THE MINARET INCIDENTS AT

PUTRAJAYA

The "Ultimate Test" Case for the Early Streamer Emission Technology & Standard

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Summary

Bypasses (i.e. lightning strike damages) to buildings installed with the early streamer emission (ESE) air terminals have been observed in Malaysia as far back as 1991. They mostly occurred at the corners of the buildings. Since the majority of the ESE air terminals were installed centrally on top of the buildings, these bypasses were located close to the limit of the ESE protection zone.

In order to conduct the "ultimate test" on the validity of the ESE standard, NF C 17-102, a tall and slender structure is required where an ESE air terminal can be installed at the apex. If the ESE standard is valid, then no part of the slender structure should be struck by lightning since they are located deep within the claimed ESE protection zone.

The minaret of the Putra Mosque is a slender 116 metre high structure which is located in Putrajaya, the new administrative capital of Malaysia. The structure was completed in 1998 and was installed with an ESE air terminal at the apex.

The slender shape of the structure made it the ideal "ultimate test" case for the ESE technology and standard since every part of the minaret is located deep within the claimed protection zone of the ESE air terminal and should not (in theory) be struck by lightning. However, periodic observations conducted on the minaret since its completion reveals that it has been struck and damaged by lightning several times.

These damages provide more compelling evidences that the ESE air terminal is incapable of protecting tall structures higher than 60 metres. Since the minaret is about four times higher than the Sigolsheim bell tower reported earlier and located in a very high thunder day region, the ESE air terminal and standard has been shown to be ineffective under all possible structural and climatic conditions.

Cover picture:
The Putra Mosque and the subject minaret located beside a lake in Putrajaya.

1. THE PUTRA MOSQUE.

The Putra Mosque is located in Putrajaya, the new administrative capital of Malaysia which is located about 25 km south of Kuala Lumpur. The annual thunder day (TD) level at this location is about 200. The mosque was completed in 1998 and has a 116 metre high minaret which has been installed with a Helita Pulsar ESE air terminal (Figs 1 and 2).

Figure 1: The Putra Mosque and minaret taken from the "circle".

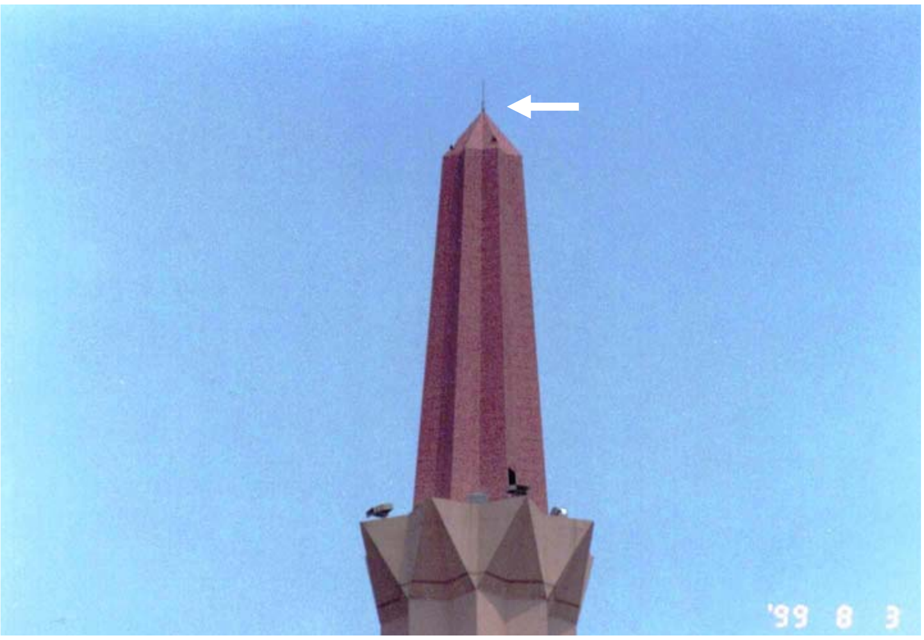

Figure 2: Close-up picture of the minaret reveals a Helita Pulsar ESE lightning air terminal installed on the apex.

Another Helita Pulsar ESE air terminal was also installed on the apex of the spire erected on the dome of the mosque (Figs. 3 and 4). This indicates that the ESE air terminal that was installed on the minaret was designed for the protection of the minaret only.

Figure 3: The dome of the Putra Mosque.

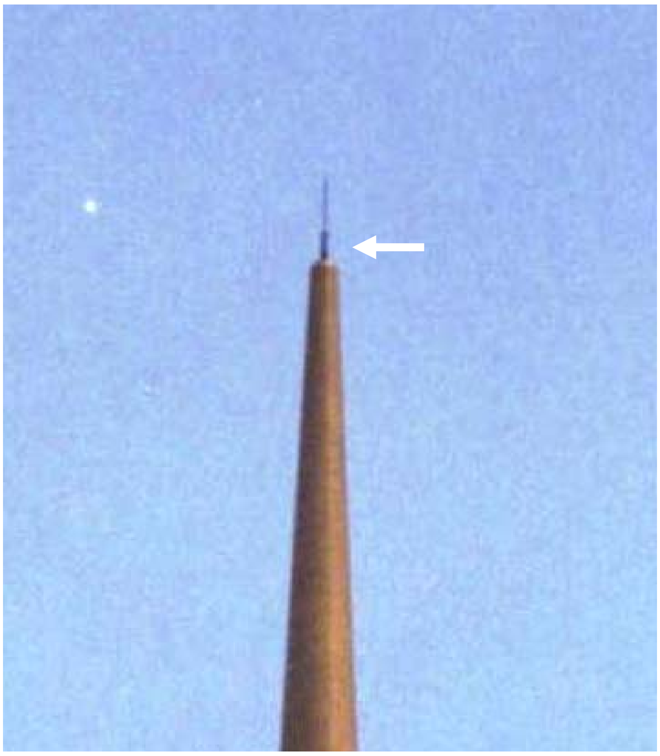

Figure 4: The Helita Pulsar ESE air terminal on top of the spire of the Putra Mosque dome.

2. FIRST MAJOR LIGHTNING STRIKE INCIDENT AT THE MINARET

In March 2005, lightning struck and damaged the tip of one of the triangular marble protrusions on the side of the minaret. The bypass was located about 30 metres below the apex (Fig. 5).

The lightning stroke broke off a marble slab which fell to the base of the minaret. This incident has been described in an article that was published in the Journal of the Association of Consulting Engineers Malaysia in 2007.

http://www.lightningsafety.com/nlsi_lhm/ACEM_Journal_Q1_2007.pdf

Figure 5: The arrow points to the location of the lightning damage in the 2005 incident.

3. SECOND MAJOR LIGHTNING STRIKE INCIDENT AT THE MINARET

In September 2010, lightning again struck and damaged one of the protrusions on the side of the minaret. This time, the bypass was located on the tip of one of the triangular concrete protrusions about 12 metres below the apex (Fig. 6). A significant portion of the concrete protrusion was broken off by the lightning stroke. Parts of the debris also knocked off a section of a marble slab from one of the lower protrusions below it.

The bypass to the concrete protrusion can be seen in the pictures below (Fig. 7). This kind of bypass is similar to those that were observed at the corners of numerous lightning damaged buildings around the country.

Figure 6: The arrow points to the location of the bypass in the September 2010 incident.

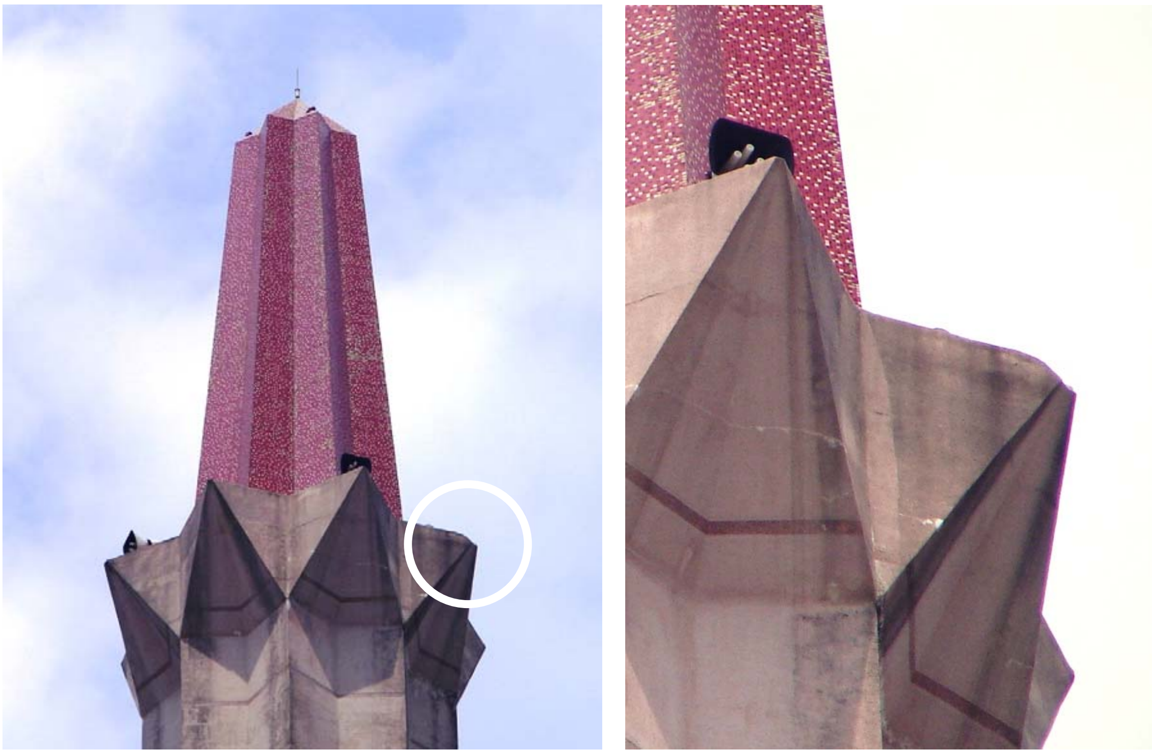

Figure 7: The location of the bypass (left) on the horizontal concrete protrusion and a close-up view of the same bypass (right). Compare this photo with that of Fig. 2 (before the strike). The Helita Pulsar ESE air terminal can be seen on the apex of the minaret about 12 metres above the bypass.

4. OTHER LIGHTNING STRIKE INCIDENTS AT THE MINARET

In addition to the two major incidents mentioned above, there were several other incidents of lightning strikes to the minaret that left only minor damages. These minor damages were virtually undetectable to the naked eye but they can be clearly seen through a binocular or a camera equipped with a zoom lens.

The horizontal concrete protrusions below the apex originally have pointed tips when the minaret was first completed in 1998. Of the original eight pointed tips which were constructed in an eight-pointed star formation, only one remains undamaged (Fig. 8).

From observations made to other buildings in the country, it is very difficult to detect the effects of a second lightning strike to an existing bypass unless the second strike causes a much bigger damage which drastically alters the shape of the original bypass. This suggests that the minaret have been struck at least eight times in the past dozen years since it was installed with the ESE air terminal.

Figure 8: A close-up photo showing three of the concrete protrusions taken from the base of the minaret. Two of the protrusions displayed minor damages while the only remaining undamaged protrusion is shown on the left.

5. LIGHTNING INTERCEPTION MECHANISM AT THE PUTRA MOSQUE MINARET AND METHOD TO PREVENT FURTHER DAMAGES

The lightning strike incidents to the minaret are not unusual since the interception positions can be predetermined by a method first developed by Professor Horvath of Hungary more than half a century ago. This method, which is known as the rolling sphere method (RSM), have been included in most national and international lightning protection standards published since 1970 (eg. NFPA780, BS6651, IEC62305).

In this method, an imaginary sphere is rolled over and around the structure (eg. minaret) to be protected (Fig. 9). The surfaces of the minaret that are at risk of being struck by lightning, and hence require protection, are those that come into contact with the imaginary sphere, such as the apex and the tips of protrusions along the sides of the minaret.

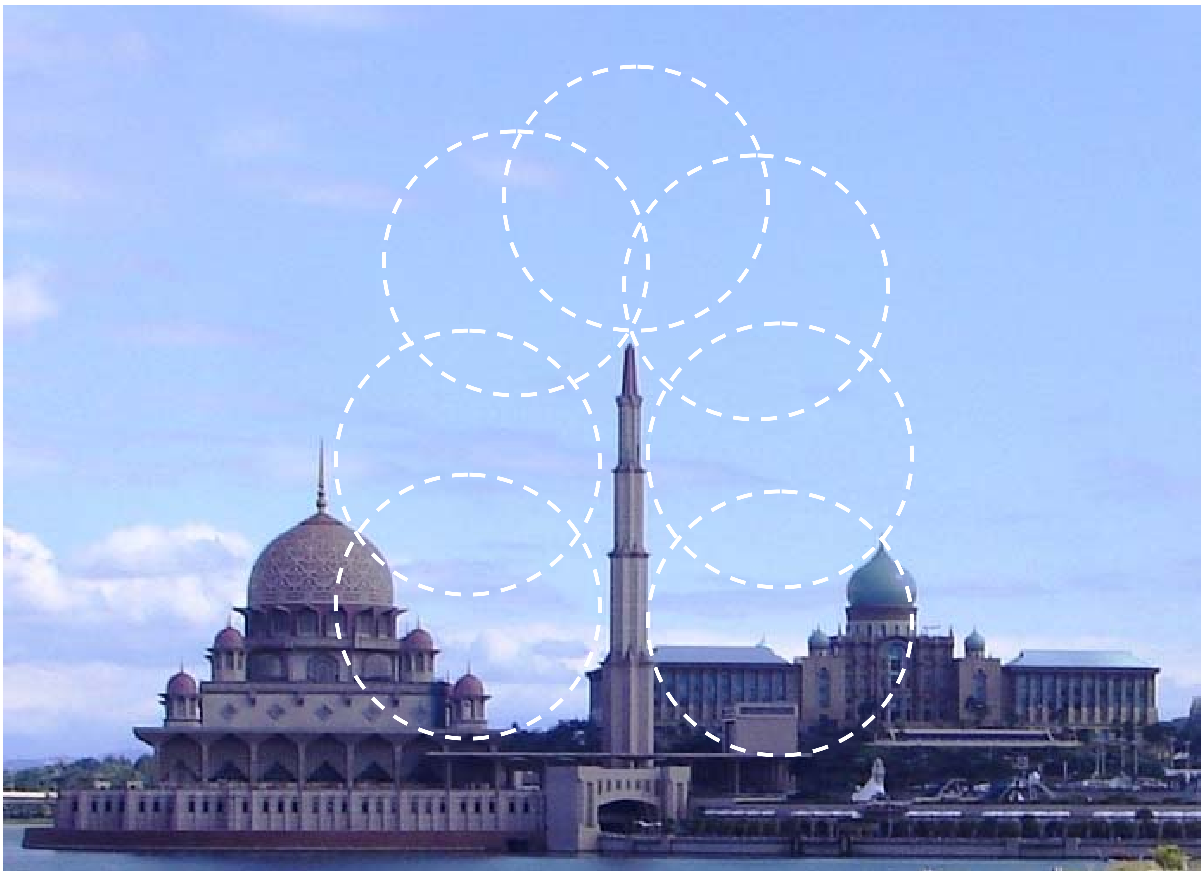

Figure 9: The rolling sphere method applied to the minaret. The method predicts that the sides of the minaret can be struck by lightning.

The RSM predicts that the majority of the lightning strikes in the vicinity of the minaret will occur at the apex. The RSM also predicts that lightning can strike the minaret below the apex and the observed bypasses to the protrusions validated this method.

Hence, in order to protect the minaret from further damages, conventional air terminals (i.e. lightning rods) should be installed at the tips of all protrusions on the sides of the minaret. To effectively receive the lightning stroke, the air terminals on the protrusions should be pointing outwards and slanted slightly upwards at an angle. This is shown in the diagram below (Fig. 10). These air terminals can be bonded to the structural reinforcement steel bars for continuity to ground.

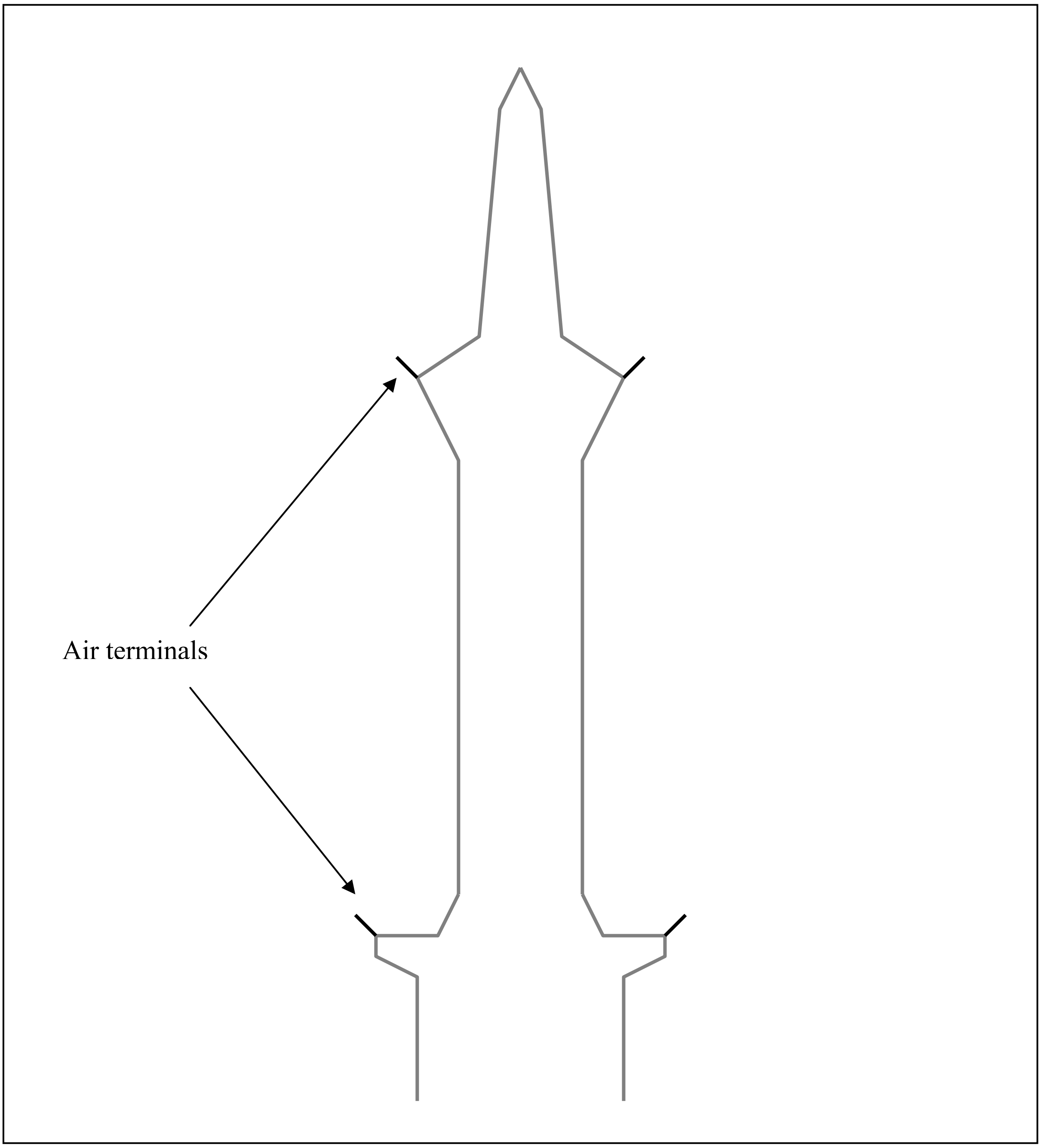

Figure 10: Vertical cross-section of the upper minaret showing the recommended position of conventional air terminals on the protrusions.

6. VALIDITY OF THE ESE STANDARD, NF C 17-102

According to the ESE standard, the protection zone starts at the tip of the ESE air terminal and takes the shape of an umbrella as it drops below the tip (Fig. 11). The radius of the protection zone at a particular height below the tip is determined by a specified mathematical formula found in the standard. At a height of about 30 metres below the tip of the ESE air terminal, the radius of the claimed protection zone should be at least 25 metres (protection level 1).

The average radius of the minaret at 30 metres below the apex is less than 5 metres, hence all the protrusions are deep within the claimed ESE protection zone. Therefore, the minaret is the ideal "ultimate test" case to validate the ESE standard, NF C 17-102.

However, the repeated failure of the ESE air terminal to prevent bypasses to the protrusions clearly suggests that the claimed ESE protection zone is non-existent and that the ESE air terminal positioning method described in the ESE standard is invalid and dangerous to apply on real buildings.

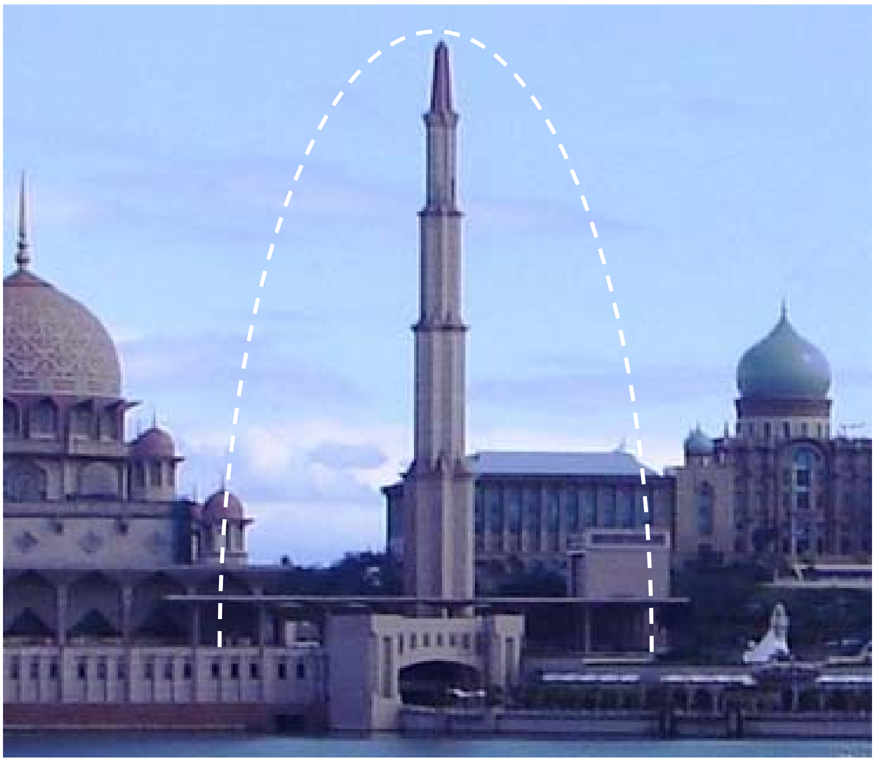

Figure 11: The dashed line indicates the claimed protection zone, according to the ESE standard NF C 17-102, of the ESE air terminal which was installed at the apex of the minaret.

7. DISCUSSION

The bypasses that occurred on the minaret of the Putra Mosque are not unique events since dozens of other similar bypasses have been observed and photographed on other buildings. They occurred well within the claimed protection zones of the ESE air terminals. A few examples of these bypasses and the nearby ESE air terminals are shown below (Figs. 12a to 12d):

Figure 12a

Figure 12b

Figure 12c

The example below shows an ESE air terminal whose positioning method follows a different design method called the Collection Volume Method (CVM). The application of the CVM has also resulted in numerous bypasses on tall buildings in Malaysia. Some of these bypasses were found to be very close to the air terminals as shown in the example.

Figure 12d

8. CONCLUSION

In our earlier article "The Bell Tower Incident at Sigolsheim" (September 2010), the ESE air terminal was found to be incapable of protecting an ancient stone cross from being struck by lightning even though the cross was installed only 6 metres away from it. The bypass occurred in spite of the fact that the tip of the ESE air terminal was higher than the stone cross, the height of the bell tower was only about 30 metres and the tower was located in a very low thunder day region (about 20 thunder days per year).

http://www.mikeholt.com/newsletters.php?action=display&letterID=930

The lightning incidents at the minaret of the Putra Mosque provide more compelling evidences that the ESE standard, NF C 17-102, is invalid. Since the ESE air terminal is incapable of protecting a tall and slender structure from direct lightning strikes, it is quite reasonable to conclude that it cannot protect real buildings too since they are much wider and their corners and edges are much closer to the limit of the claimed ESE protection zone.

This conclusion is supported by the hundreds of bypasses observed and photographed on ESE installed buildings in Malaysia over the last two decades. Some of these bypasses were found to be well within the claimed protection zone of the ESE air terminal and some were known to have caused fires on the affected roof.

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Both the Sigolsheim bell tower and the Putrajaya minaret incidents provide compelling evidences that the ESE standard, NF C 17-102, is invalid and should not be applied as an air terminal positioning method by all safety minded professionals. To do so will intentionally expose the building to direct lightning strikes and endanger the occupants and systems inside the buildings.