Improving Efficiency in Concrete Slabe Pre-casting Process using Work-Study and ECRS Techniques

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Abstract

This research aims to improve the efficiency of concrete slabs' pre-casting process by using work-study and eliminate, combine, rearrange, and simplify (ECRS) techniques. It is experimental research. From the study, the factory case study had problems with the delay of the production, in which the causes of the delay were non-standard mortar boxes, not having enough boxes to work, and the high damage rate (120 boxes per month). Based on these problems, this study combined the work-study and (3 types of) redesign the separator box in the mortar casting process by using the ECRS technique. These results showed that the handheld type was the best redesign due to mortar infiltrating into the mortar box. Therefore, the box damage rate was decreased, resulting in a more efficient production process (68.9% cycle time decrease).

Keywords: *Efficiency, production, Prefabricated slabs*

1. Introduction

In 2018, PCM Construction Material Co., Ltd. has produced Precast concrete slabs for use in residential homes and buildings about 30 million square meters representing over 300,000 home units, and the factory will produce prefabricated slabs with a flat belly, prefabricated slabs with three legs, prestressed concrete piles, glass fiber reinforced concrete, soundproof walls, precast concrete building walls, precast concrete houses, precast concrete columns, and beams for use in the construction of residential buildings. Currently, this case study factory produces 3-legged floor slabs, with the largest production reaching 12 million square meters. Manufacturing processes are according to different steps. From having received an internship, the factory wanted to reduce the working time of the mortar box pick-up station, which requires up to four people to pick up. It takes a lot of time to pick up the mortar box and the mortar box that is damaged from pick-up by about 120 boxes per month or 1,440 boxes per year. From the factory data each month, the production process is delayed, which may be caused by the material and design of the mortar box that is not standardized (Simachokdee, 2013). It applied the principles of industrial engineering of 7 tools such as fishbone diagram, flow process chart to increase the production process of precast concrete slabs. Picking methods are, therefore, a waste of time in production. The researcher created this project to explore the production of precast production slabs, design a new type of mortar box, organize a picking-up method, and select the correct pick-up tools to be applied in the factory using the method eliminate, combine, rearrange, and simplify (ECRS) with the research (Patanaprichawong, 2016) to increase production efficiency and reduce the time to produce the Precast production slaps.

2. Objective

To improve the efficiency of concrete slabs' pre-casting process by using work-study and eliminate, combine, rearrange, and simplify (ECRS) techniques.

Flow Process Chart

Activities: Precast production process	Conclusion			
	Activity	Current	After-adjust	Decrease
	Operation ○	21		
	Transport ⇨	1		
	Delay D	2		
	Inspection □	2		
	Storage ▽	1		

No.	Work procedure	Number of Worker (person)	Time (Minute)	○	⇨	D	□	▽	Remark
1.	Prepare wire size.	1	15	●					
2.	Thread the wire into the box.	4	40	●					
3.	Measure distance	2	15	●					
4.	Rubbing oil	1	15	●					
5.	Place the boxes at the specified distance.	1	5			●			
6.	Pull wire.	1	20	●					
7.	Wire tie.	4	30	●					
8.	Wedge the cement box.	1	20	●					
9.	Foreman	1	10				●		
10.	Cable car driving	1	25		●				
11.	cement	1	5	●					
12.	Step on the basket	1	20	●					
13.	Scoop	4	15	●					
14.	Concrete vibrator	2	30	●					
15.	Knock the box.	1	25	●					
16.	Pick a box.	4	42	●					
17.	The ears are tightened, not sink in cement.	2	15	●					
18.	Concrete makeup.	1	20	●					
19.	Scratch rough face.	1	15	●					
20.	General work.	2	25				●		
21.	Watering, pump seal.	1	20	●					
22.	Wait for the mortar to dry.	-	20 hrs.			●			
23.	Wire cut.	1	40	●					
24.	raise the ground.	2	10					●	
25.	Clean the box.	2	25	●					
26.	Scrape the platform.	1	15	●					
27.	Sweep the platform.	1	10	●					

Figure 1 Production process of precast concrete slabs

3. Methodology

3.1 Explore the process of producing 3-leg prefabricated slabs.

Based on the exploring of the production process by the timekeeping method, it was found that the production process of the box pick-up station took 42 minutes with four (4) workers, which were more than necessary, therefore, the researcher chose the problem to solve (Chantakit, 2013) by reducing the time in working with setting up the machine in the production line. The preliminary agreement for the analysis would be to design a more efficient mortar box barrier to make the production time in the cementing pick-up station shorter (Tantasuth, 2005), explore work in the industry to increase production quality, and reduce workers to work in other parts as shown in Figure 1 Production process of precast concrete slabs.

The research revealed a problem that arises in the production process of the 3-leg prefabricated slab, namely the Mortar box body was insufficient in the work because the problem arises from 2 reasons: 1) The selection of material and 2) Design and build a mortar box using engineering design principles (Krutz, Thomson, & Claar 1994) and quality management to increase the productivity and reduce costs from the design and material selection. Therefore, the experiments were performed by selecting the most appropriate method to determine the solution, reduce the working time, and reduce the waste of the mortar box. Regarding mortar box design, the researcher has selected 3 materials from the following: 1) Super Lean and Nylon, 2) Flat iron, and 3) Black steel plate. The mortar box has been designed and built.

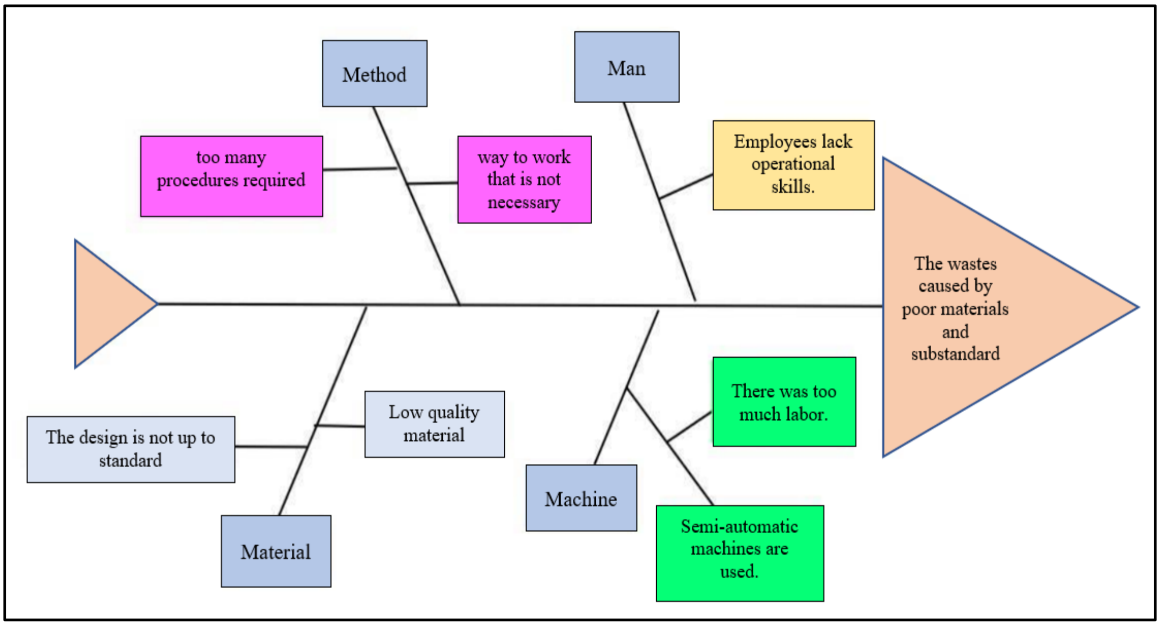

Figure 2 The herringbone diagram of the finished 3-leg Prefabricated floor panels

3.2 Increase productivity of the finished 3-leg Prefabricated floor panels.

Non-standard mortar box design caused by Non-standard mortar box. There is a Mortar seepage of cement attached to the box, which takes a lot of time, and workers in this pick-up box station result in a delay in the production process and not enough workers. Therefore, there are ways to improve by designing a mortar box to meet more standards with more advanced materials and designs than the original to reduce time and reduce the number of workers in the box picking station. The production process will be more efficient.

1) Design of mortar box material

1.1) Experimental design material used to insert into a mortar box made of Superlene and Nylon. Both types are classified as engineering plastics. It has the same special properties are such as the ability to be used at high temperatures of up to 120 degrees, toughness, excellent expansion, good elasticity, good tensile and tear resistance, torsional resistance, corrosion resistance, and resistance to chemicals and abrasion. The design of Superlene and Nylon is shown in Figure 3.

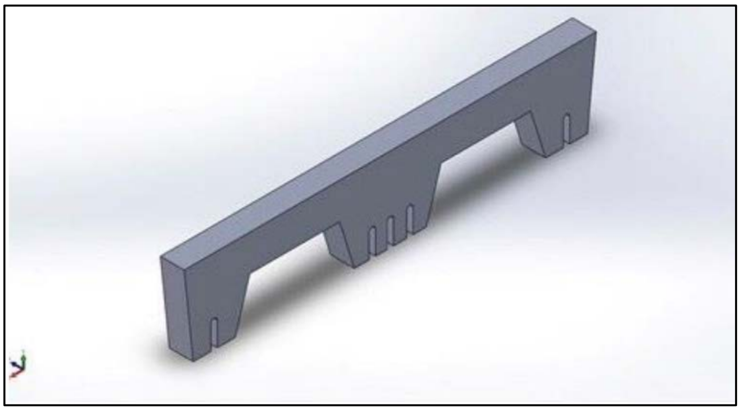

Figure 3 Design of experimental materials from Superlean and Nylon

1.2) Design the lid of the mortar box from the steel flat bar. It is a steel that is thick, durable, strong, widely used in various applications, suitable for general structural steelwork. Special features are corrosion resistance, high and low-temperature resistance, and some grades are good heat and cold resistance including sudden temperature change, easy to be assembled or processed, the manufacturer can be easily assembled with other materials. The design of the mortar box cover from the Steel Flat Bar is shown in Figure 4.

Figure 4 An example of the design of a mortar box lid from a flat steel

1.3) Designed to insert a mortar box with a handle from a black steel plate. It is made from a high-quality steel coil, controlled by modern machines without inferior quality iron. It is a rectangular sheet with a smooth surface commonly used for structural work. There are many standard sizes and thicknesses of black steel, the most popular are SS400, SS490, and SM400. The design of a mortar box holder with a handle from a black steel plate is shown in Figure 5, an example of material design with a handle for testing.

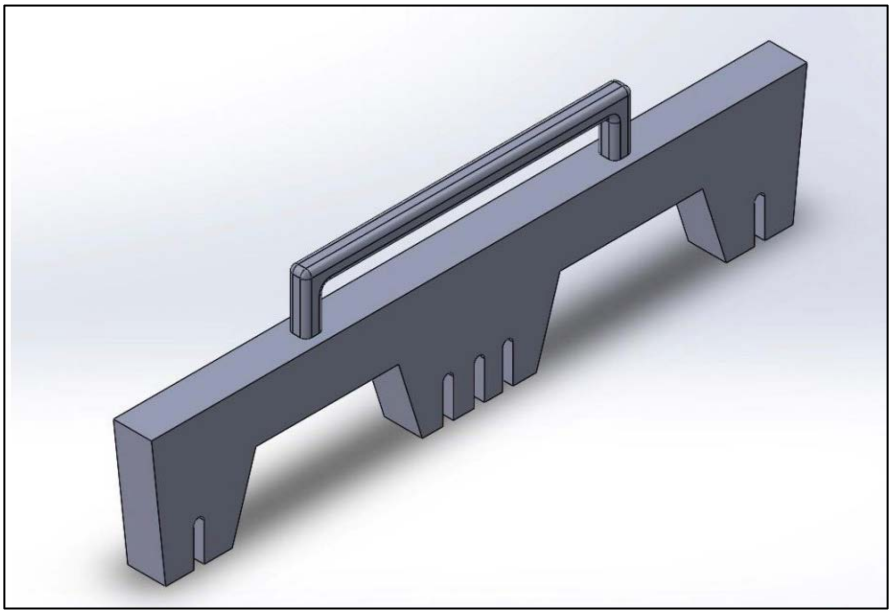

Figure 5 An example of a material design with a handle made from a black steel plate for testing.

2) Experimental procedure

From the design of the mortar box pick-up to fix in the production process of the cement box pick-up station. They can be designed using engineering design principles and use computer programs to help design (Shigley & Mischke, 1989). Machine components consist of the main components which is the machine structure that has 3 types of designs as follows: 1) Experimental design material used to insert into the mortar box pick-up made of superlene and nylon, 2) Design the mortar box pick-up lid from Steel Flat Bar, and 3) Design the mortar box pick-up holder with a handle from black steel plate.

2.1) The criteria for selecting appropriate materials and designs are as follows; 1) impact resistance and strength, 2) good heat resistance because it is an outdoor production, 3) cheap price and high durability, 4) easy to use and quick to work, and 5) there must be no water to penetrate the box after use.

2.2) Experimenting with all 3 types of materials (Chompooinwai, 2017) using the quality management and eliminate, combine, rearrange, and simplify (ECRS) techniques; and qualitative analysis.

(1) In a superlene and nylon experiment with similar properties, the results of the experiments were successful. There was no water and mortar got into the box. The advantages are that it can be used at high temperatures, strong, extensible, and has good tensile strength. The disadvantage is the expensive price of up to 1,600 baht.

Figure 6 Superlean Experiment Picture

(2) Experiment with mortar box pick-up lid made from a steel flat bar. The results showed that the experiment was successful, but there was still water. The mortar penetrates the box. As for its advantages, it has corrosion resistance and is resistant to both high and low temperatures. The disadvantage is that there is still mortar infiltrated into the box.

Figure 7 Experimental figure of Steel Flat Bar

(3) An experiment with a mortar box pick-up with a holder made from a black steel plate

The results were successful. No water and no mortar had penetrated the box. The process of picking boxes is easy and the size of the sheet's cross-section looks more beautiful. The advantages were corrosion resistance, resistance to both high and low temperatures, cheap, and ease to use.

Figure 8 Experimental figure of steel plate with handle

The experimental results of the 3 types of mortar box pick-up designed by the researcher with the handle made of black steel plate were successful, and it is very appropriate to make a choice. It was found that no water and mortar could penetrate the box, easy to use, cheap, and strong. The applications with handles resulted in a more efficient production process.

4. Research Result

The pre-modified and post-modified production processes have a mean total time as shown in Table 1.

Table 1 Pre-modified and post-modified production processes

Pre-improvement and post-improvement production processes			
Pre-improvement		**Post-improvement**	
Procedure	**Time**	**Procedure**	**Time**
Cable car driving	31	Cable car driving	Same
Crane	10	Crane	Same
Step on the basket	20.4	Step on the basket	Same
Scoop	21	Scoop	Same
Concrete vibrator	32	Concrete vibrator	Same
Knock the box	25.4	Knock the box	Same
Pick a box	43.8	Pull out the box	13.6
Pull ear	14.6	Pull ear	Same
Concrete makeup	20.2	Concrete makeup	Same

From the improvement to the production process of prefabricated floor slaps. The average production time was reduced by 30.2 minutes, representing a 68.9% reduction in time by using the ECRS principle to improve the processing time of the formwork preparation (Kamma, 2018). The results of the 5 trials show the time before - after adjustment, and the reduction time in the 5 trials as shown in Table 2.

Table 2 Experimental time before and after adjustment 5 times.

Time	Time Before Adjust (Minute)	Time After Adjust (Minute)	Time Decrease (Minute)	Percentage (%)
1	45	14	31	68.8
2	42	12	30	71.4
3	45	13	32	71.1
4	44	14	30	68.1
5	43	15	28	65.1
Average Time	44	14	30.2	68.9

From the experiment per 1 production zone, the time was reduced by 30.2 minutes / 1 pallet. In pouring cement for 1 day, all 3 pallets were poured, the time was reduced by 90.6 minutes, which was able to reduce 2 workers and the minimum wage was reduced by 331 × 26 = 8,606 baht/month/person or equivalent to 103,272 baht/year/person. If 2 people equal 206,544 baht/year and if it is applied to 4 zones, it will be able to reduce the minimum wage of 826,176 baht/year and a total of 8 workers.

5. Conclusion

To improve the production process by designing a new mortar box to create a new mortar box pick-up, the experimental materials were Superlene and Nylon. The mortar box is made of Steel Flat Bar and the handle uses Steel Plate, making it possible to cut out an unnecessary step of the box picking process that has a production time of up to 42 minutes. Therefore, the production process was adjusted by adding 1 production step, namely the process of pulling out the box. This step can reduce the number of workers working in other areas, resulting in an average of 44 minutes process time of production before the adjustment. After the improvement, the average time was reduced to 14 minutes, therefore, a total reduction time was 30.2 minutes, accounting for 68.9% and increasing the efficiency of the precast production 3-leg slab following the study's objective no. 2 and consistent. Optimizing the production of prefabricated slabs 3 legs is per one production zone. The reduction time was 30.2 minutes/platform. In pouring cement for 1 day, all 3 plinths were poured, the time was reduced by 90.6 minutes, the number of workers was reduced by 2, and the minimum wage was reduced by 331 × 26 = 8,606 baht/month/person or equivalent to 103,272 baht/year/person. If 2 people equal 206,544 baht/year and if it was applied to 4 zones, it would be able to reduce the minimum wage of 826,176 baht/year and a total of 8 workers.

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