International Journal of Scientific Engineering and Research (IJSER)
www.ijser.in
ISSN (Online): 2347-3878, Impact Factor (2014): 3.05

Study on Labour Productivity by Learning Curve Effect

Amrutha Raman[1], Aby Varghese[2]

[1]Post Graduate Student, Civil Engineering Department, TocH Institute of Science and Technology, Kerala, India

[2]Assistant Professor, Civil Engineering Department, TocH Institute of Science and Technology, Kerala, India

Abstract: ***Learning curve theory is based on the phenomenon that productivity improves through the repetitive tasks. In construction planning, the evolution of repetitive scheduling methods led to the introduction of learning concept. It is a common knowledge that performing the same activity repeatedly, and in the same condition takes less time as the activity is repeated. This phenomenon is clear in many construction activities and is known as learning experience or learning effect. A straight line model can be used as a base model of learning curve for this project. It contributes a development of algorithm for predicting construction activity time based on learning curve theory. It also identifies the factors that affect the labor productivity by conducting a questionnaire survey.***

Keywords: Learning curve effect, High-rise building, Questionnaire survey, Labor Productivity, Factors

1. Introduction

Learning curve theory is based on a basic principle of human nature; the ability to learn from past experience. The learning process stems from individuals or crews repeating the same task and gaining skill or efficiency from their own experience or practice. The principle of learning curve, which has been used effectively in manufacturing, can also be used in construction as labor productivity. It affects the cost of many repetitive activities. Estimators can use this theory in cost estimating. Contractors can apply it in productivity studies and productivity improvement and for future bidding of similar activities. Owners may utilize this theory in evaluating bids or change orders and subsequently for negotiating prices. Construction activities are repetitive from floor to floor in High-rise building construction. Learning-curve theory is based on the phenomenon that productivity improves through the performance of repetitive tasks. Various researches suggest that the learning-curve effect could be applied to the construction industry because construction activities and tasks are generally performed repetitively. Labor productivity may neither reach 100 percent of the normal level at the very first floors nor the very top floors. This study aims at exploring the relationship between floor number and labor productivity in High-rise building activities, namely construction of partition walls and finishing works. Learning curve is developed as an analytical concept designed to quantify the rate at which cumulative experience of labor hours or cost allows an organization to reduce the amount of resources it must expand to accomplish a task. It states that, whenever the production quantity of a product doubles, the unit or cumulative average cost, i.e. man-hours or cost, declines by a certain percentage of the previous unit or cumulative average rate. This percentage is referred to as the learning rate.

This study is mainly aimed at finding out the factors that influence labor productivity. It also focuses on developing a straight line model. To achieve these objectives, an extensive literature review was conducted.

1.1. Literature review

Bogyeong Lee, et al.[1] (2015) evaluated the factors that impact the manifestation process and they suggest a suitable learning curve model for high-rise building construction activities. Specifically, three influence factors such as task change, work adaptation, vertical transportation time are selected and a hypothetical learning curve is proposed for the high-rise building construction.

Eric H. Grosse, et al.[2] (2015) evaluated learning curves in production economics. In this study they developed different learning curve models and applied in the area of production economics. This paper presents the results of a meta-analysis of empirical learning curve data. This paper aimed to present a comparative performance analysis of different learning curves and to derive recommendations about which learning curve should be used to approximate learning in different practical settings.

Abdulaziz Jarkas, et.al.[4] evaluated the applicability of learning curve theory to formwork labor productivity. They conducted a case study in a building projects located in the State of Kuwait. Forty-five buildings having recurring floor configurations were selected for observation. The effect of learning phenomenon on formwork labor productivity of building floors was investigated.

From the literatures reviewed, it was found that learning curve theory has been applied to construction activities due to their labor-intensive and repetitive features .The studies were conducted on formwork labor productivity and rebar fixing labor productivity. They considered straight line model equation for finding the labor productivity. They concluded that learning curve theory is evaluated for feasibility. In this project, buildings having identical floors were identified and the learning curve method has been adopted for the construction of partition walls and finishing works. The factors affecting labor productivity can be identified .A Straight line model can be developed and it can be fitted using regression method and comparing the actual labor productivity with learning labor productivity.

1.2 Methodology

The project observed building having identical floors and labor productivity data such as work hours, number of workers, and quantity of work of identical floors for the construction of partition walls and finishing works were collected. The equivalent work hours and cumulative average labor inputs for each floor were calculated and also identify the factors that affect labor productivity.

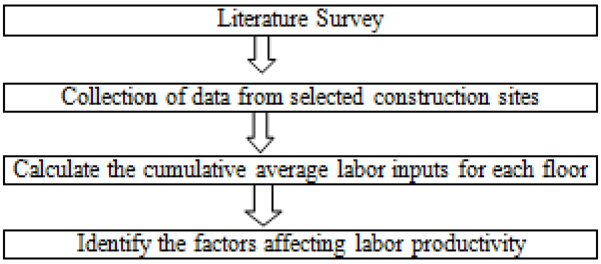

Figure 1: Methodology

2. Application of learning curve theory to Partition wall and plastering works labor productivity

2.1 Data Collection

Projects observed included residential type high-rise buildings having identical floors ranging from a minimum of five to a maximum of 30. The large number of buildings monitored and volume of data collected made it possible to achieve valid and reliable results. The characteristics of the buildings observed are provided in Table 1.

Table 1: Characteristics of buildings observed

Project no.	Project type	Floor area(m^2)	No. of identical floors
1	Residential	448	14
2	Residential	564	26
3	Residential	564	26

Labor productivity data such as man hours, quantity of work and number of workers of partition wall construction and plastering works were collected from building projects located in Ernakulam. Partition wall and plastering works labor inputs for the corresponding cycles observed were collected as shown in table 3 & 4. The equivalent work hours for each floor were calculated by using the formula.

$$\text{Equivalent work hours} = \frac{\text{work hours}}{\text{quantity}}$$

Table 2 presents the details of residential type high-rise building observed. The project has 14 identical floors located at Silver Sand Island, Vyttila.

Table 2: Details of project no.1

Company name	Silpa projects & infrastructure
Site	Army welfare housing organization, Tower A
Location	Silver sand Island, Vyttila
No. of identical floors	14

Table 3: Partition wall labor productivity data of project no.1

Cycle no:	Duration (days)	Work hours(h)	Work hours per day (h)	Additional work hours(h)	No. of workers	Quantity (m^3)	Equivalent work hours (h/m^3)	Cumulative work hours (h/m^3)	Cumulative average work hours (h/m^3)
1	10	80	8	0	7	76.34	1.047	1.047	1.047
2	9	72	8	0	7	76.34	0.943	1.99	0.995
3	9	72	8	0	7	76.34	0.943	2.933	0.977
4	9	72	8	0	7	76.34	0.943	3.876	0.969
5	8	64	8	0	7	76.34	0.943	4.819	0.963
6	9	72	8	1	7	76.34	1.047	5.866	0.977
7	9	72	8	0	8	76.34	0.943	6.809	0.972
8	9	72	8	0	7	76.34	0.943	7.752	0.969
9	9	72	8	0	7	76.34	0.943	8.695	0.966
10	9	72	8	0	7	76.34	0.943	9.638	0.963
11	9	72	8	0	7	76.34	0.943	10.58	0.961
12	9	72	8	0	7	76.34	0.943	11.52	0.96
13	9	72	8	0	7	76.34	0.943	12.46	0.958
14	9	72	8	0	7	76.34	0.943	13.41	0.957

Table 4: Plastering works labor productivity data of project no.1

Cycle no:	Duration (days)	Work hours (h)	Work hours per day (h)	Additional work hours (h)	No. of workers	Quantity (m^2)	Equivalent work hours (h/m^2)	Cumulative work hours (h/m^2)	Cumulative average work hours (h/m^2)
1	7	56	8	0	21	1666.9	0.033	0.033	0.033
2	7	56	8	0	21	1666.9	0.033	0.066	0.033
3	7	56	8	0	21	1666.9	0.033	0.099	0.033
4	7	57	8	1	21	1666.9	0.034	0.133	0.033
5	8	64	8	0	21	1666.9	0.038	0.171	0.034
6	7	56	8	0	21	1666.9	0.033	0.204	0.034
7	7	56	8	0	21	1666.9	0.033	0.237	0.033
8	7	56	8	1	21	1666.9	0.034	0.271	0.033
9	7	56	8	0	21	1666.9	0.033	0.304	0.033
10	7	56	8	0	20	1666.9	0.033	0.337	0.033
11	7	56	8	0	20	1666.9	0.033	0.37	0.033
12	8	64	8	0	21	1666.9	0.038	0.408	0.034
13	7	56	8	0	21	1666.9	0.033	0.441	0.033
14	7	56	8	0	21	1666.9	0.033	0.474	0.033

3. Questionnaire Survey

A detailed review of the literature revealed a number of factors affecting construction labor productivity. 23 factors that have a significant influence on labor productivity were identified. A questionnaire was prepared and a survey was conducted at the selected sites. A 5-point scale was used to measure the effect of the factors on labor productivity. In this scale, 5 represents "extremely significant effect", 4 represents " very significant effect", 3 represents "significant effect", 2 represents "slight effect" and 1 represents "no effect". An importance index was calculated for each factor using the following formula.

Importance index
$= 5n_1{+}4n_2{+}3n_3{+}2n_4{+}n_5/5(n_1{+}n_2{+}n_3{+}n_4{+}n_5)$.

Where n_1 represents the number of respondents who answered "extremely significant effect", n_2 represents the number of respondents who answered "very significant effect", n_3 represents the number of respondents who answered "significant effect", n_4 represents the number of respondents who answered "slight effect" and n_5 represents the number of respondents who answered "no effect".

4. Conclusions

The applicability and accuracy of learning curve is expected to improve the labor productivity. This paper represents learning development for high-rise building construction. The project observed buildings having identical floors and partition wall and plastering works labor productivity analysis were conducted. The cumulative average labor inputs increases as the cycle number increases.

The learning process stems from individuals or gangs repeating the same task and gaining skill or efficiency from their own experience or practice.

This acquired experience is attributable to: (1) increased knowledge about the task being performed; (2) greater familiarity with the task; (3) improved work organization; (4) better coordination; and (5) more effective use of tools and methods.

References

[1] Bogyeong Lee, Hyun-Soo Lee, Moonseo Park, Hyunsoo Kim, "Influence Factors of Learning-Curve Effect in High-Rise Building Constructions". *American society of Civil Engineering*.2015.

[2] Eric H. Grosse, Christoph H. Glock, Sebastian Müller, "Production economics and the learning curve: A meta-analysis". *International journal production economics*.2015.

[3] Levente Malyusz, Attila Pem "Predicting future performance by learning curves". *Science direct*.2014

[4] Abdulaziz Jarkas, Malcolm Horner "Revisiting the applicability of learning curve theory to formwork labour productivity", *American society of civil engineering*.2011.

[5] Abdulaziz M. Jarkas, "Critical Investigation in to the Applicability of the Learning Curve Theory to Rebar Fixing Labor Productivity", *American society of civil engineering*.Vol no. 29,pp 483-493,2010.

[6] Jimmie Hinze, Svetlana Olbina, "Empirical Analysis of the Learning Curve Principle in Prestressed Concrete Piles", *American society of civil engineering*.vol no.135,pp.425-431,2009.

[7] J. P. Couto , J. C. Teixeira "Using linear model for learning curve effect on high rise floor construction" , *American society of civil engineering*. Vol.23, pp.355–364,2005

[8] Sherif H. Farghal , John G. Everet "Learning curves: Accuracy in Predicting Future Performance", *science direct*.vol.no. 123, pp.41-45, 2001.

[9] Paul.s. Adler (1997)" Applying Resource Loading, Production & Learning Curves to Construction: A Pragmatic Approach", *American society of civil engineering*. Vol. 21, pp. 939-953, 1994.

[10] Adib M. Hijazi, Simaan M. AbouRizk, Daniel W. Halpin "Modeling and Simulating Learning Development in Construction", *American society of civil engineering*.vol.118, 1992