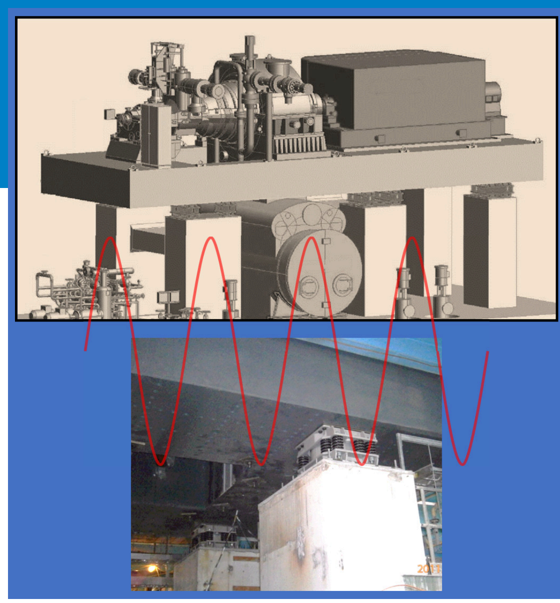
An ACI Technical Publication

SYMPOSIUM VOLUME



Foundations for Dynamic Equipment

SP-348

Editor:
Carl A. Nelson

American Concrete Institute
Always advancing

Foundations for Dynamic Equipment

Sponsored by
ACI Committee 351

The Concrete Convention and Exposition
March 24-28, 2019
Québec City, Québec, Canada

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First printing, March 2021

Discussion is welcomed for all materials published in this issue and will appear ten months from this journal's date if the discussion is received within four months of the paper's print publication. Discussion of material received after specified dates will be considered individually for publication or private response. ACI Standards published in ACI Journals for public comment have discussion due dates printed with the Standard.

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Printed in the United States of America

Editorial production: Gail L. Tatum

ISBN-13: 978-1-64195-135-7

PREFACE

Foundations for Dynamic Equipment

This special publication grew out of the Technical Session entitled "Application of ACI 351-C Report on Dynamic Foundations," held at the ACI Spring 2019 Convention in Québec City, Québec. Following this event, Committee 351 decided to undertake a special publication with contributions from those session participants willing to develop their presentations into full-length papers. Three papers included in the current publication were contributed by these presenters and their coauthors, with six additional papers provided by others. All but one of the papers deal with the subject matter of ACI 351.3—Foundations for Dynamic Equipment—updated in 2018. The one exception (the paper of Wang and Fang on wind turbine foundations) provides valuable information to engineers dealing with a lack of consistent design criteria among various codes for reinforced concrete foundations subjected to high-cycle fatigue loads.

I would like to thank the members of ACI Committee 351 for their support, in particular the current main Committee and Subcommittee C Chairpersons Susan Isble and Dr. Mukti L. Das, respectively. I also wish to express my gratitude to the authors for their perseverance through the difficult circumstances of 2020, and to the reviewers who generously contributed their time and expertise to this publication.

Last, but not least, I want to thank my wife Cindy for tolerating me (and the growing piles of paper) over the past several months as the deadline approached.

Carl A. Nelson
On behalf of ACI Committee 351

Minneapolis, December 2020

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Predicting Near and Far Field Ground Vibration for Equipment Foundations

David L. Pederson, Anthony J. Baxter and Carl A. Nelson

Synopsis: This paper discusses steps for both computing vibration from equipment foundations using the elastic half-space theory and then computing the decrease in vibration amplitude from the foundation to receivers. The steps are demonstrated on an existing foundation at a project site in Ohio that was subjected to dynamic loading from a hydraulic vehicle test rig. Several approaches are discussed to estimate the dynamic shear modulus of different soils, along with a methodology to establish an equivalent dynamic shear modulus for soils with varying shear wave velocities. Vibration transmission through the soil can affect people and sensitive equipment both near and far from the source. This paper shows a hybrid method and an SRSS method to compute the vibration attenuation through the near field and far field. The calculated results for this site were found to be very close to the measured values. Finally, vibration levels are compared for variations in stiffness, damping and attenuation to evaluate the sensitivity to calculations and/or field measurements. Variations in stiffness result in a nearly proportional change in vibration level while variations in damping and attenuation produce relatively small changes in the results.

Keywords: attenuation, damping, dynamic, elastic half-space, equipment, far field, foundations, frequency, material damping, near field, response, shear modulus, shear wave, stiffness, vibration

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INTRODUCTION

Structural engineers are often asked to design large concrete foundations supporting heavy, vibrating equipment like that shown in Figure 1, and then to analyze the effects of this vibration throughout a building and/or a neighborhood. In addition, they are often asked to do it under a tight budget and short timeframe. A calculation template is a good way to accomplish this task with some slight modifications tailored to each individual project. This paper discusses the practical aspects of using the elastic half-space theory to compute the vibration of an existing foundation in Ohio subjected to dynamic loading. Mathcad [1], a popular engineering calculation software package, was used to develop the template.

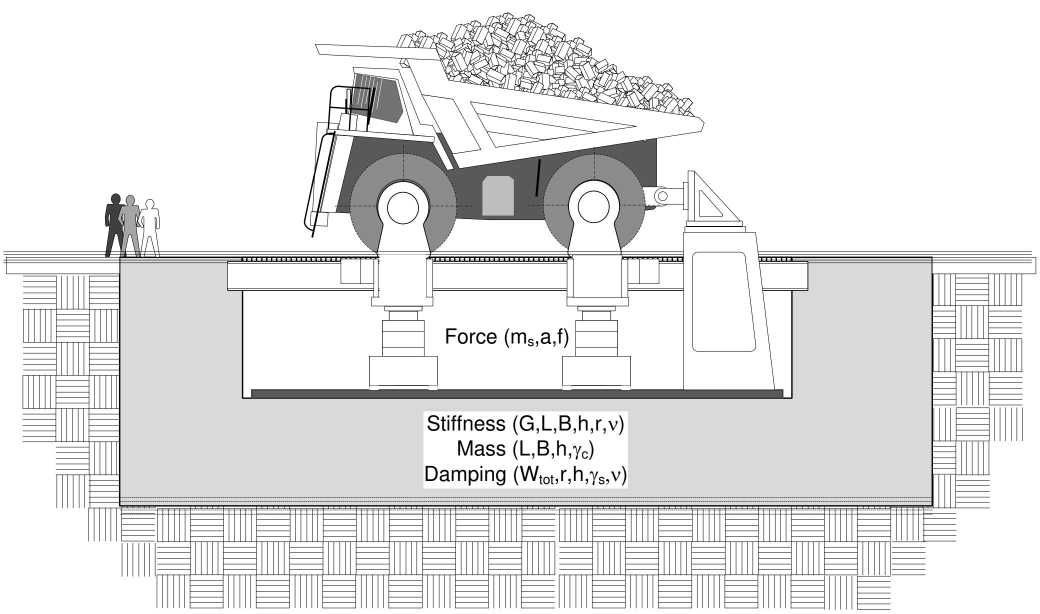

Figure 1–Large rigid concrete equipment foundation supporting a hydraulic test rig for heavy equipment

The dynamic shear modulus is the primary term driving the computations for stiffness of the elastic half-space and is a function of the measured shear wave velocity and soil density. Soils are usually stratified, and the dynamic shear modulus typically increases with depth. Various approaches are discussed to estimate values along with a methodology to establish a single equivalent value for soils with varying shear wave velocities.

Ground or floor vibration at some distance away from the foundation is almost always the main objective of the computation. Excessive vibration can be bothersome to people who are working and living nearby, as well as affect sensitive equipment near the foundation. The energy from a vibrating source disperses in the form of waves that travel