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THERMAL CALCULATION FOR THE PRODUCTION OF VEGETABLES GREENHOUSE

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Abstract.

This paper presents the calculation regarding thermic transmision through the closing elements made for a greenhouse designed for salat production, pea, spinach and cabbage, D.M. greenhouse type, with medium and large openings (12...30m) having a light roof with spatial structure from bars and thin walls made from galvanized steel or aluminium and designed at the Technique University from Cluj-Napoca. The greenhouse opening is 15.90 m, the total lenght is 40.50m and 669.53 sqm surface with 643.95 sqm usable area. After analyzing the thermal calculations for the production of vegetables greenhouse show that the heat losses are insignificant, advantage is given by the light roof with spatial structure from bars and thin walls made from galvanized steel or aluminium.

Key words: *greenhouse, roof with spatial structure, thermal calculation*

INTRODUCTION

Greenhouses are constructions for extra-season production of vegetables, flowers or seedlings, having external surfaces made from glass or other transparent materials, in wich is realized an artificial microclimate favorable to crops, independently of season and the weather condition. The evolution of greenhouses construction led to different achieving conceptions of schemes for strength structure and closing elements, depending on the types of obtained crops and the local conditions, particularly for individual and block greenhouses [7].

MATERIALS AND METHODS

The calculation regarding thermic transmision through the closing elements was made for a greenhouse designed for salat production, pea, spinach and cabbage. At the Technique University from Cluj-Napoca was designed the D.M. greenhouse type, with medium and large openings (12...30m) having a light roof with spatial structure from bars and thin walls made from galvanized steel or aluminium (fig. 1). The new type of greenhouse is equipped with all possible thermal energy saving technics and shading systems using a single or double screen etc.

RESULTS AND DISCUSSIONS

Calculations were prepared according to STAS 1907/3-97. The characteristic elements of the building location are:
- third climate area related to Romanian climate zoning map;
- orientation to the cardinal points: EV longitudinal direction, with the main facade to the west;
- the forth aeolian area related to settlements framing map in windy areas;
- the importance class related to P 100-2006;
- seismic zone related to P100-2006:F, ag=0.08;
- corner period related to P100-2006: TC=0.7 sec;

*Bearing structure and finishes***:**
The greenhouse opening is 15.90 m, the total lenght is 40.50m. The greenhouse built surface is 669.53 sqm. The usable area is 643.95 sqm.

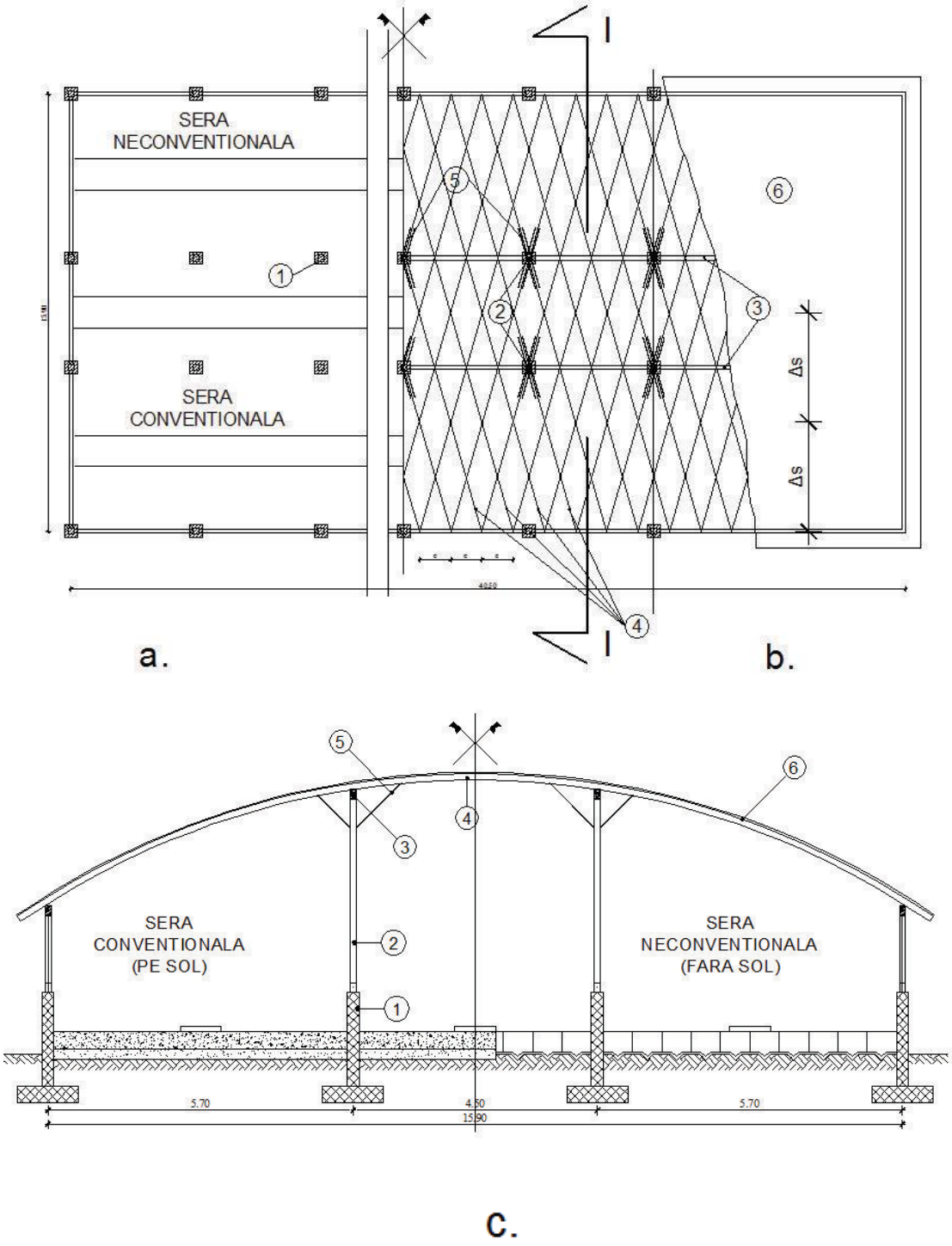

Fig. 1. Greenhouse for the production of lettuce, peas, spinach and cabbage
a-ground level plan; b-light roof plan with spatial structure; c-section cross; 1 - precast concrete pillar supporting the greenhouse roof; 2 - metal pole supporting the greenhouse roof; 3 - metal beams; 4 - light roof with spatial structure; 5 - metal struts supporting the roof; 6 - parcel of structured polycarbonate boards, glass or foil from plastic metal

The bearing structure made of rolled galvanized steel, will have 3 openings of 5.70 m, 4.50 m and 5.70 m and spans of 4.50 m, and as closing material will be used the glass, plastic foil and structured polycarbonate boards (Twinwall sau Triplewall). Prefabricated foundations have deep (from the natural field level) of -2.40 m and the socle level over the field at +0.30 m.

The envelope elements have the following composition:

- The exterior walls are made of glass, plastic wrap or structured polycarbonate boards (Twinwall or Triplewall) and metal frame. Glass, plastic wrap or structured polycarbonate boards must have the following qualities: great penetrability for sunlights, low reflection, high resistance at applications. Optimal thickness for lateral walls is 3 mm.
- The roof is made from glass, plastic wrap or structured polycarbonate boards that have the following qualities: elasticity, flexibility, high resistance at applications, low specific weight, high optical transparency.

Land area on which is located the greenhouse:
$S_{greenhouse}$= 15.90m*40.50m= 643.95m^2
Glass surface:
S_{FL}=1.50m*40.50m*2+1.50m*15.90m*2=
=169.2m^2
S_{FA}= 17.81m*40.50m= 721.305m^2
S_F= S_{FL}+ S_{FA}= 890.505m^2

Calculation of heat needed for greenhouse

Calculations shall be prepared according to STAS 1907/3-92.
So, is calculated:

$\psi(s) := 0.50$ for $S_{greenhouse}$= 643.95m^2

In the forth windy area (related to STAS 1907/3-92) "v" is the calculation speed for wind:

$$v := 4\left(\frac{m}{s}\right) \qquad v^{\frac{4}{3}} = 6.35\left(\frac{m}{s}\right)$$

α_i, α_e – superficial coefficients of heat transfer are calculated with the following relations:

$$\alpha_i := 4.65 + 1.63v \cdot \psi(s) = 7.91\left(\frac{w}{m^2K}\right)$$

$\alpha_i > 6.4$ then n:=1.70

$$\alpha_e := 5.82 + 4.07 \cdot v = 22.1\left(\frac{W}{m^2K}\right)$$

$$K_{ET} := \frac{\alpha_i \cdot \alpha_e}{\alpha_i + \alpha_e} = 5.825$$

π_n - penetration coefficient;
$\pi_n := 0.10$ for sealed greenhouses;
n- leakage coefficient of the greenhouse;
n:=1.70 for sealed greenhouses;

$$\xi := \frac{i_i - i_e}{t_i - t_e}\left(\frac{KJ}{kg/K}\right)$$

where:
i_i- indoor air enthalpy (KJ/kg);
i_e- outdoor air enthalpy (KJ/kg) or (Wh/m^3);
- greenhouse is intended to produce salad t_i:= 14^{0}C u_i:= 70%
- greenhouse is placed in climate zone III t_e:= -18^{0}C u_e:= 80%
- t_i- interior temperature of calculation;
- t_e- conventional temperature of outdoor air according to climate zoning map of Romania;

$$i_i := 9.118\frac{kcal}{m^3}$$

$$i_e := -5.07\frac{kcal}{m^3}$$

$$\xi := \frac{i_i - i_e}{t_i - t_e} = 0.443 \cdot \frac{kcal}{m^3 \cdot K}$$

K_{conv}- global coefficient of heat transfer due convection through glazed surface is $K_{conv} := K_{ET} \cdot \left[1 + \pi_n (K_{ET})^{n-1} \zeta\right]$ determined with the relation:

$$K_{conv} = 6.711\frac{W}{m^2K}$$

c- coefficient that takes into account the occurrence frequency of hours with clear sky associated to conventional temperature of outdoor air, with the value c=0.10 regardless the climate area;

$$K_{conv} = 6.711\frac{W}{m^2K} \qquad c := 0.10\frac{W}{m^2K}$$

t_i:= 14^{0}C t_e:= -18^{0}C

$S_{greenhouse}$ = 643.95m^2 S_F = 890.505m^2

Global heat demand "Q" of a greenhouse is calculated with the relation:

$$Q := 1.26 \cdot S_{greenhouse}\left[0.35\frac{W}{m^2K} + \frac{S_F}{S_{greenhouse}} \cdot \left(K_{conv} + 3.26 \cdot c\right)\right] \cdot \left(t_i - t_e\right)$$

$$= 2.618x10^5 \cdot W$$

CONCLUSIONS

After analyzing the thermal calculations for the production of vegetables greenhouse show that the heat losses are insignificant, advantage is given by the light roof with spatial structure from bars and thin walls made from galvanized steel or aluminium, model developed at the Technical University of Cluj-Napoca according to invention D.M. new type of greenhouse. The modern greenhouse has many new design with medium and large openings and with free spaces for the shielding installation under the roof and along the side walls. The energy crisis and the growth of fuel prices, from the last period, has generated interest in using new systems for the protection and use of heat sources, such as double-walled constructions to reduce heat loses, constructions with plastic closures without technique heating, using new sources of heating from solar, wind, geothermal energy etc.

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