Lightning Protection of structures are being done in 2 ways, both confirming the Indian Standards. The first method is isolated protection (for convenience called as conventional method) and the second one is to use the naturally available steel in buildings as parts of LPS such as down conductor and earthing (for convenience called as structural earthing).

In conventional method down conductors are outside the building and generally isolated from the structure. Vertical Earth electrodes are used outside the building. Generally the LPS is not connected to Equipotential Bonding bar, but in some cases earth electrodes are connected to other earthing system under soil.

In structural earthing method, continuous conductors super imposed inside RCC columns and foundation which runs along with construction steel will do the job of down conductor and earthing.

Risk Analysis on injury to living being by electric shock due to a direct lightning strike in the structure

IS/IEC 62305-2 explains the risk assessment and probability of damages in a building during a lightning. Probability of injury to living being due to touch and step potential (PA) in a building depends on the protection measures provided in the building against touch and step potentials (PTA) as well as the external LPS provided (PB).

$P_A = P_{TA} X P_B$

Protection Measures (touch and step potential)	P_{TA}
No Protection measures	1
Warning notices	10^{-1}
Electrical insulation of exposed LPS parts	10^{-2}
Soil equipotentialisation	10^{-2}
Structural Earthing	0

Protection Measures (Physical Damages)	P_B
No protection measures	1
External LPS Class IV	0.2
External LPS Class III	0.1
External LPS Class II	0.05
External LPS Class I	0.02
Air termination (Class I) + structural Earthing	0.01
Metal roof + air termination (class 1) + structural earthing	0.001

Probability of injury	P_A	Chance of accident
No protection measures	1	Each strike will create damage
Class IV external LPS and no soil equipotentialisation	0.2	One strike out of 5 can create physical damage

Class I with no protection measures P_{TA}	0.02	One strike out of 50 can create physical damage
Structural Earthing	0	NO Chance of accident

Electrical Safety and Power Frequency Fault Voltage

Industrial / IT and commercial establishments need to use TN-S network for L.V electrical distribution with in the facility. For establishments with number of electronic systems, TN-S is the recommended network by every modern standards. The method is explained and recommended in IS 3043 as PME (Protected Multiple Earthing).

Properly implemented structural earthing ensures easy implementation of PME and thereby reduce the power frequency fault voltage between electricity using equipment and extraneous conductive parts in a building during a fault. Equipotential bonding thus created avoids dangerous spark over and fire during a fault

Protection of Electronics

Modern day electronic installations are highly sensitive to Transients. Transients in a building are created due to radiated Electro Magnetic Pulse (EMP) due to various reasons. Future electronic installations will be smaller & faster which means more sensitive to EMP. Electro Magnetic Shielding plays a major role in protecting modern day electronics.

A properly installed Structural Earthing system mean a large volume shield created by natural components of the structure such as the metal reinforcement in ceilings, walls and floors, the metal framework, the metal roofs and metal facades. These components together create a grid-like spatial shield (faraday cage). The current injected into the reinforcing rods is assumed to flow through a large number of parallel paths. The impedance of the resulting mesh is thus low and, as a consequence, the voltage drop due to the lightning current is less. The magnetic field generated by the current in the reinforcing steel mesh is weak due to the low current density and the parallel current paths generating opposing electromagnetic fields. Interference with neighboring electrical conductors is correspondingly reduced.

Without any doubt, structural earthing provides the best equipotential is at ion and protection of electronic systems.

Corrosion and Associated problems

Steel inside concrete have the advantage that, if the concrete is of adequate construction and covers the steel by at least 50 mm, they are reasonably protected against corrosion, throughout the life of the building. Whereas a conventional LPS is subjected to corrosion, theft, vandalism etc hence need periodic inspection and maintenance

A properly installed Structural Earthing system is permanent in the building and well shielded, provided welded iron reinforcing bars are used for concrete outer walls. Note that a good electrical bonding is necessary. In several situations the steel reinforcing bars may not represent an adequate shield. A well-designed and implemented lightning conductor with conductive connections to structural steel is an alternate method. Some tips about this conductor are

Galvanized steel inside concrete may create problem to concrete and hence avoid GI inside concrete.

All penetrations of steel in reinforcement to an outer area need careful design and installation. Use only Copper, Copper coated steel or SS material for this application.

Use only copper, copper coated steel or SS in soil if connected to steel in reinforcement as recommended in IS/IEC standard.

Cheap and Best in long run

To achieve a cost-effective and efficient protection system, the design should be carried out during the building concept stage and before construction. This allows one to optimize the use of the natural components of the structure and to choose the best compromise for the cabling layout and equipment location. For a retrofit of shielding measures in conventional Lightning Protection System the cost is generally higher than the cost for structural Earthing.

Structural earthing and Bonding system

- More safety for human beings during lightning
- More safety for electrical installations during fault & lightning
- Protect Electronic systems against EMP
- No Corrosion and Less Maintenance
- Cheap and Best in long run

Structural Bonding is a standard construction practice in developed countries

Abstract of the paper presented during ICES-2017 at Trivandrum on 18 Feb 2017 by S. Gopa Kumar, CAPE electric pvt ltd, Chennai

Comparison of Different Earthing System for Industrial / Commercial and IT buildings		
	Current method	Structural earthing with TNS-PME
Method	(separate earth electrodes for LPS, DG, Transformer UPS, Lift etc	(Different Earthing bonded together including extraneous conductive parts)

Confirmation to standards	No confirmation to IS/IEC/IEEE standards. (IS3043 wrongly interpreted)	IS 3043, IS 732, IS/ IEC 62305, IEC 60364, IEEE 142, IEEE 1100
System Earthing (LV)	TN-S/TT/ not clearly defined	TN-S with PME
Earth Electrodes	Separate for Transformer body & N, DG body & N, Lightning Protection, UPS, Lift, Electrical installation etc. Sometime these electrodes are interconnected under soil	All earthing connected together through Earth grid formed in the building/floor satisfying the bonding regulations for increased safety and Protection of electronics.
Line to Body Fault current return path	not defined / designed through earth	PE conductor
	No supplementary PE conductor	Supplementary PE conductor through grid
Shielding	No shielding	Faraday Cage and perfect shielding
Referance for Voltage	Not defined	Well defined reference voltage
Equipotential Bonding	Less possibilities	Very Good base for equipotentialisation
Lightning current Discharge	Through independent earth electrodes at Various places in the building. Not recommended by IS/IEC 62305 for large buildings with electronic systems	Ring Earth / Foundation earthing. Recommended by IS/IEC 62305 for protection of electronics and increased safety
	Number of earth electrodes around the building damaging concrete installation / Roads.	One building / One earthing satisfying requirement of every electrical and electronic system
Advantages / Disadvantages	High cost, complication and failure in electronics	Less cost. Increased life of equipment
	Chance of Neutral circulating current through earth and failures as a result	NO failures due to Neutral circulating currents.
	Over Voltages in the installation and fire/flashover during a fault condition	No Power frequency fault voltage due to PME
Operation of Switchgear	Slow due to short and Interconnected PE conductor resulting in increased loop Resistance. High chance of fire	Quick operation of switchgear due to low loop Resistance offered by PE and PME. More human safety and less chance of fire
Electrode design	Need to be designed based on full prospective short circuit current	Only partial fault current through Earth electrode
Periodic inspection	Each electrode resistance is measured. This value varies frequently	Measured as per IS/ IEC 62305-3 (less than 0.2 ohms)
Measurement for Electrode Resistance	Requested for less than 1 ohm, very difficult to achieve	Assured less than 1 ohm. measured as per IS 3043
	Short (5 to 15 years).	Until the building last
Life	GI strip is used in General which corrodes Due to bimetallic and galvanic effects. Need replacement in every 5 to 15 years depending upon the soil condition and galvanic influence	Connections in soil are exothermically welded. Copper / Copper coated steel material is used inside concrete / soil and connecting points to Steel in concrete. High corrosion resistance and life similar to copper

IS 3043 permits to use steel in reinforcement foundations and piles as an effective electrode system without necessity to provide buried electrode for application such as power Generation and Distribution stations.

TNS-PME earthing including Structural steel is for earthing for equipment, Lightning Protection, Transformer / DG Neutral & Body. Maintenance free for decades. This method is much more efficient and used as a standard construction practice in developed countries ■

S Gopakumar

Managing Director of CAPE electric pvt ltd. Member of National Building Code (NBC-2016)