INVESTIGATION OF DYNAMIC CHARACTERISTICS OF THE OFFSHORE OILFIELD STRUCTURES

by

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SYNOPSIS

Tests of the dynamic characteristics of drilling derricks mounted on the offshore piled platforms in actual field conditions and model tests of these structures in bounded medium of the centrifugal field of force were carried out.In the result of the field tests in elastic phase and model tests in elastoplastic and plastic phases, the dependance of the periods and damping vibrations of these structures on the design of the platform,sea-depth and bottom ground nature was established.Experimental data obtained were compared with the estimated ones according to the formulas,basis of which made the simplified calculation models.

INTRODUCTION

In connection with the development of offshore oil and gas recovery and due to the fact that offshore oilfield structures are subject to considerable dynamic loads of the elemental character,including also seismic,investigation of dynamic characteristics of such structures acquires great practical importance.

The extreme complexity of the calculation scheme of the system "Offshore platform-derrick" greatly complicates the possibility of determining periods of natural vibrations of system in question by method of direct integration of vibration equation or by usage of the energetic method. But the task can be considerably simplified though by representing the system in the form of cantilever beam of the variable rigidity with variable localized masses and neglecting the influence of grounds and water medium around these platforms.

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Utilizing the variational method it is easy to obtain the canonical equation of the simple type for this case.

However,acceptability of these assumptions is open to question and in this connection experimental investigation of natural vibration of such structures is rather important.Necessity of such tests was also prompted by the fact that theoretical methods for determining of another important dynamic characteristic of the structures,coefficient of dissipation are not perfest and in many cases groundless or extremely disputable.And at last results of the calculations as well as natural vibration tests in actual field comditions reflect performance of the structure in absolutely elastic phase.Meanwhile,elastoplastic and elastic phases are of greatest interest.Owing to known reasons, such tests can be conducted only on the models.

TECHNIQUE AND RESULTS OF EXPERIMENTS

From all the types of offshore oilfield structures derrickes BM-150-41,BM-200-41 and BБ -300-53,errected on the metallic piled platforms (Fig.1) or on compound frame blocks are the most important and widely used.For drilling at sea depths up to 60m.mobile drilling units "Chazar" and "Apsheron" are used.These are powerfull floating platforms with four powerfultelescopic spuds,which are driven into the sea bottom and raise the whole unit to the predetermined elevation above the sea-surface (Fig.2)

Dynamic characteristics of these structures were tested in natural environments at different sea depths and grounds of the sea-bottom.Their natural vibrations were excited with the help of the "microseisms" from the sea waves or by momentary taking the load off the drilling device. During these tests electrodynamic vibrographs (ВЭГИК) and vibrographs for great vibrations (ВБП-3) were installed both on the pileworks,serving as derrick foundations and between the different levels of the derrick along its height.Recordings of the vibrations were made by the oscillographs H-700.

Vibration tests of the models of derricks BM-200-41 on offshore piled platforms were carried out using the method of the "effect of bounded medium of the centrifugal field of force" (I).Models of derricks and piles were constructed in scale 1:70 from the steel identical in strength and deformation characteristic to that one,from which the natural ones are manifactured.Geometric similarity of the model to its actual prototype was observed.Tests were conducted in ground and water level conditions similar to the actual surroundings of derrick and piles in field conditions.

It is not difficult to demonstrate that if the abovementioned conditions are observed the dynamical similarity of the model to its actual prototype will be ensured providing that stresses in elements of the derrick and its foundation are identical to those of the actual prototype both in pattern and in magnitude (2).In our case this condition can be easily observed by compensating lacking stresses in model by stresses from centrifugal forces.Such forces,as known,originate spontaneously in centrifugal units in the process of rotation of the model around the vertical axis.

The centrifugal experimental unit АзИС-2 (Fig.3) on which tests of the models of derricks on piled offshore platforms were conducted provides extremely favourable possibilities for such tests.The centrifugal unit АзИС-2 allows to develop acceleration to 500 times exceeding acceleration of the gravity force, whem the effective diameter of model rotation is in limits II-II,5 m.,creating thus practically a uniform field of force.

Model tests were carried out in a following way.A model of the derrick with offshore piled platforms geometricaly similar and in structure and properties of materials identical to its actual prototype was installed into each of the test chambers of the unit.Depending on the preset state of stress, a preliminary deflection was given to the pilework and was then recorded with the help of the magnetic system.After that measuring heads were installed at the approptiate points (joints) of the model and micrometrical disks of inductive transducer were fixed on the rigid frame.After the test chambers were run and gain the necessary speed,ensuring reproduction in the elements of the model the state of stress identical to the natural one, magnetic system was switched off and the model started its natural vibrations with predebermined initial amplitude.Those vibrations were recorded by oscillograpths.

Results of the field and model tests give the ground to believe that:

-the difference between estimated and experimental values of the first and second tones of periods of natural vibration of the derricks on offshore piled platforms is significant, moreover this difference is more essential for derricks on piled platforms,than for derricks on compound frame blocks;

-at other equal conditions the periods of natural vibration of derricks on muddy grounds are essentially higher,than on the hard ones;

-with increasing of the initial deflection value,or just the same,with increasing of the vibration amplitude the period of natural vibrations of the derrick and its foundation is also increasing and the difference between periods,that correspond to the phase of microvibrations and to the phase close to the maximum permissible stressed state,comes to 2 times;

-absorption and dissipation of vibration energy,determining the coefficients of damping of natural vibrations,are not constant,and the intensity of increase of damping coefficient is more essential for the stage of ultimate stress;

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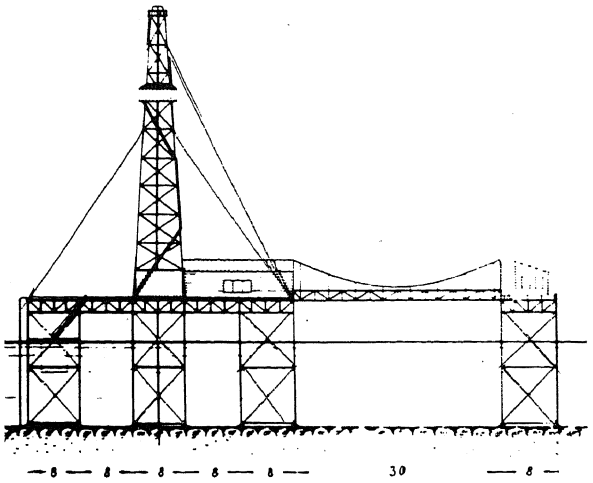

Fig.1.OFFSHORE PLATFORM on PILED FOUNDATION

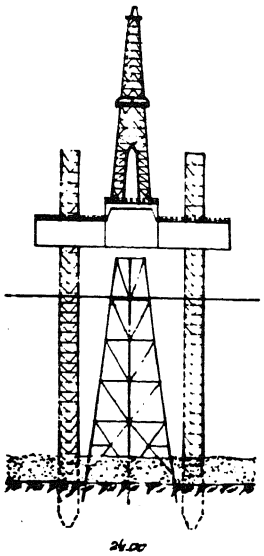

Fig.2.MOBILE DRILLING PLATFORM "CHAZAR"

Fig.3. CENTRIFUGAL TEST UNIT АзИС-2