Impact of Wind Load on Large Plate Billboards in Vietnam

Le Thuy Nguyen, Hong Son Nguyen, Van Quan Tran, Quang Hung Nguyen

Abstract*: *The paper presents the analysis of the impact of wind loads on large plate billboards, how to determine and convert input data and repeat cycle conversion ratios in calculating the wind load between Vietnam standards and foreign standards. In addition, the article presents the notes in the calculation according to different standards, thereby giving the process of calculating the determination of wind load according to Vietnam standard TCVN 2737-1995, European standard EN 1991- 1-4 and AmericanASCE / SEI 7-05 standards for large billboard advertising by MathCad calculation software, presenting calculations for a specific billboard, from the results of the presentation, we get some conclusions and recommendations.

Keywords*: *Large plate billboard construction, wind load, texture, failure, standard l.

I. INTRODUCTION

With current strong economic development, large billboard constructions are an effective and popular method to advertise products to consumers. In our country on big cities as well as highways, national highways, ... the density of big billboards is increasingly arranged due to the development of the advertising market.. However, in the construction standards of our country, only the calculation for this type of construction has stopped at the general level, not to mention its own characteristics when under the influence of all kinds of load and impact, especially the impact of wind load. That leads to the consequences that after big storms, large plate billboards, although designed very elaborately and costly, are still damaged and collapsed, causing great losses in many aspects. Therefore, it is necessary to mention the special effects of different types of loads and impacts, especially the impact of wind loads on this type of construction. First of all, it is necessary to redefine large plate billboard construction. According to QCVN 17: 2013 / BXD, large billboards are billboards with a surface of 40 m^2 or more [2] . Figure 1 shows an example of this type of construction.

Figure 1. Example of a large plate billboard

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Large billboard construction are usually designed in the form of two-sided or three-sided plate, single or double columns. In any form of structure, this construction also has certain characteristics when under the influence of the load, especially the wind load due to the large wind surface, slender structure.

For construction structures in general and billboards in particular, the impact of wind loads is not the impact of a single load but a combination of aerodynamic phenomena, including effects static and dynamic effects.[3]

Static effect causes deformation, static stress and static instability.

Dynamic effects include oscillation with limit amplitude and self-oscillating amplitude with increasing amplitude.

Fluctuations due to limitations include: Vortex - induced vibration, rain - wind - induced vibration, oscillation due to gas turbulence (buffeting) and oscillation at the end of the wind (wake - induced vibration). The self-oscillating oscillator group with infinitely increasing amplitude, means that in this vibration form the reaction of the structure produces an abnormal gas force that makes the reaction of the structure become larger, generating abnormal gas forces, This process continues to lead to fluctuating dispersion and destruction of the structure. The self-oscillating oscillator consists of two components: oscillating for galloping and for self-winding (flutter).

Induced vibration (Vortex - induced vibration) is a common form of vibration with large pieces of structure such as cable, chimney, tower or sphere. In a few cases, causing oscillation due to vortex gas acting on steel chimneys ... fluctuations in this case will be influenced by the shape of the section over time[6]

Oscillation due to vortex can occur if:

- The piece structure has a cross section of 10 to 15 times smaller than the width of the structure.
- The slender structure can be affected by eddy oscillation when placed next to large sized structures.

The turbulence of air flow (Buffeting) is random fluctuations both in time and space.

For large-scale structures such as large plate billboards, fluctuations due to vortex and turbulence of air currents significantly affect the construction and need to be calculated separately for evaluation. Exactly the impact of these phenomena. However, the content of the article only presents the considerations in the calculation according to the standards and procedures for calculating standards, but does not mention the effects of these components on the bearing capacity of the billboard structure clearly and separately evaluated, these contents will be included and presented in the next research content of the authors.

II. THEORY

A. Correlation of parameters when calculating according to different standards

Currently, when calculating and designing large plate billboards, it is found that this work is affected by various types of loads such as structural self weight, load during the erection, forced displacement of bearings, storm loads and special types of loads such as explosives, earthquakes, etc. However, in the types of impacts, the impact of storms and wind loads significantly affects the characteristics of this project. arranged in open land areas, on highways, national highways. In the standard TCVN 2737: 1995, there are instructions for calculating specific wind loads for different types of works, however for large billboards, some calculation parameters are not yet clear and Specifically, the effect of wind load on this project should be compared with the performance based on foreign standards. When applying foreign standards to calculate, it is necessary to properly understand the input of data as well as the need to convert data to suit the calculation characteristics of each standard applied as the average wind speed , repeat cycle, terrain,...

1) Terrain form

Comparing the topographic form between TCVN 2737: 1995, EN 1991-1-4 and ASCE / SEI 7-05 (Table 1), it is found that there are differences in the number of terrain forms, however, there are also common points, based on the definition of terrain types according to the standards, it can be seen that the terrain form for calculation of billboards is topographic form C (ASCE / SEI 7-05), form Terrain II (EN 1991-1-4) is equivalent to the terrain type B (TCVN 2737: 1995), because large plate billboards are located on highways, national highways, and empty terrain, airy, not shielded or shielded with relatively large distances.

Table 1. Comparison of the types of terrain specified in different standards

GEOGRAPHIC FORM						
STANDARDS	TCVN2737: 1995	**A** Empty, no or very few obstacles H<1,5m		**B** Relatively empty, sparse obstacles 1,5m <H<10m	**C** Mostly shielded, many obstacles H>10m	
	EN1991-14: 2005	**0** Sea, coast	**I** Lake, flat area, unobstructed	**II** Grass, single obstacles, separated from each other about> 20H	**III** Grass, single obstacles, separated from each other <20H	**IV** Shielded >15% surface area, H>15m
	ASCE/SEI 7-05	**D** Airy, beach		**C** Airy, rural H<9,1m	**B** City	

2) Speed of winds

Determine the wind speed by region, then apply to calculate the impact of wind load on the project under consideration in that area. Wind speed depends on time, so the average time of wind speed and the period of recurrence of the cycle will affect the average wind speed value. Different standards regulate the time taken for the average wind speed and the repeat cycle to calculate the average wind speed value.

The basic wind speed V_0 is the average velocity over a period of 3 seconds that exceeds 1 time within 20 years (TCVN 2737: 1995); 10 minutes - 50 years (Eurocode EN 1991-1-4), 3 seconds - 50 years (USA, Australia).

According to the Durst curve (Figure 2), figure C6-4, ASCE / SEI 7-05 can convert the average 10-minute wind speed to the 3s wind speed as follows:

From this curve we have: k_{v_10mins}=1.065; k_{v_3s}=1.525

Conversion factor:

$$k_{cd} = \frac{k_{v\_10mins}}{k_{v\_3s}} \tag{1}$$

$$k_{cd} = \frac{1.065}{1.525} = 0.698$$

So inferred the relationship between the average wind speed over a period of 10 minutes and 3 seconds is:

$$v_{10mins} = 0.698 \cdot v_{3s} \tag{2}$$

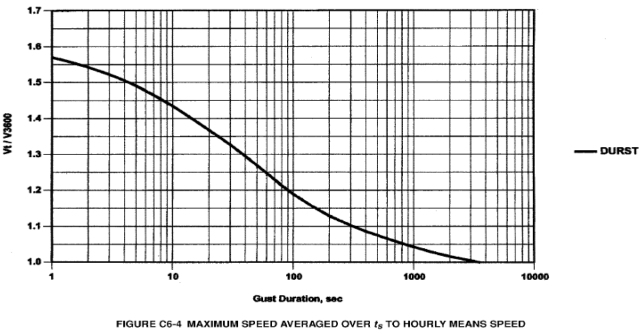

Figure 2. Convert the maximum average wind speed in seconds to the hourly wind speed

3) Cycle loop

According to QCVN 02-209 BXD, we have a table to convert wind speed from a cycle of 50 years to other iteration cycles as shown in Table 2.

Thus, the relation of wind speed with the repetition cycle of 20 years and the cycle of 50 years is as follows:

$$v_{50y} = \frac{1}{0.91} \cdot v_{20y} \quad (3)$$

Where, v_{50y} - the average wind speed over a period of 3 seconds with the cycle of 50 years (ASCE/SEI 7-05).

Average wind speed over a 10-minute period with a 50-year iteration cycle (EN 1991-1-4):

$$v_{50y\_10mins} = v_{50y} \cdot k_{cd} \quad (4)$$

Table 2. Coefficient of conversion of wind speed from 50-year repeat cycle to other iteration cycles [2]

Repeating cycle (year)	5	10	20	30	40	50	100
Transfer factor	0.78	0.85	0.91	0.95	0.98	1.00	1.06

From (4) there is a change in the average wind speed value from TCVN 2737: 1995 to EN1991-1-4 and ASCE / SEI7-05 presented in Table 3

Table 3. Conversion of average wind speed value from TCV 2737: 1995 to EN1991-1-4 and ASCE / SEI7-05

Wind pressure zone on the map		I		II		III		IV	V
		IA	IB	IIA	IIB	IIIA	IIIB		
Speed (m/s)	TCVN 2737:1995	29.95	32.56	36.8	39.37	42.36	45.16	50.29	54.94
	ASCE/SEI7-05	32.91	35.78	40.44	43.26	46.55	49.62	55.26	60.37
	EN 1991-1-4	22.99	24.99	28.24	30.21	32.51	34.66	38.59	42.16

B. . Some notes when calculating the effect of wind loads on large billboards according to EN1991-1-4 standards and ASCE / SEI 7-05

1) According to EN1991-1-4 standards

Standard EN 1991-1-4 defines the coefficient of wind pressure change according to altitude and topography based on the logarithmic wind speed profile and considers many different factors such as:

* Terrain coefficients k_r (formula 4.5) and intensity of tangles $I_v(z)$ at the height of the project:

* Structural coefficient c_{scd}, formula 6.1:

$$c_{scd} = \frac{1 + 2 \cdot k_p \cdot I_v(z_s) \cdot \sqrt{B^2 + R^2}}{1 + 7 \cdot I_v(z_s)} \quad (5)$$

+ The peak coefficient, determined by the ratio between the maximum value of the reaction part and its standard deviation, formula B.4;

+ The ratio of tangled length indicates the average shock strength of natural winds L (z), determined according to formula B.1;

+ Base coefficient B, regardless of the relationship has not been taken into account pressure on the surface texture, B.3;

+ Coefficient of resonant response, regardless of the resonant oscillation form turbulence with consideration of the structure, formula B.6

2) According to ASCE / SEI 7-05 standards

Standard ASCE / SEI 7-05 stipulates that the designed wind load is specified for each type of structure, different works and divided into 4 types of construction.:

Stiffness structure with all types of height, determined by the formula :

$$p = q.G.C_p - q_i.(GC_{pi}) \quad (6)$$

- Low-rise building, determined by the formula:

$$p = q_h[(G.C_{pf}) - (GC_{pi})] \quad (7)$$

- Soft texture, determined according to the formula:

$$p = q.G_f.C_p - q_i.(GC_{pi}) \quad (8)$$

- Retaining wall, calculated according to the formula:

$$p_p = q_p.G.C_{pm} \quad (9)$$

Standard ASCE / SEI 7-05 defines high-rise buildings or structures with a height of 4 times the horizontal dimension or the cause of natural oscillation frequency less than 1Hz (small oscillation cycle more than 1s) is considered a soft structure, so billboards will be calculated according to the formula (6-19) of the ASCE / SEI 7-05 standard.

When calculating the standard wind load, note the following factors:

* I_z, turbulent wind density at high level z = 0.6h (h - work height)

* GC_{pi}, Wind pressure coefficient in the house, based on the type of construction cover.

* C_p, The external pressure coefficient depends on the wind direction acting on the building;

* R, resonant component of texture top displacement;

* The coefficient refers to the effect of wind gusts G_f ((The first individual oscillation frequency is less than 1), is considered depending on the type of stiffness structure or elastic structure.

Thus, it can be seen that the standard EN1991-1-4 and ASCE / SEI 7-5 calculate the impact of wind on billboards in particular and construction works in general, including many parameters and accuracy of the characteristics of wind load impacts than TCVN 2737: 1995.

C. Block diagram of wind load calculation according to TCVN2737: 1995, EN1991-1-4 andASCE / SEI 7-05 with MathCad programming software

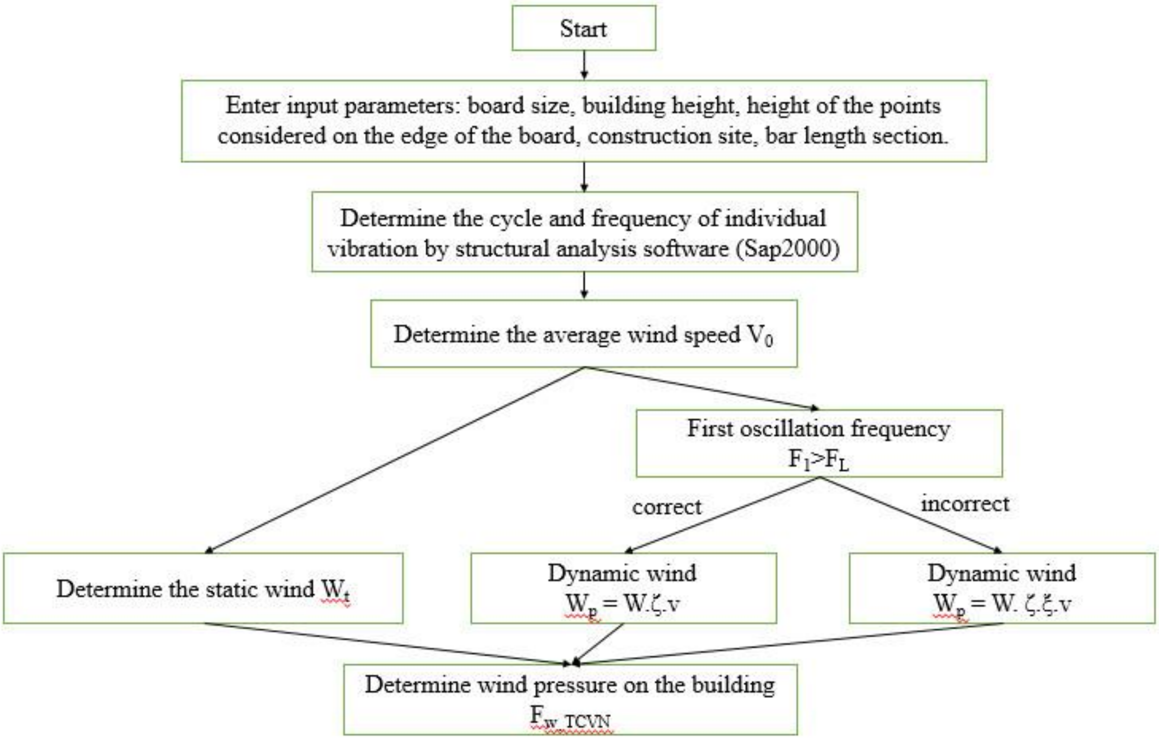

Figure 3. Block diagram for calculating wind pressure on billboards according to TCVN 2737: 1995 by MathCad software

Similarly, set up a block diagram to calculate wind pressure on billboards according to EN1991-1-4 and ASCE / SEI 7-05 standards with MathCad software shown in Figure 4 and Figure 5.

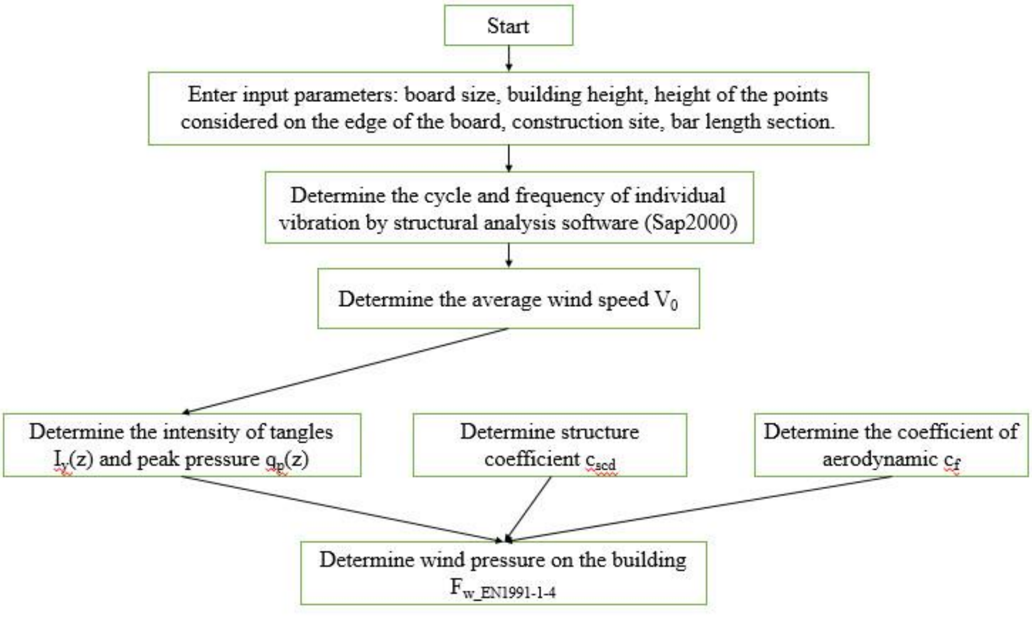

Figure 4. Block diagram for calculating wind pressure on billboards according to EN1991-1-4 by MathCad software

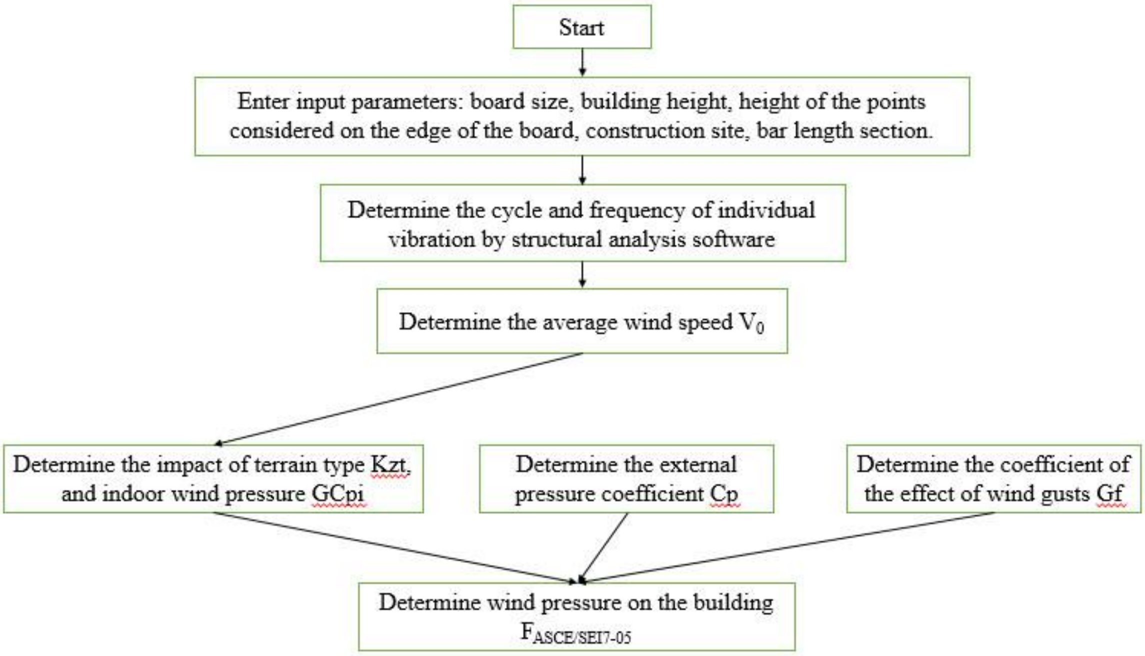

Figure 5. Block diagram for calculating wind pressure on billboards according to standard ASCE / SEI 7-05 with MathCad software

III. RESULT AND DISCUSION

According to the order of calculating the wind pressure on billboard works shown as block diagram as shown in Figure 3 and Figure 4, the author has conducted the billboard construction with the size of 18x9m, height of 27.2m, and location Construction site in Da Nang city, wind zone IIB, billboard structure is shown in Figure 6.

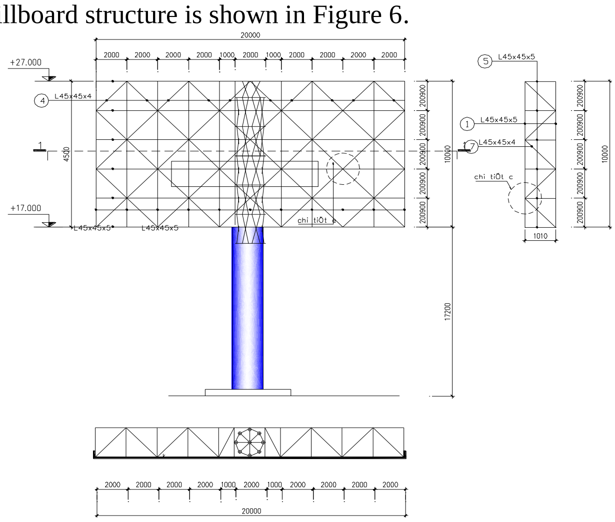

Figure 6. Example of a billboard

Based on the subprogram set by MathCad calculation software. Calculation results are shown in Figure 7.

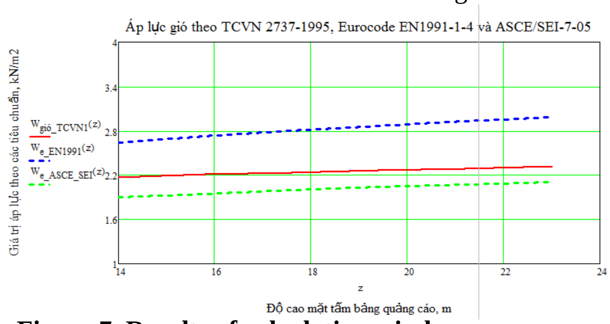

Figure 7. Results of calculating wind pressure on a billboard according to standards re

From the calculation results, it is found that the value of calculated wind pressure according to TCVN2737: 1995 and according to EN1991-1-4, ASCE / SEI7-05 is different due to European standards EN1991-1-4 and pepper American standard ASCE / SEI 7-05 takes into account many characteristics of wind load than TCVN 2737: 1995.

When calculating the wind load on a billboard project, according to EN1991-1-4, depending on the size of the construction, the change in wind pressure according to height and terrain type will be adjusted to each height section of the construction based on reference values. In TCVN 2737: 1995 and ASCE / SEI 7-05 does not take into account this factor, so the distribution of wind load acting on the construction according to height according to EN1991-1-4 is more different than that of TCVN 2737: 1995 and ASCE / SEI 7-05.

TCVN 2737: 1995 when calculating wind load separately separated static and dynamic components. With standards EN1991-1-4, ASCE / SEI 7-05, in addition to static components have taken into account the impact of dynamic components by including the formulas for calculating the impact coefficient depending on the type of terrain and characteristics in the dynamic reaction of the structure.

IV. CONCLUSION

The article provides some contents related to calculating the impact of wind load on billboards, when applying foreign standards to calculate for this type of construction, it is necessary to convert the parameters accordingly. The article presents the calculation results according to TCVN2737: 1995, EN1991-1-4 and ASCE / SEI 7-05 in the subprogram established by MathCad programming software and it can be seen that the wind pressure calculated standards have significant differences. Therefore, when calculating the design for large plate billboards under the impact of wind load, there must be a comparison between different standards to have more accurate assessments, which will bring higher reliability in the process of designing and calculating buildings..

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