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STABILITY ESTIMATION OF STEEL VERTICAL CYLINDRICAL TANKS UNDER WIND ACTION

Problem statement. Steel vertical cylindrical tanks are most commonly used in the oil and gas industry as storage tanks for petroleum products and gases. Currently, many of these structures have been seriously damaged or destroyed in Ukraine. This has created an urgent need for the construction of new tanks.

When diagnosing the tanks technical condition, it is necessary to perform an individual assessment of the technical condition of these structures. It should be taken into account specific loading conditions, geometry parameters, defects and damaging in order to identify reserves of the bearing capacity of a particular tank.

The cylindrical wall of tanks belongs to the class of thin-walled shells. The geometrical parameters of such shells are $r/t = 600 \div 3800$; $l/r = 0,6 \div 2,5$; here l, r, t are the length, radius and thickness of the cylindrical shell. The issue of stability for such structures comes to the fore.

The wind load is of great importance among the compressive loads. According to the design standards [1, 2],the wind load on a cylindrical structure is a pressure that is not evenly distributed around the circumference of the structure.

In the stability estimation, the nonuniform wind pressure is replaced by a uniform external pressure, which is called the equivalent vacuum [3]. The conversion is made by multiplying the nonuniform wind pressure amplitude by the coefficient k_w. The value of k_w is equal 0,5 for all geometrical parameters tanks.

The **aim** of the study is to clarify the validity of this approach and identify possible inaccuracies in the engineering estimation of tank stability.

Content of the research. The research was carried out using the finite element method. The calculations were performed at a wind pressure value that corresponds to the wind load on the territory of Ukraine. [1]

The static analysis has shown that the membrane circumferential stresses σ_{2M} are predominant for these shells. Their value reaches 17-20 MPa. The second for their value are the membrane meridional stresses σ_{1M}. The relationship $\sigma_{1M} = \mu \cdot \sigma_{2M}$ is observed; here μ is the Poisson's ratio. It corresponds to the basic dependencies of the shell theory.

Bending stresses in the shell are extremely low. The value of bending circumferential stresses is $\sigma_{2B} = 0,12 \div 0,20$ MPa. The highest bending stresses occur in the shell areas adjacent to the edges, that is, in the edge effect region.

It was found that the distribution of all stresses corresponds to the wind pressure distribution. The main peculiarity of the bending stress diagrams is the pronounced wave-like nature.

The nature of the stress diagrams corresponds to the radial displacement diagrams w and the deformed shell shapes. This wave-like nature of deformation was also observed in full-scale experiments [4].

Such wave deviations of the shell surface have already occurred at the beginning of deformation. As a result, the limit wind load will be lower than buckling wind load. And in this case, instead of solving the bifurcation problem of stability, it is necessary to solve the nonlinear problem of shell deformation.

Conclusions. The resulting wave-like nature of the bending stresses, radial displacements and deformed shell shapes indicate the complex actual behavior of shell structures under wind pressure. This fact is not considered in regulatory stability estimations. In order to obtain a reliable assessment of stability during the technical diagnosis of tanks in operation, it is desirable to perform a shell nonlinear deformation analysis in each specific case. At the same time, it is necessary to take into account the actual distribution of wind pressure and the real geometric shape of the cylindrical shell with existing geometry imperfections.

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CONCRETE WITH MINERAL ADDITIVES

The efficiency of using cement in concrete can usually be estimated by the following properties: workability, strength, durability. [1]:

According to the research, carried out by foreign scientists on Portland cement with the addition of limestone (PLC) and cement with the addition of ash (PAC), the following conclusions can be drawn:

-water consumption and susceptibility to concrete fading with limestone and ash additive is significantly lower than using simple Portland cement;

-in 28 days the compressive strength of concrete based on PLC and PAC with the same concrete composition, as well as the same standard strength of cement, is not lower than with the Portland cement. The strength can be higher if water saturation of cement is lower, the additives reduce water saturation of cement;

-the key durability indicators such as carbonization, waterproofing, and frost resistance in concrete using cement with additives (PLC and PAC) are almost the same as in concrete with Portland cement or Portland slag cement;

-Bernd Wicht studies indicate that concretes with PLC and PAC can have a higher resistance to sulfate aggression and chloride penetration than concretes of the same composition with sulfate-resistant Portland cement; [1]

-pozzolans and materials with hidden hydraulic properties significantly reduce the dangerous reaction between an alkali and a siliceous component due to hydration reactions and the binding of alkalis into insoluble compounds.

New types of modern concrete are emerging due to high achievements in plasticizing of concrete and mortar mixtures, as well as the most active pozzolanic additives - micro silica, dehydrated kaolin, and highly dispersed ashes. The combination of superplasticizers and especially hyperplasticizers on a polycarboxylate basis allows you to reduce the water-cement ratio to 0.24...0.28 and obtain superfluid cement-mineral dispersion systems and concrete mixtures. Currently, the nomenclature of finely dispersed concrete fillers has been significantly expanded. The pozzolanic activity of some mineral additives is presented in the Table 1.