Machine Foundation Design: Dynamic Loading, Soil Impedance and Vibration Checks

19 – 23 July 2027
Amsterdam - Zuidas business district hotel



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Ref: 882_20951 **Date:** 19 – 23 July 2027 **Location:** Amsterdam - Zuidas business district hotel **Fees:** 23500 SAR

Introduction:

Machine foundation design errors show up after start-up as excessive vibration, cracked pedestals, loosened anchor bolts and tripped compressors, because unbalanced forces, soil stiffness and frequency separation were treated as static checks. This Core Concept course trains civil and structural engineers in oil, gas, petrochemical and power plants to derive machine excitation, model soil impedance, analyse block, table-top and pile-supported foundations, verify amplitudes against acceptance criteria and check pipe racks and support structures under machine loading. Participants produce a Compressor Block Foundation Dynamic Design Check for a case plant.

Course Objectives:

- Derive unbalanced forces and moments from rotating and reciprocating machine data and vendor load sheets for foundation analysis
- Idealise a foundation as a single or multi degree of freedom system and calculate natural frequencies, mode shapes and dynamic magnification
- Estimate shear modulus, Poisson ratio and damping of the supporting soil and convert them into frequency-dependent impedance springs and dashpots
- Proportion block, table-top and pile-supported machine foundations to meet frequency separation and vibration amplitude acceptance criteria
- Assess pipe racks, compressor shelters and equipment support structures for resonance under machine excitation and select isolation or stiffening remedies
- Prepare a dynamic design check with a generic finite element model, reinforcement and anchorage details and construction controls for a reciprocating compressor foundation

Target Audience:

- Engineers who size and check concrete foundations for pumps, compressors, fans, turbines and generators in process and power plants
- Design engineers in engineering, procurement and construction teams who turn vendor load data into foundation calculations
- Checking engineers who review machine foundation dynamic analyses before approval for construction
- Plant civil engineers who investigate high vibration, cracking or grout failure on existing equipment foundations
- Geotechnical engineers who supply dynamic soil parameters and pile stiffness data for vibrating equipment

Course Outline:

Day 1: Machine Excitation, Vibration Theory and Foundation Types

- Rotating, Reciprocating and Impact Machine Classification by Operating Speed and Force Pattern
- Vendor Load Sheet Reading: Unbalance Grade, Primary and Secondary Inertia Forces and Gas Couples
- Single Degree of Freedom Oscillator: Natural Frequency, Damping Ratio and Magnification Factor Curve
- Transmissibility, Frequency Ratio and Resonance Zone Mapping for Machine Speed Bands
- Block, Table-Top Frame, Spring-Mounted and Pile-Supported Foundation Selection Matrix

Day 2: Soil Dynamics, Impedance Functions and Design Criteria

- Dynamic Soil Parameters from Cross-Hole, Down-Hole and Resonant Column Test Reports
- Elastic Half-Space Theory and Lumped Parameter Springs and Dashpots for Six Modes
- Embedment, Layered Soil and Water Table Corrections to Foundation Impedance
- ACI PRC-351.3 Approach to Foundation Classification, Load Cases and Vibration Assessment
- Frequency Separation Margins, Velocity and Displacement Amplitude Limits and Human Perception Charts

Day 3: Block and Table-Top Foundation Dynamic Analysis

- Rigid Block Mass Properties, Centre of Gravity Eccentricity and Coupled Rocking-Sliding Modes
- Hand Calculation of Vertical, Horizontal, Rocking and Torsional Frequencies for a Pump Block
- Table-Top Frame Foundation Modelling for Steam and Gas Turbine Generator Trains
- Deck Slab, Column and Base Mat Stiffness Effects on Turbine Pedestal Response
- Forced Response Amplitude Calculation at Bearing Centrelines and Comparison with Limits

Day 4: Piled Foundations, Isolation, Pipe Racks and Problem Cases

- Pile Group Dynamic Stiffness, Interaction Factors and Pile Cap Coupling for Compressor Skids
- Spring and Damper Isolation Systems, Inertia Blocks and Isolation Efficiency Checks
- Pipe Rack and Compressor Shelter Resonance Under Piping Pulsation and Machine Excitation
- Generic Finite Element Model Build: Soil Springs, Rigid Links, Mass Lumping and Harmonic Analysis
- Troubleshooting Cases: Grout Failure, Anchor Bolt Loosening, Cracked Pedestals and Retrofit by Mass or Stiffness Change

Day 5: Case Plant Reciprocating Compressor Block Foundation Check

- Case Plant Data Pack: Compressor Frame Loads, Geotechnical Report and Plot Plan Constraints
- Soil Impedance and Block Frequency Worksheet for the Case Compressor
- Amplitude, Bearing Pressure and Eccentricity Verification Against Acceptance Criteria
- Reinforcement, Anchor Bolt, Grout and Construction Joint Detail Sketches for the Block
- Compressor Block Foundation Dynamic Design Check Presentation and Checking Panel Review

Skills You Will Gain:

- Machine Load Interpretation
- Structural Vibration Modelling
- Dynamic Soil Characterisation
- Foundation Impedance Calculation
- Frequency Separation Assessment
- Vibration Isolation Design
- Harmonic Response Analysis
- Equipment Foundation Troubleshooting

Why Attend This Course:

- Leave with a Compressor Block Foundation Dynamic Design Check built from a case plant data pack
- Question vendor load sheets and geotechnical reports with the specific dynamic parameters a foundation analysis needs
- Diagnose why an operating foundation vibrates and choose between mass, stiffness, isolation or piling remedies
- Compare machine foundation practice with engineers from refineries, gas processing, petrochemical and power generation plants

Conclusion:

Vibrating equipment runs reliably when its foundation is designed as a dynamic system rather than a static support. The one week move from machine excitation and vibration theory, through dynamic soil properties, impedance functions and acceptance criteria, to block and table-top foundation analysis, pile-supported foundations, isolation, pipe rack resonance, finite element modelling and problem cases. The final day applies these methods to a reciprocating compressor and produces a Compressor Block Foundation Dynamic Design Check ready for checking on the next plant project.