Lightning Risk Assessment for Building Using Intelligent Smart System

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Abstract—**Lightning is a natural hazard which occurs during thunderstorm. Direct and indirect lightning strikes can bring harm, injury or death to humans. It is important to ensure all electrical components and buildings are being protected with the suitable protection from direct and indirect lightning strikes hazards. The objective of this work is to provide a risk factor assessment calculations graphical user interface to ensure whether buildings required protections from the direct and indirect lightning strikes. The calculations of risk assessment will be based on BS6651:1999 against direct and indirect lightning strikes. The risk assessment calculated then will determine whether certain buildings need protection against direct lightning strikes or indirect lightning strikes or both. Types of protection were discussed to give an idea what type of protections can be installed to protect humans, buildings and equipments from the hazards of direct and indirect lightning strikes.**

Keywords-lightning; direct lightning strikes; indirect lightning strikes; risk factor assessment; and lightning protections.

I. INTRODUCTION

Lightning strikes define in [1] is a hazard static electricity accumulated in parts named cell from storm cloud. Lightning can travel at about 220000 km/h and approximately can reach the temperature of 30000°C. The mechanism of lightning strikes is still can be understood by scientist however the process lightning strikes can be describe even though certain parts is still not being explained. Before any lightning strikes occur the cloud is accumulated with negatives and positives charges. The upper parts of the cloud are filled with the positives charge while the lower parts are filled with negatives charge. The ground has been induced with mostly positive charges. Lightning start to begin when the lower part that is much heavier with negative charges creates a "step leader" to the ground. This process repeats several times and creates zigzag path to the ground. During this time air is being ionize with negative charges and creates a conducting path. When the step leader is close enough to the ground, strong electric field is created and drives the positive charges accumulated at the ground to neutralize the negative charge at the conducting path. The process of discharge releases a huge amount of energy and is being called the return stroke. The lightning return stroke is far much brighter than the step leader which is the usually lightning that people see. Current in lightning return stroke ranges from about 2kA to about 200kA [1]. In [2] stated that fault that is created by lightning strikes can generally be classified into two:

1. Direct Strikes - Lightning strikes directly to the lines or distribution system
2. Indirect Strikes - Lightning strikes in the vicinity near the distribution system

The electrification of convective clouds are being discussed and the lightning phenomena have been described in [3]. Meanwhile author in [4] stated that lightning is a transient, high-current discharge whose path length is measured in kilometers. Observation process in [5] have been conducted at the Japanese sea coast to identify the characteristics of winter lightning can be classified into seven pattern based on the lightning current wave polarity and duration. Study in [6] is being attempt to provide the important Characteristics of lightning electromagnetic pulse (LEMP) to disrupted with electronic system. Positive and negative cloud-to-ground lightning models are proposed for Electromagnetic Compatibility (EMC) studies. Triggered-Lightning experiments have been done by authors in [7] where rocket-and-wire technique have been used in order to inject direct lightning strikes at the lightning protective system of a test house in Florida. Professors in [8] studied to identify the conditions whether the presence of tall strike object can become a an agent to increase or decrease lightning-induced voltages on a nearby overhead wire. Simulation model to investigate material for grounding by lightning stroke have been done in [9] and the electromagnetic filed distribution that is being hit by lightning have been analyzed. Research in [10, 11] have been conducted specifically for lightning strikes that occur in tropical countries. Recently a review paper [12] have been written to summarize lightning research and lightning protection that have been published. In Japan [13] a filed study observation of lightning strikes pattern that propagates in residences houses have been done by using lightning surge waveform detectors.

This paper discussed the calculation of the risk assessment to decide whether certain buildings need the protection from lightning or not. Risk assessment is important to ensure the right type and proper protections are being installed. It is also crucial for the risk assessments are being calculated correctly for planning purposes and avoiding financial loss. Calculations of the risk are based on BS6651:1999. Graphical User Interface (GUI) was developed to make it easier and convenience for any personnel to use it. Visual Basic was used in the development of the GUI.

II. METHODOLOGY

The designs for risk assessment for risk assessment GUI are separated by two i.e. direct lightning strike and indirect lighting strikes. After the risk is calculated it is up to consumer to decide what type of protection that they need.

A. Direct Lightning Strikes

The risk assessment for direct lightning strikes is determine as follows and simplified by the flow chart in Figure1.

Determining the Collection Area A_C by equation (1)

$$A_C = LW + 2LH + 2WH + \pi H^2 \qquad (1)$$

where,

W = width in meters (m)
L = length in meters (m)
H = height in meters (m)

Probable of strikes per year

$$P = A_C \times N_g \times 10^{-6} \qquad (2)$$

value of A_C from Equation (1) substitute in Equation (2)

Where, overall risk factor

$$R = P \times A \times B \times C \times D \times E \qquad (3)$$

value of P from Equation (2) substitute in Equation (3)

where,

A = the intended use of the structure

B = the type of construction

C = what is housed within the structure

D = the location of the structure

E = the topography of the country

values for N_G, A, B, C, D, E from BS 6651:1999

If the result obtained is considerably less than 10^{-5} (1 in 100 000), in the absence other overriding considerations, protection does not appear necessary; if the result is greater than 10^{-5}, for example 10^{-4} (1 in 10 000), it is necessary to install protection equipment for direct lightning protection.

B. Indirect Lightning strikes

The risk assessment for indirect lightning strikes are determine as follows and are being simplified by the flow chart in Figure2

Determining the Collection Area A_E by equation (4)

$$A_E = C_V + C_W + C_X + C_Y + C_Z \qquad (4)$$

Where,

C_V = collection area of building (m^2).
C_W = collection area of surrounding ground (m^2).
C_X = collection area of adjacent associated structures (m^2).
C_Y = the collection area of incoming/outgoing main power supplies (m^2)
C_Z = the collection area of data lines leaving the earth reference of the building (m^2).

Where, the calculation of Cv, Cw, Cx, Cy, Cz as per BS 6651:1999.

Probable of strikes per year

$$P = A_E \times N_g \times 10^{-6} \qquad (5)$$

Value of A_E from (4) substitute in (5)

Where, overall risk factor

$$R = P \times F \times G \times H \qquad (6)$$

Value of P from Equation (5) substitute in Equation (6)

Where,

F = the type of structure

G = the degree of isolation

H = the type of terrain

the value for N_g, F, G, H from BS 6651:1999

Then, combining together the risk (R) with the consequential loss rating and classification of the exposure level for which transient over voltage protectors should be designed can be determined to protect the building and equipments.

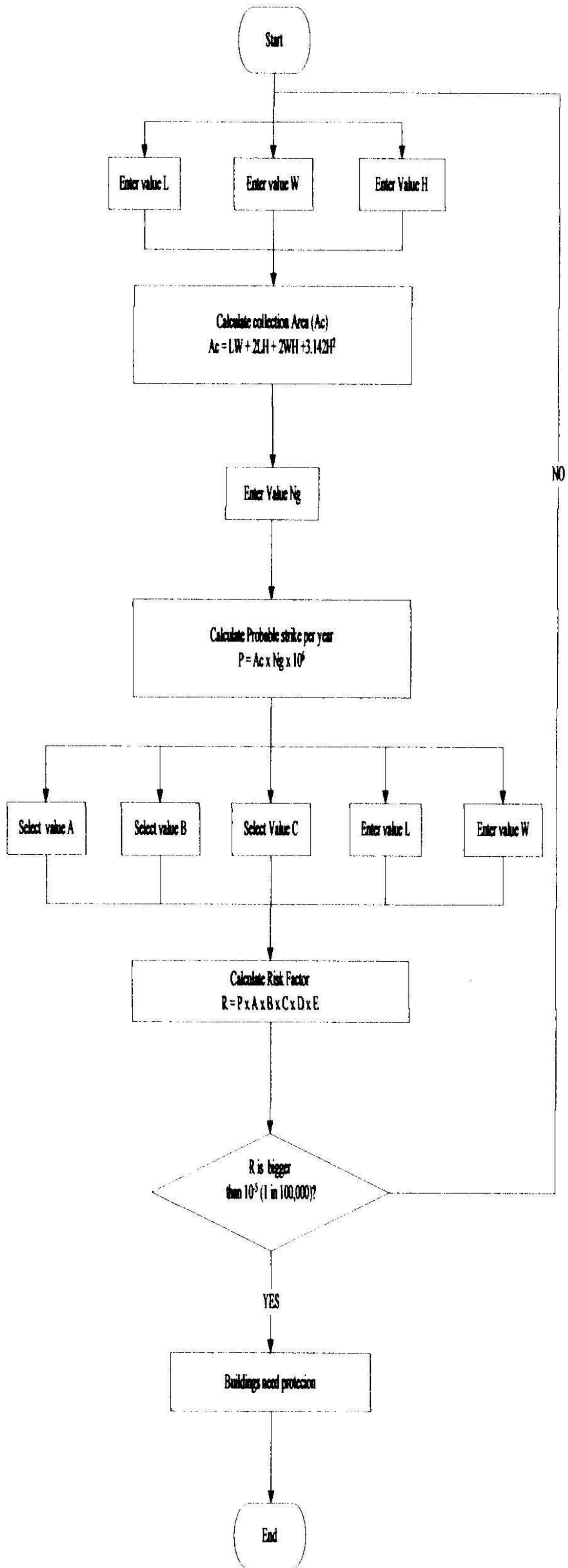

Figure 1: Building Parameters for Direct Lightning Strikes Calculations Inputted in Graphical User Interface

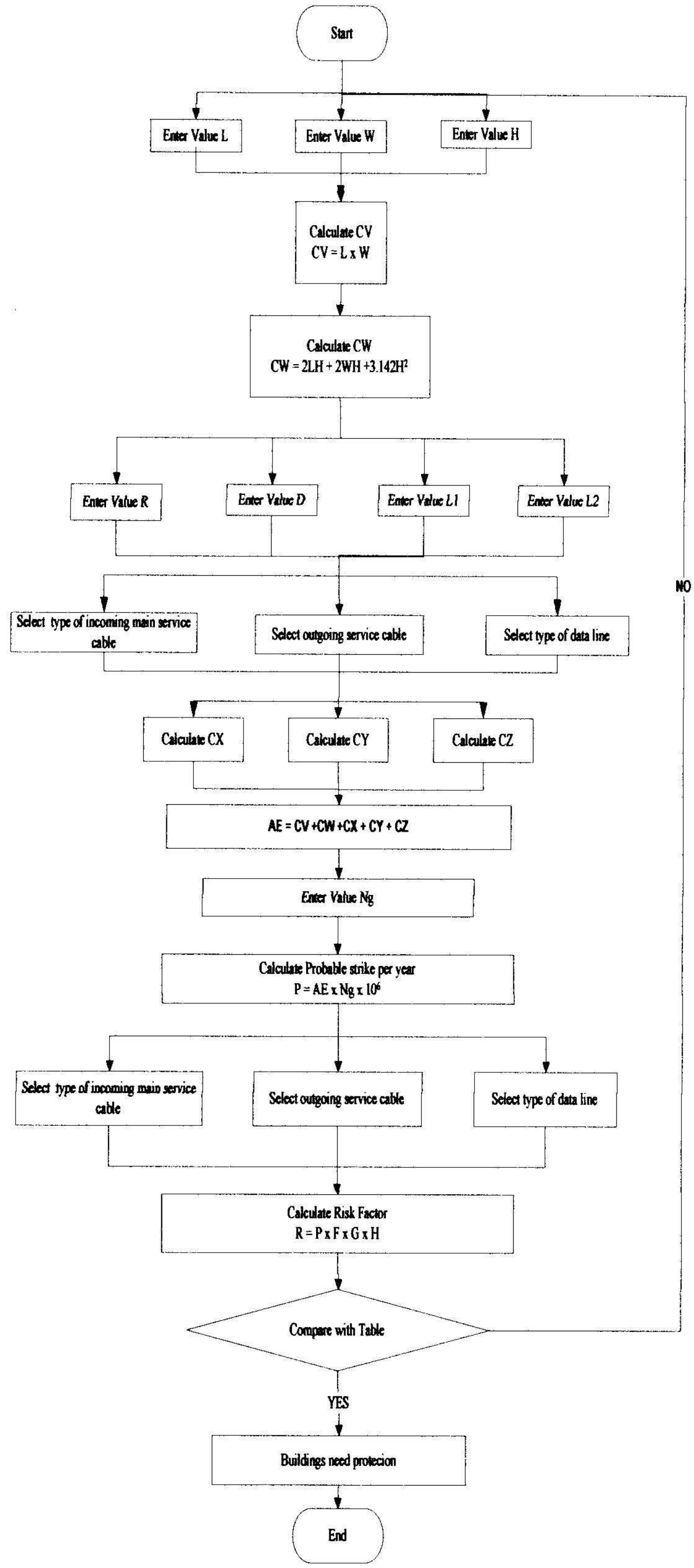

Figure 2: Building Parameters for Indirect Lightning Strikes Calculations Inputted in Graphical User Interface

III. Results And Discussions

A. Case Example

Different case of direct and indirect lightning strikes has been used to show the example of the GUI that has been developed with Visual Basic. The case example is based on BS6651:1999. Figure 3 shows the home page and of the GUI and Figure 4 shows the menu to choose for direct and indirect lightning strikes

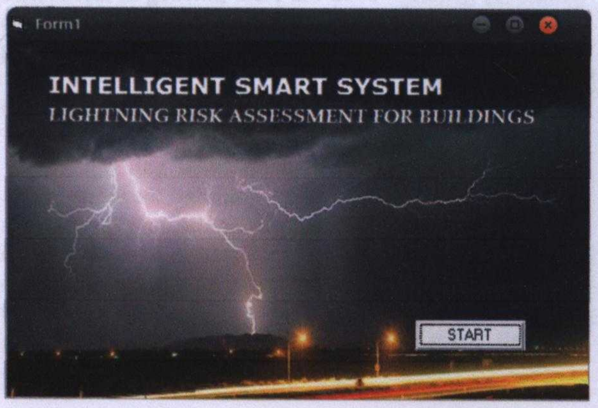

Figure 3: Home page of the Graphical User Interface

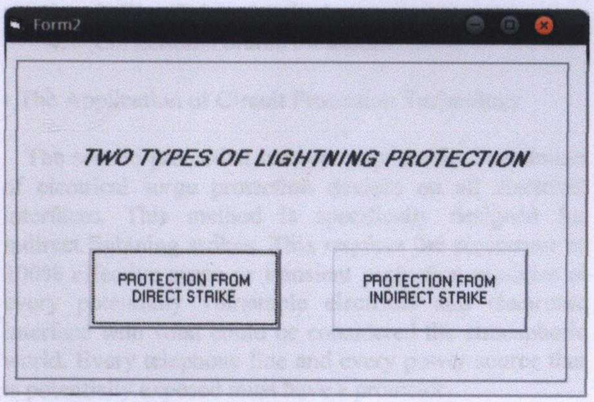

Figure 4: Menu for direct and indirect lightning strikes

i. Direct Lightning Strikes

A hospital in the Thames Valley is 10 m high and covers an area of 70 m x 12 m. The hospital is located in flat country and isolated from other structures. The construction is of brick and concrete with a non-metallic roof.

The parameters for the buildings are being input in the GUI that has been developed by using visual basic. The value of N_g, A , B, C, D, and E are being obtained from BS 6651:1999. Figure 5 depicts the parameters that have been inputted in the GUI. Protection scheme of direct lightning strikes will be discussed later. The data that have been inputted shows that the building needs protection from direct lightning strikes.

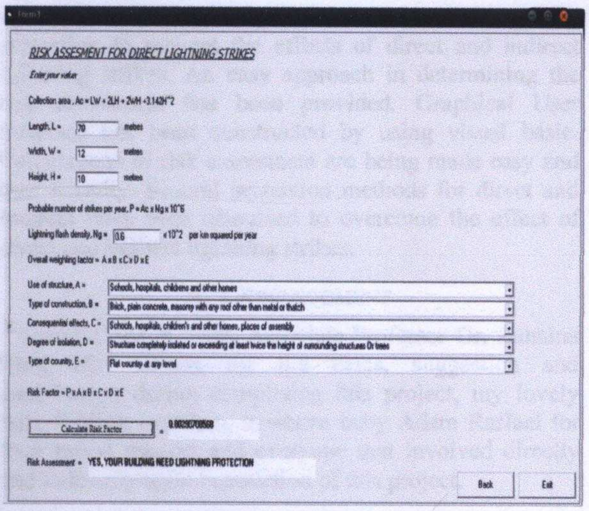

Figure 5: Building Parameters for Direct Lightning Strikes Calculations Inputted in Graphical User Interface

ii. Indirect lightning Strikes

A commercial company's computing headquarters on the outskirts of Hull is 15 m high covering an area of 100 m in length by 60 m in width. Located in flat country, the building is largely isolated from other structures of similar height and is protected in accordance with BS 6651.The incoming mains supply is a 250 m long LV underground cable and all computer communication lines are on fiber optic cable without metal armouring. An underground cable provides power from the building to a lighting tower, 7 m high, 100 m from the building.

The values are then being inputted in the GUI as being shown in Figure 8. The parameters that have been inserted in the GUI are based on the rules provided by BS6651:1999. It clearly shows that the buildings need protection from indirect lightning strikes.

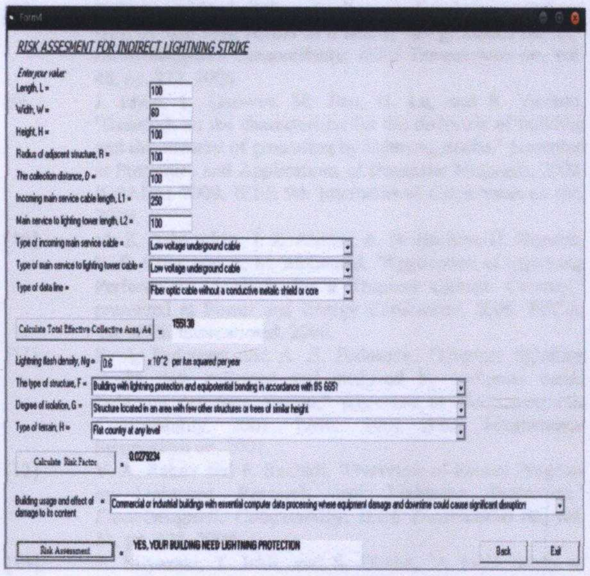

Figure 6: Building Parameters for Indirect Lightning Strikes Calculations Inputted in Graphical User Interface

B. Protection Method

There are several protection methods that are provided to protect apparatus form direct and indirect lightning strikes.

Importantly, before any lightning system protections are being install, cost-effective way of preventing fires, physical damage, system downtime, or other losses must be provided. These purposes are being accomplished by isolating the vulnerable equipment in an area against all primary and secondary forms of lightning related influences. In general, there are three lightning protection concepts that can be used to provide a lightning protection system against direct and indirect strikes.

• A Lightning Strike Prevention System

A lightning strike prevention system is designed to eliminate direct lightning strikes from terminating in the area under protection. Assumptions are made that the area or site is to protect is physically isolated, and that no other electrical paths exist that transients can travel into the electrical and electronic systems installed in the area. Among the popular method to install these lightning strike prevention system is:

1. Cone of Protection Method.
2. Mesh (Faraday Cage) Method.
3. Rolling Sphere Method.
4. Collection Volume Method.

• The Application of Circuit Protection Technology

The second protection concept requires the installation of electrical surge protection devices on all electrical interfaces. This method is specifically designed for indirect lightning strikes. This requires the placement of 100% effective surge or transient protection modules at every potentially vulnerable electrical and electronic interface with what could be considered the atmospheric world. Every telephone line and every power source that is potentially exposed must have a protector.

• The Comprehensive Closed System Concept

The third method of protection employs the best of the foregoing concepts, a lightning strike prevention system and the application of circuit protection on all interfaces into or out of the area under protection. This method involves the logical use of a strike prevention system for critical areas and the use of circuit protectors that isolate all of the electrical and electronic systems used within the area under protection.

IV. CONCLUSIONS

Direct lightning and indirect lightning strikes is a hazardous situation than can cause harm, injuries and death to human. Moreover, electric and electronic apparatus are prone to damages towards direct or indirect lightning strikes. Therefore this paper has discussed whether certain building in need or need not for protection to prevent the effects of direct and indirect lightning strikes. An easy approach in determining the risk assessment has been provided. Graphical User Interface has been constructed by using visual basic. Calculations of risk assessment are being made easy and user friendly. Several protection methods for direct and indirect have been discussed to overcome the effect of direct and indirect lightning strikes.

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