Adaptive modularized constructions made in a flux

Tolerance-free series production of high-performance concrete elements through transient interactive coupling of design and production

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Motivation

State of the art

- Out of tolerance precast concrete modules have to be scrapped or reworked

Problems

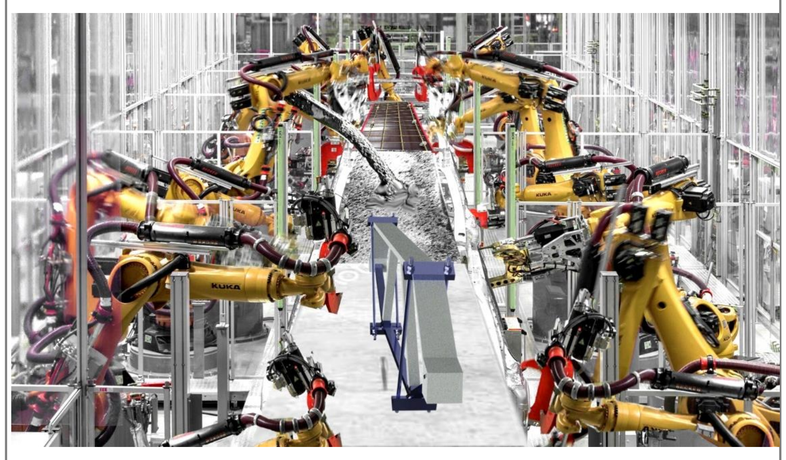
- For modular structures tight tolerances are required
- This leads to a high rate of scrap and rework

Target state

- Scrap and rework from dimensional deviations of parts is avoided

Approach

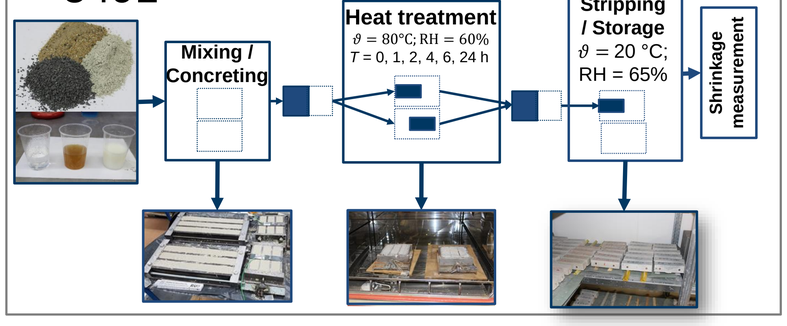
- Selective assembly of modules in a structure to compensate dimensional deviations



Methods

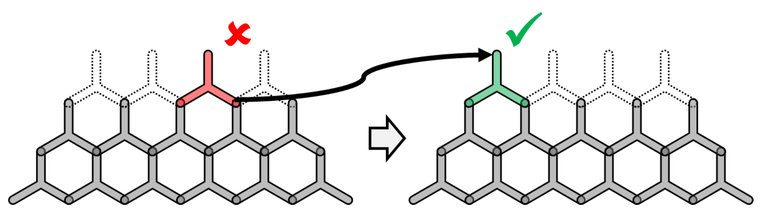
Shrinkage of rapid heat treated concrete

- High-performance concrete based on binder Nanodur Compound 5491



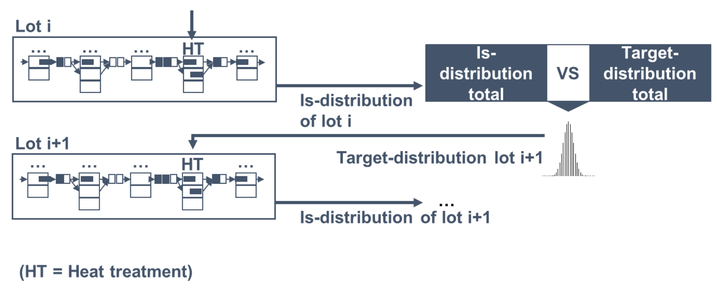
Selective assembly

Selectively arrange components in the structure to compensate for dimensional deviations.



Adaptive manufacturing

Reactively adjust dimensions from part to part for optimize the basis for selective assembly.



Results

Shrinkage of rapid heat treated concrete

- Reduction of ε_{cs} by a factor of 3
- Multidimensional modeling of ε_{cs}

$$\text{Slabs } (\rho = 1.8/3.1)\ \varepsilon^*_{cs} \approx 1 - \exp\left(\beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \beta_3 \cdot X_1^2 + \beta_4 \cdot X_1 \cdot X_2 + \beta_5 \cdot X_2^2 + \beta_6 \cdot X_1^2 \cdot X_2 + \beta_7 \cdot X_1 \cdot X_2^2\right)$$

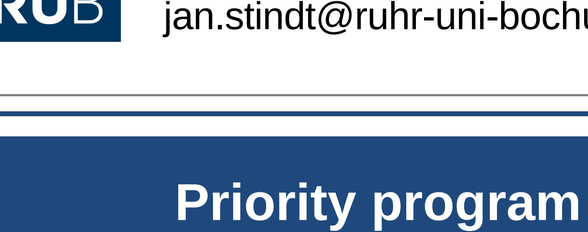
β_i	c	d
β_0	0.015403	0.010747
β_1	-0.027207	-0.036049
β_2	0.094462	0.086863
β_3	0.0076839	0.011038
β_4	-0.00060466	-0.0052499
β_5	-0.010408	-0.0094771
β_6	-0.0081902	-0.0054415
β_7	0.0037343	0.003121

Selective assembly

- The effect of dimensional deviations of the modules can be quantified
- For small structure optimal solutions can be calculated

Adaptive manufacturing

- Production control concept to react to dimensional deviations
- Quality of the resulting structure can be increased



Publications

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[2] Mark, P.; Lanza, G.; Lordick, D.; Albers, A.; König, M.; Borrmann, A.; Stempniewski, L.; Forman, P.; Frey, A.; Renz, R.; Manny, A., Stindt, J.
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[3] Frey, A.; Stindt, J.; Lanza, G.; Mark, P.
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