Quality Evaluation of Contractor's Schedule in the Bidding Phase

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Abstract

Purpose – This paper is based on research addressing quality of construction schedules. The paper aims to structure a Schedule Health Assessment method and present it as a means to carry out the evaluation of construction schedules.

Design/Methodology/Approach – The development of the Schedule Health assessment method can be characterised as constructive research. The structuring of the method is based on analysis of factors forming the overall quality of construction schedules. The method has been tested in a proof of concept study. This comprised a case study in which four master schedules developed by junior production managers were evaluated using the Schedule Health assessment method.

Findings – It is possible to construct a method for the quality evaluation of construction schedules.

Research Limitations/Implications – The completed testing is still rather limited since it is based merely on experiences of junior production managers with a single case.

Practical Implications – The Schedule Health assessment method can in a useful manner make the quality evaluation of construction schedules easy to approach and effective process.

Originality/Value – This research has produced a novel method for the quality evaluation of construction schedules.

Keywords Construction, Project management, Schedule, Quality, Construction tender, Baseline schedule

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1. Introduction

Quality evaluation of a construction schedule can be a complex task for project managers and project supervisors, especially in the bidding phase of design and build projects. In building construction projects, the master or phase schedule developed by the contractor for the bidding phase or after the contract award has to be evaluated by owner's project

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managers or consultants for bidding evaluation and/or schedule approval. After approval, the schedule becomes the baseline for project control, and therefore, it becomes one of the most important contract documents. Project supervisors or construction managers frequently use baseline schedule to justify or deny a request of time extensions, or to evaluate process efficiency and the possibility of timely or late completion. Therefore, schedule quality detection can play a major role in this project step. Schedule quality is understood as the level of accomplishment of the schedule and the scheduling process to a set of performance requirements. Based on this quality evaluation approach, a Schedule Health Assessment method has been proposed. The aim of the research work behind this paper is to understand if the Schedule Health Assessment proposed method can be used to evaluate the contractor's schedule in the bidding phase.

2. Schedule quality: previous work

Few researchers addressed the theme of construction quality assessment, despite the importance given to project scheduling in project control theory. Construction schedule in fact provides a service to the project that no other project management methods can provide. A sound project schedule can be helpful in managing construction production with the purpose of improving productivity and quality through better planning and control. Therefore, schedule quality, meaning quality of scheduling process and of scheduling output, can be very important in the selection of an appropriate project organization form and of the construction strategy (Russell, Tran, Staub-French, 2014). While satisfying the quality requirements does not necessarily mean the schedule is feasible, not satisfying them almost certainly means it is not (Edwards, 2016).

Kenley and Seppänen (2010) indicate that feasibility and predictability of the schedule can give further understanding of the quality concept of a construction schedule, and a list of the needed items for a feasibility check of the schedules is provided. The American Road and Transportation Builders Association – ARTBA (2012) – indicates that a good quality scheduling can be achieved via few elements: work structuring; Work Breakdown Structure (WBS); contract vs scheduled total project duration; schedule maintenance; construction and scheduling knowledge. Huu *et al.* (2018) search for a correlation between schedule performance and schedule models, and focus on network model complexity and its measurement. The scheduling community has expressed many times the need of schedule development recommended practices for quality assurance of the scheduling processes and of scheduling deliverables in the construction sector (Moosavi and Mosehli, 2014). Some industrial standards exists which cover procedures to achieve schedule quality, but most of those standards are outside the construction context and they do not aim at the baseline approval procedure (PMI, 2007; US-DCMA, 2012).

Generally, the owner has to evaluate the contractor's schedule before the commencement of works in the building site. The approval of the contractor's schedule indicates that the requested contract requirements are fulfilled by the promised construction process as described in the schedule, and the approved schedule becomes the baseline of the construction project. De La Garza (1990) defines a subset of scheduling principles to enable construction schedule evaluation process for subsequent automation. Zafar and Rasmussen (2001) highlight the importance of the baseline schedule approval in construction projects and indicate the major baseline scheduling requirements for major public construction projects. The US Defense Contract Management Agency (DCMA) defines a well-known 14 points metrics aimed at identifying potential problem areas with a contractor's Integrated Master Schedule (DCMA, 2012). Moosavi and Moselhi (2014) define a structured

methodology to assist owners in the evaluation and approval of detailed schedule of contractors. In essence, it is a check list that covers a set of 48 requirements for good schedules. Han, Choi and O'Connor (2016) indicate that the quality of a baseline schedule can be evaluated by 49 industry-recognised schedule quality metrics divided into nine groups: general, milestone, duration, calendar, logic, constraint, float, lag and lead.

The Lean Construction scheduling approach is addressed by well-known comprehensive work of Koskela (1992) and its application in the scheduling field of Kenley and Seppänen (2010). Lean approach highlights flow-line suitability for construction project modelling, and recent studies highlight takt time planning, meaning the pace of production process that best suits client need as another feature of schedule quality (Tommelein, 2017).

All these aforementioned approaches to schedule quality mainly focus on schedule mechanics, contract requirements and work-flow modelling with flow-lines. A more complete approach to baseline quality needs to consider these and the other following features.

3. Baseline Schedule approval and quality assessment proposed approach

Baseline schedule approval is based on contract documents and on the contract master schedule or other contract specifications. When approved by the owner's project team, the contractor's schedule becomes the baseline schedule. In this context, three major requirements are to be fulfilled by the baseline schedule of the contractor. The first is the total project duration, no late completion is allowed. Early completion can be evaluated if requested in the bidding phase. Some design-build bids evaluate early completion for contract award and can assign an extra (success) fee to reward early completion. As it can be found in all contracts, late completion during project execution is discouraged with penalty (late) fees. The second requirement is about the needed production rate. Generally, the proposed schedule should indicate, in lump sum contracts, the established money value of work to be performed for each complete year from the initiating of works on site. This requirement implies that an average production rate on site must be delivered by the construction process, and shown in the baseline schedule. Therefore, the complete scope of work as described in the Work Breakdown Structure must be included in the schedule, forecasting the requested production rate. The third requirement concerns workflow and health and safety of the construction process. An effective, feasible and safe flow of work must be indicated by the process logic of baseline schedule. No interferences, meaning time-space conflicts of crews are allowed. As the baseline approval procedure is contract-based, all of these three main contract requirements need to be completely fulfilled to obtain owner's approval.

In the research behind this paper, a Schedule Health Assessment procedure has been proposed for the evaluation of the schedule quality, and it is suggested to adopt the Schedule Health Assessment approach for the contractor's schedule review and approval (Bragadin and Kähkönen, 2016).

The proposed procedure is based upon five schedule health indicators that group 75 requirements related to the quality of schedule and scheduling process. The indicators are the following: general requirements; construction process requirements; schedule mechanics requirements; cost and resources requirements; and control process requirements.

The development process of a construction schedule consists usually of three phases: preparation of i) master schedule ii) detailed schedule (in the planning phase), and iii) schedule updating (in the control phase). Therefore, quality checking of schedules and scheduling process should be implemented in relation to those phases. If the Schedule Health

Assessment is performed in the preparation phase for a master schedule, a set of 55 requirements will be used and weighted to produce an overall schedule quality level. In case of evaluation of a detailed schedule in the bid phase, the cost and resources indicator will be included and the related set of 64 requirements will be applied (Figure 1). If the Schedule Health Assessment is performed in the schedule updating phase, all indicators are needed and the related set of 75 requirements will be applied. The evaluation can be performed easily by checking the specified detailed requirements: for each fulfilled requirement one point is earned; otherwise no points are given. Each indicator has a weight that depends on the number of composing requirements (Table 1).

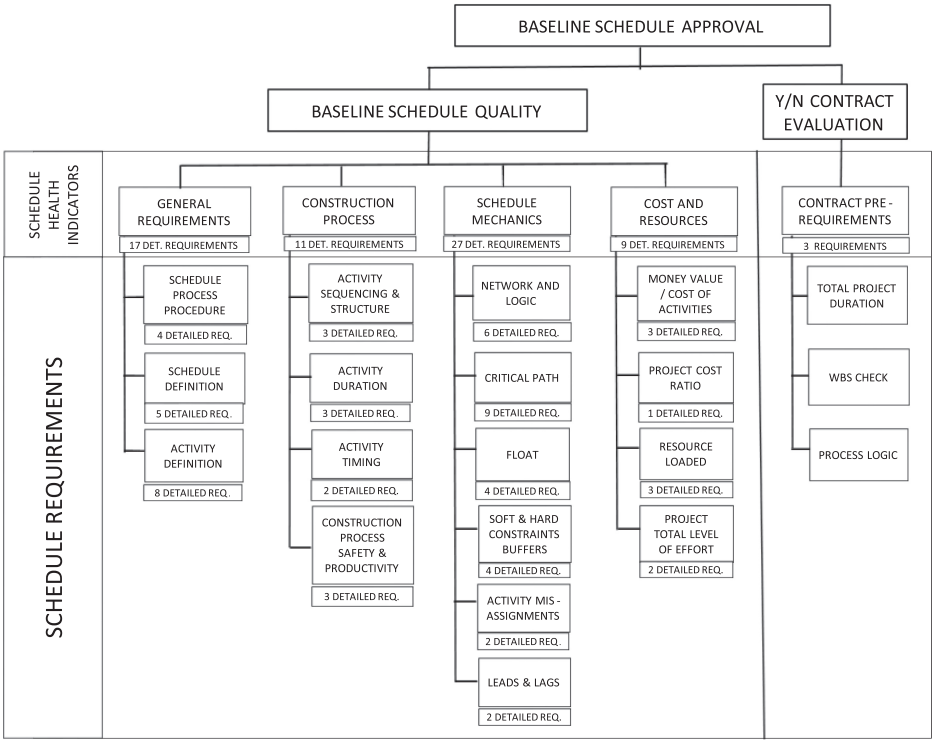

Figure 1.
Baseline Schedule Approval

	Schedule health indicators:		*1) General*	*2) Construction process*	*3) Schedule mechanics*	*4) Cost and resource*	*5) Control process*	*Total Weight*
Schedule development	*Preparation phase*	*Master schedule*	31%	20%	49%	/	/	100%
		Phase schedule	27%	17%	42%	14%	/	100%
	Update phase	*Schedule updating*	23%	15%	36%	14%	12%	100%

Table 1.
Relative Weights of Health Indicators for Schedule Evaluation

The proposed approach for baseline schedule quality assessment and approval relies on both the contract-based evaluation and the Schedule Health Assessment method. The contract-based evaluation provides a pass/fail (Yes/No) assessment of the schedule, while the Schedule Health Assessment procedure provides a total health indicator of the schedule for quality ranking. Main contract requirements are summarised as follows:

- total project duration: no late completion is allowed;
- WBS check: the total scope of work as described in the WBS to be performed in the forecasted time limits of the schedule; cost and resources are loaded upon request;
- and process logic: a feasible and safe flow of work to be indicated by the process logic of baseline schedule; no interferences are allowed.

Firstly, the contractor's schedule has to fulfil all these three baseline pre-requirements. Next, the Schedule Health Assessment method is used to evaluate the proposed schedules detecting the level of accomplishment of evaluated schedules to the needed requirements. In reference to Figure 1 and Table 1, the phase schedule Health Indicators are then used for baseline evaluation.

4. Case study

A case study based on a simulation game concerning an actual building project was used to carry out the proposed baseline schedule evaluation. The case study was the building of a new school in urban area. The total sum of building cost for the owning agency was more than five million euro and the contract duration was 660 consecutive days from project start of on-site activities. Early completion was desirable by the owning agency, and the contract type was public–private partnership. The actual project has been completed before the contract deadline in about 500 days and an early completion bonus has been paid to the contractor. The school building project was chosen for a simulation game in a learning programme for construction project managers and four junior project managers developed four different project schedules. In the simulation game, each construction manager was to prepare the bidding documents of his/her construction company to be submitted for the public bid. Each developed schedule has been evaluated with the Schedule Health Assessment approach and contract pre-requirements. Owing to paper length limits only four results are presented in Table 2.

The gained results propose that only one schedule is passing all the three needed contract specifications: Schedule #2. The Schedule Health Assessment produces four different levels of baseline schedule quality (SH index of Table 2) and Schedule #2 produces

Baseline schedule evaluation
Contract Time 660 days

	Contract pre-requirements:			Schedule Health Indicators:				
Schedule ID	*Total project duration*	*WBS check*	*Process logic*	*1)*	*2)*	*3)*	*4)*	*SH index*
Schedule #1	no	yes	yes	59%	91%	81%	11%	67%
Schedule #2	yes	yes	yes	59%	91%	81%	44%	72%
Schedule #3	yes	no	no	41%	45%	67%	11%	48%
Schedule #4	no	yes	yes	53%	64%	74%	11%	58%

Table 2.
Case Study Baseline Schedule Evaluation

the best value of quality index (SH = 72%). Schedules #1 and #4 have middle values of SH, but one contract specification is missing, while the worst SH value is the one of Schedule #3 that misses two of the three requested contract specifications indeed. Anyway, in the actual empirical case, the ranking of schedules needed to be weighted with other specific selection criteria, as described in contract and bidding documents. In fact, in the school building project, several aspects had to be evaluated other than schedule, for instance, offered costs and building site design. Each aspect needed to be evaluated by the owner's committee and weighted for the final ranking of alternative construction companies. Therefore, the application of contract pre-requirements analysis and of the Schedule Health Assessment procedure could have been useful in selecting project participants.

5. Conclusions

Baseline schedule evaluation and approval can be a complex task for owner's consultants in the bidding phase. Different proposals can entail different baseline schedules, all promising an effective construction process after the notice to proceed. A complete baseline schedule quality assessment is based upon multiple requirements evaluation. Three pre-requirements, concerning total project duration, WBS check and process logic, are used to summarise the main schedule contract specifications. After this, a detailed schedule quality analysis can be performed, evaluating the accomplishment of the selected schedule health indicators. Therefore, the application of the proposed quality assessment approach can be useful for project managers and owner consultants before and during the bid step. Future research work will continue to investigate the Schedule Health Assessment procedure, with the aim of testing the proposed method.

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