Abstract

In countries where there is a greenhouse tradition, concerning both manufacturing and cultivations, it is widely accepted that the greenhouse is a construction much more complicated than initially thought and that the safety of the structure should be an object of continuous research.

This paper studies the dynamic pressure of wind that is defined in the greenhouse standards of Greece, U.S.A., The Netherlands, France, W. Germany, Italy. It aims a) to compare these standards and to make known the wind loads which are taken into account in the structural design of greenhouses, b) to compare these standards with the Greek draft standard ELOT T.E. 32 on wind loads and make proposals so that it can be applicable to greenhouses, c) to assist in the development of an International greenhouse standard.

1. Introduction

The static wind pressure $p$ vertical at any point of a surface is often given by the following equation

$$p = C_p q$$

where $C_p$ is the pressure coefficient and $q$ is the dynamic pressure.

To compare the wind pressures of the various greenhouse standards, it is sufficient to compare the dynamic pressures. The dynamic pressure at a height $z$ is given by models of the following form:

$$q = f(p, S_1, S_2, S_3, V_0)$$

where $p$ is air density, $S_1$ is the topography factor, $S_2$ is the ground category height and structure size factor, $S_3$ is the statistical factor and $V_0$ is the basic wind speed.

It is possible for the variable $q_H$ to exist instead of the variable $V_0$. The variable $q_H$ is the dynamic pressure at a given height named basic dynamic pressure.

2. Items

The general purpose of this work is to compare the dynamic pressure of several greenhouse standards. In table 1 there are the compared greenhouse standards.

The greenhouse standard ASAE S 288.3 doesn’t specifically refer to greenhouses. Nevertheless it is applicable to all agricultural structures. That is why it was taken into account in this work.

In Greece for the estimation of wind pressures on greenhouses a method is presently used.
To make the comparison possible, the dynamic pressures were calculated with \( V_0 = 30 \text{ m/s} \) for \( T = 10 \text{ min} \). This velocity is equal to \( V_0 = 43 \text{ m/s} \) for \( T = 3 \text{ S} \) and to 80 mi/h fastest mile speed.

Concerning the French standards, where the whole country is divided in three regions, the basic dynamic pressure of the III region was used for the comparison.

In the Italian standards, the whole country is divided in five regions and each region in four zones. The dynamic pressure is the same \( (q = 400 \text{ Pa}) \) for heights less than 6 m in all the above regions. For heights greater than 6 m the values of the region B and zone 2 were used for the comparison.

The life of a greenhouse structure is assumed to be 25 years. The Dutch standard defines 15 years. The ground roughness (ground category) for the calculation of wind pressure was that of areas where greenhouses are normally set up. Concerning the topography of the ground, it is assumed that there isn’t a large local variation in the ground surface. In B.S. 5502:Section 2.4: 1981 the dynamic pressures are calculated for ground category 2 and for topography factor \( S_1 = 1.00 \). In NF U 57-064 the topography factor \( K_s = 1.00 \). In the Greek draft standard ELOT T.E. 32 the dynamic pressures were calculated for the ground categories II and III and for topography factor \( \zeta = 1.00 \). In N.G.M.A. standards the dynamic pressures were calculated for ground category C. In DIN 11535, NEN 3859, UNI 6781-71 and in the presently used method in Greece the ground roughness is not taken into account.

Figure 1 shows the variation of the dynamic pressure with the height according to various greenhouse standards.

In the ANSI A58.1-82, for the calculation of the wind pressures \( p \), the following equation is used:

\[
p = Cp q G
\]

where \( G \) is a function of the ground category named gust factor. Figure 1 has two curves for ANSI A58.1-82. Curve 6 represents the values of \( q \) and curve 10 the values of \( qG \).

3. Concluding remarks

From the curves of figure 1 we make the following remarks:

- the German DIN 11535 gives the minimum dynamic pressure, while the Greek draft standard ELOT T.E. 32 for ground category II the maximum,
- the Dutch NEN 3859, the French NFU 57-060, the British B.S. 5502: Section 2.4: 1981 and the American ASAE S288.3 give similar dynamic pressures; the values of dynamic pressure given by the French standards have to be multiplied by a reduction factor \( \delta \); this factor is a function of the dimensions of the structure; we can take as mean value the \( \delta = 0.80 \),
- the Italian UNI 6781-71 and the French NFU 57-064, taking into account the reduction factor \( \delta \) give similar values for heights less than 6 m,
- the method used presently in Greece and the Dutch NEN 3859 give the same values of dynamic pressures.
We propose the dynamic pressure that are given by curve II of figure 1 for the Greek and International standard on glasshouse structures. For plastic houses, we recommend a reduction of 20% from the above values.

**Bibliography**


Norme Française, 1983. Régles de stabilité et de sécurité pour la construction des serres-multichapelles couvertes de matériaux plastiques souples ou cintrables à froid, NF U 57-064, Mars 1983.

Norme Française, 1983. Régles de stabilité et de sécurité pour la construction des serres à vitrage plans, NF U 57-060, Mars 1983.


**Table 1**

<table>
<thead>
<tr>
<th>Country</th>
<th>Greenhouse standard</th>
<th>Wind load standard</th>
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<td>BS 5502:Section 2.4:1981</td>
<td>CP3 Chapter V: Part 2:1972</td>
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Figure 1 Dynamic pressure according to various greenhouse standards