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IN-SITU PERFORMANCE EXAMPLE OF LIGHTNINIG PROTECTION SYSTEM

Sylvain Fauveaux[1] Reynaldo Zoro[2] Bernard Thirion[3]
[1] INDELEC (France), [2] Institut Teknologi Bandung (ITB, Indonesia), [3] Institut Supérieur d'Electronique du Nord (France)

Abstract - Several lightning protection systems coexist for decades. Theoretical and some laboratory experiments were conducted to try to translate the lightning physical phenomenon into a practical way to protect structures. For more than fifteen years, some triggered lightning researches have been conducted in several countries where the lightning density is high. But in the aim to check the standard and lightning rod performances, an experiment on a real building has been preferred. So since May 2006, a new experiment has been settled in Indonesia.

1 - INTRODUCTION

Lightning researches throughout the world became very active for half a century to study and promote ways to protect peoples and buildings. As a consequence, several systems coexist for decades. Studies and practical experiments were carried out in order to create practical models for structure protection that fit lightning physics.

Furthermore, some lightning protection systems are based on the field experience and protection models proposed in the standards are still mainly rough approximations. Real life data were used as part of the models' assumptions. However, very few studies have been conducted to confirm in real life conditions that the lightning protection systems perform as they are supposed to. Air terminals protection radii evaluation, positioning and intercepted strike statistics in accordance with the required level of protection are the parameters to monitor.

The international research community made a large breakthrough in the understanding and phenomenon simulation, owing to computer algorithms [1]. Theoretical studies will probably provide new matters and requirements for future standards. However, the real life performance of the actual standards or models in terms of lightning direct protection effectiveness has not been extensively investigated [2]. This is a difficult task mainly because lightning strike probability, at the scale of a building (except some high rise buildings) is low, so a very long period of time is needed to achieve a lightning strike occurrence and therefore a significant number of strikes. So at least two major factors are required: a significantly large building and a high lightning density.

2 – EXPERIMENT SURVEY

For more than fifteen years, some triggered lightning researches have been conducted in several countries with high lightning density [3]. In order to assess the standard relevance and lightning rod performances, experiment on a real building is to be preferred. Since May 2006, a new experiment has been set up in Java - Indonesia, which is holding the world record of the largest keraunic level [4].

2.1 – SURVEY METHODOLOGY

For that purpose, a special protocol has been established. It consists in the ability to differentiate the direct discharges to the lightning rod from the direct discharges to the structure. It requires both spatial and temporal differentiation. The positioning of the conductors and the counters allow the identification of the strikes hitting the lightning rods or the building. The analysis of the lightning events is eased thanks to the collected data of the date/time stamping flash counters. Figure 1 is a schematic design of this experimental set up.. This example includes five counters : two on each side of the building and one at the top below the lightning rod. The top of the structure is equipped with Early Streamer Emission lightning rod(s) connected to the down conductor network and top belt (collecting conductor).

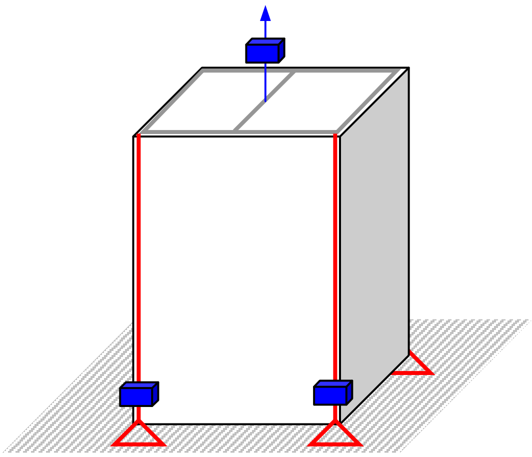

Figure 1 – Example of experimental set-up

This collecting conductor is designed to check if the lightning strikes the ESE or the building: failure of ESE coverage or discharge current lower than the minimum current given by the model [5]. It is well known that corners and edges of buildings are more prone to lightning attachment than the roof surface [6]. The conductor (gray color) is dedicated to collect the lightning in such a case and should therefore follow closely roof edges. The lightning counters are designed to measure the current (to check if the current is inside model limits or not) as well as the date and time of each event. With this light instrumentation lightning strikes on the the ESE air terminal or on another conductor are recorded. In the second case, it can be then assessed of this is due to a failure of the ESE air terminal or or if the current is too low to be collected (according to model).

2.2 – LOCATION AND EQUIPMENT

The experiment began on the 18th of May 2006. It is held at the *PAU* (*IUC*, Inter University Center) building of the Institute of Technology of Bandung (*ITB*) located in Java Island (Indonesia). The experiment is locally surveyed by Pr Reynaldo Zoro from the Laboratory of High Voltage and High Current Engineering (*ITB*). The location features are included in *Table 1*. The building is an 8 floors building located inside the ITB compound. This building has steel reinforced concrete roof and steel reinforced concrete walls. It is used as office, laboratory and radio station.

Country	Indonesia
City	Bandung
Coordinates	06°53'17''S, 107°36'36''E
Flash density	8.06
Ground flash density	7.06
Keraunic level	120
Altitude	847m ASL
Building Height	40.8m
Building Width	43.2m
Building Length	72.6m

Table 1 – Test location characteristics

Figure 2 illustrates the complete external lightning protection system. Towers A and B are both equipped with ESE lightning rods (Indelec Prevectron S6.60, 60µs) and one lightning discharge counter each. All the downconductors are also equipped with one lightning discharge counter. The earth terminations are bonded via an earth ring surrounding the building. Each earth termination show a measured resistance slightly below 10Ω.
According to the ESE standard in level I, the radius of protection of the air terminals reaches 78m which is sufficient for our case. As the two towers are by far the highest spots of the structure, then a second lightning rod were necessary to insure a perfect protection of the second tower and thus the entire building down to the ground.
Lightning rods and lightning discharge counters comply with the related standards NFC17102 [5], UTEC17106 [7]. These equipments were tested resistant at least up to 100kA laboratory lightning impulse. The lightning discharge counter technology relies on CEM robust electronic circuits involving microcontrollers, not on electro-mechanical systems.

3 - RESULTS

Since the beginning of the experiment, we recorded several lightning discharges on different counters. The following tables (*Table 2* to *Table 6*) gather all the data collected. Tower A (17m) was not initially equipped with a date stamping counter with peak current measurement ability. However, a magnetic tape sensor (single-use only) was fitted in order to record the lightning peak current.
The counter (CCF3#1) of Tower B (24m) was swapped with a new model (P8014#1) in June 2009.

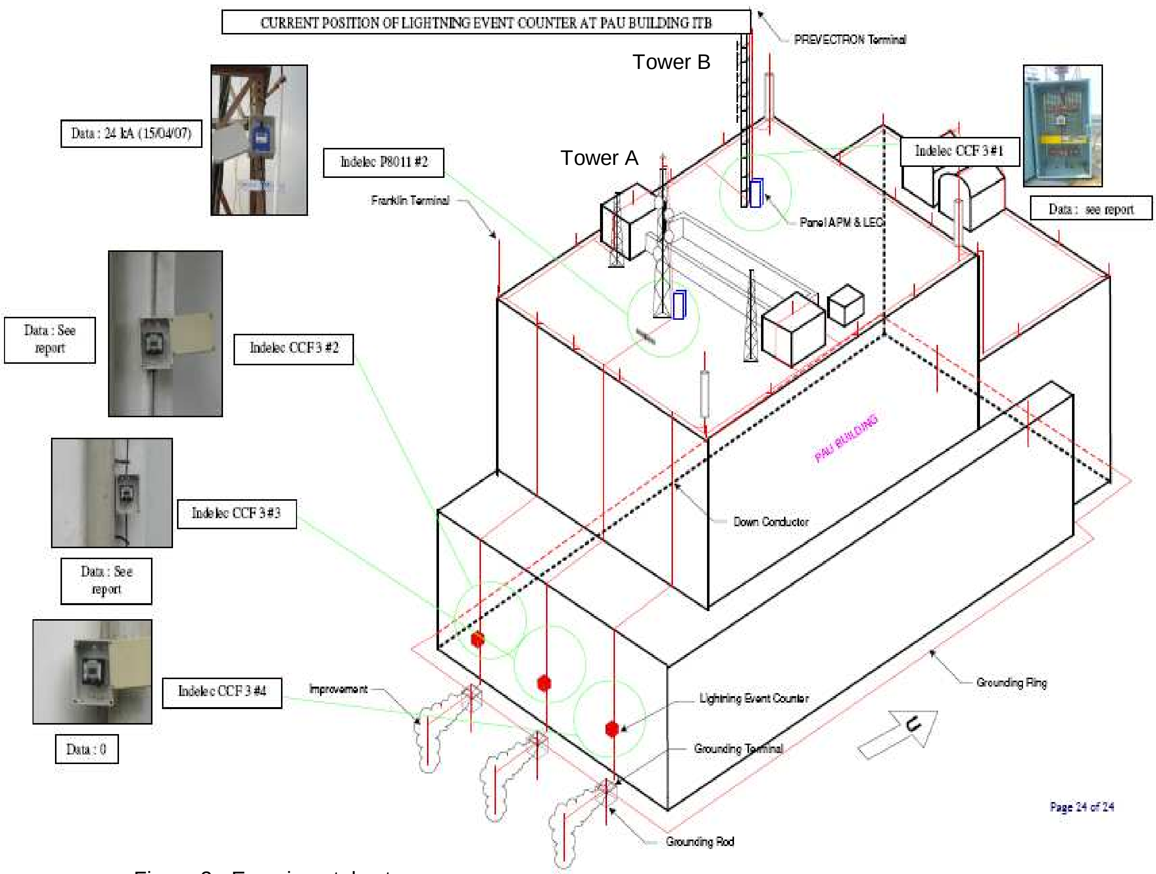

Figure 2 - Experimental set-up

Display	Read date	Peak current	Event
0 to **1**	15/04/07	24kA	#1

Table 2 – Tower A (P8011#2)

Display	Time	Date	Peak current	Event
3 to **4**	8:41	09/04/08	0.9	#4
2 to **3**	8:37	09/04/08	0.9	#3
1 to **2**	8:15	31/03/08	3.7	#2
0 to **1**	8:15	31/03/08	5	#2

Table 3 – Tower B (CCF3#1)

Display	Time	Date	Peak current	Event
0 to **1**	14:00	29/12/09	3kA	#5

Table 4 – Tower B (P8014#1)

Display	Time	Date	Peak current	Event
0 to **1**	06:41	10/04/07	1.7kA	#1

Table 5 – Bottom of the building (CCF3#2)

Display	Time	Date	Peak current	Event
3 to **4**	6:30	10/04/07	0.9	#1
2 to **3**	6:30	10/04/07	0.9	#1
1 to **2**	6:30	10/04/07	3.7	#1
0 to **1**	6:29	10/04/07	5	#1

Table 6 – Bottom of the building (CCF3#3)

Display	Time	Date	Peak current	Event
0	-	-	-	-

Table 5 – Bottom of the building (CCF3#4), no data

4 – ANALYSIS OF THE RESULTS

All the data were studied to identify all the lightning events that occurred to the building. The rightmost column of each Table indicates the related events. We were able to identify 5 different events.

Event #1 : 10/04/07
One flash to tower A, recorded by counters P8011#2, CCF3#2 et CCF3#3 (11 minutes internal clock time shift).

Event #2 : 31/03/08
One flash to tower B, recorded by the counter CCF3#1.

Event #3 : 09/04/08
One flash to tower B, recorded by the counter CCF3#1.

Event #4 : 09/04/08
One flash to tower B, recorded by the counter CCF3#1.

Event #5 : 29/12/09
One flash to tower A, recorded by counters P8014#1.

We can observe that the CCF counter model is sensible to subsequent strokes, not P8011 and P8014. One of the installed counter (CCF3#4) never recorded a single event, suggesting its faulty status. Event #3 and #4 show very low peak current on tower B, these events has not been recorded by any other counters. Indeed, the roof and down conductors are splitting the current, detection threshold being a tad below 1kA as per standard requirements [7;8].
In order to use the most useful counters and to comply with the newest standard EN50164-6 [8], from June 2009, we gradually swapped the installed counters with P8014 units featuring longer battery life, no subsequent stroke detection, date/time stamping and peak current measurement.

5 - CONCLUSION

In the lap of four years, the installed lightning rods have been hit several times by lightning strikes. No lightning rod bypass or damage to the structure was noticed or recorded. Since the building has not been hit, the lightning strike capture probability is 100% success proving the efficiency of the installed lightning rods and their associated lightning direct protection standard. Prior studies [9;10] led to similar the conclusion.
The experiments are still in progress in order to gather larger occurrence. At the same time, a new site is opening in South America to lessen the time needed to record large numbers of lightning strokes.

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Main author
Name: Sylvain FAUVEAUX
Address: INDELEC 61 Chemin des Postes 59500 Douai - FRANCE
Fax: +33 327 944 945; Phone: +33 327 944 293
E-mail: sfauveaux@indelec.com