Analysis of Reciprocating Engine by Varying Speed and Depth

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Abstract-*The dynamic analysis of machine foundation is an important parameter in the design process, as the machine creates unbalance forces while start operation. The basic theory of vibration of foundation, frequency parameter, and forced vibration are discussed. The speed variation and depth variation are discussed. The calculation are carried out by referring previous papers,. The calculations are made by coupled and uncoupled modes of vibration. The results calculated by using five examples with different variations and the graph plotted by using the calculated data the main aim is to know the frequency and amplitude of machine. the conclusion discussed in this paper shows the linear relationships. In relation to found the amplitude of foundation.*

Keywords-Machine foundation; Dynamic loads; Amplitude; Natural frequency; Soil stiffness.

I. INTRODUCTION

Foundations may subjected to static or combine effect of static and dynamic loads; further depend upon soil parameter and effect of foundation on the soil. The foundation design may be considered as a portion in soil dynamics. Soil dynamics analyse behaviour of soil subjected to earthquake and vibration loadings. The effect of soil subjected to earthquake loading is the advanced method of Geotechnical Engineering. There are many origins of generating dynamic forces are such as earthquakes, blasting, pile driving, landing of an aircraft in the nearby vicinity, effect of wind, effect of water etc.. Machines creates various dynamic effect which take the initiative on the soil. Most motion considered in soil dynamics are translational, rotational, pressure on soil, unbalanced forces amplitude of motions, effect of foundation, effect of soil etc. the motion may be periodic, steady and transient including vibrations and oscillations. Impact forces or seismic forces cause shock accounting degree of unexpectedly and severity, inducing a periodic motion in pulse or transient vibration. This causes failure of foundation and resulting damage to the whole structures. Energy imparted by dynamic forces on soil grains, may cause several changes in soil structure, internal friction and adhesion. Shock and vibration create liquefaction. The target of soil dynamics to study behaviour of soil subjected to dynamic loads and develop design procedure for foundation. The field petition of soil dynamics are varied and include:

- Shaking movement and settlement of structures, and foundation of machinery.
- Densification of soil by dynamic effect of vibration and compaction.
- Energy transfer mechanism.
- Effect of embedment of foundation.
- Earthquake effects and design resistant to earthquake of foundations.

It has been noticed that the performance of machine foundation relay on the forces which are acting but also on their behaviour subjected to dynamic loads which relay on the speed of machine and the frequency. Thus the vibration analysis became necessary. In another way it can be specified that every type of machine foundation needs detailed vibration study to know the dynamic property of foundation and its component part for proper function of machine.

The whole knowledge of load transfer process from machine to foundation and as well the knowledge of excitation forces and related frequencies are required for the correct evaluation of machine foundation. It is known fact that cost of foundation is a minute but contributing a lot in the company process cost. To study governing parameters required for design of machine foundation. To study the response of machine foundation under dynamic loads. To study the effect of varying capacity & frequency of machine on design of foundations. To study soil structure interaction.

A brief overview state that from the past few year many researcher contribute their efforts towards the analysis if machine foundation. Gieger carried out investigation to determine the natural frequencies of foundation. Rauch deal with the machine and turbine foundation and contributed special efforts to practical and theoretical development of the science. Silva discussed about the design procedure elevated reinforced concrete foundation problem formulation and optimization techniques. Anyaegbunam suggested the formula was given to predict displacement within the allowable limits one variable type of equations had been developed to obtain mass of the concrete block. A special effort was laid on the vibration problems in machine foundations. Timoshenko & Den Hartog dealt with many vibration problems in engineering practices. D.D. Barkan published his finding on dynamic effects on machine foundation. Bhandari was studied

that dimension of foundation plays important role. The foundation were design with varying depth to study various modes of vibration. Dobry was presented about arbitrary shape of foundation the whole problem with six DOF is converted in to single degree problem with calculation of damping and stiffness. Damping effect on soil was also considered with simple numerical methods. Z.Huang discussed about optimization of size of foundation for heavy machine by the shape parameters and stiffness of machine the reinforcement provided in the foundation and the thickness of the concrete in the machine pit the number of the piles and the spring the between piles and the various combination of loads varying stiffness. M.Bharthi this paper brief about the design of machine foundation using piles. The paper revolves around the soil, piles and machines parameters in relation to actual field condition. George Garetas in this paper brief about the comparison between the ancient methodology to design the machine foundation and the new developed technologies or analytical methods. The response of soil also plays importance part in the design process of foundation.

II. PROBLEM FORMULATION

The design of foundation for a single cylinder horizontal reciprocating engine coupled with motor through gear box. Reciprocating engine mounted over base frame. The design carried out with coupled and uncoupled modes, where vertical and torsional in uncoupled modes, and rocking and translational in couple modes. The mathetical model of force vibration is use to solve the problem.

Formula for calculating dynamic forces = f(t)=me^2 ω sinωt

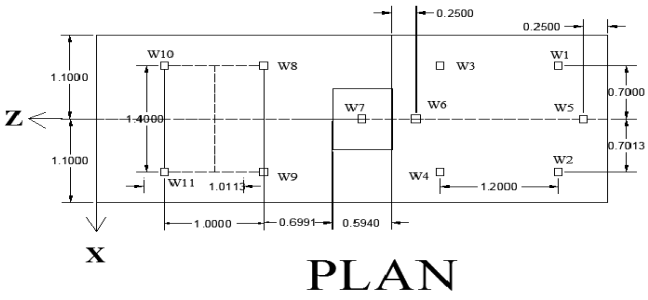
Given Data:

Machine Weight:

compressor	=	220	KN
motor (excluding rotor)	=	100	KN
motor rotor	=	14	KN
Wt of motor bearing pedestal	=	4	KN
Wt of operating Gear	=	8	KN

Machine speed:

operating speed of engine	=	360	rpm
operating speed of motor	=	720	rpm
Ht of rotor centerline above GL	=	2000	mm
Ht of machine centroid below rotor center line	=	100	mm



PLAN

III. RESULT AND DISCUSSION

The calculation of unbalance forces generated by the machine which is transmitted on foundation.

F1x =	10.10 KN
Fy =	1.72 KN
f2x =	2.70 KN
M1x =	13.52 KNm
M2x =	6.64 KNm

The value of Soil stiffness (Equivalent springs) are as follows:

Kx	=	424556.612	Kn/m
Ky	=	849113.2241	Kn/m
Kz	=	424556.612	Kn/m
Kθ	=	3826670.263	Kn/m
Kψ	=	1691858.099	Kn/m
Kφ	=	684951.3341	Kn/m

The value of frequency of machine by considering the soil stiffness by using general dynamics relation of calculating frequency:

ρx =	52.90 rad/s
ρy =	74.81 rad/s
ρz =	52.90 rad/s
ρx =	43.97 rad/s
ρψ =	64.34rad/s
ρφ =	20.10 rad/s

The value of frequency of machine by using the frequency of foundation with the following formula:

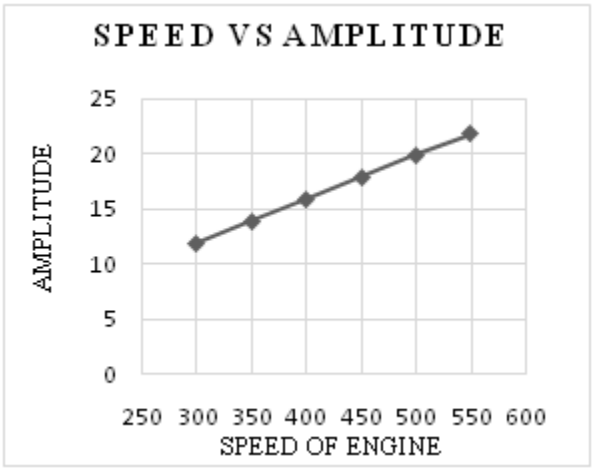
$$p_2^2 = \frac{1}{2\gamma_z}\left(p_x^2 + p_\Phi^2\right) + \frac{1}{2\gamma_z}\sqrt{\left(p_x^2 + p_\Phi^2\right)^2 - 4\gamma_z\, p_x^2\, p_\Phi^2}$$

Natural Frequencies

In X-Y plane	P1 = 19.10 rad/s
	P2 = 105.05 rad/s
In Y-Z plane	P1 = 35.71 rad/s

P2 = 105.13 rad/s

The further calculation for amplitude of foundation at top with 6Hz and 12Hz frequency in relation to unbalance forces. This paper focuses on the amplitude of machine foundation with varying speed of the engine the following table shows the values of amplitude with different speed of engine.



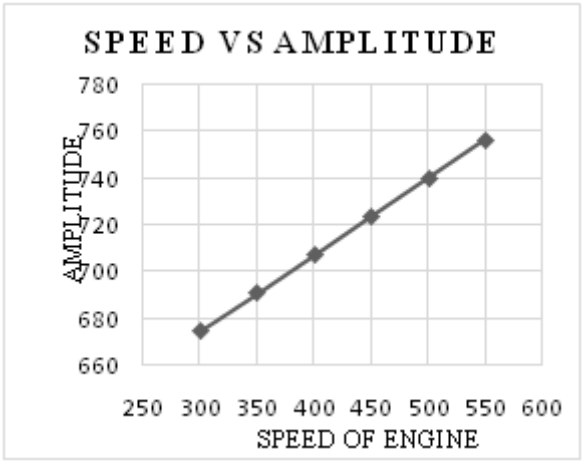
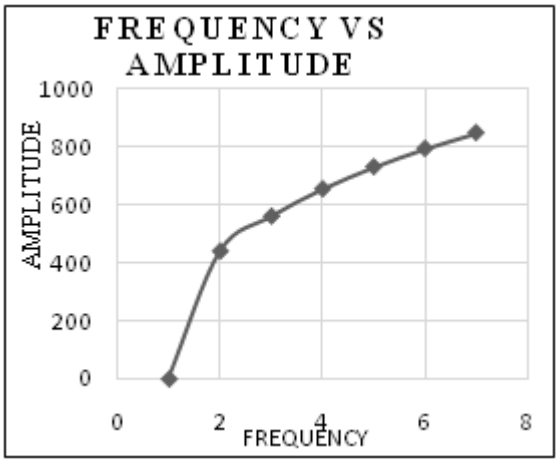


Fig1: comparison of speed of engine and amplitude of foundation for 6Hz and 12Hz.



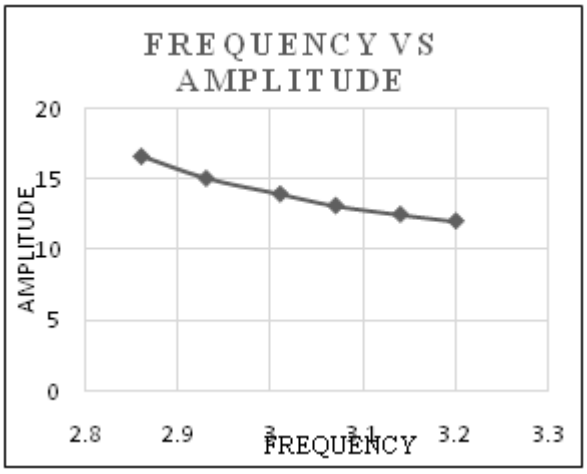


Fig 2: shows the graph of Frequency Vs Amplitude for 6Hz & 12Hz.

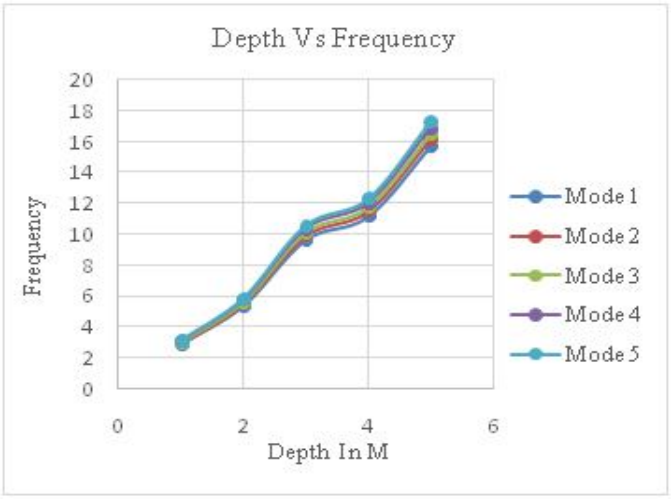


Fig 3: Shows the graph of Depth Vs Frequency.

IV. CONCLUSION

This paper discuss about reciprocating engine with varying speed of engine the conclusion is found from the above discussion is that the design is solved by keeping the

foundation size and foundation frequency constant only the speed and amplitude of machine is varying linearly. So, upto the speed of 550rpm the foundation of same size and same frequency can be used which doesn't show any harmful effects as the value of amplitude is within the permissible limits. Further work is carried out by varying the depth of foundation which shows the variation linearly varying frequency and the amplitude of machine with 6Hz frequency is increasing and the amplitude calculated with 12Hz frequency linearly decreasing.

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