High Wind Damage in Japan from Typhoon Maemi and Choi-wan on September 2003

by

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ABSTRACT

This paper presents outline of field investigations of high wind damage by two typhoons occurred in September 2003. Typhoon Maemi attacked Miyako Island and typhoon Choi-wan did Hachijo Island, respectively. Not only low-rise buildings but also wind turbine generator systems in Miyako island experienced collapses or severe damage, and traditional timber houses in Hachijo island had damage on roofing materials and so on.

KEYWORDS: Field Investigation, High Wind Damage, Typhoon, Wind Turbine Generator System

1. INTRODUCTION

On September 11th, 2003, Typhoon Maemi attacked Miyako Island located in the southern-west part of Okinawa prefecture, where buildings and constructions including wind turbine generator systems were damaged seriously. The typhoon made the closest approach to Miyako Island from 03:00 to 04:00 JST on September 11th and the maximum wind speed of 38.4m/s (03:10JST) and the maximum instantaneous wind speed of 74.1m/s (03:12JST) were observed at the local meteorological observatory in Miyako Island. The latter record value ranks seventh largest one among the past records in Japan. The lowest atmospheric pressure at sea level of 912.0hPa, which corresponds to the forth lowest value among the past records, was recorded at 04:12 JST, when the eye of the typhoon was passing. During the passing of the typhoon through the island, there were one of the dead and 96 of the injured, and about 1,900 electric poles were damaged and fallen down, which induced power failure and traffic difficulties in every area of the island. As for the damaged buildings and constructions, lots of broken windows and claddings of residential buildings and damaged roofing materials of public facilities such as gymnasiums were observed. All of the seven wind turbine generator systems were damaged, and three of which were collapsed.

On September 22nd, about ten days after the attack of Maemi on Miyako Island, following Typhoon Choi-wan attacked Hachijo Island in Pacific Ocean to the south of Tokyo. The recorded maximum instantaneous wind speed of 59.5m/s (23:24JST on September 21st) ranks the second largest one among the past records in Hachijo Island. Fortunately there weren't the dead or the injured, but about 200 local timber houses were damaged.

Local people in Miyako and Hachijo Island had been tightening against the attack of these typhoons, since both islands have ever experienced several huge typhoons which caused severely damaged disasters. The authors investigated the damaged buildings and constructions in both islands with other members of Japan Association for Wind Engineering (JAWE)[1][2] and released prompt reports[3][4] on the website of Building Research Institute. This paper describes the outlines of how the local houses and public facilities were damaged by typhoon Maemi and Choi-wan.

2. METEOROLOGICAL RECORDS

2.1 Typhoon Maemi

Fig.1 shows the course of the typhoon Maemi and Fig.2 shows the image of it. It approached the closest to Miyako Island from 03:00 to 04:00JST on September 11th and the direction of the movement changed from NW to NNE during

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passing through Miyako Island. At the Miyakojima local meteorological observatory, the maximum wind speed of 38.4m/s (03:10JST) and the maximum instantaneous wind speed of 74.1m/s (03:12JST) were observed respectively and the latter record value ranks the seventh largest one among the past records in Japan. The lowest atmospheric pressure on mean sea level dropped to 912.0hPa at 04:12 JST, which corresponds to the forth lowest value among the past records. Table 1 and 2 show the past records of maximum instantaneous wind speed and lowest atmospheric pressure on the mean sea level, respectively in Japan.

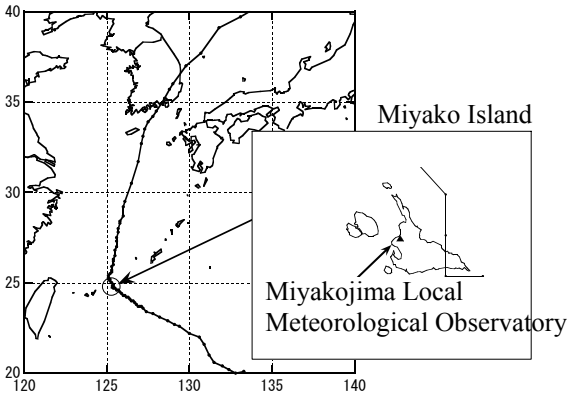

Fig.1 Course of Typhoon Maemi

Fig.2 Image of Typhoon Maemi

2.2 Typhoon Choi-wan

Typhoon Choi-wan approached Hachijo Island and its nearest was from 00:00 to 01:00 JST on September 22nd. The lowest atmospheric pressure on the mean sea level of 958.6hPa was recorded at the Hachijo local meteorological observatory. The recorded maximum instantaneous wind speed of 59.5m/s (23:24JST on September 21st) ranks the second largest one among the past records in Hachijo Island. Fig.3 shows the course of the typhoon.

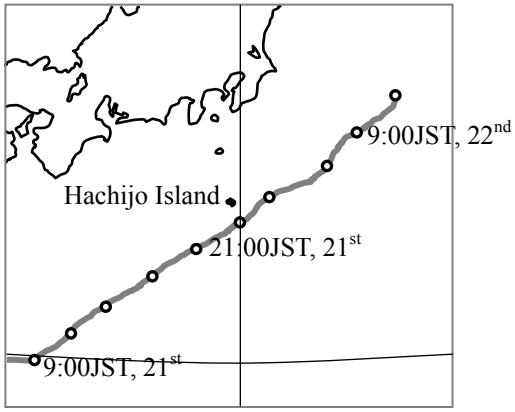

Fig.3 Course of Typhoon Choi-wan

3. DAMAGE OF BUILDINGS AND FACILITIES

In this section, the outline of buildings and public facilities damaged due to the attack of typhoons is illustrated. Houses in Miyako Island are usually constructed with reinforced concrete, since timber houses experienced wind damage in past three strong typhoons on September 15th, 1959, September 5th, 1966 and September 22nd, 1968. Therefore, in Miyako Island, not so much damage of houses was reported except that of very old timber ones. In spite of relatively small damage of houses, lots of shops and public facilities such as public halls and gymnasiums received significant damage, most of which were peeling-off of roofing materials and breakage of shop windows and walls due to flying debris. There were seven wind turbine generator systems in this island and high wind damage were observed on all of them. Fig.4 shows wind speeds observed at several points and estimated by damaged traffic signs and so on. According to this figure, it is possible that the wind they experienced was thought to be over 80m/s.

Most houses in Hachijo Island, on the contrary, are still constructed by conventional method of timber construction and many of them were damaged by Typhoon Choi-wan. It is noted that the damaged rate of buildings by this typhoon is much smaller than that by typhoon occurred in 1975, which recorded the largest maximum instantaneous wind speed in Hachijo Island, 67.8m/s. Probably it may be because the performance of houses against high wind have been improved by developing useful methods of construction and so on.

3.1 Public Facilities

In Miyako Island, lots of public facilities such as an airport control tower, public halls and gymnasiums were severely damaged. Observed damage was on the roofing materials and cladding elements such as external wall finishing, windows and so on. The causes of damage in roofing materials can be considered to be the effects of external local suctions and sudden increase of internal pressures. Most of the damage of external wall finishing and windows were caused by flying debris, but it is possible that the windows on airport control tower shown in Photo.1 was damaged by not flying debris, but external gust pressure.

Photo.1 Damaged Windows on Airport Control Tower (Miyako Island)

Photo.2 Damaged Roofing Materials of Public Hall (Miyako Island)

Photo.3 Separation of Roofing Materials of Gymnasium (Miyako Island)

Photo.4 Exfoliation of Roofing Materials of Gymnasium (Miyako Island)

Photo.5 Damaged Wall by Flying Debris (Miyako Island)

Photo.6 Broken Metal-framed Window and Ceiling Finish Materials of Gymnasium (Miyako Island)

3.2 Houses

As briefly described above, since houses in Miyako Island are usually constructed by reinforced concrete, there were not so many collapsed or damaged houses except old timber houses as shown in Photo.7. Just next to the collapsed one, there were non-damaged timber house shown in Photo.8, in which useful measures are taken for avoiding high wind damage with windows covered by lattices and with crevices of each traditional roof tiles covered up with plaster.

Timber houses damaged by high wind in Hachijo Island experienced not only damage on roofing materials and cladding elements, but also structural damage on roof frames. As shown in Photo.10, around the damaged house with collapsed roof frames, there are few trees or kind of windbreaks, which exposed the house in circumstance subjected to high wind damage. In Hachijo Island, some high wind damage which was considered to be occurred due to topographic effects was observed as well. The damaged house shown in Photo.9 is constructed at the location between a hill and a mountain and the collapsed trailer house in Photo.12 stands just near the cliff of seashore, respectively. Since kind of mountain valley and cliff are considered to generate amplification of wind speed, these houses are supposed to have experienced relatively higher wind effects.

Photo.7 Collapsed Old Timber House (Miyako Island)

Photo.8 Non-damaged Timber House next to Collapsed One Shown in Photo.7 (Miyako Island)

Photo.9 Exfoliation of Roofing Materials on Timber House (Hachijo Island)

Photo.10 Collapsed Roof Frame of Timber House (Hachijo Island)

Photo.11 Marked Contrast between Damaged and Non-damaged Houses (Hachijo Island)

Photo.12 Collapsed Trailer House Standing near Cliff of Seashore (Hachijo Island)

3.3 Wind Turbine Generator System

All the wind turbine generator systems in Miyako Island were collapsed or partially damaged by Typhoon Maemi. Their damaged parts are not only blades and nasals, but also structural elements including tower and footing. Specifications and damaged conditions of the systems are listed in Table 3. The height of all the systems is over 30m above ground. Generally, wind turbine generator systems are supposed to be designed to stop their propellers rotation by, for example, changing pitch of blades in order to reduce wind loads on a tower and blades in case of high wind more than 25m/s. Since lots of wind turbine generator systems have been recently constructed in Japan and there aren't so many accumulated data of damage, it is important to clear how they collapsed or damaged under high wind in detail, which seems to lead to contribution toward structural design of wind turbine generator systems in Japan.

Photo.13 Broken Blades and Nasal of Wind Turbine Generator System (Miyako Island)

Photo.14 Broken Tower of Wind Turbine Generator System (Miyako Island)

Photo.15 Collapsed Wind Turbine Generator System with Its Footing Pulled Out (Miyako Island)

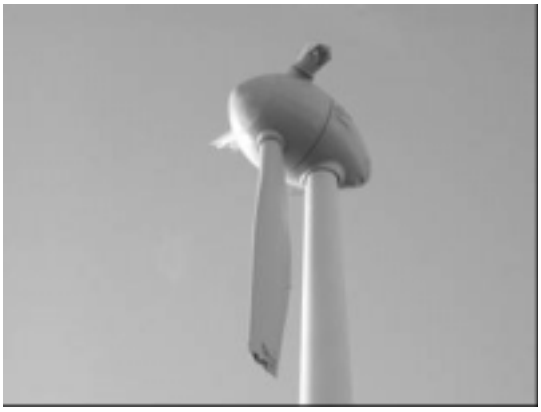

Photo.16 Damaged Blades of Wind Turbine Generator System (Miyako Island)

3.4 Traffic Signs, Electric Polls and Others

Not only buildings and power systems, but also traffic signs and so on experienced high wind damage by the typhoons as shown in Photos.17 to 21. Many rows of collapsed electric poles were seen and reported in Miyako Island, and which led to difficulties of traffics and breaks in the power supply.

Photo.17 Collapsed Traffic Sign (Miyako Island)

Photo.18 Row of Collapsed Telegraph Polls (Miyako Island)

Photo.19 Damaged Roof of Gas Station by Flying Debris (Hachijo Island)

Photo.20 Fallen Bus (Miyako Island)

Photo.21 Fallen Trees (Hachijo Island)

4. CONCLUSIONS

This paper reported field investigations of high wind damage in Miyako and Hachijo Islands by typhoons occurred in 2003. Though the damage reported here is what were observed in islands with special geographical features, the lessons obtained from these investigations must be widely applicable to general wind resistance design for low-rise buildings and wind turbine generator systems.

5. ACKNOWLEDGMENT

The authors would like to acknowledge the contributions on the field investigation of high wind damage in both of Miyako and Hachijo islands to the following members of the JAWE investigation team: Prof. Masahiro MATSUI, Prof. Yukio TAMURA, Dr. Manabu TSUCHIYA, Mr. Manabu YAMAMOTO, Mr. Koji HAYASHIDA, Dr. Koji KONDO, Dr. Kunio FUJII and Dr. Yoshio WAKIYAMA.

6. REFERENCES

1. Okuda, Y. et al.: High Wind Damage in Miyako Islands under Typhoon Maemi (2003), *Wind Engineers*, No.97, 2003 (in Japanese).
2. Kikitsu, H. et al.: High Wind Damage in Hachijo Island under Typhoon 15th, 2003, *Wind Engineers*, No.98, 2004 (in Japanese).
3. http://www.kenken.go.jp./japanese/research/str/list/topics/miyako-chosa/miyako-taifu-soku.pdf
4.

http://www.kenken.go.jp./japanese/research/str/lis t/topics/hachijo-chosa/hachijo-taifu-soku.pdf

Table 1 Past Records of Maximum Instantaneous Wind Speed

Rank	Location	Wind Direction and Speed	Date
1	Miyakojima (Okinawa pref.)	NE 85.3m/s	Sep. 05, 1966
2	Murotomisaki (Kochi pref.)	WSW 84.5m/s	Sep. 16, 1961
3	Miyakojima (Okinawa pref.)	NE 79.8m/s	Sep. 22, 1968
4	Nase (Kagoshima pref.)	ESE 78.9m/s	Aug. 13, 1970
5	Miyakojima (Okinawa pref.)	NNE 78.0m/s	Sep. 23, 1968
6	Murotomisaki (Kochi pref.)	WSW 77.1m/s	Sep. 10, 1965
7	Miyakojima (Okinawa pref.)	N 74.1m/s	Sep. 11, 2003
8	Naha (Okinawa pref.)	S 73.6m/s	Sep. 08, 1956

Table 2 Past Records of Lowest Atmospheric Pressure Reduced on the Mean Sea Level

Rank	Location	Atmospheric Pressure	Date
1	Okinoirabu (Kagoshima pref.)	907.3hPa	Sep. 09, 1977
2	Miyakojima (Okinawa pref.)	908.1hPa	Sep. 15, 1959
3	Murotomisaki (Kochi pref.)	911.6hPa	Sep. 21, 1934
4	Miyakojima (Okinawa pref.)	912.0hPa	Sep. 11, 2003
5	Makurazaki (Kagoshima pref.)	916.1hPa	Sep. 17, 1945

Table 3 Specifications and Damaged Condition of Wind Turbine generator systems in Miyako Island

Name	Karimata Wind Turbine generator systems				Nanamata Wind Turbine generator systems		Miyako Land Improvement Project
	No.3	No.4	No5	No.6	No.1	No.2	
Location	Hirara City, Karimata Area				Gusukube Town, Nanamata Area		Ueno Village
Nominal Output	400kW/100kW			600kW	500kW	600kW	600kW
Number of Blades	3	3	3	3	3	3	3
Diameter of Rotor	31m			44m	40.3m	42m	47m
Height of Tower	36m			46m	44m	35.3m	33.7m
Foundation Date	Dec. 1995			Mar.2003	Aug.1998		Oct.2000
Damaged Condition	Collapse of Tower	Scatter of Nasal Cover	Collapse of Tower	Scatter of Blades	Pulling out of Footing	Scatter of Blades	Scatter of Blades

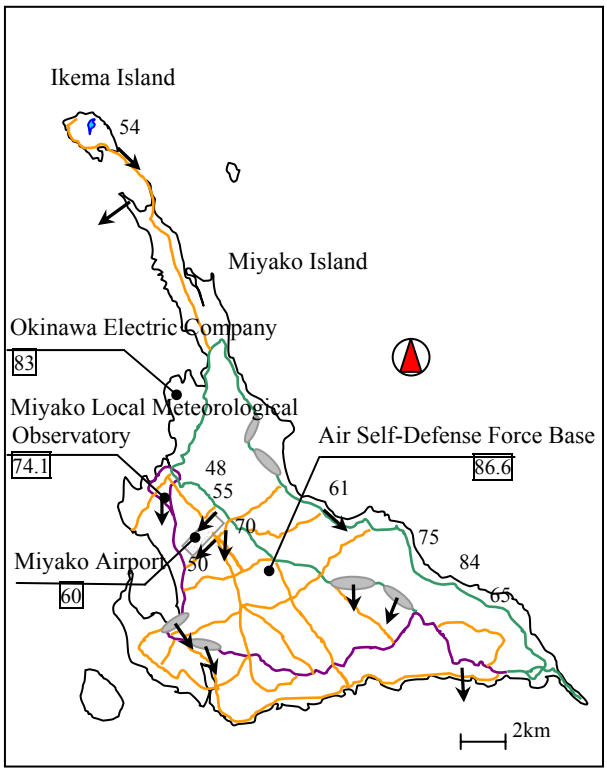

Fig.4 Wind Speed Observed at Several Points and Estimated by Damaged Signs, etc in Miyako Island (unit: m/s)

(Framed Values indicate wind speeds observed at each point and non-framed values indicate wind velocities estimated with wind pressure coefficients and material strength of damaged traffic signs. Arrows indicate directions of fallen telegraph poles.)