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Factors Affecting Construction Labor Productivity for Construction of Pre-Stressed Concrete Bridges

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Abstract Purpose – Construction labor productivity in bridges of great interest to practitioners and researchers because it affects project cost and time overrun. This paper evaluates and ranks the importance, frequency and severity of project delay factors that affect the construction labor productivity for construction of Pre-stressed concrete bridges. **Design/erection / methodology:** A total of 50 respondents consisting of owners contractors, and consulting participated in this study. The respondents were asked to indicate how important each item of a list of many bridges project related factors was to construction labor productivity for construction of Pre-stressed concrete bridges. The data were then subjected to the calculation of important indices which enabled the factors to be ranked. **Findings:** The eleven most important factors identified by them were: design factor, equipment factor, execution and construction factor, external factor, financial factor, healthy and safety factor, labor factor, supervision factor, material factor, organization factor and other project factor. **Originality/value:** From this study could be used by the project managers to take these factors at an early stage, hence minimizing the time, cost and maximizing factors that affect the construction labour productivity for construction of Pre-stressed concrete bridges.

Keywords Labor productivity, Pre-stressed Concrete, Bridges

1. Introduction

Productivity is one of the most important factors affecting the overall performance of any organization, large or small (**Kazaz and Ulubeyli, 2007**). Productivity in construction sites is important because it influences time and cost objectives (**Moselhi and Khan, 2010**). In fact, the percentage of projects exceeding Cost or time forecasts is high (**González et al, 2010, Johansen and Wilson, 2006**). In Egypt has experienced a construction bridges boom during the past years, attracting construction professionals in bridges. According to the bridges and roads Ministry, However, construction Pre-stressed beams in bridges faces some critical problems like poor labour productivity. Labour productivity is simply defined as the amount of goods and services that a laborer produces in a given amount of time.

This paper aims at identifying factors affecting labour productivity for Construction of Pre-stressed Concrete Bridges in Egypt from the owners and consulting and contractors' perspective. The questionnaire shows changes in each of the following factors like the design factor, equipment factor, execution and construction factor, external factor, financial factor, health and safety factor, labour factor, supervision factor, material factor, organization factor and other project factor were ranked according to their impact level. These findings will guide efforts to enhance the performance of the construction of Pre-stressed Concrete beams Bridge.

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2. Literature Review

Pre-stressed concrete in bridges projects differ from conventional structural engineering projects mainly in the special problems that have to be considered during construction, transportation, installation, and operation. Pre-stressed concrete is the most recent of the major forms of the construction to be introduced into structural engineering, although several patents were taken out in the last century for various pre-stressing schemes they were unsuccessful because low strength steel was used and low productivity. The idea of pre-stressing or preloading is not new but in differs from conventional structural engineering projects mainly in the special problems that have to be considered during construction, transportation, installation, and fabrication. Through better utilization of available resources. **Encyclopaedia (2010)** a study carried out by **Alinaitive, Mwakali and Hansson (2007)** ranked incompetent supervision and lack of skills of the workers as the two most significant causes of low productivity of construction workers in developing countries. Similarly, **Odusami and Unoma (2011)** noted that the problems of low productivity can be directly linked to poor and inadequate training of construction skilled workers. Previous studies have identified various factors that affect labor productivity on construction sites. Therefore, this research aim was to find out the most significant factors affecting the productivity of a construction worker on a site and productivity of a qualified skilled worker at selected level per day, to analyses the relationship between working height and the productivity of worker on a construction site. **AbolfazlSherafat (2013)**, "Designed a Model for Measuring Manpower Productivity in the Project based Service Organizations", in the designed model, added-value is calculated so that all of the organizations outputs include current activities and also the investments that will be exploited in the future. As a result, the calculated value is overall reflects of the organizations performance and also manpower productivity is calculated actually. Since, manpower productivity is the ratio of added-value to the organizations manpower, it is possible to measure every units and employee's productivity through determining every their role by organizational excellence models in creating the added-value and then determining their role in the units added-value. The designed model is implemented in an organization with the mission of supplying and distributing the electricity energy and then every unit's productivity in this organization is calculated through this method. **XiaolongXue, (2008)**, Measuring the Productivity of the Construction Industry in China by Using DEA-Based. Data envelopment analysis _DEA_ measures the relative efficiency of decision-making units and avoids any functional. Specification to express production relationship between inputs and outputs. DEA-based Malmquist productivity index _MPI_ measures the Productivity change over time. In this paper, the MPI is used to measure the productivity changes of Chinese construction industry from1997 to 2003. The results of analyses indicate that productivity of the Chinese construction industry experienced a continuous improvement from 1997 to 2003 except for a decline from 2001 to 2002... It is found that there are gaps in productivity development level among western, midland, eastern, and northeastern regions in the Chinese construction industry. **JaideepMotwani Ashok Kumar Michael Novakoski (2000)**, Identifying and evaluating the factors which influence productivity are critical issues faced by construction managers. **Martin Loosemore, (2014), Improving construction Productivity: a subcontractor's perspective.** Study the relationship between subcontractors and contractors well and participation among them in the project phases to improve the productivity of construction, taking into consideration the subcontractors from project start to an end and providing data and full information for the project to subcontractors in a timely. **George (2009)**, identify factors for improving productivity on future construction projects. It was recommended for improving construction productivity are categorized and tabulated into 10 major areas, Tarekzayed **(2014)**, in this study a case productivity model for automatic climbing system he is observed that duration of activities is similar across floors except concrete pumping Time because it is a function of height. **Sherif Mohamed (2014)**, studied the thermal environmental effects on construction worker's productivity. **Polycarp OlakuAlumbugu (2014)**, studied analysis the relationship between working height and productivity of masonry worker on construction site by investigating two project sites. **Shah et al. (2014)**, studied analysis of factors influencing productivity in Central Gujarat Region of India, so it was identified and ranked the key factors affecting the project level productivity. **Ibrahim Mahamid (2013), Principal Factors Impacting Labor Productivity of Public Construction Projects in Palestine.** This study aims at identifying the factors negatively affecting labor productivity of public construction projects in the West Bank in Palestine from contractors' viewpoint, The results show that the poor labor productivity of public construction is mostly affected by the materials and equipment. **Osama Moselhi (2009),** studied an analysis of labour productivity of formwork operations in building construction. **Kazaz (2008),** studied the factors influencing construction labour productivity in Turkey. **Paul M Goodrum (2004),** this paper examines how changes in equipment technology have influenced labor productivity in the U.S. construction industry over a 22-year time period in three parts. **Makulsawatudom (2001),** presented factors affecting construction productivity, and their potential for improvement for labor productivity, to make a questionnaire survey. **Robert c Ford (2000),** this study conducted that the weather has an influence on the productivity of people at work system. **Seonghoon Kim (2015): Earthmoving Productivity in Urban Bridge Construction.** This research also identified significant factors for the truck bunching and showed that the match factor from the urban earthmoving project does not linearly correlate with the productivity of each truck. Reducing the hauling distance for urban earthmoving projects was the principal method for improving productivity. **AshwinMaru (2009), Construction of Bridge Decks with Pre-Cast, Pre-Stressed Concrete Deck Planks.** The case study is that of the bridge deck replacements that were carried out by the Illinois Department of transportation in 1999-2000. The bridge deck replacements were done by means of PPCs. The research also aims to find whether the bridge deck replacements that were carried out had early performance issues. It was established that there were indeed early performance issues, but these could be mitigated by means of load testing and the use of high-grade materials. **H Randolph (2003), Role of Workforce Management in Bridge super structure.** This paper describes the results of four case studies of high way bridges construction performed by established contractors with little bridge building experience, in which workforce management had a significant negative effect on a labor productivity. The contractor's lack of experience in bridge construction seemed to be the cause of several problems that plagued each of the four project. The baseline of productivity of each was calculated and the loss of labor efficiency was estimated to be 80, 75, 32 and 70% the schedule slippage on the four case study was estimated to be between 127 and 329%, **SBWijekoon (2002) EVALUATION OF LABOUR PRODUCTIVITY IN BRIDGE CONSTRUCTION PROJECTS**: The main objective of this study is to identify the factors influencing labour productivity in bridge construction projects; to compare actual labour productivity rates with estimated rates and to make recommendations for improving labour productivity in identified items in bridge construction project. **Seonghoonkin, yongBai (2013),** the main objectives of this paper is how to developing a model to enhance labor productivity using bridges construction by using many steps to developing in the bridges.

3. Research Method

The main eleven factors were tabulated into a questionnaire form affect labor productivity in the construction Pre-stressed bridges projects and then the draft questionnaire was discussed with three local experts in construction bridges owners, contractor and the consulting to evaluate the content of the questionnaire. Modifications and changes have been done. The questionnaire is divided into two main parts. Part I is related to the main factor that effect the productivity in Pre-stressed beams that includes the list of the identified factors, and Part II is related the sub main includes the list that explain the main factor factors.

50 contractors working on construction bridges projects were successfully questioned. The questionnaire gave each respondent an opportunity to identify factors that they perceived as likely to contribute to poor labor productivity by responding on a scale from 5 (very high) to 1 (not high). For each factor, the mean value of the respondents' importance rating was named the importance index. From calculating the important index we will calculate Frequency Index and Severity index.

The factors were taken from relevant literature, as well as from the authors' practical experience. The "importance index" was derived for each factor using the following formula (Lim and Alum, 1995):

$$\textbf{Important Index} = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5(n_5+n_4+n_3+n_2+n_1)}$$

Where n1 is the number of respondents who answered "strongly important", n2 the Number of respondents who answered "important", n3 the number of respondents who answered "neutral", n4 the number of respondents who answered "not important", and n5 the number of respondents who answered "strongly not important".

The respondents were then asked to rate the frequency of occurrence for each factor According to three ordinal scales: high (3), medium (2), or low (1). The "frequency Index" for each factor was derived from the following formula:

$$\textbf{Frequency Index} = \frac{3n_1+2n_2+1n_1}{3(n_3+n_2+n_1)}$$

Where n1 is the number of respondents who answered "high", n2 the number of respondents who answered "medium", and n3 the number of respondents who answered "low". Finally, an overall index, the multiplication of "importance index" by the "frequency index" was named the "severity index". The severity index was used to rank the Overall implication of each factor on labour productivity for residential projects.

"Severity index" = "Importance index" * "Frequency index"

The questionnaire in this research is based on the first to range the main factors after that we ranged the sub main includes the list that explain the main factors.

4. Results of the Arrangement the Main Factors of Project Delay on Labour Productivity

Type	Factors	Factors Effecting on Labor Productivity					Range of Groups
		n1	n2	n3	n4	n5	
		1	2	3	4	5	
The design	Slow response to questions with drawing	11	10	11	7	2	5
	the Structure system and the design of cables	8	13	10	7	3	
	Technical specifications are unclear	5	11	12	8	5	
	The difficulty of the design level	5	14	13	5	4	
	Poor design ability to build	7	8	14	5	7	
	the rework in Drawings	8	14	7	8	4	
	Errors in Drawings	9	12	12	4	4	
	slow response in the Shop Drawings and schedule time	7	11	9	6	8	
	Slow response to approved the drawing from the Competent authorities	7	6	20	5	3	
	Lack of graphics and workshop	15	7	9	5	5	

Type	Factors	Factors Effecting on Labor Productivity					Range of Groups
		n1	n2	n3	n4	n5	
		1	2	3	4	5	
	Lack of clarity of drawings and dimensions compared to nature	12	15	12	1	1	
The Equipment	Lack of equipment and lack of availability	8	17	8	5	3	3
	Lack of a crane for the prestressed beams	10	9	14	5	3	
	Available of cables and tools	12	12	7	6	4	
	Hardware crashes	12	16	7	3	3	
	Lack of maintenance of equipment permanently	7	13	9	7	5	
Execution and Construction	Change in schedule	6	11	16	4	4	2
	Delaying expropriation of the land on which the bridge is built	10	11	14	4	2	
	Delay in removing obstructions (electricity, cables and wires)	12	12	9	6	2	
	Construction technology (construction method, materials, equipment system)	11	9	13	4	4	
	Work interruption (design changes, etc.)	9	12	7	6	7	
External	Lack of communication between workers and engineers in a friendly manner	9	12	10	4	6	6
	Lack of protection from weather conditions	11	7	13	4	6	
	Climate conditions (temperature, humidity and floods)	8	10	13	5	5	
	Political issues and surrounding events such as expropriation	11	7	9	8	6	
Financial	Delay payment of dues	14	10	8	5	4	8
	Stimulate workers	6	11	12	6	6	
	Operating system work (daily pay, lump sum, etc.)	2	11	12	8	8	
Health and Safety	Lack of site safety resources	17	9	10	5	0	9
	The conflicting safety policies established by different supervisors	18	8	10	5	0	
	Lack of engineers and observers for safety and security	18	9	7	7	0	
	Services provided to workers (social insurance, medical care)	6	5	11	5	14	
	Work at heights	18	12	6	3	2	
Labors	Weakness of experience, skill and performance of labor (working class)	14	15	6	6	0	7
	Wrong behaviors by labor	6	8	17	7	3	
	Lack of skilled and specialized labor	24	12	4	1	0	
	There is no communication between the agent and the supervisor	9	10	10	5	7	
	The worker is not familiar with the daily specialized program	9	8	8	14	2	
	Employment misunderstanding of required changes	17	16	4	3	3	
	Share items in personal discussions	6	9	10	12	4	
	Delay in receipt from the supervisor of the worker	8	7	13	9	4	
	Laziness after waiting	8	8	11	14	0	
	Lack of rest time during the working day	7	10	11	10	3	
	Absence of the authority to discipline labour	8	13	11	4	5	
Leadership and Supervision	clarity of instructions and information exchange	10	9	13	6	3	4
	Management of subcontractors	7	15	5	8	6	
	Overbooking	16	11	8	6	0	
	Lack of proper administrative and administrative support	5	12	13	11	0	
	Different business rules by supervisors	14	11	9	5	2	
	Efficiency of supervision work	10	13	9	8	1	
	Decisions are slow	12	15	8	4	2	
	Notify him of errors when they occur	13	14	9	5		
	Unqualified managers	15	10	6	4	6	
	Additional work (after more than 4 hours of 8 hours / day)	12	11	6	6	6	
	The consultant and site staff are advised to work extra days on Fridays and public holidays	13	7	10	6	5	

Type	Factors	Factors Effecting on Labor Productivity					Range of Groups
		n1	n2	n3	n4	n5	
		1	2	3	4	5	
Material	Lack of materials and lack of inventory at the project site by purchasing department procurement department	23	16	2	0	0	1
	High prices of materials continuously	28	6	4	3	0	
	Availability of building materials and ease of circulation (existence of concrete mixer and asphalt)	18	17	0	6	0	
	The slow adoption of materials and lack of sufficient technical publication	17	15	7	2	0	
	The problem of coordination with suppliers	7	20	9	5	0	
Organization	Do not sequence work tasks	8	10	12	6	5	10
	Lack of allocation of appropriate resources	4	12	13	12	0	
	Lack of coordination between consultants (public and private)	26	9	3	1	2	
Project Factors	Project size	14	17	8	1	1	11
	Initial equipment of the project	15	11	8	5	2	
	Preparing the site for the bridge and its preliminary works	14	8	12	7	0	
	Type of management (individual or corporate)	3	13	12	7	6	
	Sign up for a large number of simultaneous work in many tasks	6	12	12	6	5	
	Traffic equipment	18	13	10	0	0	
	Poor supervision of operations	20	14	7	0	0	
	Slow response consultant	9	12	8	8	4	
	Slow adoption of both graphics and materials	21	13	7	0	0	
	Slow delivery and abstract work	23	12	6	0	0	

5. Results of the Arrangement the Sub Main Factors of Project Delay on Labour Productivity

1-Material Factors:

Factors	Importance Index	Frequency Index	Severity index
Lack of materials and lack of inventory at the project site by purchasing department procurement department	0.902439024	0.837398374	0.755700972
High prices of materials continuously	0.887804878	0.877192982	0.778776209
Availability of building materials and ease of circulation (existence of concrete mixer and asphalt)	0.829268293	0.838095238	0.695005807
The slow adoption of materials and lack of sufficient technical publication	0.829268293	0.752136752	0.62372316
The problem of coordination with suppliers	0.741463415	0.648148148	0.480578139

2-Execution and construction Factors:

Factors	Importance Index	Frequency Index	Severity index
Change in schedule	0.653658537	0.565656566	0.369746243
Delaying expropriation of the land on which the bridge is built	0.712195122	0.628571429	0.447665505
Delay in removing obstructions (electricity, cables and wires)	0.726829268	0.696969697	0.506577975
Construction technology (construction method, materials, equipment system)	0.692682927	0.646464646	0.447795023
Work interruption (design changes,...... etc)	0.648780488	0.69047619	0.44796748

3-Equipment Factors:

Factors	Importance Index	Frequency Index	Severity index
Lack of equipment and lack of availability	0.707317073	0.666666667	0.471544715
Lack of a crane for the Pre-stressed beams	0.687804878	0.626262626	0.430746489
Available of cables and tools	0.707317073	0.720430108	0.509572515
Hardware crashes	0.751219512	0.714285714	0.536585366
Lack of maintenance of equipment permanently	0.648780488	0.643678161	0.417605831

4-Design Factors:

Factors	Importance Index	Frequency Index	Severity index
Slow response to questions with drawing	0.702439	0.666667	0.468293
the Structure system and the design of cables	0.678049	0.645161	0.437451
Technical specifications are unclear	0.614634	0.583333	0.358537
The difficulty of the design level	0.653659	0.583333	0.381301
Poor design ability to build	0.614634	0.586207	0.360303
the rework in Drawings	0.668293	0.678161	0.45321
Errors in Drawings	0.687805	0.636364	0.437694
slow response in the Shop Drawings and schedule time	0.614634	0.641975	0.39458
Slow response to approved the drawing from the Competent authorities	0.643902	0.535354	0.344715
Lack of graphics and workshop	0.707317	0.731183	0.517178
Lack of clarity of drawings and dimensions compared to nature	0.77561	0.666667	0.517073

5-External Factors:

Factors	Importance Index	Frequency Index	Severity index
Lack of communication between workers and engineers in a friendly manner	0.668292683	0.655913978	0.438342512
Lack of protection from weather conditions	0.663414634	0.64516129	0.428009441
Climate conditions (temperature, humidity and floods)	0.653658537	0.612903226	0.400629426
Political issues and surrounding events such as expropriation	0.643902439	0.691358025	0.445167118

6-Labors Factors:

Factors	Importance Index	Frequency Index	Severity index
Weakness of experience, skill and performance of labor (working class)	0.780487805	0.742857143	0.579790941
Wrong behaviors by labour	0.634146341	0.548387097	0.347757671
Lack of skilled and specialized labor	0.887804878	0.833333333	0.739837398
There is no communication between the agent and the supervisor	0.643902439	0.655172414	0.421867115
The worker is not familiar with the daily specialized program	0.63902439	0.68	0.434536585
Employment misunderstanding of required changes	0.790697674	0.783783784	0.619736015
Share items in personal discussions	0.604878049	0.613333333	0.37099187
Delay in receipt from the supervisor of the worker	0.629268293	0.607142857	0.382055749
Laziness after waiting	0.648780488	0.62962963	0.408491418
Lack of rest time during the working day	0.63902439	0.619047619	0.395586527
Absence of the authority to discipline labor	0.673170732	0.635416667	0.427743902

7-Financial Factors:

Factors	Importance Index	Frequency Index	Severity index
Delay payment of dues	0.72195122	0.729166667	0.526422764
Operating system work (daily pay, lump sum, etc.)	0.556097561	0.533333333	0.296585366
Stimulate workers	0.624390244	0.597701149	0.373198766

8-Health and Safety Factors:

Factors	Importance Index	Frequency Index	Severity index
Lack of site safety resources	0.785365854	0.731481481	0.574480578
The conflicting safety policies established by different supervisors	0.790243902	0.740740741	0.585365854
Lack of engineers and observers for safety and security	0.785365854	0.774509804	0.608273553
Services provided to workers (social insurance, medical care)	0.52195122	0.590909091	0.308425721
Work at heights	0.8	0.777777778	0.622222222

9-Organization Factors:

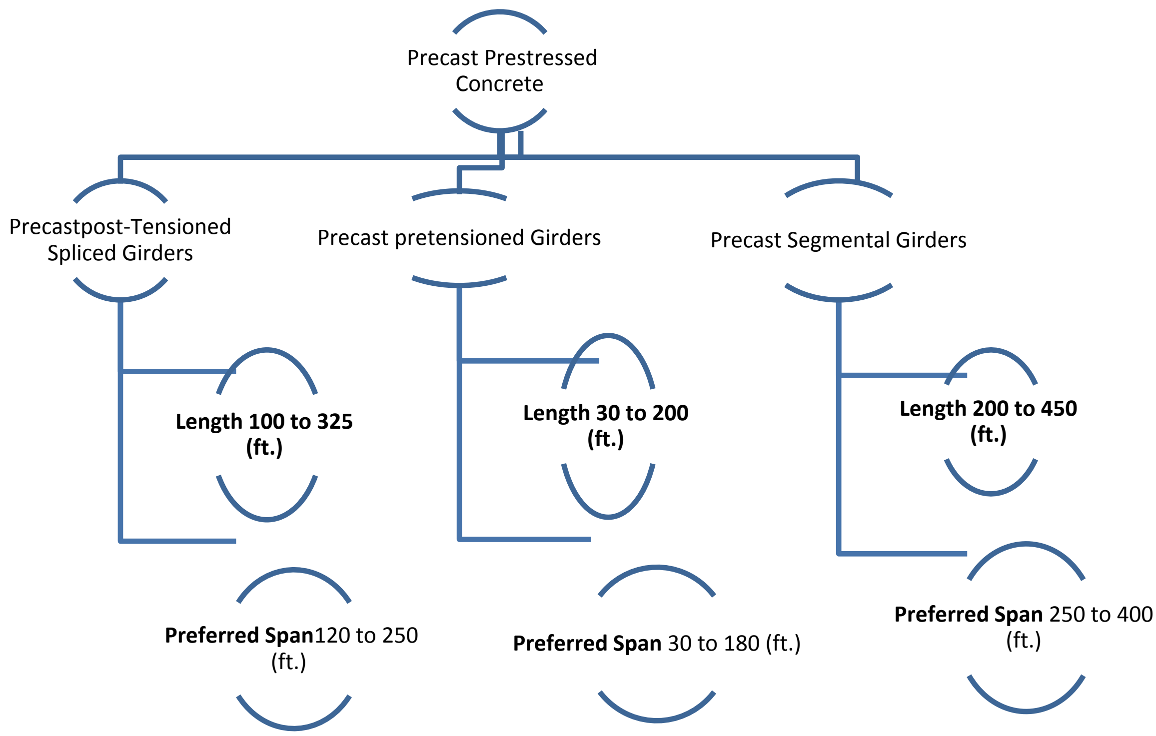
Factors	Importance Index	Frequency Index	Severity index
Project size	0.804878049	0.717948718	0.577861163
Initial equipment of the project	0.756097561	0.735294118	0.555954089
Preparing the site for the bridge and its preliminary works	0.741463415	0.68627451	0.508847441

10-Project Factors:

Factors	Importance Index	Frequency Index	Severity index
Project size	0.804878049	0.717948718	0.577861163
Initial equipment of the project	0.756097561	0.735294118	0.555954089
Preparing the site for the bridge and its preliminary works	0.741463415	0.68627451	0.508847441
Type of management (individual or corporate)	0.6	0.55952381	0.335714286
Sign up for a large number of simultaneous work in many tasks	0.63902439	0.6	0.383414634
Traffic equipment	0.83902439	0.731707317	0.613920286
Poor supervision of operations	0.863414634	0.772357724	0.666864961
Slow response consultant	0.668292683	0.67816092	0.45320998
Slow adoption of both graphics and materials	0.868292683	0.780487805	0.67769185

6. Typical Sections and Span Ranges

Prestressing systems have developed over the years the prestressing members classified into for three types of prestressing systems. There are three main PC bridge types, Precast Bridge Types and Span Lengths (Caltrans, 2012) Bridge:



The selection among these three bridge types is normally decided by span length (ft), pretensioned girder could be designed to span from 20 ft. to 200 ft. trucking length, crane capacity, and transporting routes may limit the girder length (and weight) that could be delivered. Therefore, a girder may need to be manufactured in two or more segments and shipped before being spliced together on-site to its full span length. Such splicing techniques can be applied by using post-tensioning systems for both single-span and multiple-span bridges, which span up to 325.

Prestressed Concrete girder types, including four standard California girders (I, bulb-tee, bath-tub, and wide-flange) and the California voided slab, as well as three other PC girders (box, delta, and double-tee).

Basic Concepts:

The Post tension system tension is one of methods of prestressing concrete and applied to the tendons after hardening of the concrete. The concrete members are cast first. Then after the concrete has gained sufficient strength, tendons (strands of high strength steel wire) are inserted into preformed has ducts and tensioned to induce compressive stresses in the expected tensile stress regions of the member. Concrete must be free to shorten under the precompression. The strands are then anchored and a corrosion protection such as grout or grease, is installed (Gerwick, 1997).

Stage of post tension system:

1) Casting of concrete 2) Placement of the tendons 3) Placement of the anchorage block and jack 4) Applying tension to the tendons 5) Seating of the wedges 6) Cutting of the tendons after anchoring a tendon at one end, the tension is applied at the other end by a jack. The tensioning of tendons and precompression of concrete occur simultaneously. A system of self-equilibrating forces develops after the stretching of the tendons. The simplest multi-span precast spliced girder system includes consideration of a minimum of four stages or steps after fabrication and before service loads, as follows:

1- **Transportation:** The girder acts as a simply supported beam, with supports defined by the locations used by the trucking company. Typically, the manufacturer or trucking company is responsible for design and check of loads, stability, and bracing during transportation and erection of the girder.

2- **Erection:** The girder initially acts as a simply supported beam, with supports defined by the abutments, bents or temporary falsework locations. A CIP closure pour is placed after coupling of PT tendons and reinforcing bars in the splice joint. Optionally, a first stage of posttensioning may be applied before the deck pour instead of after the deck pour.

3- **Deck pour:** The deck is poured but not composite with the girders until attaining full strength. Therefore, the girders alone carry girder selfweight and the wet deck weight.-Post-tensioning: The hardened deck and girder act compositely, and the girders are spliced together longitudinally using post-tensioning. As the number of girders that are spliced and the stages of post-tensioning increases, so does the complexity of design.

4- **Grouting**: can be defined as the filling of duct, with a material that provides an anti-corrosive alkaline environment to the prestressing steel and also a strong bond between the tendon and the surrounding grout.

7. The Relative Advantages of Post-tensioning as Compared to Pre-Tensioning are

1) Post-tensioning is suitable for heavy cast-in-place members.
2) The waiting period in the casting bed is less.
3) The transfer of prestressed is independent of transmission length.

8. Disadvantage of Post-tensioning as Compared to Pre-Tensioning is the Requirement of Anchorage Device and Grouting Equipment

Casting bed & prepare the formwork beams (Reference: sample 30june bridges)

Prepare the formwork beams (Reference: sample 30june bridges)

Prepare the steel works prestressed beams (sample 30june bridges & shoubra bnha)

Prepare the steel works prestressed beams (sample shoubra bnha 22+400 bridge)

Grouting equipment:

-Transportation:

Erection beams:

The following photographs show some steps in the manufacturing of a post-tensioned & pre-tension I-girder for a bridge 30 June Bridge and shoubra Bnha Bridges.

9. Factors Affecting Construction Labour Productivity in the Method of Statement for Construction of Pre-stressed Concrete Bridges

- Design and Approve Shop Drawings

Shop drawings are an essential part of the manufacturing process of prestressed beams. They should be submitted to the builder for checking and approval prior to casting any concrete. The builder may be required to or prefer to submit shop drawings to the designer for approval or review.

The standard convention for precast shop drawings is that each element is drawn the way the production workers will view the mould. Nonstandard finishes and special lifting and handling procedures must be clearly noted on the drawings.

Shop drawings may include an erection layout drawing and should note the requirements for special handling and propping where this is part of the precast concrete design, but will not necessarily detail the temporary propping and bracing.

The builder must co-ordinate between the precast manufacturer and the erection subcontractor to determine the requirements for propping, bracing and special lifting procedures.

- Propping and Support Details

Props are required for a variety of reasons to:

- Reduce the self-weight deflection of precast flooring systems while the cast-in-place topping concrete is placed and cured;
- Provide temporary gravity load support during construction. For example, where seating lengths are less than the specified minimum, or where the connection requires cast-in-place concrete or welding to provide permanent support;
- Resist wind loads and accidental side loads during erection;
- Prevent torsional instability or rotation of beams loaded along one edge;
- Provide fine adjustment of the precast element to the

correct level while freeing the crane quickly for the next lift; and
- Support temporary construction loads that exceed the design capacity of any part of the structure.

Where the element requires propping, that requirement should be noted on the shop drawings.

Support details for precast elements include temporary shims, rubber or plastic bearing pads, levelling bolts or mortar pads.

Direct concrete to concrete, or concrete to steel bearing should be avoided unless some edge spalling and cracking is acceptable.

Precast floors exposed to the sun (for example the top levels of caparking buildings) require special consideration as the long term effects of thermally induced movements can cause severe spalling at the support.

Permanent grouting or mortar packing of precast concrete support points requires care and supervision to ensure that the requirements for strength and durability are met.

- Lifting and Handling Stresses

Allowable lifting and handling stresses will be determined by the degree to which cracking can be tolerated. Units will either be designed to be handled with no visible cracks, or to be handled in a manner that restricts the crack widths to acceptable limits for the environment that the unit will be exposed to in service.

Lifting and handling concrete flexural stress calculations may assume an impact allowance of 50% for transport and handling. For precast units that must be transported over rough terrain, an additional impact factor should be allowed.

- Capacity of Lifting Inserts

Lifting inserts may often be required to carry more load than is apparent.

Increased loads can result from:

- The angle of lifting chains or slings;
- Impact or inertia forces;
- Unequal sling lengths, where there are more than two slings (even relatively minor variations in length can be significant);
- Suction or mould friction
- Mispositioning of anchors.

Unless special means are taken to equalise loads it is safer to assume that only two lifting inserts will be carrying the load.

- Location of Lifting Inserts and Tolerances

The position of lifting inserts are calculated to limit lifting stresses and to ensure that the precast element hangs in the correct orientation during lifting from the mould and while it is lifted into its final position.

Tolerances on the location of lifting inserts for typical precast elements.

- Stability and Buckling

Some precast elements, such as long slender bridge beams and thin wall panels, may buckle if handled or transported incorrectly. Where the designer is aware of this possibility, it should be clearly noted on the contract drawings.

The manufacturer should also check the potential for lateral instability taking into account tilting due to road camber, additional axial loads due to lifting sling angles, and wind forces on the element during erection.

10. Recommendations

The results of the survey indicated the top important, frequent and severe factors in bridges that are adversely affecting construction labor productivity in prestressed beams bridges.

This would affect the workers' motivation and productivity in bridges. Mentioned below are the recommendations which were found to be important factors for improving the crew productivity for the Construction of prestressed beams in bridge project: This study is one of the few that has been done in the area of crew productivity for the Construction of beams in bridges projects. This study is conducted to achieve the following objectives.

- To identify the factors affecting the variation of labour productivity in the construction and design PC in bridges & to assess the impact of influenced factors on the variation of labour productivity in bridges.

- To suggest recommendations in order to reduce variation of labour productivity in the construction of prestressed breams bridges. It is hoped that future studies will improve on the techniques used in this study, while taking into consideration the difficulties encountered in this study.

Finally, this research provides a basis for future work in for improving the crew productivity for the construction precast prestressed in bridges, given the numerous factors affecting crew productivity. It is hoped that future studies will improve on the techniques used in this study, while taking into consideration the difficulties encountered in this study.

11. Conclusions

The Egyptian construction bridges experiences time and cost overrun due to various project delay factors that affect construction labor productivity in the main and sub main factors. This paper has identified and ranked those factors that affect construction labor productivity. Results indicated that the eleven most important factors that affect labor in prestressed beams, they are as follows ranged by important to compare resultd with the proposed patterns geometrically such MATLAB:

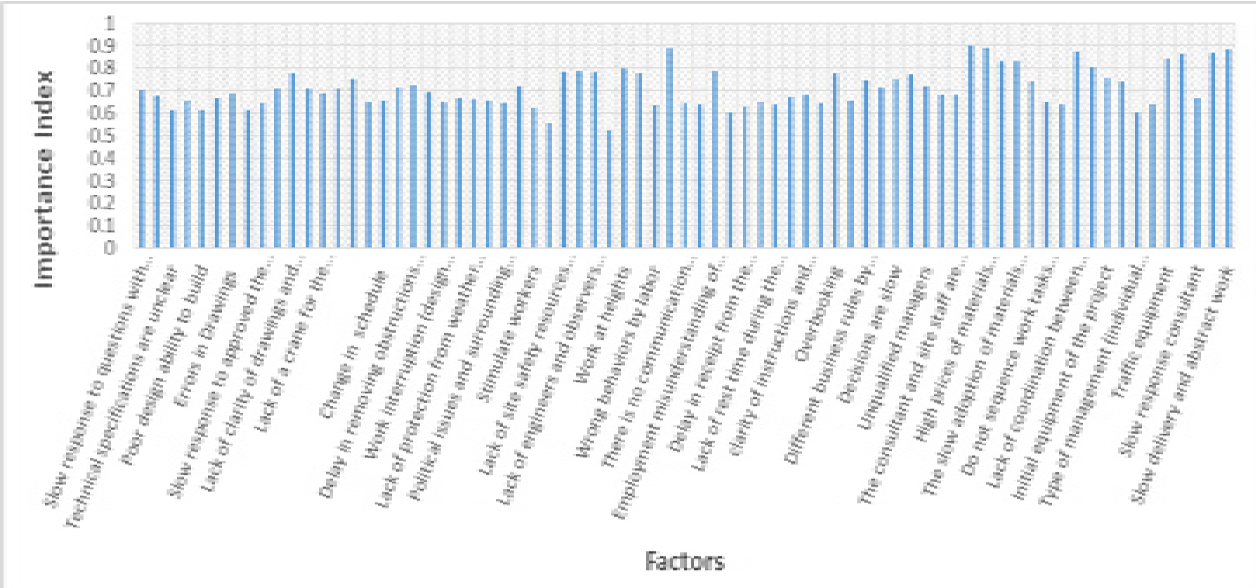
1. Material Factors
2. Execution and construction Factors
3. Equipment Factors
4. Leadership and supervision Factors
5. Design Factors
6. External Factors
7. Labors Factors

8. Financial Factors
9. Health and Safety Factors
10. Organization Factors
11. Project Factors

Finally, the most severe project delay factors are listed below ranged by the important index from all factors:

Factors	Importance Index	Rank
Lack of materials and lack of inventory at the project site by purchasing department procurement department	0.902439024	1
Lack of skilled and specialized labour	0.887804878	2
High prices of materials continuously	0.887804878	3
Slow delivery and abstract work	0.882926829	4
Lack of coordination between consultants (public and private)	0.873170732	5
Slow adoption of both graphics and materials	0.868292683	6
Poor supervision of operations	0.863414634	7
Traffic equipment	0.83902439	8
Availability of building materials and ease of circulation (existence of concrete mixer and asphalt)	0.829268293	9
The slow adoption of materials and lack of sufficient technical publication	0.829268293	10
Project size	0.804878049	11
Work at heights	0.8	12
Employment misunderstanding of required changes	0.790697674	13
The conflicting safety policies established by different supervisors	0.790243902	14
Lack of site safety resources	0.785365854	15
Lack of engineers and observers for safety and security	0.785365854	16
Weakness of experience, skill and performance of labour (working class)	0.780487805	17
Overbooking	0.780487805	18
Lack of clarity of drawings and dimensions compared to nature	0.775609756	19
Notify him of errors when they occur	0.770731707	20
Initial equipment of the project	0.756097561	21
Hardware crashes	0.751219512	22
Decisions are slow	0.751219512	23
Different business rules by supervisors	0.746341463	24
The problem of coordination with suppliers	0.741463415	25
Preparing the site for the bridge and its preliminary works	0.741463415	26
Delay in removing obstructions (electricity, cables and wires)	0.726829268	27
Delay payment of dues	0.72195122	28
Unqualified managers	0.717073171	29
Delaying expropriation of the land on which the bridge is built	0.712195122	30
Efficiency of supervision work	0.712195122	31
Lack of graphics and workshop	0.707317073	32
Lack of equipment and lack of availability	0.707317073	33
Available of cables and tools	0.707317073	34
Slow response to questions with drawing	0.702439024	35
Construction technology (construction method, materials, equipment system)	0.692682927	36
Errors in Drawings	0.687804878	37
Lack of a crane for the prestressed beams	0.687804878	38
clarity of instructions and information exchange	0.682926829	39
Additional work (after more than 4 hours of 8 hours / day)	0.682926829	40
The consultant and site staff are advised to work extra days on Fridays and public holidays	0.682926829	41

the Structure system and the design of cables	0.67804878	42
Absence of the authority to discipline labor	0.673170732	43
the rework in Drawings	0.668292683	44
Lack of communication between workers and engineers in a friendly manner	0.668292683	45
Slow response consultant	0.668292683	46
Lack of protection from weather conditions	0.663414634	47
The difficulty of the design level	0.653658537	48
Change in schedule	0.653658537	49
Climate conditions (temperature, humidity and floods)	0.653658537	50
Lack of proper administrative and administrative support	0.653658537	51
Lack of maintenance of equipment permanently	0.648780488	52
Work interruption (design changes, etc.)	0.648780488	53
Laziness after waiting	0.648780488	54
Do not sequence work tasks	0.648780488	55
Slow response to approved the drawing from the Competent authorities	0.643902439	56
Political issues and surrounding events such as expropriation	0.643902439	57
There is no communication between the agent and the supervisor	0.643902439	58
Management of subcontractors	0.643902439	59
The worker is not familiar with the daily specialized program	0.63902439	60
Lack of rest time during the working day	0.63902439	61
Lack of allocation of appropriate resources	0.63902439	62
Sign up for a large number of simultaneous work in many tasks	0.63902439	63
Wrong behaviors by labour	0.634146341	64
Delay in receipt from the supervisor of the worker	0.629268293	65
Stimulate workers	0.624390244	66
Technical specifications are unclear	0.614634146	67
Poor design ability to build	0.614634146	68
slow response in the Shop Drawings and schedule time	0.614634146	69
Share items in personal discussions	0.604878049	70
Type of management (individual or corporate)	0.6	71
Available amount of daily work (workload)	0.595121951	72
Work injuries and accidents	0.595121951	73
The initial delivery specified by the owner	0.590243902	74
The rate of the daily allowance varies	0.585365854	75
Incentive Programs	0.580487805	76
Project specifications (public and private)	0.575609756	77
Personal problems that lead to delay	0.575609756	78
Late work permits	0.556097561	79
Operating system work (daily pay, lump sum, etc.)	0.556097561	80
Lack of awareness programs for security and safety (guidance)	0.551219512	81
Physical exhaustion	0.541463415	82
Staff size and configuration	0.541463415	83
Distance between location and cities	0.531707317	84
Political competitions / performance within the company	0.526829268	85
Services provided to workers (social insurance, medical care)	0.52195122	86



It was concluded that the most important in prestressed concrete beams, frequent and severe factors were related to the availability of all this factors in site. This result was substantiated by studies carried out in Egypt out 12 bridges in construction. By acknowledging the project delay factors that cause low construction labour productivity, project managers can address the problems at an early stage, thus minimizing time and cost.

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