

Machine Foundation Design

As the structural engineer who recently designed the machine foundation for one of the largest vertical turning and milling centers in the country, in addition to over 250 other machine foundations worldwide, Bill Waldorf is an expert in his field. Mr. Waldorf, both a licensed structural engineer and architect, serves as the CEO of Larson & Darby Group—a full-service architectural and engineering firm based in Rockford, Illinois, located 60 miles northwest of O’Hare Airport.

In the following blog, Bill shares valuable information for an owner to consider when selecting an engineer to design a machine foundation, as well as offers detailed information on the foundation design process itself:

“When an owner selects a specific machine to meet the milling needs of their company, it is paramount to construct a foundation that properly supports the machine. Without a properly designed and built foundation, the machine will not function properly. Machine tool suppliers request the foundation to maintain deflections measured in microns, and with the cost of some foundations exceeding a million dollars, the design process needs to be carefully and precisely worked out. Utility layouts, trenches, pits, safety railings and numerous other items need to be planned for a complete foundation package. Larson & Darby Group has worked with industrial clients and machine tool suppliers worldwide for 30 years, designing foundations for large milling machines. Over that time span, we have developed a checklist to ensure the foundation design meets the needs of the owner and also meets the requirements of the machine tool supplier. The following is a partial checklist of items for the owner, machine tool supplier and foundation designer to consider:”

I. OWNER REQUIREMENTS

A. Assign a specific contact person who can answer questions dealing with the owner’s requirements and a specific contact for the machine tool supplier to answer engineering foundation design questions.

B. Approved layout within the facility, including these items:

Machine location

- Pits for tanks
- SU changer

- Tool changer
- Transformer cabinet
- AC control cabinet
- DC control cabinet
- NC cabinet
- Troughs

C. Factory standards

- Piping standards
- Electrical standards
- Floor plate standards
- Type
- Load capacity
- Chip/coolant systems
- Pit locations
- Trough locations

D. Design information, including these items:

Codes required

Geotechnical considerations

Seismic design considerations

Vibration design considerations

Plant engineering drawings showing site conditions

- Underground piping
- Compressed air
- Water supply for chip/coolant system
- Electrical supply
- Building column and foundation layout
- Existing foundations within area

Environmental standards for pits, troughs, and piping

Finish standards for surfaces

- Paint specifications (concrete surfaces, floor plate, guarding, and misc. metals)

Approval of the concrete and steel design standards

- Concrete - ACI 301

- Steel - AISC 1989 edition

- Welding - ASW D1.1-92

Adjacent floor surface match requirements

- Concrete to concrete

- Concrete to floor block

Plant grounding scheme

Safety standards

E. Architectural registration requirements

F. Design approval process between machine tool supplier and owner

G. Documentation requirements:

- Paper size

- Title block format

- Drawing number system

- Approval drawings, type and quantity

- Final drawings

II. GEOTECHNICAL (supplied by owner)

A. Recommendations:

Foundation designer will recommend the number, location and depth of the soil borings necessary to complete the design process.

B. Geotechnical investigation information

- Detailed description of the soil profile

- Foreign materials within the soil

- Condition of the excavated material

- Recommendations during excavation

- Backfill and compaction requirements

- Ground water elevations

- Estimated settlement

- Allowable bearing pressure

- Modules of elasticity "E"
- Modules of sub-grade reaction "K"
- Values for "E" & "K" for depths 10', 15' & 20'
- If rock is encountered: profile of stratum and bearing capacity of rock

III. FOUNDATION DESIGN

- A. Approval of all information from the owner to machine supplier
- B. Machine tool supplier/owner recommendation of the maximum work piece weight expected to be loaded on the machine
- C. Deflection criteria for all components
- D. Individual component weights for both static and dynamic conditions
- E. Monument locations to identify centerlines
- F. Foundation drawings for machine tool supplier (machine, accessories and chip/coolant system)
 - Cell layout plan with all items located and measurements shown
 - Machine plan (machine accessories located with dimensions)
 - Machine front and side views (minimum clearances noted)
 - Foundation plan
 - Anchor locations, machine and accessories
 - Trough locations and pitch
 - Concrete elevation and dimensions
 - Piping and conduit size and location
 - Grounding specification and location
 - Foundation sections
 - Anchor detail
 - Foundation sections
 - Floor slopes

- Machine/accessories/foundation relationship

-Foundation load diagram

- All component weights
- Deflection criteria (static, dynamic, deflection by areas)
- Seismic criteria
- Vibration criteria
- Cutting forces
- Special conditions (torsional, bending and combination requirements)

G. Guard and shielding drawings

- Guards and shields elevations

- Chip deflectors
- Hinged gratings
- Fencing & railings

- Guards and shields plans

- Special conditions
- Safety switch requirements

H. Utility requirements of machine, accessories and chip/coolant system

- Main disconnect size in amps

- Type of metal being machined

- Chip load

- Coolant specifications

- Coolant GPM required - machine and flushing

- Coolant pressure required - machine and flushing

- Water specifications

- Compressed air specifications

- scfm
- dew point
- pressure

-Piping, conduit and fitting specifications.

I. Team listing of all machine tool supplier personnel for each discipline

IV. CONSTRUCTION REQUIREMENTS

- A. Foundation impact on existing structure
 - Under pin, lower or move existing column footings
 - Shore excavation

- B. Crane loads during construction or when machine is in use

- C. Environmental
 - Dust barriers
 - Exhaust flumes

- D. Soil removal
 - Is it contaminated?
 - Soil stockpiled on site or removed
 - Can soil be reused for fill?

- E. Site access
 - Truck routes in and outside of plant
 - Workers access and security clearance
 - Lay down area and construction trailers
 - Wash-out area for concrete trucks

- F. Procedure for pouring concrete
 - Back-up procedure for concrete plant, pumpers, delivery
 - Proper mix design and delivery method
 - Hot or cold weather considerations for mass concrete
 - Proper curing procedures
 - Form work standards

The above outline is an excellent starting point for items to be discussed in the beginning stages of the foundation design for a milling machine. With this information, the foundation designer will be able to produce a set of drawings and specifications that a contractor can use to accurately bid and build the base. With the proper information from all parties, the owner will have a foundation that is

correctly constructed to precise measures, and thus have the right foundation on which to place the new milling machine.

For more information on machine foundations from a leader in this unique industry, please contact William J. Waldorf, SE, Chief Executive Officer of Larson & Darby Group at 815-484-0739 or via email at bwaldorf@larsondarby.com.