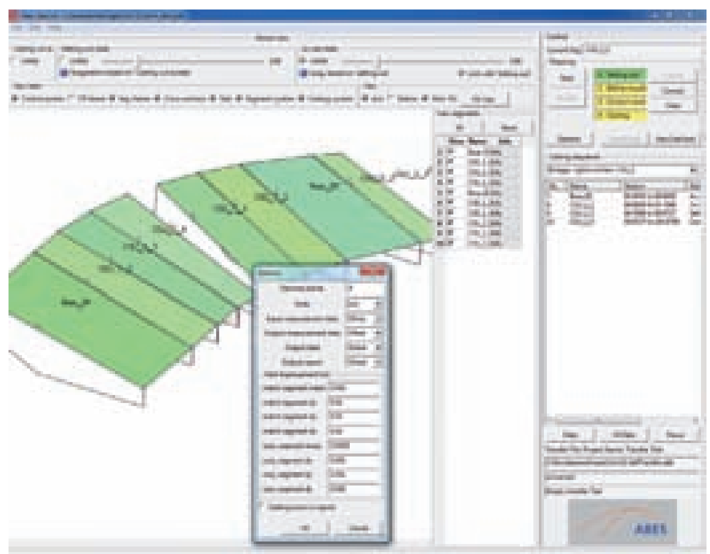
GEOMETRY LESSON

A new software package which can be used to manage production of precast segments has been applied to several bridge projects in Asia. **Michael Lüthi** and **Martin Pircher** report



Above: Segments being lifted on the F11 Hunter Expressway project in Australia
Below: Screenshot of the Geocon module

Precast segments for segmental bridges are usually match-cast against each other using either the long-line or the short-line method. The former is simpler to set up, but only suitable and economical for a repetitive span set-up, and simple bridge alignment which is straight or has a constant radius and specific segment design. The short-line method is more versatile but requires more planning and sophisticated equipment. Tolerances are usually tight and the geometry of each segment must be communicated to the casting yard very accurately.

A combination of software is traditionally used to plan precast segmental bridges and manage the manufacturing process, with geometry control during casting being a central problem. The components typically include basic spreadsheets, output from CAD systems, custom-written software, database systems and commercially available software. Data exchange between these individual software components is often makeshift and error-prone.

A new software package developed by ABES Pircher & Partner in cooperation with VSL TCA of Singapore aims to address these shortcomings. Itoffers a clearly-defined work flow that supports the planning and manufacturing process from the definition of segment layout to as-cast documentation, including geometry control services.

It consists of two modules named ABES Geodes and ABES Geocon. Geodes serves as a geometry pre-processor which maintains the exact definition of bridge girders all the way to detailed geometry definitions for each segment. The input is based on road or railway alignments which consist of standard road engineering elements such as straight lines, arcs and spiral curves for the horizontal alignment; and straight lines, arcs or parabolas for the vertical alignment. Multiple alignments can be managed and secondary axes with variable offsets to these alignments can also be defined. A cross-section modeller provides functionality to manage multiple cross-sections with parametric measurements. These parametric measurements can be defined as a function of the station which is measured along an alignment. By placing cross-sections along the alignments and interpolating parametric measurements between these cross-section placements, continuous girders with variable measurements can be defined very efficiently. Using first principles for the geometry definitions also assists in validating third-party data such as that transmitted by the design engineer to the construction engineering team.

Different types of segments can be defined including precast segments, cast in-situ segments, wet joints and also gap segments for the inclusion of bridge joints. For each segment type, specific information based on the respective engineering requirements can be generated in great detail. Using this functionality, project-specific segment libraries can be built. Individual segments can then be assembled into typical groups and placed in their exact positions on the bridge girder.

Specific engineering tasks need to be performed before casting can be initiated as part of the construction engineering for precast segmental bridges. These tasks include the design of a segmentation concept allowing for economical and feasible production not only of the precast segments but also of in situ parts of the bridge girder. The Geodes module supports the development of highly modular and repetitive segmentation concepts which consider equipment requirements or restrictions. Ultimately, well-designed segmentation leads to quicker production cycles and the software module enables engineers to achieve this goal. Control points on each segment are used during casting for adjustment of the adjacent segment before casting and for quality control purposes after casting of each segment. The specific layout of these control points depends, among other factors, on the survey system used in the yard. Geodes provides functionality to devise the control point concept to comply with various surveying methods.

Once a geometric model of a bridge girder is created and, if required the pre-camber has been added, a transfer file can be created containing all data necessary for use in the casting yard. Operations in the casting yard are supported by the second module in the package called ABES Geocon, into which a transfer file can be imported. Detailed input options are available to define the general casting yard setup, the survey system, the quality control requirements and the yard-specific parameters of the individual casting cells. As soon as all this basic information about the casting yard is known, Geocon gives precise information on the setting out data for each individual segment, and collects the survey data from the quality control survey after casting. Once the survey data is known for a given segment the casting errors are determined using a novel algorithm to filter out setting errors and measurement errors. Possible casting errors are corrected by appropriate adjustment of the dimensions of subsequent segments within a casting sequence. Setting out data including possible error compensation for each segment in a sequence is computed and documented in site-specific work sheets. In this manner the process is repeated until a casting sequence is completed. For each individual completed segment the as-cast geometry is known and stored in the database for further processing, for example in order to monitor assembly of segments on site at a later point in time.

Several casting sequences can be managed at once from a central work station. The software is also capable of using and managing several casting cells and survey stations at the same time. As such, it provides very precise geometry control services and supports casting yard management, quality control and production documentation.

Both modules provide output in various formats including automated reports in PDF format, customisable graphic representations, spreadsheet-compatible files, cut-and-paste ability from the user interface directly into spreadsheets, text files and also DFX files for import into CAD systems. Pasting data from existing spreadsheets is enabled.

They have both been applied on several projects so far by VSL TCA with lessons learned fed back into the software and practical engineering requirements catered for. This software is now commercially available for other parties through ABES in Austria.

The system was used on the F11 Hunter Expressway in New South Wales, Australia; three twin viaducts of 196m, 254m and 329m lengths, built using a total of 560 precast segments. Construction tolerances were extremely tight and Geocon was used to ensure that segments were cast to the correct alignment. The system was able to support use of a robotic total station survey, which was appreciated by the site team, allowing three casting cells to be surveyed from a single instrument operated by one person. This efficient and rapid surveying of segments is important in countries with high labour costs.

It has also been used on the Casablanca section of the Kampung Melayu – Tanah Abang Viaduct, in the heart of Jakarta, Indonesia. The twin deck viaduct is approximately 1.2km long; formed of some 800 precast segments and built using the balanced cantilever method. Here the software was used to model the bridge alignment and segmentation and to generate control point coordinates in spreadsheet form. This information was input into a third party software which the precaster was using for casting control. The modular bridge modelling and ability to counter check alignment and pier coordinates was useful as parts of the viaduct were realigned during construction.

Currently it is being used on the Tuas West Extension in Singapore. The large and complex project has up to two rail decks and four highway box girders supported on two levels by the same substructure along with two additional rail ramps and five highway ramps. The total length of precast deck is more than 24km with more than 7,000 precast segments. The ability of Geodes to model and visualise multiple alignments proved useful; it was used to verify all alignment input and pier coordinates and to define the shape of all cast-in-place pier heads. DXF export of the entire 3D bridge model allowed for efficient data transfer for production and checking of shop drawings. Geocon is in use in the casting yard in which 17 casting cells will be operating ■

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