Middle-East Journal of Scientific Research 19 (7): 919-927, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.19.7.1477

Modern Measures to Reduce the Impact of Lightning

S.M.E. Prakash

Department of E.E.E,
Bharath University, Chennai-600 073, Tamilnadu, India

Abstract: Lightning is climate related, highly localized phenomena in nature known for dangerous consequences. Many scientific experiments have given birth in inventions for lightning safety, however the problem and mystery behind lightning still persists and the exact solution is elusive still The technology of lightning protection have registered steady improvements but even with all the known precautions, complete safety is still beyond our grasp. Research and development programmes are being supported on lightning protection and this paper picks take its inspiration of the lightning effect analyzed by an article in 'The Hindu' which said that lightning claimed at least 71 lives and injured 112 between 1986 and 2002 in Kerala. Kerala ranks high among the States that suffer a substantial loss of lives and damage to equipment in lightning strikes every year, according to earth sciences expert S. Murali Das of the Atmospheric Science Division of the Centre for Earth. Science Studies (CESS) in Thiruvananthapuram. Though no cumulative estimates of the financial toll of lightning-induced damage is available, the CESS scientist has estimated the losses incurred to BSNL's fixed line phones during a season of thunder storm activity in the Thiruvananthapuram Short Distance Charging Area (the smallest telecom territorial area) to be Rs. 2 Crore. Along with Kerala, some of the other States that have been classified by experts as highly 'lightning-prone' are West Bengal, Haryana and Himachal Pradesh. This article traces evidences on the impact of lightning, analyses its properties, attempts to quantify it and popularize its impact on the masses. The article attempts to educate the builders and stresses the imperativeness and suggests safety provisions and mechanisms. This article intends to reduce the impact of lightening and the havoc it creates from a radically modern outlook and scientific viewpoint.

Key words: Phenomena in nature · Technology of lightning · Science Studies (CESS) · Popularize its impact on the masses

INTRODUCTION

Lightning is actually a visible discharge of static electricity within a cloud and also between clouds. The protection system offered by us gives that discharge might leave or enter the Earth without actually damaging non-conducting parts like those made of wood, brick and tile of concrete. The system does not prevent lightning from striking but provides a means for controlling it and avoiding damage by providing a low resistance path for the discharge of lightning energy. This article tells about the effects of lightning accidents in Kerala state and working out strategies for the alleviation of this natural hazard. For this, the past data on lightning obtained, with all possible sources. Cloud cover and thundercloud occurrence data were used from the India Meteorological Department. The study has given the following information: Data Bank on past incidence of lightning in Kerala showing the spatial and temporal distribution is made available. On an average 71 people die and 112 people get injured per annum in Kerala. This alarming situation is brought out. The loss for year 2002 to telecom in Kerala seems to be about Rs.2 Crores [1]. From Cb occurrence data from IMD Lightning in Kerala seems to be caused by thermal or convective Cb clouds and occurs at most of the time (83% of the total) in the late afternoons. In general, mid lands of Kerala are more affected than the coastal plains and high lands. Western Ghats seem to have some influence in lightning occurrence in Kerala. However, over mountains the incidence is low. Majority of personnel injury seems to happen due to ground conduction of lightning. In such

Corresponding Author: S.M.E. Prakash, Department of E.E.E, Bharath University, Chennai-600 073, Tamilnadu, India.

Country	India
States	Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu
Cities	Ootacamund, Mahabaleshwar
Highest point	Anamudi
-location	Eravikulam, Idukki, South India, Kerala, India
-elevation	2,695 m (8,842 ft)
Lowest point	Palakkad Gap
-location	Palakkad, Palakkad district, South India, Kerala, India
-elevation	300 m (984 ft)
Length	1,600 km (994 mi), N-S
Width	100 km (62 mi), E-W
Area	60,000 km² (23,166 sq mi)
Biome	forests (30%)
Geology	Basalt, Laterite
Period	Cenozoic

Fig 1: Details of Western Ghats an Overview.

cases the lighting conductor seems to be ineffective for protection. This seems to be problem peculiar to a place like Kerala with high vegetation density. The electric field measurements also show that the extent of destruction at a place could be dependent on the speed of motion of a discharging cloud. The speed depends on the wind speed of the North Easterly winds prevailing at the time. The possibility of a danger due to increase in the number of cell phone transmission towers is also considered [2].

Genesis and the Evolution of the Issue: According to Mr. Das, Kerala's problems with thunder storms originate in the Western Ghats where atmospheric conditions shows convective cloud formations towards the evening. In contrast, weather phenomena in places like Bangalore has more clouds that can lead to Lightning at any time of the day. In this southern State, it is a combination of conductive weather patterns, topography features and tall coconut palms that has proved lethal. A pioneering study commissioned by the Union Ministry of Home Affairs to see the level of risk from lightning in Kerala. Lightning caused at least 71 lives and injured 112 persons between 1986 and 2002. "The source material collected from newspaper reports and Revenue Department records" says Mr. Das, who authored the study. He says that for protecting real-time, pastl data collection analysis is important in planning worst sites in the country. As local weather phenomena also an issue, considered in safety planning is aimed at scaling down risks, says G.R. Nagabhushana, AICTE Emeritus Fellow, High Voltage Division of the Indian Institute of Science, Bangalore [3-4].

The Impact of Thunderstorms in India: [5-11] The High Powered Committee on Disaster Management (HPC), India, constituted in August 1999 with an aim towards a systematic, comprehensive and holistic approach towards disasters had identified thirty odd disasters of which Thunder and Lightning was one. Thunderstorms occur in different parts of India during different seasons, Thunderstorm has known effect on Pre-monsoon period, from March to May, every year. Some parts of the Country experience thunderstorms during the monsoon season also from June to September. During the post monsoon season from October and November, thunderstorms occur in association with cyclonic storms and depressions most over peninsular India [6].

A series of thunderstorms along a line often extending hundreds of kilometer is called a 'Squall Line'. Thunderstorms lead to other convective phenomena called tornado. Tornadoes are extremely highly dangerous. When thunderstorms occur all over India, the most probable regions of tornado occurrence are Assam and adjoining regions, West Bengal, Orissa and Gangetic plains, Punjab and Haryana.

Table 3.1.1:

CITY	A.T.D
Delhi	30
Mumbai	18
Kolkata	70
Chennai	47
Ahmedabad	11

Table 3.1.2: Depending upon average thunderstorm days (ATD) in a year, the places in India can be classified as follows:

ATD	Type Of Hazard	No. Of Places In Each Type
<10	Very low hazard	23
>=10 <30	Low hazard	61
>=30 <50	Moderate hazard	57
>=50 <80	High hazard	34
>=80	Very high hazard	05

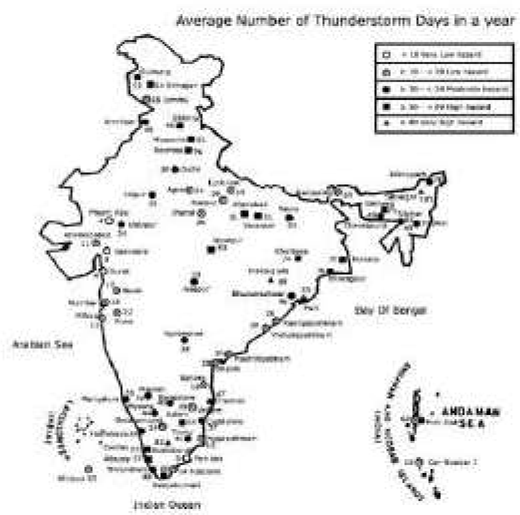

Fig 3.1: Average Thunderstorm days.

A Profile of Lightning Strikes in Major Indian Cities: The average numbers of thunderstorm days (ATD) in a year for major cities are given below. The map showing average number of thunderstorm days in a year in India is given in Figure.3.1 (BIS, 2005).

ATD in Major Cities:

An Elloborate and Detailed Analyses of Lightning

The Science and Properties of Lightning: The actual lightning density, however, depends to a large extent on geographic conditions. Thunderstorms come into existence when warm air has moisture are transported to higher altitudes [7]. This may happen in number of ways. The layers of air near the ground heat up and rise. For frontal thunderstorms, the invasion of a cold air causes cooler air to be pushed below the warm air, forcing

Fig 4.1 Downward Flash (Cloud to earth flash)

it to rise. Orographic thunderstorms are caused when warm air near the ground is lifted up. This forms up draught channels with vertical speeds of up to 100 km/h, which create worse clouds with typical heights of 5-12 km and diameters of 5-10 km.

Positively charged particles settle in the upper region and negatively charged particles settle in the lower region of the thundercloud. [8-12] If the space charge densities, which happen to be present in a thunder-cloud, produce local field strengths of several 100 kV/m, leader discharges are formed which initiate a lightning discharge. Cloud-to-cloud flashes result in charge neutralization between positive and negative clouds. The lightning electromagnetic impulses must be considered, however, because they harm electrical and electronic systems. Lightning flashes to earth lead to a neutralization of charge between the cloud charges and the electrostatic charges on the ground. We have types of lightning flashes to earth:

In the case of downward flashes, leader discharges pointing towards the ground guide the lightning discharge from the cloud to the earth. Such discharges usually occur in flat terrain and near low buildings and structures. Downward flashes can be recognized by the branching Fig. 4.1 which is directed earthwards. The most common type of lightning is negative lightning Fig. 4.2. This leader propagates in a series of jerks with a speed of around 300 km/h in steps of a few 10 m. It causes the

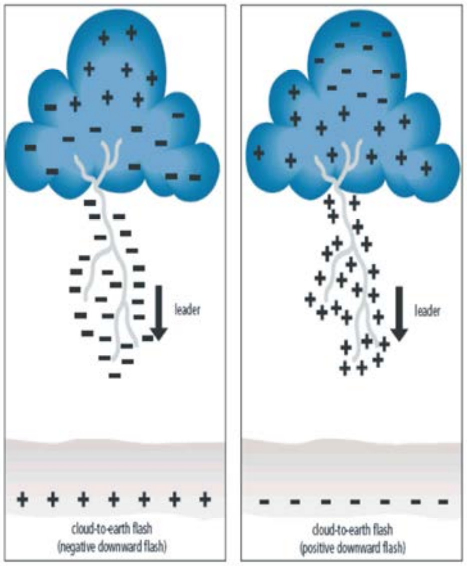

Fig 4.2: Discharge Mechanism of Clouds.

Fig 4.3: Upward Flash(Earth to Cloud Flash).

ends of buildings) to increase. These objects involved reach out to the leader by growing positive streamers which then meet up with the leader, initiating the main discharge. Positive flashes to earth can arise out of the lower, Fig. 4.2. The ratio of the polarities is around 90 % negative lightning to 10 % positive lightning. This ratio depends on the geographic location. On very high, exposed objects (e. g. radio masts, telecommunication

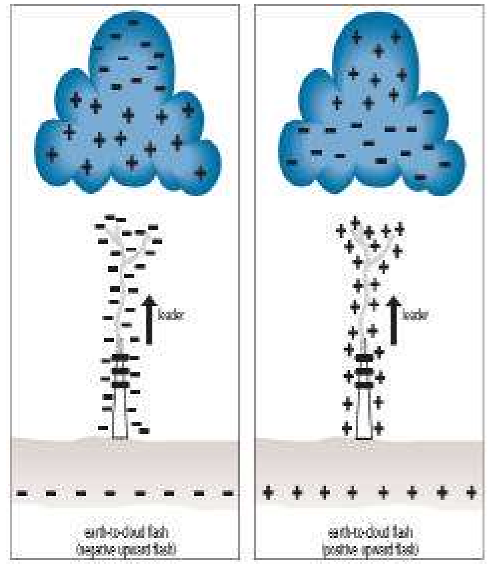

Fig 4.4: Discharge Mechanism of Clouds.

strength of the electric field of objects on the surface of the earth in the vicinity of the leader (e. g. trees, gable towers, steeples) or on the tops of mountains, upward flashes (earth-to- cloud flashes) can occur. Branches of the lightning discharge Fig. 4.3. Upward flashes occur with both negative polarity Fig. 4.4 and also with positive polarity Fig. 4.4 Since, with upward flashes, the leaders propagate from the exposed object on the surface of the earth to the cloud, high objects can be struck several times by one lightning discharge during a thunderstorm. Objects struck by lightning are subject to higher stress by downward flashes (cloud-to-earth flashes) than by upward flashes (earth-to-cloud flashes). The parameters of downward flashes are therefore taken as the basis when designing lightning protection measures. Based on the type of lightning flash, each lightning discharge consists of one or more partial strokes of lightning. [13] The possible combinations of partial lightning strokes are shown in Fig. 2.1.7 for downward flashes and Fig. 2.1.8 for upward flashes. The lightning currents consisting of both impulse currents and continuing currents are load-independent cur-rents, i. e. the objects struck exert no effect on the lightning currents. Four parameters important for lightning protection technology can be obtained from the lightning current profiles shown in Figs. 4.5 and 4.6. The peak value of lightning current I the charge of the lightning current

Qflash, comprising the charge of the short stroke Qshort and the charge of the long stroke Qlong The specific energy W/R of the lightning current The steepness di/dt of the lightning current.

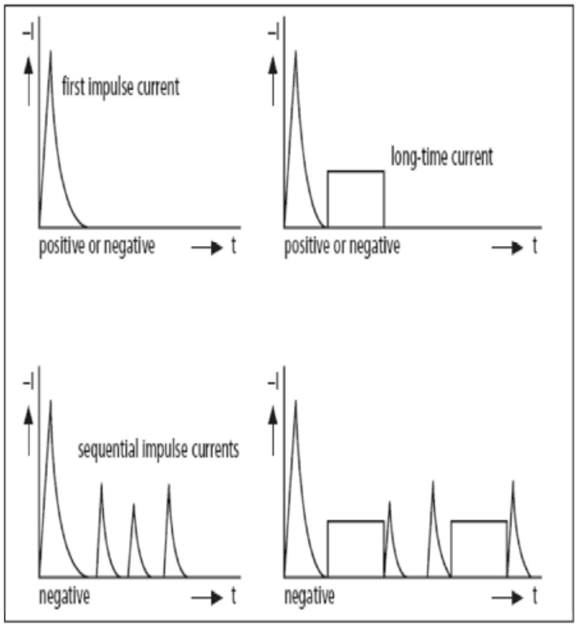

Fig 4.5: Possible Components of Downward Flashes.

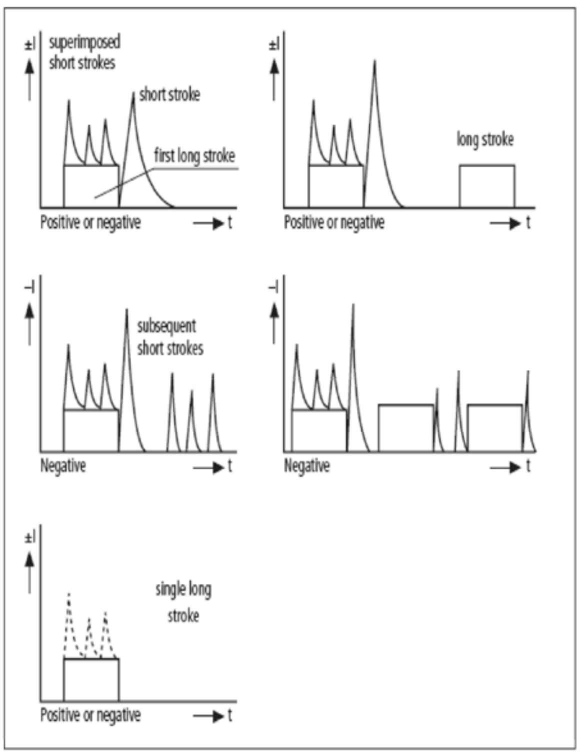

Fig 4.6 Possible Components of Upward Flashes.

A Quantitative Approach to Lightning: Lightning currents are load-independent currents, i.e. a lightning discharge can be considered an almost ideal current source [14]. If a load-independent active electric current flows through conductive components, the amplitude of the

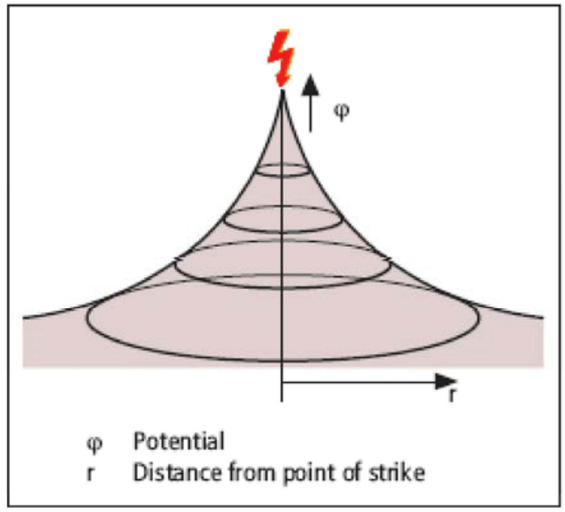

Fig 4.2.1: Potential Distribution of a Lightning Stroke in soil.

Fig 4.2.2: Animals Killed by Lightning Current due to Hazardous Step Voltage.

current and the impedance of the conductive component the current flows through, helps to regulate the potential drop across the component flown through by the current. In the simplest case, this relationship can be described using Ohm's Law. $V = I.R$ If a current is formed at a single point on a homogeneously conducting surface, the well-known potential gradient area arises. This effect also occurs when lightning strikes homogeneous ground Fig. 4.2.1.

If living beings (people or animals) are inside this potential gradient area, a step voltage is formed which can cause a shock cur- rent to flow through the body Fig. 4.2.2. The higher the conductivity of the ground, the flatter the shape of the potential gradient area. The risk of dangerous step voltages is thus also reduced.

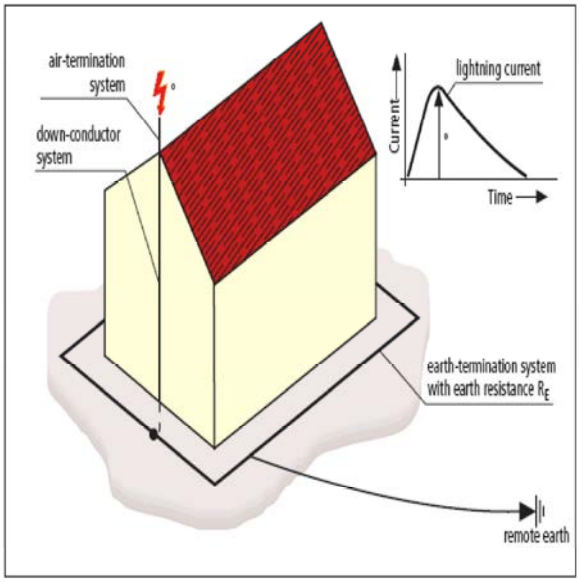

Fig 4.2.3: Potential rise of the Earth-Termination System of a building compared with remote earth.

If lightning strikes a building which is already equipped with a lightning protection system, the lightning current flowing away via the earth-termination system of the building gives rise to a potential drop across the earthing resistance RE of the earth-termination system of the building Fig. 4.2.3.

As long as all conductive objects in the building, which persons can come into contact with, are raised to the same high potential, persons in the building cannot be exposed to danger. This is why it is necessary for all conductive parts in the building with which per-sons can come into contact and all external conductive parts entering the building, to have equipotential bonding. If this is disregarded, there is a risk of dangerous shock hazard voltages if lightning strikes.

The Equation: The charge Qflash of the lightning cur-rent is made up of the charge Qshort ofthe short stroke and the charge Qlong of the long stroke. $Q = \int i.dt$ The charge of the lightning current determines the energy deposited at the precise point of strike and at all points where the lightning current continues in the shape of an electric arc along an insulated path. The energy W deposited at the base of the electric arc is given by the product of the charge Q and the anode-/cathode drop with values in the micrometer range UA,K. Fig. 4.3.1.

The average value of UA,K is a few 10 V and depends on influences such as the height and shape of the current:

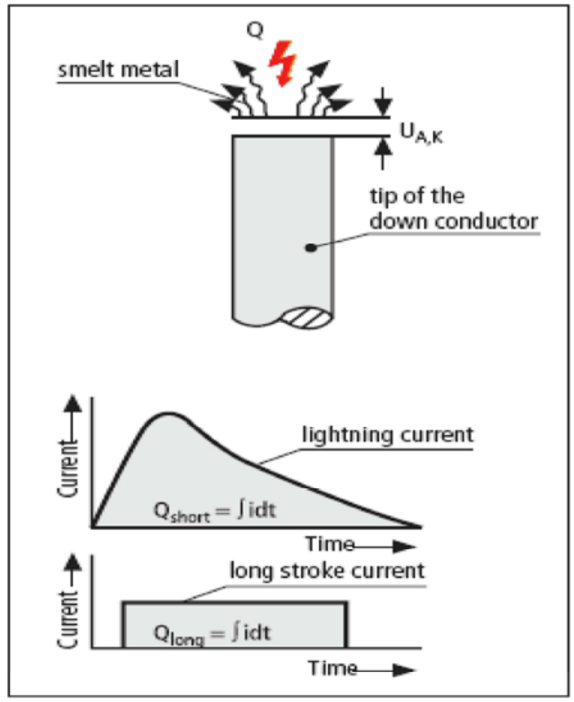

Fig. 4.3.1: Energy Conversion at the point of strike by the load of the lightning current.

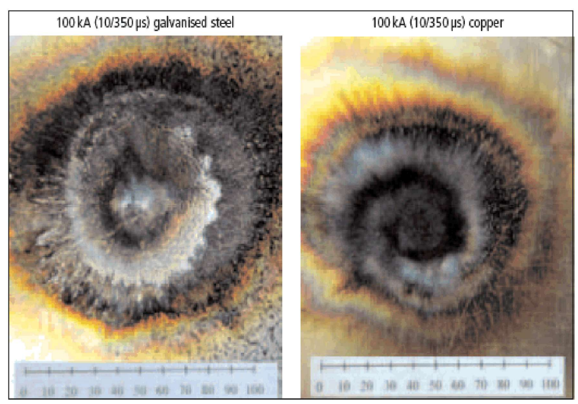

Fig 4.3.2: Effect of Impulse on Metal Arc Surface.

Hence, the charge of the lightning cur- rent causes the components of the lightning protection system struck by lightning to melt down. The charge is also relevant for the stresses on isolating spark gaps and protective spark gaps and by spark-gap based surge protective devices. Recent examinations have shown that, as the electric arc acts for a longer time, it is mainly the continuing charge Qlong of the continuing current which is able to melt or vaporize large volumes of material. Figs. 4.3.2 and 4.3.3 show a comparison of the effects of the short stroke charge Qshort and the long stroke charge Qlong.

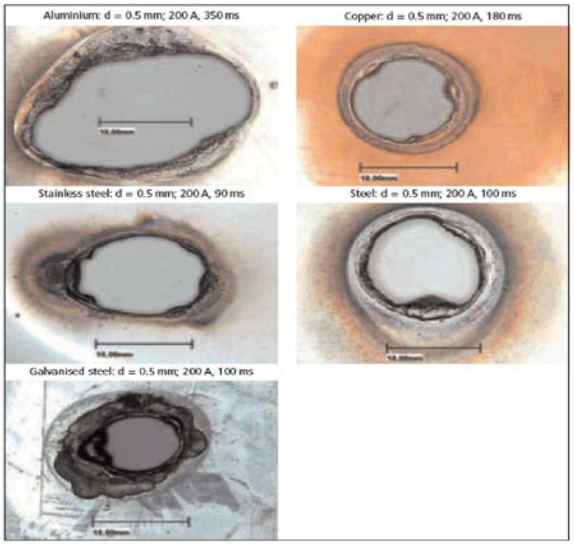

Fig 4.3.3: Plates Perforated by effect of long time arcs.

Current Parameters and Paradigms in Lightning Protection Levels: In order to define lightning as a source of interference, lightning protection levels I to IV are laid down. Each lightning protection level requires a set of maximum values (dimensioning criteria used to design lightning protection components to meet the demands expected to be made of them) and minimum values (interception criteria necessary to be able to determine the areas with sufficient protection against direct lightning strokes (radius of rolling sphere)). Table 2.6.1 shows the assignment of the lightning protection levels to maximum and minimum values of the lightning current parameters.

Table 4.41: Limit Values of Lightning Current parameters and their probabilities.

Lightning protection level	Maximum values (Dimensioning criteria)		Minimum values (Interception criteria)		
	Max. lightning current peak value	Probability of the actually upcoming lightning current to be less than the max. lightning current peak value	Min. lightning current peak value	Probability of the actually upcoming lightning current to be higher than the min. lightning current peak value	Radius of the rolling sphere
I	200 kA	99 %	2.9 kA	99 %	20 m
II	150 kA	98 %	5.4 kA	97 %	30 m
III	100 kA	97 %	10.1 kA	91 %	45 m
IV	100 kA	97 %	15.7 kA	84 %	60 m

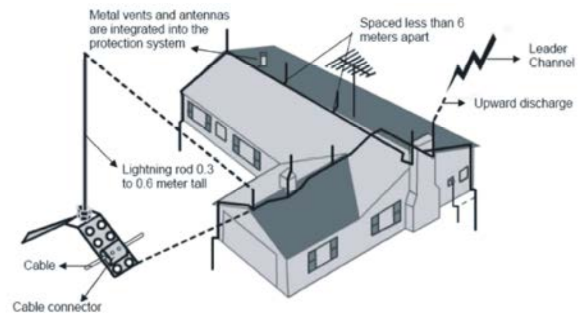

Fig 5.1: Lightning rod protection system for a residential building (Encyclopedia Britannica, 1999).

Modern Measures-a Breakthrough: Modern lightning protection measures include installing air termination systems at homes, commercial complexes and industrial units.

These systems preferentially attract, redirect and dissipate high-voltage lightning beneath the ground. Experts also recommend surge protection devices to buffer power-connected equipment against a pulse of excess voltage. Let us discuss air termination system in detail with minimum cost in design for individual properties [15].

Air Termination (vertical, horizontal) the structures may be protected from lightning by either channeling the current along the outside of the building and into the ground or by shielding the building against damage from transient currents and voltages caused by a strike. The method constrains the path of lightning currents and voltages through use of lightning rods, or air terminals and conductors that route the current down into a grounding system, as shown in the figure. 5.1 When a lightning leader comes near the building, the lightning rod initiates a discharge that travels upward and connects with it, thus controlling the point of attachment of lightning to the building. A lightning rod functions only when a lightning strike in the immediate vicinity is already immanent and so does not attract significantly more lighting to the building [16-18]. An air termination networks consists of vertical or horizontal conductors or combination of both. So houses in the mention states should have a conducting material fixed above the height of the house and should be earthed. If multiple termination systems are fixed then safe earthing of lightning is achieved.

Heralding it to the General Public: Lightning strikes are infrequent in nature, though they occur every year during the monsoon, pre and post monsoon periods in India.

It must always be remembered that no place outside is safe near a thunderstorm. Due to their occurrences, the common people really don't have concern over the danger associated with lightning strikes and it is common sight in India people being out doors watching thunder and lightning, continuing their works in paddy fields, the fishermen going to sea during lightning etc. It leads to lightning casualties and deaths leading the poor people to lose their family members. It is important to create the awareness on lightning protection and personal safety among different target groups such as educated and uneducated people, villagers, rural youths, school going children etc.

Proactive Measures Against Lightning: It is unfortunate that people are either killed or disabled by lightning just because they keep watching the beauty of rain, thunder and lightning outdoors or take a shelter under a tree or continue with their outdoor activities as boating, fishing, talking over telephone, unmindful of the damage lightning could inflict.

When you see lightning and hear thunder it is a sure warning signal that you should rush indoors to protect yourselves. If no shelter is available in the neighborhood of where you are, then seek protection by getting in to a hard topped vehicle with windows closed. You are much safer inside a car than outside because steel frame of a vehicle usually provides protection, if you be careful not to touch metal. Keep distance from trees, tall structures. Lightning can strike the same place twice and can spread out nearly 20m after striking the ground. Lightning can affect a building in three ways (a) direct hit (b) through external wires and pipes and (c) through the ground. Lightning can also travel through reinforcement in concrete walls, flooring etc. Beware Do not use wired phones. Mobile phones are the safest to use. Lightning can strike through external doors and windows. Unplug all the electrical and electronic equipment as soon as the thunder and lightning seem likely. You should go out only after ensuring lull for at least 30 minutes since the last thunder. Do not be under the misimpression that the rubber shoes you wear and the rubber tyres of your car will protect you from lightning. Good systems of protection carry lightning charge through lightning rods and cables from the building to the ground and dissipate the charge. Ensure that the building is well protected. The immediate cause of death due to lightning in most cases cardiac arrest. It is important therefore to check whether the victim is still breathing and has a pulse. Act accordingly.

CONCLUSION

To understand the lightning activity in Kerala, lightning data for the past 17 years (1986- 2002) was collected. Reports of casualties from newspapers, records of lightning accidents available from village revenue records and other sources like telecom department are used for the study. Though lightning incidents are less, whenever they strike, they cause severe damages to life. Then it was analyzed for spatial and temporal distribution of lightning occurrence. Data on cloud observations were referred from the India Meteorology Department for the stations Thiruvananthapuram, Alapuzha, Kochi, Kozhikode and Kannur for the same period. This data was used to study the occurrence of thunderclouds. From the beginning of northeast monsoon to the occurrence of the next southwest monsoon season is a period in which lightning activity is seen to be high in Kerala. The lightning occurrence data when posted on a physical map of Kerala clearly shows that midland regions of Kerala are more affected than the coastal plains and highland regions. The Palakkad gap region experiences the least strikes. This indicates that the Western Ghats play an important role in influencing the formation of clouds and properties. Casualties due to Lightning can be easily, efficiently and inexpensively avoided and lightning safety can be achieved mainly by creating public awareness. Though lightning incidents are less, whenever they strike, they cause severe damages to life and properties. Casualties due to Lightning can be easily, efficiently and inexpensively avoided and lightning safety can be achieved mainly by creating public awareness, technical education on Lightning Protections, educating people on lightning and surge protection. Stringent steps to ensure adherence of building standards and codes wherever necessary and promoting research and development on lightning protection are essential.

REFERENCES

1. The Article of Hindu-Lightning Inflicts Heavy Loss on Kerala Online Edition of India's National Newspaper Friday, Nov 16, 2007.
2. The Article of Hindu-Property Plus Kochi-The Science and Business of Protection from Lightning Online Edition of India's National Newspaper Saturday, May 06, 2006.
3. Article on The Times Lightning Claims 69 lives in Maharashtra 21 Jun 2006, 23:3 4hrs IST, TNN.

4. Report Number: CESS-PR-06-2004 Understanding Lightning Accidents to Alleviate the Hazard.
5. Details of Western Ghats from Wikipedia, the free Encyclopedia.
6. Lightning Protection Guide from www.dehn.de
7. Culture of safety Against Lightning-An Indian Perspective by C. Lakshmi Narashimhan and DVS Bhagavanalu. International Roundtable on Lightning Protection.
8. Indian Standard IS 2309:1989. Protection of Buildings and Allied Structures against Lightning-Code of Practice, Reaffirmed in 2005.
9. Murali Das, S., S. Sampath and G. MohanKumar, 2007. Lightning Hazard in Kerala.J.Mar.Atmos Res., 3: 111-117.
10. http://www.lightningsafety.com
11. Vijayaragavan, S.P., B. Karthik, T.V.U. Kiran Kumar and M. Sundar Raj, 2013. Analysis of Chaotic DC-DC Converter Using Wavelet Transform, Middle-East Journal of Scientific Research, ISSN:1990-9233, 16(12): 1813-1819.
12. Vijayaragavan, S.P., B. Karthik, T.V.U. Kiran Kumar and M. Sundar Raj, 2013. Robotic Surveillance For Patient Care In Hospitals, Middle-East Journal of Scientific Research, ISSN:1990-9233, 6(12): 1820-1824.
13. Vijayaragavan, S.P., T.V.U. Kiran Kumar and M. Sundar Raj, 2013. Study of effect of MAI and its reduction in an OCDMA system, Middle-East Journal of Scientific Research, ISSN: 1990-9233, 16(12): 1807-1812.
14. Vijayaragavan, S.P., T.V.U. Kiran kumar and M. Sundar Raj, 2013. Study of Effect of Mai and its reduction in an OCDMA System, Middle-East Journal of Scientific Research, ISSN: 1990-9233, 15(12): 1803-1808.
15. Kishwar Sultana, Najm ul Hassan Khan and Khadija Shahid, 2013. Efficient Solvent Free Synthesis and X Ray Crystal Structure of Some Cyclic Moieties Containing N-Aryl Imide and Amide, Middle-East Journal of Scientific Research, 18(4): 438-443.
16. Pattanayak Monalisa and P.L. Nayak, 2013. Green Synthesis of Gold Nanoparticles Using Elettaria cardamomum (ELAICHI) Aqueous Extract World Journal of Nano Science and Technology, 2(1): 01-05.
17. Chahataray Rajashree and P.L. Nayak, 2013. Synthesis and Characterization of Conducting Polymers Multi Walled Carbon Nanotube-Chitosan Composites Coupled with Poly, P-Aminophenol. World Journal of Nano Science and Technology, 2(1): 18-25.
18. Parida, U.K., S.K. Biswal, P.L. Nayak and B.K. Bindhani, 2013. Gold Nano Particles for Biomedical Applications, World Journal of Nano Science and Technology, 2(1): 47-57.