MICROPILES FOR MACHINING CENTERS

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ABSTRACT:

Today's Manufacturing is surrounded by a quick pace of production and precision machining that can take as little interruption as possible. Having to stop production of an entire facility to install the foundation of one machining center is a huge financial "HIT" for any manufacturer that leaves production at a standstill.

The larger machining centers can weigh over 20 tons or more and require an independent foundation from the rest of the factory. In the past this was accomplished by cutting out the factory floor, digging down to set compacted gravel for the base of a new foundation, let this settle for ??? Weeks then set forms just to pour the concrete for an independent foundation. This is a very lengthy process that takes precious time away from production.

This is one of the great advantages of MICROPILES! where you have minimal impact on your production but also create a lasting, competent foundation for your machinery.

Project Description:

We have four examples that we will show from our factory where micropiles were used as a foundation in the manufacturing. In each case we will show that we built a very competent foundation, meeting machine manufacturer's requirements and our production was still operating throughout the installation process.

Installation had to be accomplished with smaller limited access equipment, able to fit through very tight areas and perform the work required to install the micropiles.

Our Four Foundations;

- MA-500H   Horizontal Machining Center

  23,000kg setting on three points
- MillAC-761VII Vertical Machining Center

  20,500kg sets on six points
- Multus B400 Multi spindle 5 axis Machining Center

  23,000kg setting on ten points
- Hexagon Global CMM Computerized Measuring Machine

  3000kg sets on five points, needs complete isolation from the vibrations of all other equipment.

Photo#1 HCM Hydraulic Percussion Drill **Photo#2** Electric Powered Track Drill

Soil Conditions:

The general surface soil conditions for Montrose are adobe clay: an expansive soil that must be passed through in order to find a good bonding zone. Below the clay layer are eluvial soils mixed with cobble and gravel. The cobbles can vary in size, from fist-sized, to boulders as large as a car. The shale layer, at an average of 6m depth, is used as a load-bearing stratum for the piles needing a higher capacity. It is necessary to reach these deeper zones to install stable micropiles capable of supporting machining centers.

Photo#3 Cobbles at the surface **Photo#4** Shows fill below concrete pad

Tooling Used for Micropiles:

Different load sizes are required for the various sizes of machines used in manufacturing. Exclusively using the hollow bar injection method means we are able to design each set of piles specific to each individual machine and allows us to keep our factory operational during the installation process.

The 40/16 mm bar is the perfect fit for the design piles of 100 kips, as it can support the equipment used in the manufacturing area and has good load characteristics for the pile design. For lighter designs, the same equipment can be used, but with T 40/20 and B7X-38.

A carbide cross-cut style bit efficiently cuts through the cobble and gravel layer. This style of bit is also capable of driving a rock socket into the shale layer to create a load bearing base for the deeper piles.

MA-500H Horizontal Mill:

This Okuma Machining center was to be placed on three micropiles, with the design working capacity of 100 kips each, the 40/16 IBO bar with a 125mm bit fits these parameters perfectly. The soil was mostly a gravel fill from the initial construction of the building, this went for 2m from there we encountered expanding adobe clays and mixed cobbles, common to our region, to 9-11m. The finish length was drilled through competent shale. All three piles reached a depth of 12m. Below we can see some of the finish grout being contained with silica sand boundary.

PHOTO#5 Finish Grout around 40mm pile

PHOTO#6 Installation inside working area

The installation process was carried out in a single day with manufacturing still in operation. Using the IBO system and smaller equipment the crew was able to keep a clean work area and create minimal disruption.

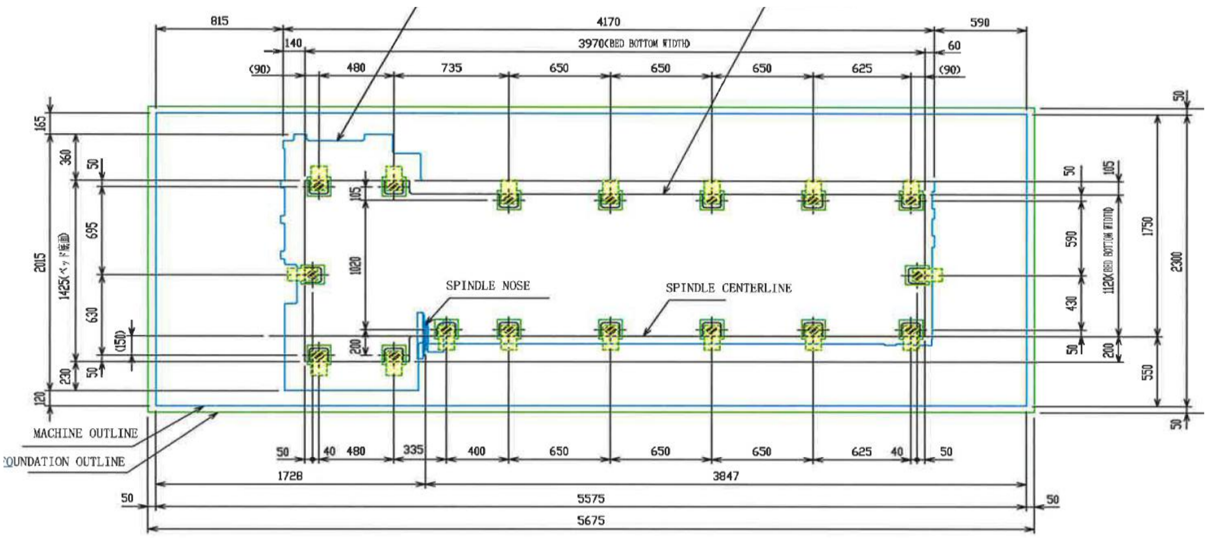
Specific gravity of the finish grout was measured using a mud balance, measuring the grout at the grout plant and at the top of the pile itself. This was allowed to cure for 7 days before testing, when one pile was pull tested to 110 percent of its maximum capacity. After testing the piles were caped with a 250mm X 16mm thick plate to set the feet of the milling machine.

PHOTO#7 Piles showing the caps after testing.

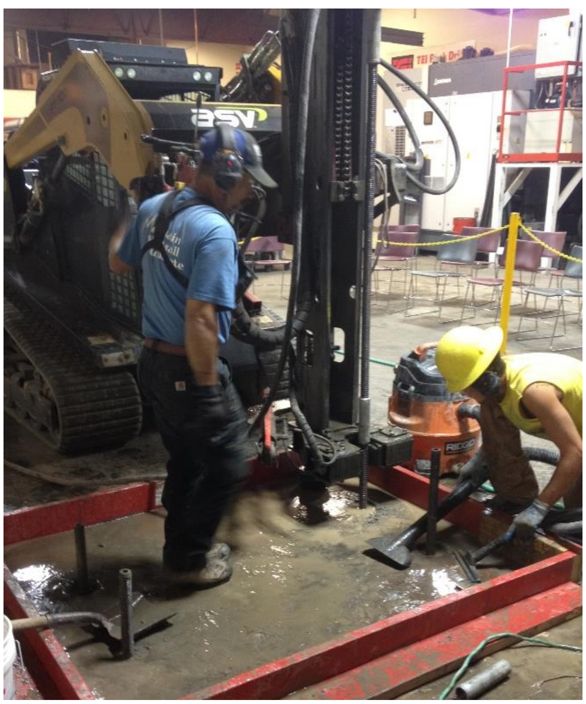
Multus B400, Five axis Machining Center:

The foundation required 10 micropiles laid out over a 4m X 1.2m span, there are 17 mounting pads for this machine but in working with the machine manufacturers engineering we were able to carry the 50 kip load design for each micropile over 10 points. The challenge was to create a stable base so that the shifting weight and torque of the spindles would not twist the machine. The pile design was not complex but the micropiles and foundation could not have any association with the existing concrete pad. This area of the shop had very loose fill and the existing pad was not very thick, with the shifting weights and large footprint of the machine we could not rely on any existing structure.

The design used 38mm IBO bar with a 76mm bit, these were drilled until they met a certain resistance (penetration rate) with the equipment being used. With this said these were drilled to a depth between 6-12m and used varying amounts of grout because of the loose fill under the concrete pad.



PHOTO#8 Layout of Machine feet covering a 4m X 2m area



PHOTO#9 Pile installation with framed barrier

PHOTO#10 Hollow bar for Installation

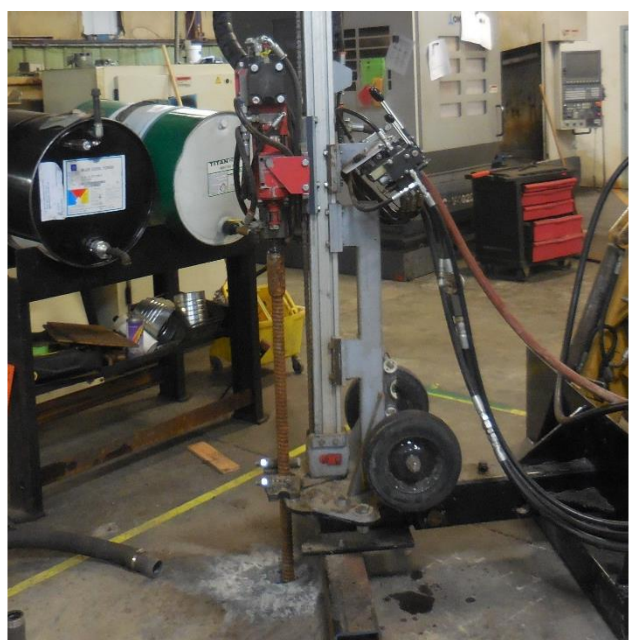
Millac-761 VII Vertical machining Center:

The MillAC is a large vertical machining center that also has rapid positioning of a large worktable. Without the proper foundation the machine can vibrate and move along the floor affecting the accuracy of the machine. The manufacturer's plans ask for pins to be epoxy set to hold the machine in place and require a concrete pad thickness of 450mm. This could take months so here we are with micropiles incorporating a lateral load with our foundation.

The foundation is designed for 6 piles to handle the 20 tons of machine and the moment of the moving parts. Material used was 38mm hollow bar with an 89mm carbide cross bit, this needed only to create a pile holding 50 kips, the larger bit was used to help with the lateral load created by the quick accelerating table.
When we started drilling you could see that our soil conditions had changed, we were in an area that had been filled with gravel and cobbles. This allowed the thin grout to drain off and gave us no returns while drilling, so we needed to find a new plan to finish our foundation.

PHOTO#11 Special collector used to collect cuttings while coring the concrete.

PHOTO#12 16-76mm cobles



PHOTO#13 Cleaned hole flushing with air

The process we turned to was:

- Core the concrete for a uniform hole and so we would know the thickness of the pad to determine if we would need a short piece of casing for our lateral load. This was finished for all six holes before moving on to the next step.
- Drill the holes using air for our flushing, this allowed us to reach our depth (3m-6m) and not plug the rod or wash out the gravel around our pile.
- Run our finish grout using the drill rotation to mix the grout and cobles around the pile.

PHOTO#14 Finished micropiles for Vertical mill with proud workers, finished in one day.

Hexagon Global CMM inspection machine;

This machine was the greatest challenge that we have had in our factory, not because of the weight but of the precision needed and its susceptibility to vibration. This foundation needed to not only be independent of the existing pad but had to be completely isolated from any vibration around it. With a full machine shop operating daily and the other equipment being used to move material to and from the machines this is where the challenge was.

I could not find a reference for this design, so we did some testing for the vibrations created from the machining centers and from the passing forklifts loaded with material. We found the forklift gave us the highest readings and we would need to base our final results from this action.
We found that a depth of 1.5m was sufficient to isolate the vibration from the forklift, by using Quick tubes of 215mm to this depth it would give us the results needed from our foundation. We took the 40mm IBO bar 3m further in depth as a bond area to carry the load of the CMM machine.
To get away from the existing pad we cut out the concrete so there would be no chance of contact or transfer of any vibration. The holes were then drilled for the Quick tubes to be installed to depth, these were auger drilled and set in place one at a time.

PHOTO#15 Cut out of concrete pad

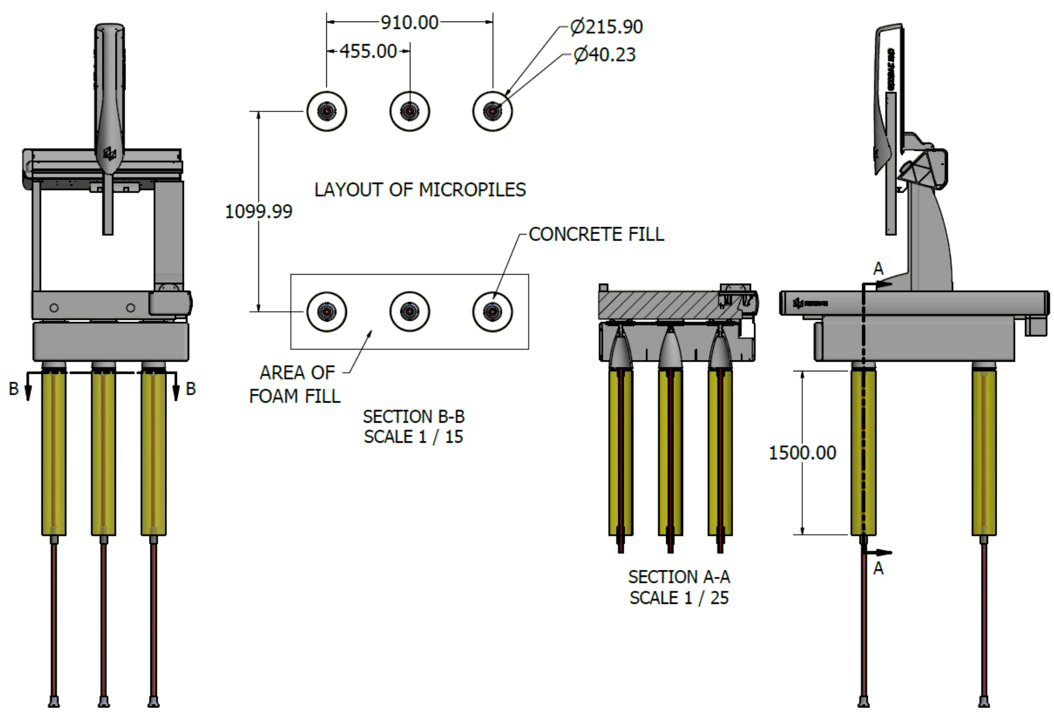
PHOTO#16 Quick tubs installed

The fill remained loose around the Quick tubes but we felt this would help to isolate the vibrations from the machinery and this is also a no bond area so this will not affect the load capabilities of the micropiles. The outer top of the tubes were encased with foam to help keep them in line but also to help with the isolation from the existing pad.
Next the hollow bars (IBO) were installed, remember we were rotary drilling before so now we needed to switch over to a top hammer percussion drill. These were installed to a 4-6m depth, after reaching our depth we used the finish grout to fill the Quick tubes. To centralize the bars we built a special fixture to keep the bars in line with the tubes and in place for the feet of the CMM.

PHOTO#17 Foam cover for piles

PHOTO#18 Fixture used for pile alignment.

The design for this foundation came from internal discussions and using our experience with micropiles, we were certainly not blessed from the manufacturer of the CMM machine. They were anything but happy when they received our design but would take their measurements when commissioning the machine.



PHOTO#19 Layout of foundation for CMM machine using casing isolation.

References;

- Cadden, Gomez, Bruce, Armour (2004) “Micropiles: Recent Advances and Future Trends”
- FHWA (2005), Micropile Design and Construction Guidelines
- HBNS Lateral test Schnabal (2012)

Conclusions:

In all four cases presented in this paper we achieved the desired results for our machine foundations. The micropiles performed as designed to carry the different loads and characteristics for each machine and were installed with little impact on the manufacturing process of the factory.

We have seen little to no movement at all in the machines setting on micropiles, the foundations have proved to be superior to the older standard of foundations and helped the life and accuracy of our automated CNC machinery.

Points:

- Building the piles with smaller equipment to work inside the factory
- Installing the piles during manufacturing operations.
- Creating a foundation independent of the existing slab floor.
- Cutting install time, time on the job
- Building a better more stable foundation.

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