PROOF OF FINANCIAL VIABILITY OF DESIGNED GYPSUM THROUGH VALUE STREAM MAPPING

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ABSTRACT

The use of the lean production tool, that can be the Value Stream Mapping (VSM), intend to represent the steps of the execution of traditional internal plastering and also compare it with the Value Stream Mapping (VSM) of the process of internal plastering, using designed gypsum as a method of technological change and indicated as being innovative, rational, and of better standardization. The objective is to identify in the traditional plastering process the waste and its sources, reveal improvement opportunities, and provide a plan of implementation of an innovative technological process in explaining a future view and associating concepts and practices of lean production. In order to identify the activities of the traditional internal plastering walls system, it was carried out a data collection at a construction site of a residential building in course of construction in the city of Goiânia, at the State of Goiás-Brazil, done by the construction company HSI. From this point, it was developed a Value Stream Mapping (VSM) by the services done by the construction company and it was proposed a new VSM for the same construction service, but using the new technological process that is the designed gypsum. It was aimed to verify how much the implementation of the more rational and mechanized system of internal walls plastering, in this case, the designed gypsum, together with the study and application of the principles of the lean construction, can bring as benefit in terms of cost and income in replacement of the traditional plastering method.

KEYWORDS

Lean production, value stream mapping, lean thinking

INTRODUCTION

Paradigm between old and new enforcement practices have proved more intriguing every time, given that many doubt how much it is worth investing in new technologies, equipment and processes, where the traditional betting that has already been acclaimed as the best way to be followed. Few make a careful analysis to determine the extent to which innovation is satisfactory.

The article "Competing Construction Management Paradigms" (Howell and Ballard 2004) describes this challenge and justify examples of changes in traditional concepts has shown satisfactory results in comparison to the low efficiency rates obtained so far.

As explained Abdulmalek and Rajgopal (2007), for companies that depend on traditional manufacturing approaches is difficult to commit, and deploy a leaner manufacturing. This is difficult to be done because of numerous aspects, including:

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obtaining raw material, supply management, management of employees and production control.

In order to change certain concepts, it is necessary a performance analysis to prove and justify the adoption of non-traditional practices. One of the instruments to be used for this analysis is the Value Stream Mapping (VSM).

Rother and Shook (1999) created and developed worldwide a simple tool called Value Stream Mapping (VSM). This tool helps to identify the material and information flow within an organization. To produce it, you just have to follow the trail of the production of a product, process details are given for a specific purpose: the elimination of waste.

VSM will be applied to analyze, demonstrate and justify the adoption of non-traditional practices, making it clear that the construction industry should follow the path of industrialization, by abandoning manufactured archaic practices that generate much waste, delay and rework.

METHODOLOGY

A diagnosis of the actual situation of the productive process of the internal plastering accomplished by HSI Construction Company was done.

It was possible to trace the process activities and its characteristics, through visits done to the construction site, photographic records, and interviews with the engineers, trainees, construction site master and executive officers, also analysis of reports and spreadsheets provided by the construction company.

With all this material, it was possible to elaborate the VSM to the actual process used, allowing the analysis and comprehension of the value aggregation of each stage, and the identification of the waste and its generating sources.

After, it was elaborated a plan of implementation of the process of internal walls plastering using designed gypsum, according to the peculiarities related to the construction analyzed. For this, it was used the VSM, as a tool which allows to show the improvement opportunities associated to the lean concepts and practices, also, expose changes, showing how the new scenery will be, when this new practice is adopted.

"A value stream map can look daunting, especially for anyone who has not worked much with flowcharts. But, a lot can be gained from starting a value stream map, even if there is not enough data to do the perfect map the first time through", by Craig Ladner (2012). Following this reasoning was developed a simplified VSM with minimal information relevant to what is wished to obtain.

DATA SURVEY

We have done eight visits to the construction site, an interview with the engineer who is the director of the construction company, two interviews with the engineer responsible for the construction, and three interviews with: the trainees, with the man who is in charge of the supplies and with the executive officer, to investigate the real situation of the activities done at the construction site, that enable the use of the traditional internal plastering. Furthermore, it was joined the execution of the parget with designed gypsum in the apartment simplex 1801 (18th floor) to serve as comparison, and real analysis of the construction, that uses an innovative system, in which it is used machinery and industrialized gypsum.

IDENTIFICATION OF THE ACTIVITIES WITH TRADITIONAL PLASTER

We tried to identify the activities that are part of the productive process, in the execution of the traditional parget, from the input acquisition to the conclusion of the service, and the preparation to the following process, in this case, the painting process.

It was found that the construction company adopts two strategies to make feasible the internal parget process. The first strategy consists of buying the industrialized mortar produced by a concrete company, which provides the material ready to be used in the walls. The second strategy is to produce the mortar at the construction site, named mortar produced at the construction site.

Below, it is shown the activities to the process using industrialized mortar, which are named in parenthesis:

- Survey of the volume and order for industrialized mortar (Order for Industrialized Mortar);
- Reception and transportation of the industrialized mortar (Reception and Transportation of the Industrialized Mortar);
- Application of the mortar to the execution of the traditional parget (Parget Application);

Beneath it is shown the activities to the process using mortar produced at the construction site, which are named in parenthesis:

- Stock control and analysis of the necessities of input acquisition (Identification of Input Necessity);
- Order for input purchase (Input Purchase);
- Sand reception (Sand Reception);
- Cement and lime reception (Cement and Lime Reception);
- Pre-mortar production to be mixed to sand, lime and water (Pre-mortar Production);
- Production of the mortar using the pre-mortar, plus cement (Mortar Production);
- Mortar transportation to the place where it is going to be used (Vertical Transportation of the Mortar);
- The mortar use to the execution of the traditional Plaster (Plaster Use);

IDENTIFICATION OF THE ACTIVITIES OF DESIGNED GYPSUM

The designed gypsum process is simplified, since most of the activities are done by an outsourcing company. So, the construction company becomes a client of the company that produces the designed gypsum. The values of the construction company clients (future residents), that are quality and time delivery, become a requirement by the construction company in relation to the outsourcing company. The advantages of this partnership can reach a great potential, if the outsourcing company shows itself efficient and the cost-benefit analysis is satisfactory.

It can be verified that the activities in the designed gypsum process are:

- Reception of gypsum bags of 40 kg to be designed (Reception and Gypsum Discharge);
- Vertical transportation to the apartment where it is going to be used/done, using the hoist (Vertical Transportation of Gypsum Bags);
- Designing and implementing of the gypsum plaster (Implementing Gypsum Plaster).

DATA ANALYSIS

The takt time to this study, is the time to execute the plaster, in this case, the walls of the apartment.

The apartment designated to the use of the design gypsum in the walls plaster was the Simplex 1801. By means of survey, in the apartment it was measured the dimensions and thickness of each wall designated to be done with gypsum, because the walls of the wet areas are not made with gypsum but with traditional plaster. The result was approximately 5 m^3 of ready plaster, taking into account: medium thickness of 2,76 cm, squared walls area of 165 m^2, filling of gaps, waste and losses.

The daily average volume of industrialized mortar and of mortar produced in the construction site, which was consumed by the 04 traditional plaster teams, was also of 5 m^3.

Thus, it was possible to compare the profit between the designed gypsum plaster and the traditional plaster.

Beneath, it is presented the charts 1 and 2 that are respectively the VSM to the plaster produced at the construction site and the plaster with industrialized mortar. Chart 3 illustrates the VSM to the plaster designed gypsum and chart 4 presents the three plaster processes and their activities including time and price. It is possible to check that, in chart 4, regarding the thickness of the plaster done with designed gypsum, it was of 1 cm, what is considered the ideal thickness to be done in this process.

Chart 1 – Simplified VSM: Plaster with mortar produced at the construction site

SIMPLIFIED VSM: PLASTER WITH MORTAR PRODUCED AT THE CONSTRUCTION SITE

Identification of Supply Necessity	
SUB-ACTIVITIES	TIME (h)
Identify stock	00:01
Request	00:04
TOTAL TIME:	00:05

Supply Request	
SUB-ACTIVITIES	TIME (h)
Verify input insert	00:02
Quote for prices	00:04
Effect purchase	00:04
TOTAL TIME:	00:10

Sand Reception	
SUB-ACTIVITIES	TIME (h)
Check invoice	00:05
Sand discharge /sidewalk	00:10
Move sand to the bays	00:25
TOTAL TIME:	0:40:00

Receiving Cement and Lime	
SUB-ACTIVITIES	TIME (h)
Check invoice	00:02
Gather hodmen to discharge	00:03
Discharge	00:10
TOTAL TIME:	0:15:00

Pre-Mortar Production	
SUB-ACTIVITIES	TIME (h)
Supply concrete-mixer with sand and lime	01:30
Mix pre-mortar	02:00
Discharge in bays	01:00
TOTAL TIME:	4:30:00

Mortar Production	
SUB-ACTIVITIES	TIME (h)
Mix pre-mortar and cement	01:30
Supply giricas	00:30
TOTAL TIME:	2:00:00

Mortar Transportation	
SUB-ACTIVITIES	TIME (h)
Transport to hoist	00:15
Vertical transportation	00:15
Discharge on the floor	00:10
TOTAL TIME:	0:40:00

Plaster Execution	
SUB-ACTIVITIES	TIME (h)
Wait to receive mortar	05:10
Homogenize mortar	00:50
Prepare mestras on the walls	04:00
Throw mortar on the walls (strung mass)	08:00

Plaster Execution (continuation)	
SUB-ACTIVITIES	TIME (h)
Wait block-board point	02:00
Block-board (pass the ruler)	08:00
Straighten with wood and steel straightener	09:00
TOTAL TIME:	37:00:00

- ARROW INDICATES DIRECTION OF FLOW VALUE OF ACTIVITIES

Chart 2 - Simplified VSM: Plaster with industrialized mortar.

SIMPLIFIED VSM: PLASTER WITH INDUSTRIALIZED MORTAR

Industrialized Mortar Request	
SUB-ACTIVITIES	TIME (h)
Mortar request	01:00
Request concrete company	00:15
TEMPO TOTAL:	1:15:00

Reception &Transportation Industrialized Mortar	
SUB-ACTIVITIES	TIME (h)
Mobilize people	00:10
Prepare giricas	00:05
Wait the concrete-mixer truck	00:05
Check note & material	00:05

Reception &Transportation Industrialized Mortar (continuation)	
SUB-ACTIVITIES	TIME (h)
Discharge volume by girica (x40)	00:40
Transport to the hoist (x40)	00:20
Waiting time in the hoist row (x40)	00:20
Vertical hoist Transportation	00:30

Reception &Transportation Industrialized Mortar (continuation)	
SUB-ACTIVITIES	TIME (h)
Discharge mortar	00:10
Hoist wait to down people	00:04
Down hoist	00:04
Giricas cleaning	00:05
TOTAL TIME:	2:38:00

Execute Plaster	
SUB-ACTIVITIES	TIME (h)
Take the water from basin	00:10
Mix mixture	00:50
Prepare walls	04:00
Throw mortar on the walls (strung mass)	08:00
Wait block-board point	02:00

Execute Plaster (continuation)	
SUB-ACTIVITIES	TIME (h)
Block-board (pass ruler)	08:00
Straighten with wood (straightener)	06:00
Straighten with steel	03:00
TOTAL TIME:	32:00:00

- ARROW INDICATES DIRECTION OF FLOW VALUE OF ACTIVITIES

Chart 3 - Simplified VSM: Plaster with designed gypsum

SIMPLIFIED MFV: PLASTER WITH DESIGNED GYPSUM

Gypsum Reception and Discharge	
SUB-ACTIVITIES	**TIME (h)**
Check invoice	00:02
Gather hodmen to discharge	00:03
Discharge	00:07
TOTAL TIME:	**0:12:00**

Vertical Transportation of Gypsum	
SUB-ACTIVITIES	**TIME (h)**
Load hoist	00:10
Waiting time of Hoist arrival	00:10
Vertical Transportation	00:10
Discharge hoist	00:10
TOTAL TIME:	**0:40:00**

Gypsum Plaster Execution	
SUB-ACTIVITIES	**TIME (h)**
Turn on projection machine	00:30
Wet walls	00:10
Shut electrical boxes with paper	00:20
Project gypsum	05:00
Block-board (pass ruler)	07:00
Completion	07:00
TOTAL TIME:	**20:00:00**

- ARROW INDICATES DIRECTION OF FLOW VALUE OF ACTIVITIES

Chart 4 – Comparison between execution processes of plaster to each 5 m^3 of material and 1 cm of thickness to designed gypsum.

COMPARATIVE CHART BETWEEN PROCESSES IN THE EXECUTION OF WALLS PLASTER TO EACH 5 M3 OF MATERIAL

PLASTER WITH MORTAR PRODUCED AT THE CONSTRUCTION SITE				
ACTIVITIES	**TIME (h)**	**R$ LABOR**	**R$ MATERIA**	**SUM COST**
Identification of Supply Necessity	0:05:00	1,56		1,56
Supply Request	0:10:00	3,13		3,13
Sand Reception	0:40:00	82,13		82,13
Cement and Lime Reception	0:15:00	26,66		26,66
Pre-mortar Production	4:30:00	58,75	371,64	430,39
Mortar Production	2:00:00	26,11	225,14	251,25
Vertical Mortar Transportation	0:40:00	12,15		12,15
Plaster Execution	37:00:00	1997,46		1997,46
Framing	8:00:00	499,37		499,37
TOTAIS:	**53:20:00**	**2707,32**	**596,78**	**3304,10**

PLASTER WITH INDUSTRIALIZED MORTAR				
ACTIVITIES	**TIME (h)**	**R$ LABOR**	**R$ MATERIA**	**SUM COST**
Industrialized Mortar Request	1:00:00	51,56		51,56
Reception and Transportation of Industrialized Mortar	2:39:00	375,84		375,84
Plaster Execution	32:00:00	1997,46	1150,00	3147,46
Framing	8:00:00	499,37		499,37
TOTAIS:	**43:39:00**	**2924,23**	**1150,00**	**4074,23**

PLASTER WITH DESIGNED GYPSUM				
ACTIVITIES	**TIME (h)**	**R$ LABOR**	**R$ MATERIA**	**SUM COST**
Gypsum Reception and Discharge	0:12:00	109,60		109,60
Vertical Transportation of Gypsum	0:40:00	36,46		36,46
Gypsum Plaster Execution	20:00:00	2310,00	825,00	3135,00
TOTAIS:	**20:52:00**	**2456,06**	**825,00**	**3281,06**

CONSIDERATIONS:	
SOCIAL CHARGES:	125 %
PLASTER THICKNESS OF DESIGNED GYPSUM:	1 cm
TRADITIONAL PLASTER THICKNESS:	2,75 cm

From chart 4, it can be observed that, the elimination of activities that the construction company has is excellent when designed gypsum is used. Since, the plaster is done by an outsourcing company, relieving the company's work excess.

The next chart illustrates the comparisons in percentage between time and cost of the traditional plaster, in relation to the designed gypsum plaster. The traditional plaster thickness is unique and the average is of 2,76 cm, what varies is thickness when the plaster is done with designed gypsum.

Chart 5 – Difference in time and cost percentage compared to designed gypsum in different thickness.

TIME AND COST ANALYSIS, COMPARISON DONE IN RELATION TO DESIGNED GYPSUM (%)			
THICKNESS	**PROCESSES**	**TIME (%)**	**COST %**
1,00 cm	Plaster done with mortar produced in the construction site	155,59	0,70
	Plaster done with industrialized mortar	109,19	24,17
1,50 cm	Plaster done with mortar produced in the construction site	139,16	-10,54
	Plaster done with industrialized mortar	95,74	10,31
2,00 cm	Plaster done with mortar produced in the construction site	124,72	-19,53
	Plaster done with industrialized mortar	83,92	-1,57
2,50 cm	Plaster done with mortar produced in the construction site	111,92	-26,88
	Plaster done with industrialized mortar	73,44	-10,56
2,76 cm	Plaster done with mortar produced in the construction site	100,63	-30,19
	Plaster done with industrialized mortar	64,20	-13,92

It can be observed in chart 5 that, the total time to the execution of 5 m3 of plaster done with mortar produced at the construction site is approximately 155,19 % bigger, and the plaster of industrialized mortar is approximately 109,19 % bigger, compared to the designed gypsum plaster that is 1 cm thick.

In relation to the total cost, it can be seen that, the plaster done at the construction site is only 0,70 % more expensive than the plaster done with designed gypsum, and that the plaster done with industrialized mortar is 24,17 % more expensive, also having thickness of 1 cm to the designed gypsum.

However, this it is only one centimeter thick to the designed gypsum plaster. From the moment this thickness enlarges, there is a significant increase in terms of cost in the mechanized and innovative process, as the gypsum consumption is directly proportional to the thickness increase. Or, analyzing better, to each centimeter of thickness it doubles the consumption of gypsum and consequently the material use.

Comparing the process with the same thickness of 2,76 cm, it can be noticed that, the time gain continues to be great, 100,63 % less than with the mortar produced at the construction site, and 64,20 % less than the industrialized mortar, but the price in relation to the gypsum is 30 % more expensive, than with the mortar produced at the construction site, and approximately 14 % bigger than the industrialized mortar.

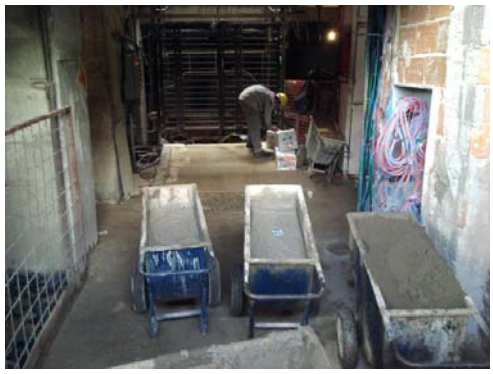
Thus, it is indispensable the care, and choices of the processes done before the designed gypsum plaster, as for example: better execution in the structure, masonry rationalization, better square control and alignment masonry/structure, search for constructive alternatives for more rational walls (normal concrete walls, concrete blocks or cellular concrete).

Beneath, it is presented Pictures 1(a,b) to 5(a,b) that illustrates the activities related to the plaster process. Some of them exemplify activities that did not add value to the target product, that is the executed plaster.

Picture 1a: Checking and waiting on the discharge of the truck of sand at the construction site.

Picture 1b: Bays for sand storage at the construction site.

Concrete-mixer that produces the pre plaster at the construction site.



Wheelbarrows filled with industrialized mortar to get into the hoist.

Picture 3a: Bricklayers waiting the mortar to start the traditional plaster procedure

Picture 3b: Workers trying to release the mortar from the wheelbarrows

Picture 4 (a): Cleaned and positioned wheelbarrows in the sidewalk, waiting the concrete-mixer truck with the industrialized mortar.

Picture 4 (b): Wheelbarrows in rows in position to get into the hoist.

Picture 5 (a): Gypsum machine projector.

Picture 5 (b): Plasterer projecting gypsum in the wall.

CONSIDERATIONS

Analyzing the comparison through VSM done between the plaster with traditional mortar, and the plaster with designed gypsum, it was possible to observe that there are some evident gains when using designed gypsum, that are:

- Reduction of total time;
- Reduction of activities that do not add value, such as: material reception, including beyond normal working time, vertical transportation of material;
- Reduction of management and control, because it decreases the number of workers and activities, allowing the redirection of this management to other processes;
- It releases the hoist to help in other processes, resulting in a solution to the major bottleneck that can be the vertical transportation of material;
- Including the reduction in the nest process, that is painting the walls done with gypsum (decreases the amount of PVA mass);

- Less waiting time (less than 07 days), while traditional plaster needs at least 21 days. This allows people to start earlier the mortar process.

In relation to cost, it is possible to assert that the final cost, that is the immediate cost of the process, is reduced according other previous plaster processes are rationalized, offering a surface that allows thickness of 1 cm of designed gypsum that is the ideal thickness in terms of cost-benefit.

The relative cost, that is the gain in time reduction, and activities that do not add any value, it is difficult to measure, as it implies in major gains if it is taken into account the viability of delivery schedule to the final client, in the assured time or this time gain allows the anticipation of other processes ahead.

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