



Real Time Quality Assurance Indexes for the Residential Houses Construction Processes

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Commission 10

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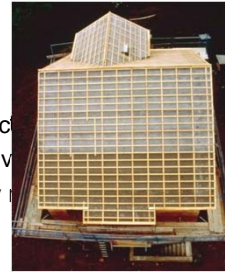
Structure

- **Introduction**
 - Motivation
 - Project QuCon
 - Quality Model in QuCon
- **Real Time Quality Assurance Indexes**
 - Basic Idea
 - Crafts, Check Items, Checkpoints
 - Weighting Factors of Checkpoints
 - Scoring of Checkpoints
- **Conclusion and Outlook**

Introduction

Motivation

- Quality control gets more and more important in construction
- Small and medium enterprises (SMEs) are the most active in the residential houses sector: problems to build up a quality management system (too expensive and time-consuming)



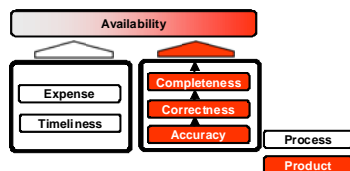
Source: Institute of Construction Management, University of Stuttgart

Project QuCon

- EU-project "Development of a Real Time Quality Support System for the Houses Construction Industry" (**QuCon**), (Partners are from Germany, Cyprus)



Quality Model in QuCon

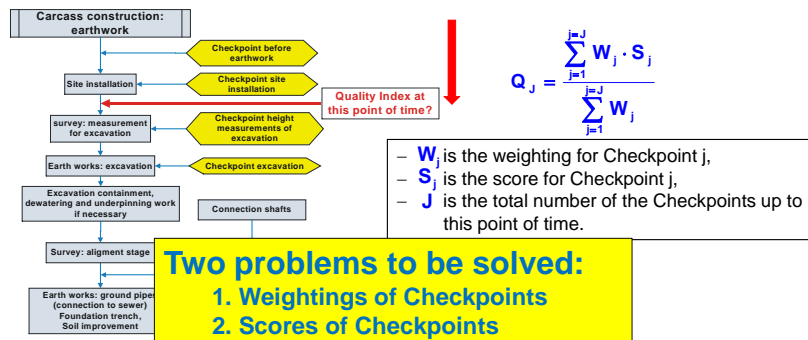


Algorithms is developed with respect to Quality Model.
Availability is the Overall Quality Assurance Index!

Real Time Quality Assurance Indexes

Basic Idea

- Quality control in construction industry is realized by site inspection, time of the inspections can be defined as Checkpoints (critical points, yellow box in figure)
- Determine the scores (=availability) and weightings of the Checkpoints
- Determine the **Real Time Quality Assurance** Indexes as the **weighted mean** of the scores of Checkpoints (example)

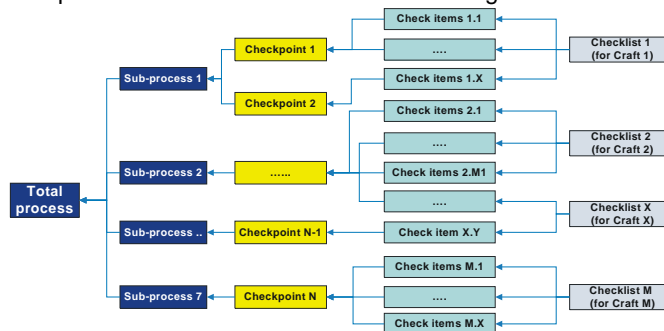




Real Time Quality Assurance Indexes

Crafts, Check Items, Checkpoints

- **Crafts:** Task groups (e.g. structural, electrical, sanitary, painting work etc.)
- **Check Items:** For the quality control of different crafts, there are checklists, that contain many check items, which should be checked by inspector (contracts, standards, literature etc.)
- **Checkpoints:** Time of the site inspection during the construction processes, One Checkpoint can contain check items that belong to different crafts



Real Time Quality Assurance Indexes

Weighting of Checkpoints

1. Define the weightings of crafts (e.g. according to cost)
2. Determine the weightings of check items
3. Determine the weightings of Checkpoints

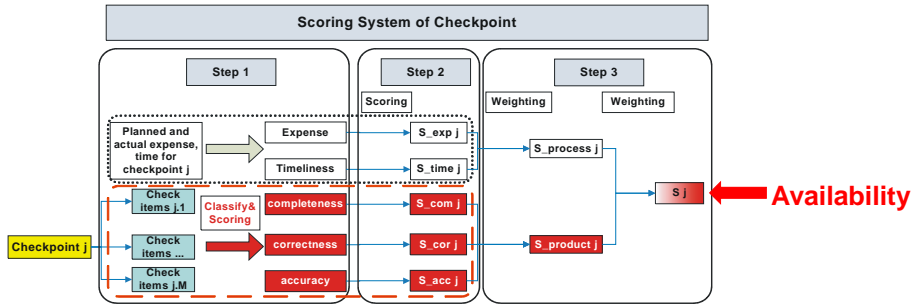
Crafts No.	Crafts	Crafts Weightings	Number of Check Items	Check Items Weightings[%]
1	Earthwork	3.6	6	0.6
2	Structural Work	31.2	63	0.4952
..		
6	Electrical Work	3.8	14	0.2714
7	Heating and Sanitary Work	12.9	40	0.3225
.....				
17	Floor Covering	4.2	6	0.7000

$$W_{\text{checkpoint for exvaction}} = 6 \cdot 0.6\% + 4 \cdot 0.4952\% = 5.58\%$$

The 1. Problem: Weightings of Checkpoints is solved!

Real Time Quality Assurance Indexes

Scoring of Checkpoints

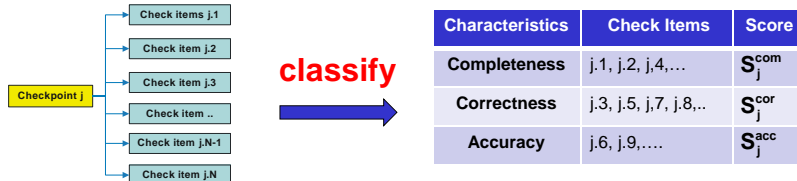


- **Step 1:** Classify and scoring of check items and input planned and actual expense and time
- **Step 2:** Scoring of product- and process-related quality characteristics
- **Step 3:** Determination of overall quality indexes

Real Time Quality Assurance Indexes

Scoring of Checkpoints

Scoring of Product-related Quality Characteristics



- Classify the check items to: for completeness, for correctness, and for accuracy (only for the high-precise)
- The S_j^{com} , S_j^{cor} and S_j^{acc} are the scores of product quality, they are **weighted mean** of the according check items, they are between 1 and 5*

$$S_j^{com} = \frac{\sum_{n=1}^{n=N^{com}} W_{n,j}^{com} \cdot S_{n,j}^{com}}{\sum_{n=1}^{n=N^{com}} W_{n,j}^{com}}$$

$$S_j^{cor} = \frac{\sum_{n=1}^{n=N^{cor}} W_{n,j}^{cor} \cdot S_{n,j}^{cor}}{\sum_{n=1}^{n=N^{cor}} W_{n,j}^{cor}}$$

$$S_j^{acc} = \frac{\sum_{n=1}^{n=N^{acc}} W_{n,j}^{acc} \cdot S_{n,j}^{acc}}{\sum_{n=1}^{n=N^{acc}} W_{n,j}^{acc}}$$

*1 represents fail, 2 is the threshold, 5 is maximum score, 3 and 4 will have a check-specific range of values



Real Time Quality Assurance Indexes

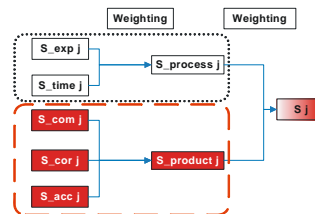
Scoring of Checkpoints

Scoring of Process-related Quality Characteristics

by comparing the actual and planned expense and time

$$S_j^{exp} = \frac{E_j^b}{E_j^a} \quad S_j^{time} = \frac{T_j^b}{T_j^a}$$

- E_j^a is the actual expense and E_j^b is the budget between checkpoint j-1 and j
- T_j^a is the actual time consumption and T_j^b is the planned time consumption between checkpoint j-1 and j
- In this way, the S_j^{exp} and S_j^{time} should be **around 1**. The bigger they are the better is the quality.



Real Time Quality Assurance Indexes

Scoring of Checkpoints

Scoring of process/ product/ Overall Quality Indexes

by weighted mean of quality characteristics

$$S_j = \frac{\frac{S_j^{com}}{5} \cdot W_j^{com} + \frac{S_j^{cor}}{5} \cdot W_j^{cor} + \frac{S_j^{acc}}{5} \cdot W_j^{acc} + S_j^{exp} \cdot W_j^{exp} + S_j^{time} \cdot W_j^{time}}{W_j^{com} + W_j^{cor} + W_j^{acc} + W_j^{exp} + W_j^{time}}$$

↑ Product-related quality ↑ Process-related quality

- S_j^{com} , S_j^{cor} and S_j^{acc} are normalized (divided by 5), so that they are also around 1
- W_j^{com} , W_j^{cor} , W_j^{acc} , W_j^{exp} , W_j^{time} are the weightings for the quality characteristics

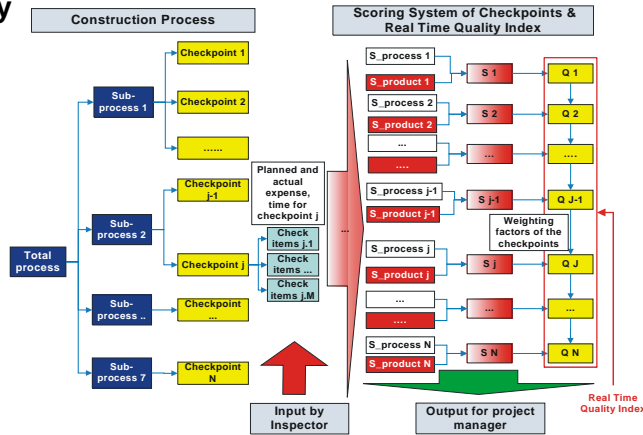
The 2. Problem: Score of Checkpoints is solved!

$$Q_J = \frac{\sum_{j=1}^{j=J} W_j \cdot S_j}{\sum_{j=1}^{j=J} W_j}$$



Real Time Quality Assurance Indexes

Summary



By using the checkpoints and scoring system, the reasonable and necessary action can be carried out, the quality of the construction can be improved and assured in real time.



Conclusion and Outlook

- An application-oriented Quality Model for the residential houses is defined.
- The algorithms of real time quality assurance indexes is developed with respect to this Quality Model.
- The research results is implemented in a web-based software, the prototype is ready-to-use.
- Checkpoints, check items, weighting system should be upgraded by feedback from the end users.
- The developed QuCon scoring system is not restricted on residential houses. (Application to other construction processes: high-building, road construction etc.)



Thank you very much for your attention !

CONTACTS

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Real Time Quality Assurance Indexes

Scoring of Checkpoints

Scoring of process/ product/ Overall Quality Indexes

• **One Score for Product Quality:**

Weighting:
$$S_j^{product} = \frac{\frac{S_j^{com}}{5} \cdot W_j^{com} + \frac{S_j^{cor}}{5} \cdot W_j^{cor} + \frac{S_j^{acc}}{5} \cdot W_j^{acc}}{W_j^{com} + W_j^{cor} + W_j^{acc}} \quad (W_j^{com} + W_j^{cor} + W_j^{acc} = 1)$$

$$W_j^{com} / W_j^{cor} / W_j^{acc} = \frac{\sum_{n=1}^{n=N_j^{com}} W_{n,J}^{com} / \sum_{n=1}^{n=N_j^{cor}} W_{n,J}^{cor} / \sum_{n=1}^{n=N_j^{acc}} W_{n,J}^{acc}}{\sum_{n=1}^{n=N_j^{com}} W_{n,J}^{com} + \sum_{n=1}^{n=N_j^{cor}} W_{n,J}^{cor} + \sum_{n=1}^{n=N_j^{acc}} W_{n,J}^{acc}}$$

• **One Score for Process Quality:**

$$S_j^{process} = \frac{S_j^{exp} \cdot W_j^{exp} + S_j^{time} \cdot W_j^{time}}{W_j^{exp} + W_j^{time}}$$

Weighting W_j^{exp} , W_j^{time} should be defined by user.

