COMPARATIVE STATIC ANALYSIS OF WOOD TRUSS DEPENDING ON OWN WEIGHT AND WIND LOADS ACTION

Fetea Marius Serban*

*Technical University of Cluj Napoca, Faculty of Building Services, B-dul 21 Decembrie 1989, nr. 128-130, Cluj Napoca, Romania, e-mail: marius.fetea@yahoo.com

Abstract

Static analyzes performed on truss until now have not take into consideration the influence of its own weight on the axial efforts that occur in beams structure. Through this paper is trying an pioneered approach for a comparative study taking int consideration the influences of axial efforts on own weight. Was adopted the asumption that truss material is considered isotropic.The problem was resolved by using analytical method.

Key words: : truss, analytical, axial, efforts, wind

INTRODUCTION

Mechanical structures truss assemblies is composed of straight beams that are connected by nodes. The nodes considered in the paper being assimilated with articulations. The conception work was taken into account following practical aspect of the trusses:metal constructions: thanks to its beams fixation in nodes by restraint systems, they become stiff, which will lead the beams to deformation and bending solicitation. Consequently, the system baeams will appear alongside the principals axial tensiles or compressive forces, the sectional efforts given by the bending moments and shear forces regarded as secondary efforts. So, in the papers was introduce some computing approximations in determining the efforts and strain. In the case of metallic beams structures the efforts corrections that must be applied does not exceed 10-15%.

MATERIAL AND METHOD

Research on the present paper were performed in the installations for constructions research laboratories of the Technical University of Cluj-Napoca, Faculty of Building Services. The research and the determination of results was done between April 2016- July 2016. The results of the studies and analyzes carried out falls into the fundamental theoretical research. Study methods applied are analytical calculation methods. The study conducted by the author can be framed in the fundamental theoretical studies. Static analysis was done by accepting as valid the following simplifying assumptions (Washizu, 1975):

1.axes bars in each node is considered as concurrent (Posea, 1976);

2. the external forces imposed are applied on nodes and the own weight of beams are considered in the centers of mass (forces of gravity);

3. bars are considered perfectly articulated in nodes (Sandu, 2003).

In this paper was started from considering a three-dimensional truss structure, with three equal sections with height $H = 1{,}5[m]$ and width $L = 2{,}0[m]$. Taking into account the truss structure symmetry by axes the staic study was done into the plan. Truss material considered is OL 37 and the bars truss structure is being considered as having a rectangular cross section (square) dimensions:

$$lxl = 0.20x0.20[m^2]$$

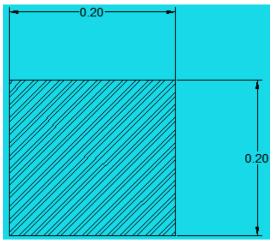

Fig. 1. Beams truss square dimensions

The role of considered structure is to supporting at to the 4.5 [m] height of a water pumping system and a water storage tank commonly used into the water supply of family type households of rural tourism.

The water tank storage is considered as the form of a load uniformly distributed forces over the entire surface. Taking into account the type of forces distributions given by the water tank and the weight of the pumping system's, the plan study it will considered the action of the resultant forces of the truss beams Q_1 into upper nodes having the components R_1, R_2. Wind loads which act on the structure were determined considering Indicative 1-1-4 CR/2012, called: Evaluation of the wind action on buildings. Using the relationships stipulated into the Indicative CR 1-1-4 / 2012 were considered the following parameters for the stuctures calculation from the III category.

1. Reference value of the wind dynamic pressure.
2. Proportionality factor.
3. Wind turbulence intensity.
4. Gust factor
5. The rugosity factor for the pressure medium.
6. Exposure factor.
7. Peak value of the dynamic pressure
8. Wind pressure.
9. Characteristic value of the beam load (the wind load resultant force) to the maximum height of 4.5 [m].

$$p_w = \frac{w_e \cdot 4{,}5 \cdot l}{2}$$

10. Considered value for the truss calculation.

Having determined the value from wind loading forces (Barsan, 1971) it was determined the beams weights values from the truss structure. The action of beams own weights is manifests mainly as of a uniformly distributed load with the intensity q (Warburton, 1976). Weight is considered as a volumetric force (Bia C. 1083), (Soare, 1999). On each side with height 4.5 [m], into the corresponding nodes will operate beams own weights.

$$Q_2 = Q_3 = Q_4 = Q_6 = Q_7 = Q_8$$

Static analysis (Fetea, 2010) involves the determination of forces from the supports of the structure. It uses static equilibrium equations written for the whole structure. It has take into consideration the forces of gravity values of the bars. In determining the tensile and compressive axial efforts occurring in beams system was used sectional method. Static analysis was performed in extreme quadrants of the truss. The axial efforts determinations using the analytical method was applied in two stages: in a first step has not been taken into account the force weight, but only the external forces apllied in the nodes beams and in the second stage the weights forces bars were considered as volume forces with the resultant forces in the middle of each beams. After determining the reactions forces in the considered system supports, the method sections was done using the following steps:

1. In the XY coordinate plane is sectioned beams 1-2, 2-7, 8-7. Sectioned beams do not have to compete in a single node.

Using the sectional method (Catarig, Petrina, 1991), (Barsan, 1979) is was determined the axial efforts values (Timoshenko, 1962) on the base section beams denoted by (I) (figure 3) and the peak section beams denoted by (III).

2. In the upper quadrant using the same method were determined the axial efforts N4-3, N5-3, N5-6 corresponding at sectioned beams 4-3, 5-3, 5-6.

3. To determine the axial tensile and compressive efforts, were written null bending moments equations null in relation to certain nodes of the system (Missir-Vlad, 2002), (Catarig, Kopenetz, 2001). Nodes in relation to which they were written equations should not be to belong necessarily to considered quadrant.

4. In the next step was calculated the axial efforts taking into account both of two: the weights forces beams and the external forces.

RESULTS AND DISSCUSIONS

Wind loads which act on the structure were determined considering Indicative 1-1-4 CR/2012, called: Evaluation of the wind action on buildings. Using the relationships stipulated into the Indicative CR 1-1-4 / 2012 were considered the following values for the stuctures calculation from the III category.

1. Reference value of the wind dynamic pressure.

$$q_b = 0,5\left[\frac{KN}{m^2}\right]$$

2. Proportionality factor.

$$\sqrt{\beta} = 2.35$$

3. Wind turbulence intensity.

$$T_v(z) = 0.86$$

4. Gust factor

$$C_{pq}(z) = 7,02$$

5. The rugosity factor for the pressure medium.

$$C_v^2(z) = 1,23$$

6. Exposure factor.

$$C_e(z) = 8,63$$

7. Peak value of the dynamic pressure

$$q_p(z) = 4,31$$

8. Wind pressure.

$$w_e = 6,03\left[\frac{KN}{m^2}\right]$$

9. Characteristic value of the beam load (the wind load resultant force) to the maximum height of 4.5 [m].

$$p_w = \frac{w_e \cdot 4,5 \cdot l(0.2)}{2} = 2,71[KN]$$

10. Considered value for the truss calculation.

$$R_v = p = 1,5 \cdot p_w = 4,06[KN]$$

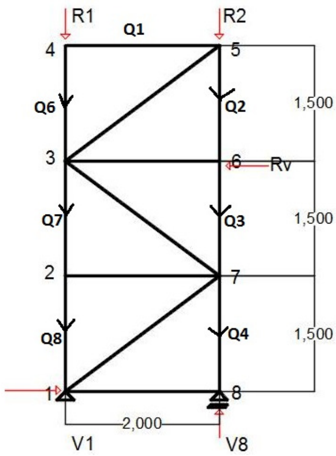

Fig. 2. Truss structure design

Having determined the value from wind loading forces (Barsan, 1971) it was determined the beams weights values from the truss structure. The action of beams own weights is manifests mainly as of a uniformly distributed load with the intensity q (Warburton 1976). Weight is considered as a volumetric force (Bia C. 1083), (Soare M. 1999) and is determined with the relasionships:

$$\rho \cdot V \cdot g = q \cdot A \tag{1}$$

$$q = \frac{\rho \cdot V \cdot g}{A}$$

$$A = 0{,}2 \cdot 4{,}5 = 0{,}9[m^2]$$

$$V = 0{,}2 \cdot 0{,}2 \cdot 4{,}5[m^3]$$

$$g = 10\,\frac{m}{s^2}$$

$$\rho = 7{,}85 \cdot 10^3 \left[\frac{Kg}{m^3}\right]$$

Where:

$\rho -$ density of material, $V -$ beam volume, $A -$ beam area.

The own weight intensity value is

$$Q_{11} = 10\left[\frac{KN}{m}\right]$$

Values forces on upper nodes will be

$$R_1 = R_2 = 10[KN]$$

On each side with height 4.5 [m], into the corresponding nodes will operate beams own weights.

$$Q_2 = Q_3 = Q_4 = Q_6 = Q_7 = Q_8$$

Static analysis (Fetea M. 2010), (Voinea, 1989) involves the determination of forces from the supports of the structure. It uses static equilibrium equations written for the whole structure (Gheorghiu A, 1974). It has take into consideration the forces of gravity values of the bars.

$$\sum M_1 = 0$$
$$\downarrow$$
$$V_8 = 155{,}42[KN]$$

$$\sum M_8 = 0$$
$$\downarrow$$
$$V_1 = 61{,}62[KN]$$
$$\sum F_X = 0$$
$$\downarrow$$
$$H_1 = 4{,}06[KN]$$

Using the efforts method (Barsan G. 1979) is was determined the axial efforts values (Timoshenko St. 1962) on the base section beams denoted by (I) (figure 3) and the peak section beams denoted by (III).

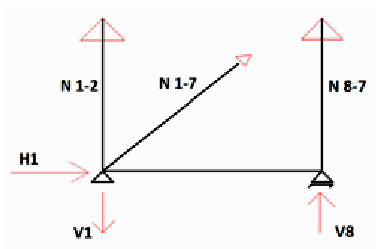

Fig. 3. Truss base section

$$N_{12} = 62{,}4[KN]$$
$$N_{87} = 155{,}4[2KN]$$
$$N_{17} = 10{,}29[KN]$$

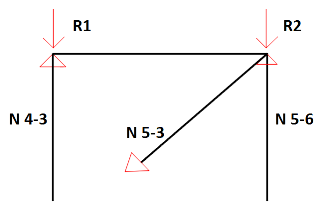

Fig. 4. Truss peak section

$$N_{56} = -10[KN]$$
$$N_{43} = -10[KN]$$
$$N_{53} = 0[KN]$$

In the case when we are not taken into account the own weight forces of beams bars, using the sections method were obtained the following results.

$$N_{12} = -13,855[KN]$$
$$N_{87} = 43,878[KN]$$
$$N_{17} = 5,075[KN]$$
$$N_{56} = -10[KN]$$
$$N_{43} = -10[KN]$$
$$N_{53} = 0[KN]$$

CONCLUSIONS

The main own contribution brought by the author in this plane study of the trusses is related to introducing in the statically calculations of its own weight forces of the beams. As a conclusion to this study can be considered the following:

- the calculation presented in this paper can be considered as an own contribution because into general as simplifying hypothesis does not consider the action of distributed forces just only concentrated forces action into the structure nodes.
- the percentage deviations corresponding to the basic section are very large.
- in the case when are taken into consideration the own weights beams, we have only tensile efforts in the truss base section I.
- in the case when are not taken into consideration the own weights beams, we have compressive and tensile stress on the truss base section I.

Following the data obtained from this calculation is found that percentage deviations occur only into the corresponding beams quadrant number I base section.

- For the axial force N1-2 from the beam number 1-2, the deviation percentage is 22.11%.
- For the axial force N1-7 from the beam number 1-7, the deviation percentage is 49.31%.
- For the axial force N8-7 from the beam number 8-7, the deviation percentage is 28.23%.

In the quadrant section number III, following data obtained from calculations it is found that there is no deviation percentage. Following the data obtained is found that the percentage deviations are extremely high with the consideration of weight forces.

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