Segment Documentation System SDS
Quality control in the segment production
AFTES 25th Nov. 2015; Loriol sur Drôme
Quality control in the segment production
What do we understand under quality control

- Is it to measure the segments?
- Is it to have the right concrete mixture for a specific segment type?
- Is it to assure that the right type of segment is available whenever needed?
- Is it to assure that the right processes are kept?
- Is it to deliver only segments to the tunnel that are fully acceptable?
- Or is it to document each lifecycle step of each segment?
Quality control in the segment production
What do we understand under quality control

It’s about all those topics - and much more.

And that with tens of thousands segments produced by piece-work.

And on the first look, one segment seems to be like the other.
Quality control in the segment production

What do we understand under quality control

But they are different
Quality control in the segment production

What do we understand under quality control

With SDS each segment becomes unique.
Quality control in the segment production
What do we understand under quality control

SDS knows, for example, the production date, the concrete batch ID and the user, that demoulded the segment, of each segment.

User ID 112
User ID 134
27.08.2015
15.07.2015
1307-150823
0807-150728
Quality control in the segment production

The segment quality starts prior to producing the segment

- Verifying the mould dimensions
- But not only distances are important, also the angle between two sides needs to be considered
- Sample segment production tolerances:

  - **Angular deviations**
    - 1.1 Border angle in longitudinal joints \( \pm 0.08^\circ \)
    - 1.2 Border angle in circumferential joints \( \pm 0.08^\circ \)
    - 1.2 Angles of longitudinal joint conicity \( \pm 0.02^\circ \)
  
  - **Linear deviations**
    - 2.1 Segment width \( \pm 0.5 \text{ mm} \)
    - 2.2 Segment thickness \( \pm 2.0 \text{ mm} \)
    - 2.3 Segment arc length \( \pm 1.0 \text{ mm} \)
    - 2.4 Inside radius (single segment) \( \pm 2.0 \text{ mm} \)
  
  - **Tolerances on a test ring**
    - 4.1 Outside diameter \( \pm 10 \text{ mm} \)
    - 4.2 Inside diameter \( \pm 10 \text{ mm} \)
    - 4.3 Outside circumference \( \pm 20 \text{ mm} \)
Quality control in the segment production
Laser tracker Industrial measurement System (LIS)
Quality control in the segment production
(LIS) 3D Quality Dimension check of moulds
Quality control in the segment production
(LIS) Geometrical Report

Actual-nominal comparison of the specified test criteria
Quality control in the segment production
(LIS) 3D Quality Dimension check of segments
Quality control in the segment production
(LIS) 3D Quality Dimension check of segments
Quality control in the segment production

(LIS) Virtual Ringbuild to verify the precise dimension of a ring
Quality control in the segment production

Processes, documentation and logistic

- The SDS is designed to have the software process matching 1:1 to the real production steps.
- If specific prerequisites are defined, SDS denies the further proceeding until all predefined parameters are fulfilled.
- Each production step is documented with a time stamp and an associated user.
- Documentation of the segment production and logistic support in one system – no need to transfer information between different data sources.
- Real-time data throughout the SDS Service span.
- Cost reduction thru minimizing discards, avoiding idle time in the production and on the construction site.
Quality control in the segment production

Process scheme

SDS.reinforcement
- Reinforcement production
  - Reinforcement
  - Moulding
  - Concreting
  - Demoulding
  - Store-in
  - Store-out

SDS.production
  - Segment production data

SDS.storage
  - Storage data

SDS.tunnel
  - As-built data
  - TBM Ring build

Data base
Quality control in the segment production
Process details / production

SDS.reinforcement
Reinforcement
Reinforcement production
Segment production data
SDS.tunnel
SDS.
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TBM Ring build
SDS.tunnel
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Quality control in the segment production
Process details / production

SDS.reinforcement

Reinforcement
Moulding
Concreting
Demoulding

Reinforcement production
Segment production data

Data base

Storage data
As-built data

SDS.storage
As-built data
TBM Ring build
SDS.tunnel
SDS.reinforcement
SDS.production
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SDS.production
Quality control in the segment production

Segment identification

- During moulding the SDS already assigned a unique segment name, but the identification was assured thru the mould label.
- After demoulding each segment receives its own identifier with its own, unique segment name
Quality control in the segment production

Damage management

- Segments with an identified damage are to be excluded from further processing or from delivery.
- The information shall be captured at the segment but being visible centralized for reporting and statistics.
- Pictures, linked to the individual segment, support the damage documentation.
- Repaired segments shall be integrated seamless in the normal segment processing, regardless where the damage has been detected.
Quality control in the segment production
Comprehensive documentation of all manufacturing steps
Quality control in the segment production

Logistic support

- To know always how many segments of which type are available.
- Assembling of delivery notes.
- Locating of single segments in the storage.
- Optimizing storage utilization.
- Allocating of best suitable segments to ordered rings.
- Traceability of segments throughout the delivery chain.
- Semi-automated ring ordering based on the TBM navigation system ring sequencing forecast (applicable with VMT TUNIS).
Quality control in the segment production

Process details / storage

Reinforcement

Moulding

Concreting

Demoulding

Store-in

Store-out

TBM Ring build

Store-in

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SDS.tunnel

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SDS. tunnel

SDS. tunnel
Quality control in the segment production

Logistic support / black-box storage

- To know always how many segments of which type are available.
- Assembling of delivery notes.
Quality control in the segment production

Logistic support / managed storage

- To know always how many segments of which type are available.
- Generating of delivery notes.
- Locating of single segments in the storage.
- Optimizing storage utilization.
- Allocating of best suitable segments to ordered rings.
- Traceability of segments throughout the delivery chain.
- Semi-automated ring ordering based on the TBM navigation system ring sequencing forecast (applicable with VMT TUNIS).
Quality control in the segment production
Process details / managed storage
Quality control in the segment production

Process details / managed storage
Quality control in the segment production
Process details / managed storage

Stack Ringpart 1

Stack Ringpart 2
Quality control in the segment production

Process details

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As-built data
Quality control in the segment production

Reporting / statistics

- Real-time information for all aspects.
Quality control in the segment production

Reporting / statistics

- Real-time information for all aspects.
- Generating of daily basic reports with a few clicks.
- Detailed report for each segment
- Detailed concrete report for information from the concrete batching plant linked to each segment or to sets of segments
- Summary reports
- Statistics for produced, stored and delivered segments.
- Export of collected information to follow-up information system.
Quality control in the segment production

Reporting / statistics

- Segment reports
Quality control in the segment production

Reporting / statistics

Statistics
Quality control in the segment production
Reporting / statistics

- Delivery notes
- Concrete delivery notes
Quality control in the segment production
Comprehensive documentation of all manufacturing steps
Please feel free to ask questions

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