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ScienceDirect

Procedia Engineering 152 (2016) 182 – 189

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Oil and Gas Engineering, OGE-2016

Theoretical researches of rammer's operating element dynamics in a soil foundation of oil and oil products storage tank

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Abstract

The development of technologies for a directional soil compaction is a new prospective task which solving will enable to obtain the required carrying capacity of soil foundations with a rational use of construction materials and to provide a trouble-free operation of engineering structures. Theoretical researches were carried out to study characteristics of physical and mechanical processes of an impact action for rammers operating elements on foundation soils for oil and oil products storage tanks. In the course of the conducted analytical studies of the dynamics for a conic model impact action on a dispersed noncohesive soil we obtained the dependence of the model's motion velocity change on impact parameters. The increase of the model impact velocity from 0.47 to 1.40 m/s resulted in the reduction of interaction process duration in a «model-soil» system from 90 to 56 ms.

Peer-review under responsibility of the Omsk State Technical University

Keywords: operating element dynamics; analytical studies; soil foundation; tank

1. Introduction

The problem of reinforcement of bases and foundations for oil and gas facilities to improve their reliability in the operation process, especially in Far North conditions, has been and remains extremely important, as the regions under development are characterized by hard engineering-geological, climatic and seismic conditions [1-6]. Underestimation of specific construction conditions and operation of transport facilities and liquid hydrocarbons storage, as a rule, results in serious ecological consequences. That holds true for oil and oil products storage tanks.

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Peer-review under responsibility of the Omsk State Technical University
doi:10.1016/j.proeng.2016.07.689

Many reasons determine technology choose or a way of reinforcement of tanks' bases and foundations. For example, the choice of a flowchart depends on the quality of facility's complex engineering surveys, structure type, its design, loadings affecting the basis and foundation, etc. However, the main goal of this technology is providing the required characteristics of reliability and reduction of material inputs and duration of work due to forming by special operating elements sets the directional compaction zones in a soil, taking into account soil properties, basis and foundation design and loadings affecting them [7-10]. To ensure the necessary operational reliability of oil and oil products storage tanks and to enhance their service life while loads on the bases and foundations increase, the problem of their reinforcement comes to a brand new level and requires new scientifically based technological solutions [11-15].

The development of new technologies of soil compaction requires understanding of physical and mechanical processes during the impact of operating elements of construction machines on oil and oil products storage tanks foundation soils. The research of impact action dynamics characteristics of construction machines operating elements on foundation soils will enable to estimate technology development prospects of the directional soil compaction.

2. Study subject

The dynamics of a rammer's operating element in a dispersed noncohesive foundation soil of oil and oil products storage tanks is the study subject.

3. Methods

In the course of conducted studies, the problem of research of operating element dynamics of a conic-shaped construction machine in the process of its impact on a soil was solved. A rammer operating element model (Fig. 1) [16] based on key principles of professor Balovnev's similarity theory was built. Theoretical and experimental studies of the conic model impact action on the soil were performed to analyze the impact dynamics.

Based on the structural model (Fig. 2) for the conic-shaped model the equation of its motion in the soil was derived:

$$m\ddot{z} = Q - N \cdot \sin\alpha - F_{Fr} \cdot \cos\alpha\,, \qquad (1)$$

where m is a model mass, Q is a model weight, N is a normal reaction force of a soil to a model's side surface, F_{Fr} is a model's side surface friction force on the soil, α is an angle between a generatrix side surface and a cone axis.

The normal reaction force of soil to the model's side surface equals:

$$N = \sigma \cdot S\,, \qquad (2)$$

where σ is a normal stress on a conic model's side surface, S is an area of the model side surface plunged in a soil.