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PERFORMANCE OF NON-STANDARD LIGHTNING AIR TERMINALS: REVISITED

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Abstract - This study is a follow-up of earlier studies on the performance of the early streamer emission (ESE)/collection volume method (CVM) air terminals. The CVM air terminals are streamer emitting terminals that utilize the proprietary CVM air terminal placement. In this study, the various new methods used by the ESE/CVM air terminal suppliers to improve the performance of their devices, such as re-designed air terminals, asymmetrical positioning of the air terminals and the deployment of two or more air terminals on the same structure, were monitored closely. By periodically observing and photographing the vulnerable parts of the target structures, the occurrences of bypasses on some of these structures were recorded. This suggests that the new and improved methods used by the ESE/CVM air terminal suppliers were ineffective. This study shows that some of the bypass locations were very close to or immediately below the ESE/CVM air terminals. This observation further confirms the ICLP stand on the ESE/CVM air terminals i.e. that the ESE/CVM hypothesis is unfounded and that the use of these air terminals are dangerous.

1 INTRODUCTION

Since the introduction of the non-radioactive ESE/CVM air terminals about two decades ago, several hundred bypasses have been observed and photographed on buildings located in and around Kuala Lumpur that were equipped with the centrally positioned ESE/CVM air terminals. On the larger and taller buildings, multiple bypasses located within their claimed protection radii have occurred on the upper corners and curved edges of the buildings. A few of these bypasses have occurred within the first year of the air terminal installation while a much smaller but growing number of bypasses were located very close to the air terminals.

Studies on bypasses that occurred within the claimed protection radii of ESE/CVM air terminals have been published and reviewed [1-10]. Studies on the ESE/CVM hypotheses also cast doubt on their validity [11, 12]. Recent studies also suggest that the ESE/CVM air terminals cannot attract natural lightning [13, 14].

Following the publication of some of the earlier findings several years ago, the ESE/CVM air terminal suppliers have taken countermeasures to overcome the inadequacy of their air terminals. These countermeasures were monitored in the same way it was conducted earlier on the centrally positioned ESE/CVM air terminals.

A study was also conducted on the few photographs of lightning strokes attached to ESE/CVM air terminals that were published and which disputed the existence of "early streamers".

2 RECENT BYPASS OBSERVATIONS

Bypasses that occur on tall buildings equipped with the centrally positioned ESE/CVM air terminals are a very common sight in Malaysia. Most of these bypasses occurred on the corners which are located several tens of meters away from the air terminals but within their claimed protection radii.

We will now report on the new observations of bypasses that have occurred with increasing frequency in conjunction with the countermeasures undertaken by the ESE air terminal suppliers.

A. Bypasses occurring very close to the ESE/CVM air terminal

These cases are becoming increasingly common as more ESE/CVM air terminals are deployed. In buildings with multi-tiered roofs, the ESE/CVM air terminals are usually installed on the highest roof which may be centrally or asymmetrically located. In such cases, the exposed corners of the roof on which the ESE/CVM air terminals are located usually lay within 10m of the air terminal.

Since observations began nearly two decades ago, a growing number of bypasses have been observed on some of these roofs that were installed with air terminals that complied with either the NF C 17-102 [15] standard (Fig. 1), i.e.

the ESE manufacturing and installation standard published by the French ESE manufacturers, or the CVM (Fig. 2). The occurrences of bypasses were recorded on many structures protected by early streamer emission (ESE) or collection volume method (CVM) air terminals. These suggest that the NF C 17-102 standard and the collection volume method of air terminal placement are defective. Therefore, the ESE/CVM air terminals are not better than the Franklin rods.

Fig. 1 – A bypass occurred close to an ESE air terminal that is manufactured and positioned according to the NFC 17-102 standard.

Fig. 2 – A bypass occurred close to a CVM air terminal that is positioned according to the proprietary collection volume method.

B. Bypasses occurring in between two ESE air terminals

Due to the high failure rate of the centrally positioned ESE/CVM air terminals in protecting large structures from direct lightning strikes, some ESE/CVM air terminal suppliers have resorted to positioning their terminals at the corner structures instead in the hope that they can better intercept the lightning stroke and protect the building.

We now report on the case study of an 80m high residential apartment building (Crimson Apartments) near Kuala Lumpur where several apartment blocks were built in a rectangular formation around a central courtyard. An observation deck has been built on top of each of the four corner apartment blocks and an ESE air terminal has been installed on the hemispherical concrete roof of the deck. Since the tower blocks are built between 120m and 200m apart, all the buildings are located within the claimed protection radius of either one or both adjacent ESE air terminals.

Since the apartment blocks were completed in 2004, seven bypasses have been observed (Fig. 3). Six of the bypasses occurred on the facades and corners in between two adjacent ESE air terminals while one bypass occurred on the corner of a tower block a few meters away from an air terminal.

This case study suggests that the use of multiple ESE air terminals to protect a large building have not prevented the occurrence of bypasses due to lightning. The study also suggests that the repositioning of the ESE air terminals towards the corners of the building have resulted in fewer occurrences of bypasses at these locations. This result is expected since the salient upper features of the tower blocks are very close to the air terminal and are protected by it in the same way a Franklin rod protects structures close to it. This repositioning has also resulted in bypasses occurring on other salient features of the building in between the air terminals. Coupled with the occurrence of a bypass at the corner of a tower block, this case study suggests that the ESE air terminals behaved just like ordinary Franklin rods and further reinforces the suggestion that the NF C 17-102 standard is defective.

A similar study had already been conducted for the CVM air terminals which showed that bypasses had occurred between two air terminals [3].

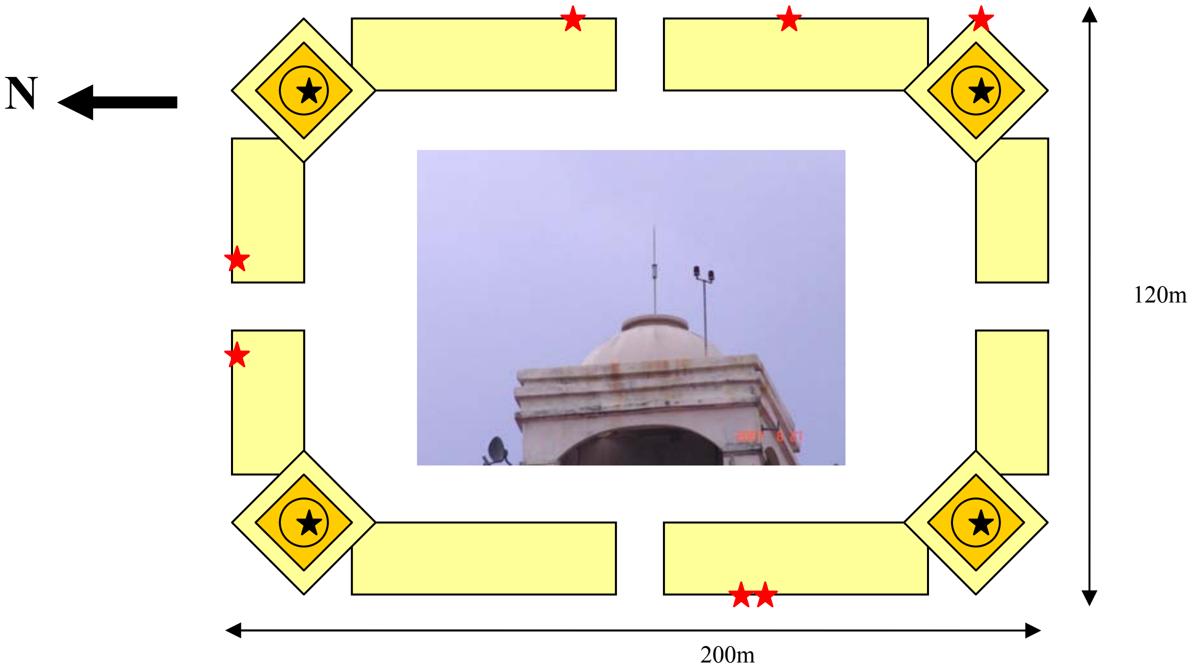

Fig. 3 – A plan view of the Crimson Apartments. The black five-pointed stars indicate the positions of the ESE air terminals on the tower block while the red stars indicate the positions of the observed bypasses. The picture in the centre of the diagram shows one of the observation decks with an ESE air terminal installed on it.

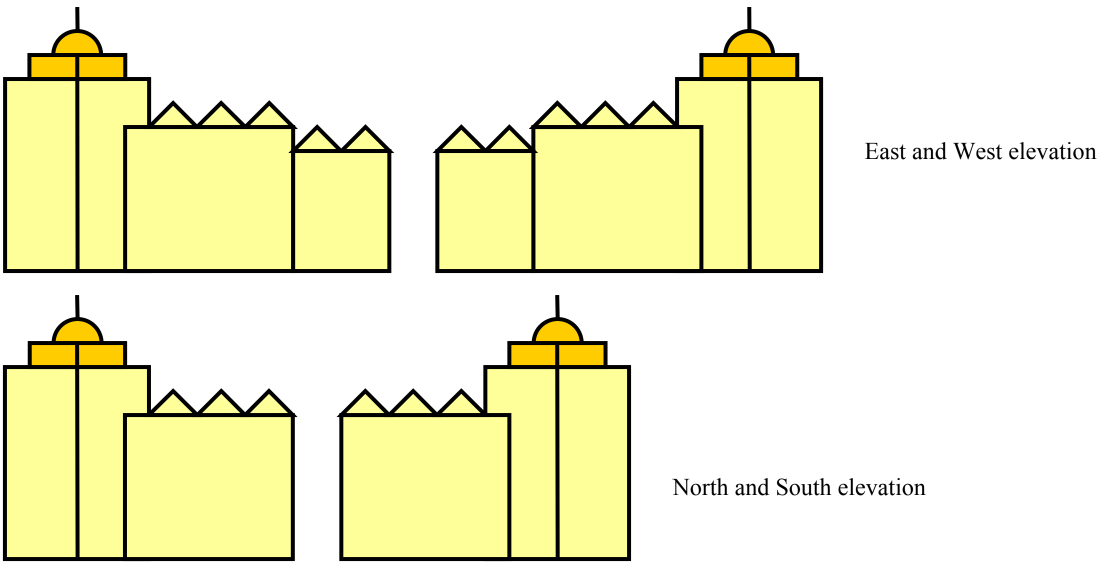

Fig. 4 – Elevation diagrams of the Crimson Apartments.

Fig. 5 – The bypass that occurred at the corner of the South-East tower block. This bypass is similar to that shown in Figs. 1 and 2.

Fig. 6 – The two bypasses that occurred at the northern side of the Crimson Apartments.

C. Bypass occurring vertically under the ESE air terminal

Lightning strokes hitting the sides of very tall communication towers and skyscrapers have been reported. This phenomenon can be easily explained by using the Rolling Sphere Method in determining the lightning attachment point to such structures.

For communication towers and other slim structures installed with the ESE air terminals, the entire structure is located well within the protection radius of the terminals. Hence, the probability of a lightning stroke hitting a slim structure is very remote if the ESE hypothesis is correct.

However, this is not the case for the 116 meter tall minaret of the grand mosque in Putrajaya, the administrative capital of Malaysia. The minaret had been installed with an ESE air terminal at the apex in 1998 and hence all parts of the structure are well within the air terminal's protection radius.

The minaret was struck by lightning and a bypass was observed on a protruding marble structure on the parapet wall of the minaret about 30 meters below the air terminal. Since the minaret has a radius of about 5m at the bypass location, it is well within the air terminal's protection radius according to the NF C 17-102 standard. This suggests that the NF C 17-102 standard is defective even for applications to very slim structures such as a minaret.

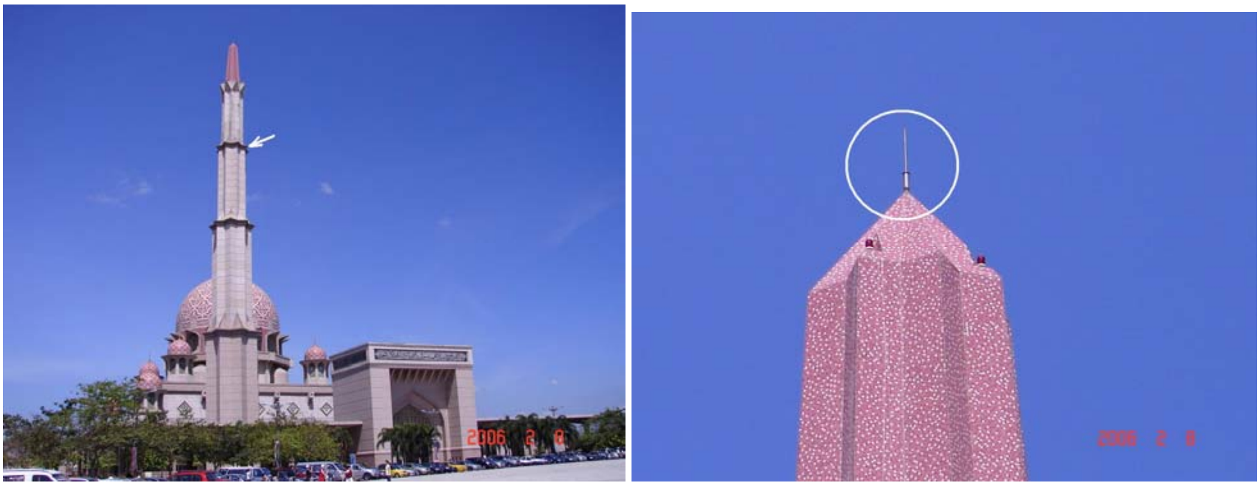

Fig. 7 – The picture on the left shows the Putrajaya mosque and the position of the bypass (arrowed). The picture on the right is a close-up photo of the apex of the minaret and shows the ESE air terminal.

Fig. 8 – The photo on the left shows the location of the bypass on the minaret. The photo of the Washington Monument on the right shows how lightning might have struck the side of the Putrajaya minaret (Courtesy: Kevin Ambrose)

3 MODIFICATION OF AIR TERMINALS

Most of the ESE/CVM air terminals commercialized two decades ago have undergone some cosmetic changes to their overall shape and size. For ESE air terminal suppliers that manufactured the terminals according to the NF C 17-102 standard, their claimed protection radii remained the same after changes were made to their air terminals. However, the CVM air terminal supplier had claimed an increase of more than 150% in the protection radius of their new air terminal.

While the original CVM air terminal had a claimed protection radius of only 80m, the new air terminal had a claimed protection radius of 202m. The claimed protection radii were mentioned in the "certificates of compliance" issued by the local CVM air terminal suppliers to the end users. However, there was no mention as to how these figures were calculated.

The claimed enhanced protection radius is doubtful since a bypass has been observed about 30m away from the new

CVM air terminal which was installed on the Dua Residency, a new residential high rise building in downtown Kuala Lumpur (Fig. 9). This bypass suggests that the new CVM air terminal is no better than the previous one at protecting buildings from lightning strikes and that the collection volume method is flawed. Incidentally, the bypass had occurred within six months of the new air terminal installation.

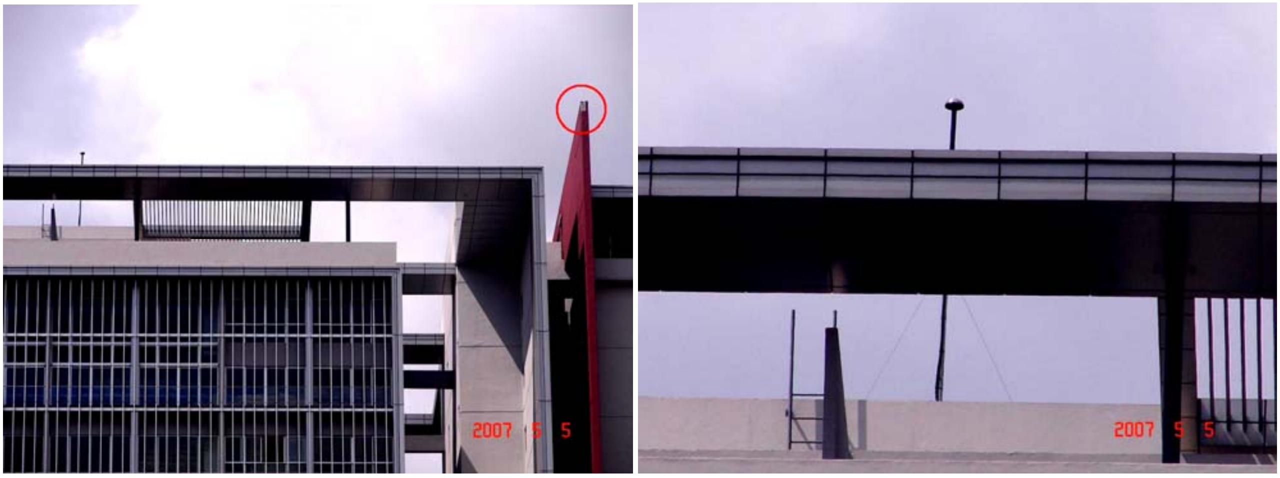

Fig. 9 – The bypass that occurred on the Dua Residency condominium (left). The new ESE air terminal (right) is positioned on the roof near the centre of the building about 30m away from where the bypass occurred.

4 LIGHTNING INTERCEPTION PHOTOGRAPHS BY ESE AIR TERMINALS

Photographs of streamers emitted by air terminals in laboratory experiments show the streamers moving upward in the direction of the high voltage discharge. In a well known 1993 photograph (Fig. 10) published by the National Geographic magazine, natural streamers emitted by grounded objects also move in the upward direction towards the downward leader. It is generally accepted that the path of the lightning return stroke follows the same path established when the upward streamer connects with the downward leader. Hence, Mousa had suggested that the “early streamer” from the ESE/CVM air terminals can be verified from the photograph of a return stroke intercepted by the terminal

Fig. 10 – A photograph showing streamers emitted in the upward direction by grounded objects. (Courtesy: National Geographic)

In the ESE/CVM hypotheses, where the direction and length of the “early streamer” forms the basis of the claimed enhanced protection radii of ESE/CVM air terminals, a photograph of the return stroke attached to an ESE/CVM air terminal should clearly support this hypothesis. Such photographs can confirm or debunk the large protection radii claimed by the ESE/CVM air terminal suppliers. Two published photographs of lightning interception by ESE/CVM air terminals, one positioned according to the collection volume method and the other according to the NF C 17-102 standard, suggest that the above ESE/CVM hypotheses are false.

The first photograph (Fig. 11) showed a lightning flash intercepted by an ESE air terminal that was positioned according to the CVM. Mousa pointed out that the presence of a horizontal component of the return stroke attached to the ESE air terminal suggested that there was no early streamer formation. Had there been an early streamer formation, the initial return stroke path would have been in the upward direction and not horizontal as shown.

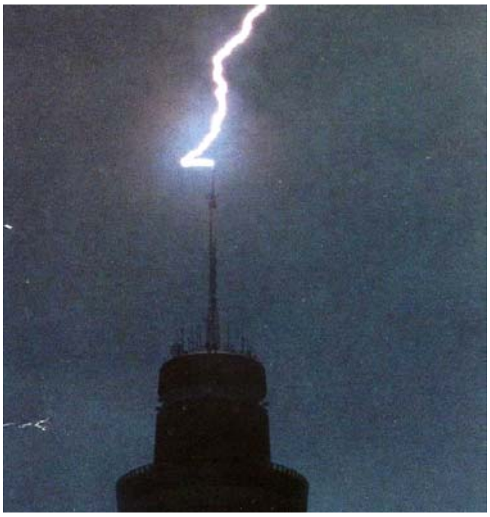

Fig. 11 – A photograph of the return stroke attached to a CVM air terminal (Courtesy: Global Lightning Technologies/Erico).

The second photograph (Fig. 12) showed a lightning return stroke intercepted by an ESE air terminal installed according to the NF C 17-102 standard. Similar to the previous photograph, there was no evidence to show that an early streamer formation had taken place from the air terminal since the initial return stroke emanating from the terminal was not in the direction of the downward leader and was non-linear.

Fig. 12 - A photograph of the return stroke attached to an ESE air terminal (Courtesy: The Star Publications, Malaysia).

5 INSULATED DOWN CONDUCTOR

This type of down conductor is normally used together with the ESE/CVM air terminal to route the lightning current through the building. This method is claimed by the ESE/CVM air terminal suppliers to be a safer method to channel the lightning current to the grounding system since the central down conductor that carries the lightning current is insulated by the outer conducting layer.

The use of this type of down conductor inside a building has been associated with breakdowns and damages to the building electrical system, in particular the elevator control system since the down conductor is usually run through or in parallel with the elevator shaft. These breakdowns were usually reported following a severe thunderstorm. It is widely believed that transients originating from the coaxial down conductor had been induced in the elevator control system cables and this led to the breakdowns.

It has been observed that some of the mounting poles of the ESE/CVM air terminals, which were made from either fiberglass or fiber reinforced plastic, have been damaged as a result of lightning strikes. This suggests that the coaxial down conductors did not fully contain the current from the lightning flash.

Fig. 13 – Photographs showing the ESE (left) and CVM (right) air terminals hanging by their down conductors as a result of damages to their non-metallic mounting poles.

6 CONCLUSIONS

With the increase in the number of bypasses to ESE/CVM air terminals, the suppliers have implemented several countermeasures to improve their performances such as redesigning the shapes of the air terminals, repositioning the air terminals toward the corners of the buildings and using multiple air terminals on larger buildings. Their actions had encouraged another round of long term observations to gauge the effectiveness of the countermeasures.

From these observations, it was found that bypasses had occurred on buildings installed with the re-designed ESE air terminals. Similar observations were obtained from buildings installed with re-designed CVM air terminals that claimed a significant increase in their protection radius.

The repositioning of ESE/CVM air terminals towards the corners of buildings seemed to have reduced the occurrence of bypasses at these locations. This is expected since some degree of protection is obtained for the tower block if the rolling sphere method is used on the relocated ESE/CVM air terminals. However, the relocation seemed to have increased the occurrence of bypasses on the other exposed parts of the building. The use of multiple ESE/CVM air terminals on a building has not prevented the occurrence of bypasses located within the protection radii of two adjacent air terminals.

A bypass had also occurred about 30m below an ESE air terminal installed on a very tall and slim structure. This event seriously put the claimed protection radii in the NF C 17-102 standard in doubt.

The damages that occurred on the non-metallic mounting poles also suggest that the coaxial cables used with some ESE/CVM air terminals cannot fully contain the lightning current. This has led to frequent breakdowns in building electrical and automation systems when the coaxial cables are run through the building instead of outside it.

The above findings suggest that the ESE/CVM air terminals and the collection volume method of air terminal placement are defective. This further reinforces the argument that the ESE/CVM air terminals are no better than Franklin rods.

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