

# Extreme Wind Climate and a Proposal to Improve the Basic Wind Map for Structural Design Purpose in Vietnam

Le Truong Giang<sup>a</sup>, Yukio Tamura<sup>b</sup>, Masahiro Matsui<sup>c</sup>, Vu Xuan Thuong<sup>d</sup>, and Nguyen Hong Ha<sup>e</sup>

<sup>a</sup>*Director, IBST/Wind Tunnel Lab., Vietnam Institute for Building Science and Technology (IBST), Hanoi City, Vietnam, ltgiangibst@gmail.com*

<sup>b</sup>*Professor, Tokyo Polytechnic University, 1583 Iiyama, Atsugi, Kanagawa, Japan, yukio@arch.t-kougei.ac.jp*

<sup>c</sup>*Professor, Tokyo Polytechnic University, 1583 Iiyama, Atsugi, Kanagawa, Japan, matsui@arch.t-kougei.ac.jp*

<sup>d</sup>*IBST/Wind Tunnel Lab., IBST, Hanoi City, Vietnam, thuongxv2004@gmail.com*

<sup>e</sup>*Director, Institute of Basic Research and Standardization, Hanoi City, Vietnam, ha.nguyenhong@gmail.com*

**ABSTRACT:** This paper presents, firstly, the extreme wind climate and wind data situation in Vietnam and, then secondly, recent studies on the extreme wind of Vietnam in which a proposal to improve the Vietnamese basic wind speed map was introduced.

**KEYWORDS:** Extreme wind climate, Extreme value analysis, Vietnamese wind-loading codes (TCVN 2737), Basic wind speed.

## 1 INTRODUCTION

Current version of Vietnamese wind loading codes, TCVN 2737-1995 [1], introduces the basic wind pressure map for structural design. As stipulated in the TCVN 2735-1995, the meteorological standards of basic wind speed are 3s-gust, 10m height above the ground in open flat country with a return period R-20 year. In 2005, an effort addressed by work of Vietnam Institute of Meter-Hydrology (VIMH) in order to improve the basic wind speed map for the New Wind loading code (Draft version TCVN 2737-2006 [2]). In this work [3], the up-to-date data until the year of 2000 was deployed and the basic return period was shifted to R-50 year. Unfortunately, VIMH'S result was rejected by Ministry of Construction, because at several sites, ambiguous basic wind speeds were found, e.g., in Ho Chi Minh City the value is higher than that given for Hanoi City-a site experienced stronger winds. Ho Chi Minh's wind data is obtained from Tan Son Nhat International airport - an open area, whereas Hanoi's wind data is collected from Lang's station locating inside Hanoi city. These data has been utilized in analyses then to make basic wind speed map. Obviously, there were no conversions from wind speed at a specific site to the values corresponding to the meteorological standard condition before making the Vietnamese basic wind speed map. In addition, an interesting point was found in TCVN 2737-1995 and TCVN 2737-2006 by Giang et al.[5] and Giang [6], the R-50 year basic wind speed of inland area at Hai Phong City locating far from coastline of about 15 km is higher than basic wind speeds given for the China coastline areas, where locates very close to the Vietnam-China boundary. It should be noted that, Hong Kong and Hainan island's coastline areas experienced much more severe typhoons than in Haiphong, Vietnam.

In the next session, the discussion on the available wind data, wind climate is briefly introduced and an appropriate procedure to improve the basic wind map of Vietnam is proposed.

## 2 AVAILABLE WIND DATA AND EXTREME WIND MECHANISM IN VIETNAM

Extreme wind climate, available wind record, actual situation of the wind anemometers, reporting wind data and so on, were well described by Giang [6] and Giang et al [7, 8]. The followings are explanations on the current situation of wind data and wind extreme mechanism.

### 2.1 *Meteorological station network and available wind data*

Winds have been measured soon in Vietnam as the Phu Lien-Hai Phong meteorological station operated since 1902. However, due to historical reasons measurements were not consecutive. The development of Metrological stations system can be divided into 3 periods as follow:

- Before 1954- The France governed Vietnam: in general, winds have been recorded since 1927 with about of 20 stations over mainland (at the big cities and airports). However, the wind records were almost lost.

- Period of 1954~1975- The Vietnamese war: The country was separated into two parts. In the northern region, up to late 1960's, there were about 100 stations equipped anemometers that were imported from the Soviet Union, East-Germany, China and so on. In this period, both northern and southern regions had 3 stations for each, which were employed radiosondes for observing boundary layer (in order to supply climate data for military aviations only, e.g. Hanoi, Dien Bien, Vinh in the north and Saigon, Nha Trang, Da Nang in the south). In fact, there were only several stations located in the northern area in which wind record could be used for reference purpose only;

- After 1975: the meteorological system was running under one standard for measuring the climate data. The equipments and measuring methods was carrying out by the standard system formed in the northern region before 1975. The same types that are used in the northern region, say, VILD anemometers, had replaced almost equipments in southern region. However, the existing anemometers in the southern area were believed to be accurate enough. Since 1995, almost stations had changed to the use of EL-anemometers (Chinese anemometers) wind speeds and directions can be read from indicator (indoor). Anyway, VILD still be utilized as standby devices if the power is off or other automatic anemometer is failed.

Up to now, in Vietnam, as stated by VIMH, there are about 190 meteorological stations. Stations are divided into several classes depending to number of climatic parameters that station measured. Less than 150 stations own over 10-year record length. However, wind data up to the end of the year 2000 is available for 108 stations (See Fig. 1 for there locations). Among them, there are 60 stations having daily maxima and for the last 48 stations, only monthly and/or annual maxima could be used.

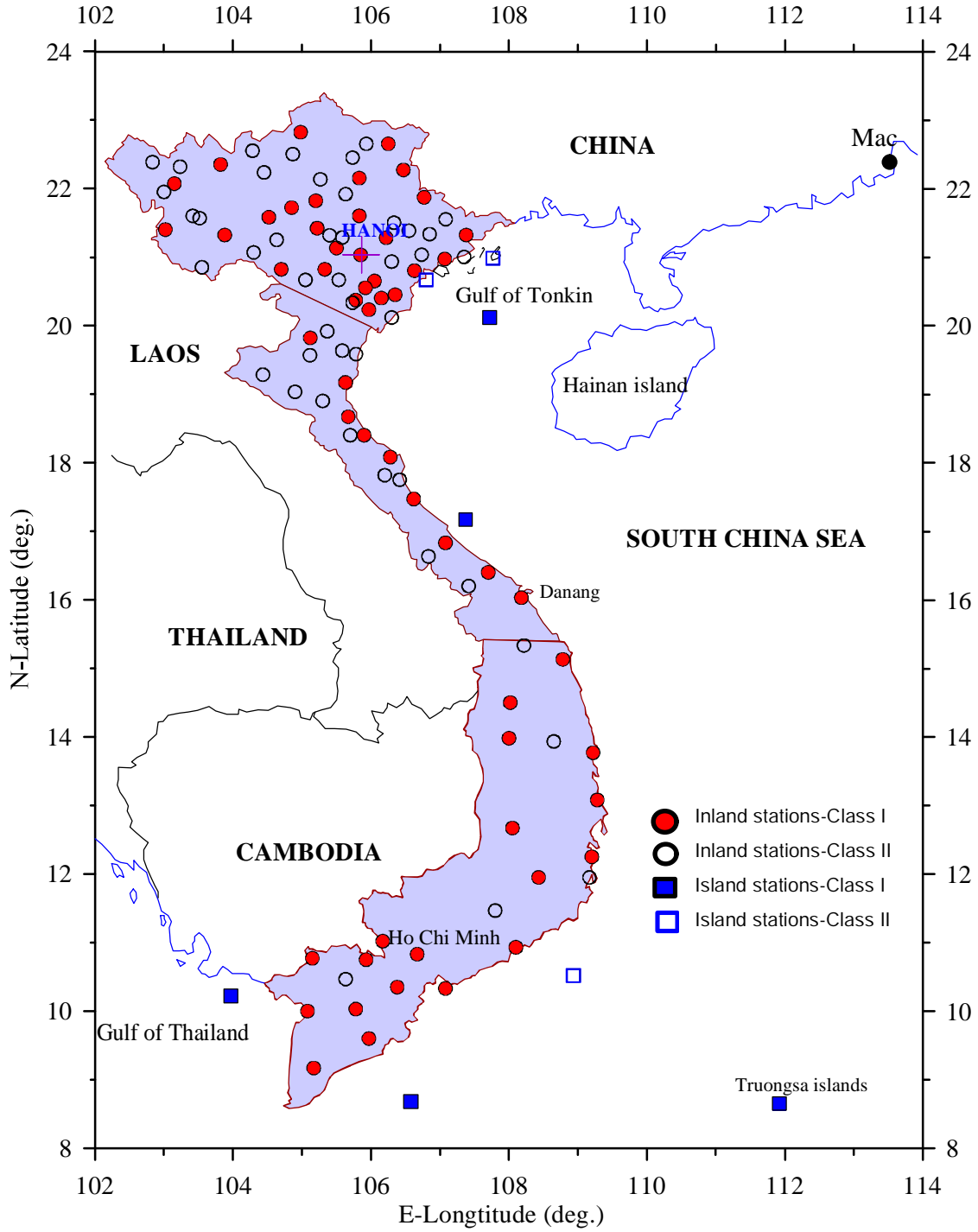


Figure 1: Meteorological station network: 108 meteorological stations in which wind data are available in the National Hydro-Meteorology database center. Class I: Stations having daily maxima and Class II: Stations having monthly and/or annual maxima.

## 2.2 Wind mechanisms

Winds sources can be divided into 3 wind climate systems including Large-scale systems (Asian monsoons), Meso-scale systems (Tropical cyclones) and Small-scale systems (e.g. thunderstorm winds, tornados, etc.).

- Monsoons: It is shown that in Vietnam monsoon does not generate very strong winds, so they have a small impact on structural design;

- Tropical cyclones: From 1961-2004, statistically, Vietnamese coastline has experienced about 4.5 cyclones annually, on average and just 2.2 of them made landfall (only tropical cyclones with Beaufort wind force of grade 6 or over);

- Thunderstorms or tornado-like: The fact is that worst windstorm disaster in Vietnam is due to Tropical cyclones, but there was also remarkable damage caused by thunderstorms or tornado-like winds (<http://www.thoietnguyhiem.net/>). Occasionally, intense thunderstorms occur over the land, most frequently in southern regions (near the equator) and in northern regions during the period of seasonal changes (e.g. see Figure 2);

- Topographical winds: Many locations in mountainous areas were subject to down-slope winds. The native people call them “Lao-wind” on the east side of the Truong Son mountain ridges Vietnam-Laos border, “Than Uyen-wind” in Than Uyen-Dien Bien province and “Oquiho-wind” in Sa Pa-Lao Cai province, etc. (<http://www.thoietnguyhiem.net/>).



Fig 2: A tornado occurred at Thi Vai Harbor, 10 July 2009 (Source: <http://vnexpress.net/GL/Ban-doc-viet/Xa-hoi/2009/07/3BA11749/>)

## 2.3 Notes on the method to measure surface winds in Vietnam

It is worthy to consider to the way used to obtain daily wind maxima. Maximum wind speed of present day is the highest value obtained by checking consecutively in duration from 7.0 pm of the previous day to 7.0 pm of the present day. It is observed through site surveys that anemometers, e.g. EL-an “automatic” anemometer (see Figures 3a and 3b) often do operate for 4 times of a day (7am, 1pm, 7pm and 1am of next day) for making daily official report and whenever “strong wind” occurs, observer will soon operate indicator of anemometer to check speeds and directions (Giang et al. [7,8]). Whereas, few stations have been equipped anemographs and they worked inconsecutively. Thus, wind events occurred during relatively long period such as monsoon, or even tropical cyclone, it is possible to obtain maxima of these events if anemometers were not failed due to very high wind speeds. However, questions on measures of thunderstorm winds are being subjected, as they are transient and localized storms and do not often pass/hit to stations. As a result, it is reasonably to deduce that

some extreme wind events in records probably were based on assessment by Beaufort scale, i.e. man-made data. This is very important point in processing wind data.



Fig 3a: EL Anemometer, Sensor (Outdoor)



Fig. 3b: EL- anemometer, Indicators (Indoor)

### 3 A PROPOSAL TO IMPROVE BASIC WIND SPEED MAP OF VIETNAM

Extreme wind climate, available wind record, actual situation of the wind anemometers, reporting wind data and so on, are briefly introduced in the previous session. In general, the acceptable wind records would be used in analysis are not long (varying from 10 to 30 years depending to particular stations). It is found in the previous studies given by Lien et al.[3,4] the traditional method of Gumbel was adopted to deal with annual maxima of wind speeds. Wind data are mixed from all windstorm types. The accuracy of analysis was not good due to the sampling error, as data length was short and the lack of concerning to the time-varying roughness around the station of interest. Further, there are no available studies for the validation of adopting-wind-profile models given by current codes. In addition, costal areas of Vietnam are often hit by tropical cyclones (TC), previous studies did analysis for annual maxima of TC only. Therefore, the basic wind speed in the TC region given by TCVN 2737-1995 [1] and TCVN 2737-2006 [2] seems to be not reasonable. Figure 4 shows a comparison of basic design wind speeds (50-year return period, 10 min-mean wind speed) in adjacent region of Vietnam and China. On the Phulien station/Haiphong City located of about 15 km from costal line, the basic wind speed is higher than that given for the Hainan Island and Hong Kong costal lines as stipulated by Chinese Loading Code (GB50009, 2001). A study on the TC-Simulation by Giang et al. [5] gave a more reasonable result of predicted wind speed for this site. Unluckily, due to the poorness of TC wind observations, it is hard to do TC-simulation for stations situated in the central costal line regions of the country.

In order to improve the basic wind speed map of Vietnam, many factors are concerned. Giang et al. [5, 7, 8] did propose the following procedure to deal with extreme wind analysis. In this procedure, physical assessments of station's sites, reasonable recorded length, and windstorm type and appropriate method of extreme value analysis are considered.

- Step 1: The length of data record up to the end of the year of 1994 should be used and the Typhoon winds (TC) wind data is separated from the Non-Typhoon. Pre-processing data to reject unreliable values is the most important in this step;

- Step 2: As record lengths of all stations are short, methods using sub-annual maxima are preferred than traditional Gumbel method for annual maxima. Method of Independent Storms seems to be most reasonable to deal with NTC data of 60 stations having daily maxima;

- Step 3: Analyzing TC- and NTC-winds separately for 60 stations having daily maxima. Dominant wind types could be clarified for each station. In this step, a Monte-Carlo tech-

nique is highly recommended to create virtual typhoon data of 5000 years or more. A simulated result conducted for Hai Phong site [5] explains well the difference of basic wind speeds at the coastal boundary of China and Vietnam;

- Step 4: Combining TC- and NTC-wind probabilities, subsequently, combined wind speed could be obtained.

- Step 5: Results obtained from the above 60 stations could be referred to check the results of other 48 stations having monthly maxima.

For the best calibration of the typhoon model that employed in the Monte-Carlo simulation, typhoon records are very important. However, as many developing countries, this job requests many efforts and kind cooperation among meteorologist and wind/structural engineers.

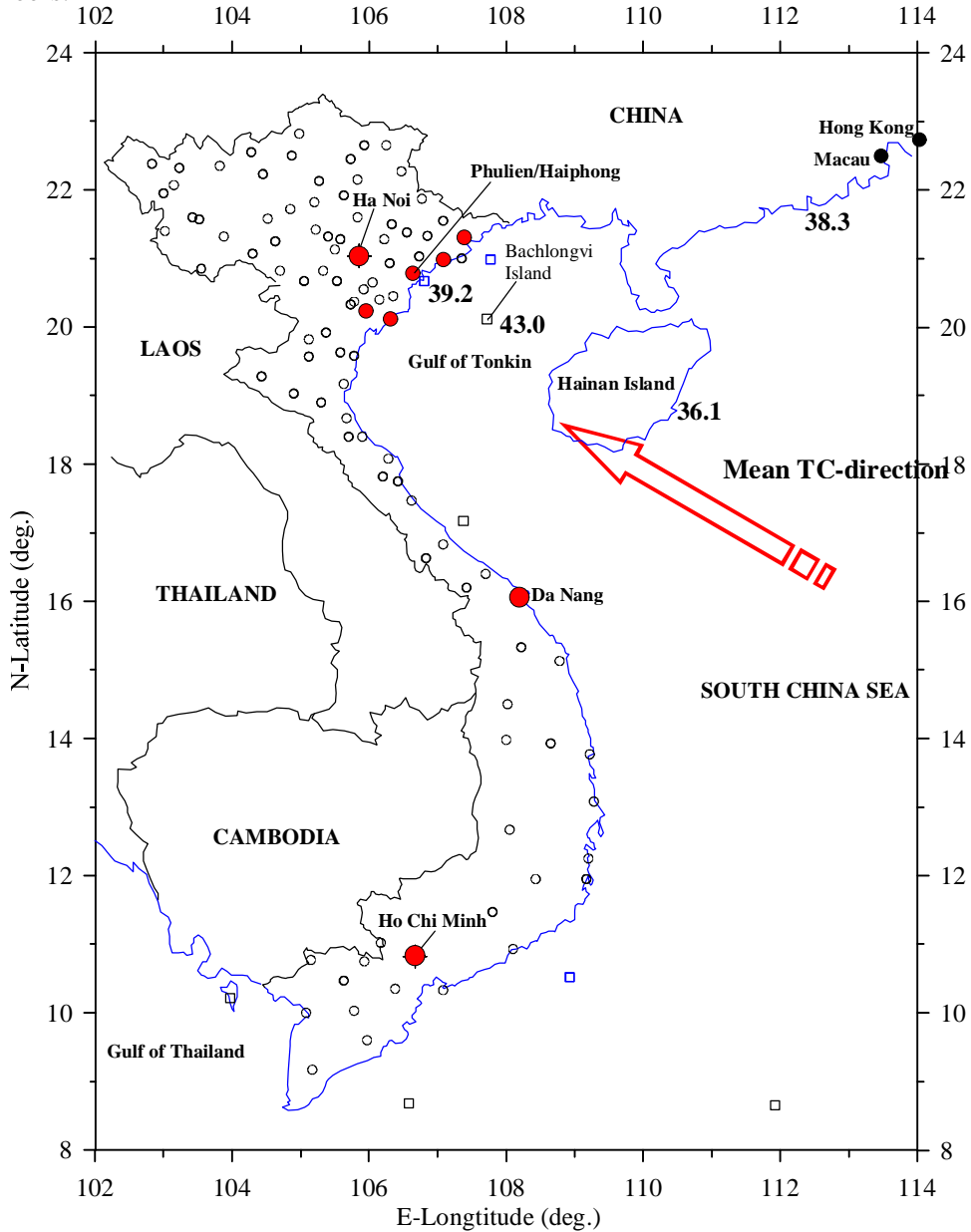


Fig. 4 Comparison of basic design wind speeds (50-year return period, 10 min-mean) in adjacent region of Vietnam and China (Basic wind speeds were shown in Vietnamese loading code TCVN 2737-2006 [2] and deduced from Chinese loading code GB50009-2001)

## 4 CONCLUSIONS

The paper outlines the extreme wind condition and proposed an appropriate procedure to predict more accurately the extreme winds for Vietnam. Currently, in order to revise basic wind speed map of Vietnam, the authors are going to submit a research project to the Ministry of Construction of Vietnam. Hopefully, this paper is a good experience for developing countries having similar situation.

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