Factors Improving the Crew Productivity for the Construction of Steel Structure Projects

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Abstract: 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 and it is differ from conventional structural engineering projects mainly in the special problems that have to be considered during construction, transportation, installation, and operation. There are many factors that impact the crew productivity in this field. The purpose of the study discussed in this paper is improving the crew productivity for the construction of steel structure projects. The research was conducted by personal interviews, literature review, researchers’ knowledge, telephone calls and correspondence via an email. It was designed model on Matlab in measuring and evaluation the crew productivity of construction of steel structure projects based on the several factors that affect the construction of steel structure process. It is recommended that contracting and consulting firms to improve the crew productivity for the construction of steel structure projects before starting and during the construction of projects. 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.

Key words: Crew productivity, steel structures, construction management, steel projects, construction productivity.

Nomenclature:

PPE Personal Protective Equipment
RII Relative Importance Index
HSSE Health, Safety, Security and Environmental
ASTM American Society of Testing and Materials
BCSA British Constructional Steelwork Association
AISC American Institute of Steel Construction

1. Introduction

Steel structures are playing an important role in the upcoming buildings, malls, convention centers, hospitals, bridges, underground works, railway stations, stadiums, industrial buildings and multi-level parking,… etc. Productivity will improve when we get the right people with the right tools doing the right stuff. So we study factors for improve the crew productivity such as planning, time, quality,…etc. There are many factors that impact crew productivity in this field. For every project, productivity, cost, quality, and time have been the main concern. At present there are no universally accepted standards to factors affecting the crew productivity in construction industry. The most challenging issue in construction industry in the last decade is how to improve the productivity. To improve productivity, we must be able to measure it. And we must be able to measure the effect of changes adopted on methods, effort, and systems. The measured values of productivity can then be compared either to those used to compile the estimate or to some production standards. Several studies related to productivity are performed for construction industry in past. Several of them were related to measuring productivity, labor productivity, improving construction productivity, factors affecting construction labor productivity and loss of productivity. At present there are no universally accepted standards to factors affecting the crew productivity in construction industry. The objective of
this thesis is study improving the crew productivity for construction and installation of steel structure projects. The primary and secondary factors effect on improving the crew productivity for the construction of steel structure projects. The construction industry can use the findings in this research as a basis for improving the crew productivity for the construction of steel structure projects.

2. Literature Review

There are many factors that are involved with crew productivity improvements, it is not an easy road to follow and it needs commitment of the highest level to achieve real improvements. Many companies are increasing their capacity to produce more, but there is a huge need to improve crew productivity. Many researchers have studied some of the factors that effect on construction productivity. Studying of factors that affecting on Productivity for 60 researches (Fig. 1). After analysis of factors influencing productivity in central Gujarat region of India, so he identified and ranked the key factors which affected the project level productivity [1]. Analysis of labor productivity of road construction in Pakistan was studied. It was carried out to identify the critical factors which are responsible for poor labor productivity of road construction in Pakistan by questionnaire based survey [2].

The factors that affect construction labour productivity in Trinidad and Tobago were studied, a questionnaire was used to gather the relevant data from members of the Trinidad and Tobago Contractors Association. And recommendations have been made in the study to address these factors [3]. Identified factors affecting labor productivity at a building construction project by a literature review and factors recommended by experts were considered to categorize the factors, and categorized factors into five groups, were analyzed and ranked considering Relative Importance Index by the questionnaires. It was concluded, final cost of the projects were higher than estimated cost [4]. It was studied improving construction labor productivity and projects’ performance, it can help improve the overall performance of construction projects through the implementation of the concept of benchmarks [5]. Studying the relationship between working at height and productivity for masonry and concluded that the six major factors affecting on productivity [6]. The factors that effect on construction industry productivity were reviewed by a structured questionnaire and he ranked factors to primary and secondary factors as perceived by the project managers who were surveyed [7]. Studying that included direct observation of steel erection activities and statistical analysis of task duration data. The data collected at steel erection sites included safety conditions such as the use of personal protective equipment PPE, elevation of the work area, environmental conditions such as temperature and humidity, and worker performance in the form of task durations. Analysis of variance ANOVA analysis of 186 of steel erection task durations collected over a six-month period showed that the use of personal protective equipment PPE, the time of day during which the operation was being performed, the elevation at which the work was being performed, and the presence of decking below the work area had statistically significant effects on the durations of steel
erection tasks [8]. Impact of equipment technology on labor productivity in the U.S was studied on construction industry [9]. It is identify factors affecting crew productivity for the Construction of steel structure projects. At present there are no universally accepted standards to measure factors affecting on crew productivity in construction industry especially construction of steel structure projects. 104 factors were identified through a detailed literature review, 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.

Steel erection is conducted by the steel erector, some fabricators may have their own erection crews or subsidiary companies; others will subcontract this work to a separate erection company, there must be a continuous strong link between erection and fabrication. For apply this model (chart) on program (Fig. 2), using (Wamp Server for login and Netbeans for writing codes)-Programming language (PHP), it help Consultants and the main contractors in the follow-up of the project since its start and through the various stages (Fig. 2).

Crew of steel structure project projects is completely different from the rest of the projects (Table 1). Generally, Erection of steel is fast paced and requires careful planning. Steel is fabricated to close tolerances. Precise layout and accuracy are important to make certain that the frame fits together properly. As these specialty firms may be more efficient at installing these items so should be called specialized contractors. Elements related to erection stages were studied [8]. The model for steel erection process was modified (Fig. 3). Bolts tightening and welding process and inspection were shown below chart (Fig. 4)).
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Fig. 3  Modification for Steel erection process model.

Table 1  Showing steel structure crew.

<table>
<thead>
<tr>
<th>Des.</th>
<th>Steel structure crew</th>
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<tr>
<td></td>
<td>Manpower</td>
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<td>Foundation (Anchor bolts)</td>
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<tr>
<td>Material handling</td>
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<td>Lifting process</td>
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<td>Installation process</td>
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<td>Fastening &amp; finishing process</td>
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3. Pre-construction Process

3.1 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).

There are two separate phases of design:

3.1.1 Structural Design

The structural steel design should be produced according to Construction Management of Steel Construction and code of steel structures, Guidelines for the erection of building steelwork, which detail how risks can be eliminated or reduced in the design stage and helping for improving the crew productivity.

3.1.2 Design for Erection

The second phase, the design for erection, is for the handling, transportation and erection of the individual members and structure. It may be produced independently of the structural design of the building. Ideally, planning for the safe erection of structural steel work should be considered at the design stage. Structural design engineers should consider the safe working conditions for those involved in the erection stage, and eliminate as many of the hazards as possible at this stage and improving the crew productivity (Figs. 5 and Fig. 6).

3.2 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:

![Fig. 5 Drawing of connection detail for column.](image)

![Fig. 6 Connection detail for column.](image)
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.

3.2.1 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.

3.2.2 For Welding
Field-Welding, Due to high costs of labor, extensive field-welding is the most expensive component in a steel frame and Shop welding is preferred over field welding. Welds are more economical than multi-pass welds. The most economical size weld that may be horizontally deposited in one pass has 5/16. Fillet welds and groove welds make up the majority of all structural welds (Table 2).

4. During Construction Process

4.1 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.

4.2 Equipment & Tools and Technology
The crew productivity improvements are attributed

| Table 2  Comparison between welding and bolting. |
|-----------------|-----------------|
| **Welding** | **Bolting** |
| Advantages | Eliminates need for punching or drilling | Easy method of connecting members on the site |
| | Simplifies complicated joints | Field-bolting is cheaper than field-welding |
| | Greater level of skill required | |
| Disadvantages | More expensive than bolting | Requires drilling or punching through all plies |
| | Weld inspection is required and is expensive | |
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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.

Selection of the lifting equipment is a specialized field and will generally be completed by experienced personnel within the erector’s organization or by outside consultants retained by the erector. When special site or lifting conditions are encountered, the erector may employ a consulting engineer and work closely with lifting equipment suppliers to determine suitable equipment.

4.3 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.

4.3.1 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.

4.4 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.

4.4.1 Competency and Training

4.4.1.1 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 for example, a
boom type elevating work platform (boom length 11 meters or less), tele-handler or non-slewing mobile crane less than 3 tones.

4.4.1.2 A site-specific Induction

Training on how to work in accordance with the SWMS developed for the task.

Training on how to eliminate or control specific hazards and risks involved in the work which are not covered by an SWMS, for example, manual handling and UV-protection.

4.5 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 labor 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 labors 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: A 10-minute phone conversation is not a lot of time. But if you have 12, 10-minute phone conversations a day, it turns into a lot of time. Try to keep people to appointments. This will help keep your eye on the project;

Avoid communication problems between supervisors and crew.

4.6 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.

4.6.1 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 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.

4.7 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. In a clearly defined safety culture reinforced with effective proven Best Practices, training, planning and clear accountability many companies have significantly reduced accidents on their projects. Safety Requirements for Steel Erection, establishes safety requirements for erecting, handling, fitting, fastening, reinforcing and dismantling of structural steel, plate steel, steel joist, and metal deck at a final in place field site during construction, maintenance and dismantling operations [10].

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. Fall Protection.
   HSSE and erector must analyze the erection process and develop a plan to protect all employees from falls. This plan may consist of a personal fall-arrest system, a static line system using lanyards, scaffoldings, nets, platforms, man lifts or any other properly engineered system.

Plan, provide and train these are simple steps to Prevent falls.

3. Hazards in the workplace
   - Hazards associated with hand tools;
   - Hazards associated with machine tools.

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 labor. 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.

4.8 Incentives & 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.

4.9 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 (Fig. 7).

A quality system consists of the following (Nee, 1996):
- Quality policy;
- Organization structure;
- Procedures;
- Processes;
- Training;
- Quality manual.

4.10 Avoid extended overtimes

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.

![Fig. 7 The Plan-Do-Check-Act (PDCA) of deming cycle for continuous improvement.](image-url)
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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 40 years. The results of many studies have been consistent, there is a direct negative impact of extended overtime (over 40 hours 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.

4.11 Time & 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. Author suggested that while analyzing productivity, in addition to temperature and humidity (weather), the complexity of work must also be taken into account [11]. Author reported that the difference between the significance of the type of work and temperature is so negligible that practically both of them would have equal influence on productivity [12]. Loss of efficiency and productivity due to effects of weather:

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 risky 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. Using weather generates flow chart (Fig. 8).

4.12 Assemble 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 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 labor to lifting process
the assembly process;

Time schedule for the assembly process and lifting
process according to the availability of labor,
equipment and tools;

Location in which they are assembly works
preferably be in the same lifting area if possible.

Photos shown below (Figs. 9-12) display more than
one case of the assembly process, which has in the
various sites in different situations:
4.13 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. These reports are very sufficient for tracking individual cost accounts. Knowing how many ton of steel str. have been erected and the labor $’s spent on that account is useful for identifying issues and taking corrective action. The only problem with quantity reporting is that it is difficult to summarize the results from many cost accounts and look at parts of the project or trends over many accounts. Reports, processing of the final form for reports of the project which are used in every department and completed documents & standards or references before starting project. It was reporting that Using S-Curves to improve Project Performance [13].

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 different types of the reports to follow the Status of the project, for appropriate decisions in a timely (Figs. 13-16).

4.14 Model

Using model on Matlab in 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. The model can be summarized in the following:

![Summary Progress Report]

Fig. 13  Shown summary progress report.
Fig. 14  S-Curve for steel structure erection.

Fig. 15  S-Curve for quality control.

Fig. 16  Shown status of project.
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The construction industry especially the construction of steel structure projects is rated as one of the key industry. It helps in developing and achieving the goal of society. Study and knowledge of construction crew 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 crew productivity, thus the project can end up adding even more time and money in order to be completed. The basic idea of the research is to study improving the crew productivity for the Construction of steel structure projects. Using model for measuring and evaluation the crew productivity of Construction of steel structure projects, 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.

\[
Y = (0.725 \times X_1 + 0.738 \times X_2 + 0.715 \times X_3 + 0.636 \times X_4 + 0.683 \times X_5 + 0.633 \times X_6 \\
+ 0.717 \times X_7 + 0.723 \times X_8 + 0.618 \times X_9 + 0.611 \times X_{10} + 0.764 \times X_{11} \\
+ 0.635 \times X_{12} + 0.711 \times X_{13} + 0.7 \times X_{14} + 0.7 \times X_{15}) \times \left(\frac{100}{102}\right)
\]

Such as that,

Y is Productivity, X₁ is Design,  
X₂ is Fabrication, X₃ is Planning,  
X₄ is equipment & tools and technology, X₅ is method statement of construction,  
X₆ is training, X₇ is a dependable supervisors,  
X₈ is material handling, X₉ is Construction Health, Safety, Security and Environmental, X₁₀ is site services,  
X₁₁ is Quality, X₁₂ is Avoid extended overtime,  
X₁₃ is Time & Weather,  
X₁₄ is Reporting and X₁₅ is Assemble process.

4.15 Validation for Model

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. 17).

5. Conclusion

The resulting of Matlab.

Fig. 17 Resulting of Matlab.
6. Instructions

Erection of structural steel for buildings, bridges or other facilities is an example of a construction process requiring considerable coordination. Fabricated steel pieces must arrive on site in the correct order and quantity for the planned effort during a day. Crews of steelworkers must be available to fit pieces together, bolt joints, and perform any necessary welding. Cranes and crane operators may be required to lift fabricated components into place; other activities on a job site may also be competing for use of particular cranes. Welding equipment, wrenches and other hand tools must be readily available.

In coordinating a process such as steel erection, it is common to assign different tasks to specific crews. For example, one crew may place members in place and insert a few bolts in joints in a specific area. A following crew would be assigned to finish bolting, and a third crew might perform necessary welds or attachment of brackets for items such as curtain walls.

With the required coordination among these resources, it is easy to see how poor management or other problems can result in considerable inefficiency. For example, if a shipment of fabricated steel is improperly prepared, the crews and equipment on site may have to wait for new deliveries.

Analyze the productivity of past construction jobs. This can help you improve the productivity on your current site. For example, you might find that jobs that used a specific tool or piece of equipment were more efficient; therefore, that item should always be used when relevant to improve productivity.

Plan the details of each job ahead of time. Schedule how long you think each phase of the project will take and order the materials for the next phase to arrive in a timely manner.

Choose your supervisors carefully. Supervisors should have both crew and management experience.

Don't be afraid of new technology. Innovations in equipment, machinery, tools and software can all make your construction job more productive. If you have outdated equipment and software, update them as soon as possible.

Explain to the crew and supervisors your plan for the job and how you want things done.

7. Recommendations

Mentioned below are the recommendations which were found to be important factors for improving the crew productivity for the Construction of steel structure projects:

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. 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. This may have introduced errors into the model and consequently reduced the models’ accuracies. Future studies should involve the acquisition of data for sub-factors, and more data related to the main factors.

Researchers should be study the relationship between consultants, Main-contractors and sub-contractors in the future research.

Researchers should be study the relationship between designs, fabrication and erection in the future research and applying it in Model.

Additional research is needed on the factors that effect on construction of steel structure projects in order to leverage future improvements in crew productivity.

Researchers should be Study resulting improve the crew productivity in the projects, especially on cost, schedule time and improve the model on Matlab.

Finally, this research provides a basis for future work in for improving the crew productivity for the Construction of steel structure projects, 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.
References


