External Lightning Protection System for Main Office Building in the Area with High Lightning Density

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Abstract

In every industry which has main office equipped with a lot of vulnerable equipments that has to be protected against any risk of damages from natural causes and others. One of the possibilities of this risk is coming from weather phenomenon which we called lightning. The number of lightning strikes per square kilometer per year is very high in the area of Subang, west Java, Indonesia. Damages of electronics equipment and the death of human life have been reported. The aim of the research is to evaluate the local lightning activity and to design and install the protection system against the danger of lightning strikes. Lightning Protection System (LPS) is needed to prevent the damages, fire, and death of human life from direct lightning strikes. The main office in this area has unique structure. Due to its unique form of the building some modification is needed for the external protection by implementing the iron plate on the location of the structure which will be hit by lightning. Lightning protection system for the whole area of main office building are analysed by using the electro geometric concept to determine the lightning protection system for the mobilization of the workers and vehicles during their activities in the region which has high lightning activity.

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Keywords: high lightning density, unique building and modification of external LPS

1. Introduction

Subang is a city located at the west of Java Island in Indonesia. In the north side of this city a 600 hectare complex of industry is build to produced high explosive materials. This area has a very high lightning density with

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more than 10 strike/sq.km/year. A proper lightning protection system has to installed and maintained in the whole area especially in the area where the explosive factory and go down is located. A main office building and a water tower have a unique form of structures and need to be protected by modifying the external lightning protection system. Most of the building are built separately within the complex and connected by roads and pedestrian. To protect the people and the vehicles in this main office area the lighting pole along the road have to be utilized by installing the lightning rod at the top of lighting pole to give suitable protection to its surrounding area. To give a good protection for the building and the structures in the complex, the external lightning protection system has to be installed and maintained in the whole area especially in the area where the explosive factory and go down is located. A main office building and a water tower have a unique form of structures and need to be protected by modifying the external lightning protection system. Most of the building are built separately within the complex and connected by roads and pedestrian. To protect the people and the vehicles in this main office area the lighting pole along the road have to be utilized by installing the lightning rod at the top of lighting pole to give suitable protection to its surrounding area.

2. Lightning Parameter

Lightning parameter such in tropical area as in Fig. 1 is quite different with the lightning parameter measured in the sub-tropical country due to its weather and geological condition. Indonesia located in the tropical country with is maritime continent and produce a lot of sea salt and moisture. Updraft of air is produce by the heating of ground surface by sun and the updraft can also be produced by to orographic condition of the terrain which have a lot of island. Two lightning current parameter that play an important role for the lightning protection system are lightning peak current \( i \) in kilo ampere and steepness of lightning current \( \frac{di}{dt} \) in kilo ampere/microsecond.

Voltage Elevation in the point of strike in (kilo Volt)

**At the grounding system**

\[
 U_s = I \times R_{imp}
\]

(1)

Probability for peak lightning current at Subang (1 January – 31 December 2000)

For office building the calculation is being done by using 50% probability of the lightning peak current probability which is 25 kA

For the explosive are the calculation is being done by using 80% probability which is 20 kA

![Fig. 1. Lightning Current Parameter](Image)

The second parameter that plays an important role in the lightning protection system is the steepness of lightning current which is recorded in the Measurement Station at Mnt. Tangkuban Perahu as high as 30 kA for 50% probability. Voltage elevation on the structure which has an inductance will give the voltage rise on the structure and grounding system:

\[
 v = L \cdot \frac{di}{dt}
\]

(2)
Where \( L \) = inductance value of the structure or down conductor in micro Henry/metre

\( \frac{dI}{dt} \) = steepness of lightning current in kilo ampere / micro Henry

\( V \) = voltage in kilo volt

3. Local Lightning Data

This building is located in the area which has high lightning density and due to their unique form of the structure the lightning protection system has to be modified to fulfil the requirement of the form of the building. Local lightning data are required to have the proper lightning protection system for calculating the coverage area using electro geometric concept (EGM) according to IEC 61305/2006 standard. The boundary marked on the map (Fig. 2) shows the lightning density in the region. It consists of offices, explosive factory; go down, storage area, etc. This facility has to be protected against lightning direct and indirect strikes, including the conference building, utility area, houses, road, etc and it will be the area protection.

To derive local lightning data, the position of latitude and longitude of the area has already been measured by the GPS which are; latitude of 6, 34° longitude of 107, 50° (Fig. 3) and by using the data from Indonesia lightning detection system these following data are derived, such lightning flash density, lightning map and the detail data of polarity of the lightning strike as shown on the following table and figures.

![Fig. 2. Map of lightning strike at the region of the office building and the explosive region at Dahana Are at the north site of Subang city, west Java, Indonesia.](image1)

![Fig. 3. Lightning Flash Density in the area with show the data of higher than 10 strikes/sq.km/year](image2)

3. Striking Distance

In order to have the protection good angle of the structure and the coverage area of lightning protection air terminal, the striking distance of the lightning current has to be determined. Striking distance is the striking point where the downward leader tip meets the upward streamer of the grounded object. The distance is between the striking points to the object above the ground. The striking distance \( R_s \) is as a function of peak lightning current:

\[
R_s = 6.7 \times I^{0.8}
\]

Or the equation from standard IEC 61302/2006 can be used as follow;
\[ R_s = 10 \times t^{0.65} \]  
(3.2)

For the external protection the striking distance is calculated by using the 80% probability of lightning incidence which is 30 kA.

By using the formula of (III-1) the striking distance \( R_s \) becomes;

\[
R_s = 6.7 t^{0.8} = 6.7 (30)^{0.8} = 102 \text{ m}
\]

This distance will be used to have the coverage area by applying the electro geometric concept for the protection of the structure at the whole area, except the explosive area which will be using the 80% probability of lightning peak current.

4. Location of Main Office Building

The main office building (Fig. 4) consist of a big auditorium located in the middle of the complex and surrounding by 5 (five) others buildings that has a half round roof (Fig. 5).

By using the local lightning data, the striking distance which is derived from the electrogeometric concept is applied to the structures and has given the protection design as follow;

The calculated protection has given the fact that to protect the whole building in this office area a 40 metre high extended mast terminal have to be installed at the roof of the auditorium (Fig. 6-8) and it is not possible due to the structure condition. This mast will be very heavy. New calculation was carried out to be able to have the proper external lightning protection system by using additional lightning rod and the iron plate at the half round building around the auditorium as shown on Fig. 9-12.
Rolling sphere method as stated on the standard have given the proper external lightning protection system that can protect not only the whole building but also the people around it. At 15 metre air terminal which installed at auditorium an early streamer emission terminal is installed as air terminal to gain more effective protection. To allow the lightning current flow to the grounding system which is embedded on the foundation structure, a double shielded down conductor was installed. It will give low inductance of down conductor and produce no side flash to the structure or human being around the down conductor, it is also can be equipped with a lightning counter installed inside a panel at the bottom of the cable.

One of the important point of this external lightning protection system is the use of the lightning counter at the bottom side of the down conductor cable. This counter will count when the lightning strike hit the LPS and it show that lightning protection system at the this main office building has work properly. The cause of the damages of the equipment inside the building such as PABX, telephone system, computer system, closed circuit tv etc can be monitored from this lightning counter. The internal Lightning Protection System, which is not reported in this research, have to be installed to protect the vulnerable equipment inside the building and minimize the equipment damages.
4. Conclusion

This complex located in the area which has a very high lightning density. The influence of lightning strikes can damage the vulnerable equipments inside the buildings and can cause death to human being due to direct lightning strikes. A suitable and proper external LPS is very important to protect the main office and the people around it. The electro geometric concept give the possibility to modify the installation of air terminal in this very unique form of office building in order to give the optimal protection against direct lightning strike. The use of double shielded down conductor cable which connect the lightning rod at the top of 15 metre tower to the grounding system at the foundation structures of the auditorium will let the lightning current flow safely inside this cable without producing induction or side flash to the surrounding area. Due to it’s very low inductance, this cable give a lot of advantages; such are, reducing voltage elevation at the grounding system that can minimize the damages of electronic equipments inside the buildings, preventing the danger of step and touch voltage in the area and recording the lightning current by using counter at the bottom of cable. This counter can gives the information about the effectivenes of external LPS and the maintenance purposes of the Lightning Protection System.

Acknowledgement
The Author like to thank PT. Dahana, Subang, West Java, Indonesia as the explotion material factory, belongs to the Ministry of Defence for their support and cooperation in doing this research at their premises.

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