TO MEASURE WORKFLOW AND WASTE. A CONCEPT FOR CONTINUOUS IMPROVEMENT

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ABSTRACT

Measuring workflow applied in a strategy for continuous improvement can be an imperative method for making production of buildings leaner. This paper sums up a research project, which has spanned 3-4 years, aiming to find a method to measure workflow with a continuous improvement approach. Two main methods are documented, one based on data gathering by observation and one by individual reports by the workmen. Workflow in site production is conceptualized as "all types of work conducted within available working hours – except obstructions such as downtime, rework and other forms of waste subtracted". To complement the findings from the research project, the paper further addresses the method to measure workflow as handover of work between trades, which lays the foundation for the Last Planner System (LPS). The research project delivers extensive empirical material as to how time is used on construction sites. The empirical results show a notable amount of waste in several construction projects.

The paper contributes to the understanding of workflow and waste in the production of buildings, and for practical purposes, methods for measuring workflow and observable waste are documented, in order that they can be applied in continuous improvement work at construction sites.

KEYWORDS

Workflow, measurement, continuous improvement, waste, construction

INTRODUCTION

This paper reports from a research project on workflow, and builds on a number of earlier works concerning the definition and measurement of workflow (Bølviken and Kalsaas 2010; Kalsaas and Bølviken 2011, Kalsaas 2010, 2012, 2013. A number of potential methods to measure workflow are addressed in Bølviken and Kalsaas (2011), and three of these are focused in the paper.

Workflow in construction is discussed in Kalsaas and Bølviken (2010), in relation to Shingo's (1988) flow concept from manufacturing, which makes a distinction between flow in process, and in operations. Flow in operations would mean the flow of work, whilst flow in process would be the flow of materials. Whilst Shingo (op cit.) claims that within manufacturing, flow in process must weigh heavier than flow in

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operations (workflow), Kalsaas (2013) argues that this lean philosophy might be fruitful in manufacturing but is not necessarily so in construction due to the different characteristics of construction work compared to manufacturing. Some main differences is related to different interdependencies between the trades and/or subcontractors and that construction is still to a large extent craft based, hence the understanding of workflow is mainly based on Shingo's dimension of operation. Through improved work methods, and reduced variation in work, a higher degree of *predictability* is expected to be achieved in workflow, which could, also improve the process flow.

The aim is moreover to measure workflow within each trade and discipline, not just between the trades as in handover of work. Further, workflow cannot be understood without, at the same time, having an understanding of waste, and vice versa (Kalsaas 2013). Waste in this site production context is understood broadly as downtime and rework, and related to value we are in the domain of process value (op cit.). Conceptualization of workflow is inspired by the OEE (Original Equipment Efficiency) concept from manufacturing (op cit.) and is conceived as made up of three different dimensions of smoothness, quality and intensity. Smoothness is expressed through the absence of downtime: quality through the absence of rework; and work intensity is assumed constant for measuring periods of approximately one week's duration (op cit.). Work-flow in construction is defined by Kalsaas (2013, p. 5) as «all types of work conducted within available working hours – except obstructions such as downtime, rework and other forms of waste subtracted. This understanding of flow is somewhat different from the focus in LPS (Ballard 2000), reliable handover of work between trades, which we can interpret to be closer to process flow in Shingo's term. That LPS-based understanding of workflow is also address in the paper. The main question under scrutiny in the paper is: **How to measure workflow in project-based production?**

The discussion on how to operationalize workflow has led us in the direction of integrating the dimensions of smoothness, quality and work intensity (Kalsaas 2013). For practical reasons, work intensity is assumed constant during the measuring periods. Observable waste, except rework, relates to the smoothness dimension, while rework relates to its quality. The most important point in the developed measuring method is to direct the focus towards continuous improvement, for purposes of analysis, however data collection also has its merits for enabling benchmarking, if applied with great care. When applied in continuous improvement the idea is to make measurements at different stages in individual projects, and discuss the findings with the workmen to identify causes of waste and improvements to be done. The aim is to understand what goes on at a building site, and use this as input to a continual process of improvement, based on the collaboration and involvement of skilled workers, across disciplines, and should not to be confused with Taylorism inspired time studies addressing how to intensify work.

The data, which forms the basis for the summary, was collected through observation on building sites in six different projects (2010-2012) in Norway, through activity studies. In one of the measuring methods, based on observation, time studies of activities are applied. The other method of measurement is based on questionnaire self-reports from different work teams.

First, the principles of the Last Planner system are accounted for. The work of earlier time studies are then presented, where direct work, value adding work and similar items are categorised based on earlier activity studies in the construction industry. A discussion of data follows, as well as the measuring method, evaluating the measuring method according to how it can contribute to continual improvement work. Finally, follows a discussion of the new measuring method currently being tested.

LAST PLANNER SYSTEM AND FLOW

The aim of the Last Planner system (LPS) is to achieve increased control of production in construction, through increased predictability in workflow, and thus reduced waste linked to variability. Ballard (2000) describes the LPS system as a work flow control system, which involves the coordination of the flow of design, supply and installation through production units. In practice, this method has appeared to work better than traditional methods of planning. The understanding of flow, which is at the foundation in Last Planner System, is understood as "the movement of information and materials through a network of production units, each of which processes them, before releasing to those downstream" (Kim and Ballard 2000; Lean Construction Institute 1999). In 2014 Lean Construction Institute[1] define workflow as "the movement of information and materials through networks of interdependent specialists". However, different expressed, we can interpret those definitions as "handoffs of work between trades".

The Last Planner System is closely linked to the continuous flow perspective in Toyota production system and in Koskela's (2000) work on the TFV theory (Ballard 2000), which is considered a production theory. Koskela's conceptualisation of production consists of three complementary elements; transformation through processing at workstations, flow *between* workstations, and the creation of value for customer or end user.

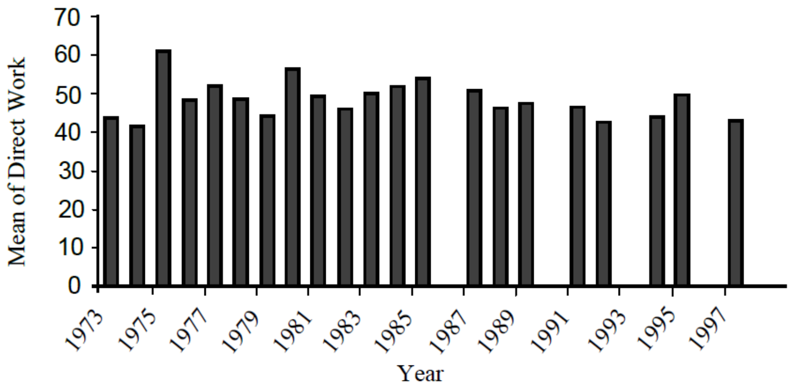
EARLIER TIME STUDIES ON THE SHARE OF DIRECT WORK

The purpose of conducting time studies is usually to map what goes on at a building site, with regard to using this as a starting point for improvement measures. Gouett et al. (2011) concluded that time studies correlate well with improved shares of direct work, when repeated studies are done on a single project, giving an indication of its usefulness. A number of time studies have mapped the share of direct work on sites. The challenges presented by comparisons are, however, significant as different studies makes use of different categories and definitions of direct work and waste. Heineck (1983) found in a literature study that a number of authors agreed on an average level of non-productive time of around 30 % in the construction industry, where, for example Forbes (1977) claimed the rule would be 1/3 value adding work, 1/3 indirect work and 1/3 non-productive work. Maybe not well documented, but Mossman (2009) claims empirical evidence shows that waste constitutes above 49.6 % within building time, where he defines waste as anything which is not necessary to

[1] http://www.leanconstruction.org/

create value for customer or end user. Serpell et.al (1997) in Josephson and Björkman (2013) found 47 % productive work and 25 % of the time made up of waiting, idle time, travelling, resting, and rework. Allmon et.al (2000) examined a collection of 72 construction projects in Austin Texas – USA, from 1973-1997, and found that direct work lies in the interval 41-61 %, as illustrated in Figure 1. Their definition of direct work includes activities such as inspection, clean-up and putting up safety equipment.

In a Swedish study by Strandberg and Josephson (2005), direct value adding work constituted 17.5 % of the work time, while indirect work, material handling and work planning in total amounted to 45.4 %. Waiting and unexploited time corresponded to as much as 33.4 % of the workers time. Alinaitwe et.al (2006) found that 40 % of construction work is productive work, where this consists of making the building grow, preparation of materials, handling materials at the workplace and clean-up/unloading, and 33 % non-value adding time (being absent, materials transfer, not working, walking around, waiting and other categories of downtime). In a survey done by Skanska Norway (Thune-Holm and Johansen 2006) the categories productive time, indirect time, change-over time and personal time were used. In four building projects the productive time of carpenters was found to be 59.4, 70.7, 70.2 and 50.7 %, while for concrete workers 65.1 and 69.5 % productive time was found. The method used in this survey is, however, significantly rougher than the method which forms the foundation of this paper. Diekmann et al. (2004) goes through a series of American studies, of which three were studies of steel erection jobs. The results for three projects showed, respectively, 32 %, 11 %, and 10 % value adding time, and 60, 57 and 67 % non-value adding time. Josephson and Björkman (2013) found an average of 13.2 % direct work for plumbers, based on a survey of 8 projects in Scandinavia. His definition of direct work did, however, only include the categories assembling and prefabrication on site, thus making comparisons difficult. We see a degree of variation in results, in the literature, partly on account of different ways of categorizing direct work and waste. In addition we observe that different trades have different levels of direct work.



Figur 1: Direct work in 72 construction projects in USA, distributed according to year (Allmon et.al, 2000)

Josephson and Björkman (2013) argues that it is challenging to compare results from work sampling studies over longer time spans without considering changes in working conditions, which is an important aspect when we evaluate validity. They claim that the researches are aimed for different use, and papers lack sufficient information on how data are collected, for example how the observers are trained and how they have interpreted situations. Different definitions and categorization is of course also challenging for validity when we compare the different findings.

MEASUREMENTS OF WORKFLOW IN CONSTRUCTION

Observation of activities was used as the method of gathering data for measurement on six different projects within construction. During observation, templates of activity categories were applied to sample data, which were later aggregated to a total of six categories: *Direct work*: direct work, inspection/control, crane operation and similar**.** *Observable waste*: direct work – remediation of mistake, direct work – remediation of mistake from a different team/trade, waiting/downtime, other personal time. *Planning, coordination and HSE*: safety work (HSE), planning meetings, coordination and problem solving on site, HSE – meetings. *Indirect work, logistics*: reception of materials and procedures connected to this, unpacking of materials, collecting of materials to work site with trolley etc., collection of materials within ca. 12 m, carrying of waste to container, displacement between worksites, moving and collecting tools, moving to/from saw bench in container and similar. *Indirect work, other*: rig up and take down, clearing to gain access to worksite, clean up after work and general clearance. *Necessary personal time*: coffee and lunch break, necessary personal time. Each registration represents a five minute period on site. For further details, see Kalsaas (2013).

The observation template developed somewhat over time, and, for the purposes of comparing results, some categories are aggregated in order to achieve consistency in this paper. The category direct work thus also contains value adding demolition and necessary «stand by». On the same basis, the category weather-related rigging was merged with rig up and take down. Compensatory work and problem solving and other administrative work were aggregated with coordination on site, and changed name to coordination and problem solving. The category other was aggregated with necessary personal time.

OBSERVATION METHOD

Table 1 shows results, distributed according to project, and aggregated for all projects. The category *direct work* aggregated on the construction projects amounted to by between 41 % and 59.4 %, with an average of 49.6 %. To this amount, 2.1 % crane operation and similar, as well as 1.1 % inspection/control has been added. Earlier time studies points at the total of direct work in the construction industry being found in the region of 18-61 %, with an emphasis in around the region of 40-45 %, including all trades. In other words, it would seem that the total of results in this survey is somewhat above the share of value adding work found in the literature.

Observable waste constitutes 9.9 % in average, and the variation lies in the interval of 4.6 to 15 %, where only one project shown more than 8.3 %. This category is referred to in detail in table 2. Amongst the individual projects, *shopping centre* shows the smallest amount of *direct work*, with 41 %, and the highest amount of *observable waste,* 15 %. Additionally, workflow is calculated for each project according to the conceptualized formula of workflow earlier mentioned, which is calculated as; "100% (man hours at employer's disposal – Wasted time / Man hours at employer's disposal" (Kalsaas 2013).

The projects measured show large variations in results. This is however not very surprisingly; different trades are observed in several of the projects, teams could be performing differently and according to reports, some teams were conducted to the study because of challenges or low performance. In two out of five weeks of observation on the shopping center which had the highest amount of waste (15%), the researcher was following a team which was performing poorly with a squad leader who was not showing initiative, and it appeared to be a lot of unproductive time.

Table 1: Overview of aggregated results on different projects

	Secondary school 1; carpenter	Apartment/business/garage; carpenter, electrical	Rehabilitation/facade; bricklayer	Secondary school 2; concrete/ iron	Apartment/garage; carpenter, plumber	Shopping center; concrete/ iron	Aggregated result
Number of registrations	1678	2715	708	3525	1267	6750	
Direct work (%)	59.4	54.1	52.8	57.4	49.6	41.0	49.6
Observable waste (%)	4.6	5.5	6.9	7.4	8.3	15.0	9.9
Planning, coordination and HSE (%)	6.0	11.0	3.0	13.3	15.4	15.3	12.7
Indirect work, logistics (%)	8.3	11.9	6.2	9.7	11.2	11.6	10.6
Indirect work, other (%)	2.8	7.0	8.8	2.0	4.8	7.2	5.5
Necessary personal time (%)	18.9	10.5	22.3	10.3	10.7	10.0	11.7
Man hours (hours)	139.8	226.3	59.0	293.8	105.6	562.5	1386.9
Observable waste (hours)	6.4	12.4	4.1	21.7	8.8	84.4	137.3
Calculated workflow (%)	95.4	94.5	93.1	92.6	91.7	85.0	90.1

In Table 2 below, categories of *observable waste* are shown in subcategories. *Other personal time* accounts for 60.3 % of the observable waste in total, *waiting/downtime* represents 32 %, and rework counts for 7.6 %. Rework involves correcting faults, both, of one's own making, and those of others. We find a large portion of rework in the secondary school (29.5 %) and apartment/garage projects (27.6 %), confer Table 2.

Table 2: Distribution of *observable waste*

	Secondary school 1; carpenter	Apartment/business/garage; carpenter, electrical	Rehabilitation/facade; bricklayer	Secondary school 2; concrete/ iron	Apartment/garage; carpenter, plumber	Shopping center; concrete/ iron	Aggregated result
Number of registrations	1678	2715	708	3525	1267	6750	
Observable waste, %	4.6	5.5	6.9	7.4	8.3	15	9.9
Rework (%)	29.5	14.0	0.0	3.5	27.6	4.3	7.6
Waiting/downtime (%)	30.8	7.3	4.1	32.7	7.6	39.5	32.0
Other personal time (%)	39.7	78.7	95.9	63.8	64.8	56.1	60.3

Table 3 presents an overview of results, distributed across the different trades. Plumber stands out as the trade which has the smallest amount of *direct work* with 31.5 % and a relatively high *observable waste* of 11.7 %. The survey by Josephson and Björkman (2013) did, however, only show 13.2 % direct work for plumbers, which suggest that this trade will perform with a lower share of direct work. However it is a small data samle in our study. A high share of direct work is found for carpenters, something which is also observed in the survey done by Skanska. The highest amount of waste was observed with concrete/iron workers, who had a share of 12.4 %. Concrete/iron workers is the trade with the highest amount of observable waste in our study.

Table 3: Overview of aggregated results in different construction trades

	Plumber; Apartment/garage	**Concrete/ iron;** Secondary School 2, Shopping center	**Bricklayer;** Rehabilitation/facade	**Electrical;** Apartment /business/garage	**Carpenter;** Secondary School 1, Apartment /business/garage, Apartment/garage	**Aggregated result**
Number of registrations	349	10275	708	276	5035	
Direct work (%)	131.5	46.6	52.8	50.7	56.5	49.6
Observable waste (%)	11.7	12.4	6.9	4.3	5.6	9.9
Planning, coordination and HSE (%)	20.9	14.6	3.0	14.5	9.6	12.7
Indirect work, logistics(%)	19.8	10.9	6.2	12.7	10.0	10.6
Indirect work, other (%)	6.6	5.4	8.8	6.2	5.1	5.5
Necessary personal time (%)	9.5	10.1	22.3	11.6	13.3	11.7

SELF-EVALUATION METHOD

Table 4 shows the results of the self-evaluation for the projects in which the method was implemented. A total of 149 questionnaires was collected from the projects which were apartment/business/garage (119), apartment/garage (21), and rehabilitation façade (9). Based on the sum of hours of waste, accounted from operators, 108.9 hours, and the available working time for the operators, 1142.8 hours, the self-evaluated waste is calculated to be 9.5 % in total, based on an 8 hour work-day subtracted 20 minutes to fill out the form. This has to be seen in connection with the average observed waste from the projects which the self-evaluation method was implemented, which comes at 6.5 %. Figure 4 shows the self-evaluated waste compared to the observed waste for each project as well.

Table 4: Self-evaluated waste versus observed (%)

	Apartment /-business/garage	**Rehabilitation/-facade**	**Apartment/-garage**	**Aggregated result**
Self-evaluated waste	8.0	9.1	18.4	9.5
Observed waste	5.5	6.9	8.3	6.5

It should be added that the self-evaluation method was implemented in two studies of a company in the mechanical industri in 2013 (Kalsaas, 2013), where a strong correlation between the two methods were found. And important, in these two studies it was registered a strong motivation in the work force to pariticipate in the continious improvement work.

Table 5 shows the results with categories of waste from the self-evaluation questionnaires. In the apartment/business/garage project, we see that non-appropriate equipment is a significant reason for waste (29.6 %). The worksite not beeing available because of other work also stands out with 26.2 %. In the apartment/garage project, the reason that the worksite had to be cleared before access could be gained stands out (21.9 %), aswell as performing work today which was not planned prior of the day, and spending time correcting faults of one self or others (both at 20.2 %). In the rehabilitation/façade project, missing or non-appropriate equipment is the biggest reason, however, this measurement was only based on 9 schemas, as mentioned.

Table 5: Self-evaluation, categories of waste for three projects (%)

Self-evaluation	Apartment/ business/ garage	Apartment/ garage	Rehab-ilitation/ facade	Aggregated result
1) Equipment missing or non-appropriate.	29,6	10,1	96	28,10
2) Worksite was not available because of other work.	26,2	25,3	0	24,42
3) Information was missing or unclear.	12,5	1,7	0	8,80
4) Worksite had to be cleared before access could be gained.	3,8	21,9	0	8,50
5) Did you perform work today, which was not planned when you started work this morning?	0,9	20,2	0	6,12
6) Did spend time today correcting faults or misunderstandings of your own, or other's making?	0,1	20,2	0	5,59
7) Faulty materials, too little, or non-appropriate materials.	6,9	0,6	0	4,75
8) Preceding activity was not finished as promised.	6,8	0,0	0	4,56
9) Preceding activity was of poor quality, or not quite finished.	6,4	0,0	0	4,29
10) Drawings missing, or faults/ deficiencies in drawings.	4,1	0,0	4	2,99
11) Other causes of delay during work.	2,8	0,0	0	1,88

Reliability and Validity

Reliability with regard to method does in this case concern the question of whether the method affects the data collected. Master students in their fifth year were responsible for collection of data, and Josephson and Björkman (2013) claims young non-experienced observers to be advantageous in this kind of study since they are less biased. However, they also points at Jenkins and Orth (2004) which argue that the observers should be knowledgeable in order to understand what they observe, which is a potential issue. The students collecting data received training in the method beforehand, and had a good dialogue, both with the supervisor and the workers who were observed. Meetings were arranged with the team before and after registration, to explain what registration involves, and evaluation was done during working hours, with students present to answer questions. However, the researcher cannot, in all cases know with certainty which activities are being performed. Some of the observations were done with intervals of several weeks, which would give two separate measurements. Weather conditions can, for instance, become a problem. There is, in addition, a great degree of variation in the number of registrations within the different trades, accordingly there will be different degrees of reliability for the results. The rehabilitation and facade project, for instance, did only have 708 measurements, and the apartment/garage project did also have a relatively low number, 1267. The shopping centre had 6750 measurements, and there is, consequently, a higher degree of reliability tied to these data when we compare them. However as pointed out empirical generalization is not the main purpose, but continuous improvement within each project. The method of observation can affect the findings by influencing those observed, but we have a strong impression that is not a big challenge in the cases studied, which is confirmed on the construction sites. One could have expected less reliability in connection with the self-evaluation, which we also found, and the method is strongly dependent on motivation from the site crew.

Validity is a question of whether the concept, developed for workflow and waste, is useful with regard to capturing the phenomena and processes they were meant for, and that is not empirical generalization, but analytical/conceptual generalization. One concern could be the question whether measuring workflow is related to productivity trends. Thomas et.al (1984) in Allmon et.al (2000) claims work sampling to be a system for indirectly measuring productivity on construction sites, by measuring how time is utilized by the workforce. Allmon et.al (op cit.) supports this claim, and is adding that analyzing work sampling data collected over a period of time can suggest trends in productivity rates during that period. Josephson and Björkman (2013) does a thorough literature review on whether work sampling can be used to predict the productivity level, in the sense that there is a correlation between the amount of direct work and volume produced. The majority of the literature supports this, however there is also a minority which makes the claim that work sampling measures how workers' time is utilized, not how productive they are. The main argument is that productivity is dependent on the method and equipment chosen for performing an activity, which means a new innovative method or equipment, that leads to more being added to the product for a given period of time, does not necessarily change the percentage of direct work (Thomas et.al, 1991; Allmon et.al, 2000 in Josephson and Björkman 2013).

Direct work is central in our method of measurement, but direct work may also include waste. That is why we also categorize waste as *observable* in the data sampling, implicating that there are some unobservable or hidden waste in the other categories (Kalsaas 2013), such as in the *Direct work* and *Indirect work* categories. Making-do (Koskela 2004) is for example an issue for those categories of activities. However, we find that the selected categories give a good indication of workflow applied on individual project for continuous improvement purpose in collaboration with the site crew.

Moreover do we in our method assume that the intensity of work is constant for practical purpose. We know that is not always valid. For example, Seppänen (2009) found in empirical studies evidence of crew slowdowns. Examples are also mentioned in Kalsaas (2013).

ALTERNATIVE METHOD: HANDOVER OF WORK BETWEEN TRADES

As a supplement to measuring on *operations*, according to Shingo's (1988) conceptualisation of flow, we aim to test the definition of workflow found in LPS, on reliable handover of work between trades. Ballard (2000) uses the term reliable workflow in relation to LPS, but one might argue that it is process flow, which he addresses, if we are to rely on Shingo (op cit.). When one trade is done on a construction object, it might be viewed as the handover of the object to the next trade within the value chain. However, in construction on site, it is the people who move, not the object. Thus, Ballard's definition of flow is, in this paper, understood as process flow. An operationalization to measure process flow on the LPS-method is currently being tested.

To register the reliability of hand over of work we have developed a questionnaire for the weekly planning meetings (Table 6), where all trades are represented by foreman and/or squad leader. In the conceptualization we have included delay measured in time units compared to plan, root causes of deviation to plan and PPC for handover of work. A condensed version of the questionnaire is presented in Table 6. Occasionally there will be more than one trade handing over work to another; hence the numbers of handovers are given in a separate column.

Table 6: Excerpt from questionnaire, handover of work between trades

From trade/sub-contractor	To trade/sub-contractor	Number of hand-overs	Handover according to plan		Delay	Cause of delay. Was this notified?	PPC
			Yes	No			

The testing of the method over two weeks shows a total of 44 handovers, where 27 activities took place according to plan, giving a PPC for handovers of 61.4%.[1] Among the findings was a door that was delivered too late in one of the activities which caused delay in a total of 10 work tasks, while the rest of the delayed tasks was caused by re-planning on site and change in sequence of work tasks. Change in sequence is actually a change in production method, and which to some extent can be expected as the involved crews learn as they are working.

CONCLUSION

We find the methods for mapping of activity on building site can be relevant for continual improvement work in project-based production. This is achieved through attention being drawn to different categories of waste, and through, both,

[1] A construction manager at the construction case company which hosted the testing of the method did in 2013-2014, over 31 weeks, register the reliability of handover of works in an apartment project. He registered 299 planned handovers of which 231 was realized according to plan (detailed master plan level).

management and operators gaining greater awareness of the processes they are involved in. The method of observation builds on the dimensions of smoothness (high level of direct work), quality and intensity, and gives a fairly accurate picture of what goes on at the building site, and is valuable to understand how time is spent at the building site, which is for instance of significant interest in production planning. However, we need to be careful with empirical generalization. The method and the findings are in a strict sense, based on research criteria, only valid for individual project sites for continuous improvement purpose. We deal then with analytical generalization as in case studies. The method based on self-reporting of waste is challenging regarding validity for work flow, and require a motivated crew. The self-reporting method is less work intensive, which is an advantage compared to the observation method. The self-reporting method has moreover a potential to be integrated in the daily and weekly registration of constraints to workflow for companies applying a standardized piecework wage system.

The calculation of workflow based on the percentage of “man hours at employer’s disposal – Wasted time / Man hours at employer’s disposal” is not the main point in the method, but the different categories of how time is used as a point of departure for discussion of constraints and improvement issues. Direct work is central in our method of measurement, but direct work may also include waste. That is why we also categorize waste as observable in the data sampling, implicating that there are some unobservable or hidden waste in the other categories. Moreover do we in the method assume that the intensity of work is constant for practical purpose, which is not always the case.

A main difference between the methods of observation and self-reporting to the LPS-method of “handover of work between trades” is that the first two also address workflow within the different trades, while the LPS-approach address the flow between trades. Moreover is the first two methods founded on *operation* and the LPS-method on *process* in Shingo’s well known conceptualization of the different flows in manufacturing. The preliminary testing of the LPS-approach is, however, also promising, and the contractor company who host the testing consider expanding their LPS-translation to include the addressed LPS-flow concept for learning and improvement work. A finding from the testing is that the sequence of work task may change during the work week as details in the production method are developed on site.

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