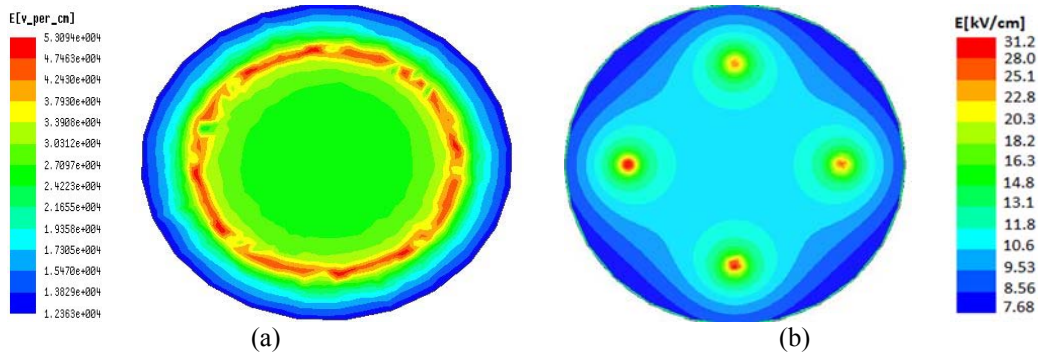


Figure 2. Electric Field Intensity on Circular Shape with and without LAT

Figure 2 represents the electric field effect on the circular shape with and without LAT. Figure 1 (a) indicates the field plot without the LAT while figure 1 (b) shows the field plot with LAT.

From Figure 2 the colour match can clearly indicates the electric field intensity. The red colour shows the high electric field intensity on the surface of the roof tops. While the green clour represents the lowest electric field.

5.2. Electric Filed on Square Shape with and without LAT

As the square shape has 4 corners when the electric field is observe by applying the high voltage the electric field is generated. The electric field shows that when there is no LAT the electric field is seen through out the building roof surface and its intensity is much higher. When the LATs are installed on every corner the lightning flashes are attracted by the installed LAT. As a result the electric field intensity is observed on the tip of the rods and thr rest of the building structure remains safe. The electric field intensity is lower at the middle and on the sides of the given shape which is given in figure 3.

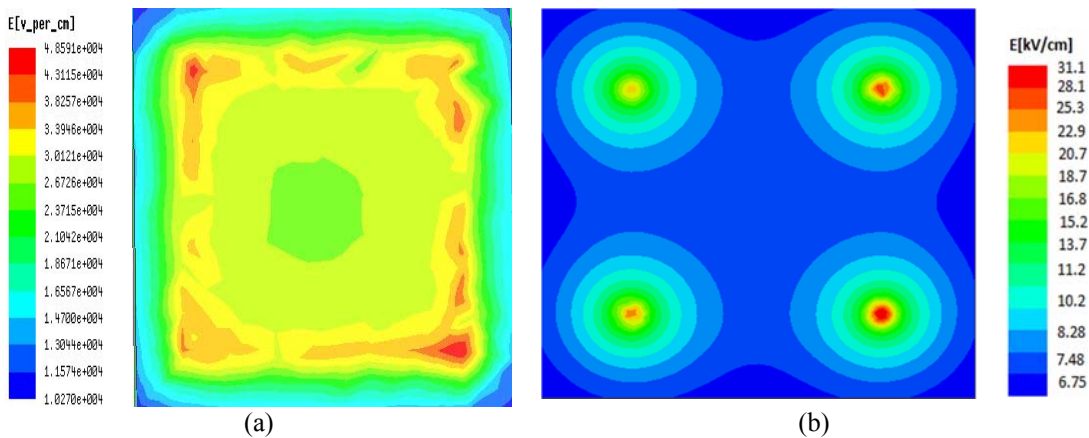


Figure 3. Electric Field Intensity on Circular Shape with and without LAT

Figure 3 show the field plot with and without LAT. Figure 3 (a) represents the electric field intensity without LAT while the field intensity with LAT is given in figure 3(b).

The red colour on the edges illustrates the highest electric field and the green colour elaborates the lowest the electric fiel.

5.3. Electric Filed on Triangular Shape with and without LAT

Triangular shape has three corners.All the three corners receive the high voltage. Due to the high voltage electric field is produced.When the triangular shape has no LATs the electric field effect is observe throughout the roof top and the magnitude of field intensity is also higher. When the LATs are installed on every corner the electric field affect is seen only on the tip of the rods. Also the electric field effect is much lower on the edges and the corners.This indicates that LAT can protect any building structure and it can diffuse high voltage thus the entire building structure remains safe. The effect of electric field due to high voltage on the triangular shape with and without LAT is given in figure 4.

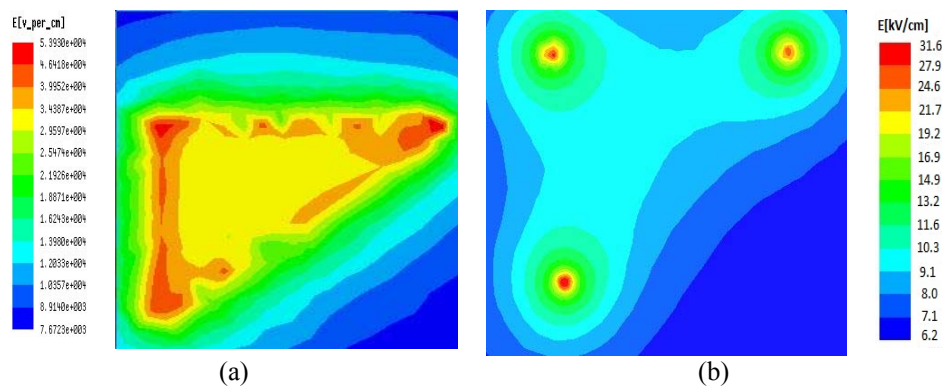


Figure 4. Electric Field Intensity on Circular Shape with and without LAT

Figure 4 shows the field intensity on triangular shape. The field intensification without LATs is given in figure 4 (a) while electric field with LATs is given in figure 4 (b).

5.4. Air Terminal Bypasses

LAT bypasses have been studied in this paper. Most of the bypasses take place in Rectangular roof top of the buildingstructures. The main reason for the bypassing is the shifting of field intensification into the side edges of the building structures and that’s why the side edges of the building structures get struck by lightning. The simulation of rectangular building structure with its bypasses can be represented in figure 5.

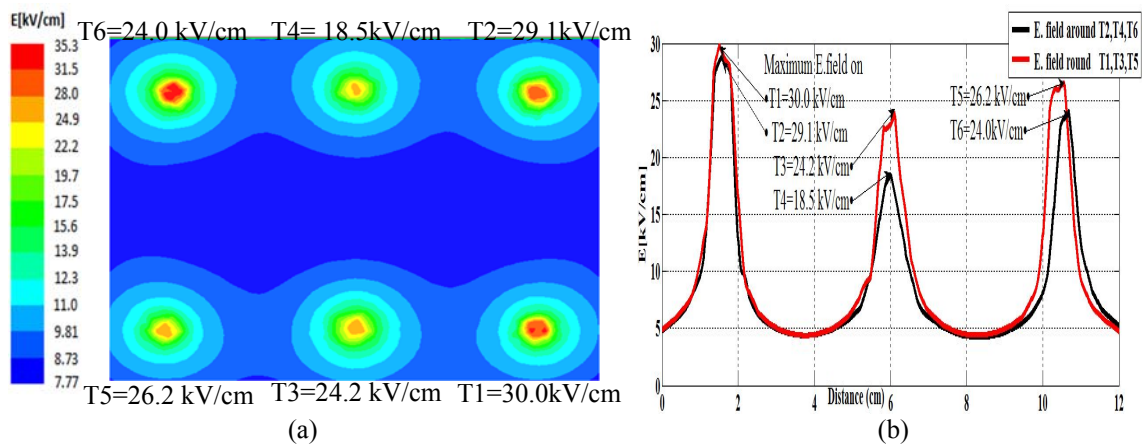


Figure 5. Bypass simulation of LAT on rectangular structures

Figure 5 indicates the electric field intensity is higher on the side edges as compared to the middle of the roof top. Therefore, it can be said that lightning air terminal bypasses take place on these structures.

Lightning air terminal can capture lightning flashes on different points of the building structure. Regarding capturing ability LAT then becomes a sacrificial point and the lightning has significant effect on the building structures. Similarly when a building has no LAT installed lightning can affect any part of the building structure and its effect is more severe on the building structure. The effect of electric field in both cases has been studied. Lightning air terminal can capture the lightning flashes on particular spots and diffuse it to the ground while, without the LAT lightning can affect any point of the building.

6. CONCLUSION

Simulation of electric field on different geometrical shapes concluded that LAT installation plays an important role in building protection system. Through the installation of LAT the lightning flashes are converged to a specific point and the electric field effect is concentrated to a specific LAT. However, without LAT the electric field effect observed around the whole structure and it can effect throughout the building structure. Therefore, the building structure can be protected by LAT installation however; LAT can attract lightning in much number and can cause more damages to the building structures. LAT bypasses were simulated and it was found that the reason for LAT bypasses was the electric field intensity on the side edges of the rectangular shape buildings.

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