Lightning Risk Assessment for Hall Building Based on Malaysian Standard MS IEC

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Abstract—**OnJanuary 2006,Malaysia adopted IEC Standard as Malaysian Standard IEC 62305-2:2006, Protection against Lightning Part 2: Risk management which applies to the risk assessment of building and public facilities. This paper based on Malaysian standards assesses risks of lightning strike to Examination Hall which is Dewan Sri BudimanUiTM Shah Alam, Malaysia for the application of the new Malaysian standards for reference. In this paper, carries out data collection and zoning on the hall as well as the lightning risk assessment according to the evaluation process and method. Comparing all the achievement Lightning risk values with reference value results of the assessment. Finally it makes the recommendation needed with lightning protection of hall building.**

Keywords-Hall Building; Lightning Risk Assessment; Malaysian Standard; Protection Measures

I. INTRODUCTION

Lightning is the visible discharge of static electricity within a cloud, between clouds, or between tile earth and a cloud. About 1700 electrical storms active throughout the world which produces in excess of 100 flashes per second and one of the most dangerous lightning strikes is between tile earth and a cloud. This risk may causes damage to structures or to services itself. Universities are one of the institute that need to be evaluated their lightning assessment of their building. Thus one of the step could bring to construct lightning protection is by assessing their high-risk areas of lightning attack on structure. This method will be proposed in the project of an assessment for lightning protection of hall building by referring to the standard for Lightning Protection Design adapted by Malaysian Standard IEC 62305.

Referring to the Malaysian Standard IEC 62305, there are three types of risks to a structure which are:

a) Damage to the structure and to its contents.
b) Failure of associated electrical and electronics system.
c) Injury to living beings in or close to the structure.

While there are three types of damage causes by lightning strike which are:

a) Injury to living beings (due to step and touch voltages).
b) Physical damage (due to fire, explosion and mechanical destruction)
c) Failure of internal system (due to LEMP – Lightning Electromagnet Impulse).

Each damages itself or combining with other, may produce different consequences loss in the building to be protected. The risk of loss that to be evaluated for a structure are shown in the table of below:

TABLE 1.1 TYPES OF TOLERABLE RISK

Parameter	Type of tolerable risk	$R_T(10^{-1})$
R_1	Risk of loss of human life	10^{-5}
R_2	Risk of loss of service to the public	10^{-3}
R_3	Risk of loss of cultural heritage	10^{-3}

In this paper,**risk of loss of human life, R_1** will be considered for every assessment for each type of losses of a structure.

II. LIGHTNING RISK ASSESSMENT METHOD

A. Methodology

The procedure to collect data can be shown as follows

i. Identify the structure to be protected
ii. Obtaining plan and data of structure's area.
iii. Gathering the structure characteristic by observing the structure's physical.

The procedures needed to assess the lightning risk divided into four:-

1. Identify the structure to be protected and its characteristic.
2. Identify all types of loss in the structure and relevant corresponding risk R_1 by calculation and the tolerable risk, R_t.

3. Evaluate the risk R1 for each type of loss using theoretical method.
4. Identify and recommend protection needed by comparing the Risk R_1 for structure with the tolerable risk, R_T.

Steps are shown in the Figure 1 as follow.

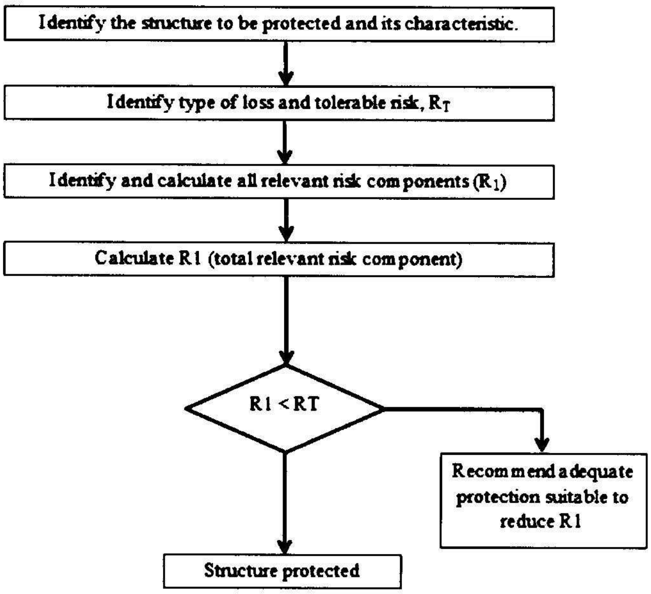

Figure 1. Procedure to evaluate risk R_1

B. The Assessment's Method for Hall Building

In this paper the structure requires to be assessed is Dewan Sri BudimanUiTM Shah Alam building.

- Survey of the Hall Building

The hall building is a double story structure in University Teknologi of Mara. Its square is 58m long (L), 30m wide (W) and 25m high (H). These dimension parameters required to calculate equivalent area of hall building which follows

$$Ad = L_b \times W_b \times 6H_b \times (L_b + W_b) + 9\pi H_b^2 \ (m^2) \quad (1)$$

The building is surrounded by other buildings and trees. Thus, from the Malaysian standard, the relative location of the building coefficient Cd is 0.5. By calculation, ND is 0.472857 times/year. Relative location coefficient can be calculated using the following equation:

$$N_D = N_g \times A_d \times C_d \times 10^{-6} \text{ (Times/year)} \quad (2)$$

The building floor are made by wooden with low of catching risk fire, rf. The firefighting facilities are fire extinguisher, plug and alarm device.

The internal power system – applied service with two winding transformer brings transformer factor, $C_t = 0.2$ while the environment factor is urban area with tall building, Ce = 0.

The special hazard is average level of panic wher^ the building designed for event or activities with a number of participants between 100 and 1000 peoples, $h_z = 5$.

Condition counted in: the difference between the floors of the inside and outside building; the hall building as the only fire protection structure.

Therefore the main area can be divided into

Z_1 (zone 1: entrance area); Z_2 (zone 2: hall building) where the building is not isolated, there are other buildings and trees nearby.

- Lightning strike risk assessment of hall building

a) Calculation of the indirect lightning strike

Lightning strike the near a structure of building, produces to an indirect risk R1, where the total of the risk are summation of R_A, R_B, R_U (power line), R_V (power line), R_U (telecom line) and R_V (telecom line). R_A is the risk component of injury to living beings when the flashes strike to a structure; R_B is risk component of physical damage to a structure; R_U is the lightning strike household line, risk of injury associated with living; R_V is lightning strike household line, risk of physical damage.

$$R_1 = R_A + R_B + R_{U(p)} + R_{V(P)} + R_{U(T)} + R_{V(T)} \quad (3)$$

$$R_A = N_d \times P_A \times ra \times Lt \quad (4)$$

$$R_B = N_d \times hz \times P_B \times r_P \times r_f \times L_f \quad (5)$$

$$R_{U(p)} = (Nl + N_{DA}) \times r_U \times P_U \times L_t \quad (6)$$
$$R_{V(P)} = (Nl + N_{DA}) \times P_V \times h_Z \times r_P \times r_f \times L_f \quad (7)$$

$$R_{U(p)} = (Nl + N_{DA}) \times r_U \times P_U \times L_t \quad (8)$$

$$R_{V(P)} = (Nl + N_{DA}) \times P_V \times h_Z \times r_P \times r_f \times L_f \quad (9)$$

In (4), Nd is number of dangerous events due to flashes to a structure. PA is probability of injury to living beings which flashes strike to a structure. Lt is loss due to injury by touch and step voltages.

Similar in (5), N_d is number of dangerous events due to flashes to a structure. h_z is a factor increasing the loss when a special hazard is present. P_B is the probability of physical damage to a structure by flashes strike. $r_P$is the factor reducing the loss due to provisions against fire. R_f is a factor reducing loss depending on risk of fire. Lf is the loss in a structure due to physical damage.

Nl is the number of dangerous events due to flashes to a service. N_{DA} is the number of dangerous events due to flashes to a structure at "a" end of line. r_U is reduction factor associated with the type of surface of floor. P_U is the probability of injury living beings which flashes strike to a connected service. L_t is loss due to injury by touch and step voltages. PV is the probability of physical damage to a structure when flashes strike to a connected service.

III. RESULT AND DISCUSSION

This paper aims to calculate the risk of human life, R_1 and compare with the tolerable risk of loss of human life, $R_T = 10^{-5}$.

TABLE 1.1 COLLECTION AREA OD STRUCTURE AND LINE

Symbol of area	Equation for collection area	Value m2 (x 10-5)
A_d	To the structure: $A_d = L_b \times W_b \times 6H_b \times (L_b + W_b) + 9\pi H_b^2$	32610.8125
$A_{l(p)}$	To the power line: $A_{l(p)} = \sqrt{\rho} + [L_c - 3H_b]$	9250
$A_{i(p)}$	To the power line $A_{i(p)} = 25 \times \sqrt{\rho} \times L_c$	250000
$A_{l(T)}$	To the structure: $A_{l(T)} = L_b \times E_b \times 6H_b \times (L_b + W_b) + 9\pi H_b^2$	9250
$A_{i(T)}$	To the power line: $A_{i(T)} = 25 \times \sqrt{\rho} \times L_c$	250000

TABLE 1.2 EXPECTED ANNUAL NUMBER OF DANGEROUS EVENT

Symbol of number	Equation for number of flashes (x 10^{-6})	Value (1/year)
N_d	$N_d = A_d \times C_d$	0.472857
$N_{l(p)}$	$N_{l(p)} = N_g \times A_{l(p)} \times C_{d(p)} \times C_{t(p)}$	0.0134125
$N_{i(p)}$	$N_{i(p)} = N_g \times A_{i(p)} \times C_t \times C_e$	0
$N_{l(T)}$	$N_{l(T)} = N_g \times A_{l(T)} \times C_{d(T)}$	0.0670625
$N_{i(T)}$	$N_{i(T)} = N_g \times A_{i(T)} \times C_{e(T)}$	0

Symbol of component	Zone 1 (Entrance)	Zone 2 (Building)	Total
R_A	4.7286×10^{-6}	0.0472×10^{-6}	5.2006×10^{-6}
R_B	-	5.91071	
$R_{U(P)}$	-	4.02375×10^{-8}	
$R_{V(P)}$	-	0.00502969	
$R_{U(T)}$	-	2.01188×10^{-7}	
$R_{V(T)}$	-	0.025148	

TABLE 1.3 RISK COMPONENTS OF ZONES

The risk R1 can be expressed by the following components:

$$R_1 = R_A + R_B + R_{U(power\ line)} + R_{V(power\ line)} + R_{U(telecom\ line)} + R_{V(telecom\ line)}$$

$$R_1 = 5.94089 \times 10^{-5}$$

The result shows the value of $R_1 > R_T$ (tolerable risk) where 5.94089 >1 × 10^{-5}, thus lightning protection need to be proposed.

According to the calculation of R_1, the main contribution factor to the value of the risk R_1 are given by:

a) *Component R_B(flash to structure) = 97.89%*

b) *Component $R_{V(p)}$(flash power line) = 0.08%*

c) *Component $R_{V(T)}$(flsah telecom line) = 0.42%*

To reduce $R_1$to a tolerable value, the protective measures influencing R_V and the component R_B should be considered. Recommended measures are as follows:

a) Installing a LPS of class III, which reduce the value $P_B$from 1 to 0.1.

Inserting the values into the equation, the new values of risk of components are obtained as follows:

$$R_1 = R_A + R_B + R_{U(power\ line)} + R_{V(power\ line)} + R_{U(telecom\ line)} + R_{V(telecom\ line)}$$

$$R_1 = 5.2006 \times 10^{-6} + 0.591071 + 4.02375 \times 10^{-8} + 0.00502969 + 2.01188 \times 10^{-7} + 0.0251484$$

$$R_1 = 0.621249 \times 10^{-5}$$

Thus $R_1 = 0.621249 \times 10^{-5} < R_T = 1 \times 10^{-5}$ has meet the objective of lightning assessment has been achieved by selecting the appropriate protection measures in order to reduce the risk of loss of human, R_T. Table 1.4 shown the summary of Dewan Sri BudimanUiTM building before and after protection adopted.

TABLE 1.4 SUMMARY OF DEWAN SRI BUDIMAN UiTM BUILDING BEFORE AND AFTER LIGHTNING RISK PROTECTION

Risk component	Before Case a)	After Case b)
R_B	5.91071	0.591071
$R_{U(P)}$	4.02375×10^{-8}	4.02375×10^{-8}
$R_{V(P)}$	0.00502969	0.00502969
$R_{U(T)}$	2.01188×10^{-7}	2.01188×10^{-7}
$R_{V(T)}$	0.025148	0.025148
R_1	5.94089×10^{-5}	0.621249×10^{-5}

IV. CONCLUSION

Through the analysis and comparison of related assessment standards, the risk assessment of lightning protection for hall building in the thesis is based on the Malaysian standard MS IEC 62305. Finally, assessing parameters for each area is listed in the form of table, and the corresponding risk value is calculated through the assessment formula. With calculation and analysis, the practical lightning risk value R_1 of hall building is higher than tolerable risk, R_T. Therefore the thesis is carried out with the conclusion that the lightning protection fixtures need to adapt new lightning protection.

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