A proposal for an Atmospheric Discharge Protection System (ADPS) for a Public School in the City of Manaus-AM

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Abstract

The present study sought to highlight the importance of protection against electric discharges to a school in the public school of the city of Manaus-AM, based on the basic recommendations and guidelines for making decisions presented in the elaboration of a ADPS proposal. The methodology of the work was based on the collection of information on the subject from the theoretical-bibliographic research, as well as the accomplishment of the field research in the school through the technical visits for data collection. The results of the research were presented in the technical verification report of the ADPS need at school, so the study carried out a detailed study on the protection risk management, the analysis of the risk components to the atmospheric discharges, general risk assessment, evaluation the design of the protection system. Based on the report, the research presented the appropriate recommendations to assist school management in decision making, considering the importance of protecting the public heritage from the damages caused by the atmospheric discharges.

Keywords: atmospheric discharge protection system; electrical discharge; public property

1. Introduction

Electricity is vital in modern life and it is unnecessary to emphasize its importance, either providing comfort to our homes or acting as an input in the various segments of the economy. On the other hand, the use of electricity requires from the consumer the application of certain precautions in view of the risk posed by electricity, many don't know, you do not know or do not understand this risk.

Accidents with electricity, at home and at work, are the most frequent and proven to have the most severe consequences. Safety rules provide that persons should be informed of the risks to which they are exposed, as well as their effects and applicable safety measures.

2. Theoretical Referential

2.1Atmospheric Discharge

Is NBR 5419 - Protection of structures against lightning - defines lightning as a phenomenon that occurs from the atmospheric origin between a cloud and the earth or between clouds, which generates electrical impulses. The National Integrated Discharge Detection Network (RINDAT) says that electrical discharges (Figure 1) are linked to phenomena of lightning and thunder, which are quite phenomena recurring in large urban areas.

Figure 1. Electric discharges

Source: National Lightning Detection Network - RINDAT (2009)

The concentration of negative charges in the lower portion of the cloud causes immersion of the positive charge migration to the area corresponding to what is called the “shadow”, so this cloud, with the help of the wind, approaches the urban space [1].

2.1.1 Basic Concepts

Some brief basic concepts can be analyzed regarding the phenomenon of atmospheric discharge. The concepts that make up the basic formation of atmospheric discharge, such as: the lightning, the thunder, The Ceráunico Index (CI),the Isoceraúnicas and Lightning Density (RD) [2].

The Earth has excess negative charges, being one of the planets with the highest degree of reference in negative charges between the planets. It is also understood that the air currents carry a large amount of moisture, which, when found at lower temperatures in higher regions, leads to condensation and formation of water droplets suspended in the atmosphere [3].

2.1.2 Discharge

The electric discharge in the earth in view of the so-called descending pilot (precursors), that is, an ionized conductive channel whose path is made by successive "leaps" towards the earth from the breakdown of the dielectric formed by air at a time when the earth exceeds a certain value with the charged cloud [3].

It is noted that the damage with electric discharge varies according to the current present, which can reach from muscle contraction from the reaction in the body to death, depending on the severity. Lightning strikes or currents are responsible for neutralizing the crowded charges in the clouds, so some studies reveal that each lightning strike can last a few milliseconds, as in multiple and sequential lightning strikes.

2.2 Protection System Against Atmospheric Discharge (ADPS)

Studies conducted on the Protection system against Atmospheric discharge (ADPS) add to an understanding of transmission line protection and performance improvement methodologies against lightning strikes that occur daily. ADPS can be considered one of the main methods used to make this optimization possible, especially with the installation of lightning rods as an efficient protection system. It is widely used in homes, small and large buildings, commercial area, public area, etc.

2.2.1 ADPS Function Definitions

The ADPS is used to protect the most different types of structures from lightning, aiming to minimize the effects and impacts generated by these discharges, in order to ensure the safety of equipment and electrical structures [4]. The main functions of the ADPS can be highlighted as: external protection system; internal protection system; neutralization with the flow of electrical charges from the environment to the earth from its system; reducing the risk of lightning striking structures.

2.2.2 ADPS Types

ADPSs are basically divided into three types: Franklin type, Faraday Cage and advance to Ignition. The Franklin Type is made up of a metal rod having its pointed end at its tip so that it accumulates more load. It is considerably cheaper compared to other types, but is less efficient [3].

Faraday Cage is a type of system that is more complex, it has several receivers that are provided at the top of the structure to wrap the entire structure. It has a much higher efficiency compared the Franklin Type, but its cost is much higher and not feasible to implement in some structures [4]. Ignition advance is the ability of the arrester to anticipate lightning and modify the lightning path. It is widely used in a medium-sized building, as it has high efficiency and low cost, but its use over longer distances compromises the receptor uptake [3] [4].

3. Methodology

The methodology of the work was based on the gathering of information on the subject from the theoretical-bibliographic research, as well as the accomplishment of the field research in the school through the technical visits for data collection.

The field research was conducted at a state public school located in the eastern zone of the city of Manaus.

The choice of the institution was based on the need to conduct the research in a space that did not have an ADPS, in order to present to the managers, based on the study results, a proposal to implement an ADPS. In the field analysis process carried out at school, there was also the descriptive process of the research, whose purpose was to observe and describe the area of study, as well as identifying which critical points observed by the absence of an ADPS project and thus collect enough data for the application of the technical study in the space.

4. Analysis and Discussion of Results

The verification report consists of the feasibility presentation of the proposed implementation of an ADPS system in the school. It is observed that this school does not have any pre-installed structure for the implementation of an ADPS, with its structure completely unprotected (Figure 2):

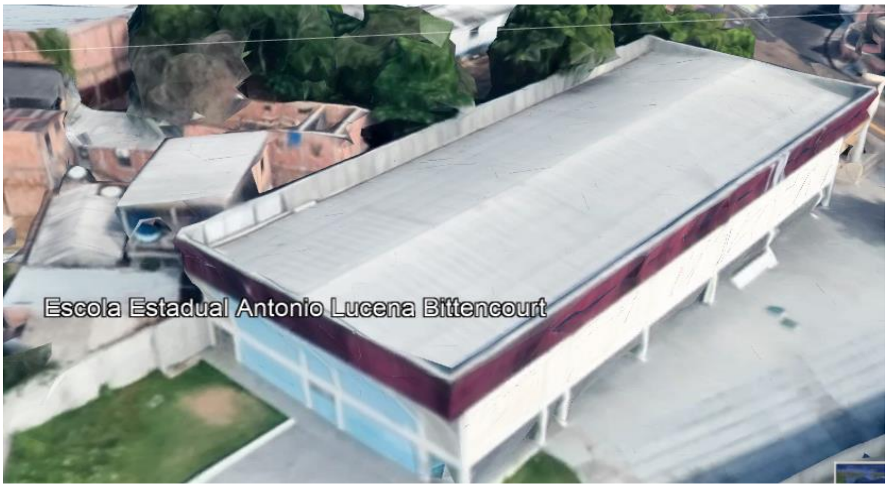

Figure 2 - Top view of the area [5]

4.1 Building Parameters

Height: 9 $m(H)$

Width: 20 $m(W)$

Length: 48 $m(L)$

4.2Protection Risk Assessment

The equivalent exposure area (Ad)corresponds to the plan area of extended structure in all directions, to take into account your height. The equivalent exposure area boundaries are spaced from the perimeter of the structure by a distance of three times the height of the structure at the point considered.

$$Ad = L{\cdot}W + 2{\cdot}(3{\cdot}H){\cdot}(L + W) + \pi{\cdot}(3{\cdot}H)^2$$
$$Ad = 48{\cdot}20 + 2{\cdot}(3{\cdot}9){\cdot}(48 + 20) + \pi{\cdot}(3{\cdot}9)^2$$
$$Ad = 6922{,}22\ m^2$$

The density of lightning strikes to earth (Ng) is the number of lightning strikes to earth per $km^2/year$. INPE (National Institute for Space Research), through the atmospheric electricity group, provided Ng data as shown in the figure below (Figure 3).:

Figure 3 - Number of rays per year per km² [6].

$$Ng = 14{,}8\ Discharges\ per\ km^2/year$$

Dangerous event numbers Nd for structure is:

$$Nd = Ng \cdot Ad \cdot Cd \cdot 10^{-6}$$
$$Nd = 14{,}8 \cdot 6922{,}22 \cdot 0{,}5 \cdot 10^{-6}$$
$$Nd = \frac{5{,}12 \cdot 10^{-2}}{ano}$$

It is recommended that loss amount values be evaluated and set by the ADPS designer (or the structure owner).

$$LA = rt \cdot LT \cdot nZ/nt \cdot tz/8760$$
$$LA = 10^{-3} \cdot 10^{-2} \cdot 450/450 \cdot 8760/8760$$
$$LA = LU = 10^{-5}$$
$$LB = rp \cdot rf \cdot hz \cdot LF \cdot nZ/nt \cdot tz/8760$$
$$LB = 0{,}5 \cdot 10^{-3} \cdot 5 \cdot 10^{-1} \cdot 450/450 \cdot 8760/8760$$
$$LB = LV = 2{,}5 \cdot 10^{-4}$$

Where,

LT - It is the typical average relative number of victims injured by electric shock due to a dangerous event;

LF - It is a typical average relative number of victims of physical injury due to a dangerous event;

LO - It is the typical average relative number of victims of internal system failure due to a dangerous event;

rt - It is a factor in reducing the loss of human life, depending on the type of soil or floor;

rp - It is a factor in reducing the loss due to physical damage depending on the steps taken to reduce the consequences of the fire;

rfIt is a factor in reducing the loss due to physical damage that may affect the risk of fire or the risk of structure explosion;

hz - It is a factor of increased loss due to physical damage when a special hazard is present;

nz - It is the number of people in the zone;

nt - It is the total number of people in the structure;

tz - It is the time during which people are present in the area, expressed in hours per year.

4.3 Analysis of Risk Components Due to Lightning in the Structure

The risk components to consider for this structure can be summarized schematically in table 1:

Table 1 - Risk components considered.

Damage Sources	S1: Discharge in the structure			S2: Discharge near structure	S3: Discharge on a line connected to the frame		S4: Discharge near a line connected to the frame
Risk Components	**Ra**	**Rb**	**Rc**	**Rm**	**Ru**	**RvRw**	**Rz**
R1: loss of human life	X				X	X	
R2:Loss of service to the public							
R3: loss of cultural heritage							
R4: loss of economic value							

Source: NBR 5419-2: 2015, 2015.

For the assessment of risk components due to lightning strikes in the structure, the following equations apply:

a) component related to injury to living beings by electric shock (D1)

$$RA = ND{\cdot}PA{\cdot}LA$$
$$RA = 5{,}12{\cdot}10^{-12}{\cdot}1{\cdot}10^{-5}$$
$$RA = 5{,}12{\cdot}10^{-7}$$

b) component related to physical damage (D2)

$$RB = ND{\cdot}PB{\cdot}LB$$
$$RB = 5{,}12{\cdot}10^{-2}{\cdot}1{\cdot}2{,}5{\cdot}10^{-4}$$
$$RB = 1{,}28{\cdot}10^{-5}$$

4.3.1 Hazardous Component Analysis Due to Lightning Strikes on a Line Connected to the Structure

For the assessment of risk components due to lightning strikes on a line connected to the structure, the following equations [7] apply:

a) Component related to injury to living beings by electric shock (D1)

$$RU = (NL + NDJ){\cdot}PU{\cdot}LU$$
$$RU = (5{,}92{\cdot}10^{-2} + 0){\cdot}1{\cdot}10^{-5}$$
$$RU = 5{,}92{\cdot}10^{-5}$$

b) Component related to physical damage (D2)

$$RV = (NL + NDJ){\cdot}PV{\cdot}LV$$
$$RV = (5{,}92{\cdot}10^{-2} + 0){\cdot}1{\cdot}2{,}5{\cdot}10^{-4}$$
$$RV = 1{,}48{\cdot}10^{-5}$$

4.3.2 Overall Risk Assessment

The R1 risk to be considered in this structure of the Antonio Lucena Bittencourt State School includes the following definition and formula [2] [6]:

a) R1: risk of loss of human life:

$$R1 = RA + RB + RU + RV$$
$$R1 = 5{,}12 \cdot 10^{-7} + 1{,}28 \cdot 10^{-5} + 5{,}92 \cdot 10^{-7} + 1{,}48 \cdot 10^{-5}$$
$$R1 = 2{,}87 \cdot 10^{-5}$$

4.3.3Protection Level Assessment

It is concluded that the level of protection is II due to the classification of the structure, ie school, whose failure in the lightning arrester system can cause the loss valuable assets or cause panic to those present.

4.3.4 Choice of Method

Faraday method was chosen because it is a structure with a large horizontal area, that consists of to engage the top of the building with a bare electric conductor capture mesh, whose distance between them is a function of the desired level of protection and given by the standard NBR 5410-3 / 2015, which establishes the width of the protective mesh module, the length of the module cannot be more than twice its width.

4.4 Sizing of Atmospheric Discharges Protection System

4.4.1 Dimensions Mesh Capture

According to the data presented in the survey of NBR 5410-3 / 2015, the width and length of the protective mesh module are a maximum of 10 × 10 m, because the protection class is level II, for this project was chosen 10 × 8 m, width and length that fits the design respectively [2] [7].

5. Conclusion

Given the relevance of the topic addressed in the research it was observed that there are several studies on the importance of designing, effectively and planned, a protection system to avoid the problems caused by electrical discharges, common in large urban areas. The bibliographic survey conducted in the research allowed the subject to be widely studied and that through the observation of other case studies it was possible to understand the efficiency of an ADPS project.

The study aimed to contribute, in a practical and academic way, to the proposal of an ADPS project for the state public school, with the objective of assisting in decision making regarding the protection of its public patrimony. Necessary recommendations were presented to avoid atmospheric accidents, as well as to make the school management aware about the preservation of its patrimony from the implementation of an ADPS. The ADPS Needs Verification Report provided all the technical information collected from the on-site survey and detailed protection risk management. The risk assessment, the analysis of the normative parameters, the assessment of the protection level and the design of the ADPS were performed. The elaboration of the report helped in the definition of the recommendations and observations about the preservation of the patrimony, which were presented to the school management after the study.

6. References

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