# Significant Factors Influencing On-site Construction Productivity: Road Contractors' Perspective

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**Abstract**— Construction industry in Ethiopia suffers with low productivity performance. The available research materials in this understudied area are small in number and productivity in road projects was not assessed as compared to the attention given to this construction sector in Ethiopia. This research chooses Addis Ababa City Road Authority (AACRA) and Ethiopian Road Authority (ERA) employed road contractors and looks closely the internal process to identify factors influencing productivity. The main objective of this study was to assess the significant factors affecting on-site construction productivity in AACRA and ERA employed contractors. The target total population is 50 high level local road contractors. An extensive literature review was done to identify the significant factors affecting productivity from previous studies. Based on this a total of 27 factors were identified. A questionnaire survey was administered in order to collect the primary data. A close ended structured questionnaire ensured the integrity of the objectives of the research and reliability of collected data. To analyze and rank factors affecting construction productivity, the relative importance index has been used. The top ten identified factors were: poor planning and scheduling (RII of 0.9), failure to follow a project schedule (0.875), wrong construction method (0.825), failure to maintain equipment on time (0.810), incomplete drawing (0.805), unfavorable weather condition (0.8), lack of technology adaptation (0.795), wrong estimation (0.790), lack of equipment (0.780), and lack of qualified workers (0.0.775) have significant negative impact on productivity. This research also found out that Management issues have a significant impact on road construction productivity, and worker issue has less impact on productivity, which verified that large road construction is not a labor driven sector. The research also determined that despite low performance, construction productivity has, in contractors' view, grown in the past five years. Finally, the research provided a list of remedial measures for significant factors on how to mitigate their negative impact. As main recommendations, contractors should develop a productivity measurement system that targets the input resources and the output work in every level. Further, contractors should identify best construction practices by establishing performance goals, and evaluating their performance accordingly.



**Index Terms**— AACRA, ERA, Productivity, Performance, On-site construction, Road Contractors, Remedial measures, Significant factors

## 1 INTRODUCTION

In construction success requires the compliant of knowledge, skill and experience to achieve goals throughout the project life cycle. The construction is a unique industry where field experience plays an important role in maintaining high levels of productivity [9]. Productivity growth is the key economic indicator of improvement [7]. Where construction industry takes about 5% to 10% of total GDP, it's essential to look out the performance of this sector. Dlamini, 2012 [8] found out that there is a strong relationship between construction activity and economic growth, but maintaining requires adaptability.

Business success in a capitalist system depends not only on a high quality product, but also on a constant increase in productivity to stay competitive; this rule certainly applies to construction [6]. Construction companies in these days are not only facing competition within a country, but also globally. These tougher competition and the urge to make a distinction in the market, have spurred companies to press ahead with product and process improvement [5]. In case where the contract price is a fixed one, construction companies have hidden profit margin that can be grasped only by increasing their efficiency and productivity. This gain is one way for Contractors, without compromising quality and time of a construction project, to further upgrade their execution capacity.

Traditional construction project management tools do not address productivity; they include schedule slippages and cost overruns [11]. Construction industry measures performance in terms of budget, schedules and conformation of specification. This is common when a construction project passes through a tight deadline and contractors measures their progress

considering the whole of the work instead per each key item. But, because construction is a labor intensive industry and the rate of automation is less frequent, human factors have a great effect on output. Understanding construction productivity in multi-method approach seems to gain ground, including the softer aspect, such as managerial factors, compared to approaching productivity in purely technical issues such as project time and cost [19].

Productivity improvement program is an ongoing process of managing construction, by established along with the routine work of measuring and benchmarking the daily performance. The main aim is to support contractors in making a decision by introducing new methods and technologies. Example construction productivity improvement program Study done by Minchin & et al, 2011 [15] on a bridge constructed on adverse conditions in Florida, USA, by identifying the challenges facing the construction process, the contractor was able to save 20% of time and effort. The contractors' achievement comes from adjustments in pile driving techniques, better equipment and additional working space.

Developing countries are affected by loss of productivity because they have a limited resource to cover the losses. Such countries characterize to have a large unskilled labor and less in skilled ones. For the work that requires technical skill, in most cases, the unskilled ones train through time in order to meet the requirement. High-end finishing materials, which require advanced technology to produce, are expensive and imported from abroad. In addition, material availability is affected by poor infrastructure of transportation. Contractors are also reluctant to introduce a modernized management system because of lack of capacity or a trend to avoid overheads. There are significant factors affecting productivity identified by researchers in developing countries such as in Thailand [14] lack of material, in Indonesia [3] poor planning and scheduling, and in Nigeria [4] use of the wrong Construction Method. The overall productivity in construction has been greatly affected by regulatory controls, the environment, climatic effects, cost of energy, and other factors [11].

The construction industry in Ethiopia suffers with low productivity performance. The available research materials in this understudied area are small in number and productivity in road projects was not assessed as compared to the attention given to this construction sector. This research chooses AACRA and ERA employed road contractors and tried to identify the significant factors influencing productivity. The AACRA Year Book, 2006 E.C [1] report shows that some of the challenges encountered by the authority are related to contractors' planning and performing capacity. Similar to this report, the 2005 E.C annual report of ERA pointed out that the main challenge the authority faces was related to local contractors work performance and mismanagement.

Although there are other variables, which contribute toward contractor performances, productivity influence physical progress, cost and time. This definitely shows that consideration of factors affecting productivity is one way to understand the problems facing contractors. Paradigm of productivity is that, even though, the project has been implemented according to budget and time, it doesn't guarantee the project is an efficient one, and applying any improvement may not have any result. It's necessary to conduct a study that explores the different factors and measure their importance.

The objectives of this research work were to answer the following questions: What are the factors affecting on-site construction productivity? Which of those factors is significantly affecting the productivity performance of local contractors employed by Addis Ababa city road Authority and Ethiopian Road Authority? And are there any measures to reduce their negative impact and improve on-site construction productivity?

## 2 LITERATURE REVIEW

The need for productivity improvement in construction industry goes far beyond the site condition and emended on the nature of how the construction work is done. Unlike manufacturing activity, where production is governed by the machines, construction depends on the management of information and resource flows [2]. I.e. most Construction processes are not automated and production decisions require human consideration. On-site construction has many unique problems that other industries don't face such as outdoor production, heavy assembly and effects of short duration on management [18].

### 2.1 Construction Productivity Factors from Previous Studies

Productivity in construction is affected by a myriad of issues, including the quality of tools, availability of up-to-date information, and the detail of planning [6]. Factors can be seen as any forces that change the variables of input or output of a construction process. Productivity issues can be divided into macro and micro-level [9]. At the macro level, one deals with contracting methods, labor legislation, and labor organization and at the micro-level, with the management and operation of a project, mainly at the job site. Durdyev and Ismail 2012 [10] classified factors into two broad groups of external and internal constraint. The external constraint contains forces outside the control of project management and grouped under statutory compliance, unforeseen events and other external forces. External forces

relate to economic issues such as inflation, energy crises, interest rate, and rapid technological advances, and political issues such as change in government, and legislation impact on construction. Internal constraints to on-site construction productivity are classified under project finance, workforce, technology/process, project characteristics and project management.

Literature review has identified many factors and their underlying relationship with productivity. Table 2.1 shows all reviewed factors affecting on-site construction productivity.

**Table 2.1 Summary of factors affecting on-site construction productivity**

| No | Group Factors | Factors Affecting On-site Productivity |
|---|---|---|
| 1 | Material | Lack of Materials |
| | | Delays of material delivery to site |
| | | Availability of material |
| | | Inflation / fluctuations in material prices |
| 2 | Drawing | Incomplete drawing |
| | | Needed information not on drawings |
| | | Availability of drawings |
| | | Design change |
| | | Design complexity |
| | | Project complexity: scale and design |
| | | Poor drawings or specifications |
| 3 | Equipment | Lack of tools and equipment |
| | | Tools/equipment breakdown |
| | | Suitability or adequacy of the plant and equipment employed |
| | | There are frequent tools/equipment breakdowns due to aging or poor maintenance |
| | | Inappropriate uses of tools/equipment |
| | | Equipment breakdown |
| 4 | Experience | Level of skill and experience of the workforce |
| | | Operatives do not pose skills and experience to perform the task |
| | | Lack of local experienced labor |
| 5 | Inspection Delay | Inspection delay |
| | | Work delay caused by Inspection delays by the Local Authority |
| | | Stoppage because of inspection delays |
| | | Inspection regime |
| 6 | Shift Work | Shift work |
| | | Poor use of multiple shifts or overtime |
| 7 | Motivation | Lack of labor motivation |
| | | Level of motivation |
| | | Motivation |
| 8 | Skill | Lack of trades' skill |
| | | Level of skill and experience of the workforce |
| | | Skilled workers are not adequate on jobs |
| | | Operatives do not pose skills and experience to perform the task |
| | | Shortage of skilled labor |
| | | Skills and experience of workforce |
| 9 | Specification | Specification and standardization |
| | | Poor drawings or specifications |
| 10 | Rework | Rework |
| | | Change orders and rework |
| | | The works need to be redone because it fails quality control inspection or testing |
| | | The works need to be redone frequently due to poor quality of documents, The jobsite layout is poor |
| | | The work needs to be redone due to changes in design, drawings or specifications |
| 11 | Error in Fabrication | There were errors in fabrication that needs to be corrected in rework |

| | | |
|---|---|---|
| 12 | Absenteeism | Absenteeism |
| | | Absenteeism and turnover |
| 13 | Construction Method | Utilizing the traditional construction methods instead of modern technology |
| | | Inappropriate construction methods |
| | | Construction method |
| | | Poor Construction methods |
| | | Adequacy of method of construction |
| 14 | Turnover | Absenteeism and turnover |
| | | Level of staff turnover/churn rate |
| | | Worker turnover |
| | | Changing of foremen |
| | | Workers turnover and changing crewmembers |
| 15 | Weather | Weather enclosures |
| | | Hot weather |
| | | Cold weather |
| | | Weather conditions |
| | | Weather |
| | | Inclement weather |
| 16 | Safety | Safety |
| | | Accident/Safety |
| | | Management does not support safety plan |
| 17 | Training | Site manager does not have the ability in training workers to perform their jobs properly |
| | | Level of empowerment (training and resourcing) |
| | | Lack of Workforce training |
| | | Lack of training and education to implement and operate new technologies |
| 18 | Project Feature Issue- Site condition | Poor site conditions |
| | | A poor site layout |
| | | Congestion and overcrowding on the site/interference among people |
| | | Poor access to work area (e.g. Poor scaffolds) |
| | | Height of worksite above ground |
| | | Working on the jobsite |
| | | Site irritants - pollution, noise |
| | | Adequacy of site layout |
| | | The site is slippery or steep imposing terrible conditions |
| | | Site conditions: access, subsoil, topography. |
| | | Site location and environment |
| | | The jobsite is too noisy/dusty |
| | | Considerable distance from home or camping site to job site |
| 19 | Planning and Scheduling | Poor planning and scheduling |
| | | There is no construction planning/project schedule in place |
| | | Schedule Pressure caused by the Government |
| | | Job planning |
| | | Lack of Pre-task planning |
| | | Adequacy of planning and risk management process |
| 20 | Cost | High cost of needed resources: material, money & Machinery |
| | | Dispute and litigation costs |
| | | Cost of the wasted materials on site |
| | | High cost of foreign labor |
| | | Lack of cost accounting control |
| | | Insurance costs |
| | | Fluctuations in exchange rate |
| | | Interest rate/cost of capital |
| | | Energy crises/costs |

| | | |
|---|---|---|
| 21 | Technology | Resistance to accept new technologies |
| | | Adequacy of technology employed |
| | | Rapid technological advances |
| 22 | Change Order | Change Order |
| | | Change orders and rework |
| | | Frequency of design changes/ change orders |
| 23 | Project Management | Resistance to change at Management Level |
| | | Better management |
| | | Relationship management/degree of harmony, trust and cooperation |
| | | Project management style |
| | | Project organizational culture |
| 24 | Estimation | Undervalued work |
| | | Poor Estimation |
| 25 | Communication | Poor communication |
| | | Lack of communication between Government Authority and Contractor |
| | | Poor communication between office and field |
| 26 | Overtime | Working overtime |
| | | Occasional working overtime |
| 27 | Other External Factor | Disruption of power services |

A-(Makulsawatudom & Emsley, 2001), B- (Alwi,, 2003), C- (Durdyev & et al., 2013),
D-.(Durdyev & Bakar. 2013), E- (Ghoddousi & Hosseini, 2012), F- (Mojahed, 2005),
G-(Heale,1993).

## 3 RESEARCH METHODOLOGY

The research objectives of this study were: 1. To identify the different on-site productivity factors arising under project level that have constraining effects on construction productivity; 2. To establish the significant factors that influence on-site construction productivity of local road contractors; and 3. To provide remedial measures which minimize the negative impact of factors affecting on-site construction productivity.

This work required the understanding of different factors affecting construction productivity and ranks them according to their degree of influence. The method used to test a wide of variables regarding productivity is qualitative method. Qualitative empirical research is almost exclusively linked to questionnaire surveys in an attempt to explore the role and significance of specific factors which are believed to affect productivity [19]. A questionnaire survey was administered in order to collect the primary data. A close-ended structured questionnaire ensured the integrity of the objectives of the research, and the reliability of collected data. One of the best ways to find the problems in an on-site construction organization or with individual operations is to ask those who are involved day after day since they are often knowledgeable, know what is going on, and have excellent ideas which they are anxious to share with the management [18].

The study population includes local road contractors with grade 4 and higher employed by AACRA and ERA. There are 12 contractors from ACCRA and 41 contractors from ERA, of those 3 contractors involved in both authorities. The total population is 50 high level local road contractors. The data were collected from CEOs, Project Coordinators, Quantity Surveyors, Site Engineers, Superintendent, and other project management participants.

To determine sample size for this research, a statistical method used by considering the precision rate, confidence level and error of estimate.

$$\boldsymbol{n = \frac{z^2 \cdot p \cdot q \cdot N}{e^2(N-1) + z^2 \cdot p \cdot q}} \qquad (1)$$

n = Size of sample
p = Probability of success
q = Probability of failure
e = Acceptable error (the precision)
N = Total population
z = Standard variation at a given confidence level

For this research, 95% confidence level where z=1.96, e=0.05, p=0.5, q=0.5, N=50 has been taken.

$$n = \frac{1.96^2 \cdot 0.5 \cdot 0.5 \cdot 50}{0.05^2(50-1) + 1.96^2 \cdot 0.5 \cdot 0.5} = 44.34 \cong 44$$

The survey questionnaire consists of four separate sections. The first section covered the company information such as the age of the company, the type and level of the company, and the number of workers employed. The second section inquired about the respondent's work experience, age and position in their company. The third section tried to find the view of respondents in the current state of construction prod-

uctivity and their insight on contractors' productivity improvement practices. The last section is letting the respondent to rank different factor affecting construction productivity based on their negative impact.

The Summated or Likert-type Scale was used to rate each factor. The advantages to use such scale are, respondents answer each statement included in the instrument: enable to compare the respondent's score with a distribution of scores from some well-defined group: and permits the use of, statements that are not manifestly related (to have a direct relationship) to the attitude being studied [13]. The rating system consists of five positions that designate 1 as Insignificant, 2 as less significant, 3 as moderately significant, 4 as Significant, and 5 as highly significant.

### 3.1 Data Processing and Analysis Technique

After data collection completed, using the appropriate measuring tool is necessary to analyze and interpret the final data. Measuring requires allocating numerical values into the variables of the instrument used. There are different measuring scale used in the research area such as nominal scale, ordinal scale, interval scale and ratio scale. From those scales, ordinal scale is a suitable in ranking productivity factors based on a Likert scale. Ordinal scale is used in ranking or a rating of data, which normally uses integers in ascending or descending order. The number assigned to the agreement scale (5, 4, 3, 2, 1) does not indicate that the interval between the scales are equal, nor do they indicate absolute quantities [20].

**Table 3.1 Ordinal Scale**

| Position | Scale |
|---|---|
| Insignificant | 1 |
| Less significant | 2 |
| Moderately Significant | 3 |
| Significant | 4 |
| Highly significant | 5 |

In order to analyze and rank factors affecting construction productivity, relative importance index (RII) is used. RII enables to have a cumulative response of summated scale questionnaire and is given by:

$$Relative\ Importance\ Index\ (RII) = \frac{\sum_{i=1}^{5} w_i x_i}{\sum_{i=1}^{5} x_i} \qquad (2)$$

Where:
$W_i$ = The weight given by each respondent
$X_i$ = The percentage of respondents scoring
$i$ = The order number of respondents

## 4 FINDINGS AND DISCUSSION

The analysis was based on the weight of different factors, by respondents as they see productivity by their own experiences in working place and their views.

### 4.1 Questionnaires Response Rate

A total of 44 contractors was included in this survey were 50 questionnaires distributed to maximize the response rate. On the final date of the questionnaire, 42 responses were recovered from 34 contractors. This shows that the response rate for the questionnaire was 80% with 77% contractors' participation which is satisfactory. There were 2 questionnaires submitted with incomplete, missing data which were removed from the analysis.

**Table 4.1 Questionnaire Response**

| Questionnaire Distributed | Questionnaire Received | Surveyed Contractors | Participated contractors | Response rate (%) | Participation rate (%) |
|---|---|---|---|---|---|
| 50 | 42 | 44 | 34 | 80% | 77% |

Among 34 contractors involved in the survey, 32 were grade 1 contractors and 2 were grade 2 contractors. Similarly, there were 2 contractors specialized in road construction and the rest are general contractors. From those contractors 44% were established before 20 years ago, and 35% percent between 10-20 years. 50% contractors said they employed more than 1000 employees under their company. Also, 58% of the contractor said they manage a range of 1 to 5 active projects per year compared to 20% who handled up to 10 projects per year. 18% of the contractor said they handled up to 20 projects per year and 5% have more than 20 contracts per year.

**Table 4.2 Contractors' Experience**

| No. of years of Experience | Contractors | |
|---|---|---|
| | No. | % |
| 1-5 years | 2 | 6 |
| 5-10 years | 5 | 15 |
| 10-20 years | 12 | 35 |
| Above 20 years | 15 | 44 |

### 4.2 Characteristics of Respondents

The characteristics of the respondents on section 2 were used to show the experience of the professionals involved in road construction projects. The respondents had been given an adequate time to fill the questionnaire and any confusion has been thoroughly communicated and solved. Among the total respondents, 5% have a position of project manager in their company. 37.5% of the respondent work as an office engineer with different level of experience. 57.5% percent of the respondents are working in various positions such as

Construction Managers, Construction Heads, Project Coordinators and Contract/site engineers.

**Table 4.3 Types of Respondents**

| Respondent | No. | % |
|---|---|---|
| Construction Dep. Managers | 8 | 20 |
| Construction Heads | 4 | 10 |
| Project Coordinator/Engineer | 5 | 12.5 |
| Project Managers | 2 | 5 |
| Contract Engineers | 6 | 15 |
| Office Engineers | 15 | 37.5 |

26% of respondents have experience with more than 10 years, 41% of the respondents have experience between 6 to 10 years. Also, the 28% of the respondents have 3 to 5 years work experience and another 5% of respondent with experience less than two years.

**Table 4.4 Respondents' Experience**

| Experience | Respondents | |
|---|---|---|
| | No. | % |
| 1-2 years | 2 | 5 |
| 3-5years | 11 | 28 |
| 6-10years | 16 | 41 |
| Above 10 years | 10 | 26 |

### 4.3 Perception of construction Productivity

The respondents were asked to measure the overall growth of construction productivity. Of the entire respondents, 80% said that road productivity has shown improvement and growing in the past five years. On the other hand, 10% of the responses expressed overall productivity growth in road sector is not encouraging and even its in decline. The other 10% showed that the overall road productivity has not changed in past five years. This shows that 20% respondent doesn't believe, taken as a whole, productivity growth exist.

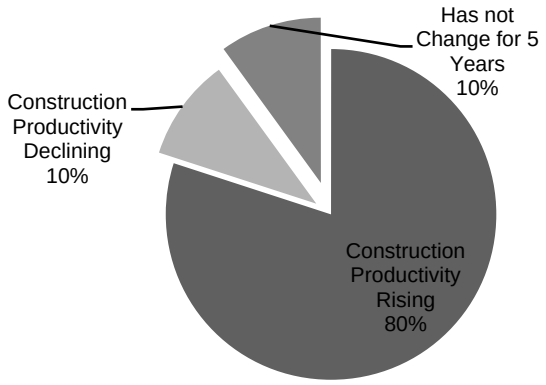


**Figure 4.1 Perceptions on Growth of Construction Productivity**

Whether there is a priority given to productivity; more than half of the contractors, about 58% give a very high priority to improve productivity. 40% of contractors also gave medium priority in advancing the efficiency in their company. A very small number of contractors give low priority to productivity. These results showed that almost all construction companies in the survey have in one way or the other had awareness in measuring production. Contractors were also asked if they have a separate management system which measures construction productivity, and use the outcome to identify construction methods. 75% of the contractors have a separate system to benchmark productivity. The other 25% contractors have no structure to measure productivity. Measuring productivity is not adequate if not practiced at all levels of management. This is because Contractors who measure productivity have performance of their company at all levels and so that management decision can be done with all levels being inclusive.

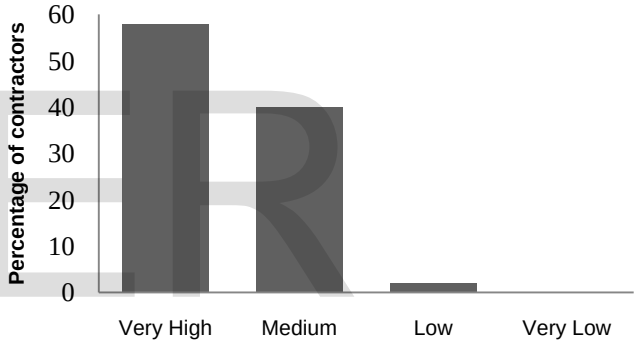


**Figure 4.2 Priority given to productivity**

38% respondents said there is productivity measurement at company level. At this level measuring the whole or partial performance of the contractors in terms of gross profit is common. Another 43% said there is a measurement taken at project level and 18% percent target at field level. Assessing performance at project level is an industry standard where projects are evaluated based on progress, and the amount of work executed again the expense of the project. Field level requires following every resource in the project compare to another level it's the less practiced. 38% of contractor said they follow up productivity at the activity level.

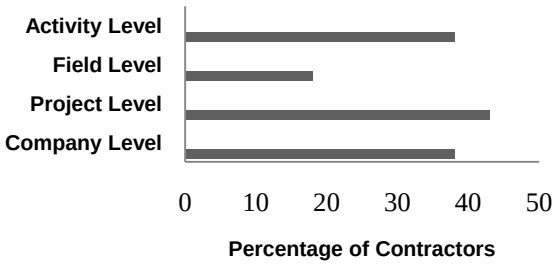


**Figure 4.3 Productivity measurement level**

### 4.4 Significant factors affecting construction Productivity

The construction process is an environment with many resources and managerial decisions that creates a large number of direct and indirect issues impacting performances. Among those twenty seven factors identified through the theoretical review of previous studies in different countries which have direct impact on on-site productivity. The respondent weight each factor for less significant as 1 to Highly Significant as 5 based on their impact. Using Equation 2, Relative Importance Index was calculated in ranking factors according to their degree of influences. Before analysis, all gathered responses were checked for any incomplete data for making sure consistencies. Table 4.5 shows the ranking of different factors, according to RII values. All of the factors have RII greater than 0.5 which shows all factors have more than average influence on productivity.

**Table 4.5 Ranked Factors based on RII value**

| No. | On-site Factors Affecting Construction Productivity | RII | Rank |
|---|---|---|---|
| 1 | Poor Planning and Scheduling | 0.900 | 1 |
| 2 | Failure to Follow Project Schedule | 0.875 | 2 |
| 3 | Wrong Construction Method | 0.825 | 3 |
| 4 | Failure to Maintain Equipment on Time | 0.810 | 4 |
| 5 | Incomplete Drawing | 0.805 | 5 |
| 6 | Unfavorable Weather Condition | 0.800 | 6 |
| 7 | Lack of Technology Adaptation | 0.795 | 7 |
| 8 | Wrong Estimation | 0.790 | 8 |
| 9 | Lack of Equipment | 0.780 | 9 |
| 10 | Lack of Qualified Workers | 0.775 | 10 |
| 11 | Lack of Skilled Workers | 0.770 | 11 |
| 12 | Unexpected Site Condition | 0.765 | 12 |
| 13 | Rework | 0.760 | 13 |
| 14 | Lack of Motivation of Workers | 0.750 | 14 |
| 15 | Delay in Inspection | 0.745 | 15 |
| 16 | Lack of Materials | 0.740 | 16 |
| 17 | Frequent Change Order | 0.735 | 17 |
| 18 | Poor Communication | 0.710 | 18 |
| 19 | Unsafe Working Condition | 0.675 | 19 |
| 20 | High Turnover | 0.660 | 20 |
| 21 | High Cost of Resources | 0.650 | 21 |
| 22 | Project Complexity | 0.645 | 22 |
| 23 | Job Site Congestion | 0.635 | 23 |
| 24 | Work Stress | 0.630 | 24 |
| 25 | Absenteeism of Workers | 0.625 | 25 |
| 26 | Long working Hours | 0.600 | 26 |
| 27 | Working at Night | 0.595 | 27 |

### 4.5 Discussion of Results on construction productivity

**Poor Planning and Scheduling**

The respondent ranked poor of planning and scheduling to have the highest impact on productivity with RII 0.9. The impact of scheduling on construction productivity also aligned with the failures of sizable contractors to deliver on time on ERA and ACCRAs' Projects. In addition, the analysis showed that more than 60% of the respondent thought that planning have a highly significant effect on productivity. This emphasis of a planning stage of construction is crucial, and the use of planning to coordinate various resources to the activity in the project is very essential. The direct impact of lack of planning on productivity lies if there is no plan to know what type of resources needed into activities, and project managers are forced to choose at every step. The advantages of proper planning for the contractors are many, as it provides the financial requirement of the project in different stages. This gives projects the capacity to facilitate the long process of procurement of materials and equipments ahead of time. The other advantage for project administrator in doing the planning is they can monitor the objectives of the project with their accomplishment. The level of detail seen on the plan is also crucial in providing the direction of the project. One of identifiable problems is that contractors don't give enough time for planning process. They are constrained to submit the master plan that roughly done without considering the specific risk challenge of the project. If the time of awarding a contract to mobilization is relatively short, the problem becomes significant.

**Failure to Follow Project Schedule**

The second ranked factor influencing on-site productivity is failure to follow a project schedule with RII 0.875. This result shows how closely is the relationship with factor no. 1, and verify the interlinks between planning and execution stage. One of the problems often scheduling is the small participation of project people in formulating the master schedule and the subsequent details. This creates the lack of ownership toward the schedule. The other problem is the failure to prepare a detail periodic plan from the project schedule. The absence of a monitoring culture of the daily routine also linked with Project people struggle to update their schedule, which often leads to wrong decisions. The relationship of a schedule and productivity

is the rate used in calculating the time required to complete the activities and the cost they incurred. The baseline productivity rate is not commonly transferred from the planning people to project people. These leaves mangers only to follow the aggregated elapsed time, which leads to project people not to verify the baseline rate with actual rates.

**Wrong Construction Method**

The third most significant factor is the use of wrong construction method with RII 0.825. Almost half of the respondents i.e. 47.5% said the use of improper method have a high impact on on-site construction productivity. Construction method is directly related to achieving high technical efficiency in construction. The choice of construction method is one of the most important issues that the contractor focuses. Especially road construction is a machinery intensive work, the consequences of wrong construction are high. Further, road construction is involved with earth work with the unpredictable Geotechnical condition, it requires adapting or changing construction method. Although there are many reasons in choosing construction methods, specification and cost play a significant role. To use improper construction methods leads to low quality work and sometimes leads to rework. A proper construction method enables construction work to complete the work with short time. But the problem with in designing construction method is it requires time, knowledge, and experience in construction which contractors think they are limited resources. In most cases project people fail to ask questions such as is traditionally accepted methods are scientific? What are the techniques to be used to accomplish the work? And are there new technologies to be adapted in the process? Another problem of contractors is that they don't document the technique they used in other projects and develop methods as a guideline.

**Failure to Maintain Equipment on Time**

The fourth significant factor is the failure of the contractor to maintain their equipment on time with RII 0.810 and 37.5% percent of the respondents said it has a high impact on productivity. There are different types of machineries involved in road construction which maintenance is necessary to reduce idle time. The most common failure of contractors is to routinely service their machinery by required skilled people. This may lead sudden breakdown of machineries which affect the equipment productivity. The loss of on-site productivity results from breakdown time and the waiting time of subsequent works and workers. The other problem is contractors usually don't regularly keep the history of the equipment they own. If they have the record they can determine the depreciation of equipment and the operation cost.

**Incomplete Drawing**

The fifth significant factor ranked by the respondent is incomplete drawing with RII 0.805. Complete drawing enables the project engineers to mobilize resources and sequence of understand the work. There are different reasons for incomplete drawing. One reason is a fast track design process that doesn't provide enough time for the designer to include all project elements that may affect the design. Another problem is the short time given for tender process for the contractor to assess the design with the actual project setting. Even after the award of the contract engineers also fail to review the design details once the construction process started. When incomplete drawing occurred contractors request clarification from the consultant. If the request is not responded at the required time, it creates resources to be idle and loss their productivity. Work which is done with partial drawing also has a consequence of complete rework or partial modification. Incomplete drawing also leads to erroneous estimation that becomes deployment of unnecessary resources to project site. The Lack of good communication between the consultant and the contractor also lengthens the request time. The other reason for incomplete drawings is because of incompetent consultant with lack of experience and knowledge.

**Unfavorable Weather Condition**

The weather is ranked the six significant factors influencing construction productivity with RII values of 0.80. Road construction is closely related to weather conditions since the surface condition is easily affected such compaction of sub grade, asphalt concrete laying or Bridge construction. Weather conditions can be a heavy rain, extreme heat condition. The geographical area that Ethiopia is, weather can be problematic. There are regarding rain, in most cases, contractors have an obligation to avoid schedule in rainy season. Although contractors plan through the dry season, rain can be unpredictable and sudden. In such cases machineries will be idle, roads to quarries will be inaccessible and in the worst cases landslide and floods can occur. Extreme high temperature is also another problem that contractors face in some region. High temperature creates unfavorable conditions in asphalt compaction if there is no technical solution given. Some machinery doesn't work in extreme temperature. The projects also unable to work through the daytime, where productivity expected to become high. With these forces contractors to pay extra time and work at night time.

**Lack of Technology Adaptation**

Respondents rank lack of technological adaptation in construction process as the seventh significant factor affecting productivity with RII 0.795. This factor influ-

ence is necessary, especially for the construction industry as young as Ethiopia in building capacity and as road construction that heavily relies on machineries. Contractors are reluctant in introducing new technology because it requires trained personnel, the cost of introducing technologies and the operational requirement needs. Technology is necessarily linked to machinery; contractors also challenged in using partially or solely software to assist the management of construction such as technology to keep, analyze, and interpret productivity and project performance.

**Wrong Estimation**

Wrong estimation is the eight significant factors affecting on-site productivity with an RII value of 0.79. Estimation is the source of cost and time needed for a project. Projects suffer from the accuracy of estimations. Error in estimation can be related to the quantity of work, contract rate and time schedule. Wrong estimation is also one of the sources of variation. The direct negative effects on productivity are contractors forced to add additional resources or/and to increase load on the existing resources. Initial productivity rates also become the source of error if they are not updated. The level of detail in estimation is important. If the estimation is broad, the error is very high. In such cases it takes a reasonable time for the Employee to collect additional funding for the project. On the contractor's side, wrong estimation incurs to incorrect plan, and excess or limited resource for the site.

**Lack of Equipment**

Lack of estimation is the ninth factor which respondent ranked which influence on-site contraction productivity with RII 0.78. Shortage of equipment can occur when proper machineries not available for the project or the missing of a part or parts of the equipment. The lack of equipment idle the project workers and materials needed for the work. Lack of rental machineries also affects production in the site.

**Lack of Qualified Workers**

The tenth factor is lack of qualified workers in a project with RII 0.775. Because of the diversity of skills and knowledge required in construction, putting the qualified person for those responsibilities is critical. A qualified person expected to be familiar with the specific knowledge the position required. Experience is also one of the requirements that contractors need. Because construction project uniqueness carry different challenges, it requires core knowledge to solve problems and experience that can reduce the learning time of project engineers. A qualified person is expected to pass decision quickly and choose a productive construction.

**Other Significant Factors Affecting Productivity**

Lack of skill in worker ranked as 11$^{th}$ most significant factor, the factor of lack of qualification. That shows skill and qualification are seen closely by the respondent. Unexpected site condition and rework ranked as 12$^{th}$ and 13$^{th}$, respectively. Unexpected site condition such as the erratic soil condition which were not seen in Geotechnical investigation. Rework can be seen as the effect of other factor and in return causes loss in construction productivity. The other factor is Lack of motivation of worker ranked as the 14$^{th}$ factor affecting productivity. Workers who lack motivation tend to give less than of their knowledge and potential. Delay in inspection ranked as the 15$^{th}$ factor affecting on-site productivity. If the approval of the work is not done within a short time, it idles laborer and site equipment. The 16$^{th}$ factor affecting productivity is lack of material in the project site. Materials if not purchased quickly or delivered to site accordingly, machineries and works forced to wait. The impact on productivity is high when the unavailable material such as asphalt, quarried material, gasoline and others affect critical activities. 17$^{th}$ significant factor is a frequent change order given by the Engineer. Frequent changes demoralize workers and act as a setback in work performance. Workers are also reluctant to demolish or make a change to a work they think they already finished. The 18$^{th}$ and 19th significant factors are poor communication and unsafe working condition. If a project has poor communication, information cannot be transferred fully and effectively. Personal conflict and lack of interpersonal skills can also become the source of poor or broken communications. If project people fail to report problem occurred to higher manager and vice versa that creates an information gap that leads to wrong decisions. Unsafe condition creates injuries to workers that creates loss of labor, and damage to machineries. High turnover and high cost of resources ranked as the 20$^{th}$ and 21$^{st}$ factors affecting productivity, respectively. High turnover creates an information and management gap between the new and the old workers which leads to loss in productivity. High cost of resources if it especially happens in sudden creates a strain in finance and even leads to cost escalation and become a prime source of reason for other factors to occur. The 22$^{nd}$ and 23$^{rd}$ ranked factors are project complexity and job site congestion, respectively. If project is a complex one with the requirement of special knowledge, and it's beyond the experience of that contractor, that creates a technical difficulty and a long path of learning curve. Even though site congestion is seldom in highway construction because of wide right of way, road construction in urban areas, and bridge construction in small could definitely impact productivity. Machineries couldn't maneuver freely, and transportation of materials to the site becomes difficult in congested site.

Work stress and absenteeism of workers are the 24th and the 25th significant factors, respectively, influencing productivity. Workers in a very stressful job condition often make mistakes, and sometimes it can lead to conflict. Absence of workers becomes a critical problem if there is no solution quickly. The absence of operators can idle equipment. The follow up of managers and engineers leads to wrong construction output. 26th factor affecting productivity has long worked hours. Workers need to recap physically and psychologically after eight hours work. But, if they are forced to work beyond eight hours repeatedly, those recoveries become difficult, and create cumulative physical exhaustion and even de-motivation of workers. Working at night is the 27th factor which is the least, but still a significant factor affecting on-site construction productivity. Working at night is unproductive because of high payment to workers, low range visibility and high risk of accidents.

### 4.6 Group Factors Affecting On-site Construction Productivity

As determined in the literature review, factors affecting productivity are divided into six major issues. These are management issues, workers' issues, work condition issues, site supervision issues, technological issues, and project feature issues. These enable us to give a comparison with their respective factors and prioritize them accordingly.

**Management Issues**

Management factors are grouped with average RII 0.772. Poor planning and scheduling is the highest ranked factor and job site congestion is the lowest factor in management issues.

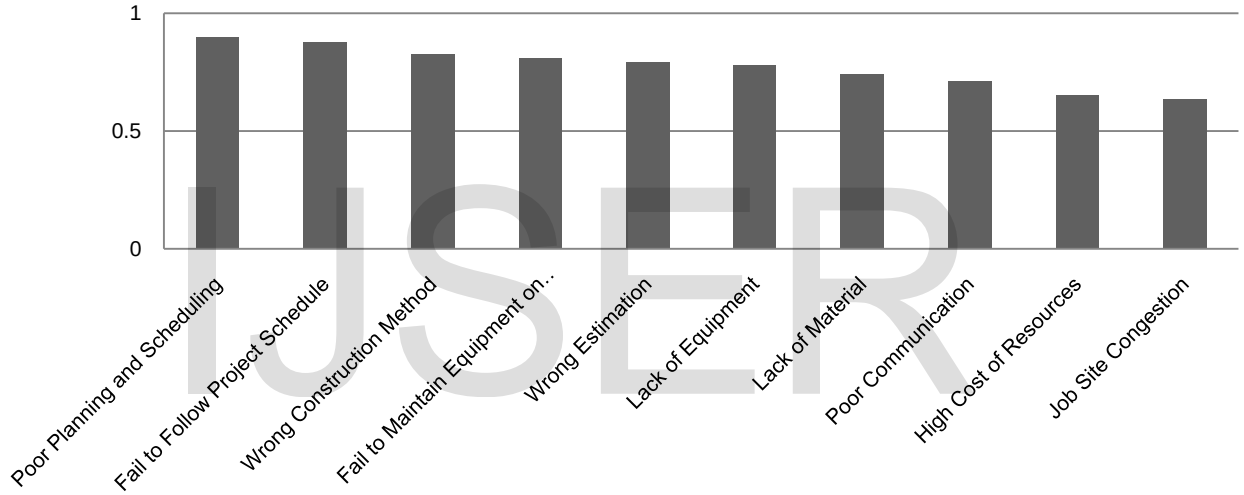


**Figure 4.4 Management Issues**

**Workers issue**

Workers issues are grouped with average RII of 0.677. 1st ranked factor is Lack of qualified workers and working at night is the least factor affecting productivity.

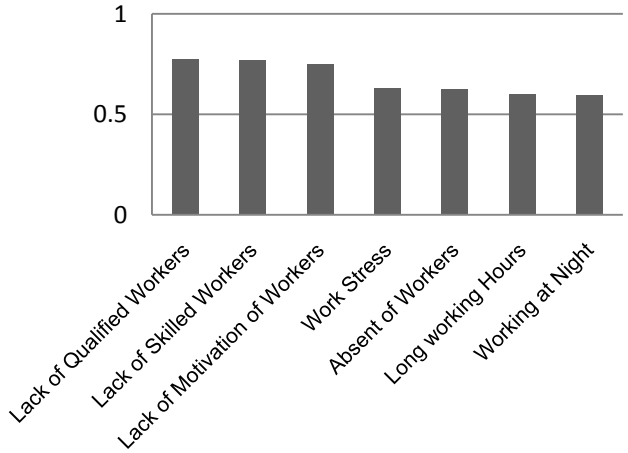


**Figure 4.5 Workers Issues**

**Work condition issues**

Good working condition enables workers to do their job effectively, and project to function well. Fig. 4.6 shows different factors arising from the project. Work condition issues have an average RII of 0.725.

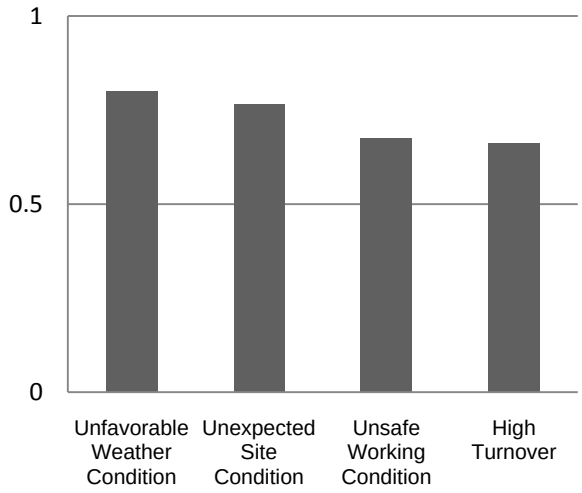


**Figure 4.6 Work Condition Issues**

**Site Supervision Issues**

The major task in monitoring and assuring project performance is to carry out well organized site supervision. Site supervision issue has an average of RII 0.761.


**Figure 4.7 Site Supervision Issues**

Other issues are a single factor issue with lack of technology adaptation with RII 0.79 and project feature issue with project complexity with RII 0.645.

### 4.7 Comparison of Factors Affecting On-site Construction Productivity

Comparison of the result of this research with studies in other countries has been done. Table 4.6 contains studies done in two developed countries and in three developing countries. The comparison showed that factors affecting construction productivity vary from country to country. Not only this, factors vary based on construction sectors, geographical location and even grades of construction companies. As an example, if we look for the first ranked factor in this study, which is 'poor planning and scheduling', its 5th ranked factor in Indonesia and 2nd place in the United States, and it is not a significant factor in the other countries. If we look further, 'wrong construction method' is the 3rd significant factor affecting productivity in this study, it is the 7th ranked factor in Indonesia and the 8th ranked factor in Nigeria and USA. The other comparison is that, in this study the top factor relates to management issues; but when we see the other countries, only in Thailand and Nigeria had the top issue related to management. All the top four factors in this study are related to the management issue compared to other countries where other half or less half of the top factor relates to management.



**Table 4.6 Comparison of Top Ten Significant Factors Affecting Productivity**

| No. | Current Study | (Makulsawatudom & Emsley, 2001)(Thailand) | (Alwi, 2003) (Indonesia) | (Odesola et al., 2013)(Nigeria) | (Mojahed, 2005)(USA) | (Heale, 1993) (Canada) |
|---|---|---|---|---|---|---|
| 1 | Poor Planning and Scheduling | Lack of material | Design changes | Availability of material | Skills and experience of workforce | Effect of contract type |
| 2 | Failure to Follow Project Schedule | Incomplete drawing | Lack of trades' skill | Specification and standardization | Job planning | Constructability |
| 3 | Wrong Construction Method | Inspection delay | Slow in making decisions | High quality of required works | Worker motivation | Inspection regime |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | Failure to Maintain Equipment on Time | Incompetent supervisors | Poor coordination among project participations | Availability of drawings | Better management | Change orders |
| 5 | Incomplete Drawing | Instruction time | Poor planning and scheduling | Project goals and milestones | Shortage of skilled labor | Availability of working drawings |
| 6 | Unfavorable Weather Condition | Lack of tools and equipment | Delays of material delivery to site | Working overtime | Late material fabrication & delivery | Site layout |
| 7 | Lack of Technology Adaptation | Poor Communication | Inappropriate Construction Methods | Working within a Confined space | Lack of Pre-task Planning | Task sequencing |
| 8 | Wrong Estimation | Poor site conditions | Design changes | Construction method | Poor Construction methods | Materials management |
| 9 | Lack of Equipment | Change orders | | Poor access to work area (e.g. Poor scaffolds) | Safety | On-site storage |
| 10 | Lack of Qualified Workers | A poor site layout | | Design complexity | Poor drawings or specifications | Gov., and regulatory inspections |

## 5 CONCLUSION

Low contractor's performance in road sector has been a great concern in Ethiopian and construction industry cannot have good performance without improving its productivity. Companies that thoroughly measure productivity and evaluate every day activities are few. This study qualitatively identified critical factors leading to the loss of productivity. In this regard, extensive literature review was done and the 27 factors affecting productivity were identified. This research found out that Management issues have a significant impact on road construction productivity, and worker issue has less impact on productivity, which verifies that large road construction is not a labor driven sector. The research also found out that despite low performance, construction productivity has, in contractors view, grown in the past five years. The data were analyzed using RII and ranked based on their value. The analyses indicated that the most significant factors affecting productivity are:

1. Poor Planning and Scheduling
2. Failure to Follow Project Schedule
3. Wrong Construction Method
4. Failure to Maintain Equipment on Time
5. Incomplete Drawing
6. Unfavorable Weather Condition
7. Lack of Technology Adaptation
8. Wrong Estimation
9. Lack of Equipment
10. Lack of Qualified Workers

Contractors usually prepare plans and submit working schedule at project commencements as mandated by the owner. But, the result shows that contractors lack planning every detail of the project. Contractors also are short of following the project schedule. One of the major problems is that the contractors don't give enough attention to planning and its output. Contractors also relied on the skill, and knowledge of their engineers in determining the construction method they use. This may cause engineers to follow the traditional approach over scientific.

## RECOMMENDATIONS

**Recommendation to the contractors**

- Contractors should develop a productivity measurement system that targets the input resources and the output work in every level.
- The contractor should use the concept of benchmarking in improving productivity. They should identify best construction practices by establishing performance goals, and evaluating their performance accordingly. They should dedicate resources in introducing new construction technologies and push other stakeholders to adopt that new knowledge on their decision. The contractor should use the power of software in order to keep project information such as productivity history and use it for making decisions.
- Contractors should prepare a very detailed project schedule that integrates time and resources on the schedule. The contractor should thoroughly check the initial estimate at bidding process and inform any error to the consultant before proceeding with the planning stage. Contractors shall use meteorological data forecast in preparing their schedule. The Contractors should develop pre-construction

plan that emanates from the detailed schedule, before mobilizing resources to activities. The pre - construction plan should include detailed work methods and resources needed on the field level. They should check their productivity and progress on everyday basis.

- The contractor should be committed to their equipment life. They should develop a routine maintenance schedule for their machineries. The contractor should provide training for equipment operators regarding equipment, safety and easy maintenance. Contractors should be committed in modernizing their company in order to be competitive. They should introduce new machineries and management system which help for efficient performance, and they should always measure their impact on construction output. Further, they should standardize their construction method so that variation in construction productivity among projects can be minimal.
- Before proceeding to construction work, Contractors should thoroughly confirm the completeness of the drawing provided.

**Recommendation to other Stakeholders**

- Government should provide an indicator for construction that states the performances of key productivity indicator such as labor wage index, labor-machinery output, that show the status of contractors' productivity performance.
- In tender process, ERA and AACRA should use a higher percentage point for technical capacity and history of contractors' of project performance in selecting contractors.

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## REFERENCES

[1] Addis Ababa City Road Authority (2006 E.C) *Year Book*, Addis Ababa.

[2] Alarcon, L. (Ed.) (1997) *Lean Construction*, 1st edition, Rotterdam: A.A. Balkema.

[3] Alwi, S. (2003) 'Factor Influencing Construction Productivity in the Indonesian Context', Eastern Asia Society for Transportation Studies, 1557-1571.

[4] Ameh, O.J. And Osegbo, E.E. (2011) 'Study of Relationship Between Time Overrun and Productivity on Construction Sites', *International Journal of Construction Supply Chain Management*, vol. 1, no. 1, pp. 56-67.

[5] Atkin, B. And Borgbrant, J. (Ed.) (2010) *Performance Improvement in Construction Management*, 1st edition, Borgbrant: Spon Press.

[6] Bernold, L.E. And AbouRizk, M.S. (2010) *Managing Performance in construction*, 1st edition, New Jersey: John Wiley & Sons, Inc.

[7] Blaug, M. (2009) 'The Economics of Productivity', *The International Library of Critical Writings in Economics*, pp. 10-28.

[8] Dlamini, S. (2012) 'Relationship of construction sector to economic growth', *Unpublished Article*.

[9] Dozzi, S.P. And AbouRizk, S.M. (1993) *Productivity in Construction*, Ottawa: National Reseach Council Canada.

[10] Durdyev, S. and Ismail, S. (2012) 'Pareto Analysis of On-site Productivity Constraints and Improvement Techniques in Construction Industry', *Scientific Research and Essays*, vol. 7, no. 7, February, pp. 824-833.

[11] Forbes, L.H. And Ahmed, S.M. (2011) *Modern Construction Lean Project Delivery and Integrated Practices*, 1st edition, Taylor & Francis Group, LLC.

[12] Heale, D.G. (1993) *Thesis on Qualitative and Quantitative Analysis of Factor Affecting Construction Productivity in Canadian Construction Project*, Memorial University of New foundland.

[13] Kothari, C.R. (2004) *Research Methodology:Methods and Techniques*, 3rd edition, New Delhi: New Age International (P) Ltd.

[14] Makulsawatudom, A. And Emsley, M. (2001) 'Factors affecting the productivity of the construction industry in Thailand: the project managers' perception', 17th Annual ARCOM, Akintoye, 281-290.

[15] Minchin, R.E., Lewis, D.W. And McLeod, L. (2011) 'Improving Productivity on a Troubled Bridge Project', *Journal of Construction Engineering and Management*, vol. 137, no. 5, June.

[16] Mojahed, S. (2005) *doctoral thesis on A Project Improvement System for Effective Management of Construction Project*, Louisiana State University and Agricultural and Mechanical College.

[17]Odesola, I.A., Otali, M. And Ikediashi, D.I. (2013) 'Ethiopian Journal of Environmental Studies and Management', *Effect of Project-Related Factor on Construction Labor Productivity in Bayelsa State of Nigeria*, vol. 6, pp. 817-826.

[18] Oglesby, C.H., Parker, H.W. And Howell, G.A.

(1989) *Productivity Improvement in Construction*, 1st edition, McGraw-Hill, Inc.
[19] Panas, A. And Pantouvakis, J.P. (2010) 'Evaluating Research Methodology in Construction Productivity Studies', *The Built & Human Environment Review*, vol. 3, no. 1.
[20] Naoum, S.G. (2013) *Dissertation Research and Writing for Construction Students*, 3rd edition, Abingdon: Routledge.