DESIGN PROCESS STABILITY: OBSERVATIONS OF BATCH SIZE, THROUGHPUT TIME AND RELIABILITY IN DESIGN

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AGENDA

- Background and gap
- Data and methods
- Results
- Discussion and conclusions

BACKGROUND AND GAP

- Batch size (BS) and throughput time (TT) reduction are recurring concepts in the lean construction literature related to the Last Planner© System (LPS).
- BS, TT and planned percentage completed (PPC) are often used to reduce variability and improve flow and reliability in work processes.
- Scholars have attempted to reduce design variability through lean design management (LDM) and agile methods, but very few studies have analysed the interaction of these parameters in the design process.
- Although several design-related studies of PPC have been published, very few are related to BS and TT in design.
- The purpose of this empirical study was to examine connections between BS, TT and PPC in design process.

DATA AND METHODS

- The research data used was gathered from a single case study consisting of seven construction sites in Finland
- Case study was client-driven subway project consisting of five stations, one depot and a railway line connecting them, with its own design teams consisting of different design disciplines.
- 6/7 of the construction sites used agile methods (Scrum) and the Last Planner System (LPS) among the structural design teams, while the one site was managed with traditional methods, and thus research data was not available from that site.
- 156 structural engineers from several structural engineering companies that operate in the Nordic countries. The structural engineers worked on the project as teams of 15 to 25 people.

DATA AND METHODS

- Design work was broken down to a workable backlog of design tasks, for which task-specific responsible persons were appointed.
- These tasks were pulled from the backlog into the two-week design periods called "sprints."
- The progress of the work was monitored over a two-year period using Jira software, where design tasks were managed based on Scrum principles.
- After the orientation phase, which was done in physical space, latter bi-weekly meetings were held in virtual space, with teleconference tools.
- Structural designers worked with other disciplines, such as architects and MEP designers, in design coordination meetings in project's "Big Room".
- Only structural engineers used the Scrum and LPS methods in this case project.

DATA AND METHODS

- The main data used in this study contains the designers' workload estimates for design tasks, PPC values (measured biweekly during the design phase) and measured TT's for design tasks.
- Task-specific workload estimates were exported from the Jira software to an Excel spreadsheet.
- PPC values were calculated using sprint reports generated by the Jira software by calculating completed and non-completed tasks during the sprint and dividing their ratio by the PPC percentage.
- TT's were calculated to the accuracy of one "sprint".
- Workload estimates were measured in hours per task, PPC values were measured as percentages and design task TT's were measured as two-week work periods (sprints nr 1, nr 2, nr 3, etc.).

RESULTS – BATCH SIZE OF THE DESIGN TASKS

Average BS's of the design tasks for the two-year follow-up period; the upper limit (40 hours) of the target BS is shown. As the figure makes apparent, only one site exceeded the target-specific maximum number of hours per task in the first year; in the second year, all sites fell below the target, and half the sites remained at less than 20 hours per planning task.
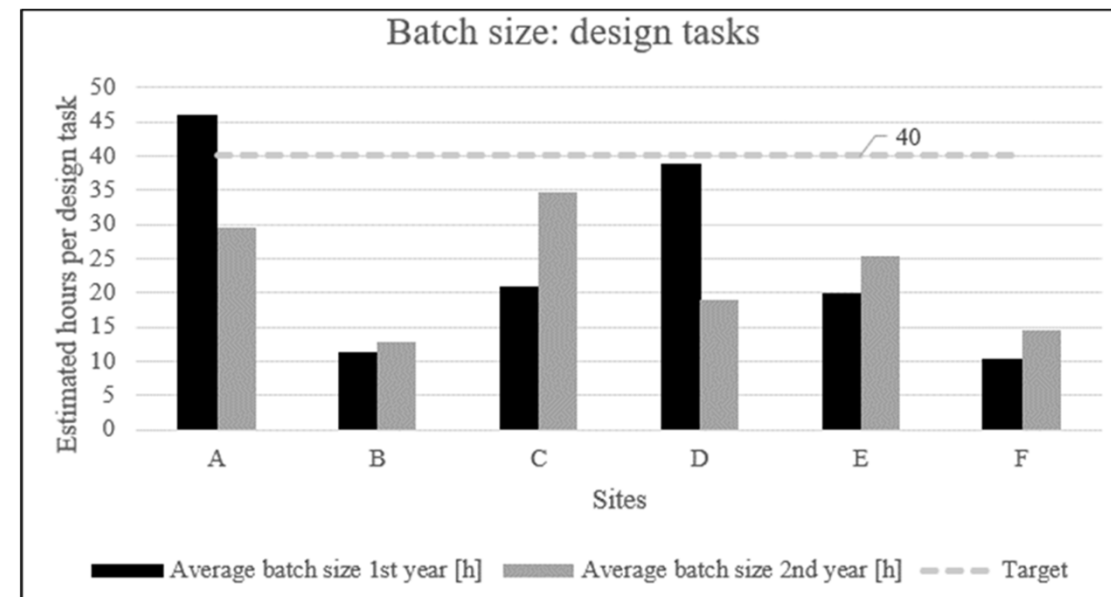

Figure 1. Estimated BS's of design tasks.

RESULTS – THROUGHPUT TIME OF DESIGN TASKS

- Sites E and F clearly differed from the other sites by having faster task TT's.
- Sites C and D had the longest TT's
- Sites A and B and were located between the two groups.
- For the TT, we noted a statistically significant difference in the results of sites E and F (group 1), sites A and B (group 2) and sites C and D (group 3).
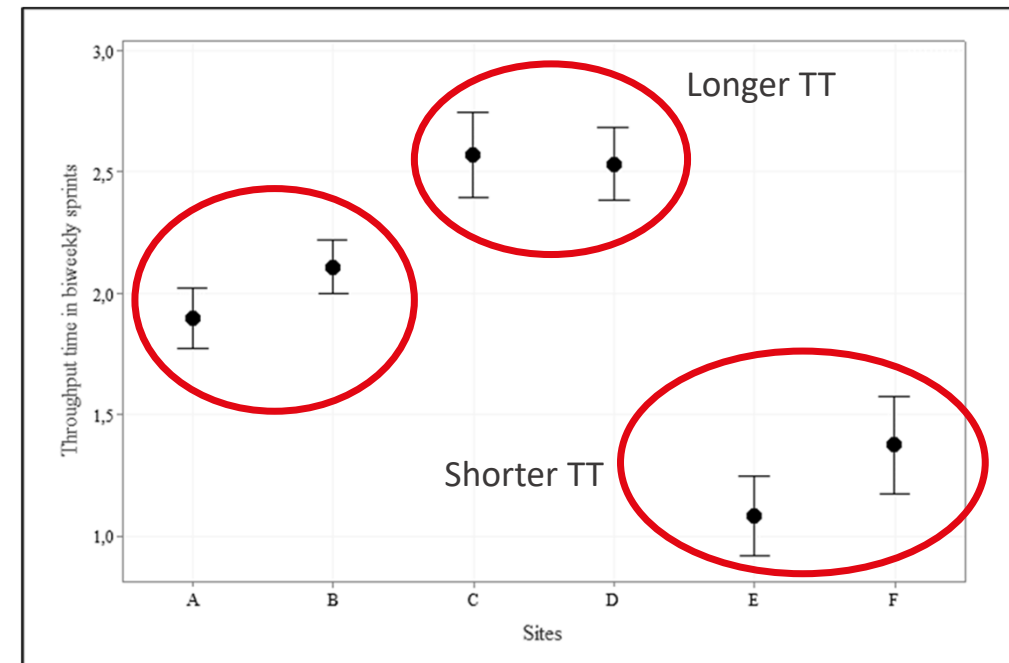

Figure 2. Analysis of variance, interval plot of TT in years 1 and 2.

RESULTS – SUMMARY

- Sites E and F differed from other sites with higher PPC values and faster TT's.
- Sites C and D, where PPC was lowest, also had the slowest TT's.
- Sites B and F were clearly lower than the other sites in both years, while for C and E BS increased in the second year.
- Sites E and F were evidently in low level in BS and TT as well in high level in PPC.

Table 1. Summary table of key metrics. PPC = planned percentage completed, SD = standard deviation, CV = coefficient of variance, LV = low variability, MV = moderate variability and HV = high variability

Site	Reliability				BS's in design tasks				Stability of design process	
	PPC ave. of 1st year	PPC ave. of 2nd year	SD of PPC 1st year	SD of PPC 2nd year	Ave. BS 1st year [h]	Ave. BS 2nd year [h]	SD in BS 1st year	SD in BS 2nd year	CV 1st year	CV 2nd year
A	38.2	56.1	37.2	23.3	45.9	29.4	88.8	46.2	1.93 (HV)	1.57 (HV)
B	26.5	58.9	26.2	24.6	11.2	12.9	12.4	8.2	1.11 (MV)	0.64 (LV)
C	13.3	52.2	14.8	22.3	20.8	34.6	13.8	32.4	0.66 (LV)	0.94 (MV)
D	24.0	51.9	26.4	24.1	38.8	19.0	59.7	26.8	1.54 (MV)	1.41 (HV)
E	37.7	71.2	36.1	14.2	19.7	25.4	13.4	27.2	0.68 (LV)	1.07 (MV)
F	35.3	71.3	32.4	19.0	10.3	14.4	94.8	11.7	9.20 (HV)	0.81 (MV)

Figure 3. Summary table of key metrics.

DISCUSSION AND CONCLUSIONS

Adding BS and TT to LPS sessions could open better perspective to the design process and the flow of design. Differences between design teams can be measured by relatively simple methods and with existing digital tools.

Future research topics:
- Find out what is optimal BS for design work (different phases / disciplines)
- How production methods based on small BS (i.e., Takt) affects design BS's and TT's.

Limitations:
- Only one discipline involved
- Data only from detailed design phase
- No evidence of a causal relationship between BS, TT and PPC

THANK YOU!

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