ELECTRICAL SAFETY ASSESSMENT ACCORDING TO BANGLADESH NATIONAL BUILDING CODE (BNBC)

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A Thesis submitted to the Department of Electrical and Electronic Engineering Of BRAC University, in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering

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Declaration

We hereby declare that

1. The thesis submitted is our own original work while completing degree at BRAC University.

2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.

3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.

4. We have acknowledged all main sources of help.

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Abstract

Bangladesh National Building Code (BNBC) provides a complete guideline on every aspect for a building in Bangladesh. 'The Electrical and electronics services for buildings' section presents specific electrical safety regulations, the violation of which can lead to severe damage to both human lives and the electronic equipment in a building.

The main objective of this thesis is to prepare and present an assessment tool using the safety regulation points extracted from 'The Electrical and electronics services for buildings' section. This work divides all the safety regulation points into two distinct sectors: Risk to Health and Risk to electrical equipment, and assigns numbers to each point based on the level of threat its violation possesses in both sectors. The points, along with their assigned numbers are then presented in a tabular form which can be used to gain statistical data on the safety of a building from an electrical and electronic standpoint.

Acknowledgement

We would like to extend our sincere gratitude to our supervisor Dr. Abdul Hasib Chowdhury, Professor, Department of Electrical and Electronics Engineering, Bangladesh University of Engineering and Technology, for his guidance, continuous support, crucial opinion and suggestions during the entire process of research which helped us in completing this thesis. We are grateful to BRAC University for providing us with all the necessary materials required for the successful completion of the thesis.

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List of Abbreviations

BNBC	Bangladesh national Building Code
HBRI	Housing and Building Research Institute
BRTC	Bureau of Research Testing and Consultancy
BUET	Bangladesh University of Engineering and Technology
MDB	Main Distribution Board
SDB	Sub Distribution Board
DB	Distribution Board
MCCB	Molded Case Circuit Breaker
MCB	Miniature Circuit Breaker

Chapter 1

Introduction

1.1 Bangladesh National Building Code (BNBC)

The Bangladesh national building Code (BNBC) is essentially a rulebook that provides clear and specific rules and regulations that are to be followed throughout the steps of constructing a building, both commercial and residential, for ensuring a safe and healthy environment for the habitants of a building. The first rendition of BNBC was a 1000-page document that was published in 1993 [1], which contained detailed specifications regarding the safe and prescribed practices during the erection of a building. Since then, the technologies and the methods of have changed over the years. As the circumstances changed, the code was updated accordingly as the old techniques of constructing buildings led to unplanned urbanization and new construction materials, construction designs, new methods had emerged [2].

A steering committee with the intension of updating the BNBC to keep pace with the current methods of building establishment was formed by the Ministry of Housing and Public Works [3]. The committee consisted of several representatives from Universities, Related Government agencies and professional societies. The Housing and Building Research Institute (HBRI), along with The Bureau of Research Testing and Consultancy (BRTC) and Bangladesh University of Engineering and Technology (BUET) have worked together in order to review and update the BNBC [4].

The updated BNBC has 10 different sections containing a total of 49 chapters, all of which contain rules and regulations and healthy practices concerning all the possible aspects of establishing a building.

One of the 10 sections of BNBC is the ‘The Electrical and electronics services for buildings’ which deals with the electrical wiring design and equipment installation in a building. This is a crucial part of BNBC that has to be strictly followed as any form of negligence can lead to unsafe, unhealthy, dangerous and sometimes even disastrous occasions.

1.2 Importance of The Electrical Safety Assessment tool

Even though there is a guideline been set by the government and top and renowned engineers in the form of BNBC, there were still lacking in implementation. For lack of following through the regulations put forth by BNBC in a successful manner, many buildings have been affected and lives were lost.

In recent years, an alarming number of buildings, mostly garments and factories have been subjected to fire hazards, most of which originate from electrical malfunction or failures [5].

The main purpose of the BNBC is to minimize damage and to have a safe environment for people to live in, but implementation is the key as BNBC is merely a tool to keep everything in check.

The safety assessment tool explores the BNBC electrical section and filters out prescribed rules and presents them in an easily understandable and more importantly, usable form. Using the safety assessment tool, the potential hazards a building might be facing due to electrical misconduct, can be easily known. Necessary steps can then be taken to address the misconducts and prevent any possible hazardous occasion from happening. This tool is also extremely useful to actualize the robust and sound environment for people in both residential and commercial areas that the BNBC hopes to ensure.

1.3 Thesis Work

This thesis is mostly based on fieldwork. The body of the thesis work consists of a theoretical aspect which tabulates the safety regulation points or threat points from BNBC and comes up with a system to rank the threat points. The practical aspect of the thesis work includes inspecting buildings using the assessment tool.

We have also accounted the locations of each electrical appliances as also the safety of each piece of equipment. As our resources were limited, we asked the authorities and also the permission of our Chair Person DR SHAHIDUL ISLAM KHAN to research the buildings of BRAC UNIVERSITY. There are 6 buildings in total which different infrastructure and number of floors. The buildings were all thoroughly examined and photos of faulty electrical connections or misconducts were taken if necessary, for the assessment.

1.4 Thesis Outlines

- **Chapter 1** presents an introduction and a short description of the BNBC and the importance of the Electrical Safety Assessment Tool, followed by the purpose of the thesis and the thesis outlines.
- **Chapter 2** explains the methodologies of the intuitive prediction-based system that was implemented to rank the threat points from 'The Electrical and electronics services for buildings' part of BNBC 2015.
- **Chapter 3** presents that Assessment tool and its functions
- **Chapter 4** discusses the data inspection using the completed assessment tool, the structure of the tool and the calculation segment presented in the tool in details.
- **Chapter 5** presents the statistical results and a brief analysis of the result in order to obtain a proper outlook at the safety of a building from an electrical safety standpoint.

Chapter 2

Methodology

2.1 Locations

The BNBC gave us a detailed and elaborate explanation in terms of necessities; pre occurring and post occurring of dangers related to electrical safety issues. Even so the elaborated version of these necessities is too widely scoped to define certain points of safety measures that can be hard to implement or to execute on short term notice. So, we had to dig out significant points referring to the BNBC with location-based safety concerns that poses threat and can be inspected over even after all the electrical installations have taken place as a system in a commercial building.

So, our primary concern was to refer visible electrical installation threat that can cause risk to both health and electrical equipment; keeping in mind the need to tackle them. As locations go, an entire building was divided into 8 specific locations.

- Substations
- Transformers
- Generators
- Rooms (Classes for our project)
- Service Shafts and Ducts
- Earthing System
- Lightning Protection
- Exit signs and means of escape illumination

All the visible electrical installations and the subsidiary environmental setup are distributed in each of the locations mentioned above. To get more clear understanding we have to look into certain examples which are taken from the tables attached later in our papers**.** For Example: 'Substation layout not according to power flow' 'Combustible materials inside substation' '11Kv/0.4Kv placed in basement' these points pertain to substation safety measures intricately. Again, 'Silica gel condition not good/not provided' for Transformers; 'Generator located on higher floor' for Generators; 'Burning signs on DB/SDB' for rooms, 'Vertical electrical shaft placed adjacent to sanitary shaft' for Service Shafts if they are provided, 'MDB does not have duplicate earth leads' for System Earthing, 'External metals on building not bonded to lightning conductor' for Lightning protection if provided. And for Exit signs 'Exit Sign not illuminated' are a few definite points that have been dug out from BNBC pertaining to its exact location and functionalities.

2.2 Sector based Risk Assessment

The above-mentioned location of electrical installation of a building was subjected with 2 kinds safety threat that can be caused any way or the other which are

- Risk to Health
- Risk to Electrical Equipment

Some of the points refer to both Risk to health and Risk to Electrical Equipment which does not mitigate the purpose or the significance of this division as they are taken into further considerations to create a ranking list among themselves.

The first objective was to take all causes that can cause destruction or damage of all pertaining locations that we talked about and divide it into 2 main sections that either deals with health damage or electrical equipment damage only.

2.2.1 Risk to Health

For Substations, the point from the table that states, ‘No instruction Board on Substation a) for first aid to electrical shock b) for artificial respiration.’ In terms of an unforeseen accident like shock or fire exposure a person’s life could be saved with primary first aid. The absence of the above-mentioned point can lead to a person’s unfortunate death, which is only pertaining to the Risk to Health sector.

Again, the point ‘Inadequate Cross Ventilation in Substations’ can lead to extreme heat and lack of air inside the room which poses health threats to anyone working inside the substation room for any maintenance purpose or any other reason pertaining to the equipment handling. This point mentioned also indicates directly to the sector ‘Risk to Health’.

For Transformers, the point ‘No separate room for transformers’ can be an extremely dangerous for any maintenance to get electrified while working on the other equipment close to the transformer in the substation room which can create to an accident of life or death situation for the person involved.

For Generators, the point ‘Generator Located on higher floor’ could be an essential and very much likely reason for many deaths of people working in the building. If the Generator is located on higher floor it creates an immeasurable instability to the structure and the foundation of the building and causes structural errors over long period of time to the point where the whole building can collapse and cause the death of a thousand people. We as a nation are already familiar with such an incident that took place on 24^{th} April of 2013 as “The Rana Plaza tragedy”. So, the point mentioned is intricately significant for the sector ‘Risk to Health’ and their safety measures.

For Rooms or Classrooms, we have noticed to be an MDB/DB or SDB panel present in each of the floor of the building for obvious reasons of maintenance. The point from the table, “MDB/DB/SDB door damaged/ does not close fully” clearly poses threat for any individual to get close proximity to these panels and get electrocuted because of the open doors of these panels that circuits multiple live wires.

For Service Shafts and Ducts, the point ‘Vertical electrical shaft placed adjacent to sanitary shaft’ can causes problem for any plumber or maintenance worker to expose himself to electrification due to a leak from the sanitary shaft or water.

For Earthing System, ‘Earthing/Lightning pits not identified’ can lead to anyone touching or getting in contact with the exposed pits and electrocuted causing death or dangerous accidents.

For Lightning protection, if ‘External metals on the building is not bonded to lightning conductor’ it can cause unwanted electric conductivity in many parts of the building proxy to switches, boards, or even wire beneath the walls causing accidents like electrification.

For Exit signs and means of escape illumination, in case of an accident or emergency, not finding the escape route can cause panic and more problems like stampedes or can be reducing casualties pertaining to the point, “Exit sign not illuminated”.

All the points discussed above are just one of many examples that we have taken to consider understanding personnel threat level and their causes. All the points in detailed have been segmented in the tool table attached below.

2.2.2 Risk to Electrical Equipment

There are some points that pertain to the sector ‘Risk to Electrical Equipment’ only.

For example, inadequate cross ventilation in substation in a heated environment slowly degrades the performance of the equipment. Another example of substation property damage can be referring to no flood water prevention. If there are no flood water prevention water streams from outside can get into the substation and cause internal damage to many equipment.

For transformers, silica gel condition can be very essential pertaining to transformer's conductivity, heat and other internal mechanisms. If the silica gel has turned into pink or white, or has no silica gel to begin with, the Condition of the transformer, worsens and become unusable at one point.

For generators, if the generator is not installed on shock absorbing mounting bases, the integral structure of the generator gets badly affected by the constant vibration.

For rooms or classes, switch board not fully enclosed, of flameproof in damp situation or where inflammable or explosive dust vapor or gas is likely to be present, can cause explosion and permanent damage to the boards close by.

In case of service shafts and ducts, vertical electrical shaft placed adjacent to sanitary shaft, can cause leaks off the sanitary shaft and cause damage to the vertical electrical shaft due to water or liquid elements.

For lightning protection, external metals on building not bonded to lightning conductor can cause unwanted conductivity throughout the internal part of the building and create overflow of current that causes permanent damage to pertaining equipment.

While we were dividing the scenarios and their results into 2 main sectors, many causes and points from the table were encountered that can pertain to both the sectors. This particular bonus segment later helped us to understand significance of each individual causes and make a ranking list among themselves.

2.2.3 Risk to both health and Electrical Equipment:

In substation, we can refer to a point from that table that states “combustible materials inside substation”. This particular point does not specifically pertain to property or personnel damage rather both of them. Because we know that combustible materials inside substations can lead to fire and explosion for many knowing and unknowing trails of causes. This destructive phenomenon can lead to severe damage of the equipment and also people close proximity.

For Transformers, the point “Water/Oil in Transformer room” is very dangerous for both the transformers due it’s reduced life because in a Danger threshold of 2% to 3% moisture, transformer becomes increasingly exposed to electrical malfunction and for presence of oil, the possibility of starting a fire increases in the transformer room which can lead to explosions and wide range fire resulting in death of human lives near the place.

For Generator, the point “Generator located on higher floor” is extremely dangerous as we have discussed previously. If the Generator is located on higher floor it creates an immeasurable instability to the structure and the foundation of the building and causes structural errors over long period of time to the point where the whole building can collapse and cause the death of a thousand people. So to mention the obvious, this particular point emphasizes on both the sectors.

For Rooms and Classrooms, the point from the tool table which states, “Combustible material inside/near MDB/SDB/DB/SB/MCB/MCCB-box/Socket” Can be extremely dangerous as it gives rise to the possibility of a created fire from minor electrical spikes that deals explosion or severe damage both to the property and the people close to the place.

For Service Shafts and ducts, the point, “Vertical electrical shaft placed adjacent to sanitary shaft” can causes problem for any plumber or maintenance worker to expose himself to electrification due to a leak from the sanitary shaft or water. Moreover, it can cause leaks off the sanitary shaft and cause damage to the vertical electrical shaft due to water or liquid elements.

For Lightning Protection, the point, “External metals on building not bonded to lightning conductor” can cause unwanted conductivity throughout the internal part of the building and create overflow of current that causes permanent damage to pertaining equipment. Moreover, it can cause accidents like electrification in many parts of the building proxy to switches, boards, or even ungrounded wires beneath the walls.

The above explained points are one of many that resembles the criteria for our created segment that deals with both the sectors. In the tool table attached, we have more of these points that signifies this particular criteria segment.

2.3 Level Based Ranking

Even Though we could manage to divide and start our mission to identify and simplify the probable causes and results, we had to give significance to each of the points from the table of a particular segment (Property/ Personnel) on the basis of their risk factors and their extent on an individual level. In order to do so we studied each of the points and dived deeper into finding the “How’s” and the “Why’s” of these individual incidents. That way it helped us establishing threat levels initially defining them as ‘High’, ‘Medium’, ‘Low’**.**

For a better understanding of this matter, we are explaining how and why we have defined a certain point from the table pertaining to ‘High’, for ‘Risk to Health’ and then for ‘Risk to Electrical Equipment’, keeping in mind that we have considered these threat level common to all eight mentioned locations and equipment installations involved within it.

2.3.1 Threat Level High:

Any causes from the tool table that discusses the probability or poses even the merest possibility of electrical Explosion with a maximum range of impact was taken into consideration of High threat level. Moreover, any accidents or malfunction that can occur due to both Fire and Shock or only Fire or Shock that can lead to further danger was also considered. It must be mentioned that for the sector ‘Risk to Electrical Equipment’, if the parts destroyed are replaceable but will not be easy in terms of installment or expensive because of necessary subsidiary parts are also considered as High threat level.

For example, in Substation,

25	Earthing	Panel body and door not earthed
26		No earthing on HT side
27		No earth bus bar on LT panel

This particular point from the tool table poses life threatening risk of electrification due to Shock as mentioned which falls under the sector 'Risk to Health' and also an unearthed HT side can create sudden overflow of huge amount of currents causing the panels to explode and deals serious damage with a wide range of impact pertaining to the sector 'Risk to Electrical Equipment'.

For Transformers,

1	No separate room for transformers

This point can lead to an accident concerning a maintenance due to shock while working in the substation on other surrounding equipment near the transformer. So, this point particularly refers to the sector 'Risk to Health'.

4	silica gel condition not good (pink or white)/no silica gel

With the increase of current, heat deteriorates into the transformer oil. This outcome into the less thick transformer oil and moves into the safeguarding stage. The heat from the transformer oil gets started dissolving in the air. This way breather transformer intakes the air containing the moisture. Such contact of oil and air with moisture may affect the purity of the oil and thus may damage its insulation parts. Silica gel is used to prevent the entry of moisture into the transformer oil. When the crystals of the silica gel absorb the moisture the color of the silica gel changes and eventually decays to pink or white. This color indicates an outdated silica gel and needs changing for the benefit of the Transformer. If not attended to, the faulty internal insulation can create current spikes and some cases explosion that falls under the sector 'Risk to Electrical Equipment'.

For Generators,

1	Generator located on higher floor

The mentioned point from the table describes both the sectors hand in hand. This could be an essential and very much likely reason for many deaths of people working in the building. If the Generator is located on higher floor it creates an immeasurable instability to the structure and the foundation of the building and causes structural errors over long period of time to the point where the whole building can collapse and cause the death of many people. We as a nation are already familiar with such an incident that took place on 24^{th} April of 2013 as "The Rana Plaza tragedy". So the point mentioned is intricately significant for both the sectors considering their safety measures as it addresses maximum range of impact both in cases of life and property.

For Rooms or Classrooms,

28	Switchboard not fully enclosed of flameproof in damp situation or where inflammable or explosive dust, vapor or gas is likely to be present,

This point mentioned could be the reason of Explosion or Fire. Which can cause imminent danger to both the sectors with a Wide range of impact.

For, Service Shafts and Ducts,

3	Vertical electrical shaft placed adjacent to sanitary shaft

This can cause problem for any plumber or maintenance worker to expose himself to electrification due to a previous leak from the sanitary shaft or water.

For, System Earthing,

1	Metal building structure not earthed

This can cause current flow instability like spikes or unwanted conduction that can lead to accidents like electrification.

For, Lightning Protection,

2	External metals on building not bonded to lightning conductor

This point can cause thunder strikes that poses a lot of danger to the people and electrical installments and equipment to be destroyed or out of order for good.

For, Exit Signs,

1	Exit sign not illuminated

in case of an accident or emergency, not finding the escape route can cause more problems in panic like stampedes or can be reducing casualties if the point was attended in the first place.

2.3.2 Threat Level Medium:

Any causes from the tool table that discusses threat but with the help of external equipment or intervention can be avoided or already have instant remedies available have been segmented in this section. More specifically, for Electrical Equipment, a scenario where no fire or explosion occurs but has a possibility of Overcurrent or Short Circuit malfunction of equipment that can be easily replaceable but less expensive than that of threat level high; are segmented in Level MEDIUM.

For a deeper understanding considering examples, of Substations,

12	Diagrams and labels	List and diagram (SLD) of circuits not available
13		No clear and permanent identification marking on distribution panel

The points mentioned above can be dealt with external intervention e.g. an Engineer partaking the construction phase of the building can intervene and communicated to deliver the required diagrams of the SLD circuits and posted on the nearest of these panels with identification markings. So, it has an instant remedy available to its posing threat.

For, Transformers,

2	No/inadequate illumination in substation

Like previously mentioned this also has an instant remedy available. The maintenance or the person of interest can just bring a flashlight with him to the designated work place for convenience. Notice, this point refers to only the sector ‘Risk to Health’ assessment.

For, Generator,

2	No separate room/temporary structure for generator

Even after Generator installation has been completed, workers can intervene and build a surrounding wall of concrete or gates, that separates the generator from the other equipment in the substation which reduced threat for both the sectors for the future.

For Rooms and Classrooms,

1	No clear and permanent identification marking on DB

This can be dealt with like explained previously through intervention of the engineer that helped set up the DB in each of the floors and communicated for detailed documentation on easier maintenance accessibility and reducing unwanted accidents for the lack of understanding.

16	Earthing	MDB/SDB/DB body not earthed

This point refers to the sector 'Risk to Electrical Equipment' where we can encounter overcurrent or short circuits malfunction in distribution boxes that can be replaced with optimum costs with proper earthing.

For, Service Shafts and ducts,

1	Electrical service shafts/duct used for purposes other than electrical and communication cables

This point as we know is not going to create a fire but can be the reason for short circuit malfunctions caused by liquid leaks or other material purpose this shaft being used for.

For System Earthing,

1	Metal building structure not earthed

This point can cause equipment malfunctions kept on those structures due to unwanted electro conductivity with short circuits and overcurrent issues. This is to be noted that this equipment can be replaced from the structure even before they are damaged thus having an instant remedy or less expensive cost exchange.

For Lightning Protection,

2	External metals on building not bonded to lightning conductor

This can cause sudden thunder strikes to affect the accessory electrical equipment like, refrigerators, Televisions, Computers to malfunction that needs to be replaced. Note that knowing this cause exists, users can plug their electrical equipment completely off during heavy rain or stormy weather, thus having an instant remedy or intervention available to the posing threats.

2.3.3 Threat Level Low:

Any causes from the tool table that discusses threat mostly by means of Gradual Degradation of Health or The Properties involved have been segmented in this section. It also addresses instant remedies and simple precautionary avoidance of danger for Personnel. For Properties it involves reduced performance issues that could be easily avoided through simple maintenance.

For a deeper understanding of Low-Level threats considering examples, of Substations,

4	Inadequate cross ventilation in substation
5	No grill fitted windows for natural ventilation

The above-mentioned points refer to causes where the lack of ventilation could be detrimental to the conditioning of the substation panels because of increasing heat and temperature which gradually degrades their property evaluation. Also, the lack of air can gradually cause lung problems or health risks for people working there for maintenance for the claustrophobic environment with the dusty air.

For Transformers,

10	Lint/dirt on transformer

Excessive lint or dirt on transformer gradually reduce the overall performance of the machine over long period of time that leads to malfunctions or even the need to change the transformer completely.

For Generators,

18	Generator not installed on shock absorbing mounting bases

The point mentioned is very important because the constant vibration of a running generator gradually impacts the internal structure of the smaller parts of the machine that leads to gradual degradation of the generator and eventually reduced performances.

For Rooms and Classrooms,

12	HT and LT, Switchgear are not vermin and dump proof

Usually Switchgears' wires that are exposed to vermin or dump can decay gradually over time and even loose its functionalities.

2.4 Assigning Numbers

We had to assess the mentioned Threat Levels and configure a ranking list among themselves to find out the Overall risk calculations, Location based risk calculations, Contribution of risk types to overall risks, Contribution of different threat levels to overall risk that we are going to go through in depth in a later chapter of our paper. To find all these data and results, we had to assign a range of numbers pertaining to each High, Medium and Low threat levels. For an in-depth explanation we have to give examples from the tool table and compare the ranking numbers in between. Note that all these numbers were assumed for the main purpose of convenience of risk calculation and finding results. That is why, these numbers were assumed according to the threat levels and their intensity pertaining to hazards that have an impact on both the sectors**.**

2.4.1 Risk to Health numbers:

The three threat levels in this sector were further analyzed to come up with a scoring system that, within the threat levels, ranked the threat points into different ranges.

2.4.1.1 Threat Level HIGH: Range (80 - 95)

- Range 95: Any kind of Fire or Explosion, improper setup that can be caused by the points from the tool table and have the maximum range of impact to its' destruction surrounding the situation, poses imminent life threat have been assigned to this number.

For example, considering the mentioned locations from the tool table:

- Combustible materials inside 'Substation'
- Water or Oil in room of 'Transformer'
- Generator located on higher floor for 'Generators'
- Combustible material inside/near MDB/SDB/DB/SB/MCB/MCCB-box/Socket for 'Rooms and Classrooms'

Are only a few examples of the High Threat Range (95)

- Range 90: Any accidents that causes due to both Fire and Shock/Electrocution (OC, SC) or either one of them that may lead to further progression of the hazard have been assigned on this range.

For example, considering the mentioned locations from the tool table:

- 'Substation' layout not according to power flow

- ‘Transformer’ earthing connection loose or body not earthed at all
- No/inadequate fire safety measures (no fire alarm system/no firefighting equipment) near ‘Generator’
- Burning sign on MDB/DB/SDB/SB/Sockets for ‘Rooms and Classrooms’
- Machines/equipment electrical parts (live) exposed of SDB/DB on floors of ‘Rooms and Classrooms’
- Vertical electrical shaft placed adjacent to sanitary shaft for ‘Service Shafts and Ducts’
- External metals on building not bonded to lightning conductor for ‘Lightning Protection’
- Exit sign not illuminated for ‘Exit signs and means of escape illumination’

Are only a few examples HIGH threat Range (90)

- Range 80: Any accidents that causes due to only Fire or Shock/Electrocution (OC, SC)

For example, considering the mentioned locations from the tool table:

- HT side of transformers within reach of persons for ‘Substation’
- No separate room for ‘transformers’
- Improper installation like Cable/ conduit messy /not clipped properly for ‘Rooms and Classrooms’
- Socket outlets inside bathrooms or toilets for ‘Rooms and Classrooms’
- Metal building structure not earthed for ‘System Earthing’
- No alternate power for ‘exit sign/means of escape’

Are only a few examples HIGH threat Range (80)

2.4.1.2 Threat Level MEDIUM: Range (60 - 79)

- Range 70: Threat level in this range deals with causes for possible threats that can be averted with external equipment or intervention.

For example, considering the mentioned locations from the tool table:

- Indicator lamps (for LT and main distribution panels) not available for ‘Substation’
- No cover on cable trench/cable run unsafe for ‘Generator’
- No free/ easy access to electrical shaft room in each floor for ‘Electrical Shafts and ducts’
- Earth lead not made of copper/galvanized steel wire for ‘System Earthing’
- External metals on building not bonded to lightning conductor for ‘Lightning Protection’

Are only a few examples MEDIUM threat Range (70)

- Range 60: Threat level in this particular range deals with causes for possible threats that have instant remedy available and further danger can be averted with a little precaution.

For example, considering the mentioned locations from the tool table:

- No/inadequate illumination in ‘Substation’ (e.g. people of interest can bring a flashlight)
- No/inadequate illumination indoors for switchboards for ‘Rooms and Classrooms’

Are only a few examples MEDIUM threat Range (60) scenarios.

2.4.1.3 Threat Level LOW: Range (40 - 59)

- Range 40 to 50: This particular range considers posing threats that have a gradual degradation of health.

For example, considering the mentioned locations from the tool table:

- Inadequate cross ventilation in 'substation' (e.g. lack of air can lead to lung diseases in far future)
- Engine exhaust pipe not taken out of the building for 'Generator'

Are only a few examples of LOW threat level.

2.4.2 Risk to Electrical equipment numbers:

For the assessment of Property Threat and its evaluation, we had to consider 3 specific numbers and assigned to High, Medium and Low threat levels for the better understanding of the probability of equipment being damaged to a specific extent. Also, it helped us finding solutions for this posable threat and accumulate results consulting the risk factors in a more convenient manner.

2.4.2.1 Threat Level High: Number Assigned (90):

If any property or electrical equipment gets damaged from the origin of a fire or explosion, the extent of the damage should be maximum and the parts can be barely replaceable. Even if replaced it will not be an easy task and will be very expensive considering the need to also replace subsidiary parts that was damaged as a whole.

For example, considering the mentioned locations from the tool table:

- Combustible materials inside ‘Substation’
- silica gel condition not good (pink or white)/no silica gel for ‘Transformer’
- Generator located on higher floor for ‘Generators’
- Combustible material inside/near MDB/SDB/DB/SB/MCB/MCCB-box/Socket for ‘Rooms and Classrooms’

Are only a few examples of Property High threat level (90).

2.4.2.2 Threat Level Medium: Number Assigned (70):

The causes from the tool table that deals with equipment and property damage but there will be no scenario of Fire or Explosion are assigned here. Note that the damage to this equipment will be due to Overcurrent, Short circuits and shocks. Moreover, the pars are easily replaceable and not as expensive as threat level high.

For example, considering the mentioned locations from the tool table:

- Cable condition not good for ‘Substations’

- No over current protection provided for ‘Generators’
- Burning sign on MDB/DB/SDB/SB/Sockets for ‘Rooms and Classrooms’
- Vertical electrical shaft placed adjacent to sanitary shaft for ‘Service Shafts and ducts’
- Earth lead not made of copper/galvanized steel wire for ‘System Earthing’
- External metals on building not bonded to lightning conductor for ‘Lightning Protection’

Are only a few examples of Property Medium threat level (70).

2.4.2.3 Threat Level Low: Number Assigned (40):

This particular range considers posing threats that have a gradual degradation of property. This segment also deals with equipment prone to show reduced performance if long period time has passed unattended.

For example, considering the mentioned locations from the tool table:

- Improper installation like No cover on cable trenches for ‘Substation’ (e.g. degrades the condition of the cable gradually as people keep walking over it)
- Inadequate cross ventilation in transformer room for ‘Transformer’ room.
- Inadequate cross ventilation in generator room for ‘Generator’ room.
- HT and LT, Switchgear are not vermin and dump proof for ‘Rooms and classrooms’

Are only a few examples of Property Low threat level (40).

Chapter 3

Assessment Tool

3.1 The Assessment Tool

The final assessment tool prepared from the BNBC 2015 is essentially a table that consists of some basic elements. The entire tool is divided into locations which makes location-based assessment easier. If a threat point from the tool is noticed in any locations of the building, the point is to be marked with a tick. The assigned numbers are kept adjacent to the points. There is also a section 'Remarks' which refers to all the sections and subsections the threat points were taken from in the 'The Electrical and electronics services for buildings' part of BNBC 2015. The 'Remarks' section also suggests to take photographs of electrical misconducts if necessary.

FORM A: ELECTRICAL SYSTEM

SL No	Description	Put (√)if TRUE	Damage to property	Damage to life	Remarks
Substation [ ]				No Substation [ ]	
1	Substation located on higher floor		90	90	BNBC 1.3.18.2
2	No floodwater prevention		90	80	BNBC 1.3.18.3
3	Partition not up to celling for each room				BNBC 1.3.18.6
4	Inadequate cross ventilation in substation		40	50	BNBC 1.3.18.6
5	No grill fitted windows for natural ventilation		40	50	BNBC 1.3.18.6
6	Windows do not have sunshades		70		Photos
7	No high velocity force ventilation (if no sufficient number of windows)		40	50	BNBC 1.3.18.6
8	Substation layout not according to power flow			90	BNBC 1.3.18.7
9	No/inadequate illumination in substation			60	
10	Combustible materials inside substation		90	95	Photo + BNBC 1.3.42.3

11	Construction materials inside substation			70		Photo+ BNBC 1.3.42.3
12	Diagrams and labels	List and diagram (SLD) of circuits not available			70	photo+ BNBC 1.3.42.3
13		No clear and permanent identification marking on distribution panel			70	photo+ BNBC 1.3.42.3
14		No instruction board on substation a)for first aid to electric shock b)for artificial respiration			90	Electricity rules 1937, section 46 and section 47

15	Indicator lamps (for LT and main distribution panels) not available			70		photo+ BNBC 1.3.42.3
16	No/insufficient rubber mat in front of panels			70		Photo+ BNBC 1.3.42.3
17	Unused openings in panel not blocked properly			70		photo+
18	Panel poor damaged/does not close properly			70		Photo+ BNBC 1.3.42.3
19		No cover on cable trenches		40	70	Photo+ BNBC 1.3.42
20		Connections without lug		70	80	photo+ BNBC 1.3.42
21	Cable condition (not good			70	80	Photo+ BNBC 1.3.42
22	Access limited or barred to substation equipment				80	photo+ BNBC 1.3.42
23	Temporary connections in substations				60	Photo+ BNBC 1.3.42.3
24	Improper installation	Loose cabling			70	photo+ BNBC 1.3.42
25	Earthing	Panel body and door not earthed		90	95	BNBC 1.3.32.2
26		No earthing on HT side		90	95	BNBC 1.3.32.2
27		No earth bus bar on LT panel		90	95	BNBC 1.3.32.2
28	HT side of transformers within reach of persons				80	BNBC 1.3.32.3
29	Indicator: Ammeter/Voltmeter/indicator/PFI auto-controller not working			70		Photo+ BNBC 1.3.32.2

30	Burning sign inside panel		70		Photo+ BNBC 1.3.32.2
31	Water/oil in substation room		90		Photo+ BNBC 1.3.32.2
32	Lint/dirt in substation room		40		BNBC 1.3.32.2
33	11kv/0.4kv placed in basement				BNBC 1.3.18.2
34	No/inadequate fire safety measures (fire alarms or fire equipment)		90	70	BNBC 1.3.37

Table 3.1: Assessment of Substation

Transformers [ ]					No Transformers on Premise [ ]	
1	No separate room for transformers				80	BNBC 1.3.42.3
2	No/inadequate illumination in substation				60	BNBC 1.3.32.2
3	Inadequate cross ventilation in transformer room			40		BNBC 1.3.32.2
4	silica gel condition not good (pink or white)/no silica gel			90		Photo
5	Horn gaps not aligned/not provided			90		BNBC 1.3.32.2
6	Inadequate room ventilation			40		BNBC 1.3.32.2
7	Earthing	Transformer earthing connection loose		90	90	Photo+ BNBC 1.3.32.2
		Transformer body not earthed		90	90	Electricity Rules 1937, Section 57
8	No soak pit for transformer (with oil content 2000+ litters)			90		BNBC 1.3.32.2 1.3.18.3
9	Water/oil in transformer room			90	95	Photo+ BNBC 1.3.32.2
10	Lint/dirt on transformer			40		BNBC 1.3.32.2
11	Dry type transformer not used industrial buildings					BNBC 1.3.18.4
12	Dry type transformer not used in hospitals					BNBC 1.3.18.4

Table 3.2: Assessment of Transformers

Generators[ ]		No standby generators [ ]			
1	Generator located on higher floor		90	95	BNBC 1.3.19.3
2	No separate room/temporary structure for generator			70	BNBC 1.3.19.3

3	No/inadequate ceiling fans for ventilation		40		1.3.19.3
4	Inadequate cross ventilation in generator room		40		BNBC 1.3.19.3
5	No built in fuel tank				1.3.42.3
6	Combustible materials inside generator room		90	95	Photo+ BNBC 1.3.19.3
7	Generator oil tank placed near controls		70	90	BNBC 1.3.42.3
8	No cover on cable trench/cable run unsafe		40	70	Photo + BNBC 1.3.42.3
9	One-point frame earthing of generator instead of two		70		Electricity rules 1937, section 57
10	No over current protection provided		70		BNBC 1.3.42.3
11	No earth fault protection provided		70		BNBC 1.3.42.3
12	No/inadequate fire safety measures		90		BNBC 1.3.19.3
13	Engine exhaust pipe not taken out of the building		40	50	BNBC 1.3.42.3
14	Generator placed in basement			95	BNBC 1.3.19.3
15	Continuous running generator placed inside building			90	BNBC 1.3.19.3
16	Water /oil in generator room		90	95	Photo+ BNBC 1.3.42.3
17	Lint/dirt in generator room		40		BNBC 1.3.42.3
18	Generator not installed on shock absorbing mounting bases		40		BNBC 1.3.19.3
19	No/inadequate fire safety measures (no fire alarm system/no fire fighting equipment)		90	90	BNBC 1.3.19.3

Table 3.3: Assessment of Generators

Rooms (Classrooms, Labs)						
1	No clear and permanent identification marking on DB				70	Photo
2	List and diagram (SLD) of circuits not available in each DB				70	Photo
3	Access limited of barred to MDB/DB/SDB/SB/sockets			70		Photo+ BNBC 1.3.42.3
4	Burning sign on MDB/DB/SDB/SB/Sockets			70	90	Photo+ BNBC 1.3.42.3
5	MDB/DB/SDB door damaged/does not close fully				70	Photo+ BNBC 1.3.42.3
6	DB box not made of sheet steel			90	90	BNBC 1.3.42.3
7	Common neutral point for more than one circuit in DB			70		Photo
8	Access to machine power control unit/switch from operator's work position not easy			70		BNBC 1.3.42.3
9	Machines/equipment electrical parts (live) exposed				90	BNBC 1.3.42.3
10	MDB/SDB/DB/SB or MCB installed on wooden floor			90	95	Photo+ BNBC 1.3.28
11	Overcurrent and undercurrent protection not provided			70		Photo + BNBC 1.3.30
12	HT and LT, Switchgear are not vermin and dump proof			40		BNBC 1.3.42.3
13	Unused openings (HT, LT) not blocked properly				70	Photo + BNBC 1.3.42.3
14	Combustible material inside/near	MDB/SDB/DB/SB/MCB/MCCB-box/Socket		90	95	Photo+ BNBC 2.7.5.3 2.5.5.1

15		Cable tray/cable trench/BBT		90	95	Photo+ BNBC 1.3.42.3
16	Earthing	MDB/SDB/DB body not earthed		80	90	Electricity rules 1937, Section 54
		No or empty earth bar/neutral bar				Photo
		Motor frame not earthed				Photo+ Electricity rules 1937, section 57
17	Improper installation	Ceiling fan /light over aisle at accessible height			80	Photo+ BNBC 1.3.3.5
		MCB/MCCB installed without enclosure			70	Photo+ BNBC 1.3.42
		MDB/SDB/DB/SB installed at inaccessible height		70		Photo BNBC 1.3.26.3
		Cable/ conduit messy /not clipped properly			80	BNBC 1.3.42
		Undressed messy wire inside MDB/SDB/DBB		70		BNBC 1.3.42
		Connections without lug in MDB/SDB/DB		70	80	Photo+ BNBC 1.3.42.3
		Wiring/cabling on the floor				Photo+ BNBC 1.3.42
		Extension power cord used		70		Photo+ BNBC 1.3.42
		Messy power cables in office room/PABX room/server room/pump room/IPS rooms			80	Photo+ BNBC 1.3.42
18	Loose/broken	MCB/MCCB-box loose/broken		70	70	Photo+ BNBC 1.3.42.3
		Socket loose/broken		70	90	Photo+ BNBC 1.3.42.3

19	BBT and cover missing			80	Photo+ BNBC 1.3.42.3
20	No instruction board in factory a) For first aid to electric shock b) For artificial respiration			90	Electricuity rules 1937 Section 46 and section 47
21	Socket outlets inside bathrooms or toilets		70	80	Photo+ BNBC 1.3.3.2
22	Socket outlet not weatherproof or waterproof (in case the socket is exposed to rain or dripping water)		70		Photo+ BNBC 1.3.3.2
23	Socket outlet in kitchen near kitchen water tap		70	80	Photo+ BNBC 1.3.3.2
24	Switches not weatherproof or waterproof (in case the socket is exposed to rain or dripping water)		70	80	Photo+ BNBC 1.3.3.2
25	Switches inside bathrooms or toilets		70	80	Photo+ BNBC 1.3.42.3
26	Switches are placed in vicinity of storage batteries and exposed to chemical fumes		90	95	Photo+ BNBC 1.3.26.3
27	Switchboard not fully enclosed of flameproof in damp situation or where inflammable or explosive dust, vapor or gas is likely to be present,		90	95	Photo+ BNBC 1.3.26.3
28	Switchboards above gas stoves or sinks		90	90	Photo+ BNBC 1.3.26.3
29	Switchboards near washing unit in washing room		70	80	Photo+ BNBC 1.3.3.2
30	No/inadequate illumination indoors for switchboards			60	Photo + BNBC 1.3.42.3

Table 3.4: Assessment of Rooms

Service shafts and ducts [ ]		**No service shaft and ducts [ ]**			
1	Electrical service shafts/duct used for purposes other than electrical and communication cables		70		BNBC 1.3.13.1
2	No free/ easy access to electrical shaft room in each floor		70		BNBC 1.3.13.1
3	Vertical electrical shaft placed adjacent to sanitary shaft		70	90	BNBC 1.3.13.1

Table 3.5: Assessment of Service shafts and ducts

System earthing [ ]					
1	Metal building structure not earthed		70	80	BNBC 1.3.32.2
2	Earth lead not made of copper/galvanized steel wire		70		BNBC 1.3.32.5
3	MDB does not have duplicate earth leads			80	BNBC 1.3.32.6
4	Earthing/lighting pits not identified			70	BNBC 1.3.32.10, 1.3.33.6

Table 3.6: Assessment of System Earthing

Lighting protection [ ]		**No lighting protection**			
1	Storage tanks/chimneys without air ducts				BNBC 1.3.33.6
2	External metals on building not bonded to lightning conductor		70	90	BNBC 1.3.33.8

Table 3.7: Assessment of Lighting Protection

Exit signs and means of escape illumination					
1	Exit sign not illuminated			90	Photo+ BNBC 1.2.7.1
2	No emergency light in means of escape			90	Photo+ BNBC 1.2.7.2

3	No alternate power for exit sign/means of escape			80	BNBC 1.2.7.2

Table 3.8: Assessment of Exit signs and means of escape illumination

Chapter 4

Data Inspection

4.1 Assessment tool Overview

After coming up with an intuitive prediction-based system that objectively and universally ranks all the potential threats, we had prepared an assessment tool that can be used to find the risk factors of a building from an electrical safety standpoint. As per the design of the assessment tool, the data derived from the buildings provides us with statistical information such as how much total risk the building induces separately on both the people residing inside the building and the electrical components that are used in the building. The tool also gives us specific information such as the percentage of risk that arises from specific locations of the building so that the locations that are in immediate need of attention can be addressed accordingly. The main purpose of using the tool is to find out if a building is under any immediate high-level threat. The multi-layered design of the tool also enables us to classify the threats into different categories (Eg. Risk from fire or explosion, Risk from electric shock, Risk from gradual degradation of electrical equipment) and extract concrete information such as what percentage of the total risk originates from which category.

4.2 Assessment tool structure

The assessment tool was structured in a simple and straightforward fashion so that that it is easy to understand and work with for an assessor. There are options for tick marks besides all the threat points. As a result, the assessor can just take the tool to inspect the building locations and simply check the boxes should any threat point mentioned in the tool is noticed in any location. The data collected with the assessment tool then can be effortlessly processed to acquire necessary statistical information regarding the safety of the building using a calculation system presented in the tool.

Rooms (Classrooms, Labs)						
1	No clear and permanent identification marking on DB		✔		60	Photo
2	List and diagram (SLD) of circuits not available in each DB		✔		70	Photo
3	Access limited of barred to MDB/DB/SDB/SB/sockets		✔	70		Photo BNBC 1.3.42.3
4	Burning sign on MDB/DB/SDB/SB/Sockets		✔	70		Photo BNBC 1.3.42.3
5	MDB/DB/SDB door damaged/does not close fully				70	Photo+ BNBC 1.3.42.3
6	DB box not made of sheet steel			90	90	BNBC 1.3.42.3
7	Common neutral point for more than one circuit in DB			70		Photo+ BNBC 1.3.42.3
8	Access to machine power control unit/switch from operator's work position not easy			70		BNBC 1.3.42.3
9	Machines/equipment electrical parts (live) exposed		✔		90	BNBC 1.3.42.3
10	MDB/SDB/DB/SB or MCB installed on wooden floor			90	95	Photo+ BNBC 1.3.28
11	Overcurrent and undercurrent protection not provided		✔	70		Photo + BNBC 1.3.30
12	HT and LT, Switchgear are not vermin and dump proof			40		BNBC 1.3.42.3
13	Unused openings (HT, LT) not blocked properly		✔		70	Photo + BNBC 1.3.42.3
14	Combustible material inside/near	MDB/SDB/DB/SB/MCB/MCCB-box/Socket		90	95	Photo+ BNBC 2.7.5.3 2.5.5.1
15		Cable tray/cable trench/BBT	✔	90	95	Photo+ BNBC
16	Earthing	MDB/SDB/DB body not earthed		70		Electricity

Figure 3.1: Data collection in the form of tick marks

4.3 Data Collection

After preparing and rounding off the assessment tool, we had then used the tool to gain field data. For data collection, the 6 buildings of BRAC University were inspected. Each of the 8 locations inside a building were separately visited and noted. If any of the locations mentioned in the tool were missing in any of the buildings, the locations were skipped in the tool and no point from that location was reviewed. Pictures were also taken for reference in necessary cases while inspecting the buildings. After inspecting the 6 buildings, enough information was gathered for us to work with using the tool which helped us having a clear idea about the safety of each buildings.

4.3.1 Overall Risk Calculation

The potential threat points in the tool are ranked based on their impact on two sectors.

- Risk to health
- Risk to Electrical equipment

The threat points were ranked separately for both sectors. It is very much possible for the violation of a threat point to be of little disturbance to one sector while causing severe reverberation on the other sector. In the calculation segment of the assessment tool, under the 'Total Risk Calculation' section, the subtotal of the assigned numbers to the threat points on each sector are provided. After inspecting a building, the threat points that were violated are checked. The adjacent numbers of the violated threat points are then added to get the "total violated threat points number'. Comparing the derived total value of the violated points to the subtotal value, the total percentage of risk factor can be found for each sector. Using the total percentage of risk factors of several buildings, it can be deftly known which building is exposed to more potential danger due to violating the regulations of BNBC and is in need of immediate attention.

Calculation Segment

Total Risk Calculation

- <u>Risk to health</u>

Total number- 5630

Total violated threat points number – 1500

Total risk percentage – 26.642%

- <u>Risk to electrical equipment</u>

Total number- 5600

Total violated threat points number- 1300

Total risk percentage- 26.785%

Figure 3.2: Total Risk calculation of building 01

4.3.2 Location-Based Risk Calculation

Using the assessment tool, more precise information about the safety of a building can be obtained. As the tool is divided into 8 locations, we can derive the location-based percentage contribution to the total risk of a building in the calculation segment.

Under the section ‘Location Based Risk Calculation’, the adjacent number of the violated threat points for each location of a building is added separately for a sector. Comparing the derived total value of the violated points for each location, to the derived total value for the whole building yields the percentage contribution of each location to the overall risk.

Location Based Risk Calculation

- Risk to health

Total violated threat points number from

1. Substation- 320
2. Transformers- 60
3. Generators- 315
4. Rooms- 545
5. Service shafts and ducts- 0
6. System earthing- 0
7. Lightning protection- 0
8. Exit signs and means of escape illumination- 260

Total violated threat points number- 1500

Location based risk percentages

1. Substation- 21.333%
2. Transformers- 4%
3. Generators- 21%
4. Rooms- 36.333%
5. Service shafts and ducts- 0
6. System earthing- 0
7. Lightning protection- 0
8. Exit signs and means of escape illumination- 17.333%

Figure 3.3: Location Based Risk Calculation (Risk to health)

- <u>Risk to electrical equipment</u>

Total violated threat points number from

1. Substation- 220
2. Transformers- 130
3. Generators- 580
4. Rooms- 370
5. Service shafts and ducts- 0
6. System earthing- 0
7. Lightning protection- 0
8. Exit signs and means of escape illumination- 0

Total violated threat points number- 1300

Location based risk percentages

1. Substation- 16.923%
2. Transformers- 10%
3. Generators- 44.615%
4. Rooms- 28.461%
5. Service shafts and ducts- 0
6. System earthing- 0
7. Lightning protection- 0
8. Exit signs and means of escape illumination- 0

Figure 3.4: Location based Risk Calculation (Risk to Electrical Equipment)

4.3.3 Contribution of Risk Types to Overall Risk

The violation of the safety regulations that were extracted from the BNBC to prepare the assessment tool can subject a building to distinct types of threats. For example, the inspected building can be exposed to potential risk from fire or explosion, risk from electric shock or risk from gradual degradation of properties for neglecting certain regulations or threat points. By studying and calculating the data collected with the assessment tool, valuable information about the types of risk the building is potentially prone to can be attained. We can also learn precisely what percentage of the total risk in each sector arises from which types of risks.

Under the section 'Contribution of Risk Types to Overall Risks', the adjacent number of the violated threat points for each types of risks are added separately for a sector. The percentage of contribution each risk type yields then can be calculated by comparing their respective total number to the derived total value.

Contribution of risk types to overall risk

- Risk to health

Total violated threat points number from

1. Fire and explosion- 270
2. Electric shock- 930
3. Gradual degradation of property- 40
4. Others - 260

Total violated threat point numbers- 1500

Contribution of risk types to overall risk-

1. Fire and explosion- 18%
2. Electric shock- 62%
3. Gradual degradation of property- 2.66%
4. Others – 17.33%

- Risk to Electrical equipment

Total violated threat points number from

1. Fire and explosion- 360
2. Electric shock- 700
3. Gradual degradation of property- 240

Total violated treat point numbers- 1300

Contribution of risk types to overall risk-

1. Fire and explosion- 27.692%
2. Electric shock- 53.846%
3. Gradual degradation of property- 18.461%

Figure 3.5: Contribution of Risk Types to Overall Risk

4.3.4 Contribution of Different Threat Levels to Overall Risk

The main objective of using the assessment tool to inspect buildings is to discern if the inspected building is under any immediate major threat. By assigning numbers, the threat points are systematically ranked based on the intensity of danger they possess. The threat points in each sector are classified into 3 levels based on their intensity. For the 'Risk to health' sector, the points ranging from 80-95 are considered 'high level' threats as they present the most potential danger if violated. The points ranging from 60-79 falls under the 'medium level' threat category. 'Low level' threats are the points that were assigned numbers 40-59. For the 'Risk to Electrical Equipment' sector, 'High level' threats are assigned number 90, 'Medium level' threats are assigned number 70 and 'Low Level' threats are assigned number 40.

By analyzing the obtained data from a building, we can precisely know what percentage of the total risk yields from which threat level. It is very much plausible for a building to have comparatively less 'Total Risk' percentage than that of other buildings. However, if a major portion of the 'Total Risk' percentage comes from 'High Level' threats, that building is considered to be more at risk and should be attended accordingly despite it having a lower 'Total Risk'.

Under the section 'Contribution of Different Threat Levels to Overall Risk', for each sector, the violated threat point numbers are added separately for each threat levels. From there, the percentage of risk that emerges from each threat level can be easily determined by comparing them to the derived total value.

Contribution of different threat levels to overall risk

- Risk to health

Total violated threat points number from-

1. High level risk (80-95)- 860
2. Medium level risk (60-79)- 600
3. Low level risk (40-59)- 40

Total violated threat points number- 1500

Contribution of different threat levels to overall risk-

1. High level risk (80-95)- 57.333%
2. Medium level risk (60-79)- 40%
3. Low level risk (40-59)-2.666%

- Risk to Electrical equipment

Total violated threat points number from-

4. High level risk (90)- 360
5. Medium level risk (70)- 700
6. Low level risk (40)- 240

Total violated threat points number- 1300

Contribution of different threat levels to overall risk-

4. High level risk (90)- 27.692%
5. Medium level risk (70)- 53.846%
6. Low level risk (40)- 18.461%

Figure 3.6: Contribution of Risk levels to Overall Risk

Chapter 5

Results and Analysis

5.1 Visual representation of data

The calculation segment of the acquired data gives us a mathematical perspective into the safety of a building. A visual representation using these data is presented at the end of the full assessment report as it makes the data more accessible and offers a more overall and easily fathomable look at the safety of the building.

5.2 Total Risk Result:

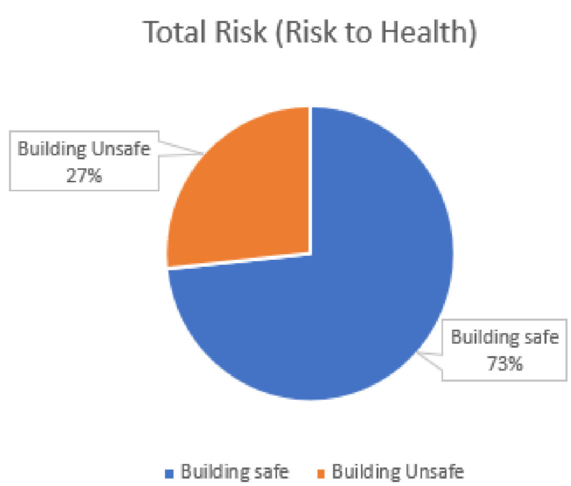

Figure 5.1: Total Risk Chart (Risk to Health)

The Total Risk for health chart shows us that the inspected building is in a total risk of 27%. The Total Risk percentage number itself is not particularly high but an in depth look at the data gives us more information about the types and the levels of risk the building is exposed to.

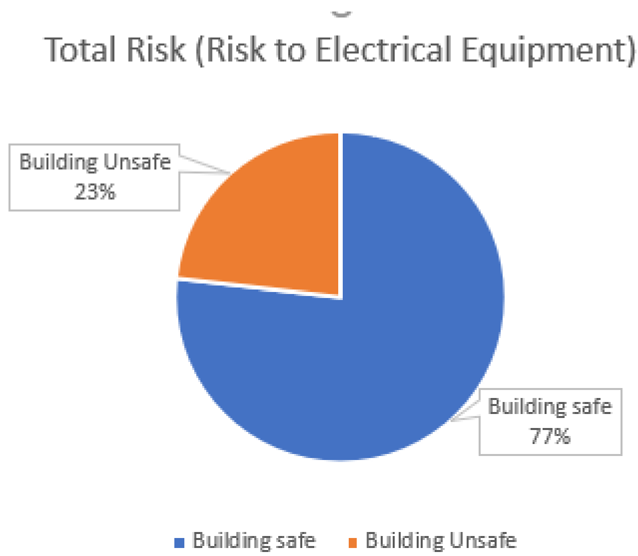

Figure 5.2: Total Risk Chart (Risk to Electrical Equipment)

The total risk for electrical equipment sector shows us that the observed building is at a total of 23% risk. More observation of the data enables for a more detailed look at the safety of the building.

5.3 location Based Risk Assessment results

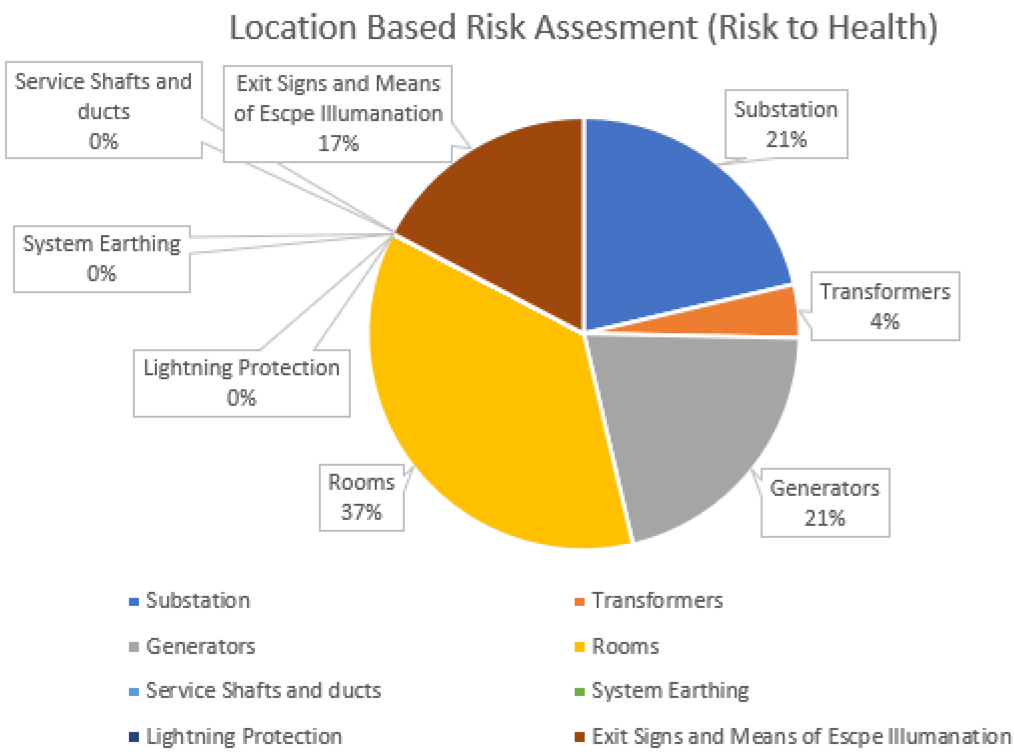

Figure 5.3: Location Based Risk Assessment (Risk to Health)

A location-based risk assessment of the acquired data shows us that, for the humans that reside or work in the inspected building, the maximum amount of risk yields from the rooms, followed by Generators and transformers who both contribute the same percentage of risk.

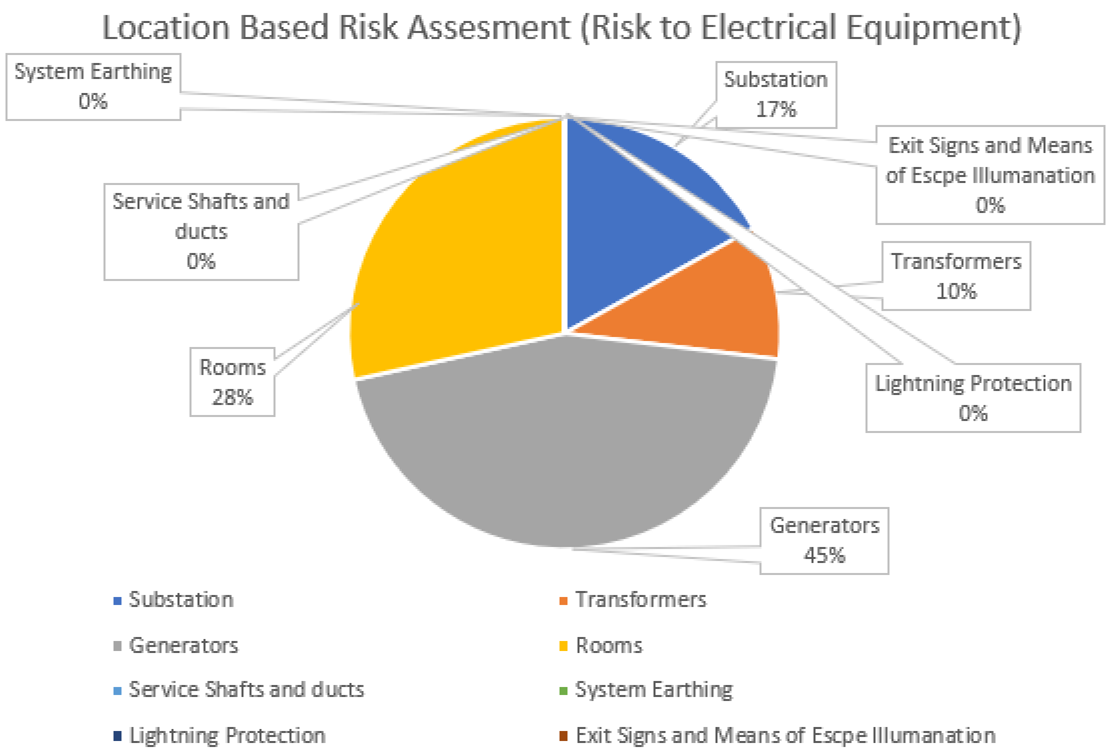

Figure 5.4: Location based risk assessment (Risk to Electrical Equipment)

A look at the visual data of the location-based risk assessment for the electrical equipment shows us that the maximum risk is contributed from the Generator Rooms. Followed by the Rooms and the Substation Room. The generator room is the location where the safety regulations from BNBC were violated the most.

5.4: Contribution of Risk types to Overall Risk results

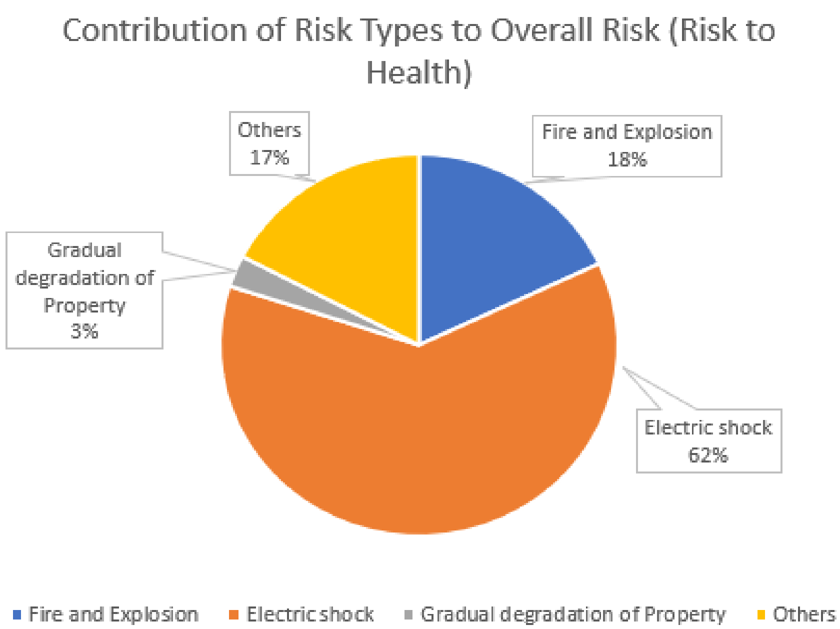

Figure 5.5: Contribution of Risk Types to Overall Risk (Risk to Health)

Contribution of risk types to overall risk is a necessary data because it shows us which types of risk that the people in the building are exposed to the most. The visual data shows that the people in the building are most likely to be affected by Electric Shock, followed by Fire and Explosion.

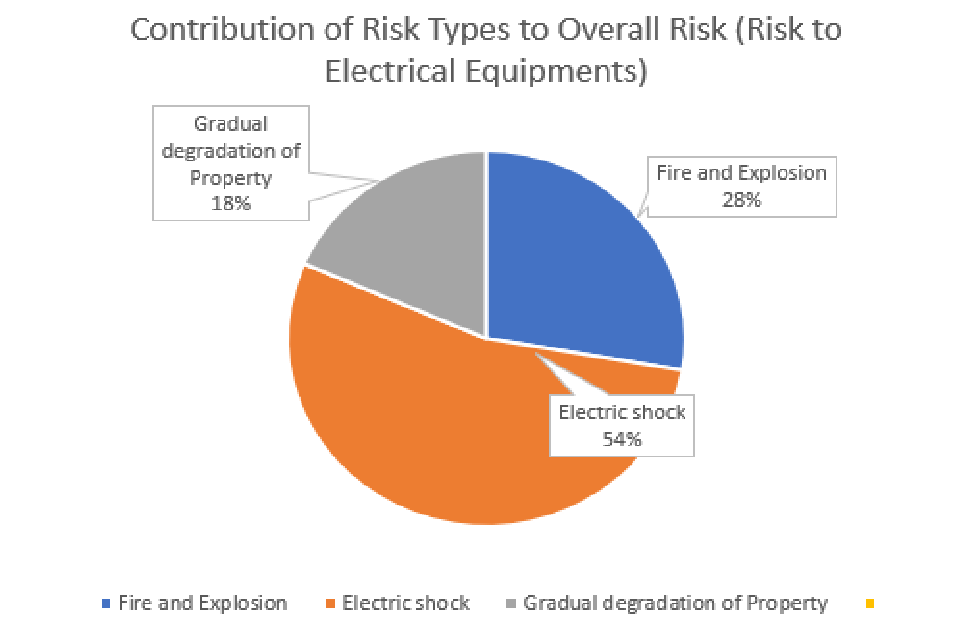

Figure 5.6: Contribution of Risk Types to Overall Risk (Risk to Electrical Equipment)

In the graph presented above, we can see that the electrical equipment of the building is most in danger of getting damaged by electrical problems such as, overcurrent, overvoltage or short-circuit and so on. The second most risk comes from fire and explosion and the least amount of risk originated from the gradual degradation of electrical equipment.

5.5 Contribution of Different Threat Levels to Overall Risk results

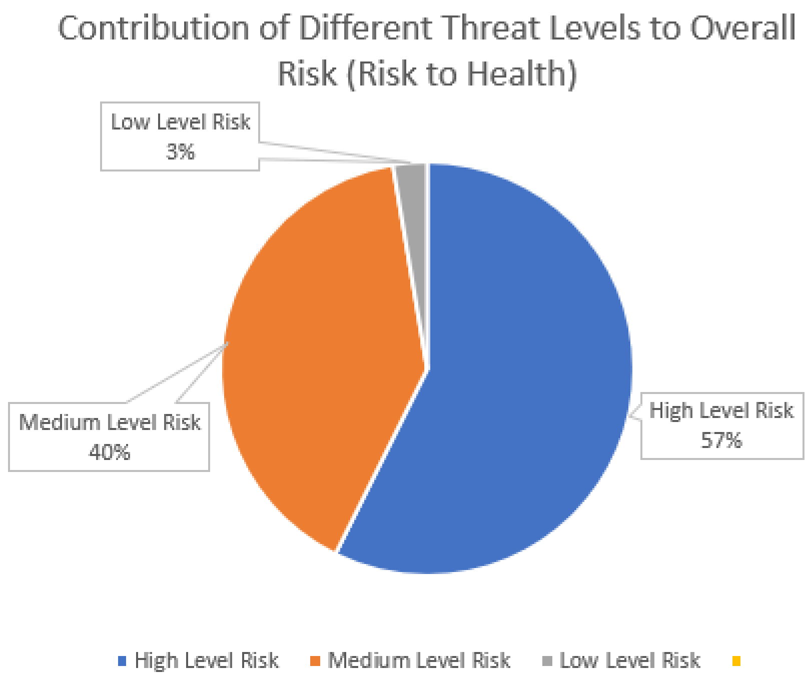

Figure 5.7: Contribution of Different Threat Levels to Overall Risk (Risk to Health)

A building can be at a great risk due to not conforming to some of the safety regulations rom BNBC despite it having a lower total risk percentage than that of other buildings. If the major portion of the possible risk comes from high level threats, the building is considered to be in higher danger as high-level risks are capable of causing more damage to both the health of the people inside and the electrical equipment.

From the graph presented above, we can see that the majority of risk to the health of the people in the building comes from threat points that are considered 'High Level Risk'. The 'High Level

Risk' points are the points, the violation of which can inflict maximum range of impact and sever health damage, sometimes death. This indicates that the inspected building, despite having a seemingly low total risk percentage, is open to the possibility of facing severe damage for violating certain safety regulation points from BNBC.

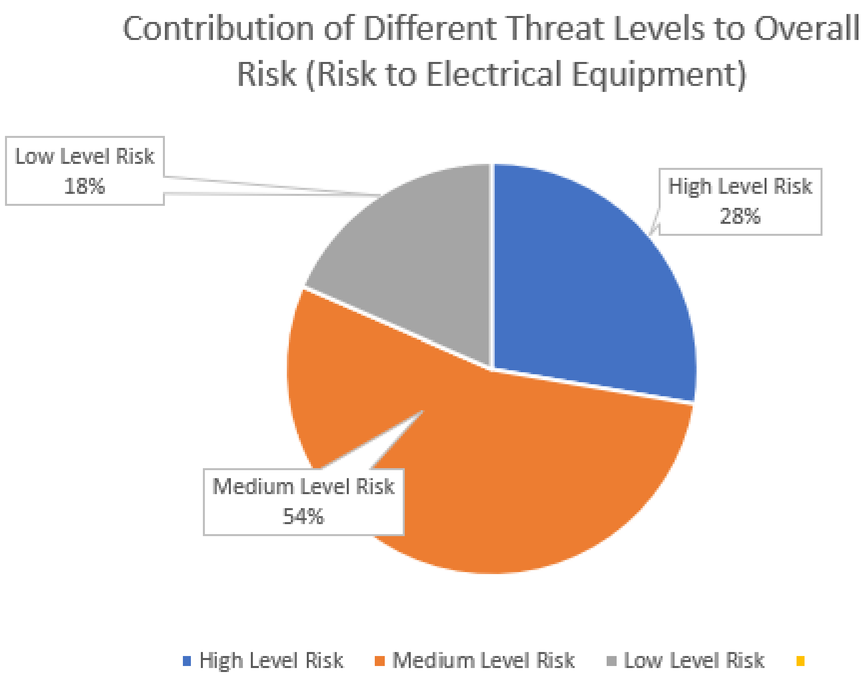

Figure 5.8: Contribution of Different Threat Levels to Overall risk (Risk to Electrical Equipment)

The figure above shows us that the majority of risks involving the electrical equipment of the building derive from violating threat points that are considered 'Medium level Risk', followed by 'High Level Risks'.

This is to be pointed out that the violation of the same threat points can conjure different levels of threat for different sectors.

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