On the wind pressure zone map of the Vietnam territory

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ABSTRACT: This paper presents the database for building a reliable wind pressure zone map for the latest edition of the Vietnamese code of practice for wind load on structures. The selection of different data processing methods is described. A data table on mean wind speed and pressure respective to different return periods is introduced.

KEYWORDS: mean wind speed, wind pressure, storm, wind pressure zone map

1 INTRODUCTION

Until now, the Vietnamese code of practice for wind pressure on building and structures has undergone 4 times of edition, of which QP 01-61, TCVN 2737-78, TCVN 2737- 90, and TCVN 2737-1995 have been considered. In each edition, the database of wind pressure over the Vietnam territory is supplemented and the wind pressure zone map is amended. The last edition will be officially published in 2005. This paper introduces the wind pressure zone map of the Vietnam territory in the last edition.

2 DATABASE FOR BUILDING THE VIETNAMESE WIND PRESSURE ZONE MAP

2.1 Database on mean wind speed

The information of mean wind speed utilized the data from 108 in a total of 175 climate stations over the whole Vietnam territory. Table 1 gives an example on the data of mean wind speed in the Lang weather station over months in the years 1956-2000.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Max of year
1956	12	12	12	8	20	8	34	12	12	9	8	7	34
1957	9	8	12	8	9	14	20	20	9	16	9	10	20
1958	13	10	10	12	12	10	9	9	8	14	7	8	14
1959	8	8	8	14	20	12	9	8	9	8	9	15	20
1960	12	8	12	12	12	10	12	20	18	10	9	9	20
1989	14	12	14	8	12	28	10	10	8	17	10	9	28
1990	12	12	10	10	14	14	8	12	10	10	12	10	14
1991	12	12	10	12	15	14	14	10	8	10	8	14	15
1992	8	8	8	8	12	20	10	8	10	10	10	17	20
1993	18	8	15	14	16	10	8	10	18	10	18	12	18
1994	9	9	12	9	14	14	10	10	15	14	6	9	15
1995	10	7	12	10	16	10	12	8	14	11	10	8	16
1996	8	13	10	10	12	9	16	17	8	10	9	8	17
1997	10	6	7	12	14	12	9	18	10	14	12	14	18
1998	10	12	10	9	12	14	8	12	8	10	11	8	14
1999	7	10	10	8	15	10	10	8	6	8	10	10	15
2000	12	8	8	16	12	10	10	10	10	9	14	10	16

Table 1. Mean wind speed in the Lang meteorological station, latitude: 21.01, longitude: 105.5, height: 5m

2.2 Database on storms

For the building of offshore and coastal structures, the data on storms from the United States in the period of 1990-2003 and from Japan in the period of 1951-2003 is used. Table 2 shows an example on the orbit of propitious tropical whirls. Table 3 describes part of the Japanese database in the abovementioned period. Table 4 indicates the schedule of affecting storms on the Vietnamese territory, in which the most severe storm velocity is measured in the Vietnam climate station networks in the period of 1956-2000.

Year	Month	Day	H	Lat.	Long.	Orbit name	Angle	V_{mean}	P_{min}	$V_{meanmax}$	Gust	Lvl
2003	8	24	0	22.1	108.6	IGNACIO	315	4	???	61	???	3
2003	8	24	3	22.3	108.7	IGNACIO	320	4	989	60	75	3
2003	8	24	6	22.5	108.7	IGNACIO	350	4	989	70	85	4
2003	8	24	9	22.7	108.8	IGNACIO	350	4	984	70	85	4
2003	8	24	12	23.1	108.9	IGNACIO	350	5	977	90	110	4
2003	8	24	15	23.3	109	IGNACIO	350	5	970	90	110	4
2003	8	24	18	23.5	109	IGNACIO	350	4	970	90	110	4
2003	8	24	21	23.7	109.1	IGNACIO	350	4	970	90	110	4
2003	8	25	0	23.8	109.2	IGNACIO	320	3	970	80	100	4
2003	8	25	3	23.9	109.3	IGNACIO	320	3	976	80	100	4
2003	8	25	6	23.9	109.5	IGNACIO	320	2	976	80	100	4
2003	8	25	9	24	109.6	IGNACIO	320	2	976	80	100	4
2003	8	25	12	24.2	109.8	IGNACIO	310	3	???	75	90	4
2003	8	25	15	24.3	110	IGNACIO	310	3	980	75	90	4
2003	8	25	18	24.2	110.1	IGNACIO	280	3	985	65	80	4
2003	8	25	21	24.3	110.2	IGNACIO	280	3	987	65	80	4
2003	8	26	0	24.3	110.2	IGNACIO	???	???	989	65	???	4
2003	8	26	3	24.5	110.6	IGNACIO	300	3	989	65	80	4
2003	8	26	6	24.5	110.6	IGNACIO	???	???	989	65	???	4

Table 2. Orbit of propitious tropical whirls in the period of 1990-2003 (data from the United States)

Y-M-D-H	sh	St	Lat.	Long.	P_{min}	V_x	V250 knot		V230 knot	
		lvl	0.1°	0.1°	hPa	knot	HR_{max}	R_{min}	HR_{max}	R_{min}
3071900	2	4	106	1355	980	55	90040	40	50180	100
3071906	2	4	105	1347	975	60	90050	50	50180	140
3071912	2	4	105	1342	975	60	90050	50	50180	140
3071918	2	5	109	1333	970	65	90070	70	50220	170
3072000	2	5	116	1329	960	75	90080	80	50300	250
3072006	2	5	121	1316	945	85	90090	90	50280	250
3072012	2	5	125	1307	935	90	90090	90	40250	230
3072018	2	5	133	1296	935	90	90090	90	40260	230
3072100	2	5	135	1281	945	85	90090	90	40270	240
3072106	2	5	140	1271	945	85	90090	90	40270	240
3072112	2	5	150	1259	945	85	90090	90	30270	200
3072118	2	5	158	1245	950	80	90090	90	30270	200
3072200	2	5	163	1230	950	80	30150	100	30325	240
3072206	2	5	169	1213	955	75	30120	90	30325	240
3072212	2	5	178	1196	960	70	80090	70	30300	200
3072218	2	5	181	1184	965	70	90070	70	50250	170
3072300	2	5	182	1167	960	70	90070	70	50220	160
3072306	2	5	187	1152	955	75	90070	70	50200	150
3072312	2	5	195	1141	955	75	90070	70	50180	150

Table 3. Orbit of propitious tropical whirls in the period of 1951-2000 (data from Japan)

Year	Name of storm	No.	TD	Day of appearance	Latitude	Longitude	Day of approach	Latitude	Longitude	Venue	P_{min}
1964	**WINNIE**	6403		25/6	8	142	3/7	21.3	107.5	Tien Yen	968
1964	**OGLA**			28/8	20.5	107.5	24/8	19.5	106.5	Thanh Hoa	
1964	**TLLDA**	6419		12/9	17	140	22/9	16.2	107.8	Hue	964
1964	**VIOLET**			13/9	13	118	15/9	14.5	108.9	Quang Ngai	
1964	**ANITA**	6421		23/9	16.7	120	27/9	17	107	Bien Hue – Da Nang	996
1964	**BILIE**	6422		25/5	12.5	142	1/10	17.2	106.7	Dong Hoi	994
1964	**CLARA**	6423		1/10	7	142	8/10	18.1	106.4	Ky Anh	980
1964	**GEORGA**	6426		19/10	10	130	23/10	18	106.5	Ky Anh	994
1964	**IRIS**	6428		31/10	12	127	4/11	13.6	110	Quang Ngai	
1964	**JOAN**	6429		4/11	11	132	8/11	13	109.2	Tuy Hoa	1000
1964	**KATE**	6430		11/11	14	117	16/11	11.8	109	Cam Ranh	988
1965	**SARAH**	6503		15/2	6.7	110.2	17/2	9.5	101.5	Tan Vinh Thai Lan	1002
1965			TD	10/6	16	111	13/6	21	107	Phu Lien	
1965	**FREDA**	6511		6/7	8.2	144	15/7	21.5	108.5	Tien Yen	925
1965	**GILDA**	6512		13/7	6.6	155	24/7	22	109	Mong Cai	985
1965	**NADINE**	6519		14/8	16.8	115.6	19/8	18	106.6	Nghe Tinh	990

Table 4. Schedule of affecting storms on the Vietnamese territory, maximum velocity of storms measured in Vietnam of climate station networks

3 METHOD FOR DATABASE PROCESSING

3.1 Extreme distribution functions

- Asymptote function type I: the function is named Gumbel, in which the variables are not intercepted.

$$F_1(V) = \exp\left(-e^{-\alpha(V-U)}\right) \tag{1}$$

- Asymptote function type II: the function is named Fisher Tippet I – Gudrit, in which the variables are intercepted in one direction only.

$$F_2(V) = e^{-\left(\frac{\beta}{V}\right)^{k_2}} \tag{2}$$

- Asymptote function type III: the variables are intercepted in two directions.

$$F_3(V) = 1 - e^{-\left(\frac{V}{\gamma}\right)^{k_3}} \tag{3}$$

in which α, μ, β, κ and γ are parameters calculated from observed data.

3.2 Analysis method

In the case of the abovementioned database, the most suitable analysis method is considered as the Kolmogorov method.

$$D_n = \max\left|F_n(x) - F(x)\right| \qquad \infty < x < \infty \tag{4}$$

$$\lim_{n\to\infty} P\left[D_n\sqrt{n} \le \lambda\right] = \sum (-1)^k e^{-2k^2\lambda^2} = K(\lambda) \tag{5}$$

The values of 1-K(λ) can be found in the tables of statistic documents. If the value $\lambda_o = D_n\sqrt{n}$ is set, then with P = 5% then $\lambda_o < 1.353$, else it is found that the distribution function is not suitable for the analysis of the measured data series.

3.3 Distribution function of monthly maximum mean wind speed

Based on the Kolmogorov analysis method, the most suitable function is found as the Fisher Tippet I – Gumbet (1) with α and U calculated based on observed data. In the projected named 42A.03.05, the monthly maximum wind speed was used to calculate the maximum wind speed with different return period. The obtained results was used in TCVN 2737-95.

3.4 Distribution function of annual maximum mean wind speed

The asymptote function Fisher Tippet I is also specified in the wind pressure standards of Canada, Australia and the United States. The analysis results over the network of 300 climate stations in the United States shows that the compatibility of the asymptote function type I can reach up to 70% whereas it is 11% for the function type II. This agrees well with the observation results from 108 climate stations over the Vietnam territory, of which 77.6% of the analysis results belongs to the asymptote function type I and 8.6% for the function type II. Therefore in this edition, the asymptote function type I is chosen to process the annual maximum mean wind speed.

3.5 Distribution function of annual maximum storm velocity

According to the project named 42A.03.05, the distribution function of annual maximum storm velocity is written as follows:

$$F_b(x) = P_b F(x)/B \tag{6}$$

in which:
P_b: probability of the affecting storms
$F(x)/B$: probability of V > x when storms occur, as measured in the respective climate stations.
With n large enough (>10), F(x) has the form of Gumbel distribution. For example, the Phu Lien meteorological station gives n = 44, $P_b = 0.864$, and:

$$F(x) = \exp\left(-e^{-0.135(V_x - 24.6)}\right),\ \lambda = 0.582.$$

4 CONVERSION OF MEAN WIND SPEED ACCORDING TO THE AVERAGE TIME

The conversion coefficient is chosen as by Dust 1985, by which an average time of 3 sec can be converted into the average time of 10 minutes and 1 hour. The Dust formula is written as follows:

$$k_{(i,j)} = 1 + \frac{0.98C(d_i)}{\log\frac{1000}{Z_o(j)}} \quad (7)$$

in which C(d) is a experimental function to time d, and C(d) can be found in many documents mentioning mean wind speed in the US (Simiu 1997). Table 5 shows the conversion results when an average time of 3 sec can be is transformed into the average time of 10 minutes and 2 minutes respectively according to (7).

Scale	Ground roughness Z_o (cm)									
(V3"/Vd")	5	10	20	30	40	50	75	100	500	750
3/600	1.40	1.45	1.53	1.58	1.63	1.67	1.76	1.85	3.15	4.50
3/120	1.28	1.31	1.36	1.39	1.42	1.44	1.49	1.54	2.09	2.47

Table 5. Conversion results of average time

The conversion coefficient for mean wind speed with gust in an average time of 3 sec into the average time of 10 minutes is 0.7143 and into the average time of 2 minutes is 0.7813. The conversion is made based on the assumption that the ground is flat.

5 CONVERSION OF THE AVERAGE WIND PRESSURE HAVING A RETURN PERIOD OF 50 YEARS INTO THE PRESSURE HAVING OTHER RETURN PERIOD

Table 6 illustrates the conversion of the average wind pressure having a return period of 50 years into the pressure having other return period.

Return period	years	5	10	20	30	40	50	60	100
Average wind pressure	daN/m^2	51.8	63.7	76.2	83.8	89.4	93.9	97.6	108.4
Conversion coefficient	-	0.552	0.679	0.811	0.893	0.952	1	1.040	1.155

Table 6. Conversion results of return period

6 DISTRIBUTION OF STORM VELOCITY

Table 7 gives an example on the distribution of storm velocity, in which the return period of 45 years respective to the distribution value P of 0.822. The storm velocity was measured at the Hong Gai meteorological station, and $F(x) = \exp\left(-e^{-0.145(V_x - 20.3)}\right)$, $\lambda = 0.899$.

Return period	years	10	20	50	100
Calculated storm velocity	ms	34.4	39.4	45.8	50.6
Revised velocity	m/s	30.8	34.5	39.3	43.0

Gust velocity	ms	39.4	44.2	50.4	55.0
Storm pressure	daN/m^2	97.0	122.0	159.0	189.0

Table 7. Conversion results of return period

Table 8 describes mean wind speed and pressure respective to different return periods.

No	Climate station	Gust mean wind speed (m/s) with return periods (years)				Mean velocity in 10 mins (m/s with return periods (years)				Wind pressure (daN/m^2) with return periods (years)				Error (m/s) with return periods (years)			
		10	20	50	100	10	20	50	100	10	20	50	100	10	20	50	100
1	PHOBANG	28.3	30.8	33.9	36.3	20.2	22.0	24.2	25.9	50	59	72	82	2.2	2.7	3.5	4.0
2	TRUNGKHANH	29.3	33.3	36.0	38.7	20.9	23.8	25.7	27.6	54	70	81	94	1.6	2.3	2.7	3.2
3	HAGIANG	29.1	32.4	34.6	36.8	20.8	23.2	24.7	26.3	53	66	75	85	1.3	1.8	2.1	2.5
4	MUONGKHUONG	29.6	32.4	34.6	36.8	20.8	23.2	24.7	26.3	55	66	74	82	1.8	2.5	2.9	3.4
5	CAOBANG	36.8	41.7	44.9	48.1	26.3	29.8	32.1	34.3	85	109	126	144	1.8	2.6	3.1	3.6
...																	
104	RACHGIA	29.3	33.6	36.4	39.2	21.0	24.0	26.0	28.0	54	70	83	96	1.7	2.4	2.8	3.3
105	SOCTRANG	26.0	28.8	30.6	32.5	18.6	20.6	21.9	23.2	42	52	59	66	1.1	1.5	1.8	2.1
106	CAMAU	27.5	31.5	34.1	36.7	19.7	22.5	24.3	26.2	47	62	73	84	1.6	2.2	2.7	3.1
107	CONDAO	36.0	42.1	46.1	50.2	25.7	30.1	33.0	35.8	81	111	133	157	2.4	3.4	4.1	4.7
108	TRUONGSA	38.5	41.9	44.2	46.4	27.5	29.9	31.6	33.2	93	110	122	135	1.8	2.5	3.0	3.5

Table 8. Mean wind speed and pressure with different return periods

7 CONCLUSIONS

The amendments and supplementary of TCVN 2737-1995 are summarized as follows:

- The database on mean wind speed in the period of 1990-2000 is added based on the measurements from the Vietnam climate station networks.
- The database on offshore mean wind speed is supplemented with information from the United States and Japan.
- The revised version of wind load standard analyzes the data series of annual maximum mean wind speed, whereas TCVN 2737-95 dealt with the data series of monthly maximum mean wind speed.
- The revised basic return period is considered as 50 years, whereas it is 20 years in TCVN 2737-95.
- The mean wind speed and pressure in both editions are not much differentiated.
- Due to the updated database, the cautious evaluation of analysis methods and the elaborate comparison of analysis results, it can be concluded that the Vietnam wind pressure zone map take another step toward completion.

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