LEAN IMPLEMENTATION FOR CONSTRUCTION TIME REDUCTION

Miss Tunyaporn Dechavas

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering Program in Engineering Management
Regional Centre for Manufacturing Systems Engineering
Faculty of Engineering
Chulalongkorn University
Academic Year 2014

การปรับปรุงกระบวนการบริหารการก่อสร้าง

นางสาวธันยพร เดชาวาศน์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
สาขาวิชาการจัดการทางวิศวกรรม ภาควิชาศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต
คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2557

Thesis Title	LEAN IMPLEMENTATION FOR CONSTRUCTION TIME REDUCTION
By	Miss Tunyaporn Dechavas
Field of Study	Engineering Management
Thesis Advisor	Professor Dr. Parames Chutima

Accepted by the Faculty of Engineering, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

....Dean of the Faculty of Engineering

(Professor Bundhit Eua-arporn, Ph.D.)

THESIS COMMITTEE

....Chairman

(Associate Professor Jeirapat Ngaoprasertwong)

....Thesis Advisor

(Professor Dr. Parames Chutima)

....Examiner

(Associate Professor Dr. Somkiat Tangjitsitcharoen)

....External Examiner

(Dhunyanon Ratanakuakangwan, Ph.D.)

ธันยพร เดชาวาศน์ : การปรับปรุงกระบวนการบริหารการก่อสร้าง (LEAN IMPLEMENTATION FOR CONSTRUCTION TIME REDUCTION) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ศ. ดร. ปารเมศ ชุติมา, 70 หน้า.

ในปัจจุบัน Lean ได้ถูกนำมาประยุกต์และปฏิบัติเพื่อให้สำเร็จตามเป้าเหมาย ซึ่งเห็นผลในเรื่องของระยะเวลาและต้นทุนการผลิต รวมไปถึงคุณภาพของสินค้าที่ผลิตนั้น ซึ่ง บริษัท โฮมเพลส ดีเวลลอปเม้นท์ จำกัด (HPD) มีนโยบายในการนำ Lean มาประยุกต์ใช้กับกระบวนการก่อสร้างอาคารคอนโดมิเนียม ซึ่งการปรับปรุงกระบวนการก่อสร้างในครั้งนี้ได้ส่งผลต่อทีมงานก่อสร้างทั้งระบบการทำงานและทัศนคติในการทำงานบุคลากรในทีมโดยตรง

HPD เป็นนักพัฒนาอสังหาริมทรัพย์ในประเทศไทยมาแล้วกว่า 35 ปี โดยมีโรงงานผลิตแผ่นคอนกรีตสำเร็จรูปเป็นของตัวเองเพื่อใช้ในการก่อสร้างที่อยู่อาศัย รวมถึงบ้าน ทาวน์เฮ้าส์ และ คอนโดมิเนียม ตั้งแต่ปี พ.ศ. 2539 ด้วยประสบการณ์การผลิตที่ผ่านมานั้น HPD ได้ปรับกระบวนการก่อสร้างโดยประยุกต์ใช้ Lean เข้ากับการก่อสร้างบ้านและ ทาวน์เฮ้าส์เป็นที่เรียบร้อย เหลือเพียงแต่กระบวนการผลิตก่อสร้างคอนโดมิเนียมซึ่งยังไม่ถูกปรับ เพราะ บริษัทฯ ไม่ได้มีการสร้างคอนโดมิเนียมอย่างต่อเนื่อง กระทั่งในปี พ.ศ. 2554 และ พ.ศ. 2555 ที่มีโครงการก่อสร้างอาคารคอนโดมิเนียม แล้วเกิดการล้าช้าจากงานก่อสร้าง ซึ่งระยะเวลาในการก่อสร้างนั้นเป็นกุญแจสำคัญความสำเร็จต่อตัวบริษัทฯ โดยส่งผลกระทบต่อต้นทุนในการดำเนินการและกระทบต่อการบริหารเงินของฝ่ายการเงิน

ในปี พ.ศ. 2556 – 2557 ซึ่ง บริษัทฯ มีโครงการก่อสร้างคอนโดมิเนียม 3 อาคาร เป็นอาคารแฝด 2 อาคารและอีกหนึ่งรูปแบบ โดยมีแผนการก่อสร้างใกล้เคียงกัน ทางบริษัทฯ มีนโยบายที่จะนำ Lean มาประยุกต์ใช้กับงานก่อสร้างคอนโดมิเนียมโดยจะทำการวัดผลจากอาคารแฝด ซึ่งอาคารแฝด หนึ่งอาคารจะถูกก่อสร้างโดยระบบก่อสร้างเดิม และอีกอาคารหนึ่งจะถูกปรับขั้นตอนทั้งหมด โดย Lean จะถูกนำไปใช้กับ 4องค์ประกอบของการผลิต (4Ms) คือ กระบวนการผลิต(Method), เครื่องจักร(Machine), คน (Manpower) และ วัสดุ(Material) รวมเพิ่มไปจนถึงการควบคุมคุณภาพในการผลิตและก่อสร้าง โดยจะเน้นความสำคัญไปในการลดระยะเวลาการก่อสร้างและควบคุมต้นทุนให้ได้เท่าเดิม

จากการทำวิจัยและประมวลข้อมูลหลังการนำ Lean มาประยุกต์ใช้เพื่อลดระยะเวลาในงานก่อสร้างนั้น ระยะเวลาก่อสร้างอาคารคอนโดมิเนียม 8 ชั้น สั้นลงจาก เดือน 9 เหลือเพียง 5 เดือน โดยยังมีผลข้างเคียงจากการปรับปรุงกระบวนการทำงานที่ไปช่วยในการ ปรับการถ่ายข้อมูลระหว่างทุกฝ่ายที่เกี่ยวข้องให้ดีขึ้น รวมไปถึงทัศนคติการทำงานของบุคลากรที่เกี่ยวข้องกับการปรับปรุงกระบวนการในครั้งนี้ ยิ่งไปกว่านั้นในการปรับลดลงของระยะเวลาก่อสร้างนั้นยังส่งผลให้ บริษัทฯมีศักยภาพในการนำรายได้และกำไรกลับมาหมุนเวียน เพื่อการลงทุนได้เร็วยิ่งขึ้น

ภาควิชา	ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต	ลายมือชื่อนิสิต	....
		ลายมือชื่อ อ.ที่ปรึกษาหลัก	....
สาขาวิชา	การจัดการทางวิศวกรรม		
ปีการศึกษา	2557		

5471234021 : MAJOR ENGINEERING MANAGEMENT
KEYWORDS: LEAN CONCEPT / LEAN IMPLEMENTATION

TUNYAPORN DECHAVAS: LEAN IMPLEMENTATION FOR CONSTRUCTION TIME REDUCTION. ADVISOR: PROF. DR. PARAMES CHUTIMA, 70 pp.

Lean has been utilized as a tool for process improvement as well as the working efficiency in many manufacturing firms. The production time and cost and product's quality were presumed as results for successful lean implementation. In this research, Lean was implemented at Homeplace Development Co.,Ltd (HPD) to decrease construction time for a low-rise condominium building and the whole construction department was evaluated.

HPD is a real estate developer located in Thailand. The company has been manufactured house, townhomes, and condominiums for sale in the past 35 years, and has its own prefabricated concrete factory to supply prefabricated concrete walls for the buildings. HPD is an expertise in manufacturing houses and townhomes where lean had already been applied for the two products. However, for condominium projects, HPD experienced two delays in the two condominium projects in year 2011 and 2012. The construction time is one of the key to success in any construction, and when delay is experienced, the company lost its opportunity cost and problems of financial management follows.

Lean was implemented on the construction department at HPD, and the results were measured from the construction time of a low-rise building which is compared with the historical data of the existing project with the same building design. The tools in Lean were used for the 4Ms in manufacturing including the method, machine, manpower, and the material, and the quality aspect of the production.

Throughout the research of Lean implementation for construction time reduction, construction time for an 8-storey condominium project was reduced from 9 months to 5 months. The other benefits gained from the implementation include the improved information flow within the department and the mindsets of the people involved in the process. Furthermore, this construction time reduction provided HPD a better reinvestment opportunity from a faster turnover for one construction project. Lean had proved to be a tool for improved process to result in the construction time reduction at HPD, and the research from this implementation could be used as guidelines for lean implementation at manufacturing firms or construction companies that aim for reduction in production time.

Department:	Regional Centre for Manufacturing	Student's Signature	....
	Systems Engineering	Advisor's Signature	....
Field of Study:	Engineering Management		
Academic Year:	2014		

ACKNOWLEDGEMENTS

I would like to express my appreciation to my thesis advisor, Assistant Professor Parames Chutima, Ph.D., for his support and for giving me this opportunity to fulfill my master degree. His keen suggestions and devotion has made this thesis possible. Also, I would like to thank Ms. Pornsuda Potaya for the exceptional support throughout these academic years. Further appreciation to Homeplace Development Co.,Ltd team for supporting the information required and for all the helps in this research implementation, I could not have implemented successfully without the team. Most importantly, I would like to send my sincere gratitude and appreciation to my family and friends for the support. Lastly, I would like to thank those who had given their advocacy for this thesis completion. It has been a pleasure thoroughly.

CONTENTS

Page

Page

Page

Page

LIST OF FIGUERS

LIST OF TABLES

1. CHAPTER I

Introduction

1.1. Introduction

Time, cost, and quality have been the keys to unlock the successes in many businesses. Many large sized businesses or listed companies which have shown the most profits are the ones who have the most efficient in processes with finest performances to deliver products with high quality into the market. Some marketers may argue that the best way for a company to be successful is to have a marketing leading strategy, but the bottom line in the balance sheet is what proves how successful any company is. Real estate development is considered one of the businesses that yield the most return in comparison with businesses in other industries. Most listed companies show similar percentage of land acquisitions to revenues, marketing expenses to revenues, but the differences found in percentage of profits to margins reflect from the cost and the operation expenses.

Lean has been the tool used for increasing efficiencies as well as reducing wastes occurred within the processes, and thus, leading to reduction in costs and expenses. Lean has been implemented mostly in a manufacturing environment, mostly within factories in the past and it has been proven to improve the overall operation to be more efficient and more cost effective from Toyota as a whole company to re-analyze a hammer to improve a turnover time in changing a die. The beneficial side effect from lean is time reductions. After the processes become very efficient, the operation time drastically drops of which can benefit companies especially on the turnovers in operation time and the interest paid for the loan in mega projects.

1.2. Company Background

Homeplace Development company (HPD) is a developer in real estate, specialized in building residential housing and buildings in Thailand (see: http://www.homeplace.co.th) [1]. HPD is a medium sized company with in-house construction teams and has its own prefabricated concrete factory to supply the prefabricated concrete walls for its construction sites. See Appendix A.1 for prefabricated walls products. The company consists of 60 employees in the office and 300 employees in the construction team (factory and construction sites).

The process line for the company's products (houses, townhomes, and condominiums) starts from land acquisition to design team to production team (factory) to construction team and then, to sales and sales support team. The project management and construction management teams, financial team, marketing team, and system engineering team are part of the back office team. Figure 1.1 represents the overall process flow at HPD.

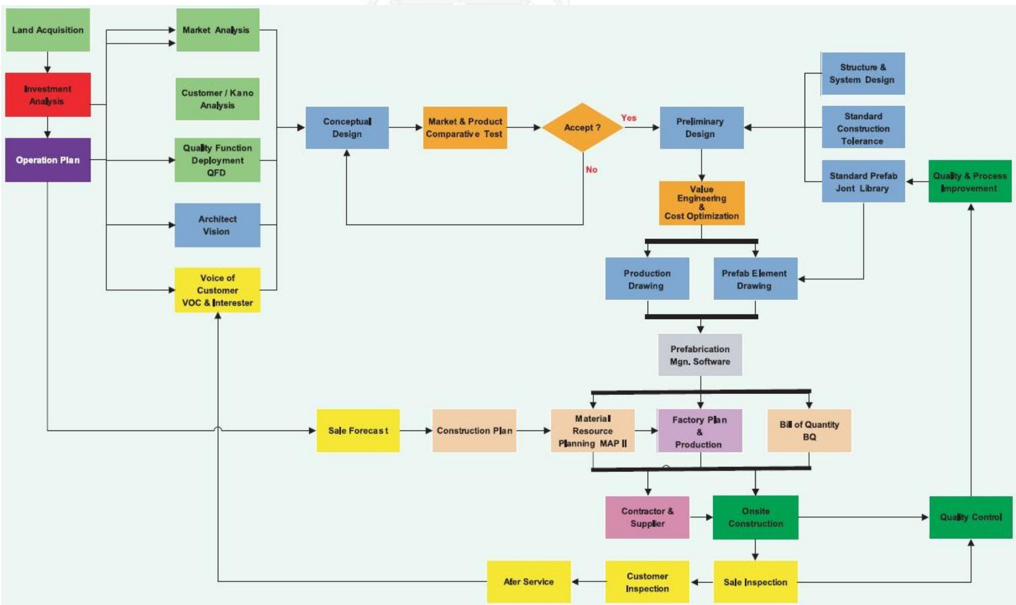


Figure 1.1 Overall Processes at HPD[10]

1.3. Problem Background

Based on the annual balance, construction cost accounts for 30 to 35% of the revenues, the other 10-15% of revenues comes from operational expenses, and a fixed 7% interest of project loans; this is where the profit is directly affected.

At the time, the regulation of the new minimum wages was imposed by the government and the problem of the shortage in labors and technicians on sites all over Bangkok due to the highly increase number of real estate projects in year 2012 and 2013, stimulated from the AEC integration leading to massive influx funding internationally. The executives, foreseeing the trend and the need for construction improvement due to the rising cost of construction that comes with the external factors, set the strategies to making adjustment on the whole production team with a clear instruction that lean would be used as a tool to improve the production system as a whole, from the physical working processes to the support system.

The two key interrelated elements in most real estate projects are the funding and the time to transfer ownership. On the funding side, when a project is considered as a short-term real estate project (real estate for sales), the funding from the bank is given at a different term from those long-term projects such as hotel businesses, shopping malls, or the office buildings for rent where the minimum loan/lending rates (MLR) are relatively low and negotiable. The MLR for the short-term loan for real estate developers tend to fall between 5 to 7% depending on negotiation. The funding is directly related to the time to transfer ownership as the interest rate runs with project time. For example, when condominium projects are placed in the market, the presales are the first indicator for the project's success to test the demand for the products which often last between four to six months. The presales are run parallel with acquiring permits for the projects and for constructions. Afterward, constructions take place between the average times of ten months for low-rise projects and two to three years depending on the sizes of buildings before the units are transferred ownership to the customers. The permits acquiring time required cannot be reduced as the process deals with city's central units, external factor. However, the construction time is still controllable.

With more than 35-years-experience as a developer and longer than 10-year of prefabricated concrete walls technology in possession, HPD has developed the one-house flow system for single houses and townhomes projects (in blocks). This one-house flow system is a system to produce a house or houses based on the demand during the time. One house has a lead-time of 45 days regarding the types of houses and one block of townhomes has a lead-time of 75 days. This one-house-flow system allows HPD to have a better ability to manage stock and cash flow the lead times products are fairly short. However, the skill has not yet developed for condominium projects.

In 2011 and 2012, HPD had two low-rise condominium projects that were delayed in schedules and had caused the company problems financially especially cash flow wise as the cash inflow was coming in as estimated. For low-rise condominium projects, HPD had defined a construction time as nine months based on the actual working processes, but the average construction time for the past two projects is ten months and a half. During the ten months, the only cash inflow for the condominium project is 70% construction loan from bank which is granted by the construction progress. When having five to six ongoing construction projects, the cash management becomes very important as one supplier may supply for 3 of the projects, and if the money is not paid on time, the suppliers tend pause the materials delivery. This can cause dominos effect on delays for the single houses and townhomes projects which have the confirmed income for the company. Thus, the most important part is to have the condominium projects finish as planned or even faster. The delays for the two previous projects led the executives to set out the new goals for construction time and the construction process revision.

On the advantages that the company can gain from reduction in construction time, HPD can have a clear estimate on the cash flow of projects with a slight benefit on interests which will not be higher than the project's feasibility analysis. Looking further on the opportunity that HPD can gain, if the product's shelf-life turnover time concept is applied to this shorter construction time, it can lead to a higher opportunity the company can gain. When the construction time of the project is shorter, the buildings are ready for ownership transfer faster, and the company can pay back the loan faster, and thus, can invest on the new project faster. If the company can improve the construction turnover time for one project down by half, it means the company has the opportunity to double the number of projects, and double in the bottom line profit. Inversely, it can mean that the longer the construction time, the higher opportunity cost the company is paying.

From the delays of condominium projects in 2011 and 2012 along with the opportunity cost that the company could have benefited from the higher turnover of the production period, construction time reduction will be the main focus by implementing the concepts of Lean to the construction department. Construction Management (CM) team, who manages resources, monitors cost and quality, and distributes the schedules for the construction sites and production plant, was identified as key person between units to the information and communication improvement, and the whole construction team contributes to the process improvement where the detail process analysis will require incorporation between all units.

1.4. Objectives

The objective of this research is to shorten the construction time for a low-rise condominium building using the concepts of Lean.

1.5. Scope and Assumptions

The research will concern mainly on the construction department at Homeplace Development Company. Construction department consists of four teams including project management team (planning and control, Bills of Quantities, Quality Control, and contractors management), factory team, construction team, and purchasing team. Each of the team will require different analysis on the change as the job descriptions are different for each team. Lean will be implemented on the existing processes to improve the efficiency of the processes and to improve the current information flow. The obtained results will be measured on from the construction time of a low-rise building project which will be compared to the existing data from another building built with the existing processes in the same working condition

1.6. Expected Benefits

From the implementation, the results should show the reduction in construction time to the given time of five months with the accurate and up-to-date data in the company’s information system. The implementation should also lead to an improvement in processes, control, and resource management, while building a more efficient working culture to the construction department at HPD. The standards that needed to be developed for the new implemented processes must also be ready for both the implementation and the future usage. The information system and software will also be set to support the changed working condition and to have the data in the system be as accurate as possible. The project management should also gain the ability to manage through system and to make good use of the data by generating statistical information and other documentation needed for future projects.

2. CHAPTER II

Literature Review

2.1. Lean implementation

“Typical results from implementing lean thinking:
90% reduction in lead times
90% reduction in all inventories
100% increase in productivity
50% reduction in errors
Fewer injuries” [2]

Lean is widely used as a tool for process improvement. It is said that that the actual time required to produce a product or deliver a service is only 5% of the total elapsed time. The other 95% is loss during the processes. Every 25% reduction in elapsed time will double productivity and will benefit on the cost side of the production. Companies that routinely reduce the elapsed time to deliver enjoy growth rates three times the average with twice the profit margins.

Many manufacturing firms have adapted the concepts of lean into their working cultures to obtain the higher level of working efficiencies that one company can perform. Toyota is one of the companies that have successfully leaned out its company.

2.1.1.Toyota Production System (TPS)

From Toyota production system, there are fourteen principles of Toyota Way that defines Toyota production system with seven principles (principle 2 through principle 8) dealing directly with Lean as Liker stated in *Toyota Culture: The Heart and Soul of the Toyota Way[3]*[4] as follow:

“…Principle2. Create a continuous process “flow” to bring problems to the surface.

Principle3. Use“pull” systems to avoid overproduction.

Principle4. Level out the workload

Principle5. Build a culture of stopping to fix problems, to get quality right the first time.

Principle6.Standadized tasks and processes are the foundation for continuous improvement and employee empowerment.

Principle 7. Use visual controls so no problems are hidden.

Principle 8. Use only reliable, thoroughly tested technology that serves your people and processes…”

All of the seven principles rooted from concepts of Lean which leads Toyota to having processes Excellency and constantly eliminating the wastes. Apart from Lean, processes management and controls are also the main support to TPS. Plan-do-check-act (PDCA) problem solving is believed to be the core of Lean at Toyota.

“Lean systems are processes that bring problems to the surface so that people can continually improve and learn through PDCA” [4]Not only does PDCA improve the process, but also develop the people. “The starting point is to clarify the problem versus the ideal stat. Defining the ideal state is a critical step. This is to avoid settling for incremental fixes to the current state. It is usual to think of 10 or 20 percent improvement as a big change, but in some cases doubling performance is feasible” (Jeffrey Liker). In Figure 2.1, PDCA for process improvement developed within Toyota could be used as a guideline to the companies that plan to develop a continuous improvement processes and systems.[4]

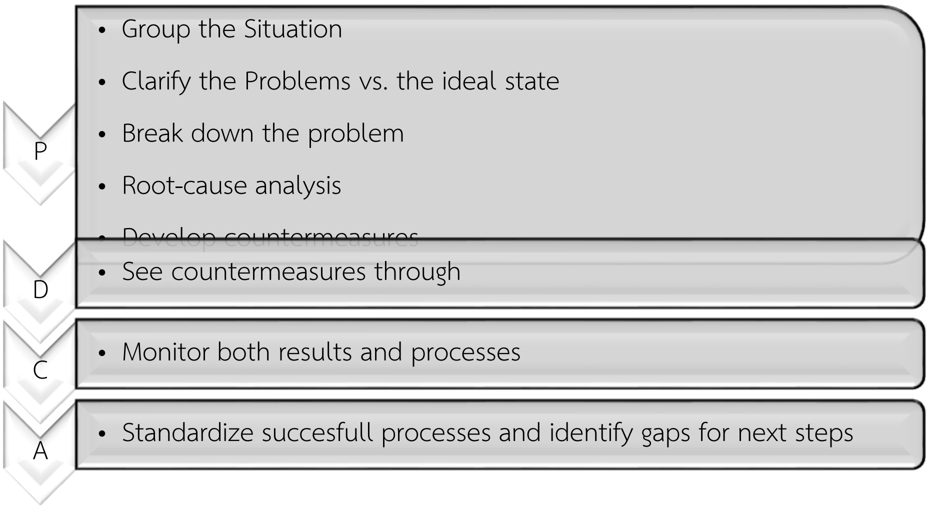


Figure 2.1 PDCA of Processes through Toyota Business Practices[4][3]

From the principles of Toyota Production system and the PDCA for process improvement previously stated, Toyota has developed a production system to produce a higher quality and lower cost products with a much shorter lead-time. Lean implementation is shown plausible for most manufacturing firms. The most important key is to understand the working cultures and the working processes of the companies being Lean implemented. Certain Lean concepts mentioned in TPS can be more discussed in the following section.

2.1.2. Lean Concepts

Lean consists of concepts that can be applied to working processes from analysis stages to implementation to data record and result analysis, and then, loop back to re-analyzing the whole process to generate a continuous improvement concept. To begin the Lean implementation, the problems or processes that needed to be improved are put on the table for cause-and-effect analysis. At the same time, the performance measurements must be defined as the causes must be fixed or improved. The performance measurements could be the expected results from the implementation or the expected change in processes that will affect the end results of the implementation.

2.1.3. Cause-and-Effect Analysis

This cause-and-effect analysis, sometimes referred as fishbone diagram, is a diagram that roots the causes of the suggested problem. The structure of the fishbone diagram has the problem as the head and the causes are lined as the bones of the fish (see Figure 2.2). Each of the main causes can be branched out further in more details to identify the most likely causes to the problem.

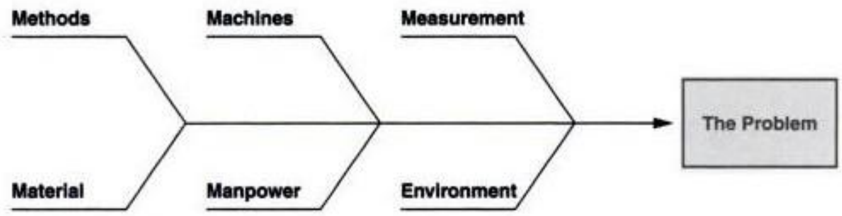


Figure 2.2 Example Fishbone Diagram[5][6]

The diagram helps stimulate the brainstorming and possibly guides the discussion of the problem and causes, and all the causes identified from this process lead to further data collection and analysis.[6][5]

2.1.4. Value Stream Mapping

Once the causes for the problem are identified and the performance measurements are defined, the process steps in making products are listed out and value stream mapping (VSM) is performed. Each of the steps is associated with operation cost, lead-time, productivity, and inventory. This VSM involves with evaluation of the current processes, design of a new improved processes, and the benefits that will gain.

VSM can be started from work breakdown and processes identification. The critical processes and precedence processes must also be identified. The critical processes are the processes that are in sequence and dependent with other processes and directly affect the total production time. These critical processes make up the critical path for the project which is the longest sequence of processes within the project. Each of the processes must also be defined with the time required to complete the task, the lead time. This lead time will be compared to takt time as a performance measurement.

2.1.4.1. Value Added and Non-Value Added

Then, the process steps are assigned as value added or non-value added of which are defined as follow:

"Value added refers to those tasks that cause the product or service to advance to a more complete stage...Non-value added is also fairly black and white. This includes the activies that do not move the product forward and fall into the seven categories of waste: the overproduction, excess inventory, transport, process waste, rejects/rework, waiting, and excess motion" [7][7]

2.1.4.2. Takt time analysis

"Takt time is the rate that products must be produced to meet customer demand."[2][2]

For implementation to improve processes, the customer demand could mean the new goal for which the improved processes should be, and takt time is then analyzed backward to get the required productivity required from each processes based on the new suggested improved processes. This is sometimes known as balance the job, so that each task has a cycle time equal to takt time. This total process change should result in shorter lead times.

According to the Power Laws of Speed [2][2], when the lead times are shorten and when the ease of working for the production line was focused, what usually follows are the higher quality, faster response times, better productivity and better use of equipment and space.

2.1.5. ECRS tool

After the evaluation is done on the current processes, ECRS is the possible forms of application to apply to the processes identified as critical or non-value added for overall process improvement.

E – Eliminate – Could the processes be eliminated? For certain processes such as quality control which may fall within the NVA processes category, it cannot still be eliminated as it contributes to the final quality of the products. However, for certain processes such as relating materials within the factory, it can be eliminated and the new process should be suggested to have materials be located at the most efficient spot.

C – Combine – Could it be combined? Sometimes, the processes can be combined into one process using one operator/unit job. By doing so, the training may be required, or the facility may need to be readjusted to support this change.

R – Rearrange – Could the processes be rearranged? This rearrange in process improvement covers process rearrangement itself ,sequencing or parallel, and it could refers to rearrange the capacities such as adding on the resources to shorten the time.

S – Simplify – Could the process be simplified? This simplification could be the change in applications to simplify the complication within the process leading to the new improved processes.

The result from the process identification along with VSM created, the improvement processes should be suggested. This improved processes will then be used further in calculating the new capacities need, the new planning required using the concept of Just-In-Time along with one piece flow design.

2.1.6.Just In Time (JIT)

Just-In-Time is also a tool helps in managing the processes. It is defined as:

"A philosophy directed towards the elimination of waste where waste is anything which adds costs but not value to a product" [8][8]

JIT is the concepts leading obtain five zeros including paper, inventory, downtime, delays, and defect. It also aims to fix the seven mudas including overproduction, excess inventory, transport, inappropriate processing, rejects/rework, waiting time, and unnecessary motion.

One of the main tools used to meet the concept of JIT is leveling. This includes process leveling and resources leveling. For process leveling, the best practice for any production system is to achieve a one piece flow processes. At Toyota, one minute die turnover time was developed. The most efficient one piece flow process is one that has the least waiting time, the least inventories, the least transporting distance, least reworks/rejects, and the least unnecessary motions between processes.

2.1.6.1. One piece flow

Is to make the work "flow" so that there are no interruptions and no wasted time or materials. Jay Arthur[2][2] has suggested a redesign for One Piece Flow as follow:

"The first step – is to focus on the part, product or service itself. Follow the product through its entire production cycle. In manufacturing plant, follow product from order to delivery

The second step – is to ignore traditional boundaries, layouts, etc. In other words, forget what you know.

The third step – is to realign the work flow into production "cells" to eliminate delay, rework, and scrap.

The forth step – is to "right size" the machines and technology to support the lots, quick changeover, and one-piece flow. This often means using simpler, slower, and less automated machines that may actually be more accurate and reliable.

The goal of the flow is to eliminate all delays, interruptions and stoppages."[2][2]

2.1.6.2. Resource Leveling

Resource leveling is a term in project management which could be equivalent to the term Available to Capacity (ATC) or some cases could be the arrangement of ATC. ATC matches the capacities with the customer demand based on variable basis. The capacities include the available facilities, machines, equipment, or labors. Each process defined from VSM will be matched with resource planning at this state.

2.1.6.3. Communication and Collaborations

Apart from lean concepts, the team structures play one of the most important roles in Lean implementation. It was believed that 60% failures of implementation are due to the failures in collaboration between the teams. The ten ingredients suggested by Peter Scholtes could be used as a guideline to forming a successful team.[6] [5]

"1. *Clarity in team goals*. As a sound basis, a team agrees on a mission, purpose, and goals.

2. *An improvement plan*. A plan guides the team in determining schedules and mileposts by helping the team decide what advice, assistance, training, materials, and other resources it may need.
3. *Clearly defined roles*. All members must understand their duties and know who is responsible for what issues and tasks.
4. *Clear communication*. Team members should speak with clarity, listen actively, and share information
5. *Beneficial team behaviors*. Teams should encourage members to use effective skills and practices to facilitate discussions and meetings.
6. *Well*-defined decision procedures. Teams should use data as the basis for decisions and learn to reach consensus on important issues.
7. *Balanced participation*. Everyone should participate, contribute their talents, and share commitment to the team's success.
8. *Established ground rules*. The group outlines acceptable and unacceptable behaviors.
9. *Awareness of group process*. Team members exhibit sensitivity to nonverbal communication, understand group dynamics, and work on group process issues.
10. *Use of the scientific approach*. With structured problem-solving processes, teams can be more easily find root causes of problems.[6] [5]

”

2.1.7.Information Flow

Similar to the idea of TPS on information flow, it is best to have a reliable technology to serves the people and the processes. Information flow is the key for a successful JIT management especially on the supply chain side. However, the information flow provides any company with good information system to control processes of lean manufacturing. According to Thomes[1], the information flow is built around three information processes including Sales and Operation Planning, Available to Capacity, and Kanban. All of the processes are suggested to be interlinked to best establish the effective system with the database that could allow the people to utilize the information at its most effective: The S&OP allow the people involved with ATC to manage the resources while the information from Kanban allow the company to understand its products and defects that could be improved.

This information system acts as the backbones for the company as it serves as the channel to provide information to every team involved.

2.1.8.Control System

The three components that are used for process control in any project management are (1) a standard or a goal, (2) a measure for accomplishment, and (3) comparison of the actual results with the standards.[5]In a project management and control, a goal is established and must be measurable quality characteristics. The data used to measure the accomplishment sometimes are done at the inspection processes, and the measure for accomplishment should be measured from time to time to be able to see the trend of change if there is any. Lastly, for the results comparison, for any implementation to improve processes, the actual results should depict differences between before and after the implementation.

2.1.9. Quality improvement

Quality is one of the advantages perceived from lean implementation. Concepts of Lean rarely mention the quality of the products, but rather quality in the processes which lead to least defects and low quality products. The defects and wastes that are eliminated along the continuous process improvement automatically lower the final products' defects. One of the key to ensure the lasting quality is the standards that are developed along the processes improvements. It is very important for a company to develop standardized processes that continuously improving with control system which are updated once there is a change.

3. CHAPTER III
Existing Conditions & Methodology

3.1. Existing Conditions & Methodology

The objective of this research is to shorten a construction time for an 8-story condominium building using concepts of Lean for the implementation. The results from the implementation will be compared to the construction time of another building in the same project with the exact same design with the data already existed.

In 2013, HPD had five ongoing construction projects including one condominium project and the other four projects were single houses and townhomes For the single houses and townhome products, HPD had developed a system of a one house flow or one block flow, where the production time for the houses takes 45 days and the townhomes takes 75 days excluding pile works. This one house flow system is analogous to the one-piece flow system in lean, which benefits the company to not having too high inventories when the economy slows down or to have the products ready fast enough when the demands are high. The condominium project, otherwise, has a much longer production time, which means a much more sunk cost that can cause a problem to HPD's cash-flow during the construction period.

The average time for construction of a low-rise condominium (8-stories building/ building height of less than 23 meters) was ten months for established construction companies and developers with fast pace construction including HPD. The requirement was given to the construction department by the executives that the total construction time must be reduced from ten months by half as the company has set its strategy to increase the profit from the turnover time of the construction, and also, the problem of uncontrollable external factors that can affect the project during the long construction period. The concepts of lean portray a good solution path to this improvement, and Lean was preferred as a tool for this change.

With the requirement to reduce construction time of condominium projects, the construction department was evaluated thoroughly. The major problem detected was lack of efficient communication between management teams, construction sites, production plant, purchase department, and the design team. A lack of well information management, then, led to losses in personnel, insufficient control in cost and process, and a decline in product's quality as no change was suggested, and the most obvious of all, the delays in the schedules. Moreover, construction processes have not been revised or improved from projects to projects in the past 3 years, and the problems from the designs found on site also have never been reported back to the designing team for the possible change.

With the preliminary analysis on the processes and the possible changes to be implemented, the information system or the company's infrastructure must also be restructured to support the future working processes or the changes to be made. As the information system for the construction department was analyzed, the data within the system was not up-to-date enough, and certain functions, such as S-Curve on time and cost or QC report, were never utilized properly. It was clear that the change to both the construction processes and the requirements for the information system, updating data and utilizing available tools to control time and qualities, must be implemented to support this construction time reduction.

The research will concern mainly on the construction department at Homeplace Development Company. Construction department consists of four teams including project management team (planning and control, BOQ, QC, and contractors management), factory team, construction team, and purchasing team. Each of the team will require different analysis on the change as the job descriptions are different for each team.

3.2. Existing Conditions

3.2.1. Construction Department Organization Chart

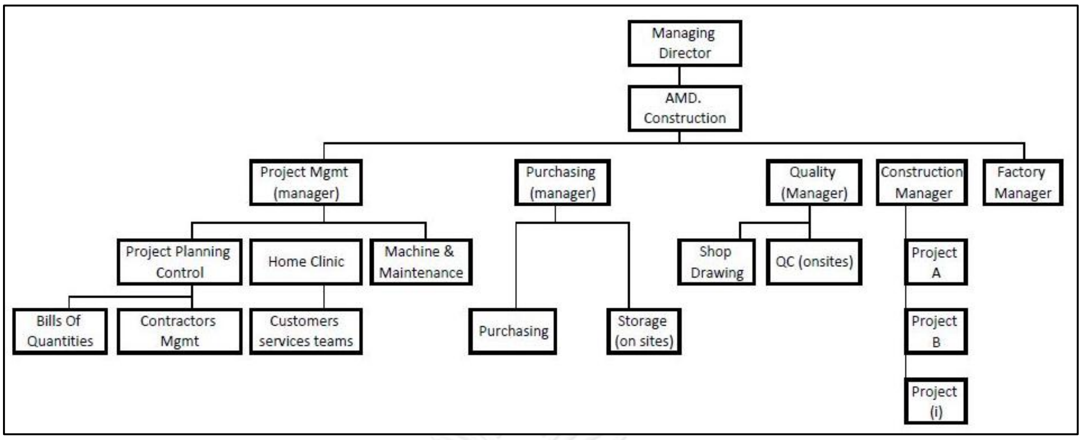


Figure 3.1 Construction Department [1][10]

3.2.2. Project Management

Project management team deals directly on the process planning, processes control, quality control, and contractors. In this research, construction processes for a condominium project will be broken down and analyzed one by one, and changes will be made to the existing process if necessary to reduce the construction time. One 8-storey condominium building (HPH002) will be used to implement the change and the results will be compared to the condominium in the same project (HPH001) that uses conventional processes in time of construction and the cost of the whole building.

As for contractor management, the most important task dealing with contractors when shortening the construction time is to recognize the contractors' and subcontractors' capacities and capabilities. The contractors and subcontractors will be analyzed in details to ensure that the contractors/subcontractors can deliver the work in time and do not have a shortage of resources when the production plan is shorten. Also, the qualification of contractors will be further studied on the system to manage the contractor selection.

Cost estimation is also another function within project management, but this process does not affect the construction time directly. Yet, the bills of quantities (BOQ) in the information system is linked two-way with purchasing department for the most up-to-date price from purchasing team while feeding the purchasing team with the exact date the materials needed to be delivered on site. This function of the information system is ready for use, but the only problem was the data were not input correctly, and the personnel tend to go back to the conventional way of using papers and pen, which most of the times leads to the loss of records. The data input will be mandatory, and accurate data must be updated into the system for the BOQ data to be used for procurement purpose.

3.2.3. Purchase

Just-in-time has been a requirement for material management at HPD. Materials to be delivered on site will be given a specified dates. As stated earlier that the day the material required on sites based on processes planning will be generated from the project management team and linked to purchasing department. With the shorten construction time, the relationship with suppliers must be closely monitored be; the material shortage or delay can cause the delay in construction time. Purchase department also must collaborate regularly with the construction team and the project management if there is any problem with material specification or the materials shortage in the market to ensure the materials' qualities and the materials' schedules.

3.2.4. Quality control

Quality control (QC) is a stand-alone unit. In the past, QC referred to the quality personnel on site which was an independent unit and only checked the quality of the products from one stage to another. The structure of QC team has been changed throughout the time, and recently QC has become involved in setting working standards. QC team is responsible for setting standards and requirements for working processes so every team has the same document. The responsibilities/job descriptions of QC team will be revised to collaborate more with other departments to help reduce the wastes during processes, and to manage standards used be every team.

Shop drawing is a part of quality team as a coordinator for design team, the construction sites, and factory for when there are working drawings that needed to be clarified. The position was recently added on to the quality team when there was a problem with incorrect design such as missing joints or design change from the construction sites that was not updated back to the office. The show drawing position acts as the coordinator for design teams and construction as well as eliminating the unnecessary “whose fault” problem.

3.2.5. Construction

Construction teams are mandatory to request for the resources needed to comply with the planning. The construction teams will need to collaborate with project management team, and possibly suggesting the change required. Also, because onsite personnel will have the best knowledge regarding the require machines and equipment when a new process is to be implemented as well as the constraints of the construction processes, such as cranes limitations or the blind spots during the construction.

The constraints on site refer to the overall site plans and construction site management. This construction site management will involve with setting locations of the working cells such the location to stock prefabricated concrete walls, or the location of cranes, or the materials management on site. Clear site plan planning must be generated prior to the start of the project as well as clear instruction on materials management to all the parties involved.

Apart for site plans and machines, the labors management is the critical part of construction both the company’s labors and the contractors’ labors. When managing labors to finish the work in a 79 units building, the job tasks must be clarified to both the foremen and the labors themselves because labors in Thailand are not skillful and discipline enough to deliver a work without clear instructions. Therefore, it is best to have “just enough” labors on site at the “right time” along with good human resource management strategies on KPI and reward system.

3.2.6. Factory

Because HPD has an in-house prefabricated concrete factory to supply the prefabricated concrete walls for the projects, the factory’s capacity becomes another constraint in the shortening processes. The factory at the time had the ability to operate at full capacity of 11 beds a day; a single house in housing projects require the average of 11 beds regarding the types. The townhomes require the same amount of beds per unit, but the construction process is done block by block. For condominium project, one floor of a building is equivalent to 4 single houses. When there are 6 ongoing construction projects, the company needs to carefully manage the factory's capacity. Resource leveling will be performed to ensure that the prefabricated concrete walls are ready in time of the usage.

3.2.7. Support System

With the objectives on shortening the construction time, information system and data management will be the main key to support the collaboration, the project management and control, and the data sharing between departments. HPD's database and information system software will be evaluated to justify with the improved working processes. The information flow improvement will begin from data input stage onwards to software fitting in order to have the information system that helps control the overall production with the measurement tools that can turn the raw data into informative records, such as the S-Curves comparing the expected and actual results on the timing and cost.

The data input and software training must be done if necessary to have the accurate and up-to-date data on the database. Also, if certain data require regular update, such as the material pricelists that are used for BOQ function or the worn out equipment and tools that should be cleared from the system, regular schedule must be set.

The software fitting will also be performed to ease the users in managing data. The feedback is mandatory to the programmers to adjust the functions of the programs be suitable with the actual working conditions.

3.3. Existing Data on the previous Building (HPH001)

The research will be measured from the result obtained after Lean implementation on construction of a low-rise condominium (HPH002). The results will then be compared directly to the existing data of already finished condominium (HPH001) in the same project, same location.

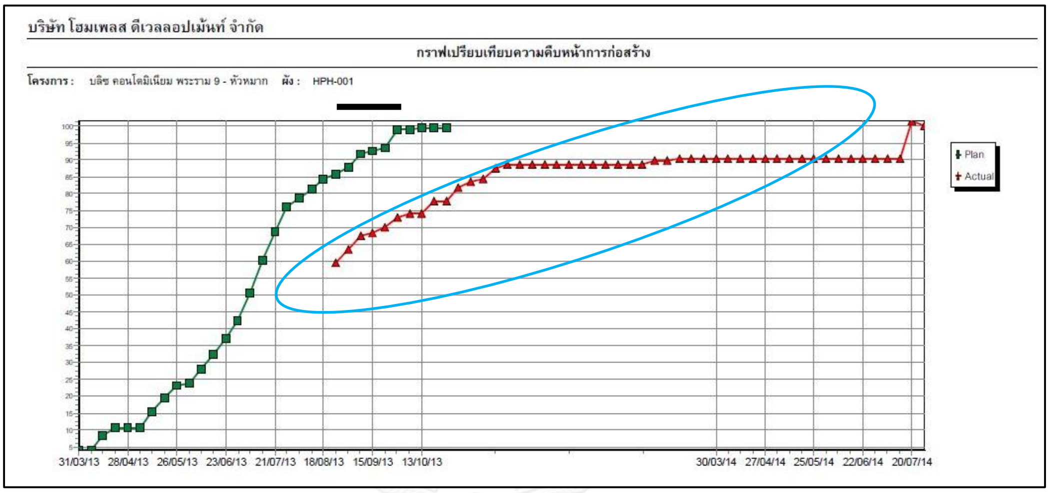


Figure 3.2 The Results from the existing processes for HPH001

The data obtained from Figure 3.2 shows a missing data in the system resulting in the incomplete S-curve for the building (in the light blue circle). Based on S-Curve, the construction time for Building HPH001 began in the beginning of April 2013 and finished sometimes around March 2014. This timeline of ten months will be used as a benchmark for Building HPH002 which will be implemented Lean on the construction processes. Also, the analysis and implementation will be done based on the historical data from building HPH001. The consistency of the data input will also be monitored closely to ensure a more accurate data for HPH002.

3.4. Problems Identification

3.4.1. Cause-and-Effect Analysis (Fishbone Diagram)

The cause-and-effect analysis is performed to identify the possible causes that affect the construction timing. All of the previous information from every team under Construction department is mapped into four categories of 4M's (Method, Machine, Material, and Manpower). Figure3.1 shows the fishbone diagram for the cause of delay in construction.

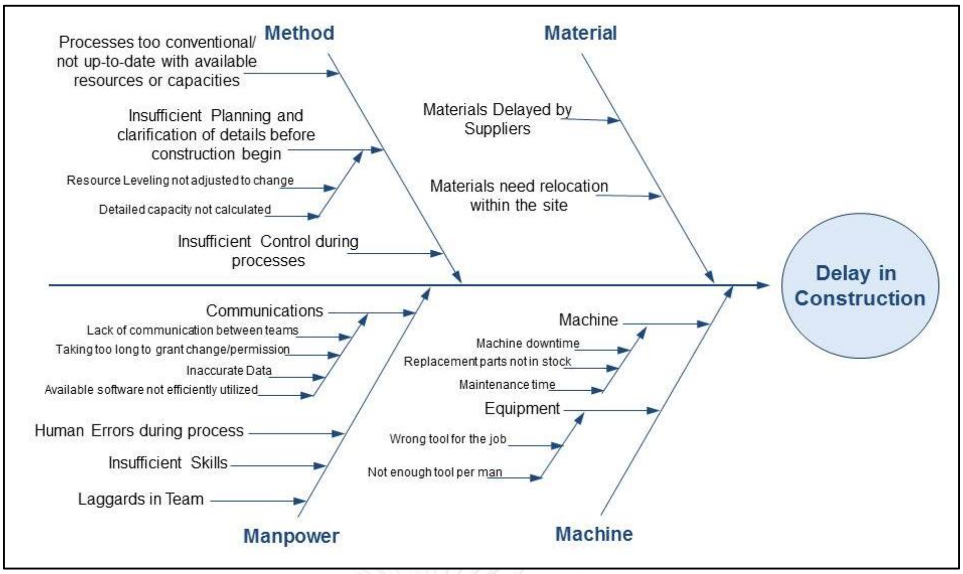


Figure 3.3 Fishbone Diagram for delay in construction

From the fishbone diagram in Figure 3.3, the major causes to the delay come from insufficient planning for each process. Without good project planning, the control in time, cost, and quality during the construction will be problematic. The planning stage includes not only the planning of schedule, but also, the overall management of the project such as costs, resources levelling, capacities check, and quality standards and control. Communication is also another main cause to the delay: the team has regular meetings but the goals for all members were not clarified on regular basis. The support systems/software for the users was not fit to the working condition. This problem leads to inaccurate data/record and unmatched information between the back office and the personnel on field. This could be the ease of use or the bugs that was never reported back to the software programmers. The last and most important cause to the delay is the reluctance to change by the people.

Prior to any change was suggested and implemented within the construction department at HPD, the causes found from Fishbone diagram were classified into three main issues including project management, Lean, or information system. In Table3.1, the roadmap to shorten the construction time is suggested based on the concepts of Lean. The roadmap, as a solution to the causes identified from the cause-and-effect analysis, represented a guideline for what would be done during the implementation. The guidelines chosen in the roadmap were based mainly on the concepts of lean, project management, and information system management.

Table 3-1 Roadmap to Implementation

	Project Management	Lean	Information system
Method	1. Processes breakdown and identify the possible critical tasks that can be improved 2. Controlling the project by improving the communications 3. Controlling the project by software	1a. Value Stream Mapping 2a. Apply ECSR to the critical path that can shorten the time 3a. One standard is used	2b. Sharing Information regarding project progress 3a. Utilize software's functions (S-curves) to control the project
Machine	1. Resource leveling for prefabricated concrete walls used		
Materials	1. Material Control 2. Collaboration with other teams	1a. Just-In-Time 1b. Construction site plan planning for best efficiencies	
Manpower	1. Capacity analysis control		3a. Process data must be input and done on the system accurately 3b. Software fitting

4. CHAPTER IV

Implementation

4.1. VSM on HPH001 Processes

With VSM concepts, the actual working processes for building HPH001 were listed out to begin with, and the critical processes were identified. The value added and non-value added were assigned as well as the suggested change using ECRS which will be further discussed in Process Revision section. In Table 4.1, the processes were further evaluated and the suggested plan for building HPH002 is shown.

Table 4-1: VSM on HPH001 Processes and the suggested change to HPH002

Process No.	Process	HPH001		HPH002		Critical?	VA/ NVA	Change Made ECRS
		day	Predecessors	day	Predecessors			
	Structure Fl.1	**19 days**		**12 days**				
2	Beam	2 days		2 days		Yes	VA	
3	Reinforced steel for beam	4 days	2	2 days	2	Yes	VA	Outsource
4	Layout hallow core for Fl.1	2 days	3FF	2 days	3SS	Yes	VA	
5	Reinforced steel in the floor - FlatSlab (Including piping and electrical)	5 days	4	2 days	4	Yes	VA	Outsource
6	Floor - Concrete pouring- FlatSlab	2 days	5	1 days	5SS+1	Yes	VA	Outsource
7	Reinforced steel work in the columns	4 days	5	2 days	5	No	VA	Outsource
8	Steel Ties in the column	3 days	7SS+1	2 days	7SS+1	No	VA	Outsource
9	Install prefabricated concrete walls	3 days	6	2 days	6	Yes	VA	Add Team &Crane
10	Columns Formwork	4 days	9SS+1	2 days	9SS+1	Yes	VA	Add Team &Crane

Table 4-2 VSM on HPH001 Processes and the suggested change to HPH002(Cont.)

Process No.	Process	HPH001		HPH002		Critical?	VA/ NVA	Change Made ECRS
		day	Predecessors	day	Predecessors			
11	Column concrete pouring	3 days	10SS+2	1 day	10	Yes	VA	Add Team&Crane
12	Install Prefabricated concrete stairs	1 day	13FF	1 day	11SS+1	No	VA	
	Structure Fl.3-8	**19 days**		**9 days**				
14	Install Dust Screen	2 days	12			Yes	NVA	Eliminate-Substitute
15	Lay out TableForm and Floor formwork for FlatSlab	4 days	14	2 days	11SS+1	Yes	VA	Outsource
16	Reinforced steel in the floor (Including piping and electrical)	4 days	15SS+2	2 days	15SS+1	Yes	VA	Outsource
17	Post Tension in the floor	4 days	16	4 days	16	Yes	VA	
18	Install Exterior prefabricated walls	1 day	17			Yes	VA	Material Change
19	Floor - Concrete pouring- FlatSlab	1 day	18	1 day	17SS+1	Yes	VA	
20	Steel Ties in the column	4 days	16	1 day	16	No	VA	Outsource
21	Reinforced steel work in the columns	3 days	19	2 days	19	Yes	VA	Outsource
22	Column Formwork	2 days	21SS+1	2 days	21SS+1	Yes	VA	Add Team&Crane
23	Column concrete pouring	3 days	22SS+1	1 day	22SS+1	No	VA	Outsource
24	Install Interior prefabricated walls and concrete fibers	3 days	22SS	2 days	22SS	Yes	VA	Add Team&Crane
25	Install Prefabricated concrete stairs	1 day	24	1 day	24	No	VA	
	Finishing Fl.1	**24 days**		**24 days**				
27	Door Frame work	1 day	11FS+8	1 day	11FS+8	No	VA	
28	Inwall electrical and piping	6 days	27SS	4 days	27SS	No	VA	
29	InteriorWall Skin work - portland cement	2 days	27SS	3 days	27SS	No	VA	
30	In Room Wall & Floor Tiles Work (Bathroom/corridor)	10 days	29	10 days	29	No	VA	

Table 4-3 VSM on HPH001 Processes and the suggested change to HPH002 (Cont.)

Process No.	Process	HPH001		HPH002		Critical?	VA/ NVA	Change Made ECRS
		day	Predecessors	day	Predecessors			
31	Wall Tiles (Elevator Frame)	4 days	29	3 days	29	No	VA	
32	Gypsum work/ Aluminum frames (indoors and outdoors)	6 days	29	6 days	29	No	VA	
33	Install Doors	2 days	30	2 days	30	No	VA	
34	Interior Painting	13 days	32SS+3	13 days	32SS+3	No	VA	
35	Install Sanitary wares and electrical equipment	6 days	34	6 days	34	No	VA	
	Finishing Fl.3-8	**34 days**		**25 days**				Start Date Change
37	Exterior wall skin - portland cement work	4 days	14	4 days	47	No	VA	
38	exterior painting	5 days	37SS+2	5 days	37SS+2	No	VA	
39	Door Frame work	3 days	15SS+7	3 days	15SS+7	No	VA	
40	Inwall electrical and piping	6 days	39SS	6 days	39SS	No	VA	
41	InteriorWall Skin work - portland cement	5 days	39SS	5 days	39SS	No	VA	
42	In Room Wall & Floor Tiles Work (Bathroom/corridor)	10 days	41	10 days	41	No	VA	
43	Wall Tiles (Elevator Frame)	4 days	41	4 days	41	No	VA	
44	Gypsum work/ Aluminum frames (indoors and outdoors)	6 days	41	6 days	41	No	VA	
45	Install Doors	2 days	42	2 days	42	No	VA	
46	Interior Painting	13 days	44SS+3	13 days	44SS+3	No	VA	
47	Install Sanitary wares and electrical equipment	6 days	46	6 days	46	No	VA	

4.1.1. Critical processes & Process Revision

Once the critical processes were identified, the job tasks were analyzed in details to find all the possibilities to shorten the construction time especially those in the critical paths. Recurring processes were found in patterns from structure through finishing. The same pattern of processes was found from floor 2 through floor 8 where the critical paths are those in structure processes and where the finishing processes are to follow the structure processes floor by floor. For example, the door framework along with the in-wall electrical and piping and interior wall skin work (Portland cement) always start one week after the Tableform are laid out for each floor. This finding leads to further analysis that each one day reduced in structure process can reduce the whole project by 8 days as each process recurred 8 times throughout the project, or 9 times on structure work as there is also another rooftop floor. The highlighted boxes in Table 4.1represent the processes that have been modified.

The examples for structure processes revision include the process for concrete pouring, reinforced steel in floor, and steel ties in column were found to require a lot of time and are all critical processes. However, when the processes do not require skillful labors, contractors with pools of labors can outsource the work with the company's foremen to ensure the quality and work process during the task while the time for each process per floor can be reduced by more than 30% of the time originally projected. On the other hand, when the tasks require skillful labors or heavy machines, the processes require further analysis, such as process #18 and #24; both are install prefabricated walls, however, the exterior walls needed to be installed before pouring floor concrete while installing interior prefabricated walls do not require such action. The two processes require heavy tools and require skillful labors to install the concrete walls with certain techniques and cannot be outsourced. In this case, the crane was found to be the constraint to prevent the ability to reduce the working days for installing concrete walls. After the analysis that the addition of crane and a team or skillful structural labor will reduce processes for each floor by more than two days, another crane and another team of skillful labors for walls installations were then granted for the project, and the installing concrete walls were shorten down by half.

For #18, the exterior walls process was further evaluated and found that the prefabricated exterior walls installations were constraints to both the structures and the finishing stages of the building processes. The possibilities to improve this process could be to change the exterior walls' material to reduce the construction time as doing so will reduce the structural process and also the finishing processes for every floor can start even earlier without having to concern about the exterior wall skin. With the decision, the whole step can be eliminated from critical process, and with this process change, the total time for finishing work per floor was reduced by almost 10 days.

As for material substitution, engineering knowledge can also be a tool to reduce the construction time. One of the ways to see how fast the building is built is to see the concrete pouring stage from floor-to-floor. The engineer can shorten the time of the building to the maximum of concrete strength. The additives to this process may cost more, but may save the interest from the loan in the end. For the revised processes, the concrete pouring from floor to floor will be reduced from working days down to 7 working days.

In a big picture, at HPH001, each floor requires 19 days of structure processes, but floor-to-floor, such as concrete pouring floor 1 to concrete pouring floor 2, requires 14 days and 35 days of finishing processes for each floor following the structure processes. With the new processes for HPH002, the structure processes were lowered down to 9 days and the speed for floor-to-floor is 6 days and the finishing processes are down to 25 days. By having the structure processes recurring of 9 floors including rooftop floor, the reduced time for the total working days of at least 72 (9 floors x 8 days reduced) working days on structure processes and10 more days for finishing process, which makes the total working day lower by 82 days equivalent to 3 months and 4 days of working period (one working month includes 26 working days). The total processes, including underground work, without any delay was expected to be 200 working days which is equivalent to 7 months and 20 days was then expected to lower to 4 months and 16 working days.

4.2. Manpower

With the new process sequences suggestion, every party involved in the processes is also affected. The numbers of the labors required during the project must be revised as well as the sub-contractors that will need to be increased if the capacity of the current team was not sufficient for the new construction pace.

4.2.1. Human Capacity (Manday)

Similar to takt time analysis, mandays are used as a tool to analyze the time (in days) required for one process/job if it was done by one man. This mandays allow the team to estimate the capacity, labors and subcontractors, required to meet the rate of construction from the newly suggested processes. The numbers or labors and subcontractors required for each process at HPH002 were then estimated to match the processes. In Table 4.2, the numbers of the mandays required is based on the actual capacity used in HPH001. Once the mandays were calculated, the concerns of insufficient in-house labors were raised along with the labor cost that can be increased if the overtimes (O.T.) are paid more as each labor will have to finish the same amount of work task in a shorter period of time.

Table 4-4 Manday Calculation Table

Task	# men	Time Required (days) per floor	Man-day per floor
			0
Reinforced steel for beam	10	4	40
Layout hallow core for Fl.1	4	2	8
Lay out TableForm and Floor formwork for FlatSlab	3	4	12
Reinforced steel in the floor- FlatSlab (Including piping and electrical)	10	4	40
Post Tension in the floor	OS	depends on concrete strength request	-
Install Exterior prefabricated walls	5	1	5
Floor - Concrete pouring- FlatSlab	14	1	14
Steel Ties in the column	6	4	24
Reinforced steel work in the columns	3	3	9
Column Formwork	5	2	10
Column concrete pouring	4	3	12
Install Interior prefabricated walls and concrete fibers	4	3	12
Install Prefabricated concrete stairs	3	1	3

Table 4-5 Manday Calculation Table (Cont.)

Task	# men	Time Required (days)	Man-day
		per floor	per floor
Exterior wall skin - portland cement work	OS	14	-
exterior painting	OS	5	-
Door Frame work	2	1	2
Inwall electrical and piping	OS	2	-
InteriorWall Skin work - portland cement	OS	3	-
In Room Wall & Floor Tiles Work (Bathroom/corridor)	OS	10	OS
Wall Tiles (Elevator Frame)	4	4	16
Gypsum work/ Aluminum frames (indoors and outdoors)	OS	6	-
Install Doors	3	2	6
Interior Painting	OS	13	-
Task	# men	Time Required (days)	Man-day
		per floor	per floor
Install Sanitary wares and electrical equiptment	OS	6	-
Total Manday			213

<u>Note:</u>

1.working hours 7.30 - 17.30 / NO O.T. / Day off on Sunday

2. OS stands for Outsource

The project management team had come up with a solution that certain works will be outsourced based on the actual mandays in HPH001 with additional 10-15% operating cost to get most of the costs fixed and lower the overrun cost from variations that could occur from external factors.

An example of capacity planning would be the times required for the outsourced tasks that are shown in Table 4.5. The processes can be shorten by adding more subcontractors as the rate of work delivered is a linear relationship between the labors and the time: for the *In Room Wall & Floor Tiles Work (Bathroom/corridor)* task, knowing that the time required for one subcontractor team is 10 days per floor, when actual construction is in progress and more capacity for the task is needed, the amount of subcontractors can be interpolated from this working rate. Similar to the subcontractors estimation, the time required for installing prefabricated walls by in-house labors can also be shorten with the increased number of labors. Because construction is a labor intensive industry, most of the works still require actual human craft, and by reduced working day does not mean that the man-day will be reduced.

4.2.2. Communication and Information Flow

Communication plays the biggest role in smoothing the whole construction processes. Without good communication and correct information sharing between the team members, the team as a whole will always encounters problems.

4.2.2.1. Communication and Collaborations

Prior to the change in processes, regular meetings were already in place for the construction site management team. A site meeting is held in the morning of every working day, and it is mandatory for all personnel on site to attend the meeting. However, from the observation, the site meeting is there to assign work tasks for all of the labors and the contractors while the goals for the whole team were not communicated and clearly stated. Also, there was no meeting set for all units involved except for the construction department meeting every other week to discuss about the problem for the project itself.

The change was made when Lean was implemented to ensure that the project would not delay and that the goal was made clear to everyone involved. Morning meetings were regularly held through the project. However, one change made was a weekly meeting for every unit involved including the project site managers, construction management team, production plant manager, and purchasing manager. This meeting will provide understandings on the tasks and deadlines and allowing discussions regarding the problems. Also, there will be two minor meetings with other departments: one is between the architect, construction management, and construction sites to discuss the possible delay based on available materials specified and change that might be needed. The other meeting will be with sales department, to discuss any change regarding the construction schedules and the quality of the products delivered to sales department.

4.2.2.2. . Information Flow

The information is also one of the most important parts in the whole processes, the more information is perceived by the team, the better team for the project it is.

"*The pre-lean implementation database is generally corrupt with inaccurate information, such as inventory, lead times, and bills of material*. " (Thomes[1])

The information system could highly benefit the project management team if it was functioning correctly with the correct data. The result found in HPH001 showed an inaccurate data from the input stage where there was inconsistency in data input function. The information system support team had been involved through the implementation to ensure that the software was function correctly. Also, the software fitting was redone for the whole construction team as it was found that the construction personnel tend to avoid the use of software when there was an error or when the software was too complicated for use.

4.2.3. Machine

Cranes were considered part of the constraint in process revision. Because the crane's efficiency can be measured from the operating time in the construction process, as it was calculated that one day of crane down-time can cost the delay to the following construction process, as most of the structure processes require cranes. The other important constraint is the crane's arm; the location of the crane sets limit to working processes in the case where the chosen cranes are static tower cranes that can only work within the radius arm that may or may not cover the whole building construction area.

Maintenance is required for the cranes. The best way to avoid crane's downtime is a regular check-up of cranes. Replacement parts for the parts that always have problems will need to be in-stock and ready for replacing the broken parts if the cranes have a normal problem

4.2.3.1. Resource leveling for factory

Apart from onsite cranes, prefabricated concrete factory is considered another machine to this whole construction processes as the factory supplies prefabricated concrete walls to the site, and now the process time is cut down by half, the factory's capacity needs to be reevaluated. The time the prefabricated walls required to be on sites are shown in Figure 4.1 as red columns. If the factory were to operate as the suggested plan, the factory manager will definitely runs into a labors management problems.

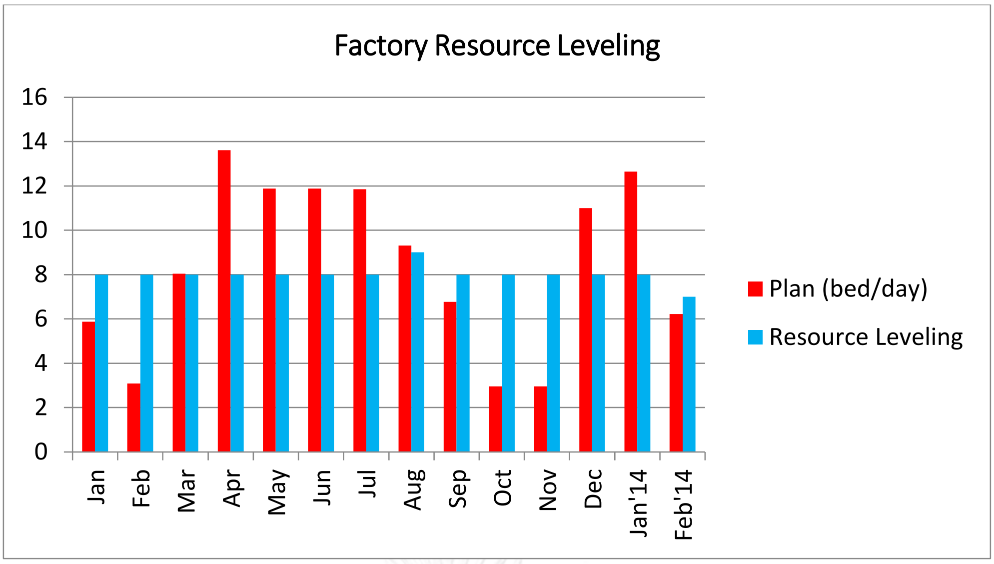


Figure 4.1 Factory Resource Leveling

With the suggested graph, capacity analysis was performed on the factory. Prior to the implementation, it was found that detail information of factory planning was not performed correctly, and some of the plans in factory change due to the executives' orders as there were no clear information to defend the order.

The factory at the time had the ability to operate at full capacity of 10 beds a day; a single house in housing projects requires the average of 11 beds regarding the types. The townhomes require the same amount of beds per unit, but the construction process is done block by block. For condominium project, one floor of a building is equivalent to 4 single houses. With the rate defined, the required construction plan was worked backward to get the total beds of concrete walls required for the projected plan for each month. With the construction plan varying from projects timing, different amount of prefabricated walls were required from the factory as shown in Figure4.1. From all project production plans, it was found that the production will require 8 beds of production a day to supply the construction sites during the fourteen months based (see Table 4.3 for detail calculation).

Table 4-6 Capacity analysis done on the factory

	Month/2013	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan'14	Feb'14	Total
Plan 2013	DRB	3	3	4	4	3	3	4	4	4	3	3	3	3	3	
	WRB	3	3	3												
(in house)	WR9	4	3	3	2	4	4	4	4	4	4	4	4	4	4	
Factory Production Plan:	HPH				16	16	16	16	16	8			16	16	6	
	TR2	2	2	2	2	2	2	0	0	0	2	2	2	2	2	
	Stock	6	6	3				0	2							
	Plan (house)	6	5	9	24	25	25	24	22	16	9	9	25	25	15	
	Plan (bed)	**66**	**55**	**99**	**264**	**275**	**275**	**264**	**242**	**176**	**99**	**99**	**275**	**275**	**165**	**2629**
1 House=	working days	15	25	26	21	25	25	26	26	26	26	26	23	20	23	333
11	**Plan (bed/day)**	**4**	**2**	**4**	**13**	**11**	**11**	**10**	**9**	**7**	**4**	**4**	**12**	**14**	**7**	**7.89**
	Total beds	**66**	**55**	**99**	**264**	**275**	**275**	**264**	**242**	**176**	**99**	**99**	**275**	**275**	**165**	
Production Beds	Adjust Capacity float(8beds/day)	54	145	109	-96	-75	-75	-56	-34	32	109	109	-91	-115	19	
	Accum float	0	199	308	212	137	62	6	-28	4	113	222	131	16	35	
	New Plan (bed/day)	8	8	8	8	8	8	8	9	8	8	8	8	8	7	

4.2.4. Materials

Because the site project area is very limited in places for stock, Just-In-Time must be applied to the materials delivered on site, and materials storing management must be done. The regulation is to have the materials used for the floor delivered to each floor especially when the work process is in the finishing phase. The site area during the structure phase is to be set for the prefabricated concrete walls.

4.2.5. Quality inspections

Quality inspections are already in most of the processes to ensure that there is no extreme defects occur to cause a stoppage during the construction period. One standard for every party is another important rule to standardize the quality. One document is used for contractors, foremen, and QC team to ensure that the quality checklists are specific on how the work should be. The construction standards already existed at HPD and were made clear to all the units involved in the construction processes. Yet, the problems encountered during the inspection processes were the specifications of the materials used that were not clear for the contractors or the subcontractors.

4.2.5.1. Clarification on Standards

The problems were found that the specifications from the architects were either not specific enough such as the thickness of aluminum (a box shape aluminum was given the dimensions but not the thickness of the aluminums) or the piping brands or electrical wires that were not specified. With the company's BOQ unit giving out the price, specifications were somewhat clear where brands were specified with the note "or equivalent to." The quality control unit was given a task to standardize all the unclear specifications with the extra options to eliminate the "equivalent to" and minimize the time that the teams spent on dispute of the issue. The examples of generated standards for specifications are shown in Figure 4.2. (See Appendix C for the actual standards used without translations).

PROJECT : ....
HOME TYPE : .... แปลงที่ : ....
CHECK BY : ....
DATE : .... ครั้งที่ : ....

HOMEPLACE
HOME PLACE DEVELOPMENT co.,ltd
541 Srinakharin Road Sounloung Sounloung
Bangkok 10250 Tel.02-322-1855 Fax.02-322-1856

Standard Specification Checklist for Piping System — H-TH-2014 UPDATE 17 มิถุนายน 2557

ลำดับ	Material	size	Class	Brand/Specs	Use	Not	Pass	Fail	Responsible
1	Clean Water Inflow								
	1.1 BLUE PVC PIPE	Ø 1/2"	Class 8.5	THAIPIPE or SCG					Contractor
	1.2 BLUE PVC PIPE	Ø 3/4"	Class 8.5	" ------- "					" ------- "
2	Used Water Outflow								
	2.1 BLUE PVC PIPE	Ø 1 1/2"	Class 5	THAIPIPE or SCG					Contractor
	2.2 BLUE PVC PIPE	Ø 2"	Class 5	" ------- "					" ------- "
3	Sewage								
	3.1 BLUE PVC PIPE	Ø 4"	Class 5	THAIPIPE or SCG					Contractor
4	Air Pipe								
	4.1 BLUE PVC PIPE	Ø 1"	Class 8.5	THAIPIPE or SCG					Contractor
	4.1 BLUE PVC PIPE	Ø 1 1/2"	Class 5	" ------- "					" ------- "
5	Outdoor Used water Drainage								
	5.1 BLUE PVC PIPE	Ø 4"	Class 5	THAIPIPE or SCG					Contractor
	5.2 ROCK FIBER CEMENT PIPE	Ø 6"	---	GENERIC					HPD

Figure 4.2 Standard Specification for Piping

The brands for the materials used were specified with one extra brand in the case of market shortage. Also, the types materials for types of work were clarified as well as the people in charged for sourcing out the materials. The same forms were used by the teams on site both company's team and the contractors, and the quality team also use them for the check record. Figure 4.3 is another example of translated standard specification forms.

PROJECT : ....
HOME TYPE : .... แปลงที่ : ....
CHECK BY : ....
DATE : .... ครั้งที่ : ....

HOMEPLACE
HOME PLACE DEVELOPMENT co.,ltd
541 Srinakharin Road Sounloung Sounloung
Bangkok 10250 Tel.02-322-1855 Fax.02-322-1856

Standard Specification Checklist for Electrical System — H-TH-2014 UPDATE 17 มิถุนายน 2557

ลำดับ	Material	size	Class	Brand/Specs	Use	Not	Pass	Fail	Responsible
1	Electricity Meter								
	1.1 Meter Size	15 (45) A	---	---					CITY ELECTRICs UNIT
	1.2 Meter Size	30 (100) A	---	---					" ------- "
2	Main Electric wiring								
	2.1 Electric Wires	10 Sq.mm	---	Thai-yazaki/BangkokCable					Contractor
	2.2 Electric Wires	35 Sq.mm	---	" ------- "					" ------- "
3	Main Ground Electrical wiring								
	3.1 Electric Ground Wires	10 Sq.mm	---	Thai-yazaki/BangkokCable					Contractor
	3.2 Electric Ground Wires	16 Sq.mm	---	" ------- "					" ------- "
4	Main Circuit Breaker								
	4.1 Main Circuit Breaker	2P-50 AT	---	BTICINO					Contractor
	4.2 Main Circuit Breaker	2P-100 AT	---	" ------- "					" ------- "
5	Inside Main Electric Wiring								
	5.1 LIGHTING	2.5 Sq.mm	---	Thai-yazaki/BangkokCable					Contractor
	5.2 OUTLETS	2.5 Sq.mm	---	" ------- "					" ------- "
	5.3 Air Conditioning	2.5 Sq.mm	---	" ------- "					" ------- "
	5.4 Water Heater	4 Sq.mm	---	" ------- "					" ------- "
	5.5 Neutron wires (Blue Wires Only)	2.5 Sq.mm	---	" ------- "					" ------- "

Figure 4.3 Standard Specification for Electrical

5. CHAPTER V
Results & Discussion

The suggested plans were implemented on the project Bliz condominiums HPH002. The results from the implementation show that the time for construction was shorten as expected. The total days used for the new and suggested construction process is five months including days off. HPH002's S-Curve showing Actual and projected % progress of the project is shown in Figure 5.1. The total construction time for HPH002 was 5 months including the holidays throughout the project period, and from the S-Curve shown, it was clear that the data displays more consistency trend.

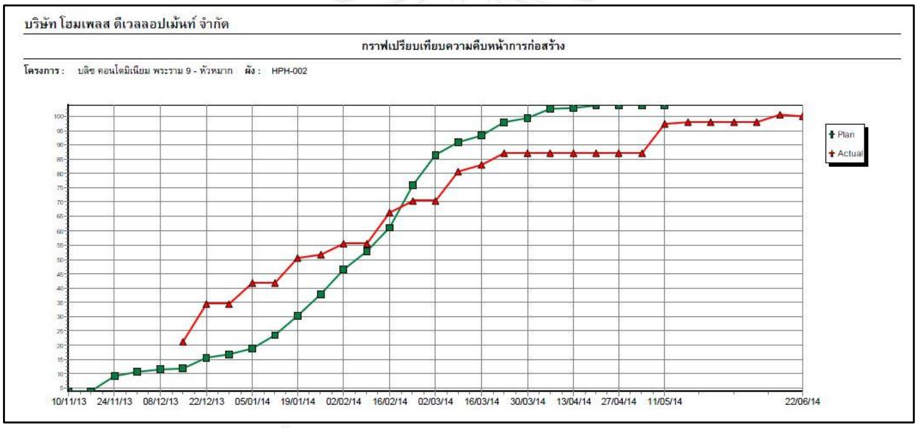


Figure 5.1 S-Curve of the work progress through time of HPH002

5.1. Results Comparison

The result from the Lean implementation at HPH002 was compared directly with that of HPH001 by matching the time period for the two buildings. HPH001 is also another building in the same project Bliz condominiums with the exact same size and design In Figure 5.2, the comparison shows that the total construction time improved greatly. The red lines in Figure 5.2 were the same dates for the two curves that were matched proportionally. The other comparison was done on the cost difference for HPH001 and HPH002 (See Appendix C.3& C.4 for S-Curve of Cost for the two buildings) where total cost reduced from the process changes from 45.84M baht to 44.96M baht. As mentioned in Implementation Chapter, construction is still a labor intensive industry, and by reducing construction time, construction costs do not also drop: the amount of materials and the amount of craftsman work required for the tasks are still the same.

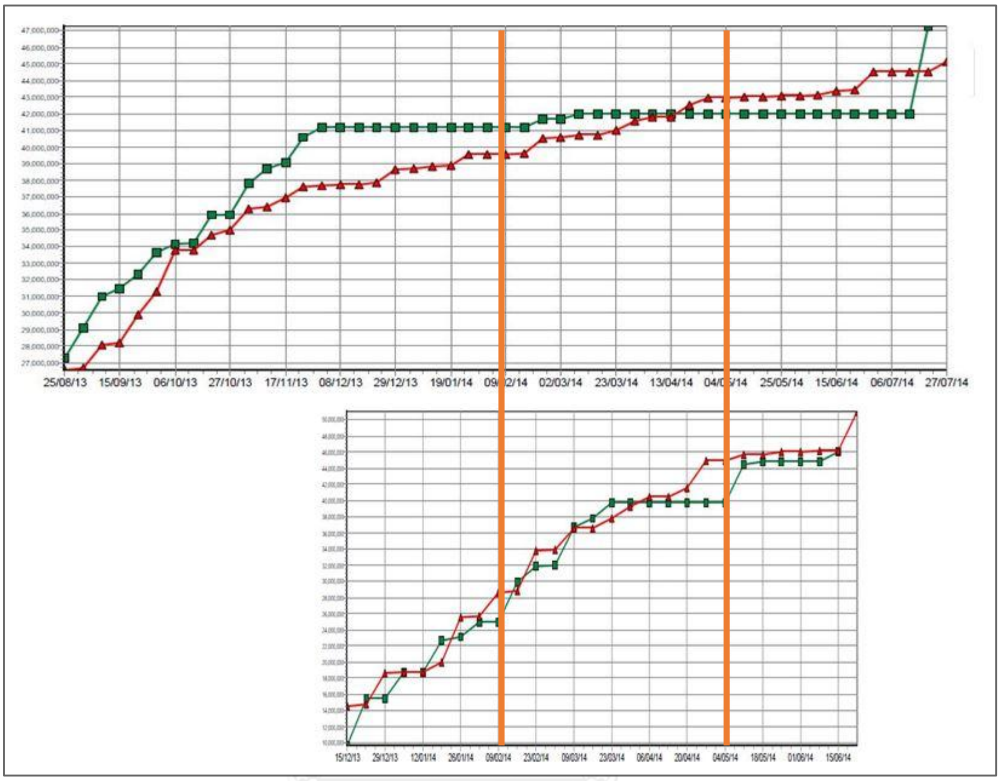


Figure 5.2 The comparison between HPH001 and HPH002

5.1.1. Implementation Evaluations

5.1.1.1. Process Timing Management

The actual number of days per floor was as expected, but the actual timing for floor-to-floor for structure processes were between 5 to 6 days which is even less than that of expected. (See pictures of the project's progress in Appendix A.1). The implementation was an intensive project management where the working progress was closely monitored along with extreme resource management including the materials, the contractors, and HPD's labors on site as well as strict management on site.

Prior to the implement, the working plan was given to the construction manager and was rearranged before the final plan for the implementation was approved. During the implementation, the progress, however, did not fall exactly as planned. For example, the plan was to have two shifts working for certain teams, but none of the labors were fully agreed with the night shifts suggested by the management teams and the construction manager. After three days with night shifts into the project, the new plan was regenerated and the little process details were changed. More process breakdowns were performed on certain tasks including the prefabricated walls installation. During the planning, one process that was not included in the beginning was “line plotting.” Line plotting is required to be done before any walls are to be installed and only two skilled labors are needed for the process. Line plotting can be done on the same night of concrete pouring day to allow the actual wall installations be done the first thing in the morning and could still have the prefabricated walls process done in the same projected days without the night shifts. In lean, it is clear that the people who do the job know best at what they do. It is important to include all ideas possible to obtain the best results.

Apart from the changes and controls on the project schedule, the checkups on the procurements of the project were mandatory. Many of the suppliers for the company were consistently confirmed on the deliveries or the capability to supply materials/raw materials for the project’s construction. Ready-mixed concrete was a good example where one ready-mixed concrete plant has to supply for many construction sites, the plant specified the exact dates where the whole plant was locked for certain mega construction projects and would not be able to supply for the project. With the required dates given to all parties involved, the purchasing department who is responsible for sourcing the suppliers had to sort out the problems and made it possible to have the ready-mixed concrete on site on such days. Another example would be the supplier could not supply the materials/products for the construction team on time, two solutions derived from the issue include the addition of suppliers for certain products by purchasing team or the help of time managing by the construction site manager. The toilet bowl supplier was one of the suppliers who could not deliver the products in time and the construction site manager, knowing that there was room for delays if the working processes were readjusted, then worked out the time rearrangement with the teams involved and sort out the problem whether the work is by the contractors or the company’s labors.

The last and most important part in this project management was the human management: the contractors and the labors. As the numbers of contractors required were worked out from the HPH001 mandays, the numbers of the contractors were not a problem, but it was found that some contractors or subcontractors tend to have an even higher capability than that specified in HPH001. Team readjustment had to be done throughout the process to obtain the right numbers of contractors required. The other important aspects for contractors management was the inspection processes and payments confirmations. In recruiting new contractors or subcontractors, the payment confirmation was doubted by most newcomers in construction businesses, but HPD's reputation at on-time payment is known by contractors and subcontractors, which has helped the construction in recruiting newcomers. Yet, the inspection processes at HPD tended to drive many contractors or subcontractors away. In example, the building system (electrical and piping) contractor has 16 installments, and the work progress has done by far equivalent to the first three installments, and the work progress is already on the fifth installment process but the tasks in the first installment was not completely finished, and the inspection team would not pass any of the payment leading to financial shortage of the contractor. These problems were resolved through the weekly meeting that was set for all units involved where the manager who could make a call made a decision for such cases.

For managing HPD's labors, otherwise, do not involve directly with money, but more towards the managing the team's drives and understandings for the goal. Tasks allocation for each personnel is the key element to best describe the management of HPD's personnel for the success of the implementation. Prior to the implementation, most of the labors would stick to only one job task with the belief that they were unable to do other jobs. Having to set a structure with learning culture where each small team has at least one person who has skill for the assigned job tasks, it was possible for the whole team to learn from that one with skill. The other concept used along with job allocation was the use of incentives. Not all of the employees are willing to do certain jobs, such as the jobs dealing with the exterior works or the cement skins on the edge of the floors especially at the higher floors. The difficulties of the certain job tasks were reevaluated during the implementation and the ones that were considered more difficult for the labors that were reallocated around were given additional pay for the jobs. With the changes implemented, not only the skills were given to the labors along with the incentives for certain tasks, but also, the teams' mindsets were the extra, yet, the best results developed through lean implementation.

5.1.1.2.Teams' Mindsets

One of the most important changes affected by Lean Implementation was the people's mindset: With the new improved processes, people mindset also adapted with the change. Most of the reactions received from the team prior to the implementation were the impossibilities of the suggested processes and schedules. Because the results found throughout the processes were better than the projected plan, the whole team learned that it was possible to shorten the time by half. Apart from the beliefs on the possibilities of changes for improvement that were changed, the whole process has built an even better bond between the team members especially between the rankings. The people in the operating level become more comfortable in inputting opinions to resolve problems or when making changes to processes which sometimes generate the even better solutions.

5.1.1.3. Communication

The meetings were held throughout the construction period as planned. During the meetings, the goal and project progress were reviewed along with the problems on site were resolved. The schedules of the projects were checked based on actual progress and the plans and were presented to the involved parties during the meetings. In addition to the project schedule updates during the meeting, many problems were solved from all units including problems from the materials shortage in the market to the unapproved payments to the problems of contractors' financial shortage that needs support from HPD. The problem between the contractors and the inspection process that was mentioned earlier were raised in the meeting and was resolved case by case and only a few exceptions were given by the top manager who attended the meeting to the contractor due to the large amount of money that the contractors had put into the work and the financial difficulties could have caused the stoppage in the total progress. The other issues include the suppliers' problem of late deliveries that were managed and resolved by the purchasing team right away.

The information sharing was well improved between the teams during the implementation which helped lessen the unnecessary clarification and discussion processes that were in place prior to the change. The new standard for the unclear specifications was one of the information sharing that was performed. With one standard/one form for every party, the issue of having to clarify specifications almost disappeared. This leads to new findings that the problems found before that had caused the unresolved issue inspection teams and the subcontractors/contractors were from the materials/raw materials. Certain shapes of materials were impossible to be manufactured exactly as the design concepts, of such problems, the coordinators brought back the specification to discuss the change required with the design team. The finding of the problems, the discussion, and the change was the working loop that had occurred from this implementation which helped smooth the processes not only within this project, but all of the projects.

5.1.1.4. Information System

The data management also facilitated the path to the improved communication between the teams. The software fittings were performed before the implementation, throughout the implementation, and even after the implementation. The improvement was found as the data input were more consistent as shown in Figure5.2. The same information generated from the software and database was used in and out of the meetings throughout the processes. Once everyone holds the same information, the communication between teams became even more effective and efficient.

5.1.2. Leadership

The implementation would not be successful without great leadership in the team members. "Leadership" was not referred only to the executives or the top management team, but rather is a characteristic that is found in any person in a team from the top management down to the operator level. It refers to someone who understands the goal, knows the path to the goal, and influences and support the others to reach the goal altogether: "a process of social influence in which a person can enlist the aid and support of others in the accomplishment of a common task."[11]

The leaders in all the units must be aware of the change, adapt early to the change, and lead and influence their teams towards the goal. They must have keen vision on what could be done and what are the precautions when changes are implemented. When any process is to be reduced in time, or to be shifted up in the working sequence, the leaders must know the possibility when making the change; they must understand the overall circumstances of the project on both the process and the people working nature.

During the implementation one of the great leaders were found from the management level, such HPD's mangers and the contractors, to operator level, such as the team leader of the prefabricated walls installation team. The construction department manager had made clear the goal and direction of the change required for the whole process and committed to the suggested plans with the follow ups on changes made throughout the processes. Not only did he make clear on the objective and commit to the change, he also had the ability to influence other more seniors in the project on the possibilities of the change using the theories to support and the skills of encouragement and involvement. In construction culture, the seniorities had played a big role to hold back the changes in any organization, and newcomers without the ability overcome the intimidation from the seniors tend to not being able to fit in and most of the time leave the company on their own. The construction manager was discussing most of the processes with the people who have direct responsibility and had been giving out clear goals with the milestones to check the progress. The most important part was the perceptions towards the team were twisted; during the implementation, the working processes were identified as the problems rather than the responsible person.

The other leadership characters were found when the wall installation team leader suggested the change for the suggested process flow and schedules. Most of the time, the people in the operating level in Thailand tend to not suggest any change with the belief that their suggestion would not benefit the company as much. By having courage to challenge the approved plan was the right thing to do if it could improve the process for the overall team. However, if the project site manager did not listen and utilize the given suggestion, the overall results found may not turn up as it did.

5.1.3. Uncontrollable Variables

With the research being a comparative type, it was essential to keep the conditions of the two comparing construction for the two buildings be as identical as possible. The two buildings, HPH001 and HPH002, locate within the same project and the two construction periods were both in the same timeline of production, and thus, the weather should not be the problem to this research. The variables that were considered to affect the comparative results were controlled. Nevertheless, the uncontrolled variables were still found mostly from external factors that affected HPD directly including the capabilities of subcontractors/contractors, the effect from the economy, and the policies from the government that affect the cost or the shift in labor pools.

When the processes were shorten down, the teams required to keep the pace of the new plan also increased proportionally. The contractors and subcontractors were the two obvious skilled labors to require for the implementation. There were new contractors/subcontracts that were recruited were not evaluated on their performances and quality of work. The two problems encountered were new subcontract who could not deliver the work on time left in the middle of the project and the work delivered had cause the after service work. For the case that caused the after service work was the aluminum work of two units where the subcontractor was new to HPD and left in the middle of the project because he could not generate the products up to HPD’s standard. The problem found was the leak between the walls and the aluminum frames which later was found that the subcontractor inserted a material between the wall and the frames because they could not make the frames as exact as the other subcontractors. The system to control the subcontractors/contractors are currently being improved at HPD to ensure that the construction work will not create more work for the after service team.

Another factor to the construction was the economy during the process. The constructions are affected somewhat by economy. The labors, the material suppliers, and the funding are the indications: During the good economy, the construction is booming, the shortage of labors and the materials' lead-time start to show while the funding was never a problem. However, once the economy starts going down, the funding was first cut, then more available labors and the shorter lead-time of materials follow. At HPD, the labors are hired on a daily contract and it is possible that the labors can leave on their wills when they find a company with better pay. During the comparing periods of HPH001 and HPH002, there were less numbers of in-house labors during HPH002 and the project manager had to resolve the problems to deal with subcontractors with a lot of labors to do the basic work and to pay by mandays.

The last uncontrolled variable that affected the construction during the period was the Government's policies. Minimum wage and the foreign labors allowance policies directly affect the project in the strategy and the cost. As labors account for 35% of the construction cost which is 30% of project revenue which the actual labor cost account for 10.5% of the revenue. When the minimum wage increased from 265 baht to 300, which is 13% that directly raised the cost in the bottom line by1.38%. The new minimum wage caused the company to set new strategy including lean implementation to ensure that the cost would not overrun. Another government policy was the AEC's labors allowance policy which allows the labors from AEC country to come work in Thailand. There are agents to directly find the labors and have them contracted directly with the company when more labors are in need. HPD decided to contract foreign labors as they require more labors for the work, but the labors brought in by the agency were unskillful and do have problems of staying. Only 30% of the total labors lasted until the project was over. These are the examples where the external factors could affect the strategy or the resources of the company, and yet, cannot be controlled.

5.1.4. Risk Mitigation

With the examples where the controls were not plausible, risk evaluation and mitigation was performed to find the solution for certain situations. When the project was shortening down, one of the decisions made was to fix the contract prices for certain jobs to ensure the cost would not increase throughout the processes. When HPH002 was in process the same as HPH001 contract pricing was used. However, in the cases of the labor shortage where HPD ended up hiring foreign labors and 70% of the newly hired could not stay and could affect the labor management at HPD, the risk was mitigated by negotiation with the contractors with a lot of foreign labors who are capable of supplying labors and deal with HPD based on the actual mandays they labors work. The risks identified in procurement processes were also mitigated by negotiating the timing and rescheduling the delivery time. Most of the risks could be mitigated by information sharing and communication, and even with external factors that could still affect the project, the risks would be minimized or mitigated.

6. CHAPTER VI
Conclusion & Recommendation

6.1. Conclusion & Recommendation

Throughout the research of Lean implementation for construction time reduction, construction time for an 8-storey condominium project was reduced from 9 months to 5 months. Homeplace Development Co.Ltd is a real estate developer in Thailand to produce houses, townhomes, and condominiums for sale with its own fabricated concrete wall factory to supply for all the projects. Prior to the implementation, HPD had already been exposed to concepts of Lean where the construction process for housing and townhome projects were adjusted into one-house flow and one block flow concept, which is analogous to the one-piece flow concept in Lean. The condominium projects, however, was not HPD's expertise in production system. The condominium projects accounted for 20% of the total projects in the past 3 years on average. In the past two years, HPD had experienced the delays in schedules for two of the condominium projects. Along with the minimum wage policy imposed by the government in 2012 into 2013, the executives foresee the possibility of cost overrun and the opportunity cost that HPD lost from the delays in the condominium projects because each condominium projects has a sunk cost during the construction period where there is no profit inflow of cash.

Construction department had utilized the concepts of Lean to the existing construction processes for low-rise condominium. The implementation was done on the Bliz condominium project where one of the two buildings with exact same designs and requirements was Lean implemented in the processes (HPH002), and the other building was built with the existing conventional processes (HPH001). The construction time reduction was the main focus in the research and S-curves for the two buildings will be compared.

In order to begin the implementation, the individual processes were listed out and categorized into three focuses including the project management, Lean, or the information system. Cause-and-Effect analysis (fishbone diagrams), critical path analysis, value-stream-map were tools used in process revision stages. The roadmap for the implementation was generated from the cause-and-effect analysis as a guideline for the implementation (See Table 3.1).

Following the roadmap, the work processes breakdown was performed, and critical processes were defined and revised. The concept of ECRS was used as a tool for the process revision where certain tasks were rearranged in resources to reduce time, and the certain tasks were simplified by material substitution and there was also a task that was eliminated.

With the new processes derived, the total processes, including underground work, without any delay was expected to be 200 working days which is equivalent to 7 months and 20 days was then expected to lower to 4 months and 16 working days. For HPH001, floor-to-floor, such as concrete pouring floor 1 to concrete pouring floor 2, requires 14 days and 35 days of finishing processes for each floor following the structure processes. With the new processes for HPH002, the speed for floor-to-floor is 6 days and the finishing processes are down to 25 days. By having the structure processes recurring of 9 floors including rooftop floor, the reduced time for the total working days of at least 72 (9 floors x 8 days reduced) working days on structure processes and10 more days for finishing process, which makes the total working day lower by 82 days equivalent to 3 months working period .

Once the new processes were derived, the capacities were then re-analyzed to comply with the new time limitation, the less time, the more condensed the resources, the more resources per day required. Mandays were calculated and worked similarly to takt time to calculate the capacities required for the suggested processes. The resource leveling was also done in details to ensure that the prefabricated walls will be ready in-time during the construction period of HPH002.

Additionally, communication within the team was readjusted to have more information sharing between the teams to help reduce the unnecessary discussion that will cause a stoppage to the construction. The regular meetings were unchanged but one full team meeting was added on to bring in all of the teams involved to resolve the problems on site every week. The specification standards for the raw material used on sites were also clarified between the subcontractors/contractors, the construction site managers, and the inspection team where one same standard form is held by every party involved.

Apart from the project management phase with lean utilization, the information system of the company was also reevaluated. Information system at HPD acted as a backbone for the information sharing. The software fitting was done for the whole team the data input became more accurate and the same and updated information were used by every unit, which yielded a higher efficacy in coordination within the team.

With the implementation throughout the construction, the total construction time was reduced to 5 month time. (See Figure 6.1)

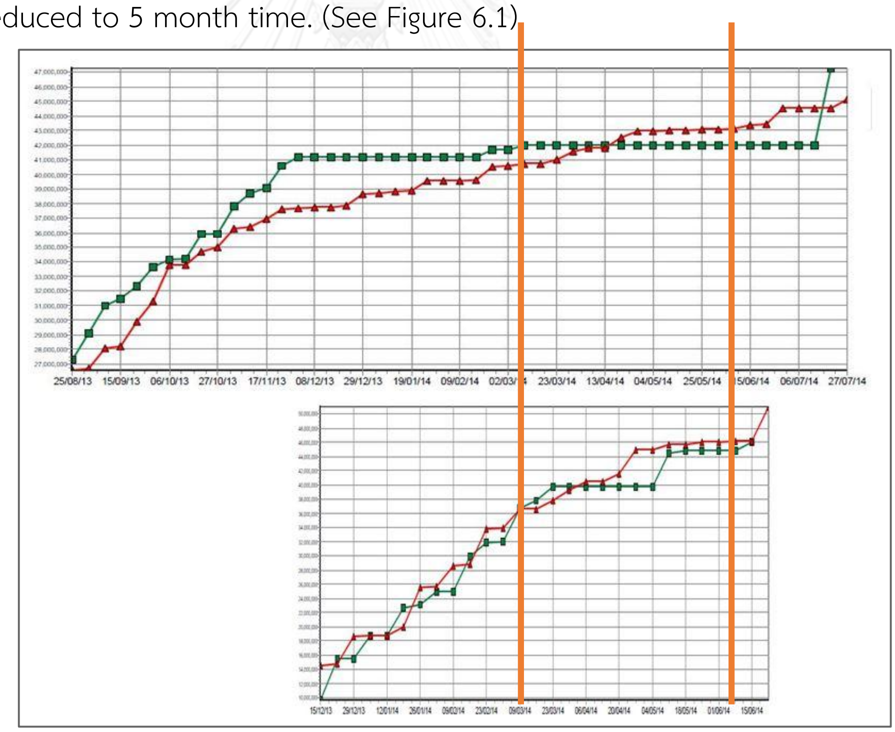


Figure 6.1The Comparison between HPH001 and HPH002 (Figure5.2)

In Figure 6.1, the working progress versus time curves for the two exact same buildings with one being the conventional construction process (HPH001) and the other one being the lean implemented processes (HPH002) are presented. The time was clearly lowered as expected. The implementation was successful as the suggested plan were followed and adapted for some changes for better. The project was not only planned, but well controlled thoroughly. The effective communication and clarification on standards also helped smoothing out the implementation along with good leadership skills that are found in the team members from all level.

The other comparison was done on the cost for HPH001 and HPH002 where total cost was reduced from the implementation from 45.84M baht to 44.96M baht. As mentioned earlier that construction is still a labor intensive industry, and by reducing construction time, construction costs do not also drop: the amount of materials and the amount of craftsman work required for the tasks are still the same. By having a lot of the material prices and the contractors pricing fixed, the total cost was not expected to be lowered. The 2% cost reduction was from the processes adaption where the tasks were subcontracted to the subcontractors/contractors and certain costs were fixed.

Only 2% of the overall cost was reduced from the change, but with shorter construction time leading to shorter time to sales, and payback time to the bank, and thus, lead to lower amount of interest from bank loan. The time of 4 months reduction was a significant result from the implementation. The shorter period for construction gave the executives a new idea for operating the company as a whole and the idea of increasing the profit bottom line profit when investing on condominium projects.

As the construction time for one 8-storey building is shorten from 9 months to 4 months, the executives found that by increasing the turnover for one project can double the profit of that extra time for the extra building. A shelf-life of products in a supermarket is a clearer example for this turnover event: If you sell chocolate bar at a price of 15. With similar logic, for one condominium project selling 79 units, with the profit of 15M, if you can have two projects finished instead of one project time, then you can possibly double the profit with the same amount of time.

6.2. Recommendations

Lean implementation is customized for every organization. When implementing lean at HPD project on its construction processes for time reduction, the culture of the company must be clearly understood along with clear working processes must be defined. The concepts and steps utilized in this research may be used as a guideline to processes improvement, not only in construction processes, but also the other manufacturing processes with further adaption. The most important to the lean implementation was the clear vision and objectives along with good understanding of concepts and existing processes and the communications within the teams.

The turnovers obtained from the implementation could be further study for the construction projects that could apply this research to. If the turnovers concepts were to be applied to construction or to real estate projects owned by developers, the obstacles and the processes beyond the construction should also be included to yield a total package to allow the successful turnovers for real estate products.

REFERENCES

[1] L. Homeplace Development Co. Available: http://www.homeplace.co.th

[2] J. Arthur, *Lean six sigma demystified*. New York: McGraw-Hill, 2004.

[3] J. K. Liker, M. Hoseus, P. Center for Quality, and Organizations, *Toyota culture : the heart and soul of the Toyota way*. New York: McGraw-Hill, 2008.

[4] L. Jeffrey and K. F. James, *The Toyota Way to Continuous Improvement: Linking Strategy and Operational Excellence to Achieve Superior Performance*: McGraw-Hill, 2011.

[5] D. W. Benbow, A. K. Elshennawy, and H. F. Walker, *The certified quality technician handbook*. Milwaukee, Wis.: ASQ Quality Press, 2003.

[6] J. R. Evans and W. M. Lindsay, *An introduction to Six Sigma & process improvement*. Mason, Ohio: Thomson/South-Western, 2005.

[7] B. Carreira and B. Trudell, *Lean Six Sigma that works a powerful action plan for dramatically improving quality, increasing speed, and reducing waste*. New York: American Management Association, 2006.

[8] "Warwick Module Notes ", Logistics and Operations Management.

[9] H. M. Thomes, *Lean roadmap : the lean leaders guidebook : eleven building blocks for a successful lean roadmap design*. [United States]: Lulu.com, 2005.

[10] M. M. Chemers, *An integrative theory of leadership*. Mahwah, N.J.: Lawrence Erlbaum Associates, 1997.

[11] J. Magretta, *Understanding Michael Porter : the essential guide to competition and strategy*. Boston, Mass.: Harvard Business Review Press, 2012.

[12] D. J. Lu and K. Nihon Noritsu, *Kanban just-in-time at Toyota : management begins at the workplace*. Stamford, Conn.: Productivity Press, 1986.

[13] T. D. Kuczmarski, *Managing new products : competing through excellence*. Englewood Cliffs, N.J.: Prentice Hall, 1988.

[14] S. R. Rosenthal, *Effective product design and development : how to cut lead time and increase customer satisfaction*. Homewood, Ill.: Business One Irwin, 1992.

[15] P. Przekop, *Six Sigma for business excellence a manager's guide to supervising Six Sigma projects and teams*. New York: McGraw-Hill, 2006.

[16] C. Gygi, N. DeCarlo, and B. Williams, *Six sigma for dummies*. Hoboken, NJ: Wiley Pub., 2005.

[17] J. Trout, *Trout on strategy capturing mindshare, conquering markets*. New York: McGraw-Hill, 2004.

[18] J. Welch and S. Welch, "Winning," ed. Princeton, N.J.: Recording for the Blind & Dyslexic, 2005.

[19] R. A. Noe, *Human resource management : gaining a competitive advantage*. Boston: McGraw-Hill Irwin, 2010.

APPENDIX

APPENDIX A.

APPENDIX A.1: Examples of Prefabricated Houses and construction processes

(Source: http://www.homeplace.co.th)

APPENDIX A.2: Implementation Working Progresses

11/30/2013

12/03/13

12/04/2013

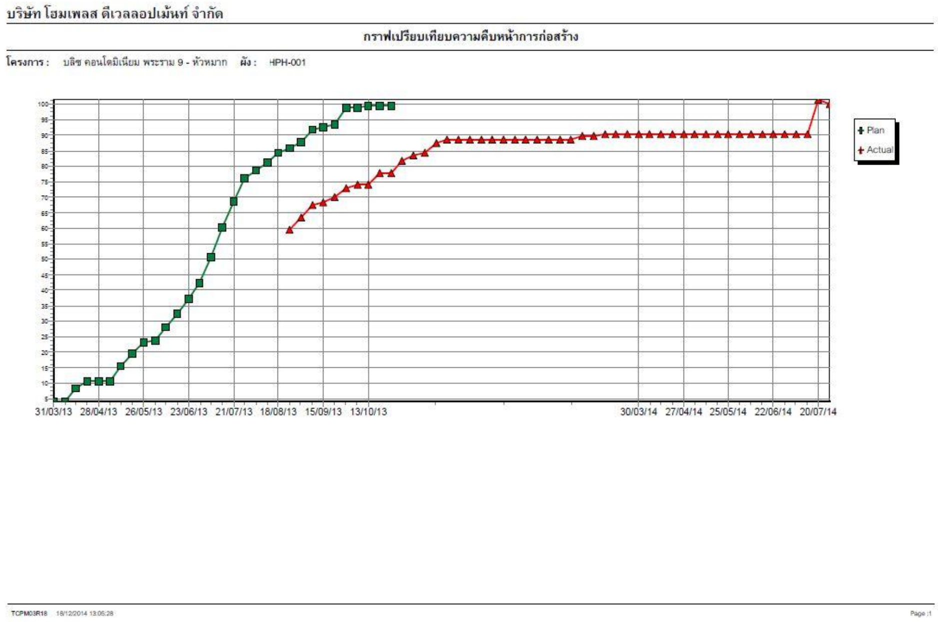
12/11/2013

12/16/2013

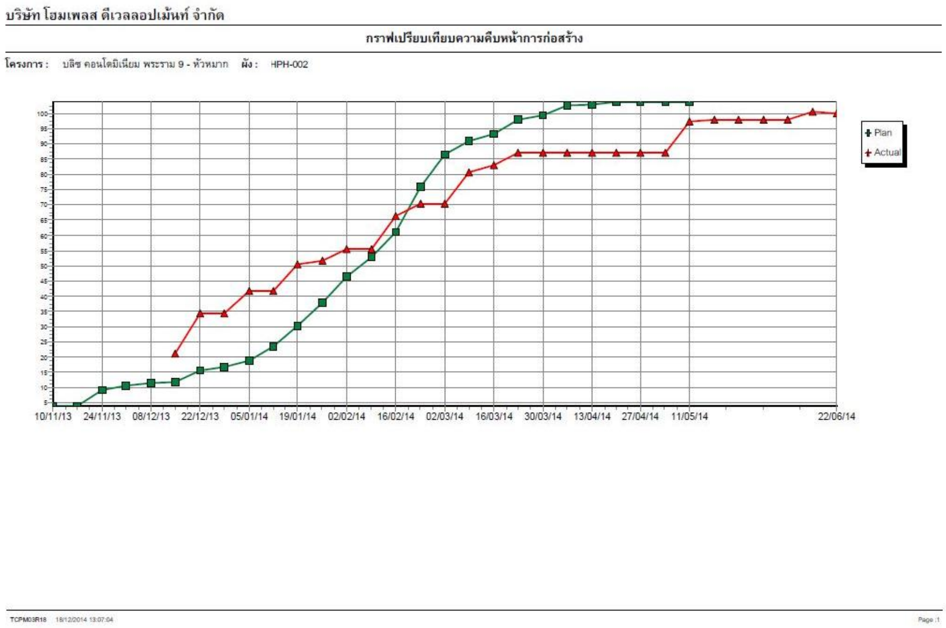
12/20/2014

APPENDIX B

APPENDIX B.1: S-Curve for HPH001 – Actual VS Projected Plan



APPENDIX B.2: S-Curve for HPH002 – Actual VS Projected Plan

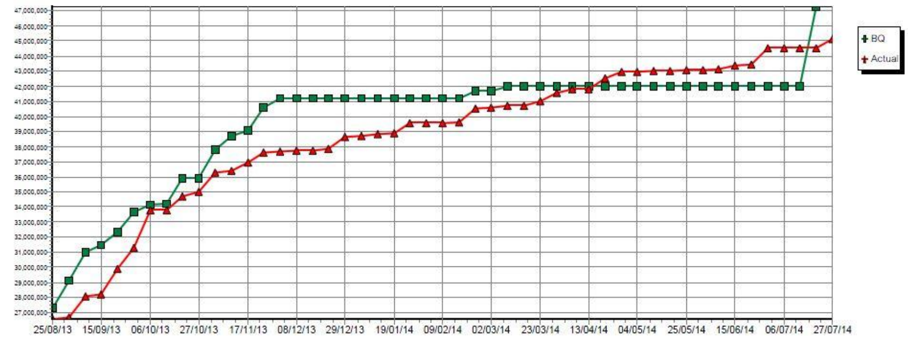


APPENDIX B.3: S-Curve for HPH001 – Actual VS Projected Cost

บริษัท โฮมเพลส ดีเวลลอปเม้นท์ จำกัด

กราฟเปรียบเทียบ BQ และต้นทุนเกิดจริง

โครงการ : บลิซ คอนโดมิเนียม พระราม 9 - หัวหมาก ผัง : HPH-001 BQ : 45,847,253.45



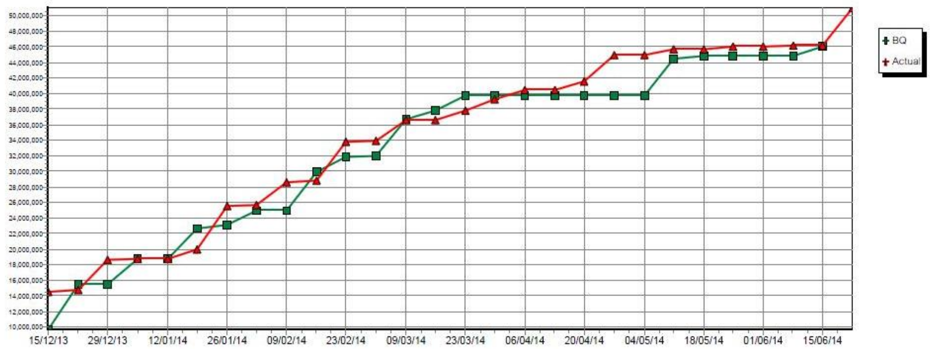
TCPM03R18 18/12/2014 13:06:08 Page :1

Appendix B.4: S-Curve for HPH002 – Actual VS Projected

บริษัท โฮมเพลส ดีเวลลอปเม้นท์ จำกัด

กราฟเปรียบเทียบ BQ และต้นทุนเกิดจริง

โครงการ : บลิซ คอนโดมิเนียม พระราม 9 - หัวหมาก ผัง : HPH-002 BQ : 44,964,885.73



TCPM03R18 18/12/2014 13:07:38 Page :1

APPENDIX C

APPENDIX C.1: Standard Specification Front Page

HOMEPLACE

HOME PLACE DEVELOPMENT co.,ltd
541 Srinakharin Road Sounloung Sounloung
Bangkok 10250 Tel.02-322-1855 Fax.02-322-1856

H-TH-2014

PROJECT : ....

HOME TYPE : .... แปลงที่ : ....

CHECK BY : ....

DATE : .... ครั้งที่ : ....

แบบตรวจเช็ครายการสเปควัสดุอุปกรณ์

1. แบบตรวจเช็ครายการวัสดุอุปกรณ์งานระบบสุขาภิบาล

Checklist of Standard Specifications

1. Standard Specification for Piping
2. Standard Specification for Electrical
3. Standard Specification for Decorated Steels
4. Standard Specification for Gypsum
5. Standard Specification for Aluminum

UPDATE 17 มิถุนายน 2557

APPENDIX C.2: Standard Specification for Piping

PROJECT : ....
HOME TYPE : .... แปลงที่ : ....
CHECK BY : ....
DATE : .... ครั้งที่ : ....

HOMEPLACE
HOME PLACE DEVELOPMENT co.,ltd
541 Srinakharin Road Sounloung Sounloung
Bangkok 10250 Tel.02-322-1855 Fax.02-322-1856

แบบตรวจเช็ครายการวัสดุอุปกรณ์งานระบบสุขาภิบาล

H-TH-2014
UPDATE 17 มิถุนายน 2557

ลำดับ	รายละเอียดวัสดุ,อุปกรณ์	ขนาด	ความหนา	ผลิตภัณฑ์ตามสเปค	ผลการตรวจเช็ค				การจัดหาวัสดุ, อุปกรณ์
					ใช่	ไม่ใช่	ผ่าน	ไม่ผ่าน	
1	ท่อน้ำดี								
	1.1 ท่อน้ำดี PVC สีฟ้า	Ø 1/2"	Class 8.5	ท่อน้ำไทย หรือ ตราช้าง					ผู้รับเหมาจัดหา
	1.2 ท่อน้ำดี PVC สีฟ้า	Ø 3/4"	Class 8.5	" ------ "					" ------ "
2	ท่อน้ำทิ้ง								
	2.1 ท่อน้ำทิ้ง PVC สีฟ้า	Ø 1 1/2"	Class 5	ท่อน้ำไทย หรือ ตราช้าง					ผู้รับเหมาจัดหา
	2.2 ท่อน้ำทิ้ง PVC สีฟ้า	Ø 2"	Class 5	" ------ "					" ------ "
3	ท่อโสโครก								
	3.1 ท่อโสโครก PVC สีฟ้า	Ø 4"	Class 5	ท่อน้ำไทย หรือ ตราช้าง					ผู้รับเหมาจัดหา
4	ท่ออากาศ								
	4.1 ท่ออากาศ PVC สีฟ้า	Ø 1"	Class 8.5	ท่อน้ำไทย หรือ ตราช้าง					ผู้รับเหมาจัดหา
	4.1 ท่ออากาศ PVC สีฟ้า	Ø 1 1/2"	Class 5	" ------ "					" ------ "
5	ท่อระบายน้ำทิ้งภายนอก								
	5.1 ท่อ PVC สีฟ้า	Ø 4"	Class 5	ท่อน้ำไทย หรือ ตราช้าง					ผู้รับเหมาจัดหา
	5.2 ท่อซีเมนต์ใยหิน	Ø 6"	—	มาตรฐานท้องตลาด					บริษัทจัดหา
6	ท่อ FLEXIBLE CONNECTOR								
	6.1 ท่อ FLEX สาย (กันหลุด) ขนาด Ø 2 1/4" ยาว 300 mm.		7.5 mm.	มาตรฐานท้องตลาด					ผู้รับเหมาจัดหา
	6.2 ท่อ FLEX สาย (กันหลุด) ขนาด Ø 4 1/4" ยาว 300 mm.		9 mm.	" ------ "					ผู้รับเหมาจัดหา
7	ข้อต่อ P-TRAP, U-TRAP								
	7.1 P-TRAP	Ø 2"	—	ท่อน้ำไทย หรือ ตราช้าง					ผู้รับเหมาจัดหา
	7.2 U-TRAP	Ø 2"	—	" ------ "					" ------ "
8	ข้อต่อ PVC สามทางทีวาย								
	8.1 ข้อต่อ PVC สามทางทีวาย	Ø 2"	—	ท่อน้ำไทย หรือ ตราช้าง					ผู้รับเหมาจัดหา
	8.2 ข้อต่อ PVC สามทางทีวาย	Ø 4"	—	" ------ "					" ------ "
9	FLOOR DRAIN								
	9.1 FLOOR DRAIN	Ø 2"	—	ตามสเปค					บริษัทจัดหา
	9.2 WALL DRAIN	Ø 2"	—	" ------ "					" ------ "
10	บ่อพัก								
	10.1 บ่อพัก	300x400 mm	—	สำเร็จรูป					บริษัทจัดหา
	10.2 บ่อดักไขมัน	400x500 mm	—	" ------ "					" ------ "
	10.3 บ่อดักขยะ	400x500 mm	—	" ------ "					" ------ "
11	อุปกรณ์								
	11.1 ปั๊มน้ำ	—	—	HITACHI WT-P150GP					บริษัทจัดหา
	11.2 ถังเก็บน้ำบนดิน	—	—	ตามสเปค					" ------ "
	11.3 ถังบำบัดน้ำเสีย	—	—	DOS COMPACT MODEL SURE 1600					" ------ "

APPENDIX C.3: Specification for Electrical work

PROJECT :
HOME TYPE : ______ แปลงที่ : ______
CHECK BY :
DATE : ______ ครั้งที่ : ______

HOMEPLACE
HOME PLACE DEVELOPMENT co.,ltd
541 Srinakharin Road Sounloung Sounloung
Bangkok 10250 Tel.02-322-1855 Fax.02-322-1856

แบบตรวจเช็ครายการวัสดุอุปกรณ์งานระบบไฟฟ้า

H-TH-2014
UPDATE 17 มิถุนายน 2557

ลำดับ	รายละเอียดวัสดุ,อุปกรณ์	ขนาด	ความหนา	ผลิตภัณฑ์ตามสเปค	ผลการตรวจเช็ค				การจัดหาวัสดุ, อุปกรณ์
					ใช้	ไม่ใช้	ผ่าน	ไม่ผ่าน	
1	**มิเตอร์ไฟฟ้า**								
	1.1 มิเตอร์ไฟฟ้า	15 (45) A	---	---					การไฟฟ้าจัดหา
	1.2 มิเตอร์ไฟฟ้า	30 (100) A	---	---					" ------ "
2	**สายไฟฟ้าเมน**								
	2.1 สายไฟฟ้าเมน	10 Sq.mm	---	Thai-yazaki, บางกอกเคเบิ้ล					ผู้รับเหมาจัดหา
	2.2 สายไฟฟ้าเมน	35 Sq.mm	---	" ------ "					" ------ "
3	**สายไฟฟ้าเมนกราวน์**								
	3.1 สายไฟฟ้าเมนกราวด์	10 Sq.mm	---	Thai-yazaki, บางกอกเคเบิ้ล					ผู้รับเหมาจัดหา
	3.2 สายไฟฟ้าเมนกราวด์	16 Sq.mm	---	" ------ "					" ------ "
4	**เมนเซอร์กิตเบรกเกอร์**								
	4.1 เมนเซอร์กิตเบรกเกอร์	2P-50 AT	---	BTICINO					ผู้รับเหมาจัดหา
	4.2 เมนเซอร์กิตเบรกเกอร์	2P-100 AT	---	" ------ "					" ------ "
5	**สายไฟฟ้าภายใน**								
	5.1 สายไฟฟ้าแสงสว่าง	2.5 Sq.mm	---	Thai-yazaki, บางกอกเคเบิ้ล					ผู้รับเหมาจัดหา
	5.2 สายไฟฟ้าปลั๊กไฟ	2.5 Sq.mm	---	" ------ "					" ------ "
	5.3 สายไฟฟ้าเครื่องปรับอากาศ	2.5 Sq.mm	---	" ------ "					" ------ "
	5.4 สายไฟฟ้าเครื่องทำน้ำอุ่น	4 Sq.mm	---	" ------ "					" ------ "
	5.5 สายไฟฟ้านิวตรอน (ใช้สายไฟฟ้าสีฟ้า)	2.5 Sq.mm	---	" ------ "					" ------ "
	5.6 สายไฟฟ้านิวตรอน (ใช้สายไฟฟ้าสีฟ้า)	4 Sq.mm	---	" ------ "					" ------ "
	5.7 สายไฟฟ้ากราวด์	2.5 Sq.mm	---	" ------ "					" ------ "
	5.8 สายไฟฟ้ากราวด์	4 Sq.mm	---	" ------ "					" ------ "
	5.9 สายโทรศัพท์	4 Core		มาตรฐานท้องตลาด					" ------ "
	5.10 สายอากาศทีวี	RG6		COMMSCOPE (คอมสโคป)					" ------ "
6	**เซอร์กิตเบรกเกอร์ย่อย**								
	6.1 ลูกเซอร์กิตเบรกเกอร์	1P-16 AT	---	BTICINO					ผู้รับเหมาจัดหา
	6.2 ลูกเซอร์กิตเบรกเกอร์	1P-20 AT	---	" ------ "					" ------ "
7	**สายไฟฟ้าร้อยท่อฝังในดิน**								
	7.1 สาย NYY (มอก. 11-2553)	4 Core x 2.5 Sq.mm		Thai-yazaki, บางกอกเคเบิ้ล					ผู้รับเหมาจัดหา
	7.2 สาย KV-CV (มอก. 2143-2546)	4 Core x 2.5 Sq.mm		" ------ "					" ------ "
8	**หลักดิน**								
	8.1 แท่งทองแดงเปลือย	5/8" ยาว 2.40 m.		มาตรฐานท้องตลาด					ผู้รับเหมาจัดหา
9	**ท่อร้อยสายไฟฟ้า**								
	9.1 ท่อฝังในพื้นสีเทา	ขนาดตามมาตรฐานการไฟฟ้า		ท่อน้ำไทย หรือ ตราช้าง					ผู้รับเหมาจัดหา
	9.2 ท่อฝังในดิน, ในฝ้าเพดานสีเหลือง			ท่อน้ำไทย หรือ ตราช้าง					" ------ "
10	**ตู้โหลดเซ็นเตอร์**								
	10.1 ตู้โหลดเซ็นเตอร์	ขนาด 12 ช่อง		BTICINO					ผู้รับเหมาจัดหา
11	**อุปกรณ์**								
	11.1 สวิทซ์ไฟ	---	---	HACO (DECO)					ผู้รับเหมาจัดหา
	11.2 ปลั๊กไฟ	---	---	HACO (DECO)					" ------ "
	11.3 ชุดหน้ากาก	---	---	HACO (DECO)					" ------ "
12	**เครื่องใช้ไฟฟ้า**								
	12.1 แอร์ (เครื่องปรับอากาศ)	---	---	---					เจ้าของบ้านจัดหา
	12.2 เครื่องทำน้ำอุ่น	---	---	---					เจ้าของบ้านจัดหา
	12.3 พัดลมดูดอากาศ	ตามสเปค	---	ตามแบบสเปค					บริษัทจัดหา (ตามแบบ)

APPENDIX C.4: Specification for Steels work

PROJECT : ....

HOME TYPE : .... แปลงที่ : ....

CHECK BY : ....

DATE : .... ครั้งที่ : ....

HOMEPLACE

HOME PLACE DEVELOPMENT co.,ltd
541 Srinakharin Road Sounloung Sounloung
Bangkok 10250 Tel.02-322-1055 Fax.02-322-1898

H-TH-2014

UPDATE 17 [illegible] 2557

แบบตรวจเช็ครายการวัสดุอุปกรณ์งานเหล็กรูปพรรณ

ลำดับ	รายละเอียดวัสดุ,อุปกรณ์	ขนาด	ความหนา	ผลิตภัณฑ์ตามสเปค	ผลการตรวจเช็ค				การจัดหาวัสดุ, อุปกรณ์
					ใช้	ไม่ใช้	ผ่าน	ไม่ผ่าน	
1	ประตูรั้วบานเลื่อน								
	1.1 เหล็กกล่อง	2" x 2"	3.2 mm.	เหล็กเต็มมาตรฐานตามท้องตลาด					ผู้รับเหมาจัดหา
	1.2 เหล็กกล่อง	1 1/2" x 1 1/2"	2.3 mm.	"------"					"------"
	1.3 เหล็กกล่อง	1" x 1"	1.6 mm.	"------"					"------"
	1.4 เหล็ก FlatBar	1"	4.5 mm.	"------"					"------"
	1.5 เหล็กเหลี่ยมตัน	9 mm.	—	"------"					"------"
	1.6 ท่อเหล็กกลมกลวง (ความยาว 1")	Ø 3"	1.7 mm.	"------"					"------"
	1.7 ลูกหล่อกลมตัน	Ø 6 หุน	—	"------"					"------"
2	ประตูบานเปิดเล็ก (ข้างประตูบานเลื่อน)								
	2.1 เหล็กกล่อง	1" x 2"	2.3 mm.	เหล็กเต็มมาตรฐานตามท้องตลาด					ผู้รับเหมาจัดหา
	2.2 เหล็กกล่อง	1 1/2" x 1 1/2"	2.3 mm.	"------"					"------"
	2.3 เหล็กกล่อง	1" x 1"	1.6 mm.	"------"					"------"
	2.4 เหล็ก FlatBar	1"	4.5 mm.	"------"					"------"
	2.5 เหล็กเหลี่ยมตัน	9 mm.	—	"------"					"------"
	2.6 ท่อเหล็กกลมกลวง (ความยาว 1")	Ø 3"	1.7 mm.	"------"					"------"
	2.7 ลูกหล่อกลมตัน	Ø 6 หุน	—	"------"					"------"
3	ประตูบานเฟี้ยม								
	3.1 เหล็กกล่อง	1" x 2"	2.3 mm.	เหล็กเต็มมาตรฐานตามท้องตลาด					ผู้รับเหมาจัดหา
	3.2 เหล็กกล่อง	1" x 1"	1.6 mm.	"------"					"------"
	3.3 เหล็ก FlatBar	1" | 2"	6 mm.	"------"					"------"
	3.4 เหล็กวงแหวนสำเร็จรูป	Ø 60 mm.	4 mm.	"------"					"------"
4	ประตูบานเปิดเล็ก (ข้างประตูบานเฟี้ยม)								
	4.1 เหล็กกล่อง	1" x 2"	2.3 mm.	เหล็กเต็มมาตรฐานตามท้องตลาด					ผู้รับเหมาจัดหา
	4.2 เหล็กกล่อง	1" x 1"	1.6 mm.	"------"					"------"
	4.3 เหล็ก FlatBar	1" | 2"	6 mm.	"------"					"------"
	4.4 เหล็กวงแหวนสำเร็จรูป	Ø 60 mm.	4 mm.	"------"					"------"
5	รั้วโปร่ง								
	5.1 เหล็กกล่อง	1" x 2"	2.3 mm.	เหล็กเต็มมาตรฐานตามท้องตลาด					ผู้รับเหมาจัดหา
	5.2 เหล็กกล่อง	1" x 1"	1.6 mm.	"------"					"------"
	5.3 เหล็ก FlatBar	1"	6 mm.	"------"					"------"
6	ชุดบานประตูห้องพักขยะ								
	6.1 เหล็กกล่อง	1" x 1"	1.6 mm.	เหล็กเต็มมาตรฐานตามท้องตลาด					ผู้รับเหมาจัดหา
	6.2 เหล็กกล่อง	3/4" x 3/4"	1.2 mm.	"------"					"------"
7	ราวบันได								
	7.1 เหล็กกล่อง	1" x 2"	2.3 mm.	เหล็กเต็มมาตรฐานตามท้องตลาด					ผู้รับเหมาจัดหา
	7.2 เหล็กกล่อง	3/4" x 3/4"	1.2 mm.	"------"					"------"
	7.3 เหล็ก Flat Bar	1"	4.5 mm.	"------"					"------"
	7.4 เหล็กแบนวงแหวนสำเร็จรูป	ตามแบบสเปค		"------"					"------"
	7.5 เหล็ก PLATE	ตามแบบสเปค		"------"					"------"
8	ระเบียง								
	8.1 เหล็กกล่อง	3" x 3"	2.3 mm.	เหล็กเต็มมาตรฐานตามท้องตลาด					ผู้รับเหมาจัดหา
	8.2 เหล็กกล่อง	1 1/2" x 3"	2.3 mm.	"------"					"------"
	8.3 เหล็กกล่อง	1" x 2"	2.3 mm.	"------"					"------"
	8.4 เหล็กกล่อง	1" x 1"	1.6 mm.	"------"					"------"
	8.5 เหล็ก Flat Bar	1 1/2"	9 mm.	"------"					"------"
	8.6 เหล็กฉาก	30 x 30 mm.	3 mm.	"------"					"------"
	8.7 เหล็ก PLATE	ตามแบบสเปค		"------"					"------"

APPENDIX C.5: Specification for Gypsum and Smart Cement board work

PROJECT :
HOME TYPE : .... แปลงที่ :
CHECK BY :
DATE : .... ครั้งที่ :

HOMEPLACE

HOME PLACE DEVELOPMENT co.,ltd
541 Srinakharin Road Sounloung Sounloung
Bangkok 10250 Tel.02-322-1855 Fax.02-322-1856

H-TH-2014
UPDATE 17 มิถุนายน 2557

แบบตรวจเช็ครายการวัสดุอุปกรณ์งานผนังเบา และ ฝ้าเพดาน

ลำดับ	รายละเอียดวัสดุ,อุปกรณ์	ขนาด	ความหนา	ผลิตภัณฑ์ตามสเปค	ผลการตรวจเช็ค				การจัดหาวัสดุ, อุปกรณ์
					ใช้	ไม่ใช้	ผ่าน	ไม่ผ่าน	
1	โครงผนังเบา								
	1.1 โครงกัลวาไนซ์ ซี 74	—	0.55 mm.	ตราช้าง					ผู้รับเหมาจัดหา
	1.2 โครงกัลวาไนซ์ ยู 76	—	0.55 mm.	ตราช้าง					*-----*
2	ผนังเบา								
	2.1 ยิปซั่มบอร์ดชนิดธรรมดา	—	9 mm.	ตราช้าง					ผู้รับเหมาจัดหา
	(ฉาบรอยต่อเรียบ)								
	2.2 สมาร์ทบอร์ด	—	10 mm.	ตราช้าง					*-----*
3	โครงฝ้าเพดาน								
	3.1 โครงเหล็กชุบสังกะสี เบอร์ 24	—	0.55 mm.	ตราช้าง					ผู้รับเหมาจัดหา
4	ฝ้าเพดาน								
	4.1 ยิปซั่มบอร์ดชนิดธรรมดา	—	9 mm.	ตราช้าง					ผู้รับเหมาจัดหา
	(ฉาบรอยต่อเรียบ)								
	4.1 ยิปซั่มบอร์ดชนิดทนความชื้น	—	9 mm.	ตราช้าง					*-----*
	(ฉาบรอยต่อเรียบ)								
	4.3 กระเบื้องแผ่นเรียบ	—	4 mm.	ตราช้าง					*-----*
	4.4 กระเบื้องแผ่นเรียบชนิดมีรูระบายอากาศ	—	4 mm.	ตราช้าง					*-----*

APPENDIX C.6: Specification for Aluminium

PROJECT :
HOME TYPE : ________ แปลงที่ :
CHECK BY :
DATE : ________ ครั้งที่ :

HOMEPLACE
HOME PLACE DEVELOPMENT co.,ltd
541 Srinakharin Road Sounloung Sounloung
Bangkok 10250 Tel.02-322-1855 Fax.02-322-1856

H-TH-2014
UPDATE 17 มิถุนายน 2557

แบบตรวจเช็ครายการวัสดุอุปกรณ์งานอลูมิเนียม

ลำดับ	รายละเอียดวัสดุ,อุปกรณ์	ขนาด	ความหนา	ผลิตภัณฑ์ตามสเปค	ผลการตรวจเช็ค				การจัดหาวัสดุ, อุปกรณ์
					ใช้	ไม่ใช้	ผ่าน	ไม่ผ่าน	
1	อลูมิเนียม								
	1.1 อลูมิเนียมชุดบานเลื่อนประตู	ตามแบบสถาปนิก	1.2 mm.	MTA					ผู้รับเหมาจัดหา
	(ตามแบบ DESIGN)								
	1.2 อลูมิเนียมชุดบานเลื่อนหน้าต่าง	"------"	1.2 mm.	"------"					"------"
	(ตามแบบ DESIGN)								
	1.3 อลูมิเนียมชุดบานเปิดประตู	"------"	1.2 mm.	"------"					"------"
	(ตามแบบ DESIGN)								
	1.4 อลูมิเนียมชุดบานเปิดหน้าต่าง	"------"	1.2 mm.	"------"					"------"
	(ตามแบบ DESIGN)								
	1.5 อลูมิเนียมชุดบานกระทุ้ง	"------"	1.2 mm.	"------"					"------"
	(ตามแบบ DESIGN)								
	1.6 อลูมิเนียมชุดช่องแสงติดตาย	"------"	1.2 mm.	"------"					"------"
	(ตามแบบ DESIGN)								
	1.7 อลูมิเนียมชุดบานเกล็ด	"------"	1.2 mm.	"------"					"------"
	(ตามแบบ DESIGN)								
2	กระจก								
	2.1 กระจกใสเขียว	—	5 mm.	การ์เดียน					ผู้รับเหมาจัดหา
	2.2 กระจกฝ้าลายผ้า	—	5 mm.	"------"					"------"
	2.3 กระจกนิรภัย	—	10 mm.	"------"					"------"
	2.4 กระจกเงา	—	5 mm.	"------"					"------"
3	วัสดุอุปกรณ์								
	3.1 บานพับบานเปิด	มาตรฐาน	มาตรฐาน	มาตรฐาน					ผู้รับเหมาจัดหา
	3.2 บานพับบานกระทุ้ง	"------"	"------"	"------"					"------"
	3.3 ชุดมือจับบานเลื่อน	"------"	"------"	NEXTSTEP					"------"
	3.4 ชุดมือจับบานเปิด	"------"	"------"	[illegible]					"------"
	3.5 ชุดมือจับบานกระทุ้ง	"------"	"------"	[illegible]					"------"
	3.6 ชุดล็อคบานเลื่อน	"------"	"------"	NEXTSTEP					"------"
	3.7 ซิลิโคน (สำหรับยึดระหว่างอลูมิเนียมกับผนัง คสล.)		—	SEALEX, SIKA FLEX					"------"
	3.8 ซิลิโคน (สำหรับยึดระหว่างอลูมิเนียมกับกระจก)		—	FORCOV-D (สีน้ำเงิน)					"------"

VITA

Miss Tunyaporn Dechavas is the Assistant Managing Director at Homeplace Development Co., Ltd. – a Thai real estate company specialized in residential housing. She recently started her own company, DInnova Co., Ltd., which is a construction contractor company supplying housing products. She has been a board member for Thai Real Estate Association (TREA) and has been involved in most events by TREA since 2012.

For her educational background, Ms. Dechavas was awarded her bachelor degrees in Mechanical Engineering (2009) and Civil Engineering (2010) from Purdue University, Indiana USA. She also received other certificates relating to her business, Young Entrepreneur Program (YEP) by Siam Commercial Bank Plc. in 2011 and other certificates relating to construction fields in programing and building technology system. She has extended her study further in Industrial Engineering (2015) for her master degree at Regional Centre for Manufacturing Systems Engineering, a co-program between Chulalongkorn University and Warwick University.