

Factors affecting the performance of Electromechanical Subcontractors in Construction Projects (Jordan case)

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ABSTRACT

The subcontractor's performance is a crucial factor in the award of a new job by the main (general) contractors in the construction industry. Many factors could affect the performance of the subcontractors. In this research, a special concern is paid on the subcontracts on the electromechanical field, which includes three types: electrical, mechanical and the related to them supply jobs. The aim of this work is to identify and classify the factors affecting their performance. A questionnaire was prepared to identify the main factors affecting performance. The collected data were analyzed using the proper statistical approaches. Results have been discussed. It is concluded that all the input factors vary in affecting the performance of the three types of subcontractors. Neither technical nor exogenous factors, such as climate conditions, have a role in performance evaluation. While financial capabilities and management factors were found to be the major groups of performance factors and ranked in the first place. Productivity was ranked in the second place. The results could be applicable to other developing countries facing similar factors in their construction sector. Other aspects could be used for further studies to be conducted on subcontractors' issues.

Key words: electromechanical subcontractors, Jordan construction industry, subcontractors' performance.

INTRODUCTION

The major steps in the construction contracting process include: bid preparation, bid solicitation, bid submission, contract award, and contract administration. After the bidding process, the construction site is awarded to the Main (General) Contractor. On any particular construction project the General Contractor divides the work among many subcontractors in order to deliver a complete project in accordance with the contract documents. These works include: earth, concrete, masonry, block, electrical, mechanical, finishing, steel, wood, supplies and others.

In most cases, the basic construction execution (including operation and preparation works) are performed by the main contractor, while the remaining tasks are performed by subcontractors or different specialty contractors. The general contractors find the right subcontractor to do such a specific work items in case of a lack of experience, or for limiting risk exposure, or to expand the available workforce so they have more opportunities to bid on new projects (Gould & Joyce, 2009). That's why subcontractors could contribute

more extensively in residential housing and institutional-commercial construction, to as much as 90% of the total project value. Henze and Tracey (1994) who worked on some projects in Europe noted that on many projects, particularly building projects, it is not uncommon for 80-90% of the work to be subcontracted. Subcontracting has greatly increased in the construction industry. But with limited resources, increasing user's requirements, and environmental awareness on one side, and high competition for construction business marketplace on the other side, subcontractors have to be capable of continuously improving their performance. Not concentrating on subcontractor's management may result in uncoordinated on site execution, and disappointing quality.

In this research, a special concern is paid on the subcontracts on the electromechanical field, which includes: electrical, mechanical and the related to them supply jobs for many reasons:-

- These three jobs are differing from the group of construction jobs.
- These three jobs are together making a common need for all types of construction projects.
- These jobs are very complex and specialized; they require a special teams or firms to deal with; they require a special tools and equipment to implement; they have a wide range of methods and types.
- In some cases these jobs are working by one subcontractor – electromechanical.
- They provide the following wide range of Electro-Mechanical services to the Clients:

Mechanical Services and supply

- Heating, ventilation & central air-conditioning for commercial & industrial premises including district cooling systems
- Plumbing (Drainage & Sanitary works, Recycling system, Piping works, Irrigation, etc)
- Fire fighting system
- Swimming pools, fountains, water features, spa and steam systems
- Supervisory control & monitoring system and smart buildings
- Sewage treatment plant
- Refrigeration systems
- Stage Equipment systems
- Operation and maintenance for all systems

Electrical Services and supply

- Installation of complete electrical systems for commercial, industrial and residential complexes
- Power distribution systems
- High Mast, Street, Landscape and Decorative lighting
- Supervisory Control & Monitoring System
- Stand-by Power Stations (Generators & UPS)
- Solar photovoltaic system
- Power and control systems (Smart lighting control system)
- Medium voltage power networks
- Low Voltage Systems (IPTV, Fire Detection & Voice Evacuation, Security Systems, Parking Guidance System, Central Clock system, Public Address System, Sound system, etc.)
- Navigational & Visual Aids, Meteorological systems, Air traffic control system
- Audio-Visual (Projection system, Display system, Classroom teaching system, Audio-Video distribution & recording system, etc.)
- Data and structured cabling
- Communication systems and Industrial process services
- Earth Networks and Lightning Protection.
- Operation and maintenance

Despite the fact that a large portion of construction projects are usually undertaken by subcontractors, the issue concerning subcontracting practice in Jordan are rarely acknowledged and the ways to improve subcontracting practice are hardly ever discussed. Moreover, despite the uniqueness of the subcontractors of electromechanical jobs, unfortunately, no attention has been paid on them in the researches worldwide.

The Aim of this research is to direct the attention to the factors that may affect the performance of these subcontractors.

In order to collect all the performance indicators that could be related to various dimensions, face to face interviews with the involved in the construction projects parties (contractors, consultants and clients), a literature review of several studies was conducted and a questionnaire was prepared to identify the main factors affecting performance.

LITERATURE REVIEW

Unfortunately, no attention has been paid specially to the subcontractors of the electromechanical jobs. All the related researches have taken all the different subcontractors as an integrated hall. Many studies were in our concern in this study. Attention was paid to those, which studied the practice of different countries:

Debrah and Ofori (1997) believed that subcontractors facilitate the work of the main contractors.

Shimizu and Cardoso (2002) stated that subcontractors are the wheels which carry the project to completion. And the most important issue in the study of relationship between the subcontractors and other parties involved in the construction project is the factors which may affect the subcontractor performance.

Some researchers like Kumaraswamy and Matthews (2000) investigated subcontractor's performance evaluations and suggested a pro forma to assess subcontractors. The pro forma was composed of eight different items such as: response to construction thoughts, quality awareness, partnering experience, etc. Subcontractors were subjectively evaluated and averages were taken for multiple evaluators. In Saudi Arabia, it has been noticed that there is a need to unify the evaluation approaches used by a variety of building owners and then focus on the main criteria used for evaluation (Al-Hammad and Assaf, 1996). In their study, Ko et al. (2007) shoed that the evaluation process of subcontractor's performance consists of two stages: primaryscore and final score. The primary score is examined by field superintendents, whereas final score is evaluated by managers of general contractor after primary evaluation. Enshasi et al. (2008) in their work aim at identifying and evaluating the main factors that influence the safety performance of subcontractors in the Gaza strip. Their study confirmed that the subcontractors hired by the main contractor have the general training skills in the work, then the reported accidents rates will decrease among subcontractors.

We used these studies and other published works to report the value of the formation of complete performance indicators can be followed to evaluate the subcontractors of electromechanical jobs and their performance.

METHODOLOGY

In case of Jordan, the situation of the construction industry is very critical and must consider the factors which may affect the performance of the subcontractors in either negative or positive way can be avoided or enhanced using several engineering techniques. Therefore this paper reports on the findings of a survey targeting project contractors, formulates a number of recommendations in order to bridge the gap different perceptions specially with subcontractors, thus improving the level of project performance.

Most of construction operations are applicable to the open conversion system by Drewin (1985). This system models the construction process and the main factors affecting its productivity and the parties involving in construction industry. With the aid of the critical factors presented in the Drewin's system, also

looking up for the researches and studies, it is possible to re-identify the main categories of factors affecting the electrical, mechanical and related supply subcontractors' performance according to their characteristics, with several aspects to cover all the sides of performance assessment survey, namely:

- Technical Factors include: subcontractor's knowledge and technical skills, experience and qualification.
- Human and Work Factors include: working time, bonding issues and health and safety.
- Productivity Factors include: project complexity, work schedule and subcontractor's private bidding.
- Management Factors include: superintendent capability, project manager relationship and communication.
- External Factors include: financial capabilities and environmental factors.

A questionnaire survey was used to elicit the attitude of Main Contractors towards the factors affecting the performance of subcontracting in construction project in Jordan. In order to justify our results we had to concentrate on fields and areas where subcontracting, specially in electromechanical jobs, plays the most vital role and where subcontracting problems are mostly visible and effective on projects,. Therefore we targeted large contracting companies working on big projects where it is inevitable to have subcontractors doing part of the works. The main mission was to carry out the study on Amman (the capital of Jordan), on Al-Abdaly Development Projects Location which will potentially be the new core for business and touristic attraction in the early future, where this research will serve the big complicated projects where it can save time and hard cash. Nevertheless, the study is carried out on many other contractors inside Amman, who have wide experience as well as credibility and past practice in the interested subcontracting. The survey revolved around subcontractors of electromechanical jobs, which includes three of the selected types of classified subcontractors: Electrical, Mechanical and related to them Suppliers.

A questionnaire forms with a list of twenty eight questions (factors) were distributed to a randomly selected Sixty contractors experienced in construction project management in Jordan for more than 15 years of experience. Based on their local experience and business history with subcontractors, they asked to fill the questionnaire survey using the level of importance of each one of the identified twenty eight in a form of a question under the main group category on a five-point frequency scale as: never, slightly, moderately, very and extremely with the weights of 1,2,3,4,5 respectively.

In order to obtain high response ratio and verify that all questions are well understood, interpreted and answered completely the questionnaires were delivered to the respondents by hands, via personal interviews and filled immediately. Fifty six responses to the questionnaire (response rate of 93%) were collected and analyzed using a proper statistic tools and methods. Results will be discussed and concluded.

DATA ANALYSIS AND RESULTS

The respondents were asked to express their perception, in terms of performance factors stated in the questionnaire based on the compiled list of factors. The ranking of subcontractor performance factor was determined by taking the respective average score of the reported data for all the respondents. All the resulting averages, P and F values are represented in table 4.1. All average values above three are considered "accepted results" and approved indicator about the subcontractor performance, which basically indicated that the corresponding performance result is a critical factor of subcontractor performance to the group in question. The values are ranked according to their average in descending order according to the highest average in the group response (table 4.2).

Table 4.1: Factors averages, P and F values.

Factors	Electrical Sub.	Mechanical sub.	Supply Sub.	Overall Average	P- Value	F- Value
<u>Technical Factors</u>						
Q 1- Knowledge and technical skills	3.30	2.21	3.29	2.94	8.272E-10	23.800
Q 2- quality of subcontractor's team	3.52	3.14	3.75	3.47	0.017	4.170
Q 3- subcontractor experience	3.57	3.30	3.52	3.46	0.275	1.300
<u>Human and Work Factors</u>						
Q 4- time to receipt orders and start working	3.21	2.96	3.11	3.09	0.421	0.869
Q 5- time to implement variation orders	3.29	2.73	3.18	3.07	0.009	4.815
Q 6- time needed to rectify defects	3.29	2.30	2.96	2.85	4.785E-06	13.206
Q 7- response of delays in contractor's payments	3.38	3.20	3.30	3.29	0.664	0.410
Q 8- availability of resources	3.48	2.63	3.30	3.14	2.097E-05	11.507
Q 9- teamwork corporation	3.41	3.43	3.21	3.35	0.201	1.616
Q 10- application of organization health and safety	2.88	2.50	2.98	2.79	0.113	2.209
Q 11- project location is safe to reach	3.11	2.79	3.18	3.03	0.199	1.626
Q 12- ensure work against accidents	3.09	2.63	3.07	2.93	0.041	3.232
<u>Productivity</u>						
Q 13- dealing with project complexity	3.13	2.79	3.18	3.03	0.205	1.597
Q 14- sequencing of work according to schedule	3.16	2.55	3.25	2.99	0.001	6.863
Q 15- subcontractor's private bidding	2.29	2.59	2.46	2.45	0.172	1.773
<u>Management Factors</u>						
Q 16- capability of particular superintendent	3.55	3.14	3.41	3.37	0.071	2.695
Q 17- contractor leadership skills to manage subco.	3.45	3.25	3.52	3.41	0.423	0.864
Q 18- speed of service to the consultant	3.16	3.16	3.32	3.21	0.866	0.145
Q 19- response of rework incidents	3.16	3.16	3.41	3.24	0.363	1.019
Q 20- capability of PM to process change orders	3.45	2.88	3.39	3.24	0.013	4.439
Q 21- communication between contractor and sub.	3.54	3.27	3.82	3.58	0.060	2.860
<u>External Factors</u>						
Q 22- bearing the cost of material and equipment	3.32	2.91	3.38	3.2	0.054	2.962
Q 23- carrying costs in excess of the budget	2.91	2.63	2.88	2.81	0.342	1.079
Q 24- financial incentives for the workers	2.64	2.27	2.57	2.49	0.192	1.670
Q 25- bearing the work of re-work	3.20	2.95	3.25	3.13	0.141	1.985
Q 26- cost control system	3.09	2.30	3.20	2.86	0.141	1.985
Q 27- climate conditions	2.48	2.96	3.30	2.91	0.001	7.558
Q 28- site condition problems	2.88	2.64	3.29	2.94	0.025	3.783

Table : 4.2: Factors' ranking for all categories

Factors	Ranks of factors for each category
<u>Technical Factors</u>	
Q 3- subcontractor experience	1 st
Q 2- quality of subcontractor's team	2 nd
Q 1- Knowledge and technical skills	3 rd
<u>Human and Work Factors</u>	
Q 7- response of delays in contractor's payments	1 st
Q 4- time to receipt orders and start working	2 nd
Q 9- teamwork corporation	3 rd
Q 11- project location is safe to reach	4 th
Q 10- application of organization health and safety	5 th
Q 5- time to implement variation orders	6 th
Q 6- time needed to rectify defects	7 th
Q 8- availability of resources	8 th
Q 12- ensure work against accidents	9 th
<u>Productivity</u>	
Q 13- dealing with project complexity	1 st
Q 15- subcontractor's private bidding	2 nd
Q 14- sequencing of work according to schedule	3 rd
<u>Management Factors</u>	
Q 18- speed of service to the consultant	1 st
Q 17- contractor leadership skills to manage subco.	2 nd
Q 19- response of rework incidents	3 rd
Q 16- capabilityof particular superintendent	4 th
Q 21- communication between contractor and sub.	5 th
Q 20- capability of PM to process change orders	6 th
<u>External Factors</u>	
Q 23- carrying costs in excess of the budget	1 st
Q 24- financial incentives for the workers	2 nd
Q 25- bearing the work of re-work	3 rd
Q 26- cost control system	4 th
Q 22- bearing the cost of material and equipment	5 th
Q 28- site condition problems	6 th
Q 27- climate conditions	7 th

DISCUSSION

The financial capability of the three types of subcontractors were considered to be the first and most frequent factor affecting the subcontractors' performance in construction projects in Jordan from the view point of fifty six contractors targeted in the questions in this research. Capability of the subcontractor to carry costs in excess of the budget is very important to perform a completed in time work.

Mechanical subcontractors are the most type of subcontractors facing financial difficulties. This is because most of them in Jordan work independent, small size of firms or teams, most of cases were limited resources to bear the cost of materials and equipment without cost control system.

Technical factors ranked as a minor performance factors for evaluating subcontractors. Nevertheless a few percentage of contractors considered this factor very critical in dealing with supply and electrical subcontractors, but moderately to slightly important for the mechanical subcontract works. The technical factors reflect the quality of subcontractors' works. This can be noticed clearly in supplying subcontracts in such a way that too many change orders could be initiated by the owners of the projects, either making or breaking a job. These orders may cause a lot of damage if it was not corrected or studied well. On the other hand it may protect the project from unseen future problems and can reduce any extra costs.

Over the experience history of the contractors, communication factor is very critical in different aspects of the project regardless of the type of subcontract work. Some of the subcontractors resort to a clear communications between them and the main contractor to avoid problems of executions and variation orders unless its mentioned by the owner. On the other hand, other subcontractors are usually worked individually or in a small teams specially the mechanical subcontractors do not commit with the main contractors in communication issues.

According to ANOVA results, management factors are considered as critical and important factor affecting the performance of subcontractors. Many researchers are also found that subcontractors deeply impacted by the manager of the main contractors of the project and his\ her leadership skills. All the three types of subcontractors affected by the capability of superintendent appointed by the managers to perform better works within the required duration.

Productivity of subcontractors also was ranked as a major factor affecting the performance of manpower from the view point of the main contractors. We might consider electromechanical subcontractors' productivity as the most affected by the project complexity according to ANOVA results. This can be related to a specific reason that the subcontractors, specialized in the installation of electrical and mechanical building services including total systems for some residence buildings, offices buildings, computer suites, hotels, or shopping complex, it is of the utmost importance to provide the best quality in their projects and any performance that proceeds under the specified provision in order to keep the client more than satisfied with the outcomes.

Where the supplier subcontractor is responsible for establishing the product or service and shall operate an effective documentation control system to ensure that the correct issue of controlling drawings and specifications are used, thus, the requested productivity.

Productivity issues might be a minor priority for mechanical subcontractors. Most of the mechanical subcontractors are working individually without a clear policy to provide and implement a quality control system that can insure overall satisfaction and a finished product which compliance with all contract requirements. In most cases this can be achieved by monitoring of the installation of systems and equipment through the final acceptance of the product by the owner.

CONCLUSION

This work has presented a research for evaluating the performance of the subcontractors of electromechanical jobs (electrical, mechanical and supply). The outcomes of this research are discussed, concentrated on the most important performance factors affecting their performance.

It is evident that many factors interplay to determine the performance of subcontractors in the construction works. On the other hand, there are some factors that do not add value to the subcontractors' work such as knowledge and technical skills, except for suppliers. This is because the nature of suppliers' work has to deal with the last versions and models of various electrical and mechanical tools and methods and to deal with the latest computer and custom software to meet the modern requirements and needs of construction

projects. Nevertheless, the time needed to for subcontractors to rectify defects is a minor factor for evaluating purposes.

It has been agree on the severity of the management factors in performance assessment within the subcontractor's initial environment. Speed and reliability of service to the main contractor which in turn delivers on schedules to the main consultant is the first most important performance factor in the evaluating process. Therefore, it ranked first or the most critical factor for the three groups of subcontractors according to the mean of the overall averages.

All the respondents agree on the severity of financial capabilities of the three types of subcontractors and the huge role of this factor in the performance evaluation according to the results of ANOVA. While the environmental factors are the lowest ranked factors including climate condition changes and site condition problems. The importance of productivity factors affect electrical in the first place then the related suppliers and finally mechanical subcontractors.

Human and work factors, the timing factors, subcontractors' working response of delays in contractor's payments appear to be most important. Bonding issues and cooperation between teamwork are also major factors, in addition to health and safety factors.

Finally, the results indicate that all the input factors vary in affecting the performance of the three types of subcontractors. The main contractors agreed that neither technical nor exogenous factors, such as climate conditions, have a role in performance evaluation. While financial capabilities and management factors were found to be the major groups of performance factors and ranked in the first place. Productivity was ranked in the second place.

This study is conducted to the country of Jordan. Its results could be applicable to other developing countries facing similar factors in there construction sector. This investigation could be improved using other aspects, and could be used for further studies to be conducted on subcontractors' issues.

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