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Institute of Engineering Geodesy

Quality assurance in building construction, based on engineering geodesy processes

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FIG WORKING WEEK 2012
May 6–10 2012
Rome, Italy

EQuiP
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1. Motivation

- construction of high-rise buildings is getting more and more faster
- requests essential improvement of the quality assurance methods (especially for building geometry) applied directly and continuously on construction site

→ engineering geodesy processes well suited for quality assurance

→ interaction between construction and geodesy is required

Analysis and results within the DFG-project **EQuiP**
"Efficiency optimization and quality control of engineering geodesy processes in civil engineering"

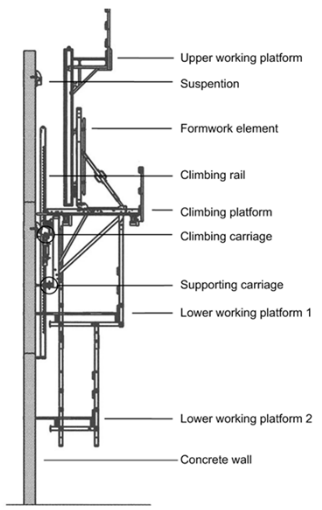
Structure

1. Motivation
2. Construction processes
3. Quality assurance concept
4. Application
5. Summary and outlook

2. Construction processes

Theoretical reference project: climbing formwork

- Construction of a core of a typical high-rise building with a climbing formwork
- Special type of formwork for vertical concrete structures that rises with the building
- To raise the formwork for the production of the current wall section special platforms based on rail-suspended carriages are used
- The production process is based on repeating procedures and is set up as a working cycle



2. Construction processes

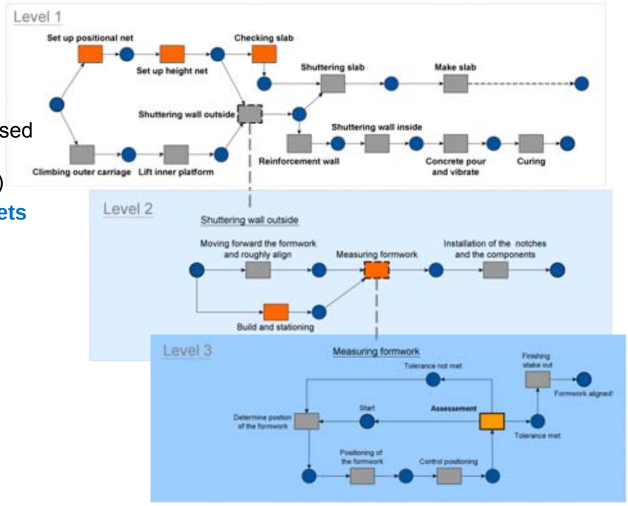
Formal model of the build process (3 hierarchy levels)

Building core

- 260 processes
- Process hierarchy based on macro and micro activity steps (REFA)
- Realized with **petri nets**

Total Time

- 1 week / storey



2. Construction processes

Integration of engineering geodesy processes

- An increase in quality of construction can be achieved through an optimized interface and better integration of the engineering geodesy processes
- Interaction takes place at different stages of construction
- Integration in the process model (orange transitions)

Example:
alignment of the formwork with the total station →

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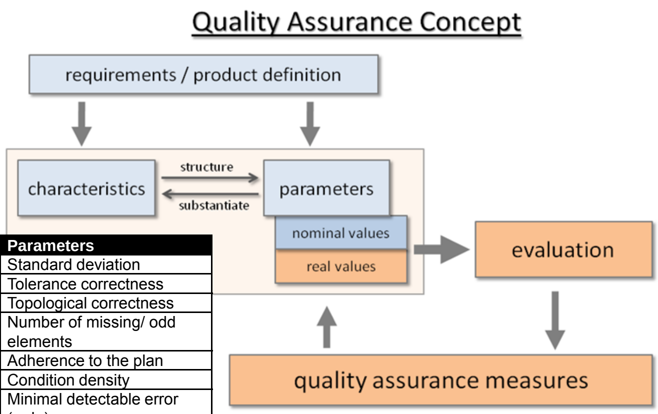
3. Geometric quality assurance



Characteristics	Parameters
Accuracy	Standard deviation
Correctness	Tolerance correctness
	Topological correctness
Completeness	Number of missing/ odd elements
	Adherence to the plan
Reliability	Condition density
	Minimal detectable error (mde)
	Impact of mde on parameters
	Vulnerability to failures
Timeliness	Time delay

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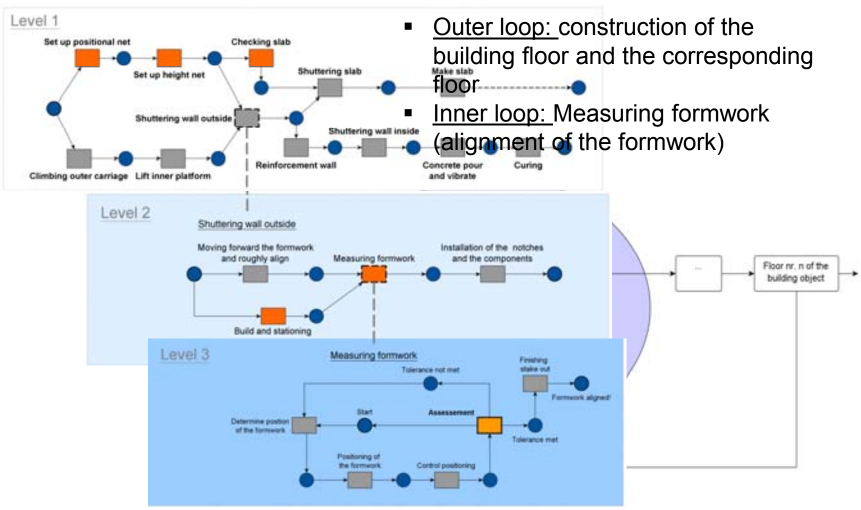
3. Geometric quality assurance



- Outer loop: construction of the building floor and the corresponding floor
- Inner loop: Measuring formwork (alignment of the formwork)

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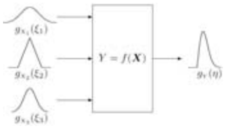
4. Application

Planning Phase

- Show impact of different input quantities (e.g. measurement configuration) on the results
- Quality assurance measure depends on the improvement of the measurement and construction processes

→ Using Monte Carlo Method to propagate standard deviation and the tolerance throughout the processes

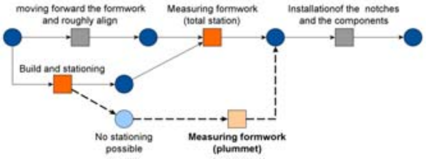


source: Supplement 1 to the GUM

Real Time

- parameter values are derived (a.o.) from the measurements
- A quality assurance measure can be the use of alternative paths

→ On the base of the parameters a decision is made in real time



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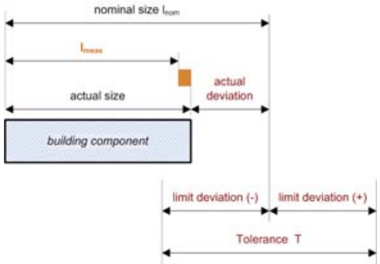
4. Application

Exemplary two parameters for describing the quality:

- Standard deviation: $\sigma = \sqrt{\frac{(x_i - \mu)^2}{n}}$
- Tolerance correctness: $tc = \frac{1}{2}\sqrt{T^2 - T_M^2} - |l_{meas} - l_{nom}|$



T – Tolerance
T_M – Surveying tolerance
l_{meas} – Measured size
l_{nom} – nominal size

4. Application

- Simulation studies (in planning phase) for parameters standard deviation and tolerance correctness

Process	Input / output variables	Input parameter values
Build and Stationing	Input: 3 x control points 9 observations (hz-, v-angle, distance) Output: 1 x station coordinates	σ_{xyz}=0.005 m $\sigma_{hz,v}$ =0.0003 gon σ_d =0.001 m
Measuring Formwork	Input: station coordinates observations (hz-, v-angle, distance) Output: 2 x stake out points 1 x tolerance	$\sigma_{hz,v}$ =0.0003 gon σ_d =0.001 m

Parameter	Output parameter values
stdv	A: σ_x = 3.2 mm σ_y =3.2 mm σ_z = 3.1 mm B: σ_x = 3.1 mm σ_y =3.2 mm σ_z = 3.1 mm
tc	tc=14.5mm (T_M=6.6mm)

→ Adaption of the process model

5. Summary and outlook

- research activities related to quality assurance in building construction
- collaborative work between civil- and geodetic engineers, which places special emphasis on the interface between construction and geodetic processes
- process model and quality assurance concept for building the inner core of a high rise building
- In real time and in the planning phase

→ Extended process modell (e.g. alternative paths) to react on disturbances

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Thank you for your Attention!

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