Design of Equipment Foundations (3-day online course)

After participating in this course, you will be able to:
Calculate dynamic loads from various types of machinery
Follow the decision process to select the type of foundation: shallow or pile
Analyze dynamic response of various types of shallow and pile foundations
Understand the dynamic response of tabletop structures for equipment support
Apply the knowledge of analysis and design procedure for equipment foundation design
Evaluate vibration damage and take suitable remedial measures

Description
Design of Equipment Foundations is a composite discipline, involving elements of structural engineering (statics and dynamics), foundation, geotechnical and mechanical engineering. The course considers the type of loads (static and dynamic) induced by the various types of machinery, modes of structural response of the foundation and/or supporting frame, as well as the response and damping provided by the soils. The course covers fundamentals of machine dynamics for derivation of the applied loads, behaviour of different types of rigid block and pile-supported foundations, analysis and design of tabletop structures for equipment support, machine foundations on frozen soils, vibration damage assessment and prevention. Practical examples implementing the introduced principles are included.

The course starts with the basic concepts and practical "rules of thumb" used in preliminary layout and sizing of the foundations but goes significantly beyond, focusing on explanation and demystifying of the basic concepts, relating them to the first principles of engineering. This course will enable you to design equipment foundations using software such as Excel and common finite element packages as well as with custom design software (DYNA 6). This promotes better understanding and control over the results and adaptability of the design for changing design parameters.

This is an advanced course targeting skilled designers who want to learn how to solve practical design problems with full understanding of the nature of the system's behaviour. However, the instruction level advances gradually, making it possible for people with little or no prior knowledge of the subject to get into the stream.

Objective
To provide participants with sound understanding of the concepts, principles, and techniques of design of foundations for different types of equipment.

Who Should Attend
Consulting engineers – civil/structural, and geotechnical – who must analyze and design equipment foundations and therefore wish to acquire in-depth knowledge and practical design skills.

Mechanical, industrial and plant engineers as well as other individuals who deal with equipment foundations but are not directly involved in their analysis and design may find this course useful

in understanding the basic concepts, methods of assessment of equipment installations and remedial techniques.

Program Outline

Faculty: Konstantin Ashkinadze, PhD, P.Eng.

Day I

Introduction to Design of Equipment Foundations
Design objectives, design procedure, degrees of freedom, pure and coupled modes of vibration, free and forced vibrations, resonance. Types of foundations and their uses: rigid block foundations, mat foundations, deep foundations, the significance of damping

Dynamic Soil Properties
Small strain elastic moduli of soil, shear wave, compression wave, methods of soil exploration for dynamic problems, method of dynamic impedance

Design of Shallow Foundations
Theory of isotropic and layered elastic half-space, response of circular footings, shape factors for response of non-circular footings, stiffness and damping functions, frequency dependence, effect of footing embedment

Design Example
Free vibration analysis of a rigid block foundation

Dynamically Loaded Foundations on Frozen Soils
Frost effects, dynamic properties of frozen soil, design considerations, static and dynamic design criteria

Day II

Design of Pile Foundations – Single Piles
Examples of piles applications, effect of vibration on static pile design, stiffness and damping of single piles, pile dynamic response – analytical methods, pile dynamic response using common FE software

Design of Pile Foundations – Pile Groups
Pile-soil-pile interaction, understanding of dynamic group effects, group factors calculation

Design Example
Common pump foundation on piles (illustrates the concept of “good” vs “bad” speed range for rotary machinery)

Dynamic Response of Vibratory Machinery Foundations

Dynamic forces from reciprocating machinery, dynamic forces from rotary machinery, high-tuned and low-tuned foundations, normal and abnormal regimes, basics of rotor dynamics, critical and tripping speeds

Dynamic Response of Impact Machinery Foundations
Types of impact machinery, foundations for impact machinery, design criteria, derivation of impact forces, mathematical models and methods of solution

Vibration Damage and Taking Suitable Remedial Measures
Design criteria, resonance separation, admissible dynamic amplitudes and velocities, stationary and transitional resonance, problem assessment and evaluation, remedial principles and techniques

Day III

Tabletop Structures
Definitions, modes of oscillation, foundation-structure interaction, stiffness and damping, static and dynamic design criteria, method of symbolic dynamic models

Methods of Analysis (based on example) – tabletop-mounted, turbine-driven centrifugal compressor
Hand analysis using MS Excel: generalized dynamic models, equations for free vibrations, equations for forced vibrations, interpretation of results

Methods of Analysis (based on examples) – tabletop-mounted, turbine-driven centrifugal compressor
Demonstration of computer analysis using common FE software

Methods of Analysis (based on examples) – skid-mounted reciprocating compressor
Hand analysis partially automated using common FE software: derivation of stiffness and inertial properties, pile group effects, equations for free vibrations, assessment of damping, equations for forced vibrations, interpretation of results, mitigation of excessive vibration

Methods of Analysis (based on example) – oil pump on pile foundation using DYNA 6
Program overview, data input, output of results, advantages and limitations of the software

Questions and Answers

1.5 CEUs/ 15 PDHs

Daily Schedule: 5 hours of instruction per day.

Faculty:
Konstantin Ashkinadze, PhD, P.Eng., is a Consulting Civil/Structural Engineer from Edmonton, AB. His record of employment includes Colt Engineering (presently Worley

Parsons), Stantec Consulting, CoSyn Technology, Techna-West Engineering, Bantrel Co. and Jacobs Edmonton. He participated in major projects of expansion and construction of oil and gas and petrochemical facilities in Alberta. Konstantin graduated with honours from Moscow State Construction University (Russia), Faculty of Civil and Industrial Construction and completed his doctorate studies in the graduate school of Central Research and Design Institute for Dwellings, Moscow. His PhD thesis was dedicated to strength and seismic resistance of intercrossing (T-sectioned) load-bearing reinforced concrete walls in residential high-rise buildings. He conducts active structural research driven by practical problems in industrial facilities design. Konstantin is the author of more than 35 technical publications and he has participated in numerous global and regional international conferences.