‘When it comes to structural monitoring, there is no room for risk. At Bryne Bros we pride ourselves in ensuring the delivery of best in class structures with the utmost of safety and care. It is integral for us to be able to work with a technology that is adaptable to the project and delivers without fail. That’s why we chose Leica Geosystems and that’s why we were able to deliver one of the largest engineering projects with absolute precision.’

Donald Houston, Byrne Bros

Byrne Bros (Formwork) is one of the UK’s premier concrete frame contractors. Byrne Bros were appointed by MACE to carry out the concrete substructure and superstructure works in a contract worth more than £50 million. The substructure will adopt ‘top down’ techniques and the main structural core will be slip formed in parallel solutions which will deliver significant programme advantages.

The top 30 floors, culminating at a public viewing gallery between levels 69 and 72, will be constructed using a post tensioned slab construction. On completion The Shard will house offices for Transport for London, a hotel and luxury apartments, all with exclusive views over the capital.

In the summer of 2009, Leica Geosystems was approached by Byrne Bros one of the UK’s and world’s leading formwork construction companies to develop a real-time slip-form rig positioning system which would be used to construct the central concrete core of The Shard. Slip-form construction is perhaps one of the safest, efficient and economical methods of building vertical structures. It enables formwork construction to rise at rates of up to 8 metres per 24 hours. Traditional methods of controlling

Renzo Piano, the architect for The Shard, considers the slender, spire like tower a positive addition to the London skyline. The sophisticated use of glazing with expressive facades of angled panes is intended to reflect light and the changing patterns of the sky, so that the form of the building will change according to the weather and seasons. The Shard London Bridge will tower 306m (1,017 feet) into the sky and will be the tallest building in the European Union and the tallest building in the United Kingdom. When completed in 2012 it will soar more than 70 floors above London.
the position of a slip-form rig as it rises is often a time consuming and labour intensive process. Normally a site surveying team will compute traverse computations from observations taken with total stations and precise optical plummets. These calculations allow the position of the rig to be obtained in the site grid coordinates. As the vertical concrete core has known offsets from the rig it is therefore possible to guarantee the core is being constructed vertically in relation to its design coordinates.

The required tolerance for this project was that rig plan position should not exceed +/- 25mm of deviation against the design coordinates. The height component is not as critical but is often useful to know. After some consultation between Leica Geosystems and Byrne Bros a combined system of TPS, GNSS and dual axis inclinometers was agreed. Real-Time GNSS positions would allow determination of the rig's position. Both the translation and rotation of the rig could be determined using GNSS technology but it would be unable to provide information on the rig's inclination which could be up to +/-75mm over the 20m square rig dependant on the correction factors applied by the rig manager. It was therefore necessary to calculate the tilt on the rig. This was achieved using data acquired from the 4 x dual axis inclinometers. By using the virtual sensors functionality (mathematical formulae) within the Leica GeoMoS software it was possible to compute a ‘tilt compensated’ position of all four corners of the rig. Third-party inclination sensors were chosen due to the large expected range of tilt and were integrated into the systems via a Campbell Scientific Datalogger.

To allow the GNSS and total station results to be correlated a set of transformation parameters were calculated within the Leica Geo Office software.

In addition to the problem of actually using GNSS technology in the ‘urban canyon’ the provision of both reliable and stable reference stations is extremely difficult. Often easy access to a stable location that provides both the necessary power supply and communication is hard to obtain. Negotiation with other building owners and businesses can be prohibitively expensive. For this reason it was decided that a real-time data feed from Leica SmartNet NRTK correction service would be utilised.

The 4 x GMX902GG receivers are connected to the site computer running on the rig. Leica GNSS Spider software takes the incoming data streams for these receivers and a real-time data stream from the SmartNet service. The internet connectivity is provided by a WLAN bridge system which comprises of 2 x directional antennae which guarantee reliable internet connectivity to the site computer on the rig as it rises nearly 3 metres per day.
The position of each antenna on the rig was computed with respect to nearest SmartNet reference station which was approximately 1.5 miles away. This yielded a 3 dimensional coordinate quality of better than +/-25mm.

The GNSS positions are computed every second within GNSS Spider and the median result of these observations are sent every 10 seconds to Leica GeoMoS where they are synchronised with the data from the dual axis inclinometers and the wind speed. A computation is simultaneously carried out within GeoMoS which applies the lateral shift caused by the tilt of the GNSS antenna to the vertical position.

Effects of Tilt on GNSS position

The rig positioning interface uses the open architecture of GeoMoS which is built on a Microsoft SQL database. An OBDC link is established between the GeoMoS database and the bespoke interface which displays the results graphically and that is easy to understand by the rig manager. This interface enables the rig manager to make adjustment to the rig position via the use of hydraulic pumps. Traffic light system of warnings are displayed within the interface. If the computed results exceed +/-25mm lateral displacement against the design position or +/-4mm/m of tilt on any corner of the rig then an orange display is shown. An exaggerated rig display and level ‘bubble’ display allow instant visualisation of results.

Project Results

This new and innovative approach for controlling the position of a slip-form rig has proved highly successful on The Shard project. The fact that the results obtained could be verified and correlated to those obtained via traditional methods was extremely important in building confidence in the system. This allied to the fact that Leica Geosystems Monitoring Support team could support this system remotely even during out of hours meant that in the early stages of this project in particular confidence in the system was assured. Already other tall buildings in London being constructed using slip-form methodology have adopted this system and Byrne Bros plan to use this system again on future projects.

For more information on monitoring solutions from Leica Geosystems Ltd contact James Whitworth on +44 (0)77 958 440 75 james.whitworth@leica-geosystems.com