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ON THE METHOD OF CALCULATION OF SEA AND OIL-GAS FIELD CONSTRUCTIONS BY APPLYING THE THEORY OF FUZZY SETS

Abstract

Principally new calculation method on stability and strength of the sea deepwater stationary platforms based on the application of the fuzzy sets elements is suggested.

The evolution of methods of calculation of sea and oil gas field constructions (SOGC) calculation methods for real external actions allowing for their random character is stipulated by some reasons:

- by the development of constructions mainly by increasing the depth on which these structures and mass of upper constructions raise that increases the pliability of constructions;
- by the growth of demands to reliability and security of such responsible constructions at exploitation;
- by developing and extending the representations on the actual nature of wind wave appearance in the sea and in the result of hydrometeorogical researches, in which it has been established, that these phenomenas have random nature.

The last has entailed necessity of revision of many former calculation methods. The reliability of work of SOGC in whole depends on regularity of its calculation with allowance of all substitutially operational forces.

At present at calculation of SOGN the two main calculationconditions are considered: normal (operational) and extremal. The designs at normal (operational) conditions allow for the regime characteristics, basically natural external effects and based on the application of reliability theory for estimation the fatigue stresses in structural elements [1]. These calculations have begun to develop only last decades. They are far from perfect and have evolution nature. The nature of methods of reliability theory for marine constructions is handicapped by failure of our knowledge about the regime characteristics of external effects at the inexact information in conditions of uncertainty.

The calculation for external conditions at which the effect on construction the external effects of small repeatability are considered, i.e. the strong gales etc. (once in 50 or 130 year), have arisen at the beginning of the building of SOGC, developed together with them and now they serve determining at designing. This calculation method is based on the determined approaching and now it is changed by new, more perfectly approaching to the investigation of strength of SOGC.

At building of SOGC large complex of technological operations and processes sequentially is executed. Improvement of the quality of efficiency at building, the reliability at exploitation of these designs in whole completely depend on the nature of fulfillment of each operation and account of influence of exposures during the simulation and calculation. The quantitative characteristics of parameters of designing of building and exploitation of SOGC are quite definite. Complexity and uncertainly of many processes in different exploitation situations in these objects doesn't make possible to find the model which could satisfy all demands. It is impossible to formalize completely mathematically the real physical processes, many factors of external influence are not stationary and they change by time that make difficult their account at calculation. The multicriterion of the exploitation process, fuzzy definition of their criterions and limitations complicates creation of calculation model very much. Usually the inaccuracy and uncertainty as shown in [2] are considered statistic random characteristics and are counted at using methods of random functions. Three main methods of computaion of fuzziness in mathematical calculation models of SOGC are used.

The first method is applied in the theory of stability. At first exact solutions on determinate theory are determined and then, their variations at vibration of initial information in allowable limits are estimated.

Here the domain of error change is observed. At the second method the stochastics model of decision making is used. At the third method the description of initial information, aims and limitation and the final decision by the diffused sets are given. The third method represents the refusal from generally accepted quantitative methods of analyses of difficult and indefinite systems for which the methods not requiring the great exactness and the mathematical formalism are necessary and the methodological scheme, beforehand allowing the diffusion of parameter are used. L.Zade determines the diffusion set as mapping on unique interval. The bases of this theory are stated in [2,3].

Let X be some set $X=\{x\}$. Then the diffusion set A on X is given as the belonging function $\varphi_A : x \to [0,1]$ which puts into correspondence to every $x \in X$ the real number in the interval $[0,1]$. The number $\varphi_A(x)$ is called the degree of belonging X to the diffusion set. Nearer the value $\varphi_A(x)$ to the unit, the higher the degree of belonging x to A. In case of discrete set X the record of diffusion set

$$A=\{x;\varphi_A(x)\}$$

is applied.

Following [2] we cite the definition of some basic notations of the theory of diffusion sets, which will be used in future for analysis and calculation of different construction of SOGC. The diffusion set A and B are equivalent $(A \equiv B)$ iff for all $x \in X$ $\varphi_A(x)=\varphi_B(x)$, $A \subset B$, if for all $x \in X$ $\varphi_A(x) \le \varphi_B(x)$ the intersection of sets $(A \cap B)$ are defined as the greatest diffusion set, containing both A and B. The belonging function is defined by the equality

$$\varphi_{A\cap B}(x)=\varphi_A(x)\wedge\varphi_B(x).$$

The unification of sets A and B $(A \cup B)$ is defined as the smallest diffusion set containing both A and B. The belonging function at this is calculated from the relation:

$$\varphi_{A\cup B}(x)=\max(\varphi_A(x),\varphi_B(x)),\quad x \in X \text{ or } \varphi_{A\cup B}(x)=\varphi_A(x)\vee\varphi_B(x).$$

The main elements of the decision making procedure in the theory of diffusion sets are:

- the diffusion aim;
- the diffusion boundedness;
- the diffusion decision.

Let's suppose that F is a diffusion aim. In this case the belongness function $\varphi_F(x)$ is used in the process of simulation, establishes the linear order in given set of the alternative $X=\{x\}$. The diffusion limitation G is also defined as diffusion set in X and it is represented by the known function of belongness $\varphi_G(x)$. The joint influence of the aim and limitation as choice of alternative is represented by the intersection $F \cap G$:

$$\varphi_{F\cap G}(x)=\varphi_F(x)\wedge\varphi_G(x).$$

The diffusion set $C=F\cap G$ is called the decision and correspondingly

$$\varphi_C(x)=\varphi_F(x)\wedge\varphi_G(x).$$

In the presence of some and limitations the fuzzy is described by the belongness function:

$$\varphi C(x) = \min\{\varphi F_i\}.$$

If at this the aims and limitations differ by importance and the corresponding coefficients with respect to the importance of aims λ_1 and limitations μ_1 is given, then belongness function of solution will be:

$$\varphi C(x) = \min_i\{\lambda_i \varphi_{F_i}\}.$$

So generalized determination of solution is formulated as the confluence of aims and limitations. These solutions can be considered as fuzzy formulated instruction, the fulfillment of which provides the achievement the fuzzy formulated aim. At that the uncertainty remains connected with its fulfillment method of fuzzy information, i.e. which alternative must be preferred. In the paper L.Zade [2] it is suggested that choice of alternatives which has the maximum degree of belongness to fuzzy solution, i.e.

$$\max_{x \in X} \varphi C(x) = \max_{x \in X} \min\{\varphi F(x), \varphi G(x)\}.$$

Consequently optimal solution is alternative at the space X which maximizes $\varphi C(x)$.

All external influences on SOGC depend on many parameters. The domain of change of every parameter we divide into three intervals: "small", "middle", "large". For different designs the different parameters can belong to one of three groups. For every group M^1 constructs the fuzzy algorithm consisting of M rules which describes the relation between input and output parameters. The aim function for calculations is the fourth group of parameters defining the interval "computation on stresses", "on stability". The domain of changing of every parameter is divided into k equal parts and the value of belongness functions form

$$\varphi_n^{l,m}(x_k) = \exp\left[-a\left(x_k - x_{cp}^l\right)\right]$$

are defined, where n is an index of parameter, k is an index of quantization, l is an index which characteristics the interval at $l = 1$. The interval is small; at $l = 2$ the interval is "middle"; at $l = 3$ the interval is "large"; a is the constant got from the condition of construction: on the domain of intervals the value of belongness function equals 0.5.

By the every rule of matrix the relation (3)

$$R_{2,3}^{m,m} = \varphi_{2,l}^{m,m}(x_k) \cap \varphi_{3,l}^{m,m}(x_k);$$

$$R_{2,3}^{m,m} = \left\{r_{i,j}^{m}\right\} = \min_{i=1,k}\left[\varphi_{2,l}^{m,m}(x_i), \varphi_{3,l}^{m,m}(x_j)\right]; \quad j = \overline{1,k}.$$

Resulting relation matrix of the m^1-th fuzzy algorithm is the unification of matrices by the every rule

$$R_{2,3}^{m} = YR_{2,3}^{m,m} = \left\{\rho_{i,j}^{m}\right\} = \max\left(r_{i,j}^{m-1}, r_{i,j}^{m}\right),$$

where $m = \overline{0,M}$; $i, j = \overline{1,k}$; $m' = \overline{0,M}$.

Finally it is important to remember as many realized matrixes relations as construction of fuzzy algorithm. At considered case $M_4 = 4$.

The parameter of influence of external, i.e. waves and currents will be x_1^0, x_2^0. At first let's analyze the x_1^0 on belongness to one of above noted groups and let's check corresponding matrix $R_{2,3}^{m}$. Then it is determined the point of quantization $x_2\left(k^1\right)$ which leastly far from x_2^0 it is constructed the belongness function $\varphi\left(x_2^0\right)$. $\varphi\left(x_0^0\right)$ is the k-th dimensional vector where the quantization component 1, and others 0. The fuzzy value of output x_3^0 is defined with the conditions

$$\varphi\left(x_3^0(j)\right)\varphi\left(x_0^0\right)=\max_{i=\overline{1,k}}\left\{\min_{i=\overline{1,k}}\left[\varphi\left(x_2^0(i)\right),r_{i,j}\right]\right\} \quad j=\overline{1,k}\,.$$

When among the components of functions there is one maximum element then its number indicates on such point of quantization x_3, which is accepted for informational value. If the maximum element is repeated $k^{(e)}$- time then consequently the linguistic value for choosing information value parameter is used [2]. Thus we got the way of solution of problem, when initial data are fuzzy. Above mentioned method gives opportunity of choosing of informational value of parameters of external influence from numerical theory of waves, underwater currents and windy loads recommended in [4].

The problem of calculation, when limitation at final aim- strength, stability, rigidity of elements or of all constructions and external influence from technological processors during the building and exploitation are fuzzy, require the additional investigations.

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