BUILDING A SOLID FOUNDATION FOR YOUR MILL

The grinding mill is at the heart of a mining operation, but a poorly designed or constructed foundation will not only affect grinding mill performance but potentially render the mill out of action – thereby costing millions of dollars in lost production.

The following advice will help ensure the foundation is right before you install a new mill.

Foundation load specification
It is the responsibility of the mill supplier to specify the mill related loads. These loads are then used by the engineer responsible for designing the mill foundation. Mill loading diagrams are inherently complicated but most reputable mill suppliers will ensure the diagrams are comprehensive enough to include all necessary information but are still as unambiguous and straightforward as possible. For example, some mill suppliers do not state the dynamic loads generated by an operating mill, ie drive train and charge related load variations. Such a document may be far simpler to comprehend, however will cause problems when it comes to correctly designing the foundation. Consideration of static x, y, z loads is not enough; capacity to accept the dynamic loads while achieving acceptable vibration levels must also be designed into any mill foundation.

Designing the foundations
A reputable mill supplier will also provide a diagrammatic foundation layout, which can be used alongside the loading diagram and gives the foundation engineer a truly comprehensive picture. This layout diagram should not be mistaken for a fully designed solution; there have been cases where this layout was copied and used, as provided, for the installed foundation arrangement. The supplied diagram can help ensure the foundations suit the mill and do not clash with rotating parts – but there is more work to be done by the foundation engineer...

Some factors the engineer should consider include:

1. Mill supplier data
Loadings and directions of loadings are easy to misinterpret, especially in dual pinion mills where one pinion experiences a downward load and the other experiences uplift. Such loadings must be carefully noted, along with critical items such as boundary constraints, displacement and vibration limits.

2. Local conditions
Small inaccuracies in strata data can dramatically compromise mill performance, so ensure the data is right. It is also important to perform sensitivity analyses and design-out any potential conflicts. In general, local concrete design standards should be applied, particularly in relation to seismic requirements, and consideration should be given to the quality of the materials being used. The capacity of the concrete needs to be carefully considered as not all concrete and reinforcing bars are the same quality!
3. Outside influences
Vibrations from other equipment, and adjacent mills in particular, can accumulate to detrimental effect. Adjacent mills of the same size and speed are particularly prone to generating vibration issues for each other. Installing adjacent mills on separate slabs is not always enough to avert problems. Other structures directly connected to the mill must also be considered and should be included in the mill model. Natural frequencies must also be considered and alignment of the foundation’s natural frequency with the dominant frequencies of the mill operation must be studied and avoided.

The construction phase should be planned so that installation and ongoing maintenance access is considered, and the service line access (ie power, instrumentation and lubrication) is appropriately placed. If service line block outs are omitted or unsuitably placed, it can necessitate expensive core drilling or compromise installation runs.

Constructing the foundations
The mill foundation is often the largest monolithic concrete structure on a mine site - and it is also the element most likely to bring a concrete contractor unstuck. Following are some key tips to help reduce foundation construction risk, but there are many areas in which concrete construction can go wrong, so choosing a quality contractor is crucial.

The contractor must appoint an experienced team and work with a licensed surveyor. It is also advisable that a plant manager employs a civil construction manager, independent of the contractor, to oversee the work. Without scrutiny, issues can be literally covered over.

1. Pre-pour
Ensuring correctness of cast-ins is a given, as poorly arranged cast-ins can cause problems such as base plate instability. As a result of a poor cast-in box design, the washers for the hold down bolts in the photo above were located partly on a steel open section and partly on a steel plate - some 8mm difference in elevation. This error resulted in a hold down bolt that could never be kept tight and led to pinion bearing base plate instability.

Incorrect foundation bolt installation with uneven washer support

Just as important is the proper location of the cast-ins within the reinforcing so as to ensure they do not move during the concrete pour. Core drilling is sometimes needed to correct misalignment, so it’s worth getting this right! It is also important to avoid any air pockets under or around the cast-ins during the pour.

Likewise, be sure reinforcing is properly installed. Once it is covered by concrete it is virtually impossible to check. Reinforcing must encapsulate base plate shear keys and go all the way to the top of the concrete. Block out profiles should follow the shape of the shear key, leaving 50mm of clearance for later grouting.

Make sure the reinforcing is not too close to the concrete surface. If there is a loss of cover exposing reinforcing to the surface, or if the concrete is allowed to absorb fluids that will corrode the reinforcing, concrete cancer will result.
The above picture shows a badly leveled jacking plate which needs to be removed and reset. As concrete is very dense, a large buoyancy induced force can be generated during the pour that acts against the cast-ins. Vibration of the poured concrete only makes this force higher. The cast-ins must be very securely fastened pre-pour such that the ultimate location of the cast-in is the intended location and not displaced by the buoyancy induced forces.

2. During the pour
Large concreting jobs are generally done in stages – but delays between pours can make it difficult to get a good bond between concrete layers, resulting in a ‘dry joint’ which can lead to serious cracking. A dry joint can allow the concrete section above the joint to move somewhat independently to that below the joint. Once this independence is established, the vibration of the mill equipment connected to the independent foundation quickly increases beyond acceptable levels.

If there is the potential of a dry joint due to the pouring process, there are ways of achieving a good bond between the already-poured concrete and the new pour. The responsible engineer should determine which methods are acceptable.

3. Finishing the foundation
The completed foundation needs to be properly grouted so choose the right grout for the job, ensure the concrete is properly scabbled in preparation, and fit hold down bolts with sleeves to allow tightening stretch.

Only the underside of the base plates should be grouted and it is important to ensure there are no air pockets underneath. Chamfer the grout edges away from the base plate to encourage water dissipation. Base plate grouting should be an integral part of the installation specification.

If there are any process solutions on site which could degrade the concrete over time, the concrete must be sealed. This sealant may take the form of a simple epoxy coating to a more sophisticated vinyl ester resin; the choice depends on the type of process solutions liable to come into contact with the foundation.

Conclusion
Producing a good foundation takes attention to detail in the planning, design and construction phases. If the foundation engineer or installer is ever in doubt regarding specific issues, the most important advice is to seek advice. A competent mill supplier will, at the very least, point you in the right direction. Careful management of those phases will ensure your mill is built on a solid, high quality foundation, thereby avoiding any unnecessary, costly problems.