Dynamic Analysis of Machine Foundation

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Abstract – *The analysis of Machine Foundation involves not only static loads but also the dynamic loads which are caused due to the working of the machine. Therefore, the machine foundation should survive these loads. Therefore, it becomes vital to reduce the natural frequency of soil beneath the foundation. One such treatment is to prepare a layered soil beneath the foundation by trenching the soil and placing different types of isolation materials.*

Key Words: **Frame foundation, Sinusoidal load, Rubber, Rock basalt, Springs, etc**

1. INTRODUCTION

The dynamic loads that act on the machine foundations may be caused due to various reasons such as vibrations of machines while in running conditions, due to the vehicles moving on top of the foundations, in case of impact machines due to the impact of hammers, nuclear blasts in the vicinity, shock waves etc.

Therefore, as a designer one should be thorough with the ways with which these dynamic loads can be transmitted from machines to the soil beneath the foundation which can either be done by providing an elastic support such as rubber or a spring underneath the foundation in order to reduce the vibrations.

2.0 RECENT STUDIES AND OBJECTIVE

Shamsher Prakash (2006) discusses the method for determining the responses of foundations subjected to vibrating loads. Here the soil-foundation system is assumed as spring mass – dashpot model. Here the block foundation is considered. Mulugeta (2003) aims at incorporating impedance function by using expressions and dimensionless graphs for determining the dynamic stiffness and dashpot coefficients. In the paper by Piyush K (2014) reciprocating machines are installed on a block foundation on the ground surface as well as placed at different depths. Here the values of frequency and amplitude in different modes of vibration are compared.

Karlik (2013) has presented on the sensitivity and reliability analysis of machine foundation depending on the soil stiffness. Silipus (2015) has discussed the analytical and numerical models as how complex have to be in order to model the vertical dynamic response of machine foundation system. S. Patel has studied the foundation supporting rotary type of machines. There two types of rotary machines under consideration in his paper Attar (2016) has presented methods to reduce vibrations by different isolation materials which are placed between the block foundation and the machinery. Nikhil (2016) presents the test sample for a roto dynamic model at various speed. It also discusses the various types of foundation which produces min vibration for a particular type of machine.

2.1 Objective

In design of machine foundation, it is vital to reduce the natural frequency of the soil beneath the foundation, which by doing so the vibrations produced can be easily dealt with.

One such treatment is to prepare a layered soil beneath by trenching the soil and prepare a layered soil by proper combination of different types. In this thesis, an attempt is made to reduce the vibrations transferred from machines to the foundations (frame type) by using layered soil medium underneath the foundation.

3.VIBRATION ISOLATION FOR MACHINE FOUNDATION

Even if the machines are rigidly connected to the floor ,the vibrations created by these machines get transmitted through the floor and to the soil below the foundation which will be large,even at long distances the transmitted vibrations create harmful effects. Also when these machine foundations are provided with elastic material there is a danger of creating resonance condition due to elasticity of the material

3.1 Following steps will help to reduce the vibrations upto a certain extent

(i) **Selection of sites for the foundations** : The machinery and the foundation should be located as far as possible from the foundations of adjacent structures in order to reduce the vibrations felt by the adjacent structures.

(ii) **Dynamic loads should be well balanced**: The machine should be so balanced that even after the dynamic loads are applied it should be nullified without causing any harmful effects.

(iii) **Providing Suitable foundations** :Depending on the type of machine ,the load coming on the foundation ,its operating freequency ,the designer should design the foundation in such a manner so as to reduce the vibrations being transmitted from machine to the soil below the foundation

(iv) **Providing proper isolation**: When machine foundations are unavoidably very close to the adjoining structures, the care should be taken to properly isolate the other structures from machine foundation by proving isolation material such as rubber or wood below the machine foundation.

4. ANALYTICAL STUDY

Frame Foundation

Frame type machine foundations usually consists of structural members such as beams, columns and slabs. The slabs are placed at the top in order to support the machinery. These structural members are constructed either in RCC or composite materials.

Section properties

Column section– 200mmX450mm

Beam section -200mmx300mm

Slab 200mm

Loading

Dead load of machine -2000 kg

Operating frequency – 1500 rpm – 25 cycles/sec

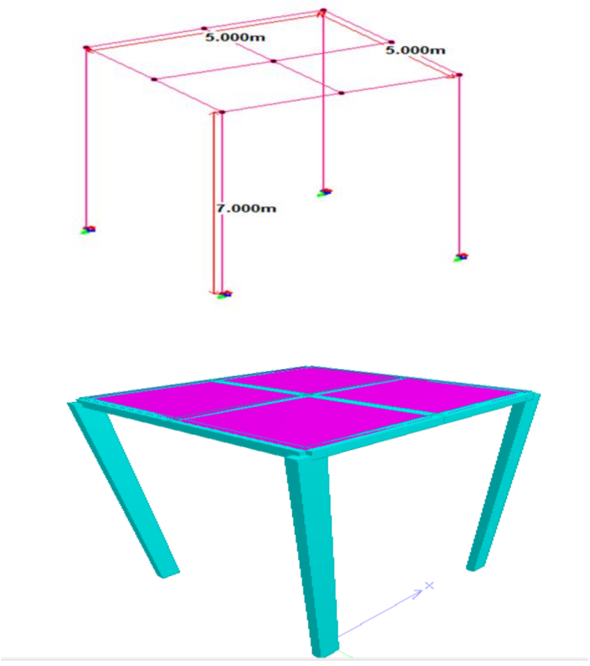

Fig -1: STAAD model

4.1 Determining the natural freequency of the system and plotting frequency response curves

Considering that the columns are infinitely rigid, the slab stifness can be detemined using the slab deflection formula:

$Y_{max} = 0.0454x(q_o \text{ x } a^4) / (Eh^3)$

Here q = Load

a = slab dimensions = 5m

E = Young's modulus of concrete = 40Gpa

h = thickness of the slab = 0.2m

considering Ymax as unity we get load as 11.27 kN/ m, this is also the stiffness of the slab. On comparing the slab stiffness with the stiffness of the spring we can neglect the slab stiffness since it is very small.

$1/K_{eff} = (1/11.27) + (1/15000)$

Therefore $K_{eff} = 11.26$ kN/ m

Frequency $= 1/2\pi\ (\text{sqrt}\ (k/m))$

$= 0.37$ Hz

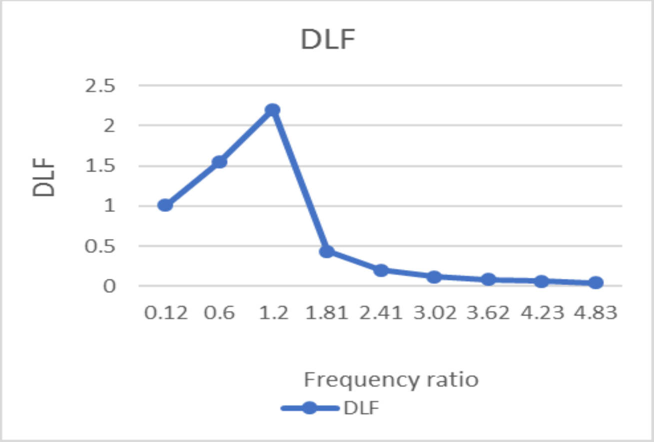

Chart -1: For K = 15000 kN/ m

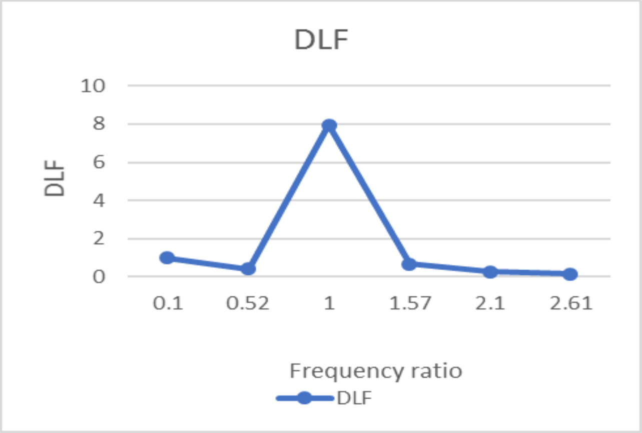

Chart -2: For K = 20000 kN/ m

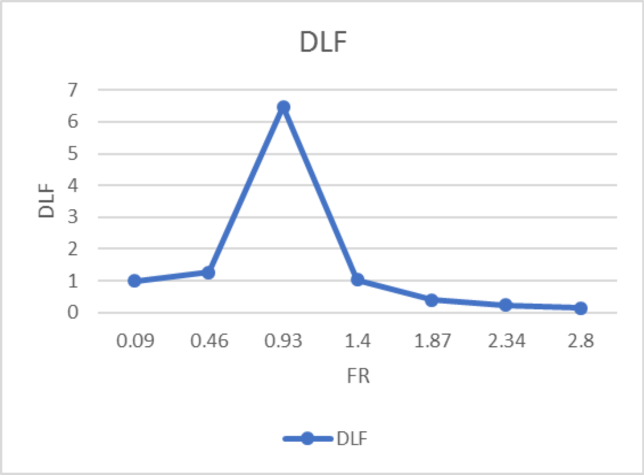

Chart -3: For K = 25000 kN/ m

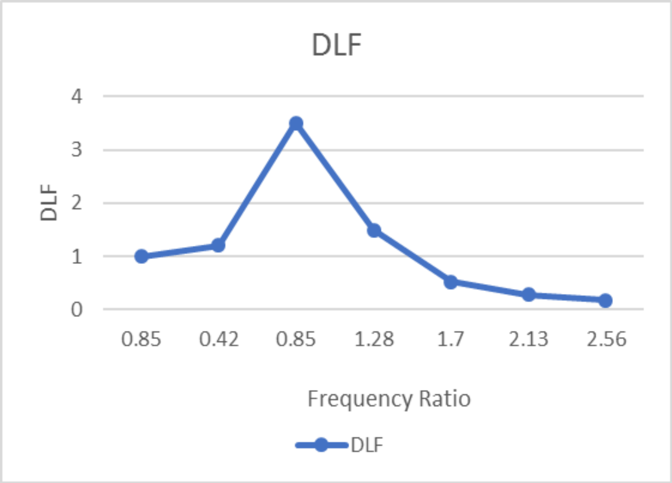

Chart -4: For K = 30000 kN/ m

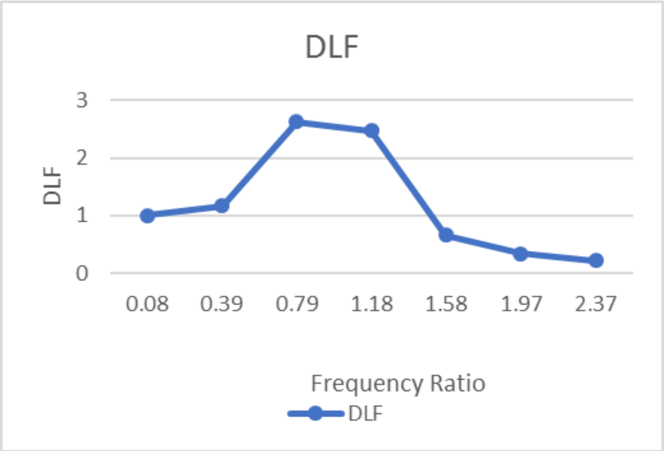

Chart -5: For K = 35000 kN/ m

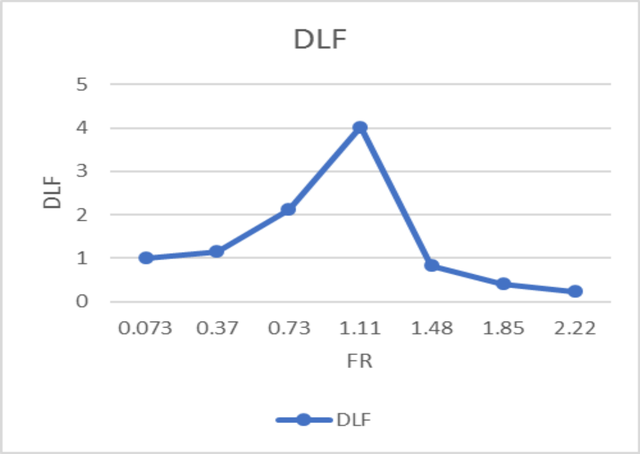

Chart -6: For K = 40000 kN/ m

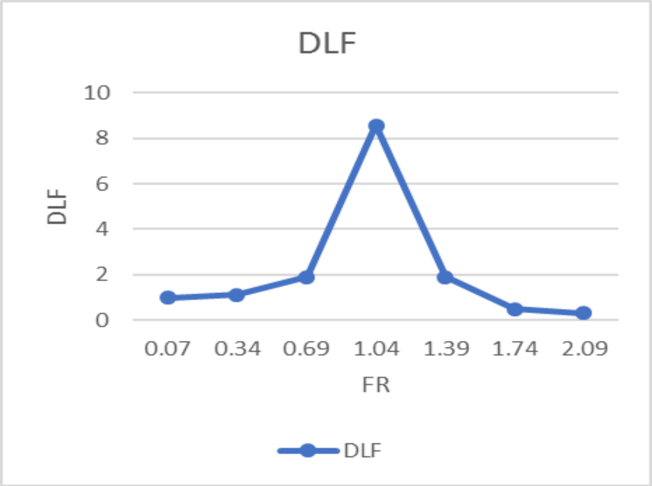

Chart -7: For K = 45000 kN/ m

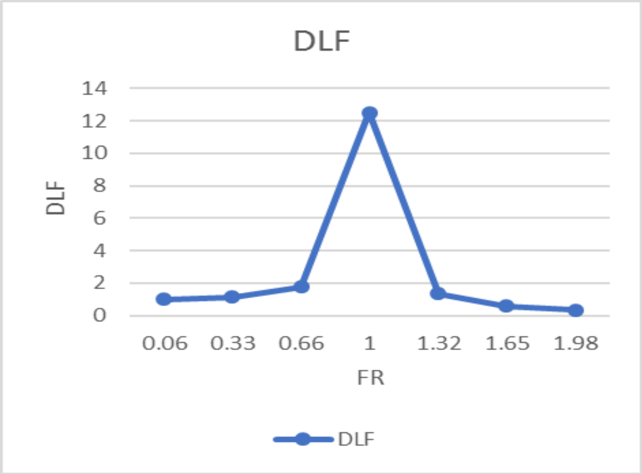

Chart -8: For K = 50000 kN/ m

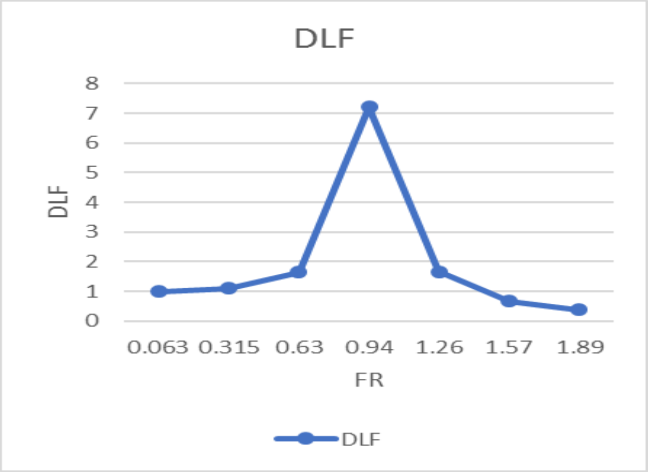

Chart -9: For K = 55000 kN/ m

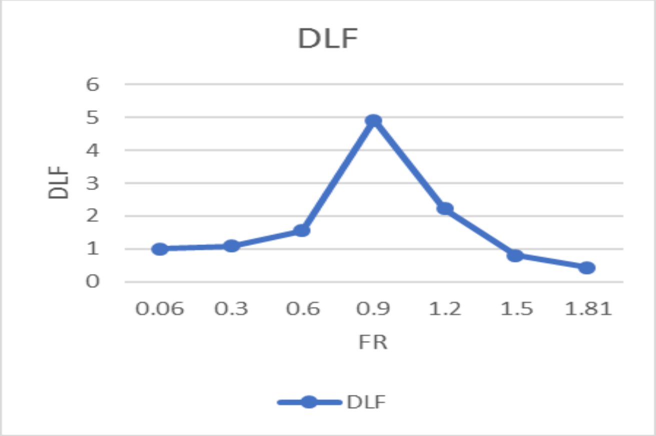

Chart -10: For K = 60000 kN/ m

4.2 Plotting transmissibility curves

It is the ratio of maximum amplitude i.e., the force transmitted to the foundation to the amplitude of applied force is known as transmissibility of the support system.

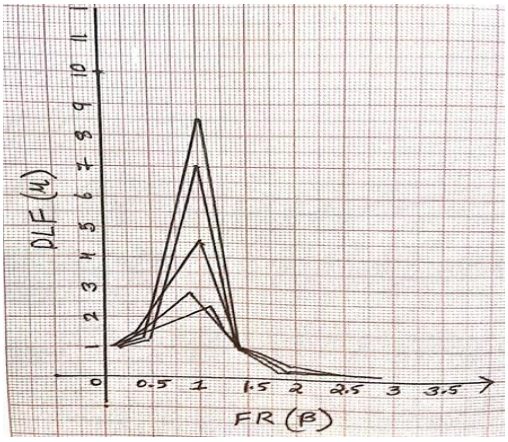

Fig -1: Transmissibility curve

5.1 Machine foundation with spring supports

In this model the frame foundation is supported by a spring support as shown below. Some of the practical examples of machine foundations supported by spring supports

Here an attempt is made to try and reduse the vibration trnsmitted from machine to the soil beneath the foundation by providing spring supports

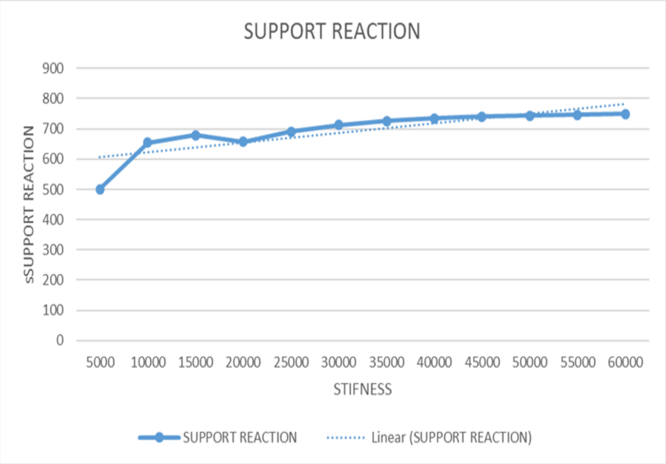

Chart -11: stiffness v/s support reaction

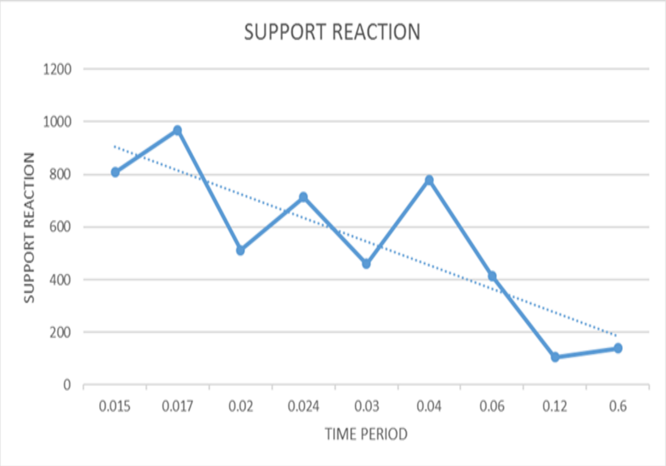

Chart -12: Time period v/s support reaction

STIFNESS (kN/m)	SUPPORT REACTION (KN)
5000	515.5
10000	683.3
15000	676.7
20000	746.2
25000	780
30000	794
35000	799
40000	799.5
45000	798.5
50000	796.5
55000	794.4
60000	792

Table -1: Data for support reaction v/s stiffness

5.2 Machine foundation provided with a hard material (Rock basalt) below the frame foundation

Material properties assigned in stadd model

Young's modulus – 1.96^10^7

Poisson's ratio – 0.15

Frequency – 25 Cycles/sec

In this model the frame foundation is supported by layers of hard material such as rock basalt with the following materrial properties as listed above.

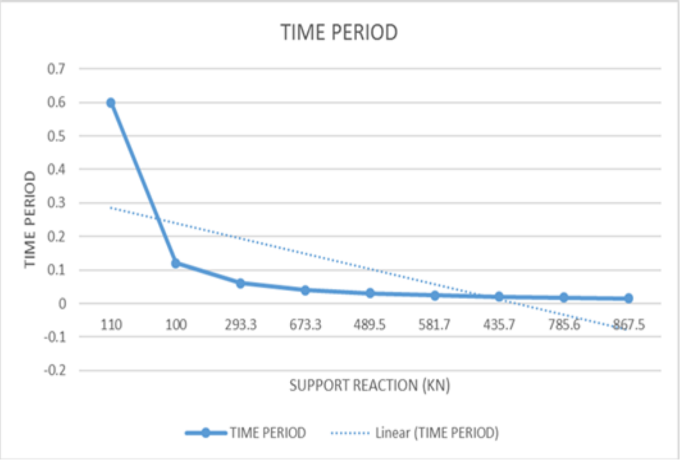

Chart -13: Time period v/s support reaction

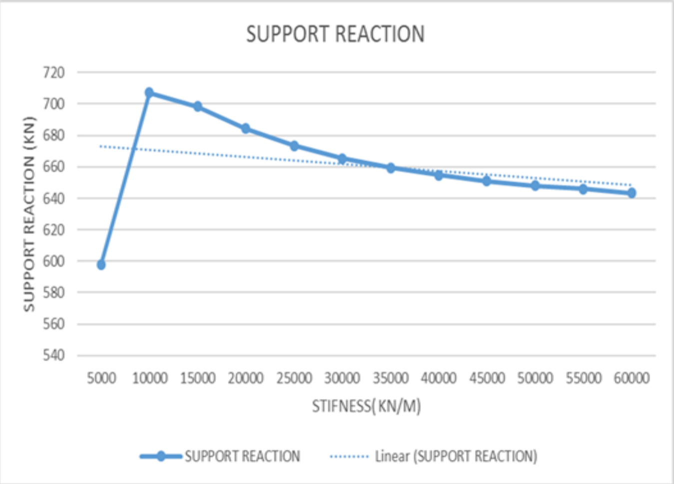

Chart -14: stiffness v/s support reaction

STIFNESS (kN/m)	SUPPORT REACTION (KN)
5000	597.7
10000	707
15000	698.4
20000	684.2
25000	673.4
30000	665.4
35000	659.3
40000	654.7
45000	651
50000	648
55000	646
60000	643.4

Table -2: Data for support reaction v/s stiffness

5.3 Machine foundation provided with a soft material (Rubber) under the foundation

Material properties assigned in stadd model

Young's modulus -50000 kN/m^2

Poisons ratio -0.48

Shear modulus-20000 kN/m^2

Stiffness – 25000 kN/m

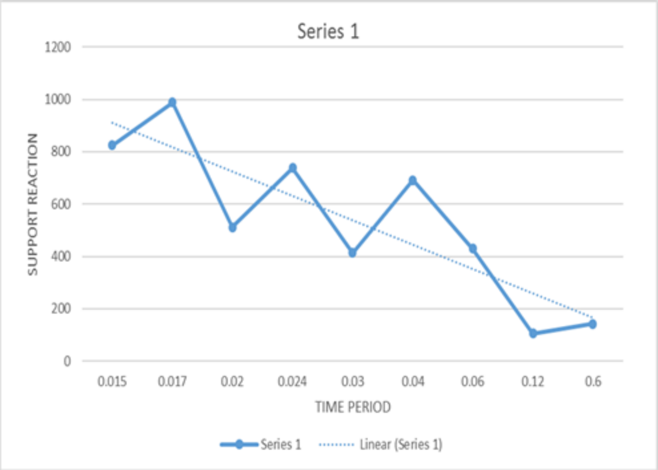

Chart -15: Time period v/s support reaction

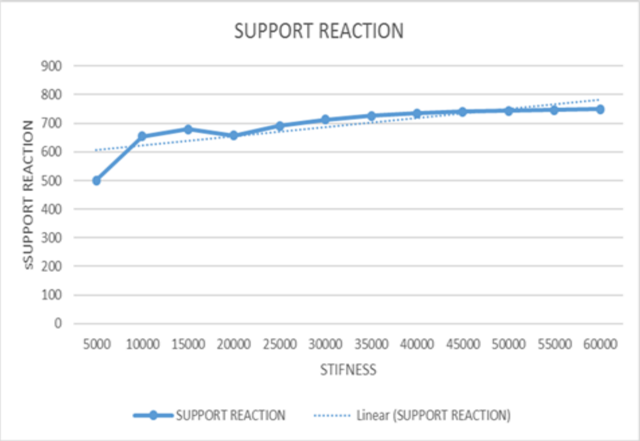

Chart -16: stiffness v/s support reaction

Stiffness (kN/m)	Support reaction (KN)
5000	301.1
10000	654.7
15000	678.5
20000	656.7
25000	691.5
30000	712.3
35000	725.6
40000	734.3
45000	740.2
50000	744.2
55000	747.1
60000	749.1

Table -3: Data for support reaction v/s stiffness

6. FINAL COMPARISON AND CONCLUSION

(1) From the above list of tables, we can conclude that the support reactions are considerably reduced when the Rock-Basalt material is laid as a bed in number of layers below the frame foundation

(2) Support reaction by using rock basalt is reduced by 106 kN when compared to the reactions by using a rubber material and also by 148 kN when springs are used

(3) Therefore, a hard material such as rock prevents the vibrations better from being transmitted from machine to the soil below the foundation when compared with rubber and springs as a isolation material.

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