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MECHANICAL DESIGN AND MATHEMATICAL MODELING OF A SHOCK ABSORBER CONSTRUCTION

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ABSTRACT

This paper aims at providing an insight to a structural model which can work satisfactorily in severe shocks and vibrations. This paper provides reasoning with uncertainty in mechanical and building design also aims at providing a forum to present and discuss new approaches to deal with it. In addition, it will put a special emphasis in the problems of understanding the intended semantics of various mechanics applications. The understanding will lead to ability to access the relative merits and demerits of different applications. In this research, the methodology adopted is design of structure, studying different shock conditions and its effect at various levels such as continuous light shock, sudden shock, tangential impact etc.

This modeling can be used in various defense and strategic applications and also in critical earthquake-prone areas. This paper leads to an idea and an engineering approach to prevent the hazard cause by natural forces, and hence serves for betterment of humanity.

Keywords—Mass, dampers, spring, machine design

1. INTRODUCTION

The civil and other strategic construction is based mainly on the truss and hence the strength of construction is based on the strength of the truss materials. It is very much necessary to control the damage caused by any undesirable conditions e.g., vibrations, earthquake etc.

This research is combination of very few mechanical engineering subjects like strength of material, automatic control systems etc. having basic knowledge of the subject is sufficient to understand all the concepts while adding knowledge of other subjects led to perfection in field of stability and design.

2. FORMULATION OF PROBLEM STATEMENT

2.1*Primary Stage:*

In primary stage the author want to create a structure that can survive in heavy shock conditions and also in severe vibrations. The special emphasis is put on the validity of the structure to make it useful for the residence of human beings.

2.2 Secondary stage:

After getting the success in the primary stage, the emphasis is put on the utility of the structure in civil construction. It is believe by the author that the design usable for absorbing the shock and vibration in machine can also be useful in absorbing the shock caused by earthquake and other natural calamities.

Hence in secondary stage the construction of civil structures is considered.

3. UNITS

We are going to make the shock absorbing model hence it is obvious that we have to think about the present shock absorbing systems and their capacities. Afterwards we have to move toward the development in this mechanisms and systems, if necessary. Here author has considered the spring as well as dampers or compressors as the shock absorbing system. In primary stage there is no issue of capacity but as we move toward the secondary stage the question of capacity as well as the stability of the system arises... The following fig. shows various components of translator mechanical system.

a) Mass:

b) Spring: (K= stiffness (force/length))

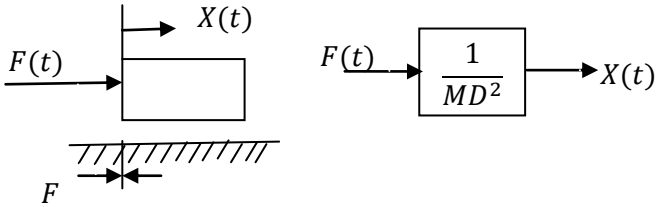

Fig.1. Mathematical modeling of mass

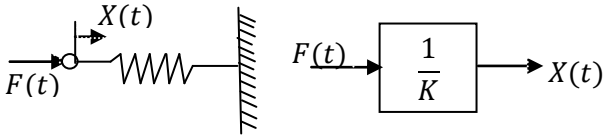

Fig.2. Mathematical modeling of spring

If Z=Impedance then T.F. = $\frac{1}{Z}$ *where* $Z = MD^2$

c) Damper: (i) If cylinder is fixed **(ii) If cylinder ismoving**

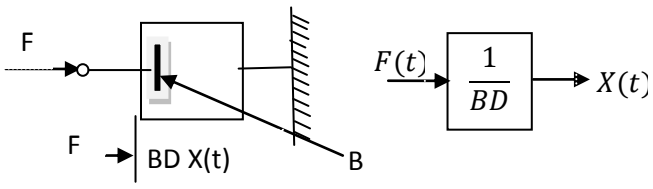

Fig.3.mathematical modeling of damper (i)

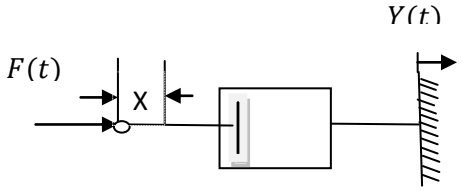

Fig.4.mathematical modeling of damper (ii)

Here impedance Z= BD.

Firstly, we have to consider a generalized model for the mathematical modeling and afterwards we have to consider the particular design. Now, few designs are proposed by the author and further he is going to describe the best among them.

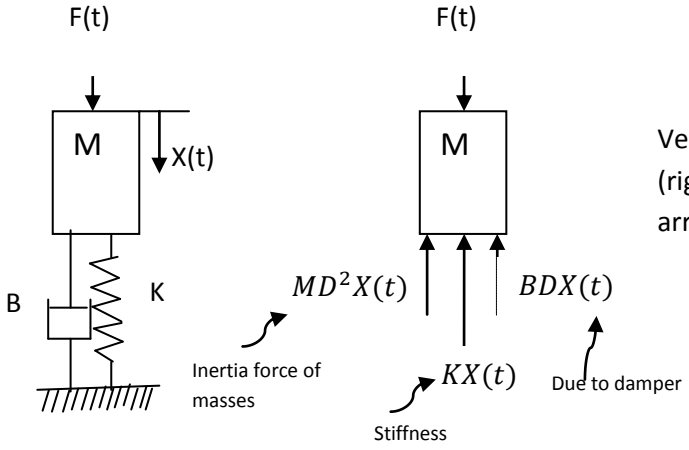

Fig.5.design of proposed model 1.

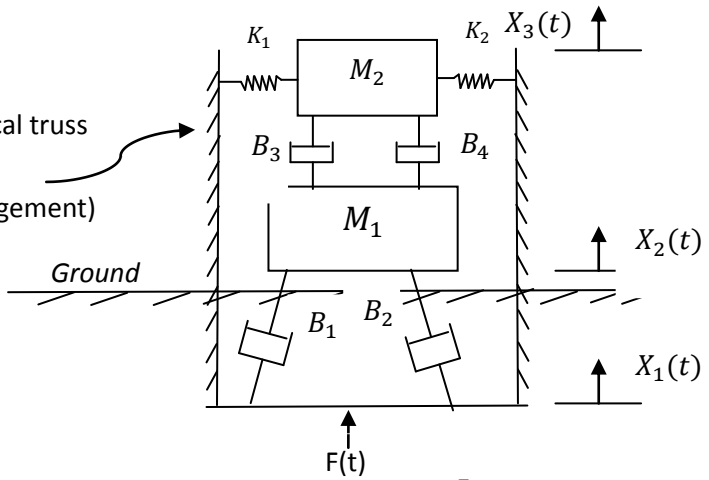

Fig.6.design of proposed model 2**Front view**(by improving model 1).

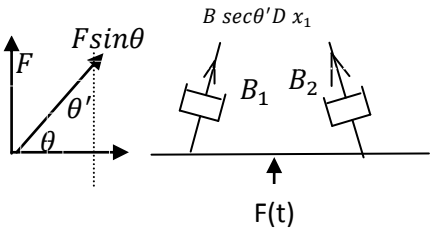

Fig.7.F.B.D. 1 (F.B.D. of base)

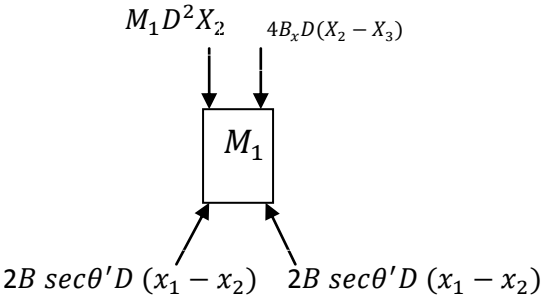

Fig. 8. F.B.D. of level 1 (lower level)

As shown in figure it is a two leveled structure. It is one of the most stable structures as it is pyramidal at base while tapers as it go up. It is also supported by vertical truss structure. At base four dampers (Air compressors) are used which reduces the shock as well as its whole steel body make it most suitable for heavy duty.For sake of understanding let us select a mechanical design2 (fig no. 6) and now we have to mathematically model it. Here M_1 and $M_2$are considered as the total dead load of ground floor as well as first floor. Here B is the damper while K is the spring. F is the applied force. Let $B_1 = B_2 = B$ and $B_3 = B_4 = B_x$

. Consider the F.B.D. of base as shown in fig 7.

From F.B.D., $F = 4B\ sec\theta' D\ (x_1 - x_2) . . (\alpha)$

Consider the F.B.D. of first level as shown in fig. (See fig. 8). Fromfig 8,$M_1D^2X_2 + 4B_x(X_2 - X_3) = B\ sec\theta' D\ (x_1 - x_2) \dots \dots (\beta)$

Similarly for upper part,$M_2D^2X_3 = 4B_xD(X_3 - X_2) \dots \dots \dots \dots (\gamma)$

Now, from (γ) we get,$\frac{x_2}{x_3} = \frac{4B_xD - M_2D^2}{4B_xD}$.

Putting this value in equation (β) we get.

$$(M_1D^2 + 4B_x + 4B\ sec\theta' D)\frac{(4B_xD - M_2D^2)}{4B_xD}X_3 = 4B_xDX_3 +$$

$4B\ sec\theta' D\ x_1$.

Finally transfer function to the top level from vibrations at bottom is given by: $\frac{X_3}{X_1} = \frac{(4B_x D)\,(4B\ sec\theta' D)}{(M_1 D^2+4B_x+4B\ sec\theta' D)(4B_x D-M_2 D^2)-16B_x^2 D^2}$.

Now for side, from the fig.9, we get the relation. $F = [M_2 D^2 + 2(k_1 + k_2)]X_{side}$

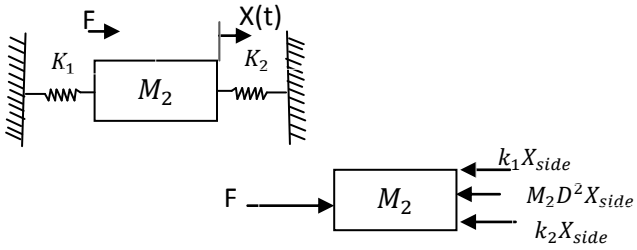

Fig.9.Mechanical design and mathematical modeling of the sideways of structure.

When human and sensitive device oriented structure is considered then temperature is one of the most important factor is to be considered.Firstly we have to cover-up all the structure with the help of any non-conducting material such as plastic or wood. Afterwards, we have to think about the temperature variations. For this section we have to move towards heat transfer. The wall is covered from all around by non-conducting material hence it reduces the heat transfer a lot.

A. *Probable cross section of wall (covers of wall)*

Between the insulating materials we are placing few steel components. It is very similar to holes in a pipe. Hence following consideration are shown to find out the heat transfer-rate through the walls. Heat transfer rate in general is given by: $Q = U\ A\ \Delta t$. Where, Q= heat transfer rate. U= overall heat transfer coefficient. $\Delta t\ is\ temperature\ difference$. Compare to total area being exposed to surrounding the area of metallic parts id very less. Hence it may be assumed that it is covering the whole surface with very less thickness. So, considering it as two slabs wooden and metal having thermal conductivities $k_w\ and\ k_m$resp. they are placed in contact but due to roughness only very few percentage area is in contact (say 30 %), and the gap in remaining area is very thin (say about .025mm thick) and is filled with air (see fig.10). Thus the equivalent resistance is given by,

$$R_{th}\ equivalent = \frac{1}{R_{th}M_1} + \frac{1}{R_{th}air} + \frac{1}{R_{th}W_1}$$

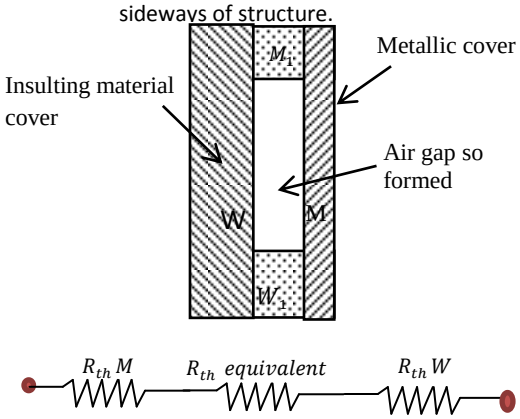

Fig. 10. Cover of either side of wall (composite slab)

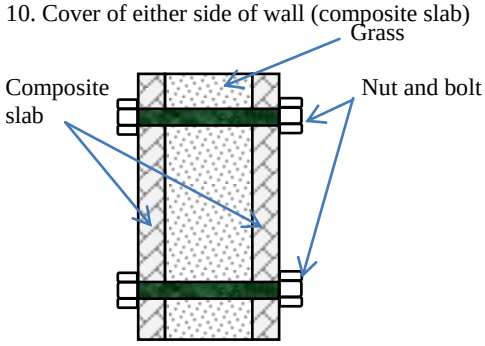

Fig. 11. (composite) Wall of building

B. *Thermal design of wall*

Above described wall cover (composite slab) is capable of being the insulation boards for air-conditioning purposes. Now it (wall) is considered as made of three layers, middle being of packed grass *g mm thick* and sides are made of composite slab each of *c mm thickness.* They are supposed to be joined by nut and bolt arrangement. Suppose '*n*' *numbers of bolts* are used to join it with '*d*' *mm diameter* and having k_d as thermal conductivity of the bolt material. The following diagram shows the possible arrangement of wall to be built. When the layers are joined by nut bolts the heat transfer rate is given by,

Area of each bolt,$A_b = \frac{\pi}{4} d_{bolt}^2$. The equivalent thermal resistance is given by,

$$\frac{1}{(R_{th})_{eq}} = \frac{1}{R_{th}comp1+R_{th}grass+R_{th}comp2} + \frac{n}{R_{th}bolt}$$

Now heat flow per m^2 of area is given by, $q = \frac{(\Delta t)_{overall}}{(R_{th})_{eq}}$

A. *Design of Dampers*

Dampers are nothing but the compressors under high pressure hence it is suitable to design the damper (compressor) as the pressure vessel. If the internal pressure of fluid is less than 1/6 of the allowable stress, then it is called thin shell. On the other hand, if the internal fluid pressure is greater than 1/6 of allowable stress, then it is said to be thick shell. The analysis of stresses is induced in a thin cylindrical shell are made of following assumptions (ref. 5):

a) The effect of curvature of the cylinder wall is neglected.

b) The tensile stresses are uniformly distributed over the section of walls.

c) The effect of the restraining action of the heads at the end of the pressure vessel is neglected.

When a thin cylinder is subjected to an internal pressure, it is likely to fail in the following two ways: (see fig. 19.)

a) It may fail along the longitudinal section (i.e., circumferentially) splitting the cylinder into through

b) It may fail across the transverse section (i.e., longitudinally) splitting the cylinder into two cylindrical shells. Thus the wall of a cylinder subjected to an internal pressure has to withstand tensile stresses of the following two types:

i) Circumferential or hoop stress

ii) Longitudinal stress

OTHER MODELS:

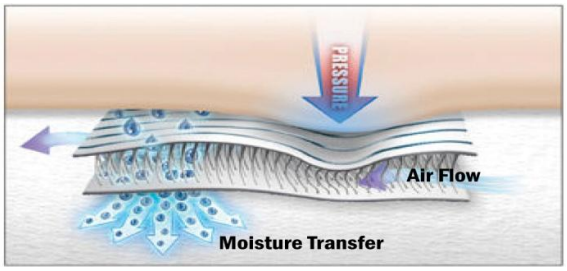

Fig.12.Proposed design 2 of base. (μ-springs.)

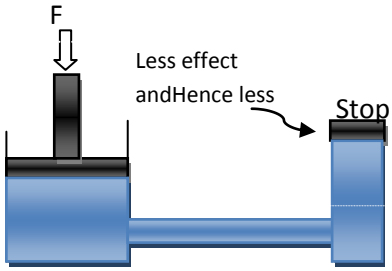

Fig.13.Hydraullic Press reversed function

As shown in figure 6, it is a two leveled structure. It is one of the most stable structures as it is pyramidal at base while tapers as it go up. It is also supported by vertical truss structure. At base four dampers (Air compressors) are used which reduces the shock as well as its whole steel body make it most suitable for heavy duty. For base there is another arrangement as shown in fig.. This structure contains the micro springs (μ-springs), as shown and hence the stresses are divided more evenly. It loses its economy in terms of initial investments but is better in terms of end results.**For easiness in demonstration we are considering the simple piston cylinder arrangement (compressor) but in real we have to use the hydraulic press but in reversed function.**For any shock or the force which is acting on it, if it is not able to compress the enclosed fluid then the enclosed fluid will act as incompressible fluid e.g., molten iron is incompressible with in artificially applied force range (till now available.) but it is compressible up to solid state in the earth's core (and other heavenly bodies) due to very high forces.

4. DIFFERENT APPROACHES AND FUTURE PROSPECTS:

1) Bio Mimicry: a) Spider Above is purely a mechanical way, while we can also utilize the bio-mimicry way. Closely observing during shock and other similar conditions, it is known that along with strength, stretchiness is also required. Hence from different biological species, silk of spider-web is best suited for the application. But the problem is commercial production of spider-web silk.

b) Honey bee hive: It can be seen that from various structures present in nature the very frequently and friendly observed structure is typical hexagonal structure like a hive of honey bee. Hence it can be used for our purpose. The specialty of this type of structure is, the entire load is evenly distributed, hence increases the validity of the structure. Distributed load causes less stress and also increases the life of the system as a whole. It can be best observed by the honey filled hives itself.

2) Vyaminkashastra: some of the aspects of design are discussed in Vyaminkashastra (ancient texts of aeronautical engineering in India). In this, several times they had mentioned about the 'saudamini kala (science of electronics)'. Where this is used to create turbulence and also to create severe shock conditions for enemy Vimana(flying crafts),during flying while also capable of surviving under severe shock conditions. Where it is mentioned special kind of material alloy which contains 'lauh (iron)', tamra (copper), 'rasaraj' (mercury), which is capable of surviving under critical conditions of temperature and pressure.

5.CONCLUSION

This paper gives the broad aspects of mechanical engineering. In this paper a few subjects of mechanical engineering are blended to get an optimum output. The design presented is capable of accelerating the changes required and at the same time it solves the security issues of the buildings and other similar structures. This paper may be regard as the initiative toward a new era of building, but further development is possible and needed.

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[6] *Vimanas- Ancient Flying Saucers of Atlantis and Lemuria* "Facts do not cease to exist because they are ignored." - **Aldous Huxley** (1894-1963)