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CALCULATION OF FOUNDATION SCREWS REGARDING THE VIBRATING TABLE "MEVI"

Aurora Felicia CRISTEA

Abstract: *This paper is intended to be a continuation of another paper dealing with sizing and designing a large, massive "MEVI" vibrating table, and the present work also provides calculations for sizing the clamping screws in the foundation.*
Key words: *Foundation screw, vibrating table.*

1. INTRODUCTION

This paper is intended to be a continuation of another paper dealing with designing and dimension problems of a large, industrial table.

The present paper brings the completion of this work in terms of design calculations of the screws for foundation. Foundation screws have a special role in the stability of the vibratory table and the work on it.

2. FOUNDATION SCREW'S CALCULUS

2.1 Generalities

A concrete foundation screw [6] must have the following features:

- The lower part of it will be embedded in the concrete; Screw stem partially embedded in concrete, threaded at the other end; The top is fastening.

We are particularly interested in: the minimum and maximum distance between the two adjacent screws; Maximum support accepted; The distance between the screw axis and the edge of the concrete; The thickness of the reinforced concrete shall be at least 200 mm; The tightening of the nut must be such as to produce a residual effort of 25-30 N/mm^2;

- The anchoring screws in the foundation were chosen according to the standards (STAS 10108/095, STAS 10108/9) as dimensioning and did not insist on this study, only resistance calculations were made;

- According to the calculations and according to the design, M20 anchor screws were selected, according to STAS 10108 / 0-95 and STAS 10108/90, in this case of work four pieces per plate (Fig.1).

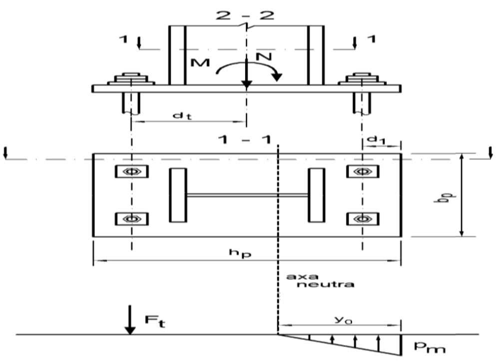

Fig. 1 Pressure diagram regarding foundation screws [6].

2.2 Axial force dimension F_t

The equilibrium moment equations [6] are written in relation to the center of gravity of the unitary compression forces, respectively in relation to the axis of the screws, determining the values sought as a function of the width of the compressed area.

$$F_t = \frac{M - N \cdot \left(h_p / 2 - y_0 / 3\right)}{d_t + h_p / 2 - y_0 / 3} = \frac{5{,}281 - 12{,}187 \cdot (1{,}7/2 - 2{,}125/3)}{0{,}4 + 1{,}7/2 - 2{,}125/3} = 6{,}569N \quad (1)$$

where $p_{m\max} = 30\ N/mm^2$ – the *maximum compressive stress* on concrete at the edge of the base plate.

$$y_0 = \frac{n_e \cdot A_t}{b_p} \cdot \left[\sqrt{1 + \frac{b_p}{n_e \cdot A_t} \cdot \left(2 \cdot d_t + h_p\right)} - 1 \right] = \tag{2}$$

$$= \frac{6{,}4 \cdot 1{,}02}{0{,}65} \left[\sqrt{1 + \frac{0{,}65}{6{,}4 \cdot 1{,}02} \cdot (2 \cdot 0{,}4 + 1{,}7)} - 1 \right] = 2{,}125\,m$$

$$y_0 = 2{,}125m < 3{,}5m \; (on \;\; enssamble \;\; scheme) \tag{3}$$

Over-estimation [3], [6] within weighted equivalence coefficients (3) will increase the security of the catch. This causes an increase in the foundation screw sizing effort and a decrease in the maximum theoretical pressure in the concrete. If the width of the compressed area is small enough to cause stretching under the effect of the considered stress (compression with single axial bend) in both vertical sections caused by the screw rods ($y_0 < d_1$) it is accepted the relations (1), (2).

2.3 Calculation of the tension from the foundation screw and the maximum pressure on the submerged concrete

The notations in figure 2 will be studied, so additional notations appear:

a1 - the distance between the tensioning screw axis and the table foot of the table;

l_0 - the distance between the axis of the tensile screw and the edge there of from the compressed base plate;

At - the area of the total nominal section, the foundation screw subjected to stretching;

$$A_t = b \cdot l_0 = 1{,}7 \cdot 0{,}6 = 1{,}02 \; [m^2] \tag{4}$$

The width of the compressed area is:

$$x = \xi_1 \cdot l_0 = 7{,}426 \cdot 0{,}6 = 4{,}455\,m$$

$\sigma_b -$ *the maximum compressive load* in concrete

$\xi_2 -$ see catalogues [6].

By writing the moment equations in relation to the center of gravity of the pressure diagram, and the use of successive approximations in the sense of safety, the relation of the tension in the screws:

$$N_a = \frac{3}{3-\xi_1} \cdot \left[\frac{M}{l_0} - N \cdot \left(\frac{3}{3-\xi_1} - \frac{a_1}{l_0} \right) \right] = \tag{5}$$

$$= \frac{3}{3-7{,}426} \cdot \left[\frac{5{,}281}{0{,}6} - 12{,}187 \left(\frac{3}{3-7{,}426} - \frac{0{,}1}{0{,}6} \right) \right] = -12{,}941 \frac{N}{m^2}$$

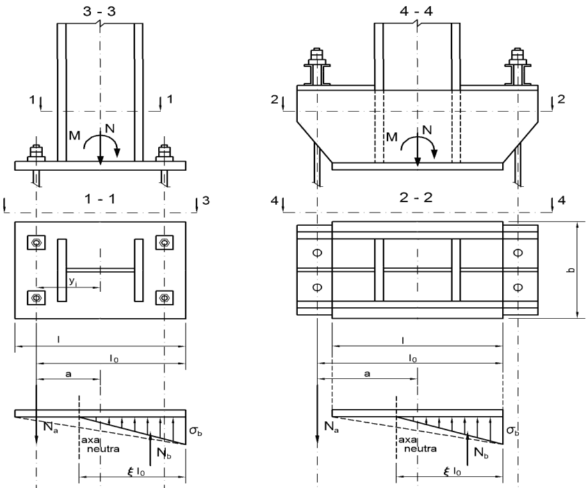

Fig. 2 Pressure diagram regarding the foundation screws [6].

By writing the moment equation with respect to the tensioned screw rod and using successive approximations, in the sense of its safety, the relation of the maximum compressive *tension in the concrete* relationship was determined (6).

$$\sigma_b = \frac{6 \cdot \left(\frac{M}{l_0} + N \cdot \frac{a_1}{l_0} \right)}{\xi_1 \cdot (3-\xi_1) \cdot b \cdot l_0} = \frac{6 \cdot \left(\frac{5{,}281}{0{,}6} + 12{,}187 \cdot \frac{0{,}1}{0{,}6} \right)}{7{,}426\,(3-7{,}426) \cdot 1{,}7 \cdot 0{,}6} = \tag{6}$$

$$= -1{,}635 \frac{N}{m^2} < \sigma_{a_{beton}} = 30 \cdot 10^6 \frac{N}{m^2}$$

The condition imposed by the hypothesis of flat sections under stresses in the elastic field was expressed by a unique equation, taking into account the different elastic characteristics of steel and concrete

$$\frac{A_t \cdot \sigma_b}{N_a} \cdot \frac{E_a}{E_b} = \frac{\xi}{1-\xi} \tag{7}$$

This relationship was obtained by processing the equation system (8):

$$\frac{\varepsilon_b}{\varepsilon_a} = \frac{\xi \cdot l_0}{l_0 - \xi \cdot l_0} = \frac{\xi}{1-\xi}$$

$$\varepsilon_b = \sigma_b \cdot E_b \tag{8}$$

$$\varepsilon_a = \frac{N_a}{A_t} \cdot E_b$$

To this, two equilibrium equations were added:

$$N_b = N_a + N$$

$$M + N \cdot a_1 = N_b \cdot \left(l - \frac{\xi \cdot l_0}{3} \right) \quad (9)$$

By taking over the three equations (relations 7,8), having unknowns ξ, σ_b and N_a, Can be reduced by replacing the whole system to an equation given by the relation (10):

$$\alpha \cdot \xi^2 + 3 \cdot (1 - \alpha) \cdot \xi = y \cdot \left(\frac{1}{\xi} - 1 \right) \quad (10)$$

where:

$$\alpha = \frac{N \cdot l_0}{N \cdot a_1 + M} = \frac{12{,}187 \cdot 0{,}6}{12{,}187 \cdot 0{,}1 + 5{,}281} = 1{,}125$$

$$y = 6 \cdot \frac{E_a \cdot A_t}{E_b \cdot A_b} = 6 \cdot \frac{21}{3{,}3} = 38{,}18$$

and

$$E_a = 21 \ N / m^2$$

$$E_b = 3{,}3 N / m^2$$

Relationship (10) allows the determination of the unknown ξ, whose knowledge is sufficient and necessary to determine unknowns, N_a and σ_b following the calculation relations (4), respectively (5).

$$N = \frac{1}{2} \cdot p_m \left(d_t + \frac{h_p}{2} \right) \cdot b_p = = \frac{1}{2} \cdot 30 \left(0{,}4 + \frac{1{,}7}{2} \right) \cdot 0{,}65 = 12{,}187 N \quad (11)$$

$$M = \frac{1}{2} p_m \left(d_t + \frac{h_p}{2} \right) \cdot b_p \left[\frac{h_p}{2} - \frac{1}{3} \cdot \left(d_t + \frac{h_p}{2} \right) \right] = = \frac{1}{2} \cdot 30 \left(0{,}4 + \frac{1{,}7}{2} \right) \cdot 0{,}65 \cdot \left[\frac{1{,}7}{2} - \frac{1}{3} \cdot \left(0{,}4 + \frac{1{,}7}{2} \right) \right] = 5{,}281 N \cdot m \quad (12)$$

$$M_{\max} = \frac{3 \cdot M}{h_p - d_t} = \frac{3 \cdot 5{,}281}{1{,}7 - 0{,}4} = 12{,}186 \ N \cdot m \quad (13)$$

2.4 Calculation of resistance screw of foundation

The admissible tightening force shall be calculated:

where: β = 1,3 – the coefficient which takes into account twisting of the screw at the time of tightening;

d_1 – the inside diameter of the screw thread;

σ_a = 30 N/mm^2 – admissible strength for steel OL37, the material from which the screw is

$$F_{strangere} = \frac{1}{\beta} \frac{\pi d_1^2}{4} \sigma_a = = \frac{1}{1{,}3} \frac{\pi \cdot 18^2}{4} \cdot 30 \cdot 10^6 = 5869{,}38 \cdot 10^6 N \quad (14)$$

made.

3. VERIFICATION BY CALCULATING THE FOUNDATION SCREEN SECTION

3.1 Load groups that lead to foundation screw dimensioning

In the case of foundation screws [6], the dimensioning demand is caused by horizontal loadings on the structure (e.g. wind, earthquake, roller shutter action, etc.).

Equivalent formula, sizing of foundation screw is obtained from the grouping that determines the maximum bend moment or the group that determines the minimum axial force in the foot attachment of the "MEVI" metal foundation.

Anchorages do not accept incursions in the plastic field, making dimensioning obligatory to stresses corresponding to the elastic response of the structure. Moreover, due to the uncertainty of local behavior, coefficients of working conditions are adopted that bring significant reductions in the material's resistance to computation. When choosing as a recess in both directions, groups that lead to high bending moments are studied, on both directions (length and width).

If the constructional solution does not allow the cutting force to take over in another way, the foundation screws will take over this load. This case requires additional consideration of the group leading to the maximum cutting force, increasing the number of unfavorable stresses of the base of the metal element.

The foundation screws [3], [6], [8] are dimensioned at the most unfavorable load group. Therefore, dimensioning is usually done in the group that includes external action, in accordance with the requirements of P100-1 / 2006.

The *sectional efforts* at the base of the foot are determined by the formula:

$$E_{F,d} = E_{F,G} + 1{,}1 \cdot \gamma_{ov} \cdot \Omega \cdot E_{F,E} \qquad (15)$$

$E_{F,d}$ – *the total calculation effort* at the base of the pillar (table foot, "MEVI"), which also includes the external action;

$E_{F,G}$ – *the partial effort* of the inner actions contained in the load group;

$E_{F,E}$ – *the fractional effort* resulting only from the external action;

γ_{ov} – f*actor to amplify the flow limit* of the material (over-resistance); $\gamma_{ov} = 1{,}25$ (16)

Ω – *factor of multiplication of effort* $(M_{ld,E}, V_{ld,E})$, for the design of the non-dissipative structural elements.

$$\Omega = \frac{M_{pl,Rd,i}}{M_{Ed,i}} \qquad (17)$$

where: $M_{pl,Rd,i}$ – the plastic moment at the base of the foot;

$M_{Ed,i}$ – the actual moment in the group that contains the external forces;

According to formula (16), the efforts from the outside are amplified with the value $1{,}1 \cdot \gamma_{ov} \cdot \Omega \cdot E_{F,E}$, this coefficient being superior to the response in the elastic domain of the structure:

$$1{,}1 \cdot \gamma_{ov} \cdot \Omega \cdot E_{F,E} < q \qquad (18)$$

q – factor of behavior to external actions of the structure (seismic force reduction factor). The detail of the foundation of the foot is of particular importance for the good behavior of the anchor screws over time. And the norm P100-1/2006 recommends that "the transmission of horizontal forces at the level of the superstructure should not be achieved by means of foundations screws".

4. CONCLUSION

With the dynamic forces developed in the vibrating table movement, it was impetuous necessary the resistance dimensioning the foundation screws by means of tensile, shear strength, etc., so that large masses would not be torn at the foundation leg or overturned.

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Calcularea şuruburilor de fundaţie, privind masa vibratoare "MEVI"

Abstract: *Lucrarea prezenta se doreşte a fi o continuare a altei lucrări, lucrare care trata dimensionarea şi proiectarea unei mese vibrante industriale, de mari dimensiuni "MEVI", iar lucrarea de faţă aduce în plus, calcule de dimensionare a şuruburilor de prindere în fundaţie, a acesteia.*

Aurora Felicia CRISTEA, Lector Ph.D Eng., Technical University of Cluj-Napoca, Building of Machine Faculty, Mechanical Engineering Systems Department, e-mail: cristea_fa@yahoo.de.