APEC-WW2010 Economy Report: Chinese Taipei

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ABSTRACT: Taiwan lies in the path of severe tropical cyclones known in East Asia as typhoons. With their violent winds and extremely heavy rainfall, these storms often cause severe damages. Also, dense populated urban areas and numerous ongoing economic activities have caused serious environmental problems, especially the air pollution problems. Most Asia-Pacific Economics face the same problems as Taiwan. This paper provides the information of wind structural loading codes and status of wind disaster and loss and post-disaster reconstruction of Typhoon Morakot overviews of Taiwan as references for neighborhood countries to improve individual standard/specification and to harmonize the wind load and wind environmental specifications in APEC.

KEYWORDS: building wind code, design wind load, wind disaster loss, post-disaster reconstruction, Typhoon Morakot

1. INTRODUCTION

The current wind load provisions for Taiwan building code and the *Specifications for Building Wind Resistant Design* was announced in January 1st, 2007. Since these were insufficient wind code related researches in Taiwan, this building wind code is a combined transformation from USA and Japan wind code, i.e., ASCE7-02 and AIJ-96. This article will describe the framework of this building wind code (detail can be found in the APEC-WW 2004 report).

According to the historical data from 1990 to 2009, there were at least three land typhoon warnings issued every year, and the average numbers of typhoons to land were three. The data from 2002 to 2009 shows that the average of insurance indemnity for wind disaster losses were all below 7%, average was 3%, amongst the engineering disaster losses in a year, except in 2002, the insurance indemnity was 12%. Typhoon Morakot wrought catastrophic damage in Taiwan, leaving 681 people dead and 18 others missing. The storm produced copious amounts of rainfall, peaking at 3,079 mm (121.2 in). The extreme amount of rain triggered enormous mudslides and severe flooding throughout southern Taiwan. To effectively carry out the reconstruction, the Morakot Post-Disaster Reconstruction Council was formed on August 15, 2009. (7 days after Typhoon Morakot Disaster)

1 CURRENT STATUS AND FUTURE DEVELOPMENT OF TAIWAN BUILDING WIND CODE

1.1 *Taiwan building wind code*

Taiwan building wind code, “*Specifications for Building Wind Resistant Design*“, is constructed primarily based on the wind load provisions in the ASCE Standard: *Minimum Design*

Loads for Buildings and Other Structures (ASCE 7-02), with augmentations on the acrosswind and torsional design wind loads from the AIJ Recommendations for Loads on Buildings (AIJ-96). The Taiwan building wind code, "*Specifications for Building Wind Resistant Design*", consists of six chapters; including (i) General (ii) Design Wind Loads for Main Wind Force Resisting Systems (iii) Design Wind Loads for Components and Cladding (iv) Wind Induced discomfort (v) Wind Tunnel Test (vi) Other Issues. Details of the Specification can be found in the APEC-WW 2004 report [4]. The 10-minute wind speed with return period of 50 years, at 10m height in open country is used as the basic design wind speed.

1.2 *Areas for future wind code revision*

In Taiwan, almost all residential buildings are engineered reinforced concrete structures to resist strong earthquake, these buildings are generally robust for the wind loads. Therefore, Taiwan building wind code is mainly for the wind resistant design of tall building and large span roof structures during strong typhoon. In other words, by adopting wind code from nation with different building types, terrain configurations and wind climates, there will be inevitably some deficiency in the wind code that needed to be modified to better fit into Taiwan's unique requirements. A few wind code provisions are currently under investigation for the future revision.

1.2.1 *Wind profile characteristics*

In the current Taiwan building wind code, the wind profile was classified into three categories: Exposure A (large city) with power law exponential $\alpha = 0.32$ and gradient height $\delta = 500m$; Exposure B (suburban) with $\alpha = 0.25$ and $\delta = 400m$; Exposure C (open country) with $\alpha = 0.15$ and gradient height $\delta = 300m$. This classification was originally from ASCE7 with minor modifications. It is essential to define the turbulent boundary layers that would truly reflect the local wind characteristics and the terrain effects. Currently, there is ongoing field measurement project to collect wind profile data for the next version of Taiwan wind code. Some of the field measurement data is presented in this report.

1.2.2 *Wind load combination*

Since Taiwan building wind code is a combination and compromise of ASCE7 and AIJ recommendations, certain uncoordinated situation would be inevitable. It was found that, for certain building geometry, mainly buildings with low aspect ratio, the acrosswind/ torsional design wind loads and wind load combination are not well defined. Therefore, the ASCE7-05 article 6.5.12.3, design wind load cases, is proposed for buildings with low aspect ratio.

1.2.3 *External pressure coefficients*

A relatively simple version of external pressure/force coefficients was adopted in the current Taiwan wind code. Reference to a few national wind codes, a more comprehensive version of external pressure/force coefficients is proposed to replace the current one.

1.2.4 *Comfort criteria*

For most of the building design in Taiwan, the design lateral loads for main structural systems are generally dominated by seismic loads. Wind loads become the dominant design lateral loading largely due to the serviceability concern instead of structural strength. The current building wind code specifies that the peak lateral acceleration at corner of a building's highest inhabited story should not exceed a flat number 0.05 m/s^2 under six months return period wind speed. This article has caused some controversy among building designers for the comfort criteria check-up is mandatory for all buildings whilst most of cases are known to be satisfactory. Therefore, it will be proposed that a regular shaped building with height less than 50 meters shall be exempt from conducting the comfort criteria check.

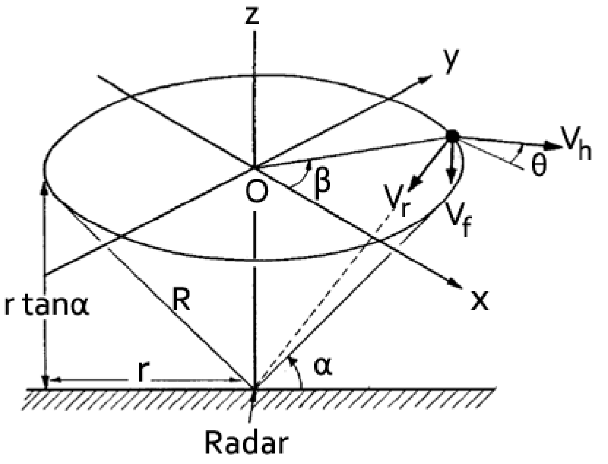

Fig. 1. Diagram of VAD (modified from Browning and Wexler, 1968)

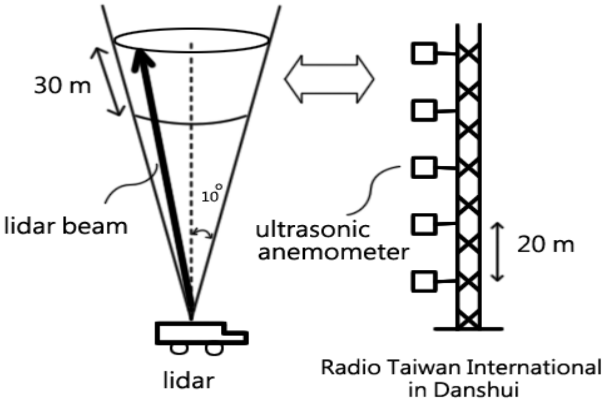

Fig. 2. Diagram of the comparison experiment

2. SOME PROGRESS ON THE WIND PROFILE STUDY

The traditional strategy for wind profile measurement is to install anemometers on a high tower or mast. Normally it is difficulty to find an appropriate tall mast on the frequent typhoon routes. The other option will be introducing portable remote sensing devices that can be brought to meet the high wind. Sodar (Sonic detection and ranging) system has been used by many wind engineering researchers to take measurement of the atmospheric boundary layers. Sodar system emits acoustic pulses and receives the return signals. The wind speed and wind direction are calculate from the intensity and the Doppler frequency shift of the acoustic signals. On ideal situations, the Sodar systems have maximum ranges up to several hundred meters. The short come of Sodar system is noise: it emits annoying noise that limits its usefulness in the residential areas. On the other side, Sodar system is sensitive to the background noise that limits its usefulness in the raining situation. Unfortunately, typhoon is almost always with quite heavy rain.

Lidar is a meteorology instrument available in recent years. The principle of Lidar is similar to weather radar. The differences are Lidar use the shorter electromagnetic wave in wavelength and get the information via the scattering of the aerosol in the atmosphere. Less operation noise, safer electromagnetic waves and better portability are the advantages of Lidar. At the same time, the shorter wavelength means much more attenuation especially met the thick and moist atmosphere. Although Lidar has weakness in some specific weather condition, it is one of the better remote sensing instrumentation for the measurements of low-level atmospheric data.

1.3 *Lidar specification and wind speed measurement*

The Mitsubishi model LR-08FSⅢ Lidar was used in this project. The wavelength is 1.5 to 1.6 micrometer; the pulse width is 200 nanosecond; the spatial resolution is 30 meter; the possible observation rage is from 30 to 600 meter above the ground; the maximum radial wind velocity is 30 m/s; in theory, the maximum horizontal wind velocity could reach 173 m/s; the maximum wedge speed is 20 degree per second, 18 second to make a full circle.

Lidar measure the movement of aerosol to calculate the wind field data. In order to compute the wind field on each layer, the VAD (Velocity-Azimuth Display) method was used. The diagram of VAD (Browning and Wexler, 1968) is shown in Figure 1.The center on the ground is the location of Lidar. The east-west direction regard as x axis; north-south direction is y axis; the vertical direction is z axis. Lidar system emits laser beams in a circular motion at constant wedge speed with elevation angle α. An imaginary horizontal circle with radius r can be established at various altitudes. Since Lidar measures the radial wind velocity V_r only, the horizontal and vertical wind speed at the center of the imaginary circle was decomposed from the radial wind speed through.VAD method. Since the full circle measurement data was then used to estimate the mean wind speed at center, Lidar can not produce turbulence feature in the current data processing scheme.

1.4 *Comparison with ultrasonic anemometer*

In order to validate the accuracy of the Lidar system, the measurements of two-dimensional ultrasonic anemometers installed on a100 meter mast was used for comparison. Five calibrated ultrasonic anemometers were installed at 20, 40, 60, 80 and 100 meter. The wind speed and wind direction measurements of both Lidar and ultrasonic anemometer at 60m were compared and shown in Figure 3 and 4. Generally speaking, the wind direction given by Lidar system is quite consistent with the ultrasonic anemometer measurement. As the wind speed measurement, when the mean wind speed is higher than 8 m/s, the difference between two instrumentations is less than 10%, usually, Lidar gives the higher value. But the error percentage can be unacceptably high when the mean wind speed is less than 5 m/s.

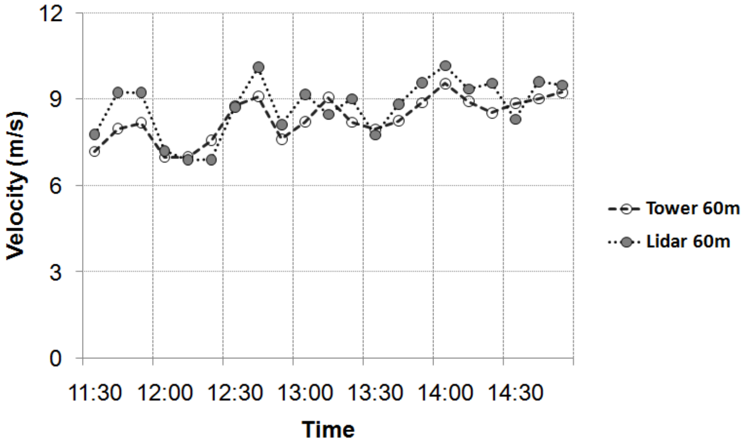

Fig. 3. 10-minute average wind velocity comparison of Lidar and ultrasonic anemometers (60m, 3 September 2009)

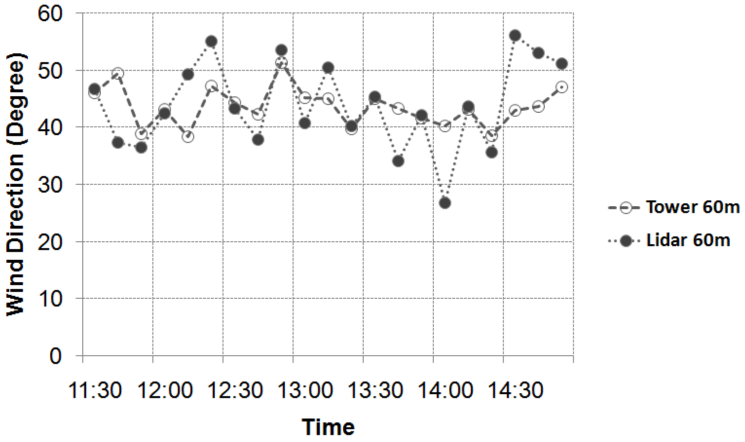

Fig. 4. 10-minute average wind direction comparison of Lidar and ultrasonic anemometers (60m, 3 September 2009)

Wind profile at urban terrain

During the last monsoon season, form 2009/12 to 2010/4, several wind profile measurements were taken at a monitoring site with urban environment. This monitoring site locates in a residential-commercial mixed region. Most surrounding buildings are 4 to 7 stories residential apartment buildings, some 10 to 12 story commercial buildings, very few higher buildings. In the wet monsoon weather condition, the Lidar measurement range (with acceptable S/N ratio) is no more than 420m. For example, shown in Figure 5 is the 10-minute mean wind speed and wind direction at of the 2010/4/13 measurement. Based on the S/N ratio report, it was determined the highest meaningful data is at 390m, and only those data are presented. The wind direction data was used to ensure the wind records are subjected to the similar terrain effects. Then these wind data was used to estimate the power law index α. α values from all measurements are listed in Table 1.

Table 1. Wind profiles at urban terrain

Time	Wind speed at 100~300m	Wind direction	α	δ
2010/2/26	5~7 m/s	SW-NW	0.249	>390m
2010/3/7	6~12 m/s	NE	0.256	>420m
2010/3/7	8~12 m/s	NE	0.261	>330m
2010/4/13	10~17 m/s	NE	0.279	>390m

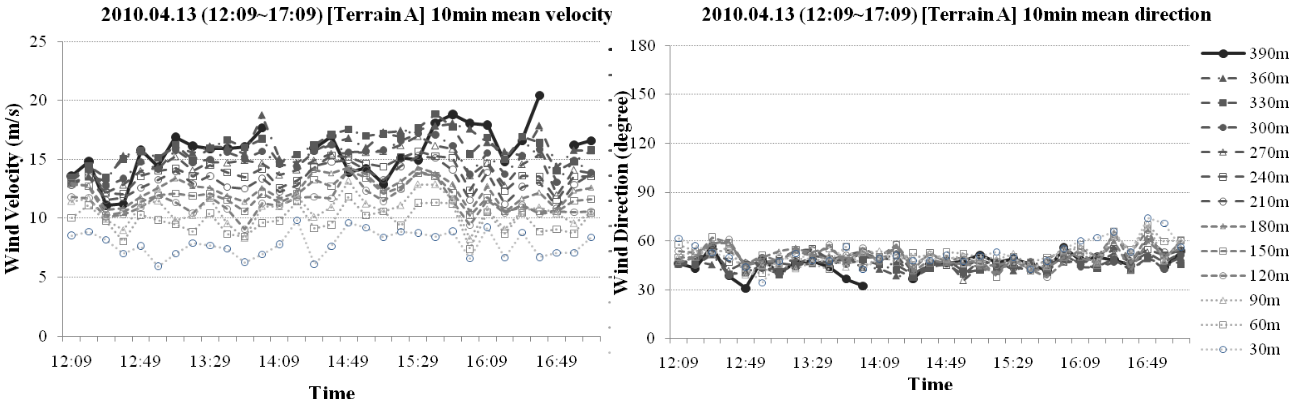

Fig. 5 10-minute mean wind speed and wind direction measurements at urban terrain site.

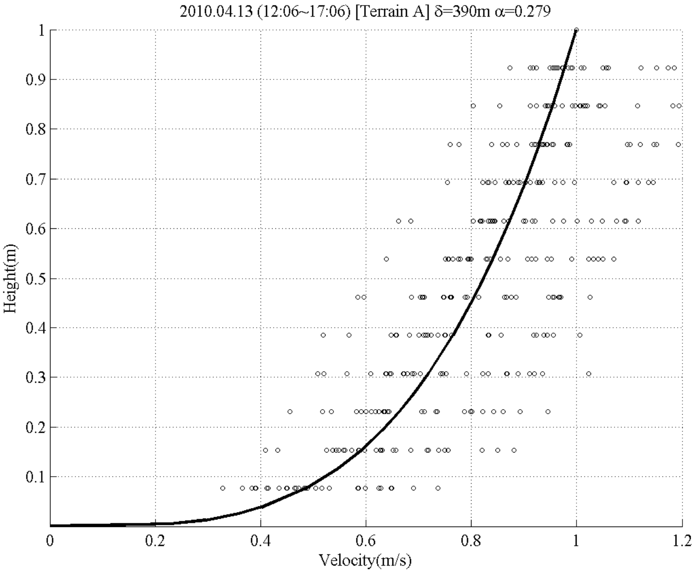

Fig. 6 10-minute mean wind speed and wind direction measurements at urban terrain site.

Wind profile at open terrain

2009/10/5, Typhoon Parma passed through southern part of Taiwan. Wind profile was measured at I-Lan monitoring site that locates at an open terrain area. This monitoring site is an elementary school play ground in a farming community. The surrounding landscape is mostly rice paddy with scattering trees and one or two story farm houses. The Lidar measurement range was found to be around 300m. The 10-minute mean wind speed and wind direction are shown in Figure 7. The power law fit of the wind profile is shown in Figure 8. This wind profile measurement gives α=0.122 and δ=210m.

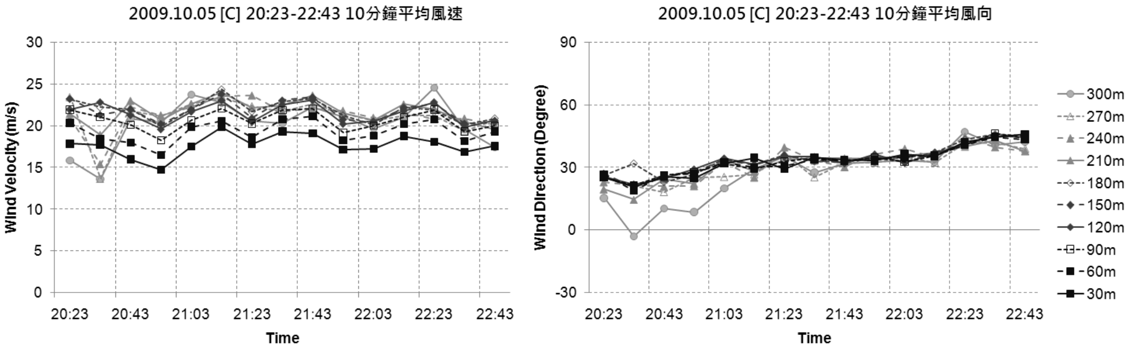

Fig. 7 10-minute mean wind speed and wind direction measurements at open terrain site.

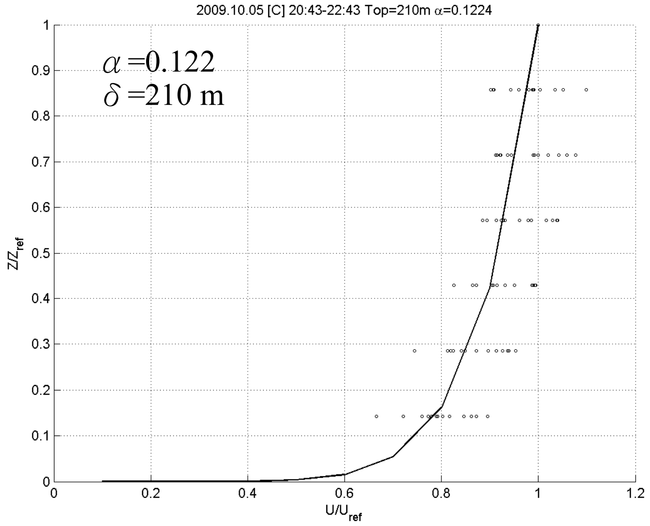

Fig. 8 10-minute mean wind speed profile at open terrain site.

2 WIND HAZARD IN TAIWAN

2.1 *Status of wind disaster and loss in Taiwan*

Taiwan lies in the path of severe tropical cyclones known in East Asia as typhoons. With their violent winds and extremely heavy rainfall, these storms often cause severe damages in Taiwan. According to the historical data from 1990 to 2009, there were at least three land typhoon warnings issued every year, and the average numbers of typhoons to land were three. The statistics also showed that the typhoons caused the most severe casualties were Toraji and Nari in 2001, which caused 225 people dead, 129 people missing and 585 people injured. Moreover, according to the data from 2002 to 2009, the average of insurance indemnity for wind disaster losses were all below 7%, average was 3%, amongst the engineering disaster losses in a year, except in

2002, the insurance indemnity was 12%. Therefore, it can be seen that the losses caused by wind disaster were not the major ones in Taiwan every year. Most of the losses were flood caused by heavy rainfall in days of typhoon. The reason of the wind disaster losses were less than other disasters is because that wind and earthquake loads are two primary lateral loadings for land based structures and buildings in Taiwan. Taiwan locates at an area that both effects are severe. For resisting of earthquake, almost all residential buildings are in the form of reinforced concrete, which is generally sturdy for the wind loads. Figure 9 show the residential buildings and damages of trees and advertising signs by typhoon.

Fig. 9. Residential buildings and damages of trees and advertising signs by typhoon.

3.2 *Typhoon Morakot disaster*

Typhoon Morakot (International designation: 0908, JTWC designation: 09W, PAGASA name: Kiko) was the deadliest typhoon to impact Taiwan in recorded history. It formed early on August 2, 2009 as an unnamed tropical depression. During that day the depression gradually developed before being upgraded to a tropical storm and assigned the name Morakot, by the Japan Meteorological Agency late on August 3. The large system gradually intensified as it tracked westward towards Taiwan. By August 5, the JMA and JTWC upgraded Morakot to a typhoon. Due to the size of the typhoon, the barometric pressure steadily decreased; however, maximum winds only increased slightly. Early on August 7, the storm attained its peak intensity with winds of 150 km/h (90 mph 10-minute sustained) according to the JMA. The JTWC reported the storm to be slightly stronger, with winds peaking at 155 km/h (100 mph 1-minute sustained), the equivalent of a Category 2 hurricane on the Saffir–Simpson Hurricane Scale. Morakot weakened slightly before making landfall in central Taiwan later that day. Roughly 24 hours later, the storm emerged back over water into the Taiwan Strait and weakened to a severe tropical storm before making landfall in China on August 9. The storm gradually weakened as it continued to slowly track inland. The remnants of the typhoon eventually dissipated on August 11.

Hitting Taiwan on August 8, 2009, Typhoon Morakot brought heavy rainfalls of more than two thousand millimeters to mountain areas in central and southern Taiwan. The accumulated rainfalls of 1,624 millimeters, 2,361 millimeters, and 2,854 millimeters in Alishan area in time spans of 24 hours, 48 hours, and 72 hours, respectively, posted record highs in Taiwan history, with the first two nearly reaching the world record rainfalls of 1,825 millimeters and 2,467 millimeters in time spans of 24 hours and 48 hours, respectively. Such heavy rainfalls in just 72 hours caused devastating disasters in central and southern Taiwan. In addition to rescue efforts from the government and the private sector of Taiwan, many countries expressed their concerns and offered rescue and relief assistance. A total of 85 countries expressed their condolence and concerns, while 48 countries donated money of more than NT$480,000,000 to Taiwan. Thirteen countries donated relief materials, and the United States, the European Union, Japan, Korea, and the United Nations Office for the Coordination of Humanitarian Affairs sent specialists to assist in rescue efforts and disaster investigation. Taiwan government expresses her most sincere gratitude to these countries for their true friendship and timely assistance in such a difficult time. The storm also caused severe flooding in the northern Philippines that killed 26 people.

2.2 *Post-disaster reconstruction for Typhoon Morakot*

To effectively carry out the reconstruction, the Morakot Post-Disaster Reconstruction Council was formed on August 15, 2009 (7 days after Typhoon Morakot Disaster) pursuant to Item 1 of Article 37 of the Disaster Prevention and Protection Act. On August 28, 2009, just 20 days after the disaster, the Morakot Post-Disaster Reconstruction Special Act was enacted, and 94 days after the disaster, on November 10, 2009, a special budget for the reconstruction was approved. With joint efforts from the central and local governments and the private sector, 611 permanent houses were quickly built in Daai Park in Shanlin Township and Taihe Village in Taitung County only six months after the disaster, indicating unprecedented effectiveness of the reconstruction implementation.

Post-disaster reconstruction has been implemented proactively in the past year. In community reconstruction, 1,480 permanent houses have been completed, benefiting nearly 6,000 survivors of the disaster. In infrastructure reconstruction, 138 sections with a total length of 653 kilometers in the six major highway systems and eight sections of round-the-island railway that were damaged by Typhoon Morakot have been repaired and made accessible by the end of December 2009. Indicator reconstructions such as Jiaxian Bridge and Alishan Highway have been made accessible earlier than originally projected. The amount of sediment dredging of rivers and creeks totaled more than 9,200 cubic meters, way over the average annual 2,000 cubic meters in past years. In industry reconstruction, grouper farming has been restored over 80 percent with government's assistance, while orchid growing has been fully restored as its export value between January and May in 2010 were up 36% compared to the same period of last year. In addition, the government has been pushing for the One Township One Industry Program and the Twelve Industry Reconstruction Exemplary Sites Program, along with the planning of matching industries and package tours of the permanent housing communities, aiming to revitalize local economy in disaster areas.

A year after the disaster brought by Typhoon Morakot is not deemed the end of a period but rather a time to evaluate what has been done and what still needs to be done in the reconstruction so that with joint efforts from the government and the private sector, most disaster survivors may rebuild their communities and restore their peaceful and happy lives. Faced with abnormal climate change under global warming and increasing threats of future typhoons, Taiwan government has made necessary revisions to the Disaster Prevention and Protection Act to enhance the nation's overall capabilities in disaster prevention and rescue. With regard to the environment of the disaster areas and public facilities, the government will strengthen the mechanism of warning, evacuation, and rescue under the disaster prevention and rescue policy of "Forecasting all scenarios and preparing for the worst" to evacuate residents in possible disaster areas temporarily to avoid losses of lives and property. The government firmly believes that it will do an even better job in the future in disaster prevention and rescue and post-disaster reconstruction in the events of natural disasters. Table 2 shows the summary of the Morakot Post-Disaster reconstruction.

Table 2. Summary of Reconstruction Reports

No. of Deaths	681 People	Roads Blocked or Impassable	0 Places
No. of Missing	18 People	Pct. Of Resettlement Relief Funds Released	100%
Shelters	4 Places	Pct. Of Flooding Relief Funds Released (to disaster victims)	99.99%
No. of Persons Provided Shelter	660 People	Project Providing Temporary Employment after August 8 Natural Disaster	17,859 (No. of Persons Employed under the Project)

3 CONCLUSIONS

1. The Taiwan building wind code has been announced and kept intact since 2007. Some modification and upgrading on wind load combination, external pressure/force coefficients and the applicability of comfort criterion have been proposed.
2. The Lidar system was introduced for the field monitoring of wind profiles at sites in urban, suburban and open terrains. The initial results indicate that Lidar can produce mean wind speed profile up to 300 to 400 meters in rainy and windy weather.
3. The losses caused by wind disaster were not the major ones. Most of the losses were flood caused by heavy rainfall in days of typhoon. In 2009, Typhoon Morakot wrought catastrophic damage in Taiwan, leaving 681 people dead and 18 others missing.
4. To effectively carry out the reconstruction after Typhoon Morakot, the Morakot Post-Disaster Reconstruction Council was formed on August 15, 2009. Taiwan government has made necessary revisions to the Disaster Prevention and Protection Act to enhance the nation's overall capabilities in disaster prevention and rescue.

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