GEOMETRY CONTROL SOFTWARE

TCAA in partnership with ABES initiates the development a software to control the geometry of precast segment during the casting process

The problem faced when constructing a bridge using the precast segmental method is that the bridge is constructed in pieces at a totally different location to where it will eventually stand. Hence the bridge geometry needs to be accurately transferred from the final location into the casting location. Precast segments are match cast against each other using the longline or shortline method. In the longline method a casting bed stretching over a whole cantilever or span is setup, segments remain stationary and the external side and internal formworks move along the cantilever or span. Control of the geometry is in this case relatively easy as the whole cantilever or span can be seen and surveyed. However, long-line casting is only suitable for straight alignment both in plan and elevation. For curved alignments segments are usually cast using the short-line method whereby segments are cast in a stationary formwork against a conjugate segment. Once cast, the conjugate segment is moved to storage and the new segment is moved into the conjugate postion, hence the geometric relationship between the two segments is lost. This means that the relationship between two segments needs to be captured (surveyed) before the segments are separated. The survey data are then analysed for casting errors and setting out coordinates for the next casting step need to be calculated based on casting curve, past errors and corrections and new errors.

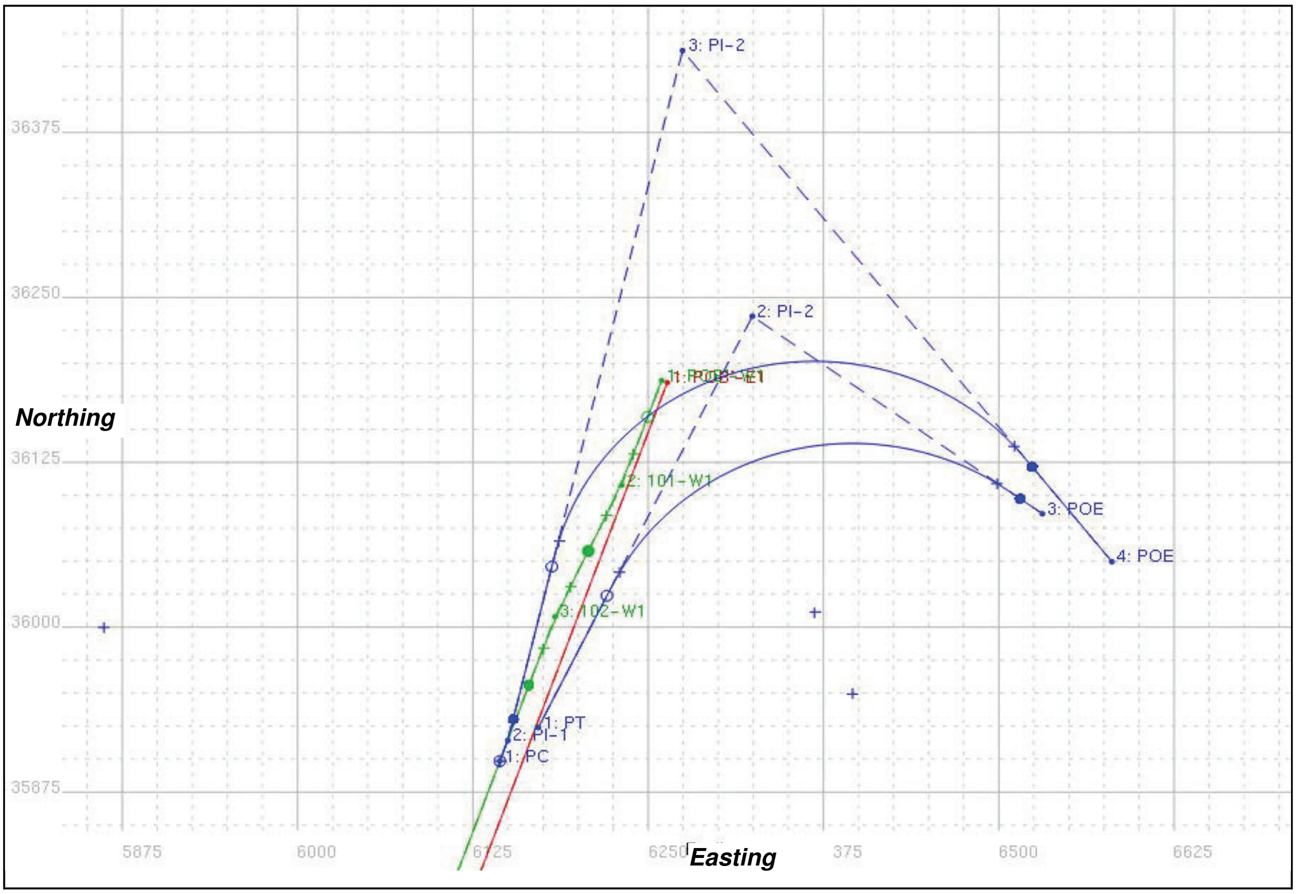
The purpose of the geometry control software is first to define the theoretical bridge and segment geometry, and second to process the survey data during the casting process.

TCAA has been involved in geometry and erection control for bridge construction for more than 20 years. In this article TCAA's latest developments for geometry control software is presented.

Short line casting cell

GeoCon and GeoDes Software

Starting with the first geometry control software for Seoul Expressway Project in South Korea, TCAA has partnered up with software engineers to develop custom designed software to model the bridge alignment, segmentation and control points and to control the casting process of segments in the casting yard. The current software, developed with ABES (Advanced Bridge Engineering Systems), represents the 4th generation of such a software and replaces the geometry control within the Sofistik software package which in turn replaced FormSet2. Over the years the software packages have been continuously refined and features have been added to allow modelling of ever more complex structures but also to incorporate user feedback and requirements. The software package presented in this article consists of two modules: GeoDes, used to create the bridge geometry, and GeoCon, used to control the casting process in the yard. TCAA has a long term relationship with ABES, allowing for close collaboration and short reaction times for problem solving as well as future development and maintenance.



Horizontal alignment with base polygon

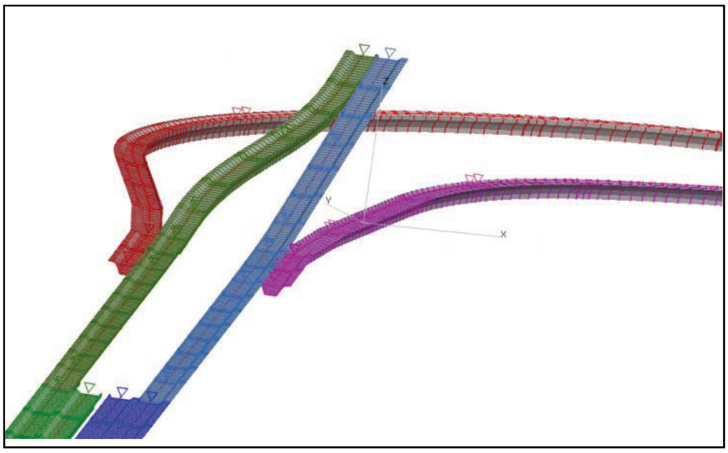
Bridge Geometry

GeoDes module is used to model the bridge geometry including segmentation. This work is typically done by a TCAA engineer as a lot of engineering expertise flows into this task. The engineering works provided by TCAA includes the following:

- Definition of a segmentation concept that allows a productive construction not only of precast segment but also of in-situ parts of the bridge. The aim is to achieve a highly modular and repetitive segmentation that allows for quicker production cycles. Formwork, structural and construction (erection equipment) requirements and restrictions are considered.
- Review of alignment drawings and modelling of the bridge geometry based on first principle input. The bridge aligment is recalculated and coordinates of alignment points and piers are checked against values provided in drawings. Discrepancies are investigated and corrections proposed.

- Definition of geometry control point concepts. Geometry control points are physical survey marks which are used to define the segment geometry during casting and are also used for setting out of the segment during erection.
- Proposal of survey concepts in the casting yard as well as during erection.

GeoDes provides the necessary tools to execute the above engineering works. Horizontal and vertical alignment are modelled on base polygons with curve definitions that provide accurate modelling also for large scale projects. Multiple bridge alignments and secondary alignment can be modelled and plotted against alignment points provided in drawings. The bridge segmentation is modelled through segment modular groups that represent cantilevers or spans. Each segment group consists of sequence of segments which are of 4 basic types: precast, in-situ, wet-joint and expansion joint gap.



3D Bridge model

The segment type “precast” has 3 sub-types that allow the modeling of starter segments (cast against two bulkheads), typical precast segments (cast against a bulkhead and conjugate segment) and a precast segment that is cast against 2 conjugate segments. Bulkhead angles can be varied from the typcial 90° position. The segment type “in-situ” allows the modelling of cast in-situ pier segments or even longer cast in-situ stretches of the bridge. End faces can have arbitrary orientation in plan as well as in elevation. Cross section modelling is fully parametric and any number of report points (coordinates only) and control points (coordinates and survey) can be defined. The resulting bridge geometry is presented in tabulated form (export to Excel) and as a 3D model for CAD software through a dxf interface.

GeoDes - major features and innovations:

- *Horizontal and vertical alignment modelling with base polygone and curve defintion*
- *Multiple alignments and secondary alignments*
- *Full cross section modelling with parametric, alignment dependent input (new)*
- *Un-limited number of report and control points anywhere within the cross section (new)*
- *Connection point: defines the intersection between pier and deck, it can be defined anywhere within the cross section (new)*
- *4 segment types: precast, in-situ, wet joint and expansion joint gap (new)*
- *Precast segment cast against two conjugate segments (new)*
- *Input of precamber in x, y and z*
- *Graphic superposition of external data points (new)*
- *Tabulated data for use in Excel (new)*
- *Automated model report (new)*
- *Customizable 2D and 3D diagrams with export into various file formats (emf, png, pdf, dxf) (new)*

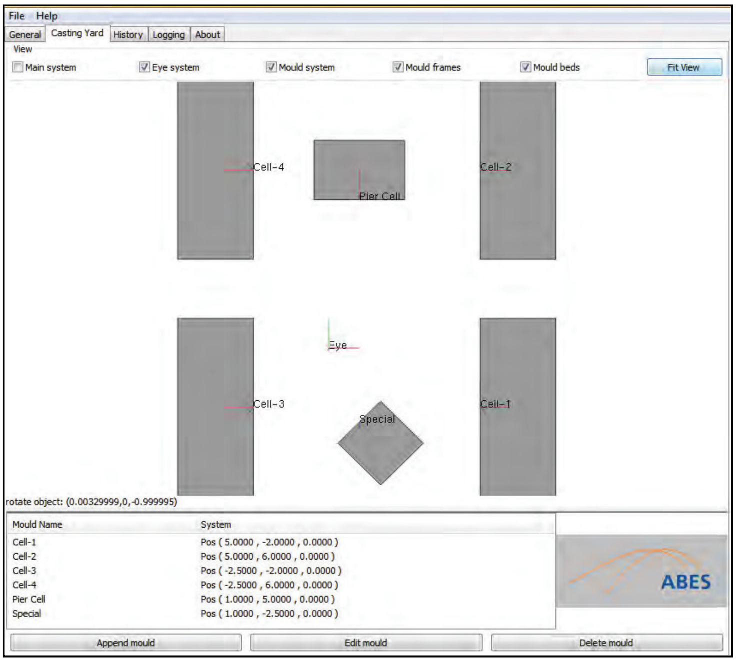
Casting Process

Geometry control in the casting yard consists of the following steps:

1. Setting out coordinates for conjugate segment and bulkhead
2. Survey of bulkhead, new segment and conjugate segment after casting
3. Verification of data and check of casting errors
4. Calculation of correction to setting out coordinates of next segment
5. Calculation of as-cast coordinates of finished segment

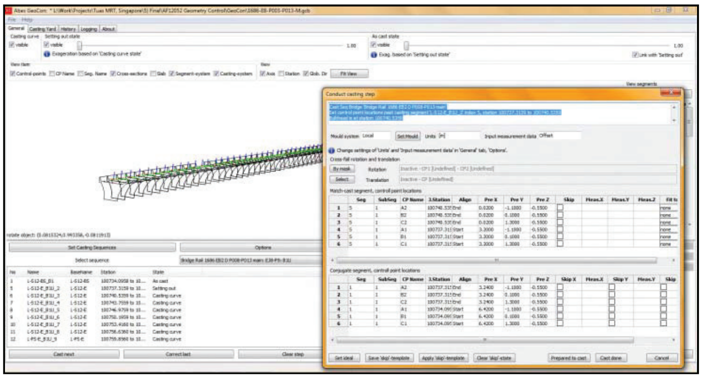
The tasks for the casting yard are covered by the GeoCon module. The separation of the software into two modules allows for an easy to use software on site and gives a better control over the bridge model and modifications to it. Data communication between the two modules is by means of transfer files in binary format to prevent tampering.

A major development step in GeoCon from FormSet2C is the implementation of survey methods using global station instruments, while traditional survey methods are still supported. With total station instruments x, y and z coordinates for each control point are measured. A typical set-up with 6 control points per segment results in over determinated geometry. A "best fit" method is then used to calculate the casting errors. The impact of survey or user input errors is reduced and can be easily spotted by comparing individual and average errors. Another benefit of using total station instruments is that several casting cells can be surveyed from one instrument position, hence greatly reducing set up times of instruments. With a robot total station even one man operation is possible.



Casting yard model

For this purpose one can define a casting yard layout within GeoCon with its own coordinate system. All input and output can then be produced in the casting yard coordinate system. Casting of segments can be started in one casting cell and continued in another cell within the modelled casting yard. Finally a data sheet for each segment with theoretical casting curve, setting out values and as-built shape is produced, including casting errors for each control point. Control point coordinates of the precast segments are also available in tabulated form for use in Excel or as 3D models through dxf export.



GeoCon user interface: Data input and 3D visualization

GeoCon - major features and innovations:

- Total station and traditional survey methods supported
- Casting yard model allows survey of multiple cells from one instrument position
- Data transfer with tamper-safe/proof binary files
- Tabulated data for use in Excel
- 3D visualisation of casting process

Expanded Use

The features of GeoDes do not limit its use for precast segmental construction only. The ability to model detailed parametric cross sections along a 3D curve make it a useful item to define, for example, complex geometry for cast in-situ bridges (on falsework or formtraveller), long-line cells or the 3D shape of beams used in monorails.

Conclusion

TCAA has started using this software on 3 bridge projects. On Hunter Project in Australia the new features "total station survey" and "casting yard model" were implement. Three casting cells were covered by a permanently installed robotic total station enabling a one man operation of the survey work, which improve survey accuracy and provided cost savings for the project. The software will also be used for Tuas MRT extension in Singapore, where over 20 alignments are modelled for the combined rail-road viaduct and ramps.