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A METHOD OF TECHNICAL DIAGNOSTICS FOR OFFSHORE STRUCTURES

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SUMMARY. This paper discribes the results of measurements and analysis of the parameters, characterising technical state of offshore platforms in Vietnam Sea. Based on decreasing in time material characteristics because of corrosion and local destruction assessment on residual life time of platforms is given and variants for its repair are recommended.

The results allowed to confirm advantage of proposed technical diagnostic method in comparison with others and have been used for oil and gas platform of Joint Venture "Vietsovpetro" in South Vietnam.

Key words *technical diagnostics, offshore structures, corrosion, local destruction*

INTRODUCTION

There are many fixed offshore platforms built for last 10 years in Vietnam Sea for exploiting oil and gas. Under action of sea environments in this regions the platforms have been rapidly declined. In order to estimate the durability and life time of this platforms, it is necessary to investigate sea-structures interactions, and to measure characteristics of structures and analyse the measured results as well as the real construction scheme.

Vietnam sea is a region, in which the weather and climate are complicated and changing. The wind velocities reach 60 m/s. In the Eastern Sea usually waves move in the directions of the two monsoons: the North - East direction is observed from October to March of next year and the West one is normally from April to September of every year.

The wave height reaches 10-15 m, especially 20 m during seastorms. The surface currents are over 3m/s. Therefore the loads due to above factors are considerable. Beside the mechanical actions, in tropical sea condittions the constructions have been also strongly corroded. Corrosion velocity reaches 0.8 mm/year in case the coatings are full destroyed.

More than one method has been used to assess the life time of a structure. According to the theories of Miner or Palmgreen (Wieland, 1989) those structures which have low vibration frequencies have a rather long life time. The methods only relying on environmental actions upon critically local points (hot spot) of structure, have estimated that those structures have a very short life-time (Steklov, 1990). The difference between the two groups of methods sometimes can be tens of years (Son, 1992). This method of assessing structure durability through periodical investigation has gradually perfected with the collaboration and investiment by oil and gas company "Vietsovpetro". The method consists of two main problems: practical measurement and numerical analysis.

MEASUREMENT

It is well-known that during exploitation on sea or in the offshore, fixed sea-structures are subjected to actions of different marine environments: the marine air, the sea water and the marine soil environment. Therefore, we can demonstrate the general measuring diagram of parameters of fixed offshore platforms (FOP) as follows (diagram 1)

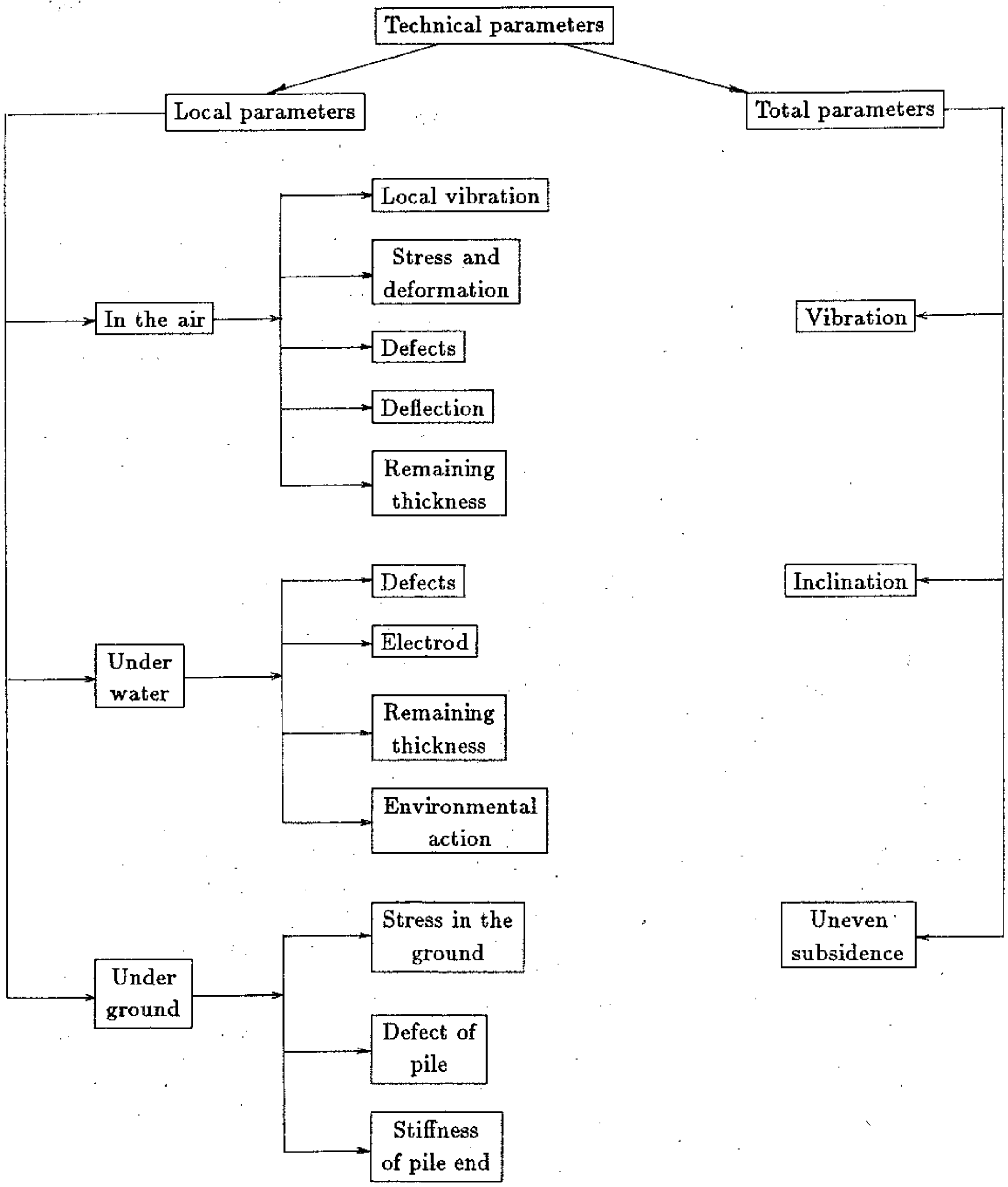


Diagram 1

Corresponding to the parameters which need to be measured, the equipment for investigation of FOP has been divided in the following four groups: equipment to measure vibration, equipment to measure stress and deformation; equipment to measure displacements and equipment to measure remaining thickness of steel. Practical observation and measurement (Sakharov, 1991; Son, 1992) show that the main causes leading to the destruction of offshre structural elements are corrosion, appearance and propagation of cracks and local destruction. On the basis of the visual investigation and measurement of the remaining thickness we carry out analysis of structures

ANALYSIS

Regarding the methodology of investigations, on the basis of the research results about sea-structures interaction it has led to some formulae, as follows:

For displacement

$$u = f(D, E, P, T); \tag{1}$$

For frequency of free vibration

$$\omega = f(D, E, M, T); \tag{2}$$

For stress

$$\sigma = f(D, P, T), \tag{3}$$

where $E =$ elastic modulas of the material; $P =$ load; $M =$ mass; $D =$ geometrical characteristics of the section (thickness of tubular elements or its functions as moment of inertia, cross section or moment of resistance)

The variable of time T can be divided into periods, as was preestimated every six months. The geometrical characteristic D is present in all formulae and due to action of corrosion it will be reduced with T.

It is obvious that when D alters, it leads to the change of values of u, ω and σ. Its law must be defined. First of all, we study this law for a structural elements:

- Regarding displacement, when P and E are constant, u is the function of D.
- Regarding frequency of free vibration. From the formula (2) we can take it into the form

$$\omega = f(M, D). \tag{4}$$

If M is regarded as changing unremarkably ($M =$ constant), then ω is in proportion to D, namely when D decreases, ω decreases.

- Regarding stress, the formula for checking takes the form (for every tubular member):

$$\sigma = \frac{N}{F} \pm \frac{M}{W} \leq R\gamma. \tag{5}$$

where $M = (M_x^2 + M_y^2)^{1/2}$; W is a polar moment of resistance. May be N is negative, but σ always has its maximal value. From the above formula, we find that σ has a law with complicated change. When $\delta_2 - \delta_1 = \Delta\delta$, $N \to \Delta N$, $M \to \Delta M$, but $\sigma \sim \dfrac{\Delta N}{\Delta\delta^2} \pm \dfrac{\Delta M}{\Delta\delta^3}$. So, that is to say the decrease of denominator is smaller than numerator and then stress σ increase.

NUMERICAL EXAMPLES

Based on the spot investigation, we have recognized a number of factors influencing on the calculating scheme or input parameters. In later analysis it can be considered in the two following ways:

Firstly, the structure is locally destroyed, such as deformed and cracked, due to ship collision, deep corrosion into the thickness of section and others. Secondly, the steel tubular members are not deeply eroded but corrosion spreads widely onto the steel surface in contact with the environment

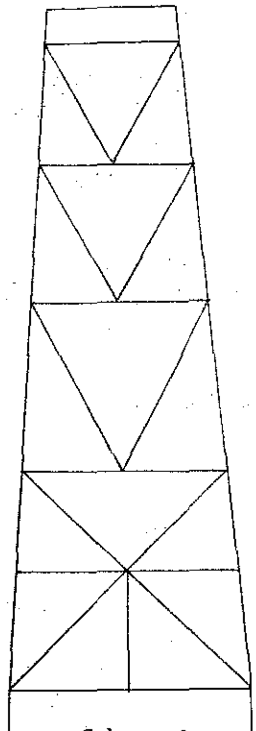
1. Analysis of Construction with Local Destruction

In this case, it can be considered that the locally destroyed elements are not workable and excluded from the scheme of calculation and the analysis of redistribution of internal forces of the system can be made. And based on this diagram of internal force redistribution a new scheme of calculation will be determined and so on.

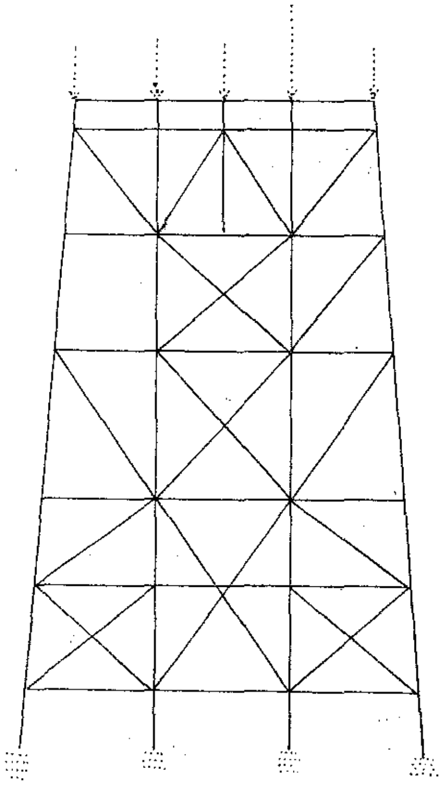
Some results will be shown in Table 1, where variant "0" is the initial scheme and variants "1", "2" and "3" are schemes with local destruction (Fig. 1).

Table 1. Change of frequency, displacement and stress of platform due to local destruction

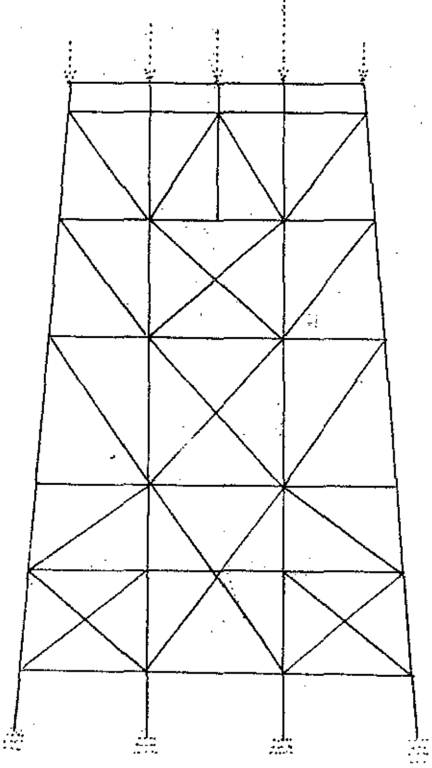
No	Variant	Frequency $\omega_{\min}$(Hz)	Displacement $u_{\max}$(m)	Stress $\sigma_{\max}$(MPa)
1	0	0.2448	0.1095	194
2	1	0.2437	0.1078	201
3	2	0.2422	0.1115	197
4	3	0.2400	0.1122	199



Scheme 3



Scheme 1



Scheme 2

Fig. 1 Schemes of Local Festructed Construction

The influence of local destruction on decreasing mechanical parameters of construction can be shown in Table 2

Table 2. Change in percentage of frequency, displacement and stress of platform due to local destruction

No	variant	$\omega(\%)$	$u_{\max}(\%)$	$\sigma_{\max}(\%)$
1	Slanting	$\sim$ 0,5	- 1.0	3.58
2	Belt bar (oy)	1.06	1.82	1.81
3	Belt bar (ox)	$\sim$ 2.0	2.40	2.47

2. Analysis according to the State of Corrosion

In this case the complete destruction of the structure does not occur, but the fatigue corrosion failure can be measured by the remaining thickness of the steel tube. During each periodical measurement the thickness is decreasing and therefore mechanical characteristics of the material will be changed. In the above mentioned case, the calculation is based on the original scheme, but the input data (characteristics of sections) would be changed.

In analysing structures, we have used the equation of equilibrium written under the forms of matrix by finite element method

$$K(\delta)u = P(t) \tag{6}$$

or the equation of motion

$$M(\delta)\ddot{u} + K(\delta)u = P(t) \tag{7}$$

in which $K(\delta)$ is the matrix of hardness with the thickness of steel tubular members δ, and $M(\delta)$ is the matrix of mass, where δ is changing with time T.

Results of analysis according to corrosion process as well as change of mechanical parameters characterising strength, stiffness and stability of construction due to this process are given in Fig. 2.

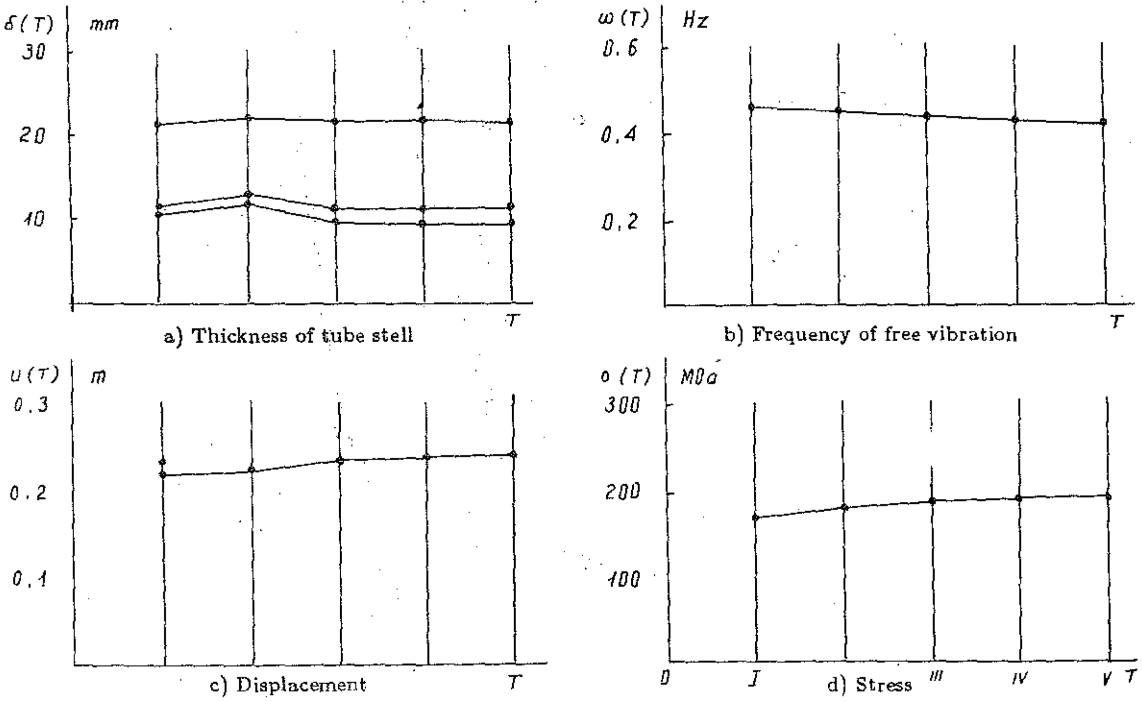


Fig. 2. change of Technical Parameter of FOP's Construction in Time

The life time of structure subjected to the process of corrosion and local destruction is presenting in the Fig. 3 in comparision with the fatigue life time curve of material.

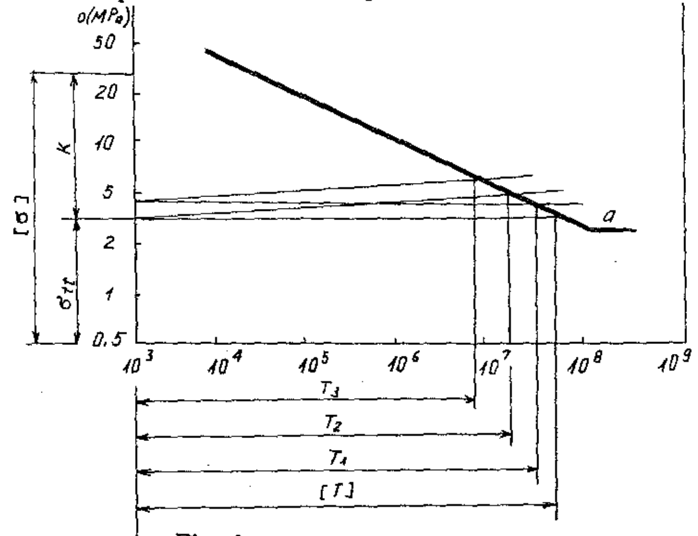


Fig. 3. Decreasing of FOP's life time

a - fatigue life time curve of material; $[T]$ - design life time; T_1 - corrosion; T_2 - life time in local destruction; T_3 - life time in local destruction and corrosion; K - safety of construction; $[\sigma]$ - permissible stress; σ_{tt} - calculation

CONCLUSION

A methodology of technical diagnostics used in this paper has been gradually improved and broadened on the basis of the research results about the sea-structure interaction. Results of measurement and analysis have initially confirmed the law of change in characteristics of strength, vibration and stability of an offshore platform.

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