

Dynamic Analysis of Piled Block Foundation Using SAP: 2000 VS. 18

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ABSTRACT: The design of a machine foundation is more complex than that of a foundation which supports only static loads. In machine foundations, the designer must consider, in addition to the static loads, the dynamic forces caused by the working of the machine. These dynamic forces are, in turn, transmitted to the foundation supporting the machine. In the present work, pile is chosen as supporting system for block foundation. The foundation system was simulated in SAP: 2000 VS.18 software and dynamic response of foundation was analyzed. The results are compared and validated with the mode shapes and frequencies published in the book "Foundations for Industrial Machines" published by Dr. KG Bhatia.

KEYWORDS: Rotary machine, Piled block foundation, Soil structure interaction, Dynamic analysis, SAP: 2000 VS. 18.

I. INTRODUCTION

Introduction of piling in the machine foundation system will affect damping, mass and stiffness. In addition, stiffness can be proved as a quantifiable design variable. So that the designer can use one more accurate variable, stiffness. With the use of stiffness foundation becomes less massive. Reinforced concrete piling are quite competent for axial loads and inflexure to take lateral components and are most resistant to the many deleterious elements in the air-soil-water interactive zone.

Bharathi M., Dr. Saran Swami and Dr. Mukerjee Shyamal(2012) described the behavior of reciprocating machines resting on piles. MATLAB programs were developed for different modes of vibration and the machine foundation system was analyzed for different soil, pile and machine parameters. **Dr. Sevelia Jigar K., Patel Utkarsh S., Mangukiya Siddharth H., Miyani Ankit L., Patel Hardik A. and Vora Smit V.(2015)** studied the dynamic behaviour of a foundation structure for blower type machine subjected to forces due to operation of blower machine. **Chun-yu Song, Long-zhu Chen, and Rui-feng Wang** has reviewed the conventional dynamic tests of composite foundation and the velocity or mechanical admittance method for a block on the single-piled composite foundation is then recommended in this paper. **M.Z. Asik and C.V.G. Vallabhan** developed a simplified semi-analytical method, to compute the response of a rigid strip and circular machine foundations.

Dr. Mohammed Y. Fattah and Dr. Mohammed J. Hamood concluded that as the pile cap thickness increases, the oscillation of displacement decreases due to material damping inherent in the concrete of the cap. **Novak (1974)** computed the vertical response of a machine and its foundations. **Bhatia (2008a and b)** found that the suitability of machine foundation depends on the forces to which they will be subjected to, their behaviour when exposed to dynamic loads. **S. K. Guha** reviewed various methods which are in vogue presently for analyzing the vibrations of block type machine foundations are presented. In this paper, optimization of block type machine foundation resting on piles is performed. Main objective of study is to check resonance condition for various parameters of soil and structure. In order to check those conditions, simulation of model is performed in software, SAP 2000 : VS. 18.

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II. A PROBLEM VALIDATION IN SAP 2000 V 18

The rotary machine, which is investigated, consists of driving rotor. It is laid on the RCC block foundation which is supported by nine reinforced concrete piles. Reinforced concrete with the M20. A finite element model of the structure was made in the software for the finite element analysis SAP 2000 V 18 . Weight of the rotary machine is 100.00 t. Machine operating speed is 50Hz.

III. INPUT DATA

- Machine weight = 100 t
- time history analysis input

period	0.06
number of steps per cycle	20
number of cycles	20
amplitude	1

- Rigid Foundation Block

Length	4.0 m
Width	2.0 m
Height	3.75 m
Poisson's ratio μ	0.15
Specific mass density ρ	$2500 \text{ kg/m}^3 = 2.5 \text{ t/m}^3$
Modulus of elasticity	$2 \times 10^7 \text{ kN/m}^2$

- Soil

Poisson's ratio μ	0.33
Specific mass density ρ	$1800 \text{ kg/m}^3 = 1.8 \text{ t/m}^3$
Modulus of elasticity E	89218 kN/m^2
Co-efficient of uniform compression C_u	$4.48 \times 10^4 \text{ kN/m}^3$

- Soil spring stiffness

Translational : $k_x = k_z = 17.97 \times 10^4 \text{ kN/m}$

$k_y = 35.94 \times 10^4 \text{ kN/m}$

Rotational : $k_\theta = 95.5 \times 10^4 \text{ kNm/rad}$ (about X – axis)

$k_\psi = 44.8 \times 10^4 \text{ kNm/rad}$ (about Y – axis)

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$$k_{\phi} = 23.9 \times 10^4 \text{ kNm/rad (about Z - axis)}$$

- Pile

Length	5 m
Number of pile	9
Diameter of pile	0.45 m

IV. MODELLING METHODOLOGY

The block and pile for the Rotary Machine, piled block foundation has been modeled in SAP 2000 VS 18 using solid Elements. Use of solid elements in SAP 2000 gives excellent results for the Free Vibration analysis/ Modal analysis. The entire machine load acts on the centre of gravity (C.G.) of component. The machine is connected to the top of the foundation at the bearing points using rigid links. The soil structure interaction is obtained by modeling soil as spring which is connected to the bottom of the block. The block is supported by 9 piles. Translational and rotational spring stiffness are given to the piles to model surrounding soil.

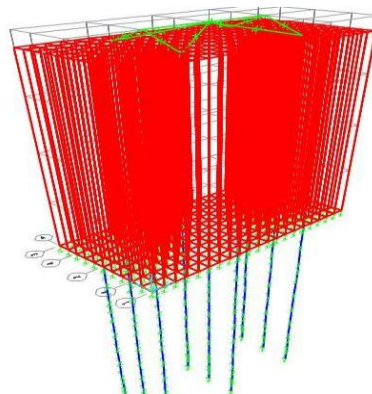


Figure 1 : Piled block foundation model using SAP 2000 v 18

V. RESULTS AND DISCUSSION

The results of displacements of different modes of referenced book are compared with the model developed in SAP2000 software. The percentage difference is quite law.

Mode Number	First Six Natural Frequencies in Hz		
	KG Bhatia	Our research work in SAP 2000 V 15	Percentage difference
1	3.62	3.96	8.58
2	5.62	4.66	17.08
3	9.44	7.88	16.52
4	10.89	10.23	6.06
5	15.39	15.9	3.20
6	15.44	16.71	7.6

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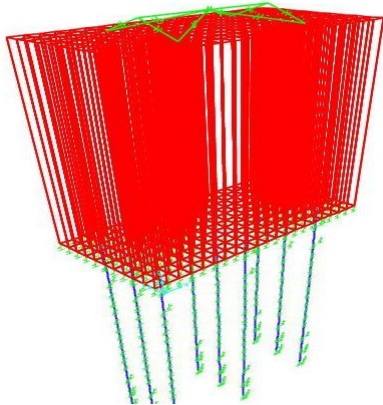


Figure 2: Mode Shape 1 translational vibration along Z direction 3.96 Hz

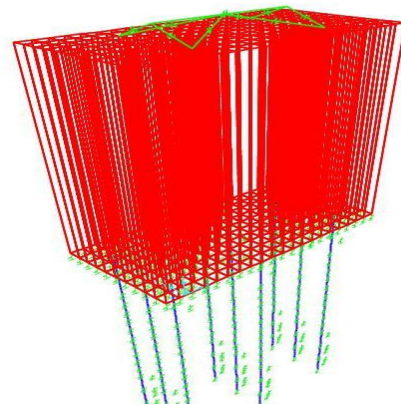


Figure 3: Mode Shape 2 translational vibration along X direction 4.66 Hz

VI. TIME HISTORY ANALYSIS

Time history analysis has been done at all the bearing locations and at the end of the pile tip. Maximum displacement is between 7×10^{-6} m to 9×10^{-6} m and minimum displacement is found to be in between -6×10^{-6} m to -4×10^{-6} m. Here in figure time history plot has been shown, in which time is plotted on X – axis and displacement is plotted on Y – axis.

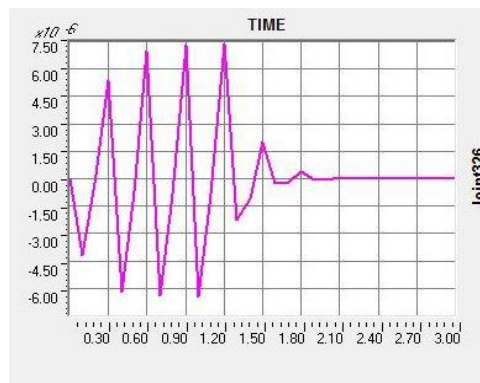


Figure 4 : Time history analysis curve at end of the pile

VII. CONCLUSION

For block foundation resting on soil, piles and soil can be modeled by spring elements, the dynamic behavior can be represented accurately. It is recommended for block foundation to include the whole structure and replace the soil / piles by spring elements. The eigen value increases with each mode. From the results we can conclude that by inserting pile in block foundation, value of displacement can be minimized.

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