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Methodology for Determining the Strength of Underground Pipelines Based On the Wave Theory of Earthquake Resistance of Structures

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ABSTARCT: In this article analyzed earthquake resistance which, was formulated in structure considered earthquake-resistant if its design at a given damage pattern (reaching a predetermined limit state) retains at a calculated seismic.

KEYWORDS: Structural analysis, calculation, earthquakes,statically,strength condition, Constructions norms, pipelines.

I.INTRODUCTION

The theory developed by Sh. G. Napetvaridze and his school. This theory is also called "static theory." In the theory of Sh. G. Napetvaridze is considered that the interaction (friction) on the contact surface of the underground pipeline and soil is absent and therefore the interaction forces are not taken into account. The deformation of the soil and the pipeline under the action of seismic loads is considered equal. These are the assumptions that formed the basis of the theory of Sh. G. Napetvaridze, incorrect, since never the deformation of the pipeline can be the same with the deformation of the soil. It was a forced hypothesis to at least somehow get solutions to the problem of earthquake resistance of underground pipelines in the 50s of the last century.

The dynamic theory of earthquake resistance of underground structures developed by T.R Rashidov and his school. The dynamic theory takes into account the forces of interaction of an underground pipeline with soil on the surface of their contact. However, further in dynamic theory the soil is considered undeformable, which is not true. In addition, the dynamic theory cannot be applied in cases where the pipeline slides relative to the ground and the interaction force turns into friction.

The wave theory of earthquake resistance of underground structures developed by K.S Sultanov and his school. The wave theory takes into account all the shortcomings of the previous theories, i.e. takes into account the forces of interaction and friction, the soil is considered to be deformable, the dynamic stress state of the soil during the propagation of a seismic wave in the soil, the complex nonlinear properties of the soil and the forces of interaction (friction) when the soil is deformed.

Currently, CNR 2.01.03-96 and its new edition (2019) calculate the earthquake resistance of underground pipelines based on a dynamic theory with the above errors. The result is incorrect calculated data on the strength of underground pipelines during seismic impacts. To remedy this situation, it is necessary to develop a method for determining the seismic strength of underground pipelines based on the wave theory of the earthquake resistance of underground structures and introduce the developed method into the practice of design and construction through its inclusion.

II.METHODS OF RESEARCH

Structural analysis of seismic effects is carried out using the limit state method. According to him, it is believed that the design resists
external loads until the internal forces (or deformations) in the design section are less than the limit value. The limit value of the efforts (deformations) corresponds to the accepted design limit state. In Constructionsnorms 54257-2010 "Reliability

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of building structures and foundations. Basic provisions and requirements," limiting conditions are divided into three groups:

1. the first group - the state of construction objects, the excess of which leads to the loss of the bearing capacity of building structures and the emergence of an emergency design situation;
2. the second group - conditions, when exceeded, the normal operation of building structures is violated, their durability is exhausted, or comfort conditions are violated;
3. special limit states - states arising from special influences and situations and the excess of which leads to the destruction of structures with catastrophic consequences.

Constructions Norms 54257-2010 states that the list of limit states and relevant criteria that must be taken into account when designing a construction project is established in the design standards and (or) in the task for design. Unified list of limit states for calculation earthquake resistance in Uzbek standards is not yet.

It should be noted that when calculating the limit states of the first group

This refers to the local bearing capacity of the calculated cross section. But the concept

“Bearing capacity” also has a broader meaning when it comes to the structure as a whole. The loss of the bearing capacity of a structure is equivalent to its full destruction or transformation into a mechanism with subsequent loss of stability.

Failure to meet the strength conditions in the cross section does not always lead to catastrophic consequences. For example, reaching the limit state in a section of a statically indeterminable steel beam and the appearance of a plastic hinge in it will not lead to its kinematic variability, for this there are several such hinges. If the stretched reinforcement of a reinforced concrete beam reaches the ultimate state at which the stresses are equal to the yield strength,

the beam is covered with cracks, is strongly deformed, but destruction will not occur.

Thus, reaching the limit state of the cross section is not necessary

entails the loss of the bearing capacity of the structure as a whole.

It is much more difficult to formulate a criterion for achieving the limiting state of a structure than for a single section. For each design, this will be its own individual limit state, perhaps not the only one.

This should be linked to the destruction mechanism for a given impact, that is, with the order and type of disruption of the bonds between the elements:

scenario or with the formation of plastic hinges.

The ultimate force for the cross-section or connection must correspond to the dynamic nature of the load, that is, take into account that with cyclic loads beyond the proportionality limit, the strength characteristics of elastoplastic media decrease, and internal damping due to damage accumulation increases.

Thus, starting the calculation, it should be understood from what ultimate state it will protect the structure, and what will happen if the strength condition is violated. The problem is that the classical set of limiting states is not quite suitable for problems of the theory of seismic resistance for the following reasons:

1) The calculation is carried out on one or more design sections with maximum efforts, in fact, ensuring the elastic operation of all the others

elements.

2) The limiting state refers only to the cross section, and not to the bonds between structural elements. In other words, if the disconnection of some connection leads to the appearance of a cinematically variable system, from the point of view of the method

limiting states in its present form, the strength of the structure will still be ensured. This means that the calculations of the strength of dynamic systems with breaking connections, the calculations of progressive fracture and survivability do not yet fall within the scope of the limiting state method. For

Such tasks should be formulated a special definition of the limiting state of the bonds, providing bearing capacity.

3) The ultimate forces in terms of seismic resistance correspond to static loading.

In other words, the limiting state of the structure should be related to the safety of elements and bonds providing load-bearing capacity. therefore

the limiting state will be individual for each structure. Calculation of seismic resistance should guarantee the safety of the supporting core of the structure.

Thus, it is necessary to make the transition from the limiting state in the cross section to the limiting state of the entire structure. Before the calculation, a set of requirements for the sections of the bearing elements and the connections between them should be formulated, ensuring the elastic operation of the bearing core. This limit state should not be associated with damage to elements that are not important from the point of view

providing bearing capacity. Marginal forces should be calculated taking into account the dynamic rapidly changing nature of the impact.

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I.I. Goldenblatt, realizing that the problem of seismic stability in a nonlinear setting is unlikely to ever be solved by the engineers of design institutions,
proposed a much simpler way - the concept of double calculation.

He reasoned as follows: earthquakes can be divided into frequent weak with a repeat interval of tens of years and rare strong, the repeatability of which significantly exceeds the life of the structure. Calculation of frequent weak shocks
can be carried out along the elastic stage by the classical method of limiting states, so as to protect the building from damage. This is the first design situation, known as the design earthquake (DS) calculation, that is, that which can occur at this site at least once during the life of the structure.

The second calculation is carried out for the case of a rare strong impact - on the maximum estimated earthquake (MEE), potentially possible for this
site according to seismological studies. In the case of strong earthquakes, the retention of the structure in the elastic stage is impractical. I.I. Goldenblatt and S.V. Polyakov wrote in this regard: “We cannot demand that structures erected in areas of eight-, and even more so nine-magnitude earthquakes - are fully preserved without any damage afterearthquakes. ... Cracks and local damage may appear in the buildings, which will later necessitate repairs, sometimes even major ones, but if people's lives and the most valuable equipment are preserved,
similar buildings and structures can be considered earthquake-resistant. Thus, we come to a slightly different definition from the limit
condition. As is known, the ultimate state is understood as one in which further operation of the facility is impossible. In this case, you need to abandon this definition.

In essence, the task of the theory of earthquake resistance is to ensure structures from large damage; in individual facilities, local defects and damage can be considered permissible”.

In the calculation of strong impacts, all internal reserves of the structure, such as plastic deformation, cracking, rebuilding, are taken into account
internal structure, increased damping, etc.
Since complex nonlinear calculations are exceptionally laborious, I.I. Goldenblat suggested immediately considering the design scheme of the damaged object and ensuring its elastic operation by linear calculation. Design scheme
the damaged object is selected after a preliminary analysis of the most likely for a given impact of the transition of the structure to
close to the limit throughout the duration of the earthquake.

The optimal variant of the damaged design scheme is selected, which, firstly, can be designed so that it will work elastically until the end of the earthquake, and secondly, it will not require large material costs.

The purpose of the calculation is to strengthen the selected structure of the damaged structure so that it retains the bearing capacity at maximum seismic loads until the end of the earthquake.

It is clear that the main difficulty lies in the correct choice of the design scheme of the damaged object. A detailed scientific analysis of the destruction mechanisms of similar structures after past earthquakes, good knowledge in the field of structural mechanics, engineering experience and intuition will help here.

At the scientific school TSNIISK called at V.A. Kucherenko, the idea of I.I. Goldenblatt found its continuation in the form of the “three models” method, which reflects three stages, through

which the structure undergoes during the earthquake:

A is the elastic stage for calculating in the PZ. The design works elastically throughout the impact, internal forces do not exceed the limit. Physicomechanical characteristics of the system are constant and the same as before the earthquake. The calculation is carried out by the linear spectral method. The intensity of the impact is set by the seismicity coefficient. Coefficient

K1

equal to one

since the earthquake is weak and the model is elastic. The purpose of the calculation is to prevent damage during weak earthquakes.

In - elastoplastic stage for calculation on the MRI. The internal forces in some elements exceed the limiting ones, they undergo plastic deformation, and it is possible to turn off the bonds. Physical and mechanical characteristics

vary from cycle to cycle, stiffness degrades over time. The impact is set in the form of extreme scenario accelerograms. The calculation is carried out by integrating nonlinear equations of motion in the time domain.

Coefficient

K_1

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equal to unity, since plastic deformation is taken into account in the calculation. The purpose of the calculation is to clarify the process of localization and accumulation of damage to select the design scheme of the damaged object. The calculation is so complicated that at present it can only be implemented in a simplified

close up view.

C is the elastic stage of the bearing core for calculation on the MRI. It is assumed that some of the peripheral elements are damaged or destroyed, but the main bearing elements have not reached the limit state and are deformed elastically.

Physic-mechanical characteristics of the structure are changed, but constant during

time; stiffness reduced, damping properties increased.

The symmetry of space-planning decisions is broken, which will lead to bending-torsional vibrations. The calculation is carried out by the linear spectral method.

Intensity of the impact is set by the seismicity coefficient. Coefficient

K_1

equal to one, since the mechanical parameters already correspond to the damaged model. The purpose of the calculation is to test the ability of a damaged structure to withstand operational loads and resist possible aftershocks.

III.CONCLUSION

Consequently, in general criterion for earthquake resistance was formulated: the structure is considered earthquake-resistant if its design at a given damage pattern (reaching a predetermined limit state) retains at a calculated seismic.Exposing its bearing capacity.

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