Industrial Engineering & Management
ISSN: 2169-0316

Rashid et al., Ind Eng Manage 2016, 5:4
DOI: 10.4172/2169-0316.1000201

Research Article Open Access

Construction Performance Control in Steel Structures Projects

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Abstract

Steel structural projects are relatively special field of construction projects. The steel structure projects differ from conventional structural engineering projects mainly in the special problems that have to be considered during construction, transportation, installation and operation. The productivity improvements are attributed to the technology advances in equipment and construction methods over the last two decades. Steel structural projects are a relatively special field of construction projects. There are many factors that impact on productivity in this field. The construction industry especially the construction of steel structure projects is rated as one of the key industries. It helps in developing and achieving the goal of society. Study and knowledge of construction productivity are very important because they influence the economics of the construction industry; this is because prior knowledge of crew productivity during construction can save money and time. Investments for these projects are very high and because of the complexity in construction of steel structure projects, various factors can highly affect overall productivity, thus the project can end up adding even more time and money in order to be completed. The main purpose of this paper is present a methodology for modeling on Mat lab to construction performance control for construction process of steel structure based on the several factors that affect the steel structure processes. The Mat lab model is used for controlling on construction productivity of steel structure projects. The construction industry may use the findings of this paper as a basis for controlling and improving productivity and construction performance for the construction of steel structure projects. The ability of the estimating team to accurately determine productivity for different activities will have a significant impact on crew cost component, time schedule of the project and improve projects' performance. The use of the Mat lab model is expected to result in savings in cost and time schedule of construction of steel structure projects as well as savings in the cost of the overall project.

Keywords: Steel structures; Control; Projects Performance; Mat lab model; Productivity

Introduction

For every project, productivity, cost, quality, and time have been the main concern. At present there are no universally accepted standards for the factors affecting the crew productivity in construction industry (Figure 1).

Knutson [1] mentioned that "A specialty contractor can work for a general contractor on a large project or may have a direct contract with an owner on a project where the owner handles the general contractor responsibilities of overall project coordination and control". They defined that "subcontractor is defined as a specialty contractor performing under contract of the general contractor". Generally the "Subcontractors or specialty contractors make up the largest portion of the construction industry. Subcontractors have a specialty to do different works such as electrical, mechanical, steel erection, acoustical, drywall, painting and carpeting". Tennessee Department of Commerce & Insurance, board for licensing contractors in license and bidding requirements summary (2013) mentioned that

Heavy Construction Categories

1. Structural Steel Erection

2. Tower and Stack Construction

3. Foundation Construction, Pile Driving, Foundation Drilling, and Stabilization

4. Demolition and Movement of Structures

5. Clearing, Grubbing, Snagging and Rip Rap

6. Slip form Concrete Structures

7. Rigging and Crane Rigging

8. Welding

Measures of construction performance: Construction performance involves all aspects of the construction process. It is a broad inclusive term that includes four elements:

- Safety
- Schedule time
- Quality
- Productivity

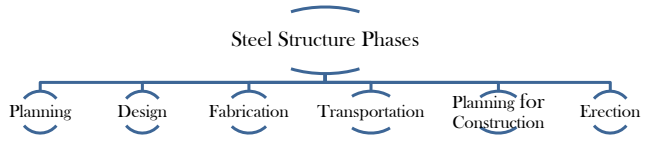

Figure 1: Steel structure phases.

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Received September 28, 2016; **Accepted** October 13, 2016; **Published** October 15, 2016

Citation: Rashid IA, Aboul Haggag SY, Mahdi I, Elhegazy HM (2016) Construction Performance Control in Steel Structures Projects. Ind Eng Manage 5: 201. doi:10.4172/2169-0316.1000201

Literature Review

Steel construction process: Javier [2], presented direct observations of steel erection activities and statistical analysis of task duration data (Figure 2). Lingguang [3], presented an approach to measure productivity, collect historical data, and develop productivity models using historical data and applied it to model steel drafting and fabrication productivities. Al Aomar [4], presented study for incorporating time standards into CAPP of CSB Empirical formulas are developed to generate time standards for variant steel beams based on their CAD files (design parameters and geometry) and process parameters (operational conditions). A Motion and Time Study (MTS) is used to estimate times for manual work elements such as load/unload activities and to validate the generated time standards. A generic parametric model is developed with Excel and integrated into the CAPP system to automatically estimate the standard time of each process operation. It showed that developing the time standards module for process operations and integrating its spreadsheets into a generative CAPP has helped process planners to arrive at better estimates of process parameters and has helped production management and the overall project management process in CSB industry. And it incorporates time standards into the architecture of CAPP system for accurate time and cost estimation and effective re-source allocation and project management and it utilizes motion and time study (MTS) to collect complementary process data and validate the model-generated cycle times. Lee and coworkers [5] was introduced an integrated simulation system named Construction Operation and Project Scheduling. Majority previous researches cared to study the labor productivity because the Labor cost in construction industry is estimated to be about 33-50% of the entire project cost Hanna [6]. Because labor is more variable and unpredictable than other project-cost components, it becomes necessary to understand the effects of different factors on labor productivity. An increase in productivity can reduce the labor cost in a direct proportion. It can either benefit or reduce a project's profit, making it of vital interest to the construction industry for its success, but in the study of construction of steel structure projects, the situation is completely different it must studying the crew productivity. Construction projects suffer various problems and complex factors such as cost, duration, quality and safety. Construction sector is diverse as it contains contractors, consultants, designers, owners, and others.

Rules of manpower, equipment and tools in the construction process

Improve productivity leads to saving a lot of time and costs in the steel structure projects. No attention has been made to improve crew productivity as a whole. The effect of crew in this type of projects is less expensive than the equipment and tools, and these projects depend mainly on the equipment and tools. Shah et al. [7], studied analysis of factors influencing productivity in Central Gujarat Region of India. They identified and ranked the key factors affecting the project level productivity. The data were collected to determine the most influential factors on productivity of the project through a survey by explorative questionnaire to the respondents who were involved in the management of projects in various regions in the central Gujarat region of India. Abu Bakar and Khurshid [8], stated that analysis of labour productivity of road construction in Pakistan was carried out to identify the critical factors which were responsible for poor labour

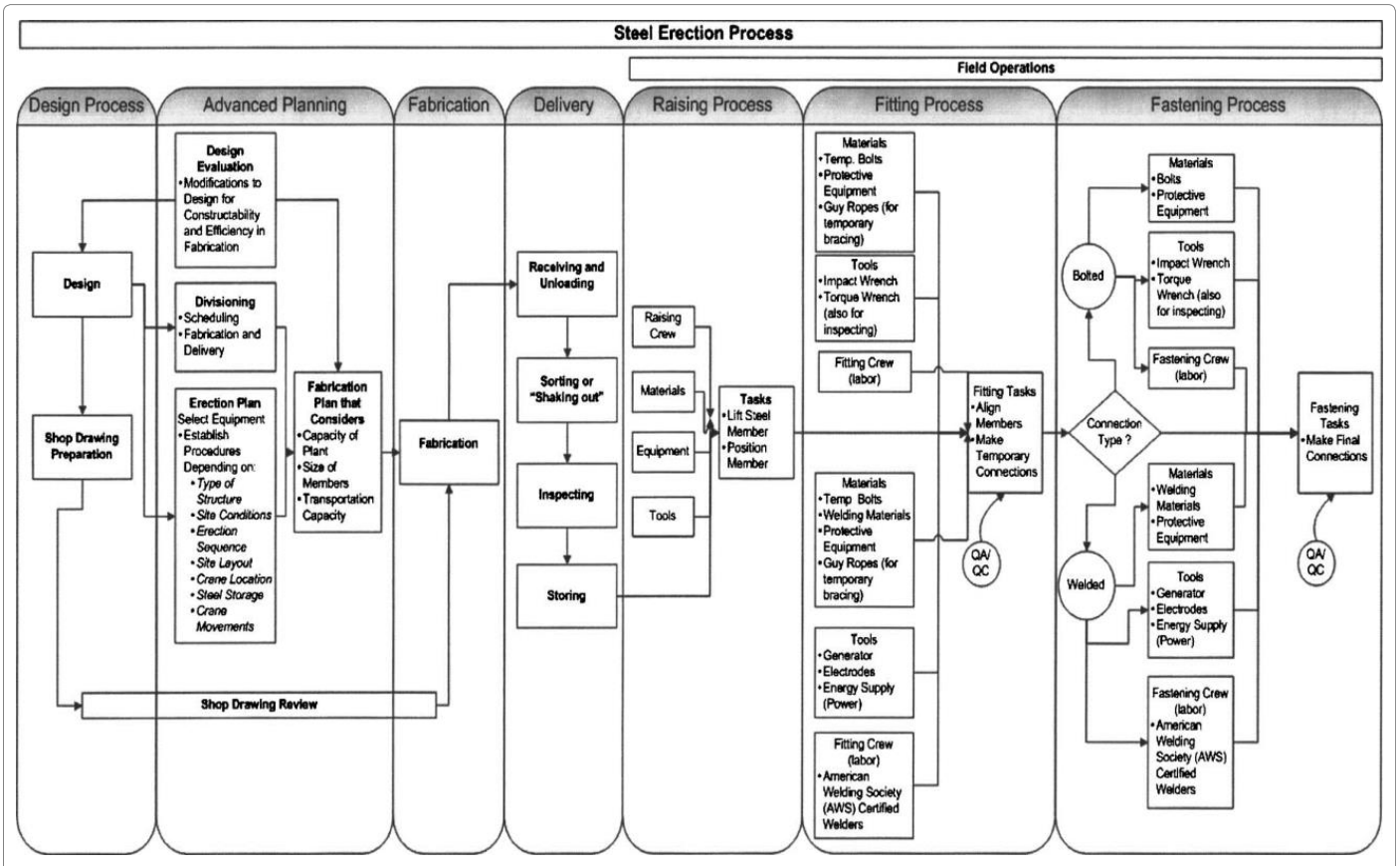


Figure 2: Steel erection process model (Javier Irizarry, 2005).

productivity of road construction by questionnaire based survey. It was the basic needs of labours must be fulfilled initially to expect good output results from them. They recommended adopting the critical issues of road construction to produce remarkable figures in construction industry of Pakistan competing with construction industries of other developing countries. Shehata and coworkers [9], was studied improving construction labour productivity and projects' performance. It covers the construction labour productivity definitions, aspects, measurements, factors affecting it, different techniques used for measuring it, and modeling techniques. They provided a guide for necessary steps required to improve construction labour productivity and consequently, the project performance. Ghoddousi and Hosseini (2010), defined as determining the factors and grounds affecting subcontractor's productivity and evaluate their overall negative side effects on project productivity via a structured questionnaire. The analysis indicated that the most important grounds affecting subcontractor's productivity in descending order include: Materials/ Tools, Construction technology and method, Planning, Supervision system, Reworks, Weather, and Jobsite condition. Project managers should focus on the identified major grounds and relevant factors in order to improve productivity as long as they commit construction activities to subcontractors. Park [10], 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 contains a list of direct and indirect accounts and data elements grouped into seven major categories was developed. Xue [11], was used the MPI to measure the productivity changes of Chinese construction industry from 1997 to 2003 and 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. William Ibbs [12], reported that project change is disruptive and detrimental to labour productivity. Hanna (2005), presented an analysis of the impacts of extended duration overtime on construction labour productivity, and showed a decrease in productivity as the number of hours worked per week increase and/or as project duration increases. Haas and Paul [13], studied the impact of equipment technology on labour productivity in the US construction industry. Olugbenga [14], when studying predicting industrial construction productivity using Fuzzy Expert Systems, the existing labour productivity models are classified into two categories, namely: Neural Network productivity models, and other productivity models. Sweis [15], proposed a methodology to model the variability of masonry labour productivity. Sandbhor et al. (2014), applying total interpretive structural modeling to study factors affecting construction labour productivity, the total interpretive structural modeling (TISM) is implemented as a methodology for identifying and summarizing relationships among factors which affect productivity of labour. Alqumboz [16], "developed a model for integrating safety, quality and productivity in building projects in Gaza Strip" and reported 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 steel erection process model presented by Irizarry [2] for the model is shown in Figure 3.

Factors of similar nature were grouped together; giving rise to 15 main groups arranged in excel sheet and divided to pre-construction process and during construction process.

Identification of Factors Affecting the Performance of Steel Construction

Pre-construction process

Design: 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 a design is practical and cost efficient (design for construction).

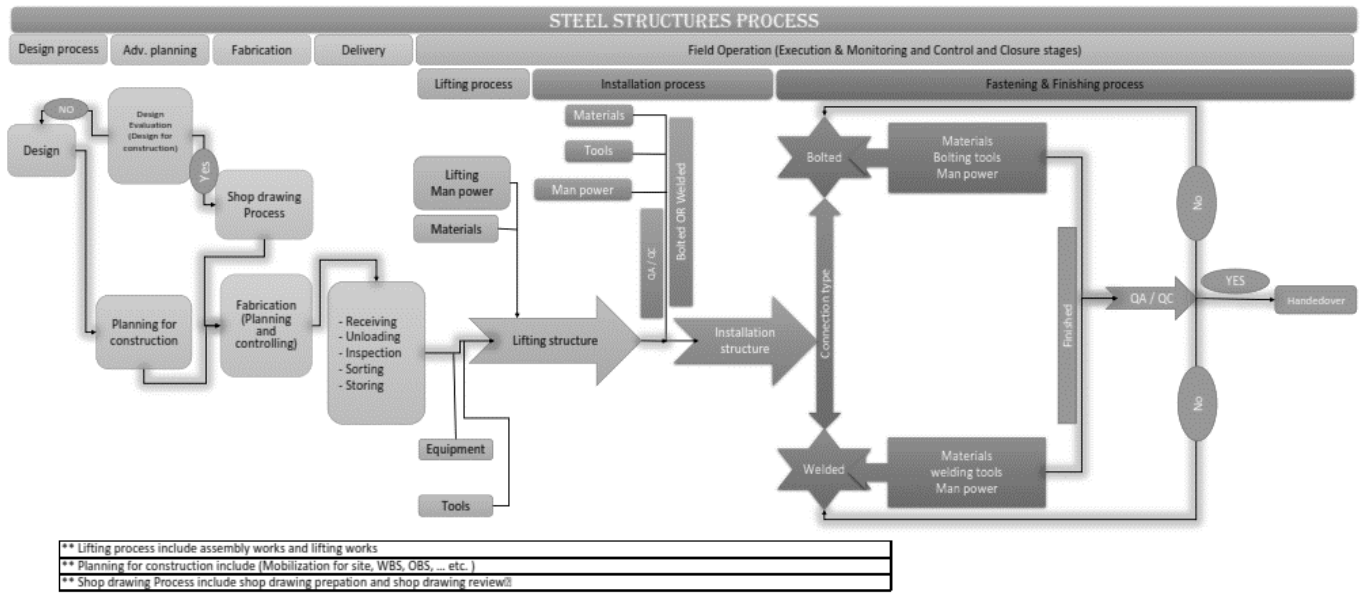


Figure 3: Modification for steel erection process mode Factors of similar nature were grouped together; giving rise to 15 main groups arranged in excel sheet and divided to pre-construction process and during construction process.

There are two separate phases of design:

- Structural Design
- Design for Erection

Fabrication: 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. Fabrication involves handling of the stock members, cutting them to size, punching and drilling for connections, and preparing the connections, as well as shop painting or finishes when required. The principal activities at the fabrication works:

Pre-assembly butt welding

Cutting and profiling

Drilling and edge preparation

Assembly

Welding

Fitting of stiffeners

Shear connectors

Trial erection (rarely carried out)

Coating application.

Fabrication considerations: There are many factors that must be considered during the fabrication and have a great impact on improving the crew productivity for the Construction of steel structure projects:

- Accuracy
- Handling and transportation
- Shortage materials
- Damaged or defective material
- Delivery priority
- Schedule time for fabrication.

During construction process

Planning: It is a fact that known factors impacting crew in construction. Good work planning will help identify and quantify them upfront in the estimate and the work packages. By identifying them early, the estimate will be more accurate, and work planners can concentrate on reducing and eliminating these crew factors. Some of the critical elements to consider in the site layout are listed below:

- Mobilization, Processing of project in terms of the tools and offices, stores and equipment enough to start project unless stoppage
- OBS, Responsibilities and reporting
- Site size and configuration
- Location of adjacent roads, buildings and utilities, subject to damage
- Location of roads available for transporting materials and equipment
- Likely access points to site and buildings on the site
- Location, height, size, configuration of building being constructed
- Relationship of building and its components to the site
- Proposed construction methods for major building systems
- Construction sequence and schedule
- Erection and installation equipment requirements for major building systems
- Material quantity, storage, and delivery requirements
- Entrance points for workers to site
- Worker parking
- Tool and equipment storage requirements
- Construction operations facilities and trailers
- Safety
- Fire protection
- Efficiency of materials movement and management.

Equipment and technology: The crew productivity improvements are attributed to the technology advances in equipment and construction methods over the last two decades, the use of technology can expose inefficiencies, enable visualization of problem areas, and improve construction planning accuracy, as well as provide documentation and visualization to support or defend change order requests and construction claims. Technology can help work planners manage and control crew impacts by providing users the ability to add and adjust crew factors for their project. The erector may lease or own the lifting equipment for the project and will select equipment based on the following criteria

- Lifting loads
- Reach required
- Lifting heights
- Crane radius
- Setup and maneuvering space available
- Mobility requirements
- Strength of the ground base
- Construction sequence
- Erection sequence (i.e., horizontal or vertical sections)
- Number of cranes to be used
- Fabricated steel delivery points
- Times the crane will be used
- Costs
- Availability of equipment

Method statement of construction: Erection method statement is a very crucial document as it helps all the parties right from client to front end engineering and approval team to site execution team to visualize the actual construction prior to beginning of the project. The determination of how to erect a building depends on many variables

that must be studied by the erection engineer long before steel begins to arrive at the erection site.

Contents Erection Method Statement

- General introduction
- Layouts
- Pre cambering of trusses
- De-propping procedure
- Structural geometry of permanent structure
- Leveling and alignment
- Tolerances
- Plant and equipment
- Bolting and welding
- Principles of erection
- Requirements of scaffolding
- Risk analysis and safety measures
- Logistics
- Erection sequences
- Organization chart
- Engineering drawings of temporary

Training: There are a lot of training that must be done for crews to work inside and outside of the site for the safety of the crew and improve productivity projects and private Construction of steel structure projects that need to be continuous and accurate training, such as: training personnel, fall hazard training and special training programs. Improve efficiency by training your crew, an important element to improving productivity is increasing efficiency on the project by training crews.

Construction companies should always be ready to train their crew in order they could deliver higher quality of work.

- Competency and Training
- Construction induction training (such as a "construction induction card" or equivalent)
- Training in the use of plant that does not require a license for high risk work to operate
- A site-specific Induction

A dependable supervisors: For any project, it can't just leave a construction crew to police their own activities. Like any job, you need a manager on site to ensure that work is progressing on schedule, jump in if help is needed, report to officials, and basically do whatever is necessary to promote an efficient work environment. You'll need someone with experience (A background in skilled labour is just as useful as previous management) who is reliable and trustworthy. This is absolutely essential to the success of any construction project. There are some factors that supervisors must be followed in the work environment to achieve higher productivity:

- The supervisor should provide the means to ensure that all labours are adequately instructed and trained, ensure that labors doing dangerous work have adequate training, experience and other qualities to carry out the work safely
- They should be different between Skilled Workers vs. Unskilled Workers
- For steel structure projects, Supervisor should be too familiar with common steel erection problems and suggested solutions
- Supervisor should be too able to manage meeting and maintaining effective working relationships with other people, managers and instructors
- Avoid Unnecessary Meetings and Phone Calls. This will help keep your eye on the project
- Avoid communication problems between supervisors and crew.

Material handling: Materials handling which includes procurements, inventory, shop fabrication and field servicing requires special. Structural steel shall be stored and handled in a manner that prevents damage or distortion. And do not store materials on the structure in a manner that might cause distortion or damage to members of the supporting structure. Keep steel members off the ground by using blocking, cribbing, platforms, or other supports.

*Delivery of materials***:** Fabricated structural steel shall be delivered in a sequence that will permit efficient and economical fabrication and erection and do not adversely affect productivity, where the delivery of materials on dates before starting the duration of erection suitable time helps to improve the crew productivity t where they will be reviewed and transferred to the erection at the suitable time, The transfer of materials to the erection site before starting the process of erection is one of the most important factors that affect the improving crew productivity.

Anchor rods, washers, nuts and other anchorage or grillage materials that are to be built into concrete or masonry shall be shipped so that they will be available when needed. The owner's designated representative for construction shall allow the fabricator sufficient time to fabricate and ship such materials before they are needed.

If any shortage is claimed relative to the quantities of materials that are shown in the shipping statements, the owner's designated representative for construction or the erector shall promptly notify the fabricator so that the claim can be investigated. The quantities of material that are shown in the shipping statement are customarily accepted as correct by the owner's designated representative for construction, the fabricator and the erector.

If material arrives at its destination in damaged condition, the receiving entity shall promptly notify the fabricator and carrier prior to unloading the material, or promptly upon discovery prior to erection.

Construction health, safety, security, and environmental: There is no doubt that the Construction Health, Safety, Security and Environmental a major role in the success of the projects and has the role on productivity in any project, especially in terms Construction of steel structure projects, the implementation of these projects need any great interest in Construction Health, Safety, Security and Environmental. For construction safety is has been proven that it is essential that company and project leadership be committed to eliminating accidents and achieving a zero-accident environment.

Safety in construction is considered the success of project; safety is one of the key measurements of good productivity which the

people seldom realize. Safety on all construction sites is a vital issue. With structural steel erection, the potential risks for exposure of workers to equipment, falls, being struck or caught between material and equipment are ever present. This manual is not intended to be a detailed guide to safety in steel construction.

Safety in the erection steel structure has always been a major issue. Wherever reliable records are available, steel construction is found to be one of the most dangerous on safety and health criteria. Though much improvement in steel construction safety has been achieved, the erection steel structure still continues to lag behind most other activities with regard to safety. The principal safety objectives when erecting steelwork are:

- Safe access and working positions;
- Safe lifting and placing of steel components;
- Stability and structural adequacy of the part-erected structure;

Security, Accidents and injuries, theft on site and vandalism are the main risk factors that were placed under the composite "security" risk factors. Theft on sites is one of the strange things; the workers as well as outsiders try to steal materials, tools and equipment. When this happens, it creates problems for the organizations because they have to purchase these items all over again, although vandalism is very destructive.

Protection Occupational Safety and Health is divided into:

1. Personal protection
   - Head and eye protection
   - Hand protection
   - Foot protection
2. Fail protection
3. Hazards in the workplace

Security, Theft at construction sites is fairly common, especially when materials are left unguarded and out in the open. Instead of setting up a fence that anyone with four usable limbs can bypass, hire a security firm to provide a night-guard so that expensive copper pipes and lumber don't simply get up and walk off the site, costing you both materials and labour. The broad contractors and subcontractors safety responsibilities include:

1. Developing all required safety plans and documentation

2. being directly responsible for safety of own employees

3. Maintaining proper supervision during the work

4. Providing proper personal protective equipment as necessary

5. Maintaining and operating equipment in a safe manner. Further information regarding the health and safety during construction of steel buildings and bridges are available in the following BCSA (British Constructional Steelwork Association) publications:

- Safe site handover certificate and checklist
- Guide to steel erection in windy conditions
- Code of practice for erection of multi-storey buildings
- Guide to the erection of steel bridges
- Code of practice for metal decking and stud welding
- Guide to the management of site lifting operations
- Code of practice for the erection of low rise buildings
- Health & safety on steel construction sites: guide for employees.

Incentives and on-site services: Incentive is one of the important factors affecting construction crew productivity. It can best be accomplished when crews' personal ambitions are similar to those of the company. Factors are, such as payment delays, a lack of a financial motivation system, non-provision of proper transportation, and a lack of training sessions.

On-site services, it is very important for any project because it is considered that backbones for projects specially steel structure project.

Quality: The definition of quality in the past as "compliance to standards" is now found to be inadequate and replaced with the current definition as "customer satisfaction". Quality considerations need special care. Especially when the production (construction/installation) is not in place, cost of remedial works may go extremely high if attention is not paid to quality assurance. In the modern construction market, quality is a major function in construction organization. Quality is rapidly becoming as important factor as price has been traditionally.

A quality system consists of the following

- Quality policy
- Organization structure
- Procedures
- Processes
- Training
- Quality manual.

Avoid extended overtime: There are many factors that can affect productivity, some of which have nothing to do with the overtime situation. While obvious, it is often forgotten that manpower is not the only resource or component that is consumed at an accelerated pace in an overtime situation. If a project is behind schedule, working overtime may simply exacerbate the problem. Therefore, whenever overtime is discussed, the surrounding circumstances must be clearly understood. Long term overtime may lead to increased costs but decreased crew productivity. The effect of continued overtime work on crew productivity is, perhaps, one of the most studied productivity loss factors in the construction industry. The impact of extended overtime on construction productivity has been studied for over a 40 years. The results of many studies have been consistent; there is a direct negative impact of extended overtime (over 40 h for more than 2 weeks). There can and are debates to how much impact there will be, but there isn't much argument that extended overtime reduces productivity.

Time and weather: Like most civil engineering activities on site steel erection is subject to the vagaries of the weather. In developing the erection method different aspects of weather conditions can affect productivity, detail planning, and the behavior of the structure. And cause hazards for health & safety. The character of the weather at the particular site during the period of the year when erection is to take place has to be appreciated, as does its significance for each operation.

The weather, everybody watches it, talks about it, but nobody does anything about it, or so it's said. But in the construction industry, that's not really the case. Most contractors take careful notice of local and regional weather patterns, the norms and trends, and schedule their

construction projects accordingly. As-planned construction schedules, prepared between the time of estimating and the project's startup, are almost always "weather sensitive" and are prepared to take advantage of favorable seasonal, local, or regional weather patterns and avoid the unfavorable ones.

Weather and season changes, Performing work in a change of season, temperature zone, or climate change resulting in work performed in either very hot or very cold weather, rain or snow, or other changes in temperature or climate can impact workers beyond normal conditions.

Rain, most crafts do not work in the rain, but many do, especially those who live in wet regions of the country and must work or risk losing too much in wages. Work can, and does occur in the rain, but not without inefficiencies due to rain gear, visibility, safety, morale, discomfort, hazards, and other issues. For steel structure projects, work in rain is very risk and it has a very negative impact on productivity because the production crew rate will be extremely low.

Safe work practices, too much salt can cause higher body temperatures, increased thirst and nausea. Workers on salt-restricted diets should discuss the need for supplementary salt with their doctor. A person working in a very hot environment loses water and salt through sweat.

Reporting: Daily, weekly and monthly reporting helps for improving productivity for any project, it can identify the status of project and helping in decision-making. In brief, there must be reported to anything for the project and the report is directed to those responsible timely to be take the appropriate decision and help for planning in the future. To improve productivity, you need to know how you are doing so you can confirm that you are improving. Most contractor cost reporting systems report the quantity completed, how much has been spent and how long has been spent. Reports, processing of the final form for reports of the project which is used in every department and completed documents & standards or references before starting project. It was reporting that using S-Curves to improve project performance. An S-Curve allows the status of a project to be monitored graphically as it progresses, and displays an historical record of actual to date.

Coordination and reporting, for fast paced structural steel construction projects, coordination and reporting among the parties is essential. Many coordination and reporting activities are mandated by the project contract documents, and others are simply good management practice. Coordination and reporting help to improve crew productivity because it helps for fast paced that increase the progress for any project. Since structural steel is a major component of the project, the steel contractor should be an active party in these meetings. Delay in responding to requests for information that is the prominent factors affecting the crew productivity.

Daily report, It should be prepare daily report include status for all items in project clearly.

As shown below Figure 4 examples for reports to follow the Status of the project, for appropriate decisions in a timely.

Assembly process: The assembly process is considered one of the basic processes in the construction of steel structures but differ from site to site another Due to variation of nature of each site. Assembly work is considered on site of the important work that will increase the productivity of the crew, where they help to complete the lifting process in the shortest possible time and there is a great interest in the

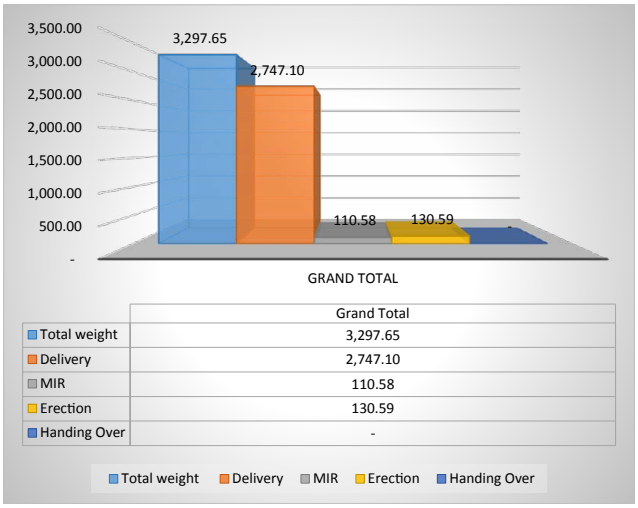


Figure 4: Shown status of project.

work of the assembly in steel structures, although it is not directly study the assembly process in previous research, particularly Researches relating to productivity. Required for assembly work on site of several important factors, including:

- Equipment that must be available during the assembly process (cranes)
- Equipment that must be available during lifting process whether cranes or Man-lift
- The proper tools that must be available during the assembly process and the lifting process
- The proper study for method of construction
- The availability of suitable labour to lifting process the assembly process
- Time schedule for the assembly process and lifting process according to the availability of labour, equipment and tools
- Location in which they are assembly works preferably be in the same lifting area if possible.

Figure 5 showing studying of factor that affecting on productivity for 60 researches that published on international journals.

Proposed Model of control (Measure of high performance level and control)

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 [17-21]

$$\mathbf{RII} = \frac{5\mathbf{n}_5 + 4\mathbf{n}_4 + 3\mathbf{n}_3 + 2\mathbf{n}_2 + 1\mathbf{n}_1}{5\mathbf{N}}$$

To calculate the average RII of each main factor, the summation of RII of each sub-factor is divided by the number of sub-factors belonging to the same main factor by using excel sheet (Figure 6). Example: Average RII of main factor "Design" =(0.7583+0.8103+0.725)/3=0.765

The data collection process used in this research had the option of basic methods: personal interviews, literature review, researchers'

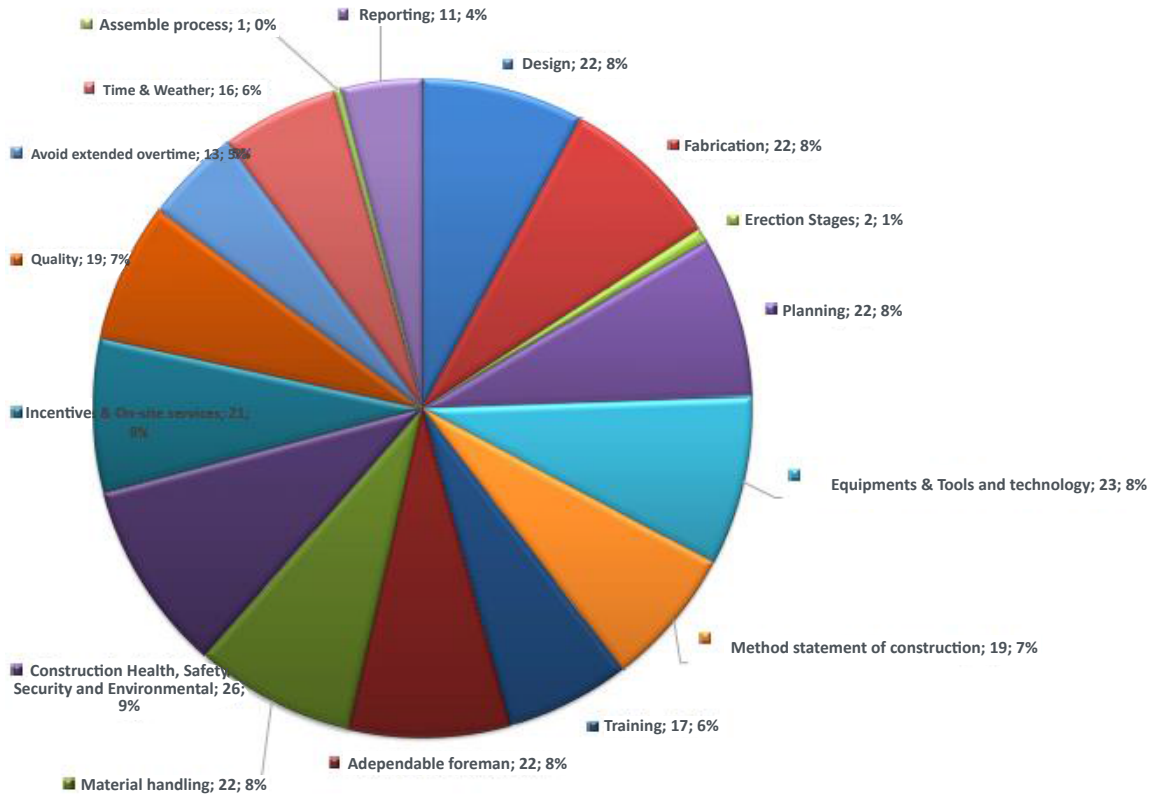


Figure 5: Detailing for studying of factors that affecting on Productivity for 60 researches.

knowledge, telephone calls and correspondence via an Email. Data were collected from literature reviews from books, journals, articles, seminar conferences, and websites which emphasize construction productivity for 14 factors, and they were collected from personal interviews for assemble processes which were identified RII (a15) for the assembly process valued 0.7.

Steps of model measure and evaluate crew productivity

- Literature related to research subject has been reviewed.
- Identify and classify Input and Output Factors
- Identify Functions for Input and Output Factors
- Solve Model for Input and Output Factors using MATLAB R2013a.
- Test Model (Model verification and validation) using the published data or actual projects.

Defining the factors affecting crew productivity and the resulting model

Input factors

1. Design
2. Fabrication
3. Planning
4. Equipment and Tolls and technology
5. Method statement of construction
6. Training
7. A dependable supervisors
8. Material handling
9. Construction Health, Safety, Security, and Environmental
10. Incentives and On-site services
11. Quality
12. Avoid extended overtimes
13. Time & Weather
14. Assemble process and
15. Reporting.

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

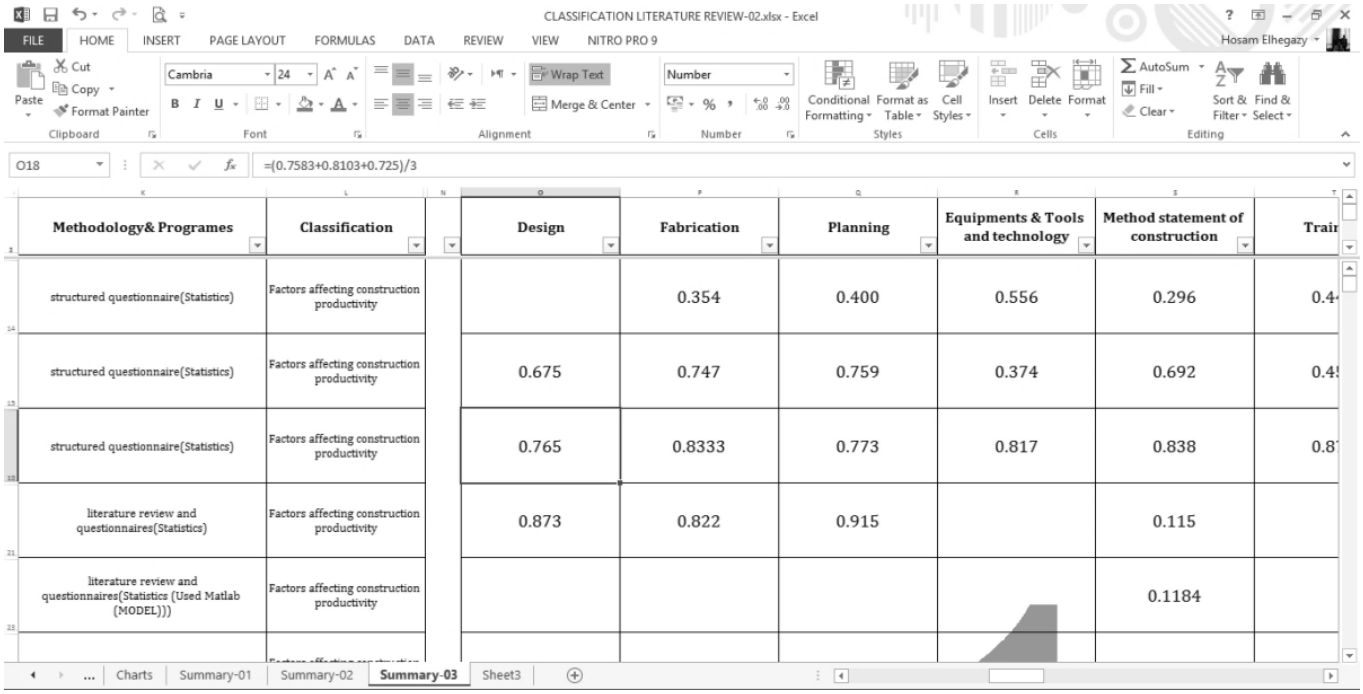
Level of measurement

Level of measurement for input: According to Olugbenga [14], numerical values or subjective values (on a scale of zero to 10) such as 0 to 10 descriptors (0=poor, 5=average, 10=good) (Figure 7).

Level of measurement for output: Figure 8 shows Evaluation Scale (Output-Productivity)

Model formulation: The model can be summarized in the following:

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



Methodology& Programes	Classification	Design	Fabrication	Planning	Equipments & Tools and technology	Method statement of construction	Trai
structured questionnaire(Statistics)	Factors affecting construction productivity		0.354	0.400	0.556	0.296	0.4
structured questionnaire(Statistics)	Factors affecting construction productivity	0.675	0.747	0.759	0.374	0.692	0.4
structured questionnaire(Statistics)	Factors affecting construction productivity	0.765	0.8333	0.773	0.817	0.838	0.8
literature review and questionnaires(Statistics)	Factors affecting construction productivity	0.873	0.822	0.915		0.115	
literature review and questionnaires(Statistics (Used Matlab (MODEL)))	Factors affecting construction productivity					0.1184	

Figure 6: Shown Average Rii of main factor.

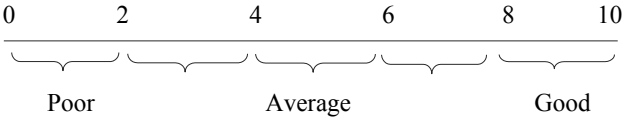


Figure 7: Evaluation Scale (Input-Factors).

Figure 8: Evaluation Scale (Output-Productivity).

Such that;

Y=Productivity,

100=The expected result of score of productivity,

X_1=Design

X_2=Fabrication,

X_3=Planning,

X_4=Equipments, Tools and technology,

X_5=Method statement of construction,

X_6=Training,

X_7=A Depandable supervisors,

X_8=Material handling,

X_9=Construction Health, Safety, Security and Environmentally,

X_{10}=Incentives and on and site services,

X_{11} = Quality,

X_{12}=Avoid extended overtime,

X_{13}=Time and Weather,

X_{14}=Reporting and

X_{15}=Assemble process.

Model Verification and Validation

The model was verified through testing on actual projects. The results show that it is easy to use and useful as a tool for measuring and evaluating the crew productivity of construction of steel structure projects. Figure 9 shows results of Matlab applying project. Figure 10 shows results of factors for crew productivity and Figure 11 shows results of percentage of factors.

Conclusions

The basic ideas of the research are to study construction performance control and improving productivity for the construction of steel structure projects. Using model on Matlab for controlling on productivity and construction performance of construction of steel structure projects based on the several factors that affect the steel structure process. The model was verified through testing on actual projects. These techniques were used to model objective and subjective data that were extracted from an actual productivity study. Since the data collected in the productivity study represent the type of data that would be available within organizations, this research demonstrates how such data can be used for controlling, improving, measuring and evaluation the productivity of construction of steel structure projects for construction processes of steel structures .Work sequences can also be affected due to rework.

Recommendations for future research

Mentioned below are the recommendations which were found to

```
21/06/15 ص 01:16    MATLAB Command Window                    1 of 1

please input design valu = 6
please input Fabrication valu = 5
please input planning valu = 7
please input Equipment, Tools and technology valu = 8
please input Method statement of construction valu = 7
please inputl Training valu = 6
please input A dependable supervisors valu = 5
please input Material handling valu = 7
please input Construction Health, Safety, Security and Environmental valu = 9
please input Incentives and On-site services valu = 9
please input Quality valu = 8
please input Avoid extended overtimes valu = 7
please input Time and Weather valu = 6
please input Reporting valu = 7
please input Assemble process valu = 5

y =

   67.5388


Evaluation =

Good

Recommendations : To improve your crew productivity you should be improve:
design
Fabrication
planning
Method statement of construction
Training
A dependable supervisors
Material handling
Avoid extended overtimes
Time & Weather
Reporting
Assemble process

Please input average weight value = 15

The expected weight after improving crew productivity (EW):

EW =

   22.2094

>>
```

Figure 9: Resulting of Matlab applying Project.

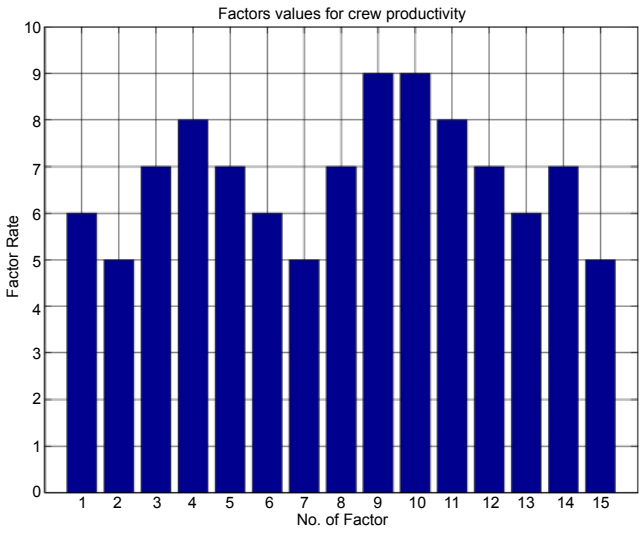


Figure 10: Factors values for crew productivity.

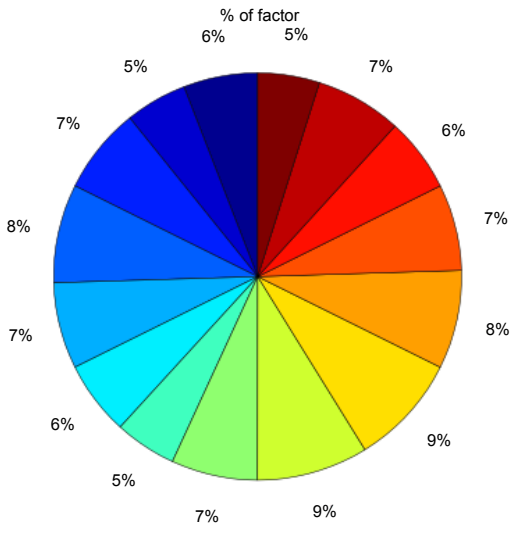


Figure 11: Percentage of factors.

be important factors for improving the crew productivity and projects' performance for the Construction of steel structure projects:

- This study is one of the few that has been done in the area of crew productivity and projects' performance for the construction of steel structure projects modeling using Matlab. It is hoped that future studies will improve due to the techniques used in this study.
- Researchers should be study results improvement in the crew productivity in the projects, especially with respect to cost, schedule time and improve the model on Matlab.
- It is hoped that future studies develop the model that used in this thesis to apply it on bridges structure, offshore structure, construction road etc.

Finally, this research provides a basis for future work in improving the crew productivity and project performance for the construction of steel structure projects, giving the numerous factors affecting crew productivity. Future studies will hopefully improve the techniques used in this study, while taking into consideration the difficulties encountered in this project.

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