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Assessment of Lean Construction Principles: A Case Study at Semarang Medical Centre Hospital Project

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Abstract

The lean construction frameworks have been developed for years to enhance the poor performance of Indonesian project delivery system which influenced by the waste of non-value adding activities. Never the less most of the developments were limited on working process and lack in people empowerment. Toyota Way which integrate working process optimization and people empowerment, was developed as a lean construction frame works. This paper aimed to assess the implementation of Toyota Way principles in project delivery system by observing project's delivery current state (status quo). The assessment began by conducting a questionnaire survey about Toyota Way implementation which then validated by interview with involved stakeholders and field observation. The assessment showed that project's stakeholders were still unfamiliar with Toyota Way concept. Although some Toyota Way guidelines have been used in projects completion process such as visual management and training program, it found that those guidelines had not fully implemented. The project delivery system was lack of process focus and concerns more on relationship inter-parties. It also found thatToyota Way implementation will constrained by the difficulties to change the status quo of project delivery. Moreover, it seems that construction projects need practical guidelines to simplify the Toyota Way implementation in project delivery system such as project flow evaluation and system of reflection.

Keywords: *Toyota way, Lean construction, Project delivery system, Status quo assessment, Non value adding activities.*

Abstrak

Kerangka kerja lean construction dikembangkan untuk meningkatkan perfoma buruk dari penyelesaian proyek konstruksi di Indonesia. Namun demikian, pengembangan yang dilakukan masih terbatas pada proses kerja dan belum adanya pelibatan sumber daya manusia. Konsep Toyota Way yang mengintegrasikan proses kerja dan pelibatan sumberdaya manusia, dikembangkan sebagai salah satu kerangka kerja pada lean construction. Penelitian ini bertujuan untuk mengkaji penerapan prinsip-prinsip Toyota Way pada penyelenggaraan proyek konstruksi, dengan mengkaji sistem pelaksanaan proyek yang ada. Penelitian diawali dengan pengisian kuisioner mengenai penerapan Toyota Way untuk pihak-pihak yang terlibat pada penyelesaian proyek, yang kemudian divalidasi dengan wawancara serta observasi lapangan. Hasil kajian menunjukkan responden kurang mengenal konsep Toyota Way. Beberapa panduan penerapan Toyota Way telah dilakukan pada penyelesaian proyek seperti manajemen visual dan pelatihan pekerja, namun demikian

penerapannya masih dirasa belum secara utuh. Lebih lanjut, hasil kajian juga menunjukkan sistem penyelenggaraan proyek kurang berfokus pada proses kerja dan lebih berfokus untuk menjaga hubungan baik antar pihak. Penerapan Toyota Way juga mendapat hambatan sulitnya mengubah kondisi eksisting dari sistem penyelenggaraan proyek. Lebih lanjut, beberapa panduan praktis penerapan Toyota Way diperlukan untuk memudahkan penerapan Toyota Way pada proyek konstruksi antara lain evaluasi waste pada alur kerja dan sistem refleksi akan hasil kerja.

Kata-kata Kunci: *Toyota way, Lean construction, Sistem penyelenggaraan proyek, Kajian status quo, kegiatan tidak bernilai tambah.*

Introduction

The growth of Indonesian economic is now running slowly. One reason for this economics decline is the decreasing performance of Indonesian projects delivery (Bank Indonesia, 2014). Moreover, Indonesian construction project's productivity and quality are low (Willar, 2010). This poor performance of construction projects performance was affected by the waste of non-value adding activities on projects life cycle (Alwi, 2002). Waste that are common to see in Indonesian construction projects, i.e. waiting, projects delay, changeorders, overstocking inventories, and projects site untidiness (Hadiman et al., 2014). This type of waste are affecting the project's completion process and productivity, and was caused by the low commitment on quality of construction project's stakeholder pertaining with construction delivery process (Soekiman et al., 2011; Larasati and Watanabe, 2009).

It also stated that construction project completion in Indonesia is still suffered from conflict/disputes among involved parties because of poor coordination system. Moreover, in Indonesian construction projects, only 75% of working time is value adding activities, human resources empowerment only 67%, and project completion percentage only 87% from all projects activities (Larasati and Watanabe, 2009; Alwi, 2013). In addition, waste of non-value adding activities are still considered as common things for most of construction project's stakeholder and were not need to have any root-cause solution (Andi et al., 2005).

One developed solution for those problems is Lean Construction. As a working concept, lean construction aims to eliminate waste of non-value adding activities while focusing on customer's value generation. Lean construction was developed from lean production system on manufactur, Toyota. The conservative view of production system divides macro production system into smaller sub process of input-output convertion, in which arising the waste of non-value adding activities. New production concept has been developed that viewing production process as conversion and flow process (Figure 1), which aims to eliminating non-value adding activities in flow process and focusing on value generation for customer in conversion process.

For years, development of lean construction resulting in lean construction frameworks and its implementation guidelines. However, most of lean concept development werebased on lean thinking concept by Womack and Jones (1996). Lean thinking comprises 5 principles consist of defining value for customer, creating value stream, steady flow system, pull system, and perfection. Nevertheless, some arguments to lean thinking are focused only on working process, exploitative into human resources and lack of human resources skill improvement and people empowerment (Gao and Low, 2014). Lean thinking concept assessed to be unsuitable to be implemented in construction sector (Winch, 2006). Some lean construction tools have been successfully implemented on project delivery process such as 5S to maintain workplace tidiness, visual management to achieve better working condition through visual signs. However, it was limited only on process focus tools. The project delivery system is still lacking in human resources empowerment.

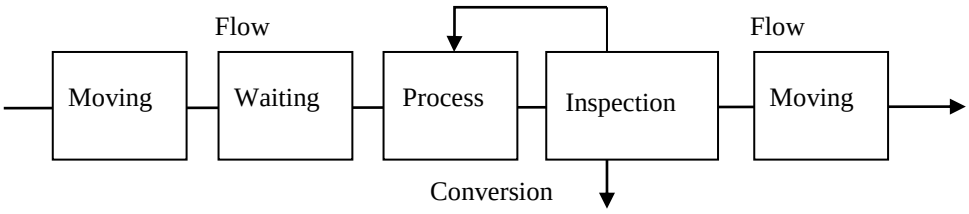

Figure 1. Conversion and flow (Koskela, 2002)

Recent studies on lean construction framework developments were on Toyota Way as lean construction philosophy. Toyota Way was developed as working philosophy in manufacturing and was later developed and adopted in construction sector (Gao, 2013). Toyota Way concerns on process optimization and human resources empowerment. Toyota Way comprises 14 basic principles divided into 4 models, which are philosophy model, process model, people and partner model, and problem-solving model. Toyota Way principles integrate "hard factor" or working process and "soft factor" or human resources empowerment. Toyota Way is in accordance with the concept that stated lean construction should be established with integration between these two major factor of project delivery system.

In order to assess Toyota Way implementation on construction project delivery system, a case study research has been made to assess the extent of Toyota Way implementation by observing the project's status quo of the project delivery process. The first stage was conducted by developing a questionnaire about Toyota Way implementation guidelines and assessment on lean construction implementation. The quantitative used to observing the implementation level of Toyota Way guidelines on a real-life construction project. Then, qualitative method used to validate the result by doing interview and project site observation in order to achieve a better level of understanding on how Toyota Way guidelines have been implemented in the case-study project. It then followed by the review the hindrance on Toyota Way implementation at the construction project. Following these, an assessment was made about the extent of project delivery system on case study project. Finally, a discussion on practical Toyota Way guidelines were held to improve the project delivery performance.

Lean construction toyota way

Basically, lean construction is a working philosophy to generating a steady flow system that focusing on identification and elimination waste of non-value adding activities in construction supply chain (Ogunbiyi, 2014). Lean construction is an attempt to implement lean concept into construction sector. Lean implementation on construction sector became crucial because of non-value adding activities in construction that leads into waste, which attain 55-65% of total activities in construction process. While only 5-10% of activities are value adding activities (Diekmann et al., 2004).

Many research has been conducted this far todeveloplean construction frameworks in attempt to implement lean concept into construction sector. Most of lean construction framework developments was based on the Lean Thinking concept which relatively only focused on value generation and enhance working process value stream (Ogunbiyi, 2014; Picci and Graja, 2004, Eriksson, 2010). One of the lean construction framework development is observed by Gao (2013) which try to track back lean framework development with basic concept of Toyota lean production named Toyota Way. Toyota consists of 14 principles that can be divided into 4 models (Figure 2).

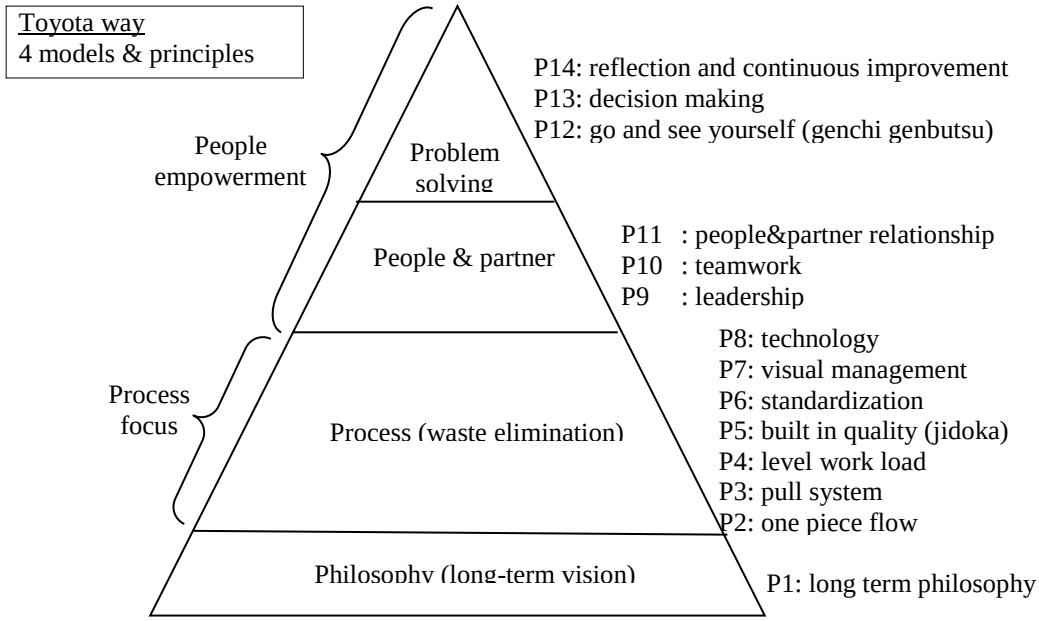

Figure 2. Toyota way models and principles (*after* gao and low, 2014)

Toyota way principles			
P1	Long term philosophy	P8	Reliable technology
P2	One piece flow	P9	Leadership
P3	Pull system	P10	People and teamwork
P4	Level out workload	P11	Respect partners
P5	Built in quality	P12	Go and see yourself
P6	Standardization	P13	Decision consensus
P7	Visual control	P14	Kaizen and continuous improvment

Lean thinking by Womack & Jones

- Defining value from customer
- Clear value stream
- Continuous flow
- Pull system

Figure 3. Toyota Way concept and Lean Thinking concept

This Toyota Way concept model integrate the process focus and people empowerment system. With philosophy as a base point for this concept, process focus and people empowerment are built. Philosophy model is a long-term vision that could be the hardest factor for Toyota Way implementation. Implementing a long-term philosophy is about changing the status quo of the project delivery system. This could be achieved by focus on working process to eliminating waste and creating steady flow system, which supported by human resources empowerment on respecting others involved parties, challenging and developing working partners, growing leadership passion, and creating better coordination system in a teamwork. The succeed of lean implementation also supported by a good problem-solving method as a learning process, which achieved by system of reflection and continuous attempts of improvement.

In contrasting with lean thinking concept, Figure 3 briefly compare the principles of Toyota Way and Lean thinking. It is clear that Toyota Way principles are much beyond the principles of Lean Thinking, in which Toyota Way comprise both process focus and human resources empowerment while Lean thinking concept only focused on working process.

Toyota way implementation assessment

Green and May (2005) observed about the extent of lean concept implementation by observing current condition of construction projects delivery system and stated that there are 3 basic types of projects delivery system. The first is the model of waste elimination. In this model, the projects only view the delivery system only as process focused activities with aims to reducing waste of non-value adding activities. Lean principles that used on this type of projects are principles that more practical and process focus, such as 5S system, visual management, and Just in time.

The second model is model of Partnering. This model have more focus on maintaining a good relationship among involved parties in the projects supply chain by enhancing a good relationship. A good relationship arises from better coordination system affected on project delivery. This second model is sought to eliminate disputes inter parties, especially from owner into main contractor. This second model mostly speak about system sharing, knowledge sharing, and trusting inter parties. Lean principles that used in this type of projects such as long-term contract, workshop, workers training program, and facilitator.

The last model and also the most sophisticated model is the Lean construction model. This model emphasized on integration between waste elimination and maintaining good relationship inter parties. This model attempts to implementing lean construction concept with changing the status quo of project delivery system. This model also emphasized on individual role in achieving good project delivery system with having a responsibility and commitment on working process, reflection on what have been done, and continuous improvement to attain better level of project delivery. The principles used in this model such as the using of reliable technology, prefabrication system, consideration of constructibility and buildability design system, and bottom-up system activities related to problem-solving activities and feedbacks from workers.

In order to adjusting the guidelines of lean implementation assessment, a lean construction guidelines compliance was made. The lean assessment guidelines were compile with the Toyota Way implementation guidelines (Table 1), based on Gao (2013).

Table 1. Lean classification with toyota way guidelines

Lean classification green-may	Toyota way implementation guidelines
Model 1: Waste elimination	
– Waste elimination is paramount – Focus on technical problems – Aims to one piece flow – Reducing variance – Limited on working process	– Establishing one piece flow with waste elimination on working process – Just in time in material supply – Site layout adjustment – Pull System – *Zero inventory level* – Kanban Tools – Quality control – Reducing variability with establishingstandard operating procedure – S*afety sign*as visual management
Model 2: Partnering model	
– Focusing on long term relationship – Reducing disputes – Collaboration system – Sharing information and experience – Teamwork	– Establishing one piece flow by focusing on long term relationship inter-parties. – Fullfil customer requirements – Level out the workload – Work – Reducing conflict/disputes – Information sharing – Leaders support system – Working with limited partners – Decision making considering other involved parties
Model 3: Lean construction	
– Focusing on changing the status quo – Structural change way of thinking in design and working process – Using reliable integrated technology – Worker training program – Reflection and continuous improvement	– Having long term vision – Workers awareness on defect-reworks – Responsibility on quality – Cross trained member – Technology to simplify process – Well knowledged leader – Root cause evaluation – Second opinion consideration – Reflection and continuous improvement

Research Method

The method used in this research is combination case-study conducted by integrating quantitative and qualitative methods. In order to assess Toyota Way implementation on construction delivery system, a current condition (status quo) reviewof the project's delivery process has been made. The respondents used in this research were chosen by purposive snowball sampling method, and involving inter-parties of projects stakeholder (owner, project management, and main contractor) in order to find broader information of project's stakeholders interaction in project delivery process. This research was conducted in the Semarang Medical Centre project development. This single research object choosen because of its complexity, multi-years projects, invloving national and international stakeholders, and has to deal with some obstacles to performing this mega project construction process among densely populated residential, and right beside this existing building.

The first stage of this research was developing a questionnaire about Toyota Way implementation guidelines and assessment on lean construction implementation. The quantitative used to observing the implementation level of Toyota Way guidelines on a real-life construction project. Then, qualitative method used to validate the result by doing some interview and project site observation in order to achieve a better level of understanding on how Toyota Way guidelines have been implemented in the case-study project. The complete of this research phase are presented in Table 2 as below.

Table 2. Research phase

Reseach purpose	Process	Qualitative/quantitative
Identification lean construction principles with Toyota Way principles	Preliminary Survey	Qualitative, Literature Review
Develop a lean classification system based on literature review	Phase 1	Qualitative, Literature Review
Observing the extent of Toyota Way principles implemented in project delivery system	Phase 2	Quantitative, Qualitative
Comparing research result with literature review	Discussion	Compile of Previous findings

The questionnaire used in this research is adapted from the questionnaire developed by Gao (2013). The questionnaire consisted of 14 major question of Toyota Way principles and divided into some specific sub-question about those principles implementation guidelines. the questionnaire using 5 point Likert Skale importance-performance. The average result of this questionnaire then plotted into matrix of importance-performance.

Data analysis and Disscussions

The questionnaire resulted means of Toyota Way performance and importance principles. The result (table3) showed that all Toyota Way principles has been moderatelty implemented in project delivery process, which showed high rating point (between 3,75-4,4 Likert Skale). Along with this, the importance factor also gota good result with high rating point (above 4 Likert Skale). The result then plotted into importance-performance matrix which shown in Figure 4.

Table 3. Questionnaire mean results

No	Toyota way principles	Mean	
		Implementation	Importance
P1	Long term philosophy	4.29	4.62
P2	One piece flow	4.19	4.71
P3	Pull system	3.90	4.69
P4	Level out the workload	3.81	4.60
P5	Built in quality	4.02	4.67
P6	Standardized work	3.83	4.43
P7	Visual control	3.88	4.64
P8	Reliable technology	3.93	4.25
P9	Leadership	4.43	4.64
P10	Teamwork	4.24	4.52
P11	Respect partners	4.21	4.52
P12	Go and see yourself	4.38	4.57
P13	Decision making	4.10	4.31
P14	Reflection and continuous improvement	3.98	4.60

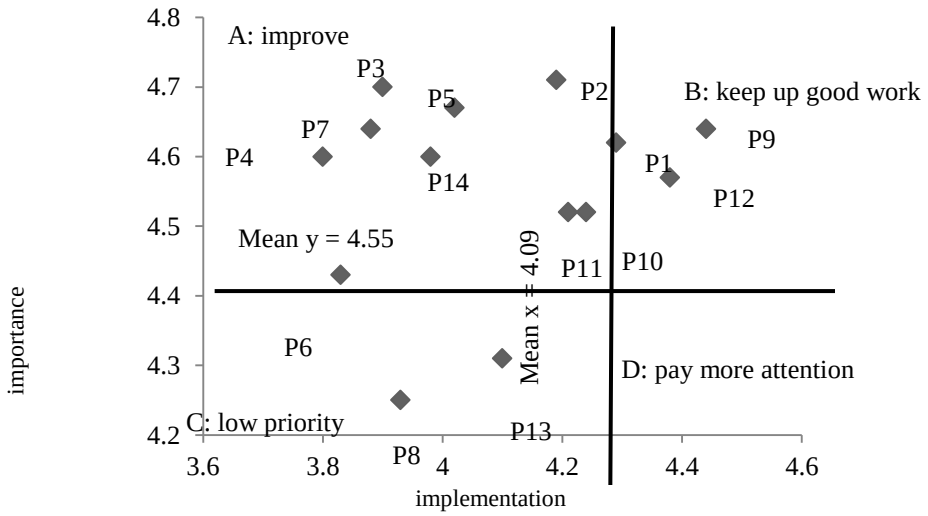

Figure 4. Toyota Way concept and Lean Thinking concept

Figure 4 clearly shows that all Toyota Way principles are plotted in the range of 3-4 Likert Skale point. From this result, it could concluded that at case-study projects delivery system, Toyota Way principles has been moderately implemented and almost all of those principles are considers to be important enough in delivery system.

Hindrance in Toyota Way Implementation

As the questionnaire result, the biggest hindrance of Toyota Way implementation is financial constrain. As at most of respondent stated that they have to allocating extra funding related to worker training program and also providing safety tools and other visual management tools.

Table 4. Hindrance in toyota way implementation

Hindrance	Mean
Have no working philosophy	2,929
Unfamiliar with lean concept	2,857
Financial factor	3,571
Lack of worker empowerment	2,857
Lack of management supports	2,714
Too much working partners	3,000
Unfair Competition inter-parties	2,571
Unable to make decision while needed	3,357

Moreover, as some respondens said that Toyota Way implementation would also facing the hindrance to change the project delivery system's status quo. As the difficulties to chage working culture that has been implemented at construction delivery process for years.

The Findings

In short, from the interview with project's stakeholders resulted that Toyota Way have not been fully implemented in project delivery process. The respondent stated the terms "lean construction" was a new things, although some respondent said the terms "Toyota Way" is more familiar. From the interview, we found that the respondent mostly unfamiliar with Toyota Way principles but still familiar for some Toyota Way implementation guidelines such as Just in Time, Huddle Meeting, and Visual System. Eventhough there were only small number of respondent that stated they were familiar or ever heard about Toyota Way principles in manufacturing sector, but never knowing Toyota Way principles have been adopted for construction project.

From the interview and the project site observation, resulted some findings that its not in accordance with the questionnaire finding. From the interview, resulted that Toyota Way principles implementation on the project site was not fully implemented. Project site still constrained with some basic problems in construction, such as waiting, delay, defect-rework, and disputes inter-parties. The research findings are described on Table 5 as follow.

From the interview findings, Toyota Way principles are not fully implemented in project delivery system. Moreover, those results are not in accordance with the questionnaire result, and it could be concluded that this study-case site project was not familiar with the Toyota Way concept. The questionnaire reflects the project's stakeholder understanding on viewing their own delivery system. It could be concluded that the project's stakeholders views the project delivery system was pretty good reflected by high level of Likert Point on all Toyota Way principles. Nevertheless, from interview and site observation it found that project delivery system was not fully implemented Toyota Way principles. There are still discrepancy on Toyota Way implementation guidelines on this project's delivery sistem.

Toyota Way implementation assessment (Toyota Way classification system)

To assess the extent of Toyota Way implementation on construction project, an assessment system has been made based on assessment system by Green and May (2005) that divided project delivery system into 3 different models as stated in previous section of this paper. The Toyota Way implementation guidelines were compile with exsisting guidelines from Green and May to adjust with these research scope. The result was presented on Table 1.

The assessment on the extent of lean implementation was found by observing the current state of project delivery performance. The concept was to found the greater match of implementation guidelines on each models with the project current state. The assessment used the findings from previous interview and site observation on how Toyota Way has been implemented in construction project. The result of this assessment in short, showed that the case-study project have more focus on maintaining a good relationship inter-parties. However this projects assessed to be lack of focus on waste elimination at working process.This projects also still far away to attaining the the model of truly lean construction. The complete assessment system was describe in Table 6.

Table 5. Research findings

Toyota way principles		Research findings
P1	Long term philosophy	– Project management knowing the philosophy to delivering the project in the right quality, budget, and time – Low level of workers still have not familiar with this philosophy, and tends to performs their job to meet the daily work target and not too consider on its results. – Sometimes change orders given but were not in accordance with the projects completion progress.
P2	One piece flow	– Project completion process were not aware of waste non-value adding activities – Just-in-time could not fully implemented, increasing the risk of double handling
P3	Pull system	– Inventory control with manual system – Low respect to do the working process accordance with standard operating procedure – Could not implement zero inventory concept for safety reason
P4	Level out the workload	– There are coordination meeting to discuss about workload adjustment – Delay in daily workload would overburden the next day daily workload – The lack of human resources affecting ability to complete daily workload
P5	Built in quality	– Quality control system – Low level worker were not aware on quality, tends to relying on inspection system from project supervisor
P6	Standardized work	– Attempt to reducing variability by standardized on used material – Workers were not aware on standard operating procedure. – Using only limited prefabricated material (piles and ready-mix concrete) – Lack of workers empowerment to established working standard
P7	Visual control	– Management supports on safety was good – Low level workers were not aware on safety, including not aware of safety tools – Lack of tidiness commitment on working site.
P8	Reliable technology	– Utilization of technology, but limited only on simple, practical, and familiar technology to support daily activities.
P9	Leadership	– Management support system in projects completion – Lack of workers empowerment in decision making system – There were no system to grow leaders from workers
P10	Teamwork	– Workers training programs are limited to some level of workers – There were no cross trained member
P11	Respect partners	– Establishing long term relationship inter-parties – Understanding customers value – Works with lots of partners, leads to difficulties in coordination inter-parties
P12	Go and see yourself	– There were attempt to go and see problems in project site – Observation that was held only limited on solving the arising problems – Only little attempt to find and solve the root cause
P13	Decision making	– Decision making system was based on consensus, but not always implemented due to limited project completion time – Decision making sometimes rely on the leader experience
P14	Reflection and continuous improvement	– Plan-Do-Check-Act System limited only as inspection of work outputs – Lack of reflection and continuous improvement

Conclusion

Based on previous findings, it could be concluded as following:

1. Toyota Way concept are in accordance with concept of lean construction principles that integrating process focus and people empowerment.

2. As the result from survey, the Semarang Medical Centre's stakeholders are still unfamiliar with Toyota Way concept. It also found that implementation of Toyota Way principles in the project delivery system were not fully implemented.

3. The lean assessment resulted that Semarang Medical Centre Project's delivery system was lack of focus on working process, and have more focus on maintaining good relationship inter-parties. The Semarang Medical Centre Project's current state, more likely to be in Partnering models. To achieve steady flow, it is needed to adjust the working proces and maintain good relationship inter-parties.

With respect to project delivery process, its significant to change the conventional view that stated Toyota Way implementation will need extra funds and the hindrance to change the status quo of project delivery system. However, Toyota Way implementation should be implemented gradually with smaller group of training, and small efforts

Table 6. Toyota way classification system

Model 1 waste elimination			Model 2 partnering			Model 3 true lean construction		
Classification guidelines	**Project current state of delivery system**		**Classification guidelines**	**Project current state of delivery system**		**Classification guidelines**	**Project current state of delivery system**	
Steady flow by focus on waste elimination	X	Unaware of waste	Maintaining good relationship	V	Establishing long term partners	Living the long term philosophy	V	Management long term vision
Just in time inventory	X	Not always just in time	Conform the needs of customers including change orders	V	Conforms the customer's needs	Stop fix the problems	X	Not extent
Project layout adjustment	V	Layout adjustment to eliminate double handling	Make sure all have been done before starting new task	X	Not always done	Responsibility on task to be done	X	Observed in huddle meeting
Pull system	X	The distraction of project delivery performance	Level the workload	V	Daily workload adjustment	Material prefabrication	X	Just a little of prefab materials
Zero inventory level	X	Not always impelemted due to safety reason	People empowerment in working standard establishing	X	Not any	Reliable technology	X	Not always
Kanban tools	X	Using manual system	Information sharing	V	Information sharing by visual system	Practical technology to support delivery system	V	To support the delivery process
Daily workload completion	X	Still constrained from delays and impacted to project's completion progress	Manajement support on safety	V	Penalty system not implementing safety	Deep knowledged leader	X	Sometimes still lack of knowledge
Quality control	V	There is quality control system	Trainig system	V	Training system only some level of workers	Root cause analysis	X	Not always
Variance reduction by establishing standard operating procedure	V	Some extent have been implemented (standardized materials), but stll lack awareness of sop	Teamwork	V	Sharing system on working process	Cross trained member	X	Not ectent
Safety signs	V	Well established but lack of impementation	Works with limited partners	X	Large supplier/partners	Go and see yourself	V	By field trip obsevation
Project site tidiness	X	Workers not aware on site tidiness	Consensus decision making	X	Not always	Alternatives option	V	As a backup plan
			Communication system, knowledge sharing	V	Communication system by coordination meeting	Reflection system	X	Lack of system reflection, by experienced bad vluent
						Plan-do-check-act	X	Only on observing working process
Percentage 36%			Percentage 65%			Percentage 38,5%		

such as establishing leadership system and growing responsibility from workers. It also needed to enhance the working completion system by following the established standard operating system. It needs to observing the waste of non-value adding activities on project delivery system and also system of reflection and continuous improvement.

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