# ANTI-VIBRATION ISOLATION OF A FOUNDATION FOR AN ELEVATING MECHANISM BY MEANS OF RUBBER

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**ABSTRACT.** *The auxiliary elevator within a supra-aternary park functions as a roller-chain cam and cam follower system and thus, due to the torque transmission from the electric drive motor to the cam, i.e. the change of direction of travel at the end of the course, at start-up and at stop, vibrations can occur. This system must be supported by a foundation in order to achieve an anti-vibration insulation. There are several possibilities for this damper insulation, among which are spring suspension, rubber carpet or standardized rubber elastic elements. The cushioning factor is much higher for rubber than for steel the foundation on standardized rubber elastic elements. Calculation of the rubber damper required for the auxiliary elevator*

**KEYWORDS**: Parking, damping, elastic rubber elements, anti-vibration insulation

## 1. INTRODUCTION

In order to increase the number of parking spaces in the center of the capital, it is desirable to design a multi-level car park above the Dambovita river which includes two or more elevators for lifting and lowering cars and of which one to be performed as an auxiliary elevator for a robot and performed as a model-a translant cam and a translant follower with a roller. This system operates in the alternate left-right mode for the cam and thus, thanks to the transmission of the torque from the electric actuation motor to the cam, respectively the change of direction at the end of the route, at start and to stop, vibrations may appear within the system. For these reasons it is particularly important to carry out an appropriate suspension for that system which contributes to a decrease in the level of vibration transmitted to the surrounding area in order to avoid resonance.[1]

There are several possibilities to achieve this suspension, including elastic suspensions (on springs) or rubber elastic elements. Table 1 compares the features of the materials used to isolate vibrations. [3].

Table 1

| Material | Maximum load on isolator, N | Maximum arrow, mm | Layer thickness, mm | Stress | Minimum inherent frequency, Hz | Damping % |
|---|---|---|---|---|---|---|
| Rubber | (1…2)*$10^4$ | 6…8 | 25 | Shearing | 6 | 2…5 |
| | | | 100 | | 3 | |
| | | | - | Compression | 10…15 | 2…5 |
| Steel | (8…12)*$10^4$ | 35…50 | - | Springs | 1…5 | 0.5 |

## 2. PARAMETERS NEEDED TO PERFORM THE CALCULATION

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

For the determination of the characteristics required for this suspension, we start from several parameters used for the construction of the elevator. These are:

1. The suspended mass of the elevator
2. The maximum mass of the vehicle parked on the platform
3. The number of elastic elements that can be used in suspension - even number, depending on needs, areas and surfaces where they can be mounted
4. The characteristics of the rubber dampers that can be used

The important feature of the rubber to be used for depreciation of oscillations is its high elasticity when operated by external forces (such as compression in the case of the elevator) and return to a initial shape when the external forces cease.

Unlike steels that are used for springs and to which they must be specially made in the form of helical springs, in sheets, etc., rubber elasticity does not depend on the shape of the piece. Rubber admits elongation much lower than steel at breakage but the tear resistance is much lower than steel, about 300 daN/ cm2.[2]

Rubber dampers also do not require maintenance in operation and are easy to mount.

You can use these rubber dampers for the chassis on which the elevator is fixed because the rubber is used typically in static decomposition which, for compression, are between 10.... 35% of the original size of that item, the area entered in the area of proportionality of the deformations (linear zone) with the applied load. .[3]

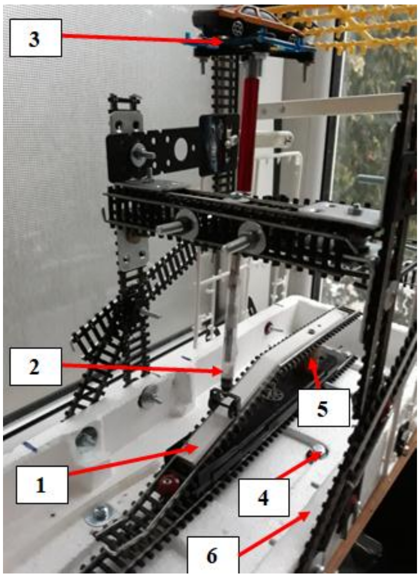


Figure 1. Model of a car park fitted with an auxiliary translant cam - translant follower with a roller elevator model(by Carmen Elisabeta Radu)

**3. NECESSARY PARAMETERS FOR CALCULATING THE SUSPENSION ON ELASTIC ELEMENTS**

In order to avoid the phenomenon of resonance, it is necessary to make the antivibration isolation of the system, which can be done by means of springs mounted on the foundation or by means of a rubber elastic rug fitted to the foundation.[4]

Advantages of the elastic rubber rug foundation:

1. Rubber can take over strong shocks
2. Rubber elastic elements have low elastic constants and realize own reduced pulses of the machines supported on them
3. The rubber has pronounced damping properties and is an excellent noise damper

In order to study the antivibration isolation of the system are necessary the following:

1. Machine features (gauge dimensions, masses, disturbing forces)
2. Environmental characteristics (adjacent buildings and machines and their sensitivity to vibration and noise)
3. Choosing of the calculation model (spring or rubber shock absorber foundation)
4. Calculation of vibration amplitudes
5. Resistance design asurements

This suspension system is considered adaptable to the auxiliary elevator that lifts on a few tens of centimeters the vehicle in order to deposit it on the robot's transport platform to the parking lot.

In order to be able to adopt such a suspension, is necessary data regarding:

1. The maximum load on a damper (depending on the full mass of the lifted vehicle and of the fully equipped elevator)
2. The dimensions of the existing rubber part (parts presented in standards)
3. The mechanical characteristics of the rubber from which the silencer is made.

**4. Foundation on standardized elastic rubber elements [5] [6].**

Rubber is incompressible, so a volume of rubber subject to compression in an enclosed space behaves like a non-deformable material and the material will become suppressed, changing its shape within the same volume. This element is very important in the case of using the standardized elastic rubber elements for the presented calculation because the compartments in which these elastic elements are included must be dimensioned, similarly to the boxes in which the metal springs are included.

***4.1. Calculation of the rubber damper required for the elevator [2].***

We start from a standardized rubber safety damper that is currently used (Fig. 2). Its dimensions are D= 270 mm, d= 130 mm și h= 40 m

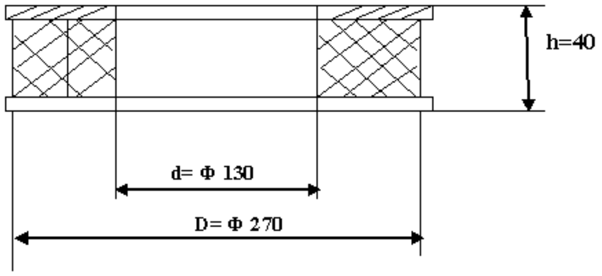


Figure 2. Rubber Damper [2].

The hardness of the rubber used is of 62 0 Sh (according to the Shore hardness scale for rubbers) and thus the transverse elasticity module of the rubber G= 9,7 daN/ cm2 according to Figure 3.

For a car with the mass m= 2000 kg și un elevator de 3000 kg and an elevator of 3000 kg results the calculation of the suspension in the following stages.

1. **Axial compression force** $G_{tot}$= 50000 N = 5000 daN as static load
2. **Will be adopted the number of dampers** n= 4
3. **Compressive force on each damper**

$$G_t = \frac{G_{tot}}{n} = \frac{5000}{4} = \frac{5000}{4} = 1250 \text{ daN} \quad (1)$$

4. **Damper shape factor**

$$K_f = \frac{(D-d)}{4h} = \frac{(270-130)}{160} = 0.875$$

(2)

5. **Compression section**

$$A = \left(\frac{\pi}{4}\right)(D^2 - d^2) = \left(\frac{\pi}{4}\right)(27^2 - 13^2) = 440\ cm^2 \quad (3)$$

6. **Volume of rubber**

$$V = Ah = 440 \times 4 = 1760\ cm^3 \quad (4)$$

7. **Transverse elasticity module, as shown in Figure 3, for hardness of 62 0 Sh (according to standards 7278 and 7277)**

G= 9,7 daN/ $cm^2$

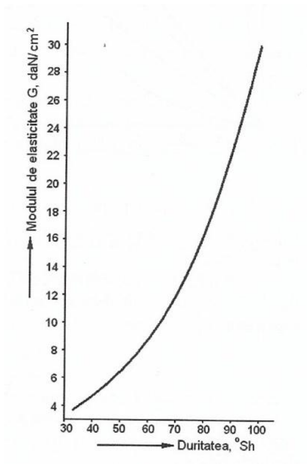


Figure 3 Elasticity module G depending on the rubber hardness[6].

8. **The correction factor for the form factor of the previously calculated part (Kf) of Figure 4 shall be adopted, resulting K= 10**

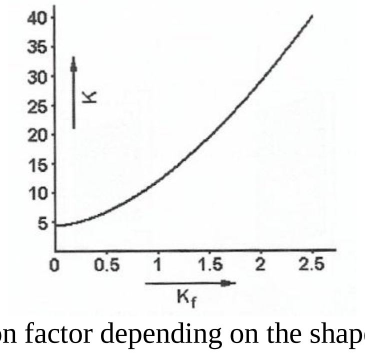


Figure 4 Correction factor depending on the shape factor of the part

9. **Longitudinal elasticity module**

$$E == 97\frac{daN}{cm^2} \quad (5).$$

10. **Rigidity of the part**

$$c = \frac{EA}{h} = 97 \times \frac{440}{4} = 10670\ daN/cm \quad (6)$$

11. **Deformation under the static load of 1250 daN**

$$f_{max} = \frac{G_t}{c} = \frac{1250}{10670} = 0.117\ cm \quad (7)$$

12. **Percentage deformation under the static load of 1250 daN**

$$f\% = (1{,}17\ /\ 40) \times 100 = 2{,}93\% \quad (8)$$

13. **Mechanically compressive work of $L_m$**

$$L_m = (1/2) G_t f_{max} = 0.5 \times 1250 \times 0.00117 = 0.73\ daNm \quad (9)$$

14. **Specific request σ for compression**

$$\sigma = \frac{G_t}{A} = 1250/440 = 2{,}85\ daN/cm^2 \quad (10)$$

Using as damper buffer the part in Figure 2 for a limited request, it can be concluded that it resists according to the specific request calculated in point 14. If the number of shock absorbers increases, for example it uses n = 12 then the specific request is reduced, becoming, σ = Gtot/n A = 5000/ 12/ 440 = 0,95 daN/ cm2

In Figure 5 are presented the results obtained by calculating about percentage deformation fpr(%) and sigma specific stress(daN/cm2). [7].

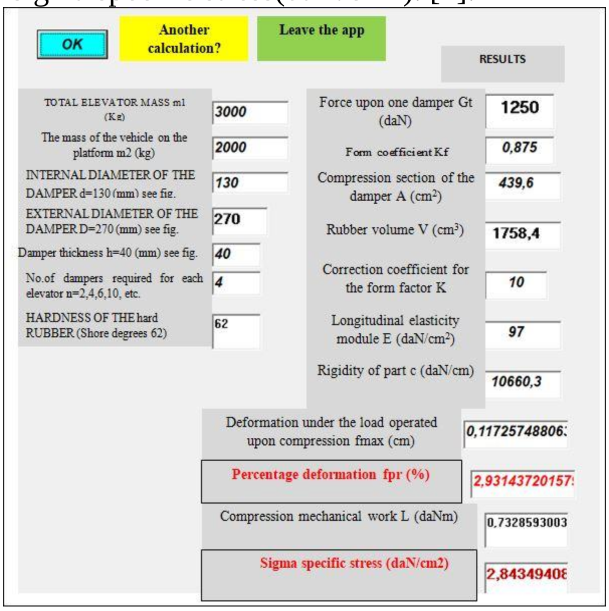


Figure 5 Results obtained using the calculation program

## 4. CONCLUSIONS.

**Advantages and disadvantages for each solution [6].**

1. In the case of using springs, several models with a different number of spires may be chosen, thus resulting in more possibilities if varying the unitary efforts.
2. Due to the high deformations, the springs allow the execution of foundations with very low inherent frequencies, avoiding resonance

3. Springs may be sized for a wide variety of loads, usable in both light and very heavy cars.
4. In terms of price, the cheapest solution is to use a rubber mat that can be divided into a certain number of dampers, the constructions being simple and light.
5. The damping factor is higher for rubber than for steel, the internal damping being necessary in case of suddenly applied forces, in case of resonance when starting or stopping the elevator, as rubber bears accidental overloads.
6. Rubber stores more energy than steel at the same volume.
7. Elastic rubber systems are more stable than those of steel.
8. The elastic modulus of rubber, depending on the coefficient of shape and hardness of rubber ($E = (2\text{-}12) * 10^6$ N/m$^2$), is much lower than that of spring steel ($E = 2.2 * 10^{11}$ N/m$^2$) and thus rubber provides supporting systems with low inherent frequencies, avoiding resonance.
9. Rubber does not require in-service maintenance.
10. Under the influence of environmental factors (light, water) and petroleum products (oils, diesel), the elastic features of rubber are diminished. Mechanical protection elements (boxes) must be made in which the rubber elements are inserted in order to avoid these problems. The use period of the rubber elements depends on these environmental factors.
11. Due to the rubber aging phenomenon, its resistance and elasticity decrease, removing the system from operation after a certain period (between 5-20 years). Thus, after this period, the rubber damping elements must be replaced.

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