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Designing a Model for Measuring and Evaluation Crew Productivity for the Construction of Steel Structure Projects

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ABSTRACT

Factors influencing the crew productivity of construction of steel structure projects were identified which serves as the basis and reference point for implementing productivity model and productivity improvement. The main purpose of this paper is to present a methodology for model on Matlab in measuring and evaluation the crew productivity for construction process of steel structure based on the several factors that affect the steel structure process.The research was conducted by Personal interviews, Literature Review, Researchers' knowledge, telephone calls and correspondence via an Email. The factors included in the model in this study were determined by the availability of data for each factor, because the data published in 12 researchers, were used in this study. The data do not cover all the possible factors affecting the crew productivity of construction of steel structure projects since it would be difficult to consider all the possible factors affecting construction of steel structure projects in the model. Using model on Matlab for measuring and evaluation the crew productivity of construction of steel structure projects based on the several factors that affect the steel structure process. The construction industry can use the findings in this paper as a basis for improving the crew productivity for the construction of Steel Structure projects. The ability of the estimating team to accurately determine crew productivity for different activities will have a significant impact on the crew cost component, time schedule of a project and improve projects' performance, due to the use of the models is expected to result in savings in cost and time schedule of construction of steel structure projects and savings in the cost of the overall project. This study is one of the few that has been done in the area of crew productivity for the construction of steel structure projects modeling using Matlab.

KEYWORDS : Productivity, Steel Structures, Projects performance, Matlab Model, Construction Productivity, Crew Productivity, Measuring Productivity.

Introduction

Pre-construction process

Design is the starting point in any project, the integration between the design and construction phases will result in greater crew productivity as construction considerations are taken into account at the design stage. Designers of steel structures should be aware not only with design process requirements for the structures but also with fabrication and erection methods to ensure that a steel Structure design can be safely, economically and reliably executed (fabricated, assembled and erected),these may determine whether adesign is practical and cost efficient **(design for construction)**(Fig.1), (Fig.2), (Fig.3) and (Fig.4).

There are two separate phases of design:-
1-Structural design
2-Design for erection

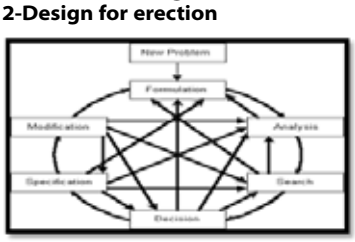


Fig. (1) Design Process

Fig (2) Connection detail for column

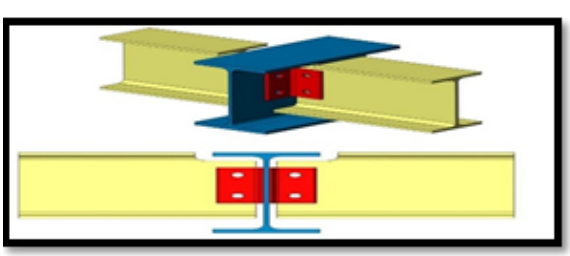


Fig (3) Connection detail for beams

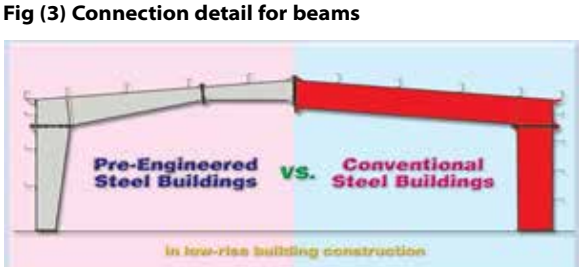


Fig (4) Types of designs Rafter

Fabrication is the process used to manufacture steel structures components that will, when assembled and joined, form a complete frame. The frame generally uses readily available standard sections that are purchased from the steelmaker or steel stockholder, together with such items as protective coatings and bolts from other specialist suppliers (Table 1)

The principal activities at the fabrication works are:

- Accuracy
- Handling and transportation
- Shortage materials
- Damaged or defective material

- Delivery priority
- Schedule time for fabrication.

	Welding	Bolting
Advantages	•Eliminates need for punching or drilling. •Simplifies complicated joints.	•Easy method of connecting members on the site. •Field-bolting is cheaper than field-welding.
Disadvantages	• Greater level of skill required • More expensive than bolting. • Weld inspection is required and is expensive.	•Requires drilling or punching through all plies.

Table (1) Comparison between welding and bolting

- During construction process
- Planning
- Equipment & Tools and technology
- Method statement of construction
- Training,
- A dependable supervisors
- Material handling
- Construction Health, Safety, Security and Environmental
- Incentives & On-site services
- Quality
- Avoid extended overtime
- Time & Weather
- Reporting
- Assembly Process
- Literature Review

Although Steel structural projects is a relatively special field of construction projects which is concerned with the design and installation of different project elements according to various purposes. Improve productivity leads to saving a lot of time and costs in the steel structure projects, but the most discussed at this point did not pay attention to improving crew as a whole, but research in general about the productivity in construction projects only and some of them discussed the improvement of labor productivity only, despite the fact that Crew in this type of project labor is less expensive than the equipment and tools, and these projects depend mainly on the equipment and tools in addition to the labors. Studying of factors that affecting on Productivity for 60 researches (Fig. 5).

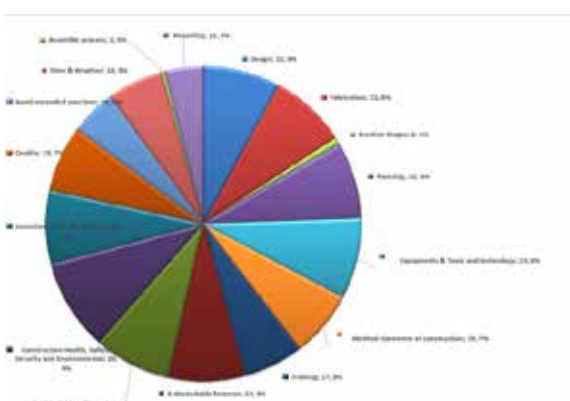


Fig. 5: Detailing for studying of factors that affecting on Productivity for 60 researches

Meet P. Shah et al. (2014), studied analysis of Factors Influencing Productivity in Central Gujarat Region of India, so he identified and ranked the key factors affecting the project level productivity. The data was collected to determine the most influential factors on productivity of the project was done through a survey by explorative questionnaire to the respondents who are involved in the management of projects in various regions in the central Gujarat region of India.**Abu Bakar Muzamil et al. (2014),** studied that analysis of Labour Productivity of Road Construction in Pakistan, carried out to identify the critical factors which are responsible for poor labor productivity of road construction in Pakistan by questionnaire based survey, concluded that the basic needs of laborers must be fulfilled initially to expect good output results from them, and recommended that should be adopted addressing the critical issues of road construction to produce remarkable figures in construction industry of Pakistan competing with construction industries ofother developing countries.**Mostafa E. Shehata et al. (2012),** was studied improving construction labor productivity and projects' performance, It covers the construction labor productivity definitions, aspects, measurements, factors affecting it, different techniques used for measuring it and modeling techniques,and provided a guide for necessary steps required to improve construction labor productivity and consequently, the project performance.**Hee-Sung Park (2005),** was established a common set of construction productivity metrics and their corresponding definitions. As a result of this research effort, the Construction Productivity Metrics System, which contain a list of direct and indirect accounts and data elements grouped into seven major categories, was developed. **Javier Irizarry (2005),** was studying that included direct observation of steel erection activities and statistical analysis of task duration data.**Xiaolong Xue (2008),** was used the MPI to measure the productivity changes of Chinese construction industry from 1997 to 2003 and resulted 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.**Lingguang Song (2008),** was presented an approach to measuring productivity, collecting historical data, and developing productivity models using historical data and applied it to model steel drafting and fabrication productivities.**William Ibbs (2005),** was reported that reaffirms that project change is disruptive and detrimental to labor productivity. **Awad S. Hanna, P.E. (2005),** was presented an analysis of the impacts of extended duration overtime on construction labor productivity. And showed a decrease in productivity as the number of hours worked per week increase and/or as project duration increases. **Paul et al. (2004),** was studying the impact of Equipment Technology on Labor Productivity in the U.S. Construction Industry. **Lu (2001),** observed that it is difficult to create a conventional analytical model that incorporates the impacts of numerous factors on productivity. **Lu et al. (2000),** noted that when the estimator determines industrial productivity, he or she usually over-estimate or under-estimate labor rates (man-hours per unit quantity). This is done by using a difficulty multiplier to indicate overall favorable or unfavorable conditions. **Ayodele Olugbenga (2002),** studying predicting Industrial Construction Productivity Using Fuzzy Expert Systems and the existing labor productivity models are classified into two categories, namely: Neural Network Productivity Models, and Other Productivity Models. **Rateb J. Sweis (2009),** proposed a methodology to model the variability of masonry labor productivity. **Sandbhor et al. (2014),** studying Applying total interpretive structural modeling to study factors affecting construction labor productivity, Total interpretive structural modeling (TISM) is implemented as a methodology for identifying and summarizing relationships among factors which affect productivity of labor. **Moheeb Abed Abu Alqumboz (2007),** "developing a Model for Integrating Safety, Quality and Productivity in Building Projects in Gaza Strip" and reporting that Productivity measurement does not have one type of measurement. There are many techniques used in measuring productivity according to the nature of the construction projects.

Modification for Steel erection process model (Javier Irizarry, 2005) (Fig. 6)

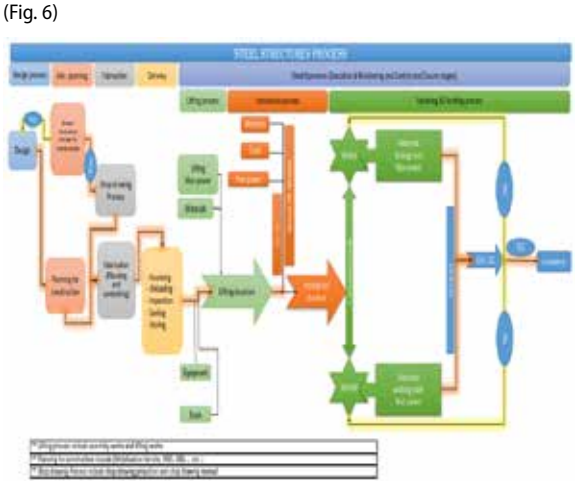


Fig. 6: Modification for Steel erection process model (Javier Irizarry, 2005)

Data collection:-
Relative Importance Index (RII) is a commonly used method in construction to obtain priority rankings of attributes. The mean item score for each factor within groups is calculated to obtain the relative importance index as follows (Odusami, 2002; Kumaraswamy and Chan, 1996; Chinyio et al, 1997; Cheung, 2000; and Tam et al, 2000):

The data collection process used in this research had the option of basic methods: **Personal interviews, Literature Review, Researchers' knowledge, telephone calls and Correspondence via an Email**. Data was collected from **literature reviews** from books, journals, articles, seminar conferences, and websites which emphasize construction productivity for 14 factors, and it was collected from **Personal interviews** for assemble process which were identified Rii (a_{15}) for the assembly process valued 0.7

Steps of Model measure and evaluate crew Productivity (Fig. 7):-

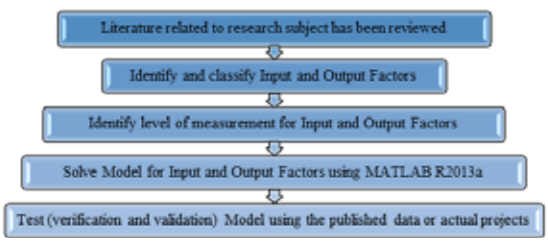
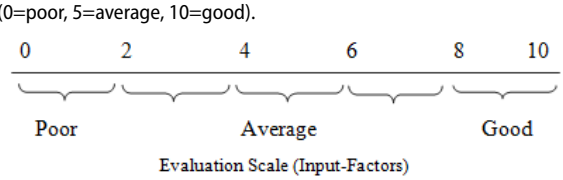


Fig. 7: Steps of Model measure and evaluate crew Productivity

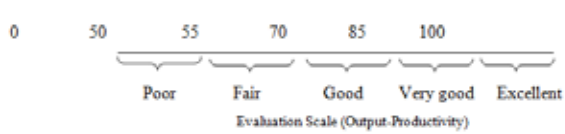
Defining the Factors Affecting crew productivity and resulting model
- Input factors:-
- Design;
- Fabrication;
- Planning;
- Equipment & Tolls and technology;
- Method statement of construction;
- Training;
- A dependable supervisors;
- Material handling;
- Construction Health, Safety, Security and Environmental;
- Incentives & On-site services;
- Quality;
- Avoid extended overtimes;
- Time & Weather;
- Assemble process; and,
- Reporting

Output factors:-
- Productivity (Measuring, Evaluation and recommendations for crew productivity)

Level of measurement:-
Level of measurement for Input
According to Ayodele Olugbenga (2002), numerical values or subjective values (on a scale of zero to 10) such as 0 to 10 descriptors (0=poor, 5=average, 10=good).



Level of measurement for Output
(Poor - Fair - Good - Very good - Excellent)



2.4 Model Formulation: -
The model can be summarized in the following:

$$Y = (0.725 \times X_1 + 0.738 \times X_2 + 0.715 \times X_3 + 0.636 \times X_4 + 0.682 \times X_5 + 0.633 \times X_6 + 0.717 \times X_7 + 0.723 \times X_8 + 0.618 \times X_9 + 0.611 \times X_{10} + 0.764 \times X_{11} + 0.625 \times X_{12} + 0.711 \times X_{13} + 0.7 \times X_{14} + 0.7 \times X_{15}) \times \left(\frac{100}{103}\right)$$

Such that;

$Y \equiv$ Productivity, $100 \equiv$ The expected result of score of Productivity,
$X_1 \equiv$ Design, $X_2 \equiv$ Fabrication, $X_3 \equiv$ Planning,
$X_4 \equiv$ Equipments & *Tools and technology*,
$X_5 \equiv$ Method statement of construction, $X_6 \equiv$ Training,
$X_7 \equiv$ A dependable supervisors , $X_8 \equiv$ Material handling,
$X_9 \equiv$ Construction Health, Safety, Security and Environmental,
$X_{10} \equiv$ Incentives & *On – site services*, $X_{11} \equiv$ Quality,
$X_{12} \equiv$ Avoid extended overtime, $X_{13} \equiv$ Time & *Weather*,
$X_{14} \equiv$ Reporting and $X_{15} \equiv$ Assemble process .

2.5 Model verification and validation
The model was verified through testing on three Construction of Steel Structure projects. The results show that it is easy to use and useful as a tool for measuring and evaluation the crew productivity of Construction of Steel Structure projects (Fig. 8) show resulting of Matlab applying Project, (Fig. 9) show resulting of factors values for crew productivity and (Fig. 10) show resulting of percentage of factors.

```
please Input design valu = 6
please Input Fabrication valu = 7
please Input planning valu = 6
please Input Equipment & Tolls and technology valu = 5
please Input Method statement of construction valu = 6
please Input Training valu = 5
please Input A dependable supervisors valu = 6
please Input Material handling valu = 7
please Input Construction Health, Safety, Security and Environmental valu = 8
please Input Incentives & On-site services valu = 9
please Input Quality valu = 8
please Input Avoid extended overtimes valu = 7
please Input Time & Weather valu = 9
please Input Reporting valu = 6
please Input Assemble process valu = 5
Y =
   66.0359
Evaluation =
Good
Recommendations : To improve your crew productivity you shouldbe improve:
design
Fabrication
planning
Equipment & Tolls and technology
Method statement of construction
Training
A dependable supervisors
Material handling
Avoid extended overtimes
Reporting
Assemble process
Please input average weight value = 15
The expect weight after improving crew productivity (EW):
EW =
   22.5104
```

Fig. (8) Resulting of Matlab applying Project

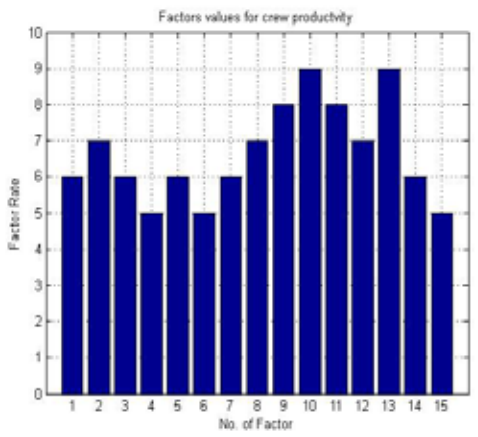


Fig. (9) Factors values for crew productivity

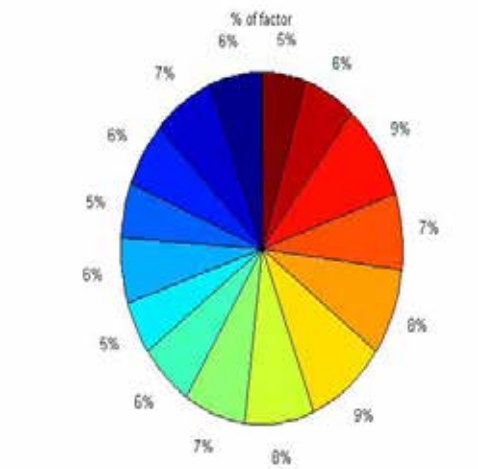


Fig. (10) Percentage of factors

Conclusion

In today's world, the construction industry especially the construction of steel structure projects is rated as one of the key industry. The basic ideas of the research is to study improving the crew productivity for the construction of steel structure projects. Using modelon Matlab for measuring and evaluation the crew productivity of construction of steel structure projectsbased on the several factors that affect the steel structure process, the model was verified through testing on three Construction of Steel Structure projects. The results show that it is easy to use and useful as a tool for measuring and evaluation the crew productivity of Construction of Steel Structure projects.Using these techniques to model objective and subjective data that were extracted from an actual crew productivity study. Since the data collected in the crew productivity study represent the type of data that would be available within organizations, this research demonstrates how such data can be used for improving, measuring and evaluation the crew productivity of construction of steel structure projects for construction process of steel structure based on the several factors that affect the steel structure process. These factors can be costly and time consuming if the work has been done. Work sequences can also be affected due to rework.

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