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Analysis and Behavior of a Rigid Foundation Massif under the Effect of Vibrations (Application of Barakan Method)

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ANALYSIS AND BEHAVIOR OF A RIGID FOUNDATION MASSIF UNDER THE EFFECT OF VIBRATIONS (APPLICATION OF BARKAN METHOD)

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ABSTRACT

This communication proposes a count mode of a rigid foundation massif frequencies, relaxing on a homogeneous soil, semi-infinite having an elastic linear behaviour.
Several data programs process using the finite elements method, are proposed for the dynamic analysis. Nevertheless, these programs don't appear the physical phenomenon yielded, they depend on data introduced by the user and are applicable only for the elastic foundation massifs.
The BARKAN method is an analytic one that appears the physical behaviour of the different displacements and their coupling modes, the involvement of soil by its different dynamic stiffness modules, as well as a constant verification of its application. Well, it remains an approached method because it doesn't exist an exact count method currently.

Key words: foundation, vibration, dynamic analysis , coupling, dynamic stiffness.

INTRODUCTION

The construction of a foundation submitted to dynamic efforts (effects of shocks, regular efforts) is more complex than a foundation supporting only static loads (own weights, constant efforts).
The dynamic strengths caused by vibrations must be added to the static loads. Therefore, the engineer must know the begotten dynamic loads as well as the behaviour of the foundation and of soil underneath.
The problematic is divided then in two parties:

1. Transmissions of loads to the foundation.
2. Transmission of the foundation to soil.

The ignorance or the carelessness of this vibratory phenomenon lead the structure to the ruin.

VIBRATIONS GENERALITY

Before all analysis of the foundation and soil, it is necessary to have all information concerning sizes and features of dynamic loads implied. [1]
Efforts dynamic shocks – The vibrations which can be transmitted to the foundation, then to the soil of foundation, are of two orders (Figure 1):

- It can be about shock effects, appropriately said : presses, machine of HAMER, hammer–pestle, ...etc. In this case, the produced vibrations are irregular. (no periodic).
- It can be about regular effort begetting regular vibrations: alternative machines (movement of goes and comes) or centrifugal. In this case the produced vibrations are regular harmonic simple, having a sinusoidal shape.(periodic).

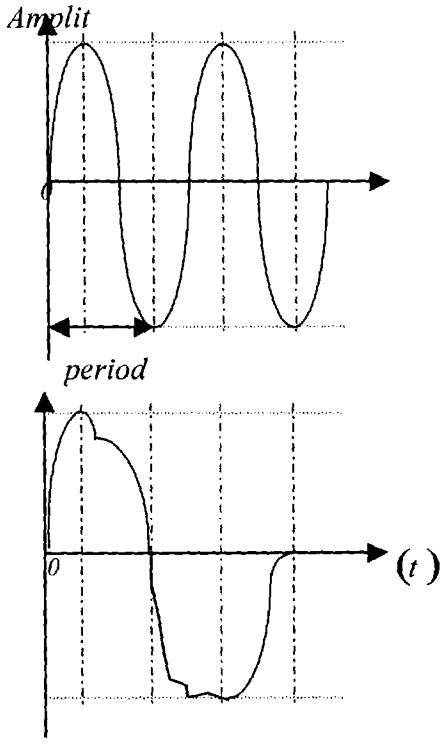

Figure 1 : Vibrations types.

System With One Free Degree

Let be the system composed of a mass on spring and a shock absorber (Figure 2). Strengths that exercise themselves on it are : [1]

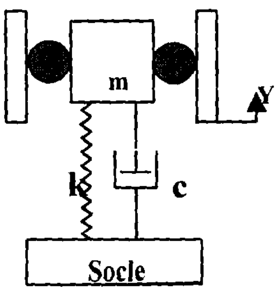

Figure 2: Analogical model of a system with 1 free degree

1. The strength of inertia : $f_i = m\ddot{y}$
2. Strength of elastic recalls: $f_s = k(y + \delta_{sta})$
3. The strength of amortisation: = $f_c = c\dot{y}$
4. Strength owed to the weight : = $f_w = mg$

According to The principle of d' ALEMBERT, a mass produces a proportional and opposite inertia strength to its acceleration, the mathematical writing will be :

$$P(t) - m\ddot{y} = 0 \qquad (1)$$

With : $P(t)$ the resultant of many types of strengths acting on the mass.

THE METHOD USED (BARKAN method)

This method [2] neglects the effect of the soil amortisation, so, of its involvement, it supposes that the foundation has linear displacement and that the gravity centre of the machine and of the foundation are on the same vertical by-report to the gravity centre of the contact surface foundation –soil.
The (Figure 3) shows a massif foundation of combined mass, machine–foundation $m\,(W/g)$ and of basis area A_f , submitted to the action of dynamic solicitations $P_z(t)$, $P_x(t)$ and $M_y(t)$.
We choose the main axes that pass by the gravity centre, the combined machine–foundation as axe of coordinates, and s as the distance between the centre of gravity and the contact surface, K_z , K_x and K_{θ_y} represent respectively the rigidity of the elastic support under a vertical compression, a horizontal shearing and a rotation around the axis Y , φ_y, represent the mass inertia moment around the axis Y.
Then, x , z and θ_y are respectively the displacements along the axis X , Z and rotation around the axis Y.
The equations of the foundation movements for a soil without amortisation in the plan XZ are:

1. Vertical : : $m\ddot{z} + k_z z = P_z(t)$.
2. Horizontal : : $m\ddot{x} + k_x(x - s\theta_y) = P_x(t)$.
3. Balancement :
   $\varphi_y\ddot{\theta}_y - k_x s x + (k_{\theta_y} - Ws + k_x s^2)\theta_y = M_y(t)$.
4. Torsion : $\varphi_z\ddot{\psi} + k_\psi \psi = \tau_z(t)$.

For having the movement equations in the plan YZ , suffixes x and y must be interchanged.
φ_z is the mass inertia moment around the axis Z . ψ is the angle of torsion. k_ψ is the rigidity of the elastic support for a rotation around a vertical axis.

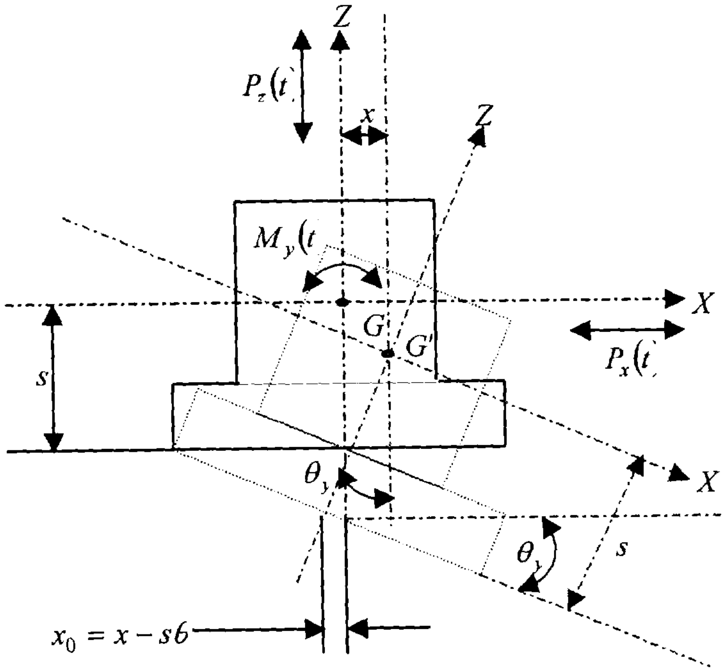

Figure 3 : Massif submitted to dynamic solicitations

Calculus Hypothesis

The foundation is a rigid mass [2] of rectangular or circular shape of size L and B
- Figure4 - relaxing on the surface of a homogeneous soil semi–infinite, having an elastic linear behaviour characterised by G its module of shearing and ν its Poisson coefficient .

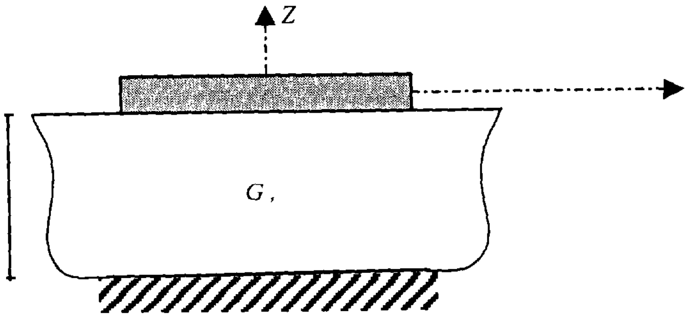

Figure 4 : Massif on homogeneous soil semi–infinite .

CALCULUS PARAMETERS

A - Attenuation Coefficients

1. Coefficient of compression elastic uniform C_z :

Table 1: Coefficient Cz according to the category of soil.

Categories of soil	Constraint adm. (Kg/cm^2)	C_z (Kg/cm^3)
Bad	1	2
	2	4
Medium	3	5
	4	6
Good	5	7
Rocky	Superior to 5	Superior to 7

Values data in the picture are valid only for foundations of which the basis area is superior or equal to $10m^2$. If the basis is lower to $10m^2$, the values of the picture must be multiplied by $\sqrt{10/A_f}$.

2. Coefficient of no-uniform elastic compression C_θ : $C_\theta = 2C_z$.
3. Coefficient of uniform elastic shearing C_τ : $C_\tau = 0{,}5C_z$.
4. Coefficient of no-uniform elastic shearing C_ψ : $C_\psi = 0{,}75C_z$.

B - Dynamic Elastic Stiffness

1. Vertical transfer : $k_z = C_z A_f$
2. Horizontal transfer (plan X , plan Y) : $k_{x,y} = C_\tau A_f$.
3. Swing around (X , Y) : $k_{\theta_{x,y}} = C_\theta I_{x,y}$.
4. Torsion around the axis Z : $k_\psi = C_\psi I_z$.

C – Own Frequencies

1. Vertical transfer : $\omega_z = \sqrt{k_z/m}$.
2. Horizontal transfer (plan X , plan Y) : $\omega_{x,y} = \sqrt{k_{x,y}/m}$.
3. Swing around (X , Y) : $\omega_{\theta_{x,y}} = \left(k_{\theta_{x,y}} - mz\right)/\varphi_{0_{x,y}}$.
4. Torsion around the axis Z : $\omega_\psi = \sqrt{k_\psi/\varphi_z}$.

D - Criteria of Calculus (according to MR. BET)

- Low frequency : $\omega_n \rangle\rangle \omega_m : \omega_n \geq 130\,\%$.
- High frequency : $\omega_n \langle\langle \omega_m : \omega_m \geq 70\,\%$.

We must respect this criteria to avoid the resonance.

APPLICATION

The gotten results are :

a - Stiffness of the Soil :

Table 2: Numeric values of soil stiffness.

N° case:	1	2
Rigidities	$C_z = 2.10^4$ KN/m^3	$C_z = 4.10^4$ KN/m^3
$K_v(KN/m)$	1202400	2404800
$K_h(KN/m)$	601200	1202400
$K_{\theta_x}(KNm/rad)$	9023080	18046160
$K_{\theta y}(KNm/rad)$	16088840	32177680
$K_\psi(KNm/rad)$	9416970	1883394

b -Own Frequencies :

Table 3:Numeric values of own frequencies.

N° case:	1	2
Own frequency	$C_z = 2.10^4\,KN/m$	$C_z = 4.10^4\,KN/m^3$
$\omega_v(\omega_z)$	78,22	110,63
$\omega_h(\omega_x, \omega_y)$	55,31	78,22
ω_{θ_x}	155,26	163,01
ω_{θ_y}	123,26	174,33
ω_{θ_ψ}	86,28	122,02

INTERPRETING

According to the technical data provided by the constructor of machines, the own frequencies of these ones are :

1. Operation frequency of the motor : $7{,}03s^{-1}$.
2. Operation frequency of the compressor : $7{,}03s^{-1}$.

However, according to the criteria of M.PARIS, [3] the vibrations relative to the excited movements must remain outside of the interval [0,7-1,3] multiplied by the exciting frequency of every machine making part of the system and that give :

- Motor : Superior interval : $1{,}3 \times 7{,}03 = 9{,}14s^{-1}$.
  Inferior interval : $0{,}7 \times 7{,}03 = 4{,}92s^{-1}$.
- Compressor : Superior interval : :$1{,}3 \times 7{,}03 = 9{,}14s^{-1}$.
  Inferior interval $0{,}7 \times 7{,}03 = 4{,}92s^{-1}$.

The lowest own frequency of the massive is: $55{,}31s^{-1}$,that is extensively above the area of the machine frequency. **There is not possibility of the resonance effect.**

CONCLUSION

1. The structure is steady facing the resonance, because its frequencies of vibrations are above limits of the operation frequency.
2. The structure is steady facing the vibration amplitudes, because these kinds of vibrations amplitudes are lower than 200μ , that is the admissible amplitude, therefore there is not important risk of subsidence, ruin of the structure or danger for people.

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