

# GKSPRO® – A MODERN SOFTWARE SOLUTION FOR DATA ANALYSING, STORING; MANAGING AND VISUALISATION

Maria-Barbara SCHALLER<sup>1</sup>, Jan-Owe BRENTLE<sup>1</sup>

<sup>1</sup> GGB mbH, 04571 Rötha OT Espenhain, Germany  
[schaller@ggb.de](mailto:schaller@ggb.de), [brentle@ggb.de](mailto:brentle@ggb.de)

**Abstract.** 20 years ago GGB started the development of a software solution for data management called GKSPro. At the beginning the focus lay on the field of geotechnics but during the last years because of the consistent advancement of the software capabilities new areas of application opened up.

The derivation of condition information from complex data situations demands besides efficient technologies for analysis and visualisation primarily efficient concepts for the systematisation of the accruing data and data formats. The requirement for this is based on the increasing complexity of engineering and measurement tasks in nearly all areas of constructive engineering.

The step towards integrated systems which already consider a multidisciplinary perception on the level of information technology and especially in consistent data management concepts is necessary and this independent for example from different measurement technologies which are used to collect the data. Common procedures for project navigation offer on the one hand access to the data and on the other hand geometric facts can be visualised directly and therefore are accessible for an effective interpretation and control. This will be illustrated by further sample applications.

## Introduction

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Projects which are for example spread over a wide area as well as with a distinct local and organizational dispersion and autonomy require special methods regarding the centralised measurement data management. The derivation of condition information from complex data situations demands besides efficient technologies for analysis and visualisation primarily efficient concepts for the systematisation of the accruing data and data formats. The requirement for this is based on the increasing complexity of engineering and measurement tasks in nearly all areas of constructive engineering it doesn't matter if your monitoring object is a mine, a street, a dam, a bridge, a building or even complex mechanical units like a wide-bucket excavator for open pit mining or an airplane!

Wherever in a project at different locations and with different measurement techniques and sensor systems measurement data will be collected which have to be administrated centralized and nevertheless be available user-defined for all involved parties online or locally a well-engineered software based system is required which is capable for this task.



With the “City-Tunnel Leipzig” such a system will be illustrated. The basic requirements set by the purchaser regarding the applied data managing software were:

- The centralization of the data because of the assignment of different contract sections to different contractors and the heterogeneous project structure (the intra-urban tunnel, construction of the stations, connection to the existing transport network, foundation and building ground stabilisation)
- The traceability of data manipulation processes
- A high data security
- Long-term availability of all data

All measurement data (data of the structural health monitoring of buildings, injection works and foundation soil monitoring, of the tunnelling, of the groundwater monitoring network) as well as documented information (inter alia data of the preservation of evidence, the delivery notes and the correspondence) will be recorded at decentralised and autonomous locations at databases, periodically reconciled with the central database and – centrally controlled- distributed to authorised recipients (for example the purchaser or project management).

Additionally tasks of analysis and visualisation, of the direct communication with data sources (data logger, external data basis) as well as the data allocation for continuative software systems will be realised consistently.

## 1 Targets

Heterogeneous measurement data stocks are typical of complex projects. This diversity and complexity stem from different sources:

- Organisationally: project structure, project participants, reciprocal dependencies
- Locally: distributed data acquisition and processing
- Technical: different methods of measurement data acquisition, data storage and evaluation

In general the handling of measurement data is initially affected by organisational, local and technical isolated applications. Under certain aspects those isolated applications are advantageous and inevitable. On the one hand specialised software for ascertained measurement systems and technical processes can't be replaced easily just as for example the flexibility of a table calculation. On the other hand there is the need not only to define the general data stock in a project but also to handle it in compliance with aspects of quality. This includes:

- The systematic storage in a consistent data technical basis (normally in databases)
- The centralisation of the data
- Securing transparency, traceability and long-term availability
- The comprehensive evaluation of data from different locations and measurement systems and the different parties involved etc.

Regarding the “City-Tunnel Leipzig” these requirements which were set by the purchaser were implemented in the conception of the measurement data management. The basis of the implementation was the data management software GKSpro completed by a specific tunnelling module designed and programmed for the requirements of the project. Due to the structure of the software it is possible to program and implement project specific modules at any point in time.

## **2 Consolidation of data from different measurement systems and other data sources**

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GKSpro is based on a database schema which supports the typical structures within the scope of application. The regular implementation of different and new data formats and interfaces is intended from the onset. The focal points of the monitoring tasks were:

- Structure monitoring
- Monitoring of foundation soil stabilization and the influencing activities (uplift injections, soil freezing) as well as building ground monitoring
- The tunnelling excavation
- Excavation pits
- Groundwater monitoring network

Furthermore data of the following sensor and control points were implemented:

- Geodetic control points and data
- Hydraulic measuring systems
- Horizontal and vertical inclinometers
- Strain sensors
- Pressure gauges
- Fissurometer (crack meter)
- Groundwater observation wells
- Machine and guidance system data of the tunnel boring machine (TBM)
- Time-related development of all uplift injections (amount, pressure)
- Documents: monitoring programs, photo documentation, administrative documents, delivery notes, work reports, inspection certificates etc.

The following interface types were used:

- Data transfer from measuring systems and manual measurements
- Import of the data from external databases
- Import of transfer formats of other systems and applications
- Standardized Excel and ASCII interfaces

Furthermore GKSpro manages the data of the geometry of structures and buildings especially if they are relevant for project purposes.

## **3 Combination of the data of organizationally and locally autonomous units**

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The segmentation of the project into contract sections leads to organizationally, locally and even largely technically independent units.

The targets were:

- Autonomous functioning sites; performance of the measurement data processing even in the case of failure or restriction of the communication lines; regular systematic and automated comparison of structures and data amongst the sites (section databases) and the central database

- Gradual generation of partial data sets and of an overall total stock of data corresponding to the requirements of the sites, users, and evaluations; adaptability of the structures to growing and varying requirements
- Separation of data to be provided locally or centrally
- Inclusion of external users with a viewer functionality only (for example: assessors) on the basis of definable rules of data allocation as well as with an explicit separation of organization and data technology
- Comprehensible data history (adding, modifying, cleanup of data) on the level of data transfer; possibility to control or to restore earlier states of the system

The realization is carried out on the basis of the GKSpro-transfer technology. It is based on a replication process optimised for the scope of applications which occur in the project. The partial databases of the single sites as well as the central main database are supervised by GKSpro-entities and possess the same database schema. These entities execute the data synchronisation at specified points in time and with defined release rules (one-sided or reciprocal). The data communication is supported by using different technologies (for example: VPN-connections, FTP, offline via data storage mediums etc.).

Partial databases are located at:

- the contractors of the project units
- the site management / third-party field inspection
- the purchaser

The general database is administrated centrally.

#### **4 Volume of data**

Foremost the task was to promptly record comprehensive datasets to transfer them and to make them available. Some figures below serve to illustrate this:

The general database at the end of the project contains over two billion datasets. Beside the expected huge amount of measurement data from deformation monitoring (from manual and automatized measurement systems) these are datasets with archiving functions (inter alia over 200 single parameters of the TBM were recorded in a short time during the tunnelling phase; also more than 30.000 injection points with the related injection parameters, .....). During the tunnelling phase the data increased by a rate of three million datasets a day.

The software is amongst others specifically designed for the storing and calculation of dynamic data. It is possible to calculate and to display over 8 million measurement data within 12 seconds online. In all evaluations and calculations processed by the software the original data will remain stored and unchanged in the database and thus they remain available at any later time for other analysis and reconsiderations.

#### **5 Aspects of data evaluation**

The described method of data integration was created for an evaluation which exceeds the restrictions found in single measurement systems and organizational units. The integration of data is supported independent of their origin and structural classification in the project. Features for the operational evaluation enable a fast analysis and classification of the independency between data streams for example between operation and reaction contexts. Furthermore different fixed evaluation types were defined for the project. For example:

- The visualization of deformations in cross- and longitudinal sections for the different measurement systems and building sections
- The laminar deformation examination (uplift and settlement) by using a isoline-view with coloured area identification and deposited maps and plans

- The visualization of the dependency between injection and deformations
- Furthermore the integrated data source serves as a source of data exports for external specialised software.
- Extensive assessments are instruments to evaluate data quality and plausibility while comparing neighbouring systems and those with overlapping systems contents wise.

## **6 An example for the consolidation of different measurement systems in evaluations**

GKSpro supports the geometric interpretation of a measuring tube for inclinometer measurements as a line of 3D-points. On the basis of the executed measurements and the connection to the main coordinate system these points will depict a 3D-polygon which shows the position of the measuring tube in relation to time. Each point along the measuring tube can be interpreted as a single control point with time related attributes X, Y and Z and is thus directly combinable to comparable geodetic control points, tube water levels, points of other measuring tubes etc. during the evaluation.

This refers to all GKSpro evaluation types, besides isoline-views also to laminar evaluations or the visualization of displacement vectors. The determination of the time related coordinates takes place automatically during the import of the measurement data (manually as well as automated measurements).

## **7 Operating experiences and conclusion**

The application of GKSPro ensured that the requirements of the purchaser regarding a centralised and systematised data pool which will on the one hand support the comprehensive assessment of the project for the construction supervision and on the other hand assure a long-term availability of all data were met.

The continuity of data acquisition and the prompt data provision in one central place enables the responsible employees of the construction supervision to assess the data flexibly and appropriately regarding the set requirements.

In the sector of measurement techniques new technologies increasingly gain in importance. Among them fibre optical technologies plays a significant role. With this technique it is not only possible to record punctual data furthermore by using distributed fibre optic technologies temperatures, strain, vibration and acoustic data can be measured over long distances. By using so called Fibre-Bragg-Grating-Sensors (FBG's) for local and punctual measurements the measurement data can be recorded and calculated analogue to conventional sensor systems. In the case of distributed fibre optical measurement systems it is different. During distributed fibre optical measurements over long distances up to several kilometres thousands of data will be recorded at the same time. Depending on the measurement method and the length of the fibre optic sensor cable received data will represent the conditions within a certain area of the cable. This means for example in the case of a temperature measurement along of a two kilometre sensor cable with a spatial resolution of 0.25 m 8.000 values will be recorded in a string per measurement. With GKSpro it is possible to convert this value string into quasi single measuring points without changing the original data whereby they can calculated and displayed together with all other data of a project arbitrarily.