



Lightning Protection – Introduction

Structural lightning protection design considerations

BS 6651 (Protection of structures against lightning) clearly advises strict adherence to the provision of a conventional Lightning Protection System (LPS) – to the total exclusion of any other device or system for which claims of enhanced protection are made.

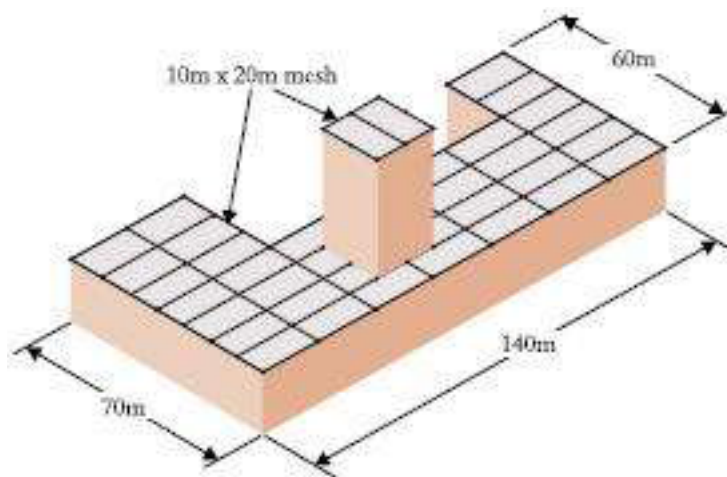
Principle components of a conventional structural lightning protection system, in accordance with BS 6651 are:

- Air termination network
- Down conductors
- Earth termination network
- Bonding (to prevent side flashing)

Air termination network

On high risk structures such as explosive factories, no part of the roof should be more than 2.5m from an air termination conductor. This is generally achieved by applying a 5m x 10m mesh to the roof.

However, for most structures, a mesh of 10m x 20m is considered sufficient, giving a maximum distance from any part of the roof to the nearest conductor of 5m.



The zone of protection does not seem to be applied because of the need to interconnect the down conductors of the tall block to the air termination of the lower block. In such cases it is necessary to connect the lower air termination up to the lower down conductors to facilitate this inter connection, even though this extension is within the zone of protection of the tower.

Figure 1 - Air terminations for tall conducting structures





The 'Zone of Protection' offered by an air termination network is considered to be 45° for heights up to 20m. Above this height, the zone of protection is determined by the 'Rolling Sphere Method'.

This involves rolling an imaginary sphere of 60m radius over a structure. The areas touched by the sphere are deemed to require protection. On tall structures, this can obviously include the sides of the building.

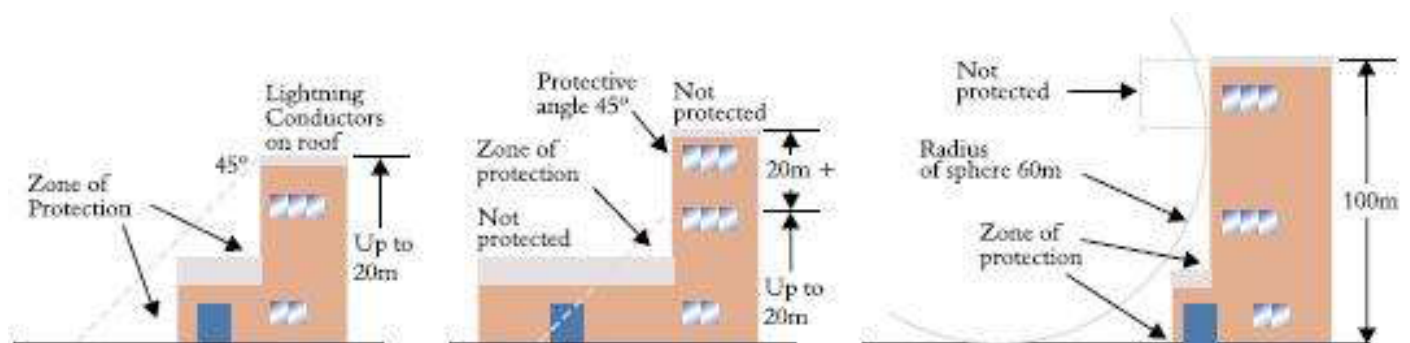


Figure 2 - Zones of protection

Down conductors

Down conductor positioning and distancing is often dictated by architectural constraints. There should be one down conductor for every 20m or part thereof of the building perimeter at roof or ground level (whichever is greater). These should be evenly spaced and distances apart of more than 20m avoided if possible.

If the building is above 20m in height or of an abnormal risk this distance should be reduced to 10m.

They should be routed as directly as possible from the air termination network to the earth termination network to avoid risks of side flashing. Re-entrant loops are also to be avoided. BS 6651 recommends that the length of conductor forming the loop should not exceed eight times the width of its open side.



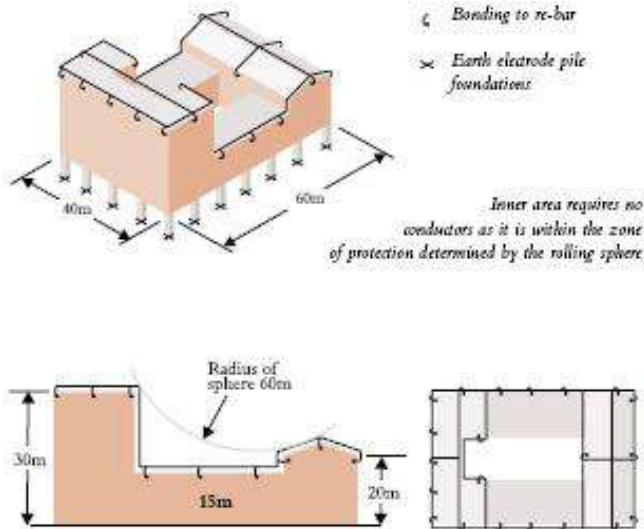


Figure 3 - Lightning Protection Scheme to BS 6651 using the reinforced concrete within the structure for down conductors

BS 6651 allows the use of 'natural conductors' such as rebars and structural steelwork, provided that they are electrically continuous and adequately earthed.

Earth termination networks

Each down conductor must have a separate earth termination. Moreover provision should be made in each down conductor, for disconnection from the earth for testing purposes. This is achieved with a test clamp (see Figure 4).

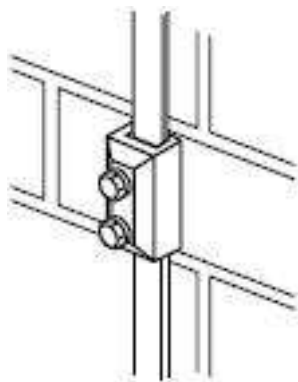


Figure 4 - Oblong test or junction clamp

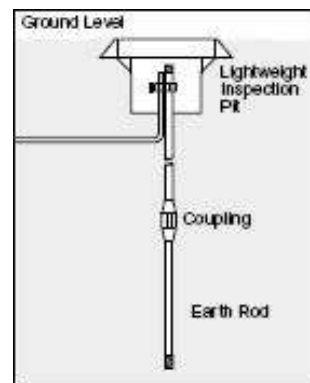


Figure 5 - Deep driven earth electrode



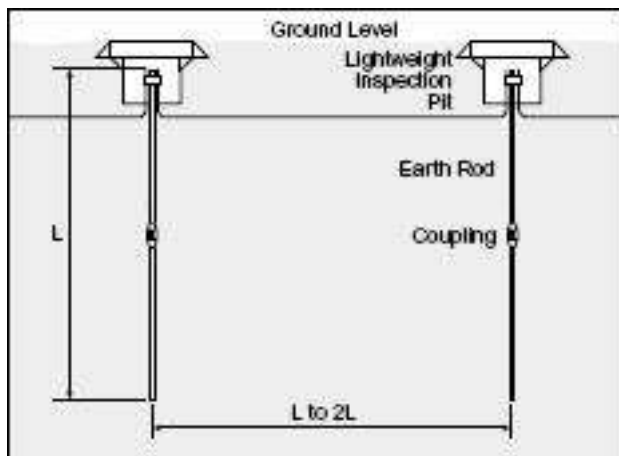


BS 6651 stipulates that the resistance to earth of the lightning protection system measured at any point, should not exceed 10 ohms.

With the test clamp disconnected, the resistance of each individual earth should be no more than ten times the number of down conductors in the complete system. e.g. for a system with 15 down conductors, the individual earth readings should be no more than $10 \times 15 = 150$ ohms.

Several types of earth electrode are permissible, but by far the most commonly used are deep driven earth rods. BS 6651 states that the combined earth rod length of a system should be no less than 9m whilst each individual earth rod should be no less than 1.5m in length.

Parallel earth rod electrodes



**Figure 6 -
Spacing of parallel earth rod electrode**

Where ground conditions make deep driving of earth rods impossible, a matrix arrangement of rods coupled to one another by conductors can be used. If possible, the earth rods must be spaced at a distance at least equal to their driven depth.

If earth rods cannot be driven in a parallel line a “Crows Foot” configuration can be used, ensuring that the spacing/depth ratio is still maintained.

High resistivity soil conditions can be overcome by backfilling earth rods with a suitable medium such as Marconite conductive concrete which effectively increases the diameter of the earth rod and hence its surface area, thus lowering resistance to earth.





Bonding

All metal work, including water pipes, gas pipes, handrails, air conditioning units, metal cladding, metal roofs etc, in the vicinity of the LPS must be bonded to it, to avoid the danger of side flashing.

For the same reason, the LPS earth should be bonded to the main electrical earth, as well as any other earthing system present in the structure.

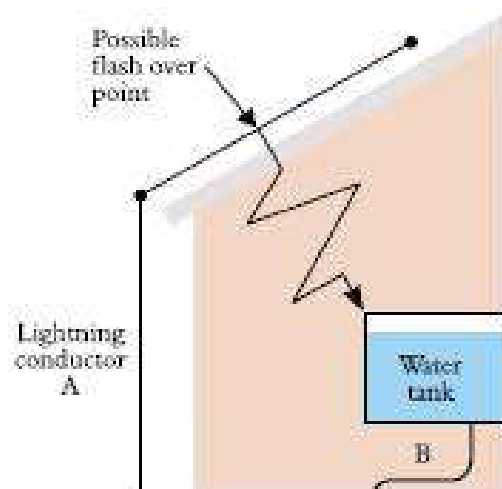


Figure 7 - Example of side flashing

If the lightning protection system on a structure is hit by lightning, then the current flowing through the system and the resistance/impedance offered by the conductor path will determine the magnitude of the potential difference seen by the lightning conductors with respect to true earth. The lightning conductors can, instantaneously, have a potential magnitude of megavolts (1,000,000V) with respect to true earth.

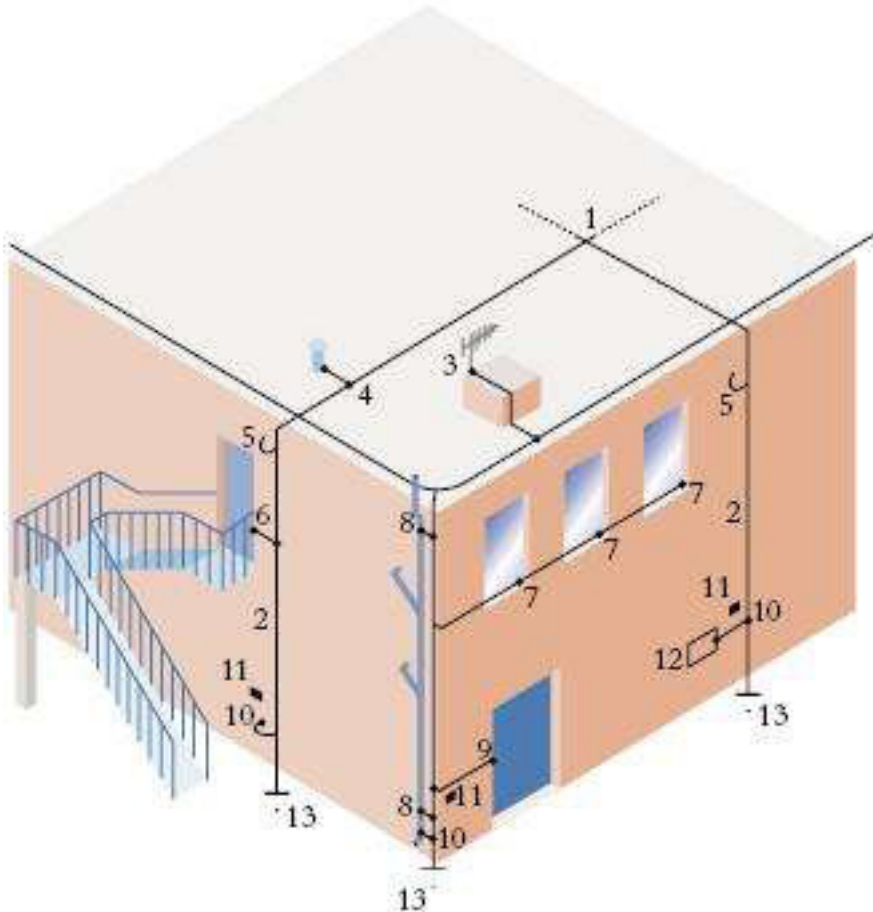
Typically, at instant of discharge:

potential difference at **A** = 1,500,000V
potential difference at **B** = 0V]





Figure 8 - Bonding to prevent side flashing



1. Air termination
2. Down conductor
3. Bond to aerial
4. Bond to vent
5. Bond to re-bar
6. Bond to metal staircase
7. Bond to metal window frame
8. Bond to vent pipe
9. Bond to steel door/frame
10. Test clamp
11. Indicating plate
12. Main earthing terminal of electrical installation
13. Earth termination point]

Corrosion

BS 6651 contains tables of materials suitable for use in Lightning Protection System (LPS) components. Adherence to these requirements is vital to avoid corrosion problems.

The correct choice of material and installation design should ensure a life span of 30 years for the earth electrode system.

Inspection, testing, records and maintenance

The code adequately details the requirement for inspecting an LPS, the testing required and the detailed records that should be maintained.

Observance of clauses 32 to 34 of the code will highlight any maintenance of the system required. Of particular importance is the regular detailed examination of the complete LPS for any evidence of corrosion.





If this check is not carried out then vital components within the LPS, which may have suffered from corrosion and which could exhibit a high resistance could be missed. This will have a detrimental effect on the whole system making it an unattractive high impedance path for the lightning current to follow.

To minimise this problem, along with regular inspections, the selection of the correct materials should be made in accordance with the recommendations of BS 6651.

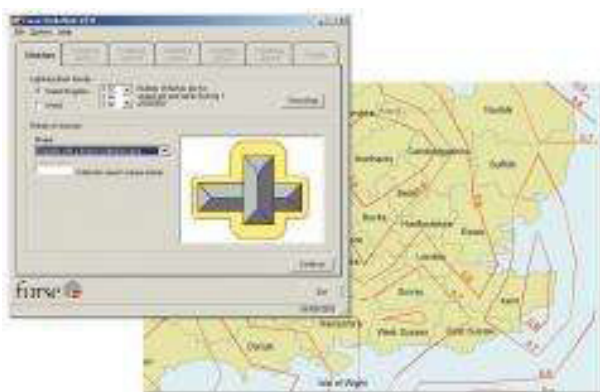
The need for protection

Before proceeding to design a lightning protection system, first carefully consider if the structure actually needs protection.

In many cases, it is obvious that some form of protection is required. High risk structures e.g. explosives factories, oil refineries, etc. will require the highest possible class of lightning protection to be provided. In many cases the need for protection is not so evident. BS 6651 provides a simple mathematical overall risk factor analysis for assessing whether a structure needs protection.

The standard suggests an acceptable lightning strike risk factor is 10^{-5} (1 in 100,000) per year. Therefore, having applied the mathematical analysis to a particular set of parameters, the scheme designer will achieve a numerical solution. If the risk factor is less than 10^{-5} (1 in 100,000), for example 10^{-6} (1 in 1,000,000) then in the absence of other over-riding considerations, protection is deemed unnecessary. If however, the risk factor is greater than 10^{-5} for example 10^{-4} (1 in 10,000) then protection would be recommended.

Using in house risk analysis software, Furse can quickly determine whether or not your structure requires protection.



StrikeRisk (illustrated, left) is an application developed by our own engineers to enable you to quickly and accurately identify if your building requires structural lightning protection in accordance with BS 6651.

StrikeRisk can be downloaded from www.furse.com. Alternatively, call +44 (0)115 964 3800 or fax +44 (0)115 986 0538 to request a copy.

