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DESIGN OF VIBRATING TABLE FOR CONCRETE MOULD

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Abstract: The design of a vibrating table for a concrete mould as well as any supporting machinery is part of this project. Composites can have a variety of structures depending on their components and manufacturing methods. Vibration is required to remove air bubbles that are produced in the interior structure of composite materials produced using the mould casting procedure. The final construction ought to be homogeneous and void-free. The scope of this study comprised the design and construction of composites made of resins and aggregates as well as the design and construction of a vibrating table with various uses.

Keywords: Vibrating Motor, Stand Frame, Top Plate, Spring Suspension System, Nut, Bolt, Etc.

I. INTRODUCTION

The project's overarching objective is to build a vibration table. This will be utilized to fund local products in both urban and rural areas. The manufacturing of concrete roof tiles and paving bricks from moulds will involve the use of the table during a vital stage. Vibrated concrete contains less voids, which lowers the water to cement ratio. This allows for a stronger finished product and maximizes the use of the components. Additionally, vibration improves the shine on the product's outside surface, extending its lifespan by reducing the possibility that cracks may appear due to foreign contamination.

Composite materials are final products with greater attributes than the individual components alone since they are comprised of at least two or more components. One of the major problems in manufacturing composites is the inability to achieve a homogeneous structure. One of the most important elements is the air gaps that are still there in the building. The presence of greater air gaps in comparison to the ideal homogeneous structure may adversely affect one of the desirable qualities of the composite. Commercial vibration tables are made and made available for purchase. The vibration table is an essential piece of machinery for producing concrete moulds for items that are believed to have been made using aggregate and for use in construction.

II. METHODOLOGY

The preliminary design of the Vibration Table will consist of the following components: - Table top (Plate), Compression springs, Main frame, Inner frame (for further support when the load is applied), Bolts, External vibrator.

Vibration Table Specifications

Dimensions For Table Top: Length :2 m Width :2 m Thickness: 2 cm Estimated weight: 75 kg (including the external vibrator)

Intended Design Goals

- Being able to vibrate about 3000 kg of concrete.
- Maintain the amplitude of vibration that is equal to (0.5-2) mm.
- Must operate within the frequency range of (2000-2880 rpm)
- Durable: must last without major repair for 2-5 years
- Must be easily built and repaired using parts available from nearby department store and tools that are readily accessible.

Vibration Concepts

Concrete Vibration Usually, concrete requires a very high frequency of vibration in order to remove air bubbles, mix the aggregate and provide a smooth, clean finish. Common types of isolators we can be used such as: rubber isolators, springs

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Recommended Acceleration and frequencies of concrete vibration

Vibration Method	Recommended Acceleration (Without Concrete Load)	Recommended Frequency	Vibration/ Min
Internal	100-200	150-250	9000-15000
Form	5-10	50-200	3000-12000
Surface	5-10	50-100	3000-6000
Table	5-10	50-100	3000-6000

Amplitude is the maximum departure for a point of rest during displacement cycle under vibration. Most concrete vibrator operate with an amplitude of 0.5 mm to 2.0 mm. The cycle of vibrations travels through the concrete, transferring their energy to the particles in the mix.
The most important parameters in the process of concrete vibration are:

- Centrifugal force
- Amplitude
- Frequency
- Acceleration

The concept of Vibration isolation: Consider a vibrating table, bolted to a rigid floor. The force transmitted to the floor is equal to the force generated in the table. The transmitted force can be decrease d by adding a spring and damping element.

Transmissibility: the ratio of transmitted force to the input force.

$$T = \frac{F_T}{F_O} = \frac{X}{\delta_{st}} = \frac{1}{\sqrt{(1-r^2)^2-(2\tau r)^2}} = 0.0059$$

The effectiveness of the isolator is:

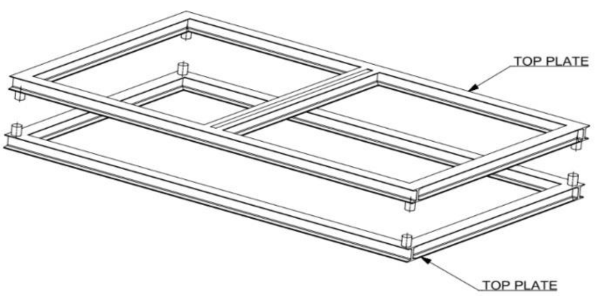
% Isolation=(1-T) ×100= 99.4 %

For minimum transmissibility (maximum isolation), the excitation frequency should be as high above the natural frequency as possible.

III. DESIGN ANALYSIS

A. Table Top Analysis

The tabletop is rectangular in shape to accommodate the concrete mould, which weighs between 30 and 50 kg. It is constructed of a material with a very strong installation property, such as Cast-Iron Alloy, and measures 2 meters in length, 2 metres in breadth, and 2 metres in thickness. There are four bars at the bottom of the tabletop, which strengthen the strength of the top. These bars are symmetrically placed and have a 2 cm thickness.



Vibrating Table Frame

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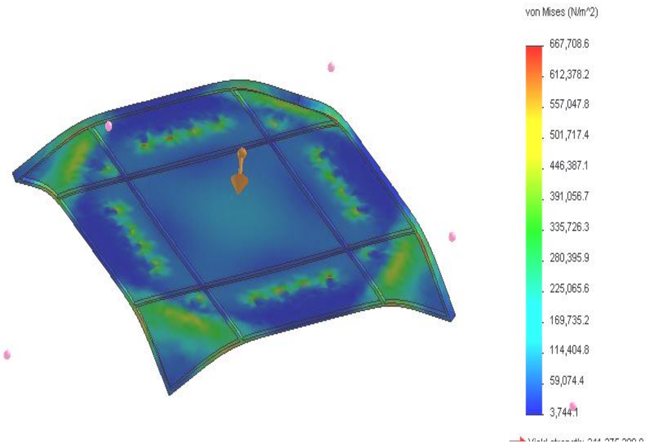

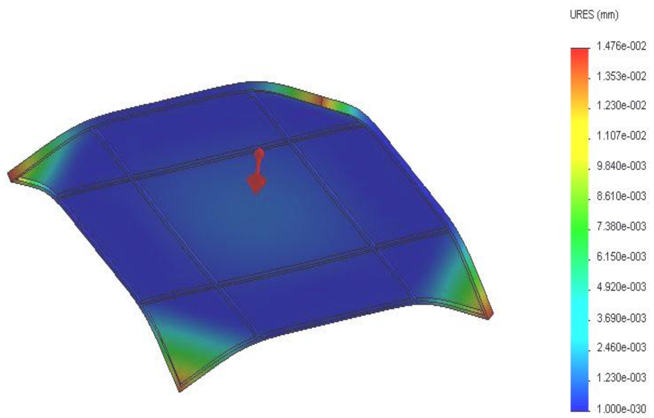

Tabletop Simulation Stress By Solidworks
The Maximum Displacement Appeared In Angles Of Tabletop

B.Compression Springs Design

The number of springs is twenty to reduce the applied force to small amount. By Solid works program each spring have a compression force not exceeded to solid force (Fs) . So the average compression force in the all spring is equal 1500 N Assuming approximate weight of concrete to be 20kg to 30 kg load = 200 N to 300 N over an area of 1524 mm × 954 mm

Total load on spring = 300 + weight of unloaded tabletop
= 300 + 110
= 410 N

Consider, Spring made of Patented and cold drawn steel wire of Grade 1.
The constants (A=1753, m=0.182, G=81370 N/mm^2)
Permissible shear stress for spring wire= 50 % of Ultimate tensile strength (S_{ut})
Spring index c is 6,

Step 1 Permissible shear stress (τ)

$S_{ut} = \frac{A}{d^m} = \frac{1753}{d^{0.182}}$

$\tau = 0.5\left(\frac{1753}{d^{0.182}}\right) = \frac{876.5}{d^{0.182}}$ N/mm

Step 2
From load stress equations

$\tau = k\left(\frac{8pc}{\pi d^2}\right)$

Here, Wahl factor (C=6)

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k $=\frac{4C-1}{4C-4}+\frac{0.615}{C}=\frac{4(6)-1}{4(6)-4}+\frac{0.615}{4}$ =1.2525
Now load stress equation,

$\tau = k\left(\frac{8pc}{\pi d^2}\right)$

$\frac{876.5}{d^{0.182}}=1.2525\times\left(\frac{8\times102.5\times6}{\pi(d)^2}\right)$ here, d= 4.30 mm or 5 mm

Step 3 Design check
Grade 1 and 5mm diameter
from standard table S_{ut}= 1090 N/mm

$\tau_S = 0.5(S_{ut})$ = 0.5(1090) = 545 N/mm

$\tau = k\left(\frac{8pc}{\pi d^2}\right) = 1.2525\times\frac{8\times102.5\times6}{3.14\times5^2}$ = 78.54 N/mm
Here,
$\tau < \tau_S$ Design is safe and satisfied for 5

Step 4 find D

For relations $c=\frac{D}{d}$
D= cd =6×5 = 30 mm

Step 5 number of active coil (N)
From load deflection equation

$\Delta=\frac{8PD^3N}{Gd^4}$

$30=\frac{8\times102.5\times30^3\times N}{81370\times5^4}$
=6.89 ≈ **7coil**

Step 6 total number of coil (N_t)
Assume that spring has square and grounded end
Number of active coils = 2
N_t=N+2=7+2= **9 coil**

Step 7 free length of springs
Solid length (S.L) = N_t × d = 9×5 = 45mm
Assume gap of 1 mm between two adjacent coils
Total axial gap = (N_t-1) × gap between two adjacent coils
= (9-1) ×1= 8 mm
Free length = solid length +total axial gap + Δ
= 45+8+30 = 83 mm

Step 8 Pitch of coil

$P=\frac{Full\ length}{N_t-1}=\frac{83}{9-1}$ = 10.37mm

C.Table Base Design

The table's base should be sturdy enough to support this substantial weight. Also When the shaking begins, the table must be fixed to the ground by the weight of the base. Cast alloy steel, which is the substance of the table, adds strength to the design. The base weighs close to 32 kg.

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D. Bolt Design

Assumption: -

1. The shear loads are carried by friction.
2. The attached members are rigid and do not deflect with loads.

Material selection

So the material we chose for bolt has to have high wear resistance and good machine ability

a. Diameter of the bolt, d = 20mm
b. Diameter of the hole, d0 = 20+2 = 22mm
c. For bolts of grade 4.6: fub = 4 x 100 = 400 Mpa
d. fyb = 0.6 x 400 = 240 Mpa
e. Thickness of connecting plate = 12mm
f. Thickness of covering plate = 10mm
g. For Fe 410 grade of steel fu = 410 MPa

To Find: Strength of Bolt (Bolt Value)

(Note: Bolt value is the smallest of Design Shear strength of Bolts and Design Bearing Strength of Bolt)

Solution:

Single cover lap joint, The bolts will be in single shear

The Design Shear strength of bolt

$$V_{sb} = \frac{\frac{f_u}{\sqrt{3}}(n_n A_{nb} + n_S A_{sb})}{\gamma_{mb}}$$

Here, $n_n = 1$ and $n_s = 0$ (Single Shear assuming shear plane to be in threaded portion)

$A_{sb} = \pi d^2 / 4 = 3.14 \times 20^2 / 4 = 314\ mm^2$

$A_{nb} = 0.78 A_{sb} = 0.78 \times 314 = 245\ mm^2$

$$V_{dsb} = A_{nb}\frac{f_{ub}}{\sqrt{3}\gamma_{mb}} = 245 \times \frac{400}{\sqrt{3} \times 1.25} \times 10^{-3} = 45.26 \text{ kN}$$

The strength of bolt

$$V_{dpd} = 2.5\ k_b d t \frac{f_u}{\gamma_{mb}}$$

The bolt will be in single shear. The thickness to beconsidered are the thickness of the main plate or the sum of cover plates, whichever is less. Hence, t= 10mm

To find k_b

Edge distance e = 1.7 d_0 =1.7×22=37.4 say 40 mm

Pitch, p =2.5d =2.5×20=50 mm

k_b is least of $\frac{e}{3d_o} = \frac{40}{3\times 22} = 0.6$; $\frac{p}{3d_o} - 0.25 = 0.5$

$$\frac{f_{ub}}{f_u} = \frac{400}{410} = 0.975$$

Hence $k_b = 0.5$

Therefore, bearing strength of the bolt

$$V_{dpd} = \frac{2.4 \times 0.5 \times 20 \times 10 \times 400}{1.25} = 80kN$$

Design strength of bolt is the smallest of design shear strength of bolt and design Bearing strength of bolt

Therefore, Design Strength of bolt = 45.26 kN

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IV. ADVANTAGE

• A concrete vibrator can be used to compact a structure with substantial reinforcement with ease.
• When a building is constructed with Concrete Vibrator, it becomes dense and waterproof.
• When using a concrete vibrator, a low water-to-cement ratio can be used in building.
• When employing a concrete vibrator, the rate of work is accelerated.
• Using a concrete vibrator allows for the use of a high aggregate-to-cement ratio.
• Using a Concrete Vibrator during construction strengthens the link between the building's steel reinforcement and the concrete, improving the building's overall strength.

V. FUTURE SCOPE

We can condense a structure with substantial reinforcement with ease. Initially, this machine is run electrically; however, in the future, electric motors will be swapped out for hydraulic or pneumatic motors. Low maintenance costs and rising mass production rates. The majority of the plants are situated in rural areas; therefore, electricity is a significant issue.

VI. CONCLUSION

In our project, we cover practically every element that is linked to the vibration table, from getting and computing the necessary vibration parameters (natural frequency of the system, desired amplitude transmissibility, stiffness of springs, and vibration isolation), to aspect related to the design analysis that we require in this vibration table, from the table top analysis, the table base design, the compression springs design, to the bolts design, and weld design.

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