Bangladesh University of Engineering and Technology

EEE 414

Electrical Services Design Laboratory

Assignment Topic: Lightning Risk Assessment of ECE Building of Bangladesh University of Engineering and Technology

Project Group: 04

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Lightning Risk Assessment:

Lightning risk assessment is the process of evaluating potential risks of lightning strikes to a structure. It assesses the vulnerability of a structure to lightning strikes and allows to take necessary measures to protect it from lightning strikes. It is crucial for determining the necessity of lightning protection and ensuring safety in lightning-prone areas.

Importance of Lightning Risk Assessment:

1. Protection of human lives and saving structures from fatal attacks

2. Lightning strikes can initiate fire attacks in certain attacks. Lightning risk assessment allows taking necessary measures to avoid such incidents.

3. Risk assessment identifies weak and vulnerable points in the structure prone to lightning strikes and hence protects structures.

4. Lightning damage to critical structures such as industries or power plants can increase downtime, leading to significant losses. Risk assessment can help take necessary measures to avoid such incidents.

Standards for Lightning Risk Assessment:

1. **IEC 62305-2:** Provides a detailed framework for assessing risks and designing protection systems.
2. **NFPA 780:** Addresses lightning protection systems in the United States.
3. **Local Standards**: Ensure compliance with regional codes or practices.

Lightning occurrences in Bangladesh:

Bangladesh experiences high frequency of lightning strikes due to the geographical location and the weather trend in this part of the world. Lightning has become one of the leading natural hazards in Bangladesh.

Between 2010 and 2020, lightning killed 3,273 people in Bangladesh, or about four people a week. In 2021, there were about 5, 757, 836 lightning counts in Bangladesh, or about 42.44 lightning events per sq. km. [1]

From 1990 to 2015, there were a total of 5,468 casualties in Bangladesh due to lightning, including 3,086 deaths and 2,382 injuries, with an average of 114 deaths and 89 injuries each year. [2]

Such vulnerability towards lightning strikes in Bangladesh makes risk assessment an even more crucial necessity.

Damage and Loss due to Lightning Strikes:

BS EN/ IEC 62305 identifies 4 main sources of danger-

1. S1- Flashes to the structure
2. S2- Flashes near the structure
3. S3- Flashes to a service
4. S4- Flashes near a service

Each source of damage may result in one or more of three types of damages:

1. D1- Injury to living beings due to step and touch voltage
2. D2- Physical damage (fire, explosion, mechanical destruction, chemical release) due to lightning current effects including sparking
3. D3- Failure of internal system due to Lightning Electromagnetic Impulse

The following type of loss may result from damage due to lightning:

1. L1- Loss of Human Life
2. L2- Loss of service to the public
3. L3- Loss of cultural heritage
4. L4- Loss of economic value

Point of Strike	Source of Damage	Type of damage	Type of Loss
Structure	S1	D1 D2 D3	L1,L4** L1,L2,L3,L4 L1*,L2,L4
Near a Structure	S2	D3	L1*,L2,L4
Service Connected to a Structure	S3	D1 D2 D3	L1,L4** L1,L2,L3,L4 L1*,L2,L4
Near a Service	S4	D3	L1*,L2,L4

* Only for structures with risk of explosion and for hospitals or other structures where failures of internal systems immediately endanger human life.

** Only for properties where animals may be lost.

Index figures associated with Lightning Protection Design:

Assessment of the risk is based on a set of indices for the various factors involved, as mention in BNBC-

1. **Use of Structure (2-10):** It denotes the specific use of the structure to be assessed
2. **Type of Construction (1-10):** It denotes the type of the structure along with the type of roof it uses
3. **Contents of Consequential Effects (2-10):** It denotes the specifications of the buildings which might have consequential effects in making it lightning-prone

4. **Degree of Isolation (2-10):** The relative exposure of a particular building will be an element in determining whether the expense of lightning protection is warranted. In closely built-up towns and cities, the hazard is not as great as in the open country.
5. **Height of Structure (2-30):** Height of the structure is an important factor for the purpose of lightning protection. Taller structures are subject to greater hazards than smaller structures and, therefore, lightning protection is more desirable for tall structures. Structure taller than 53 metres require protection in all cases.
6. **Lightning Prevalence (2-21):** The number of thunderstorm days in a year varies in different parts of a country. However, the severity of lightning storms, as distinguished from their frequency of occurrence, is usually much greater in some locations than others. Hence, the need for protection varies from place to place, although not necessarily in direct proportion to the thunderstorm frequency.

Risk Index:

Risk index is the sum of all the factors mentioned above. A risk index above 40 means that lightning protection is compulsory.

Calculation for ECE Building, BUET:

ECE building of BUET is situated at Palashi, Dhaka. It is a twelve-storied structure which houses laboratories with expensive electrical equipment, classrooms with significant number of electrical loads, seminar rooms and multiple student spaces. The roof of the ECE building houses multiple solar panels as well.

Lightning Risk Assessment for ECE Building, BUET:

Index A: Use of structure

Index A: Use of Structure	Index
Houses and similar buildings	2
Houses and similar buildings with outside aerial	4
Small and medium size factories, workshops and laboratories	6
Big Industrial plants, telephone exchanges, office blocks, hotels, blocks of flats	7
Places of assembly, for example, places of workshop, theatres, museums, exhibitions, department stores, post offices, stations, airports, stadiums	8
Schools, Hospitals, Children's homes and other such structures	10

Since ECE building is primarily an educational institution, it falls under **Schools, hospitals, children's homes and other such structures** category.

Index for use of structure: 10

Index-B: Type of Construction

Index B: Type of Construction	Index
Steel framed encased with nonmetal roof	1
Reinforced concrete with nonmetal roof	2
Brick, plain concrete, or masonry with nonmetal roof	4
Steel framed encased or reinforced concrete with metal roof	5
Timber formed or clad with any roof other than metal or thatch	7
Any building with a thatched roof	10

ECE building is a twelve-storied massive structure, covering a huge area and built to accommodate various utilities. Its structure has been made to be very resilient and durable. Reinforced concrete has been used along with normal concrete and brick for its construction. Its roof does not contain major metallic constructions, rather it has multiple solar panels for power generation purposes. So, it falls under the category **Reinforced concrete with nonmetal roof.**

Index for Type of Construction: 2

Index-C: Contents of Consequential Effects

Index C: Contents or Consequential Effects	Index
Ordinary domestic or office building, factories and workshops not containing valuable materials	2
Industrial and agricultural buildings with especially susceptible contents	5
Power stations, gas works, telephone exchanges, radio stations	6
Industrial key plants, ancient monuments, historic buildings, museums, art galleries	8
Schools, hospitals, children's and other homes, places of assembly	10

Since ECE building is primarily an educational institution, it falls under the last category i.e., **Schools, hospitals, children's and other homes, places of assembly**

Index for Contents of Consequential Effects: 10

Index-D: Degree of Isolation

Index D: Degree of Isolation	Index
Structure located in a large area having structures or trees of similar or greater height, e.g. a large town or forest	2
Structure located in an area with a few other structures or trees of similar height	5
Structure completely isolated or exceeding at least twice the height of surrounding structures or trees	10

ECE building is situated at the heart of Dhaka where there are few other structures of similar height near Eden College, Azimpur Colony etc. So, the ECE building falls under the category **Structure located in an area with a few other structures or trees of similar height.**

Index for Degree of Isolation: 5

Index-E: Type of Terrain

Index E: Type of Terrain	Index
Flat terrain at any level	2
Hilly Terrain	6
Mountainous terrain 300m or above	8

ECE building is situated in West Palashi, which is a flat terrain. There are no slopy areas anywhere near, so it falls under the category- **Flat terrain at any level**

Index for Type of Terrain: 2

Index-F: Height of Structure

Index F: Height of Structure	Index
Up to 9 m	2
9-15 m	4
15-18 m	5
18-24 m	8
24-30 m	11
30-38 m	16
38-46 m	22
46-53 m	30

Each floor of ECE building is 11 ft in height and for 12 floors, the total height is $12 \times 11 = 132\ ft$. If plinth height is taken as 5 ft, the total height= $(132 + 5)ft = 137\ ft$= 41.7576 m, which is in between 38-46 metres.

Therefore, the risk index for Height of Structure= 22

Index G: Lightning Prevalence

Index G: Lightning Prevalence	Index
Number of thunderstorm days per year:	
Up to 3	2
4-6	5
7-9	8
10-12	11
13-15	14
16-18	17
19-21	20
Over 21	21

From Karmakar Et al. [3], the thunderstorm days for each month were determined and averaged for the entire year.

Average thunderstorm days= $\frac{0.9+3.4+10.1+20.8+29.4+24.5+18.9+16.2+22.2+11.2+1+0.4}{12} =$ $11.2\ days/year$

Therefore, it falls in the category **10-12** thunderstorm days per year.

Index for lightning prevalence= 11

Risk Index Calculation for ECE Building:

Parameter	Index
A: Use of Structure	10
B: Type of Construction	2
C: Contents or Consequential Effects	10
D: Degree of Isolation	5
E: Type of Terrain	2
F: Height of Structure	22
G: Lightning Prevalence	11
Total	62

Therefore, total index figure= $10 + 2 + 10 + 5 + 2 + 22 + 11 = 62$

Since index figure is above 40, protection is necessary for the construction.

LPL index for ECE Building:

The **LPL Index** refers to the **Lightning Protection Level Index**, a term often used in the context of lightning protection systems (LPS) design and risk assessment. It is primarily based on standards such as **IEC 62305**, which outline different protection levels for structures based on their risk factors.

Recommended LPL for Typical Building 1

SI No	Application	LPL
1	Computer data centers, military applications, high rise hotels/hospitals, nuclear power stations, airports, essential services such as telecom	1
2	Low rise hospitals/hotels, ex-zones in industry and chemical factories, fuel retail outlets, gas station, compressor station and similar installments	2
3	Schools, banks, residential buildings, temples, churches, mosques, community halls etc	3,4

LPL refers to the case of maximum surge current, based on the 10/350μs pulse current waveform, which is applied to the case of Type I protectors used in power entry level into a building. The ratings for 4 types are:

LPL	**I**	**II**	**III**	**IV**
Max. Current (kA)	200	150	100	100
Min. Current (kA)	3	5	10	16

Since ECE building is an educational institution, it falls in the category of **Schools, banks, residential buildings, temples, churches, mosques, community halls etc.**

The LPL index is 3,4.

Recommendation for ECE Building, BUET:

After risk assessment, it is evident that lightning protection is mandatory for ECE building, since its risk index is way above 40. Moreover, there aren't many high constructions right adjacent to ECE building, which makes it even more lightning prone. So, proper lightning protection is required.

References:

[1] https://cch.icddrb.org/lightning

[2] Dewan A, Hossain MF, Rahman MM, Yamane Y, Holle RL. Recent lightning-related fatalities and injuries in Bangladesh. Weather, climate, and society. 2017;9(3):575-89.

[3] Karmakar, Samarendra. (2008). Climate Feature of the Thunderstorm Days and Thunderstorm Frequency in Bangladesh. Proceedings of SAARC Seminar on Application of Weather and Climate forecasts in the Socio-economic Development and Disaster mitigation, 05-07 August 2007, Dhaka, Bangladesh. Published by SMRC in 2008.