Control Survey Grids for SSC Civil Works

Tim Toohig
SSC Central Design Group

1 February 1988

A working session on requirements for control grids for the civil construction aspects of the SSC facility was held at RTK in Oakland on 7 December 1988. Present were M. Riddle and D. Scapuzzi (RTK), J. Sanford (DOE), G. Drouet, K. Edwards, D. Shuman, and T.E. Toohig (CDG), J.S. Kor and W.S. Robinson (Towill, Inc.). Discussions covered the scope and accuracy of the control grids, current survey techniques with emphasis on instrumentation, and transfer of a surface grid to underground works. Installation of technical equipment was not considered appropriate to this forum, except to note that with the longer sightlines available in the completed tunnel, and with the absence of contractor activity the accuracy that can be achieved for the technical installations working from the same primary grid is much greater than what is attainable and necessary for the civil construction phase.

1. Instrumentation

Even within the past year there has been significant development in and miniaturization of survey equipment. A notable aspect of this development is the increased onboard capabilities being provided for data storage, calculation and reference. Examples of these developments are "lunch-pail" size satellite readers for Global Positioning System (GPS) work, "smart" theodolites which store their readings internally for direct input to calculating programs, the reduction in the size of dual-frequency electronic distance measuring devices (EDM's) to half of

a model as recent as that used at CERN for the LEP project. Also the market for such equipment has developed so that a dual-frequency EDM, for instance, is available essentially off the shelf.

2. Control Grid

A primary control grid would be laid out to encompass the site making use of the Global Positioning System (GPS). This is a precision surveying system making use of the military Navstar satellite-based navigational system. Using the new, B class, GPS a positional accuracy of $1{:}10^6$ can be readily achieved. A conventional, ground-based survey would be used as a check in a conservative approach. The ground-based survey would use a gyrotheodolite and a dual-frequency EDM. With this primary grid the relative accuracy of the points at either end of the major axis of the lattice ellipse would be approximately 1 inch.

Secondary control points would be laid out by traverse from the nearest set of primary points, or by GPS. These secondary points would preferably be located at the Service Areas near the access shafts where they could be readily transferred underground. The secondary points would have an inherent accuracy of $1{:}10^5$. The machine lattice is connected to the control points by the Virtual Survey Markers (VSM) in the lattice database.

3. Transfer of the Grid to the Underground Space

While the surface points on the secondary grid have an accuracy of 1:100,000, the best that can be achieved in the transfer to the underground space is ± 20 seconds, or 1:10,000. This level of accuracy, if uncorrected, would result in a precision for civil works from this blind shaft location of about 1.28 feet to the next shaft location. Use of an intermediate survey shaft within 1–2000 feet of the access, can improve the precision to 1:50,000. It was noted that in the underground survey during construction, the attainable precision will be limited by such things as interference from construction operations, variation in tunnel air density, etc.

4. Summary of Control Grid Requirements for Conventional Construction

Provisional primary and secondary reference grids need to be established as soon as possible on the site. When the final lattice and alignment are determined a correction may have to be applied to the secondary grid to align it more closely with the lattice. The primary grid is presumed extensive and dense enough not to need correction.

Once construction of a tunnel sector is completed it is turned over to the Laboratory for technical installation. At this stage longer sight lines are available in the tunnel than during the construction phase and the interference from contractor operations has disappeared. It would then be possible to improve the precision of survey points to the level required for the technical installation.