ON THE ECONOMY AND BENEFITS OF 3-D DESIGN METHOD IN BRIDGE ENGINEERING

Rauno Heikkilä, Mika Jaakkola
Oulu University, Research of Construction Technology
P.O.Box 4400 (Kasarmintie 4), FIN-90014 Oulu, Finland
rauno.heikkila@oulu.fi, mika.jaakkola@oulu.fi

Pekka Pulkkinen
ConsultingKORTES Ltd.
Rautionkatu 2, FIN-90400 Oulu, Finland
pekka.pulkkinen@kortes.fi

Abstract: The paper examines the economy and benefits of 3-D design method in concrete bridge engineering. New 3-D CAD design tools and 3-D measurement methods were developed and tested in the several real bridge construction projects in Finland during 2001-2004. The paper describes these observations and suggests some conclusions for future developments as well as more expansive utilization especially in bridge construction in Finland. The next steps to be projected are also described.

Keywords: bridge design, 3-D CAD

1 Introduction

In bridge engineering the management of geometry creates a basement and frame for successful execution of bridge design and construction. Superstructures of bridge must be accurately designed according to road geometry. The substructures needed for a bridge depend essentially on the terrain geometry of bridge site as well as ground features. The dimensions of bridges are often so large that construction works must inevitably be operated phased during a long time schedule. Therefore the creation and maintenance of a common and accurate coordinate system is an unique prerequisite to carry out different construction activities. The management of geometric information throughout the total process is one of the most essential key tasks in the domain of bridge engineering. It is important to control information flows from early initial measurements to design phase deriving the optimal geometry for the bridge. Again, different site control models must be derived from the design models enabling also the comparisons between as built measurements and control models. Hence, the R&D efforts on to the improvement of the geometric management will be directed to one of the most important core of the total process in bridge engineering.

2 Method

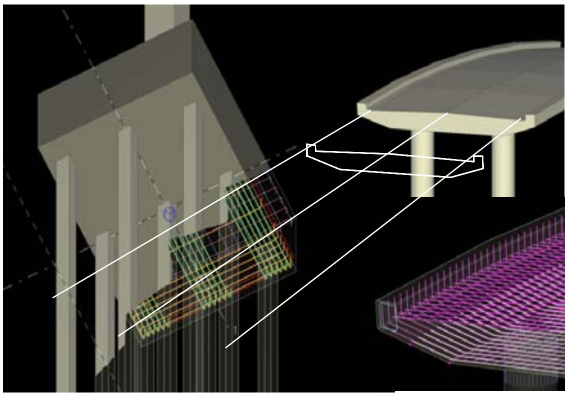

Fig. 1. Principles of 3-D bridge extrusion.

In the project a new logic and design method having 3-D features was developed and tested: input of 3-D digital terrain model, ground base model and road geometry (from road design), accurate 3-D modeling of the bridge, principle of extrusion. The experiments consist of several real bridge cases which have been tested (both concrete and steel ones). In the design MicroStation, AutoCAD, Tekla Structures were used as CAD tools.

The most essential working applications are different extrusion tools, with which most of the different types of bridge structures can be modeled. Each of different profiles of total bridge structure are separately modeled using 3-D road lines as well as digital terrain model as initial data. The needed dimensions for objects were entered by the aid of parameterized variables.

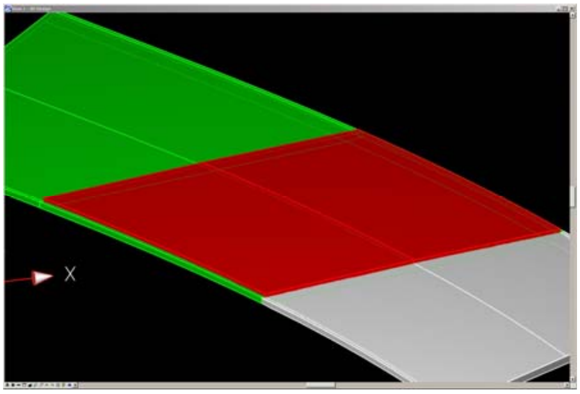

Fig. 2. Modelling three-dimensionally the superimposed structure.

3 Results

Working in 3-D space was evaluated to decrease design errors. The labor productivity of design work was evaluated to be improved. Still more important was proven to be the possibility to connect models directly to 3-D site measurements. This eliminates transfer errors due to human factors and format conversions.

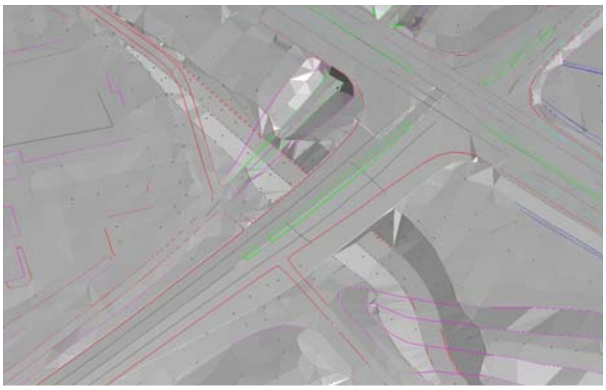

Fig. 3. The Initial data model (Digital Terrain Model) for Bridge Design (pilot Oulu 2004-2005).

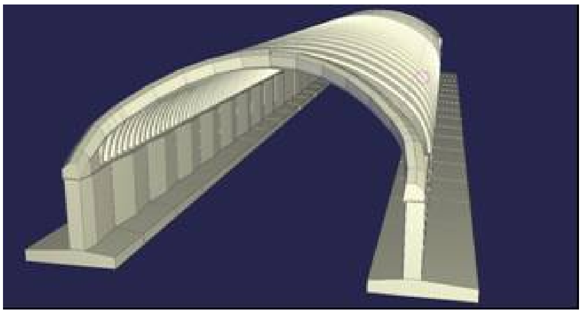

Fig. 4. A 3-D Bridge model (Tekla Structures, pilot Oulu 2004-2005).

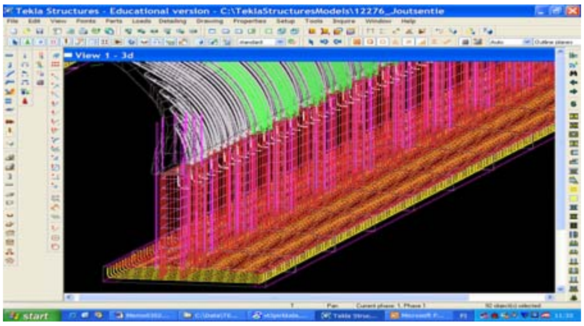

Fig. 5. A Detail of a 3-D Concrete Bridge Model (Tekla Structures).

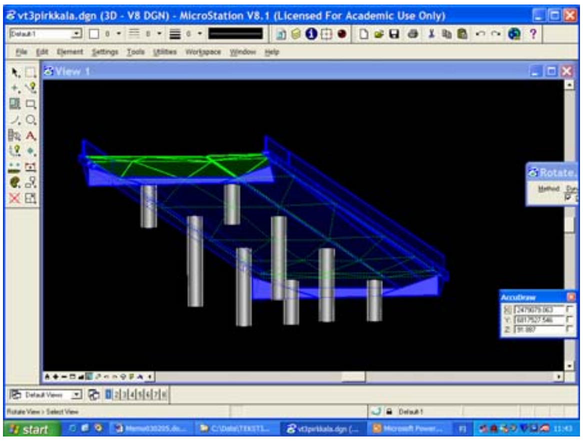

Fig. 6. A 3-D Bridge Model (MicroStation, old bridge case to be rebuilt).

4 Conclusion

New extrusion base design methods were developed for modeling the different parts of concrete bridges. In future, it is also possible to complete 3-D geometry model with non-geometry information. The transition to this new 3-D process seems to be well-founded on account of the results of the project. Different technological and economic benefits were evaluated to be attainable both in bridge design as well as in site measurements.

More widely, the direct data transfer connection from bridge design to site measurement planning and operation is also very essential. It is possible to pick up needed data from 3-D bridge model without separate coordinate calculation. Also it's possible to control a robotizated total station using CAD model. The needed identification data can be connected to bridge model. Laser scanners enabling the measurements of 3-D point clouds seem to be very applicable to the control measurements of moulds and complete bridges. Using the developed new tools or alternatively the analyzing software of some laser scanning systems, the deviations in location, dimension and shape can be three-dimensionally examined.

3-D methods are strongly coming into bridge design. The benefits of 3-D method are found to be clear and visible. The 3-D methods and tools must still be developed. The next steps of our R&D will be focused on the connection of different attributes into the geometric product model.

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