THE VIBRATION OF THE BALANCER AS A DOUBLE-ARTICULATED ELEMENT INCLUDED IN THE DOUBLE ELEVATING SYSTEM PROVIDED WITH A HYDRAULIC PERFORMANCE INCREASE SYSTEM

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Abstact: *In order to solve the problem of parking, an innovative solution that would refer to an unused surface up to this point would be a smart parking lot on a metallic structure along the Dâmbovița river, over it, in the areas that allow this. The necessary parking mechanism. Determining the inherent pulsation of the balancer*
Key-words: *elevator, resonance, inherent pulsation of the balancer, mechanism*

1. INTRODUCTION

In order to increase the efficiency of traffic in Bucharest, it is necessary to meet several absolutely necessary conditions. Among them, a special role is played by the following:
Maintenance of all existing road networks, easy connection of the roads to be put into service to existing networks and the use of durable and easy-to-maintain materials,
The construction of parking lots so that they could lead to simultaneously solve several problems raised by the existence of many vehicles that are parked and/or move alternatively to certain areas where the density of vehicles and buildings is high.
In order to solve the problem related to the parking lots that include a small number of spaces as compared to the very high number of cars that transit the Romanian capital every day, an unconventional solution should be used that would appeal to an unused surface up to this point and which can be used to make a low-cost parking lot as compared to other existing models.
Thus, a metallic structure parking lot can be built along the Dâmbovița river, above it, in the areas that allow this.

2. THE PARKING LOT MECHANISM

The parking lot mechanism is shown in figure 2. For the entry and exit of vehicles in and inside the parking lot, which is built on several levels (depending on needs and financial possibilities), there is a mechanism provided with a double elevator. At one end, there is an auxiliary elevator with a translating cam and a roller translating follower (5 and 6 in fig. 2) that lifts the car a few tens of centimeters and places it on the platform of a robot with a platform that moves alternately, parking the car.
In figure 1 is presented a model which includes an elevator with a translant cam and a translant follower with a roller. In the figure are numbered
1- translant cam
2- translant follower with a roller
3- the platform on which the car is lifted or lowered by the elevator
4- the elastic element required for the vibration depreciation
5- the electric motor of the translant cam actuation
6- the chassis on which the elevator is mounted

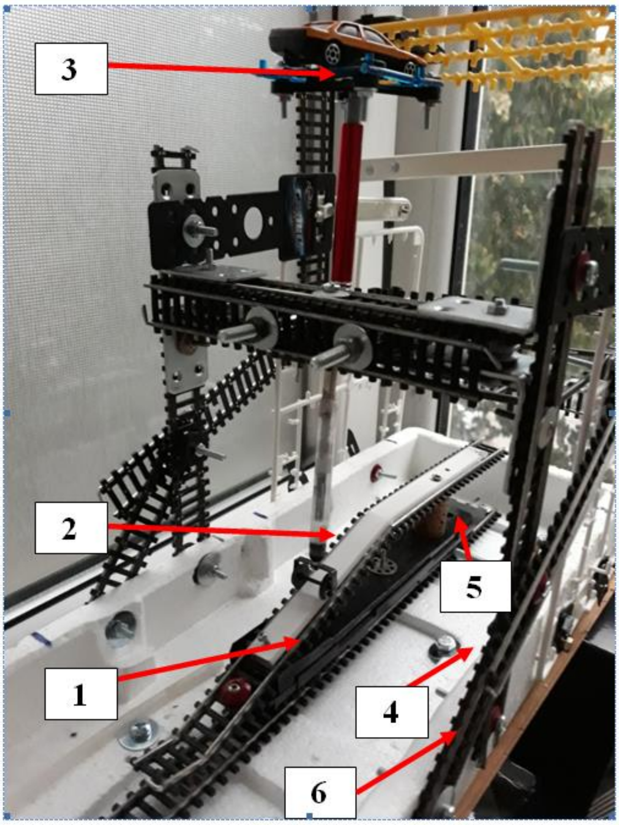

Fig 1 Model of a car park fitted with an auxiliary translant cam - translant follower with a roller elevator model (manufactured by Carmen Radu)

At the other end, there is an elevator made as a rod articulated (2) in the middle with a crank (1) and at the lower end, articulated with a balancer (3). Between the translating cam (5) and the balancer (3) there is a hydraulic cylinder (4) with several compartments which controls the movement of the two elements (balancer 3 and cam 5) according to the commands given by a remote control for various needs of lifting or lowering the vehicles.

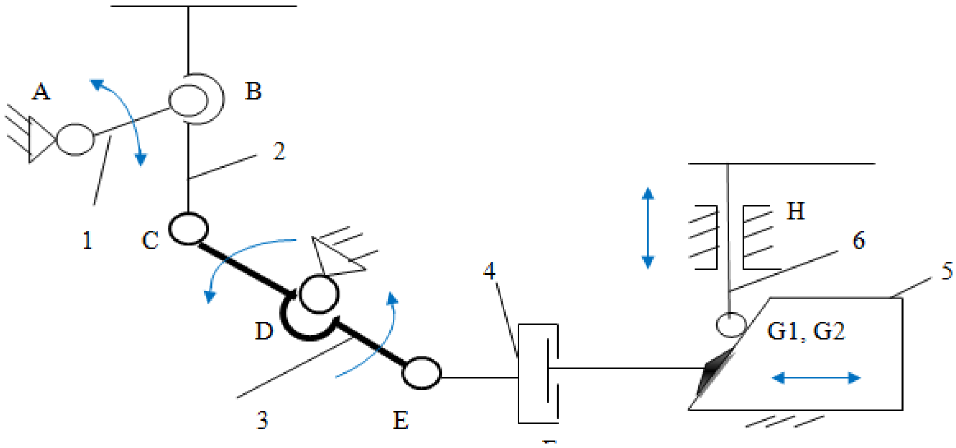

Fig. 2 Double-elevator mechanism required by parking

3. DETERMINING THE INHERENT PULSATION OF THE BALANCER [1]

One considers a mass body (m) connected to an elastic constant spring (k) - see figure 2. If the system has been removed from stable balance (moved downwards) and then allowed to oscillate vertically, it will perform its inherent vibration, tending to return to the stable balance position.
The amplitude and speed of the vibration depend on the initial conditions, but the oscillation period T only depends on the system itself and it is called inherent period. T(s).

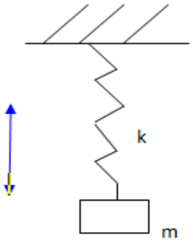

Fig. 2 The inherent pulsation of a system

The inherent pulsation is p = 2π / T (rad/ s) and consequently depends on the system itself, while the vibration is called free vibration.

$$p=\sqrt{\frac{k}{m}} \tag{1}$$

An inherent pulsation corresponds to each system that can be modeled as a mass + elastic constant assembly.
If a periodically variable external force having a certain pulsation (e.g. F = F0 cos ωt) acts on the system, then the vibration is maintained.[2]
If the inherent pulsation of the system p is equal, in this case, to the external force pulse ω, then the resonance phenomenon occurs, which leads to the destruction of the system.
Resonance is the tendency of a system to oscillate with greater amplitude at certain frequencies than at others. The frequencies at which the amplitude is maximum are called resonant frequencies or resonance frequencies. At these frequencies, even small forces can cause large amplitude oscillations because the system accumulates kinetic energy. [3]
Resonance occurs when a system can easily store and transfer energy between two or more states.
Avoiding the destructive resonance is a major objective, as the structures are made so that resonances would occur at frequencies that are difficult to reach.
It is absolutely necessary that the pulsation of the wave be different from the inherent pulsation of the system under research, in order to Avoid the resonance phenomenon that leads to the destruction of the system.
The vibrating systems have a mass M and elasticity characterized by coefficient k

Inherent pulsation $\omega=\sqrt{\frac{k}{M}}$ (2)

Inherent frequency $\nu = \frac{\omega}{2\pi}$ (3)

The reversals of the inherent frequencies are called inherent vibration periods.
The balancer (fig.4) is a double-articulated rod, at both ends (no. 3 in fig.2), modeled as a mass bar m, length l, driven by two masses M, 2M respectively, at its ends, articulated at level α (in figure 1 in the middle, at point D) and provided with an elastic constant spring k located at distance β against the upper area of the bar. Both upon starting and stopping the mechanism, the system is taken out of its balance state and vibrations may occur, as the balancer freely oscillates around articulation D. In figure 1, the spring is not presented because, as the vibrations are reduced upon starting and stopping, its role can be taken over by the elasticity of the rod. The balancer has its inherent pulsation which must be determined in order to avoid the resonance that can be transmitted also to the coupled elements and therefore the most general case has been considered.
In the simplest case, the inherent pulsation [4] of an element or system is determined according to its mass and the elastic constant of the elastic element existing within the system. The calculation shows a value of the inherent pulsation p (rad/s), and between this and the period of vibration T (s) there is the relation
p = 2π/ T
Using the energy method of determining the inherent pulsation, one starts from the fact that the system is conservative (it does not receive or transfer energy in motion). Taking this hypothesis into consideration, at any given moment, the sum between the kinetic energy and the potential energy of the system is constant, resulting in the inherent pulsation of the element.
Ec+ Ep= const.
The system has one single degree of freedom (the angle θ) and according to the Lagrange's equations, the total kinetic energy of the system is :

$$Ec = \frac{1}{2} J\,\omega^2 + \frac{1}{2}\,M(\alpha L\omega)^2 + \frac{1}{2}\,2M((1-\alpha)L\omega)^2 \tag{4}$$

where the moment of inertia J is:

$$J = \frac{mL^2}{12} + mL^2\left(\frac{1}{2}-\alpha\right)^2 \tag{5}$$

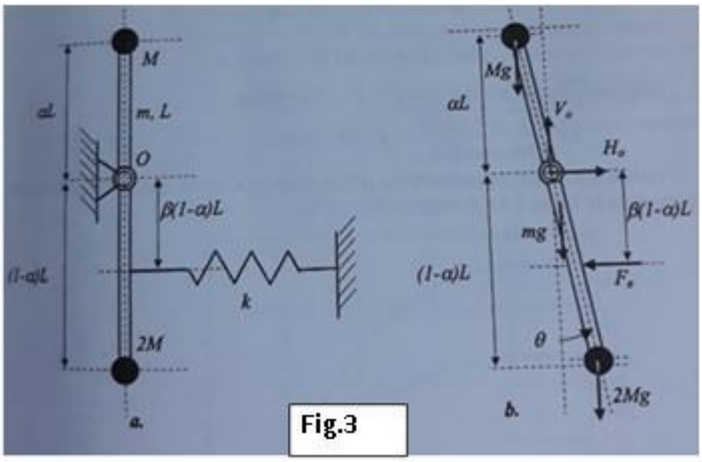

Fig. 3 The balancer model considered for the parking mechanism [1]

The potential energy of the system is

$$Ep = \frac{1}{2}\,k\,(\beta(1-\alpha)L\sin\theta)^2 + L(1-\cos\theta)(2Mg(1-\alpha)-Mg\alpha+mg(\tfrac{1}{2}-\alpha)) \tag{6}$$

For small angles, one can approximate $\sin\theta \sim \theta$ and the differential equation of vibrations follows

$$(\frac{m}{3}(3\alpha 2-3\alpha+1)+M(3\alpha 2-4\alpha+2))\,\varepsilon+(k\beta 2(1-\alpha)2+\frac{Mg}{L}(2-3\alpha))\,\theta = 0 \tag{7}$$

The inherent pulsation of the system is

$$p=\sqrt{\frac{k\beta^2(1-\alpha)^2+\frac{Mg}{L}(2-3\alpha)}{\frac{m}{3}(3\alpha^2-3\alpha+1)+M(3\alpha^2-4\alpha+2)}} \tag{8}$$

while the inherent period is

$$T=\frac{2\pi}{p} \tag{9}$$

Using the calculation program in fig.4 and inserting the values m= 4000 kg, l= 6 m, α= 3m, β= 6 m, M= 5000 kg, k= 15000 N/m, the inherent pulsation of the balancer p= 1.11 rad/ s and the inherent period T= 5.61 s follow (the values in fig.5 that must be avoided in using the system, so that the dangerous resonance phenomenon would not occur.)

```
Sub Calcul()
Dim M1, L, alfa, M, beta, k, g, V, EC, J, teta, p, T, a, b, c, d, p1 As Double
M1 = CDbl(Text1) 'masa barei (kg)
L = CDbl(Text2) 'lungimea barei
alfa = CDbl(Text3) 'dist de aplicare a articulatiei cil
beta = CDbl(Text4) 'dist de aplicare a arcului
k = CDbl(Text5) 'const elastica a arcului (N/m)
M = CDbl(Text10) 'masa la capat
g = 10
V = 0.5 * k * (beta * (1 - alfa) * L * (Sin(teta)) ^ 2) + L * (1 - Cos(teta)) * (2 * M * g * (1 - alfa) - M * g *
a = k * (beta ^ 2) * ((1 - alfa) ^ 2)
b = (M * g * (2 - 3 * alfa) / L)
c = (3 * alfa ^ 2 - 3 * alfa + 1) * M1 / 3
d = M * (3 * alfa ^ 2 - 4 * alfa + 2)
p = ((a + b) / (c + d)) ^ 0.5 ' pulsatia proprie

p1 = ((3 / 4 / L) * (k * L + 8 * M * 10) / ((M1 + 9 * M))) ^ 0.5
T = 6.28 / p1
Text7 = CStr(p1)
Text9 = CStr(T)

End Sub

Private Sub altcalcul_Click()
Text1 = "": Text2 = "": Text3 = ""
Text4 = "": Text5 = "":
Text7 = "": Text8 = "": Text9 = "": Text10 = ""
Text1.SetFocus
End Sub

Private Sub iesire_Click()
UnloadMe: End
End Sub
```

Fig.4. The calculation program for obtaining the results

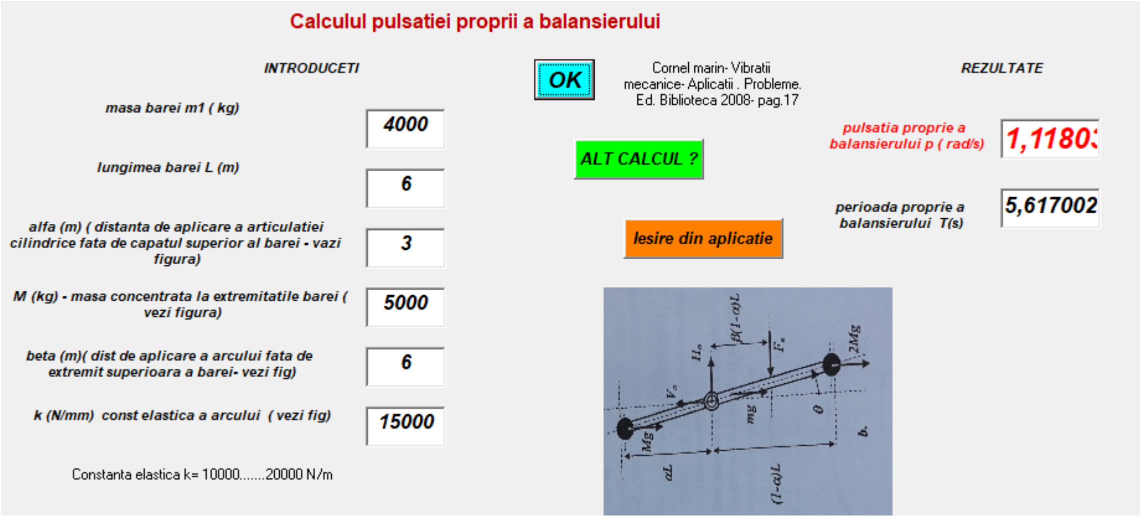

Fig. 5 The results obtained by means of the calculation program

4. CONCLUSIONS

After studying the system by using other data, the following conclusions can be drawn:
The inherent pulsation of the bar decreases as its mass increases (keeping the other data constant), which leads to the increase of the inherent vibration period of the balancer, a fact which must be taken into account in the design.
The inherent vibration period of the balancer varies very little along with the variation of the spring elastic constant. Along with the variation of the elastic constant from 10,000 N / m to 20,000 N / m, the inherent period of the balancer decreases from 5.79 s to 5.45 s, i.e. only by approx. 6%.

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