Research Article

Evaluation of Dalla Bridge Project in Tikrit City According to Lean Construction

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Abstract: Aiming In this research was to have a clear view about the construction phases of Dalla Bridge, to see whether its implementation phases matched with the lean principles. In the beginning, interviews through a survey forms were carried out with management of the bridge and other professionals. The results of questionnaire were analyzed by using a statistical software (SPSS). Which showed that lean principles have been applied poorly during the bridge construction. Focusing on the most important principle, Eliminate the Wastes which represent the Core for Lean theory. The implementation was only 6% while 93% of the experts put this principle into the important category. Alternative methods are studied to reduce the wastes found. The uses of self-compacted concrete compared with the use of traditionally vibrated concrete, results showed that 55%of the participants totally agreed that this technique will reduce the work time and labour required while 40% partially agreed that work will be reduced and only 5% Not agreed. The use of prefabricated steel also compared with the traditionally steel reinforcement; results showed that 35% of the participants totally agreed with the use of this technique will reduce the steel activities on site while 65%partially agreed that work will be reduce. Also, the effects of formwork types studied, and it showed that 40% totally agreed that it will speed up the works and 60%partially agreed. The researcher found out there is a high level of acceptance from the Dalla team to apply the principles and tools of Lean, and there is a good compatibility with the terms of lean management to be applied in Iraqi construction projects.

Key words: Principles of lean; Project Evaluation; Reduce construction wastes.

تقييم مشروع مجسر الدلة في تكريت وفقا لمعايير التشييد المرشد

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الخلاصة

في هذا البحث تم تقييم مراحل العمل والتنفيذ لمجسر الدلة وفقا لمبادئ التشييد المرشد. في البداية، تم إجراء المقابلات وجمع اجوبة الاستبيان مع إدارة المجسر بعد شرح المبادئ بالتفصيل. ثم تحليل نتائج الاستبيان باستخدام برنامج إحصائي (SPSS). أظهرت النتائج أن معظم مبادئ التشييد المرشد قد تم تطبيقها بشكل ضعيف في اعمال بناء المجسر خاصة مبدأ ازالة الهدر والذي كان تطبيقه ٦% فقط رغم اهميته كانت بنسبة ٩٣% ثم تم دراسة الطرق البديلة الممكن اعتمادها في اغلب مشاريع الهندسة المدنية من خلال عمل استبيان اخر مع العاملين في المجسر.الطرق البديلة المقترحة هي ١/ استخدام الخرسانة المضغوطة ذاتيًا بدلا من الخرسانة التقليدية المهتزة وأظهرت النتائج أن 55٪ من المشاركين بالاستبيان وافقوا تمامًا على أن هذه التقنية ستقلل من وقت العمل والايدي العاملة المطلوبة بينما 40٪ منهم وافقوا جزئيًا على استخدامها و 5 ٪ فقط لم يوافقوا 2 / استخدام الحديد الجاهز بدلا من الحديد الاعتيادي، أظهرت النتائج أن 35٪ من المشاركين بالاستبيان وافقوا تمامًا على ان استخدامه سيقلل من الانشطة اللازمة لأعمال الحديد في الموقع بينما 65٪ منهم وافقوا جزئيًا على ان هذه التقنية ستقلل أنشطة الحديد في موقع العمل، 3 / استخدام انواع معينة من القوالب حيث أظهرت النتائج أن 40٪ وافقوا كليًا على ان استخدامها يساعد في انجاز العمل بشكل اسرع وتقليل تسرب معجون اللصق و 60٪ وافقوا جزئيًا على ذلك.

الكلمات الدالة: معايير التشييد المرشد, تقييم المشاريع, تقليل ضوائع الاعمال الانشائية.

1. Introduction

In 1950's after World War II, the ideas of new production philosophy were originated in Japan. Toyota Production System was the most prominent in enforcing this philosophy. The fundamental idea of the Toyota Production System is the elimination of inventories and other wastes through small lot production, reduced set-up times, semiautonomous machines, co-operation with suppliers, and other techniques **(Monden 1983, Ohno 1988)**.

The idea of lean was thoroughly described in the book, "The Machine That Changed the World" by **(Womack et al. 1990).** In a consequent volume, Lean thinking by the same authors distilled these lean principles even further to five components: specify value, identify all the steps in the value stream, flow, and pull and pursue perfection **(Womack et al. 2003).**

According to the National Institute of Standards and Technology Manufacturing Extension Partnership's Lean Network, Lean is a systematic approach towards reducing the waste, continuously attempt to improve further and to maintain the production rate as per the requirement of customer **(Kilpatrick, 2003).** The current construction relies on both mass production and artisan-based technologies. A large part of the work on the construction site is carried out in the old ways, as many workers often work in arduous jobs and studies have shown that 50% or more of the effort to hand over a building is not a value-added effort and most construction work does not satisfy the customer in terms of productivity, scheduled time of delivery and the budget, so the construction industry needs to be changed. By turning Lean Production ideas into Lean Construction, improvements in productivity, economy and ergonomics can be expected.

According to the **(Marhani, Jaapar, & Bari, 2012)**, Lean production system is a collaborative approach of various parameters towards maximization of benefits or production with minimum waste. Lean construction is kind of innovation in construction industry as its approach is different from typical conventional one. Whenever there is a change in certain arrangement, there is always a back-out from its usage like innovation **(Egmond&Erkelens, 2008)**.

(Kahvandi et al.,2018) use the Flow Chart Methodology (FCM) based dynamic modelling to overcome the challenges in construction projects. The findings of the study suggested that flexibility in schedule is one of the main advantages to implement integrated projected delivery to a construction site.

(Koseoglu et al.,2018), Studied the interaction and synergies between lean and mobile BIM implementation procedure at construction sites. The findings of the study concluded an improvement in the workflow activities of the construction project.

(Xu et al. 2018), proposed a cloud-enabled platform for lean prefabricated project delivery in construction projects. The findings of the study conclude that the proposed framework of cloud based IoT and Lean construction would save time, money and shall improve the efficiency and safety of the operations at the construction sites.

(Saieg et al., 2018), studied the combined effect of applying Lean construction sustainability, and BIM of construction projects. The methodology adopted for the study is the use of a systematic review of the literature of studies published in Scopus. A total of 32 articles were analyzed by the authors for the systematic review of the literature and the authors concluded that the combination of lean and BIM leads to the implementation of green and sustainable construction in the AEC industry.

(Sarhan et al., 2018), studied the barriers in the implementation of lean in construction projects in the KSA (Kingdom of Saudi Arabia). There was a total of 282 responses received for the survey and 22 barriers attributes were analyses using SPSS software. The author's findings suggested that the topmost barriers in the implementation of lean construction in KSA were traditional practices, performance and knowledge, and the client's interest in the project internal functioning.

2. CASE STUDY: Dalla Bridge

Cast In-Situ concrete bridge located in Salah-Aldeen/Tikrit at coordinates (34.599176, 43.684552) as in **Figs. (1), (2), and (3)** illustrates the overall location, site layout and some insight details within the bridge heights. The total length of the bridge is 1780m with total height 16m and Span length 35-38m. The construction works within this concrete bridge was suffered from many issues related to some mistakes, the work started in (23/10/2013) and had to stop till (16/1/2014) during some issues with the coordinates. The reworks started in (16/1/2014) and it

returns to stop regarding to the security issues another stop happened again regarding to issues with girder heights and such stops effected on the efficiency of the bridge where the reinforcement required more than 2 months to remove the rust from the steel of the around foundation rebars.

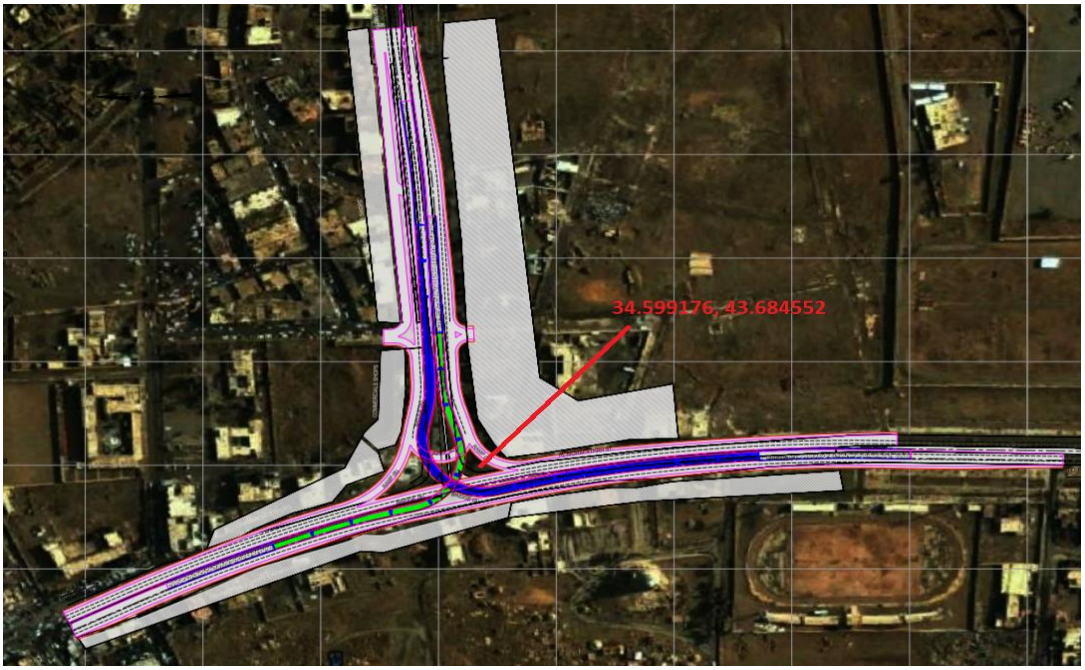


Figure 1. Overall location.

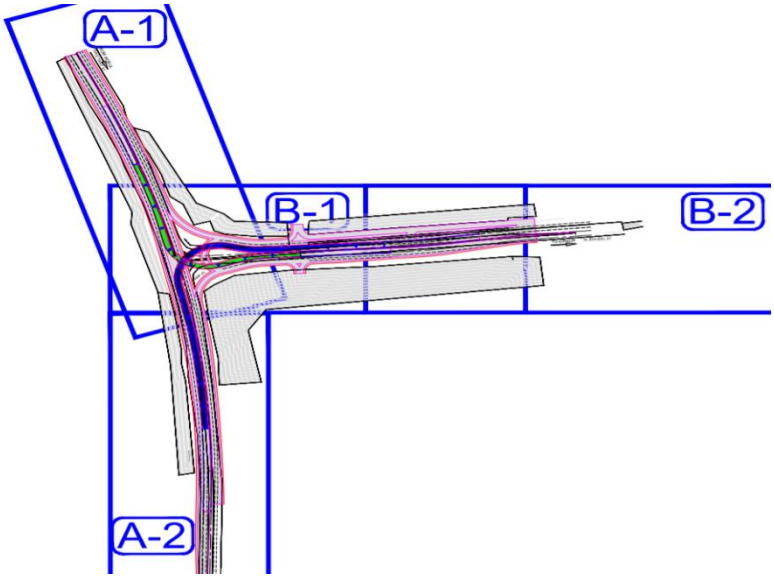


Figure 2. Site Layout.

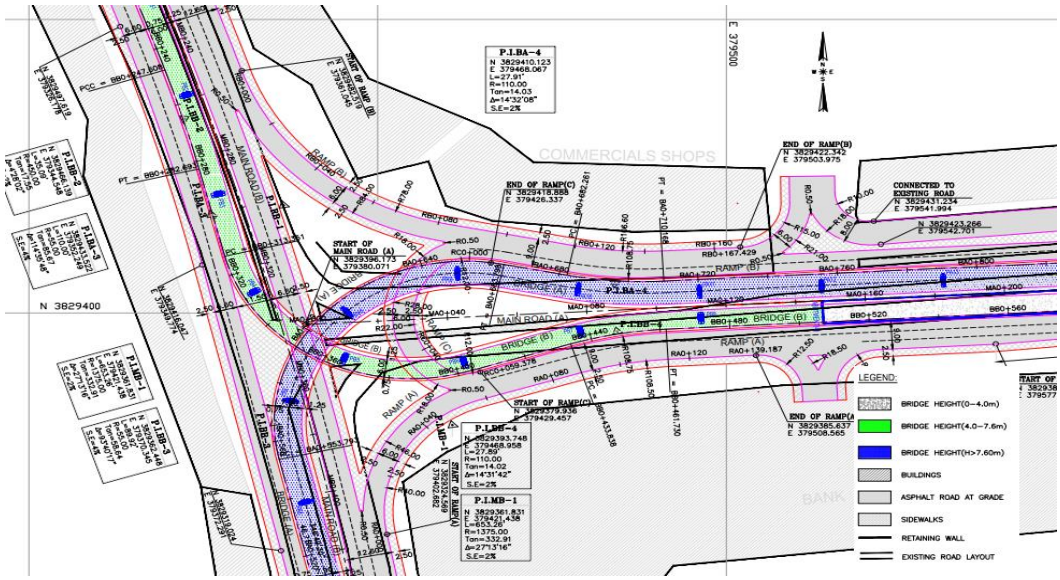


Figure 3. General Site Plan.

3. Study strategy taken

According to **(Yin ,1994)** study strategies can be in the form of case studies, experiments, surveys, history, computer-based analyses of archival records. Some of the most used study strategies within construction is according to **(Woksepp ,2007),** interviews, experiments, case studies, ethnographic study, and action research. Also stated that case studies were earlier only used for the exploratory phase of an investigation and that surveys and history were appropriate for the descriptive phase. This is on the other hand not accurate since a case study can be both descriptive and explanatory **(Yin ,1994).**

data has been collected through four of the most used study methods mentioned above: interviews, case study, action research and computer-based analyses. interviews have been carried out through survey forms and actual meetings with many engineers in the level of professionals, they are involving in different projects specially bridges.

(Yin ,1994) illustrates one of the most significant sources of information gathered in a case study is through interviews. Interviews are important when the researcher is unable to observe behavior, feelings, or how people interpret activities or occurrences around them, **(Merriam ,1988)**.

The effect of the principles of Lean on the construction industry is transferred in the form of a questionnaire as in **Fig. (4)** to find out the importance of each principle in the eyes of experts and to find out whether these principles implemented during the construction of Dalla.

Workplace:
Specialization:
Years of Experience:

Scope of practice:

1	2	3	4	5
Very Good	Good	Moderate	Poor	Too poor

Level of significance:

1	2	3	4	5
Very Important	Important	Moderately Important	Unimportant	Unimportant at all

No	Principles	Level of Significance (Importance)					Scope of Practice				
		1	2	3	4	5	1	2	3	4	5
1	Identify Value from the Customer's Point of View تحديد أهمية المشروع والتحقق من متطلبات المستخدمين وهل تم انشاء المشروع بناء على متطلبات المستخدمين. تحديد اهمية المنتج حسب وجهة نظر المستخدم والتركيز على متطلباته مع توحيد جميع العمليات لتسليم منتج يلبي تلك المتطلبات.										
2	Define the Value Stream بعد تحديد أهمية المشروع حسب نظر المستخدم، تأتي خطوة تحديد خطوات سير المشروع من الاعداد الضرورية للعمال، المعلومات، المعدات، والمواد وازالة الخطوات التي لا تضيف قيمة للمشروع. تحديد خطوات سير العمل وازالة الضائعات، هذا يعني الالمام بمجريات العمل وازالة العوائق التي تسبب تأخر او تعرقل سير العمل.										
3	Eliminate Waste الهدف الأساسي هو إزالة او تقليل الضائعات. هذه الضائعات قد تكون: (1) الأخطاء الناتجة عن التنفيذ بصورة غير صحيحة من البداية. (2) ضياع الوقت مثلا انتظار العمال لعمل معين قبل وصول المواد. (3) عدم كفاءة العمال لأداء عمل معين. (4) النقل المستعجل للمواد قبل التحضير لعمل معين. (5) المواد الغير مطلوبة في الوقت الحاضر تعتبر مخزن فائض (6) المسافة بين العمال والمعدات تعتبر حركة غير ضرورية. (7) الاعمال غير الضرورية للعمل الرئيسي.										
4	Pull Planning and Scheduling جعل بيئة العمل موثوقة، وهذا يتم بمشاركة كافة الأطراف المساهمة بالعمل و(subcontractors) لوضع جدول بالأعمال.										
5	Continuous Improvement إمكانية التحسين المستمر للأعمال وتقليل الضوائع هو جوهر هذه النظرية. ويجب ان يطبق ويعمم هذا التحسين في المشاريع المستقبلية										
6	Flow of Work Processes التواصل المستمر بين الأطراف المنفذة للمشروع ضروري لتحقيق تسلسل عمل صحيح. عند تقدم او تأخر فقرة بالعمل يجب ان يعلم بها الجميع ليتم إعادة العمل بتسلسل الفقرات										

Figure 4. Questionnair

Two types of experts participated in this questionnaire as in **Table (1):**

a) Implementing engineer.

The engineers who are implementing Dalla bridge, denoted as No.2 in SPSS questionnaire. Where 4 engineers engaged in.

b) Supervise engineer.

The engineers who are supervising and consultants on the works of Dalla bridge, denoted as No.1 in SPSS questionnaire. where 12 engineers engaged in.

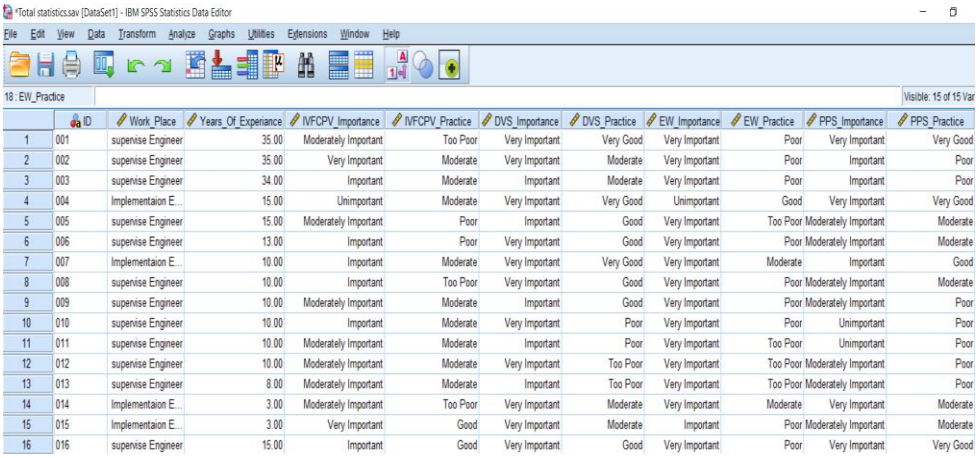
Table 1. Engineers' workplace

		participants	Percent	Valid Percent	Cumulative Percent
Valid	supervise Engineer	12	75.0	75.0	75.0
	Implementation Engineer	4	25.0	25.0	100.0
	Total	16	100.0	100.0	

4. Computer program

The results from the interviews and the results from the follow ups are compared and analyzed using IBM SPSS® Statistics, which is a powerful statistical software platform. It delivers a robust set of features that lets you extract actionable insights from its data as in **Fig. (5).**

Figure 5. SPSS



	ID	Work_Place	Years_Of_Experiance	IVFCPV_Importance	IVFCPV_Practice	DVS_Importance	DVS_Practice	EW_Importance	EW_Practice	PPS_Importance	PPS_Practice
1	001	supervise Engineer	35.00	Moderately Important	Too Poor	Very Important	Very Good	Very Important	Poor	Very Important	Very Good
2	002	supervise Engineer	35.00	Very Important	Moderate	Very Important	Moderate	Very Important	Poor	Important	Poor
3	003	supervise Engineer	34.00	Important	Moderate	Important	Moderate	Very Important	Poor	Important	Poor
4	004	Implementaion E...	15.00	Unimportant	Moderate	Very Important	Very Good	Unimportant	Good	Very Important	Very Good
5	005	supervise Engineer	15.00	Moderately Important	Poor	Important	Good	Very Important	Too Poor	Moderately Important	Moderate
6	006	supervise Engineer	13.00	Important	Poor	Very Important	Good	Very Important	Poor	Moderately Important	Moderate
7	007	Implementaion E...	10.00	Important	Moderate	Very Important	Very Good	Very Important	Moderate	Important	Good
8	008	supervise Engineer	10.00	Important	Too Poor	Very Important	Good	Very Important	Poor	Moderately Important	Moderate
9	009	supervise Engineer	10.00	Moderately Important	Moderate	Important	Good	Very Important	Poor	Moderately Important	Poor
10	010	supervise Engineer	10.00	Important	Moderate	Very Important	Poor	Very Important	Poor	Unimportant	Poor
11	011	supervise Engineer	10.00	Moderately Important	Moderate	Important	Poor	Very Important	Too Poor	Unimportant	Poor
12	012	supervise Engineer	10.00	Moderately Important	Moderate	Very Important	Too Poor	Very Important	Too Poor	Moderately Important	Poor
13	013	supervise Engineer	8.00	Moderately Important	Moderate	Important	Too Poor	Very Important	Too Poor	Moderately Important	Poor
14	014	Implementaion E...	3.00	Moderately Important	Too Poor	Very Important	Moderate	Very Important	Moderate	Very Important	Moderate
15	015	Implementaion E...	3.00	Very Important	Good	Very Important	Moderate	Important	Poor	Moderately Important	Moderate
16	016	supervise Engineer	15.00	Important	Good	Very Important	Good	Very Important	Poor	Very Important	Very Good

Software

The results from the follow ups were after that altered through the introduction of industrialized working methods. New unit times for production, like new and different methods for fixing the reinforcement are theoretically inserted in the previously gathered results and analyzed again. This is done to be able to perceive any possible economic benefits or productivity benefits with new and different working methods from a theoretical point of view.

5. Analytical works

5.1 Study Model

The importance of lean principles has been investigated with the engineers supervising bridges and the extent of application of each principle also checked during Dalla construction works as in **Fig. (6)**

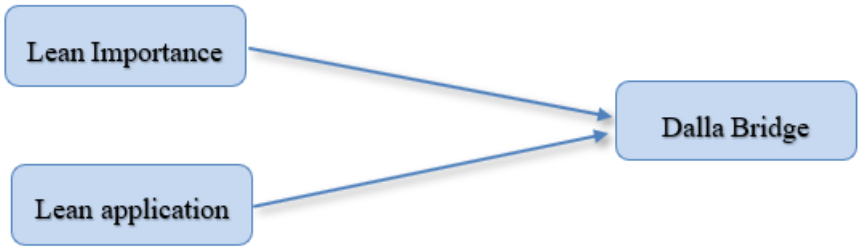


Figure 6. Study Model

5.2 Reliability Statistics

The reliability of the questionnaire that was used for data collection is used properly as in **Table (2)** to understand the opinions of the study participants. The questionnaire that is being used must be reliable to provide effective information that is critical for the progress of Dalla bridge. It is assessed by focusing on if the questionnaire is providing credible information if the same questionnaire is used to collect information from other places and whether it provides credible information or not. The reliability statistic using Statistical package for Social Sciences (SPSS) is used with the help of Cronbach's Alpha it was detected that 12 items of the question was 76.7% that means the information is credible. A value higher than 50% is considered sufficient and in this case, it is 76%.

Table 2. Reliability Statistics

N of Items	Cronbach's Alpha Based on Standardized Items	Cronbach's Alpha
12	.760	.767

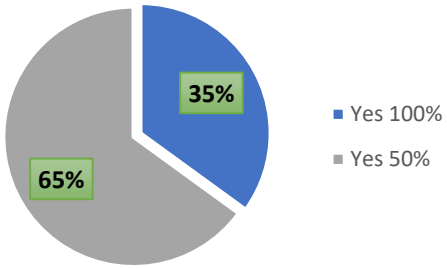


Figure 7. Participants Years of Experience in percentage

5.3 Years of Experience

The years of experience for the respondence that participated in the questionnaire was according to as in **Fig. (7).** It shows that 63% of the engineers were having years of experience from 1-15 years, 19% were having 15-30 years and another 19% were having years of experience above 30 years. The information shows that engineers from different years of experience were able to share their views and ideas that allowing to get diverse information from the various people participating in the study as in **Table (3).**

Table 3. Participants Years of Experience.

		Participants	Percent	Valid Percent	Cumulative Percent
Valid	3.00	2	12.5	12.5	12.5
	8.00	1	6.3	6.3	18.8
	10.00	6	37.5	37.5	56.3
	13.00	1	6.3	6.3	62.5
	15.00	3	18.8	18.8	81.3
	34.00	1	6.3	6.3	87.5
	35.00	2	12.5	12.5	100.0
	Total	16	100.0	100.0	

5.4 Statistical Treatment Methods

To answer the study questions, the data were processed using the SPSS program. Use the following statistical methods in the analysis:

- Frequency distributions and percentages to display the characteristics of the sample and to know the degree of agreement of its members with the statements.
- The arithmetic means in order to know the degree of approval of the sample members for each statement separately and the degree of approval for the axis as a whole.
- Standard deviation to know the extent of dispersion of the sample members 'answers from their arithmetic mean.

5.5 Descriptive Statistics

Table (4) shows the descriptive statistics was used in SPSS for analyzing the study findings based on the information that was collected by using the questionnaire. The results showed that the attitude of the sample members was positive towards the axis of importance, because all the mean values ranged between 1.25 and 2.4375 which falls in the first and second categories of Likert scale, which express the degree of importance (very important and important). All the standard deviations were close to each other in the answers of the sample members for all data from this axis, they characterized by acceptable dispersion from each other. The mean, minimum value, the maximum value, standard deviation of the data, the skewness and kurtosis of the data were all checked to analyze the results. The criteria of skewness and kurtosis is supposed to be between -2 and +2 which was sufficient except one of the principles the kurtosis was too high as result of the great contrast between the importance and the application **(George & Mallery, 2010).**

5.5.1 Identify Value from the Customer's Point of View

The results in **Tables (5) and (6)** showed that the importance and application of this principle was weak, especially the application 13% only because most users unable to specifying the importance of the bridge, the construction requirements, or the strategic plan for its construction.

Table 4. Descriptive Statistics.

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
IVFCPV-Importance	16	1.00	4.00	2.4375	.81394	-.195	.564	-.208	1.091
IVFCPV-Application	16	2.00	5.00	3.3750	.95743	.667	.564	-.323	1.091
DVS-Importance	16	1.00	2.00	1.3125	.47871	.895	.564	-1.391	1.091
DVS-_Application	16	1.00	5.00	2.6875	1.30224	.460	.564	-.639	1.091
EW-Importance	16	1.00	4.00	1.2500	.77460	3.443	.564	12.222	1.091
EW-Application	16	2.00	5.00	4.0000	.81650	-.840	.564	1.223	1.091
PPS-Importance	16	1.00	4.00	2.4375	1.03078	-.227	.564	-1.078	1.091
PPS-Application	16	1.00	4.00	3.0000	1.15470	-.891	.564	-.570	1.091
CI-Importance	16	1.00	3.00	1.5625	.72744	.942	.564	-.284	1.091
CI-Application	16	1.00	3.00	2.3750	.71880	-.731	.564	-.541	1.091
FWP-Importance	16	1.00	4.00	1.8750	.95743	.798	.564	-.235	1.091
FWP-Application	16	1.00	3.00	1.9375	.77190	.113	.564	-1.194	1.091

Table 5. The importance of identify value from the Customers' Point of View.

		Participants	Percent	Valid Percent	Cumulative Percent
Valid	Very Important	2	12.5	12.5	12.5
	Important	6	37.5	37.5	50.0
	Moderately Important	7	43.8	43.8	93.8
	Unimportant	1	6.3	6.3	100.0
	Total	16	100.0	100.0	

Table (6). The application of identify value from the Customers' Point of View within Dalla bridge.

	Participants	Percent	Valid Percent	Cumulative Percent
Good	2	12.5	12.5	12.5
Moderate	9	56.3	56.3	68.8
Poor	2	12.5	12.5	81.3
Too Poor	3	18.8	18.8	100.0
Total	16	100.0	100.0	

5.5.2 Define the Value Stream

The results in **Tables (7) and (8)** showed that the importance of this principle was 100% and the application was 50%. Determining workflow steps and removing work obstacles is very important in any project, but in Dalla Bridge there were many obstacles that facing the progress of work, this led to delaying and returning work in some cases, so the application of this principle is little compared to the importance.

Table (7). The importance of define the value stream.

		Participants	Percent	Valid Percent	Cumulative Percent
Valid	Very Important	11	68.8	68.8	68.8
	Important	5	31.3	31.3	100.0
	Total	16	100.0	100.0	

Table (8). The application of define the value stream within Dalla Bridge

		Participants	Percent	Valid Percent	Cumulative Percent
Valid	Very Good	3	18.8	18.8	18.8
	Good	5	31.3	31.3	50.0
	Moderate	4	25.0	25.0	75.0
	Poor	2	12.5	12.5	87.5
	Too Poor	2	12.5	12.5	100.0
	Total	16	100.0	100.0	

5.5.3 Eliminate Waste.

The results in **Tables (9) and (10)** showed that the importance of this principle was 93% while the application in Dalla was only 6%. There were many sources of waste in the project due to errors resulting from incorrect implementation from the beginning, and the project was subject to many interruptions. Where there was an error in the coordinates of the bridge, a mistake in the girder's design and many stops, that means there is waste in time, cost and efforts. So, its application is very weak.

Table (9). The importance of eliminate wastes.

		Participants	Percent	Valid Percent	Cumulative Percent
Valid	Very Important	14	87.5	87.5	87.5
	Important	1	6.3	6.3	93.8
	Unimportant	1	6.3	6.3	100.0
	Total	16	100.0	100.0	

Table (10). The application of eliminate wastes within Dalla Bridge

		Participants	Percent	Valid Percent	Cumulative Percent
Valid	Good	1	6.3	6.3	6.3
	Moderate	2	12.5	12.5	18.8
	Poor	9	56.3	56.3	75.0
	Too Poor	4	25.0	25.0	100.0
	Total	16	100.0	100.0	

5.5.4 Pull Planning and Scheduling

The results in **Tables (11) and (12)** showed that the importance of this principle was 44% and the application was 25%. The importance and the application of this principle are weak because it depends on the participation of all the work team in scheduling work steps and benefiting from everyone's experiences, and this was not applied in Dalla, where one team is responsible for scheduling work and the other implementing.

Table (11). The importance of pull planning and scheduling.

		Participants	Percent	Valid Percent	Cumulative Percent
Valid	Very Important	4	25.0	25.0	25.0

	Important	3	18.8	18.8	43.8
	Moderately Important	7	43.8	43.8	87.5
	Unimportant	2	12.5	12.5	100.0
	Total	16	100.0	100.0	

Table (12). The application of pull planning and scheduling within Dalla Bridge

		Participants	Percent	Valid Percent	Cumulative Percent
Valid	Very Good	3	18.8	18.8	18.8
	Good	1	6.3	6.3	25.0
	Moderate	5	31.3	31.3	56.3
	Poor	7	43.8	43.8	100.0
	Total	16	100.0	100.0	

5.5.5 Continuous Improvement

The results in **Tables (13) and (14)** showed that the importance of this principle was 87% and the application was 51%. Any change, improvement and overcoming the obstacles that the bridge passed it were circulated to benefit from them in other projects. So, the application of this principle is relatively acceptable.

Table (13). The importance of continuous improvement.

		Participants	Percent	Valid Percent	Cumulative Percent
Valid	Very Important	9	56.3	56.3	56.3
	Important	5	31.3	31.3	87.5
	Moderately Important	2	12.5	12.5	100.0
	Total	16	100.0	100.0	

Table (14). The application of continuous improvement within Dalla Bridge

		Participants	Percent	Valid Percent	Cumulative Percent
Valid	Very Good	2	12.5	12.5	12.5
	Good	6	37.5	37.5	50.0
	Moderate	8	50.0	50.0	100.0
	Total	16	100.0	100.0	

5.5.6 Flow of Work Process

The results in **Tables (15) and (16)** showed that the importance of this principle was 75% and the application was 75%. There was a constant communication between the work staff, when a paragraph is submitted or delayed, everyone is informed about it. So, its application is good.

Table (15). The importance of flow of work process

		Participants	Percent	Valid Percent	Cumulative Percent
Valid	Very Important	7	43.8	43.8	43.8
	Important	5	31.3	31.3	75.0
	Moderately Important	3	18.8	18.8	93.8
	Unimportant	1	6.3	6.3	100.0
	Total	16	100.0	100.0	

Table (16). The application of flow of work process within Dalla Bridge.

		Participants	Percent	Valid Percent	Cumulative Percent
Valid	Very Good	5	31.3	31.3	31.3
	Good	7	43.8	43.8	75.0
	Moderate	4	25.0	25.0	100.0
	Total	16	100.0	100.0	

5.6 Technical Platform

There are three major material types involved when constructing a bridge: concrete, formwork, and reinforcement. The technical platform needs solutions that are based upon these types together.

5.6.1 Reducing Concrete Wastes

SCC is an important link in the development of the industrialization process of civil engineering projects as it can, if managed properly, decrease the number of workers needed during casting and concrete workers can perform other activities during casting and the construction site becomes less congested with possibly reduced risk for accidents as a result (**Cussigh F,2007**).

A question was asked in the questionnaire form to see whether using SCC would reduce work time and labor. as in **Fig. (8),** the answers were 55% of the participants totally agreed that using SCC will reduce the work on the site while 40% partially agreed as in **Fig. (9).**

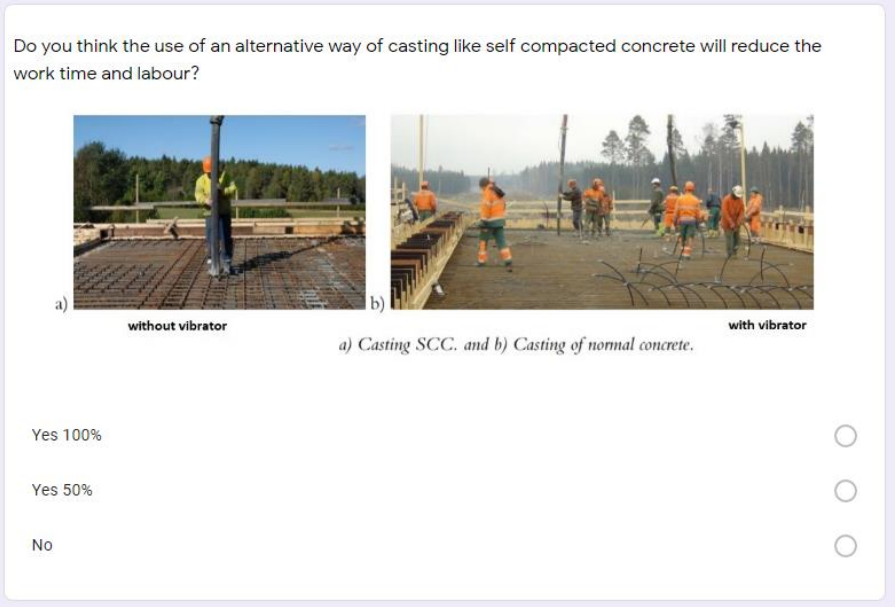


Figure (8). SCC importance on reducing work time and labor.

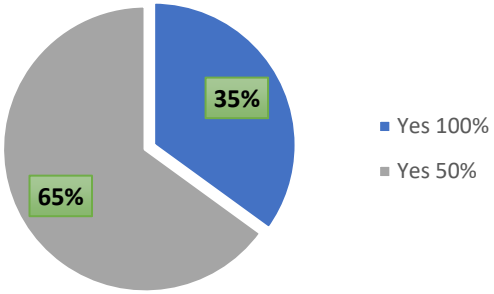


Figure (9). Questionnaire reviews on SCC importance

5.6.2 Reducing Steel Reinforcement Wastes

An alternative to traditional placing of reinforcement is prefabricated reinforcement. It often consists of ready to use traditional mesh reinforcement or reinforcement bars welded together to cages varying in size. It decreases the number of stressful working positions for the workers and increases construction pace **(Ålander ,2004).** The **Figs. (10) and (11)** show the difference in work schedule between ordinary steel reinforcement and the prefabricated steel. The question asked was to find out if the use of prefabricated steel will minimize the reinforcement works on Site**.** The answers were 35% will totally reduce the works and 65% half of the works required will be reduced as in **Fig. (12).**

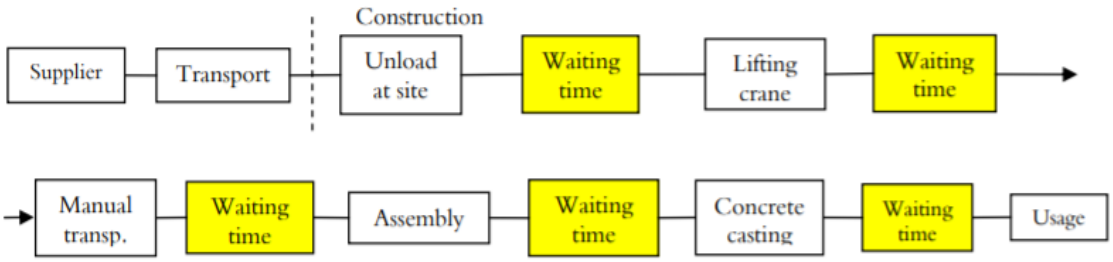


Figure (10). Value stream of traditional handling of single piece reinforcement on a construction site.

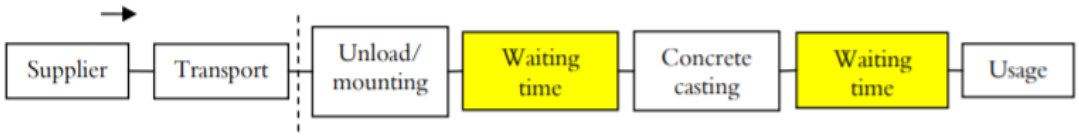


Figure (11). Value stream when handling the prefabricated reinforcement sections for the foundation at the first full scale project.

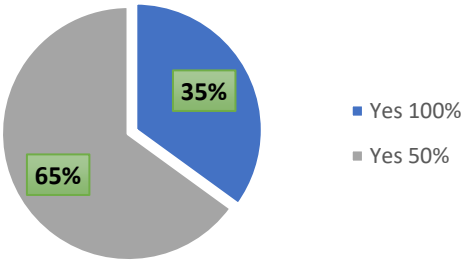


Figure (12). Questionnaire reviews on prefabricated steels importance

6. Conclusions

After displaying the importance and the application of each principle during Dalla construction works the below points conducted:

1) Most of the principles of Lean theory are important according to the opinion of the participants in questionnaire who are working in Dalla bridge.

2) Most principles of Lean theory are inconsistent with bridge implementation works, especially the principle of reducing and eliminating waste, which is the core of the Lean theory.

3) Poor management, lack of proper planning and design, lack of responsibility to solve and overcome problems quickly, and lack of attention to the element of time, which led to the work being exposed to many sources of waste and stops.

4) By using SCC, the work time and the labour force will be reduce since it will not need to use any vibrators during concrete casting.

5) By using prefabricated steel, the steel works will be minimize, and it will not need to stock high quantities of steel within the site as it will be transport upon request and this will also reduce site congestion.

6) There is a high level of acceptance from the Dalla team to apply the principles and tools of Lean, and there is a good compatibility with the terms of lean management to be applied in Iraqi construction projects.

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