BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LIX No. 4/2007	41 - 44	Seria Tehnică

Aspects Regarding an Upper Traverse Oil Pipes System Strength Analysis

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Abstract:

In this paper, the authors present the results of static situation calculus for the resistance structure of an upper traverse oil pipes system over a river. They analysed the magnitude of stresses and displacements for the most disadvantageous loading situation, when the upper traverse oil pipes systems is submitted to many combined exterior actions, such as: gale, water rush and weights.

Keywords: *upper traverse, oil pipes, stresses, displacements*

Basic concepts

The analysed upper traverse oil pipes system is, in principle, done of two pylons. In their structure, we can find an inferior part named girder pole and a piece head as a superior part, both making a spatial structure, statically indeterminate, having a total height, related to the projected (initial) level of the base, of 20845 *mm*.

The girder poles are guyed to the rock flow by tubular piles of ϕ 273,1 x 14,3, which were jointed by cementing to the drilled holes walls. Because of the water erosion, these tubular piles suffered a severe un-shielding of approximate 2 *m* and this fact leaded to a serious damage of the initial structure assembly properties from the point of view of its resistance to the various possible loadings (weights, wind, water pressure or dynamic factors).

The other component elements of each pylon of the upper traverse oil pipes system are made of pipes.

On the pylons top level there is a traverse made by bottom-welded pipes on which three fluids transmission lines of 10″, 12″, 14″ are resting against. Each transmission line has a wall thickness of 8 *mm*. Through a roller system placed at the superior part of each pylon, there are settled the steel cables which can take over a part of the three fluids transmission lines and of the transported fluids weights. The weight force is transmitted to each of the two pylons, settled on the two riverbanks.

The model for the static situation calculation of the upper traverse

The static situation calculation for the upper traverse oil pipes system pylons was made using the Finite Element method, with a specialized program. For this purpose, all the beams, which compose the pylons, were divided in finite elements such as spatial beam (fig. 1). We obtained

389 elements as beam type and 156 de nodes. The tubular piles of ϕ 273,1 x 14,3, which initially were buried in the riverbed underground, were considered having a 2000 *mm* length and being integrated in the pylon's structure.

For the static situation calculation, the initial entering data were: a). all the pylon's structure nodes coordinates; b) the material's mechanical characteristics (according to the documentation, a grade A steel with $\sigma_a = 130 MPa$); c) geometrical characteristics (cross section areas, diameters, axial and polar moments of inertia) of each beam; d) the joints with the ground; the pylons were considered jointed to the ground by rigid fixing in 88 … 96 nodes (fig. 1); e) data of pylon's structure loadings. We considered three static loading cases: e1) the pylon's structure component elements weight and the three transmission lines pipes weight (having fluids) which is distributed to each pylon; e2) the wind action as a gale. This one was introduced as a distributed load on the all pylon's beams in the general X axis (fig. 1). The wind pressure was determined according to STAS 10101/20; e3) the rush water action.

All these loadings were considered working simultaneously, so taking for the calculation manner the eventuality of the most unfavourable situation that can be met.

Loading determination for the static calculation. Stresses and displacements determination

Loadings determination

Weight forces. Based on the presented data, for all the pipes, the program automatically calculates the total weight of the construction. So, this weight is of 284 *kN*. We considered the weight that devolves on one the upper traverse oil pipes system pylon because of the three fluids transmission lines of 10″, 12″, 14″ and because of the fluids (for oil, $\rho = 900\ kg/m^3$) is of 81666 *N*. Because the distance between the pylons was of 46 *m*, we distributed these weights, with the aim of calculating the loads for a pylon, on 23 *m*. The total weight was distributed in the following nodes: 79, 81, 108, 114, 138 and 144 (fig. 1).

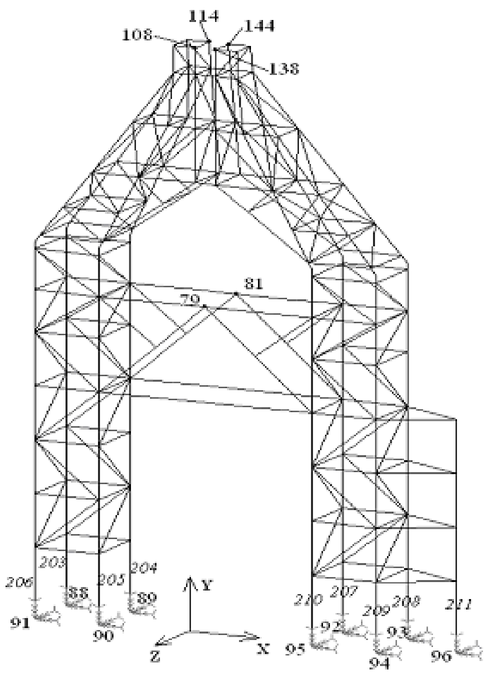

Fig. 1. The simulation with finite elements

Wind action. The wind action was considered as a distributed load on all the pylon's beams, along the general axis X (fig. 1). The wind intensity was calculated according to the STAS 10101/20 foresights. We considered a very big intensity of the wind (a gale), of 100 *km/h*, for which it resulted, as the mentioned standard provides, a value of the basic dynamic pressure for the pipes of $5{,}8 \cdot 10^{-4}\,MPa$. This pressure was distributed on each element of the construction, in relation with every pipe exterior diameter. The longitudinal distributed loads intensities, on each pipe, were: $q = 0{,}158 N/mm$, $q = 0{,}082 N/mm$ respectively, related to the exterior pipe diameter.

Water action. We considered the water action as a water rush action. According to a report from A. N. Apele Române S. G. A., it was recorded a water rush on the Prahova river in 2001, corresponding to a water velocity of $5{,}55 m/s$. So, we analysed the possibility of a recurrence of this situation, which can overlap the effects given by the wind action. The water rush height was considered of 6 *m*, so it can practically cover both the tubular piles and the first two pylon's levels. The water pressure was introduced on the corresponding beams, along the general axis X (fig. 1).

According to the considered velocity, with the relation between fluid pressure and its velocity ($p_a = \rho \cdot v^2/2$), we determined the pressure in the case of a water rush of 0,0157 *MPa*, applied along the affected pipes length. The following values given by calculus were obtained, in relation with the exterior pipes diameters: q=4,287 *N/mm* and, respectively, q= 2,215 *N/mm*.

Pylon's elements stresses and displacements determination

The static calculus of pylon's structure was realized for three loading types: the proper weights of the elements composing the pylon's structure and the weight of the three transmission lines having fluids (oil) that are applied to one pylon; wind action; water action as a water rush. The most considerable effect on the real stresses level the of structure's elements is given by the water action. The simultaneous action of these three loads leaded to a structure's nodes state of displacements and stress considered to be the most unfavourable. In the following, we present the results of the static calculus in this situation, when the three loads are simultaneously combined.

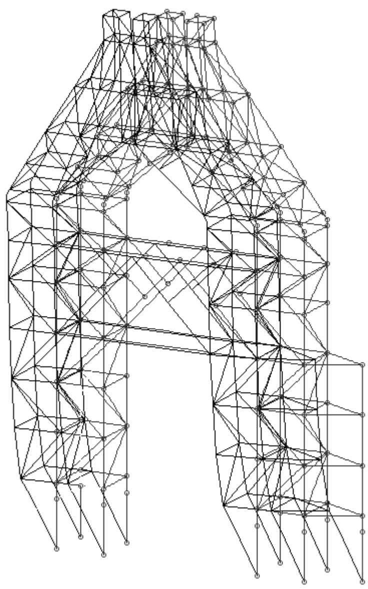

Fig. 2. The deformed form of the structure

In figure 2 is presented the deformed form of the structure. The biggest displacements occur in the nodes 108, 114, 138 and 144, positioned at the pylon's superior part, and have the following values: $u_x = -8{,}7mm;\ u_y = -0{,}5mm;\ u_z = 1{,}3mm$.

The maximum stress level occurs in the elements 203 … 211 (fig. 1), positioned at the structure's base.

Having the sectional loadings, given by the program, they calculated the σ stresses from these elements, using the known relations from the strength of materials and the resulted values were: $\sigma_{203} = -121{,}37MPa$; $\sigma_{204} = -108{,}5MPa$; $\sigma_{205} = -107{,}92MPa$; $\sigma_{206} = -122{,}78MPa$; $\sigma_{207} = -110{,}96MPa$.

We can see that the maximum stresses are inferior to the allowable stress and, for the most stressed beam, a safety coefficient $c = \frac{\sigma_c}{\sigma_{\max}} = 1{,}702$ is assured.

Conclusions

For the static calculus of the presented structure, the authors considered the most disadvantageous situation, given by the simultaneous action of three different loads: the proper weights of the elements composing the pylon's structure and the weight of the three transmission lines having fluids (oil) that are applied to one pylon; wind action and water action as a water rush, both having the same direction.

The structure's maximum stress level occurs in the elements 203 … 211 (fig. 1), positioned at the structure's base, where the calculus indicates the biggest stress values.

The maximum calculated values are close to the pylon's material allowable stress. The static calculus was realized for a wind velocity of 100 *km/h* and for a water velocity of 5,55 *m/s*. the water pressure increases in proportion to its squared velocity. So, an increase over 5,55 *m/s* of the water velocity (very possible in actual conditions, when the meteorological phenomena are more and more violent and unpredictable) will have as effect a stress level rise and the allowable stress could be exceeded.

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Aspecte privind calculul de rezistență al unei supratraversări

Rezumat

În lucrare se prezintă rezultatele calculului static realizat pe structura de rezistență a supratarversării unui râu de un sistem de conducte. Se fac aprecieri cu privire la nivelul tensiunilor şi al deplasărilor pentru cea mai defavorabilă situație de încărcare.