

Work Measurement Techniques Utilized by The Building Industry in The Midlands Province Of Zimbabwe

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Abstract

The Zimbabwean construction industry, both in the private and public sector, is characterized by cost and time overruns. Whilst the causes are innumerable, labour productivity control, through use of effective work measurement techniques, is paramount as labour constitutes a considerable portion of any construction project. It is therefore expedient that an investigation of the work measurement techniques utilized by the industry be undertaken. Focus was made on the Midlands province, it being resident to a considerable number of mining entities undergoing building construction growth momentum on the back of significant investments since 2009. The survey was undertaken through use of interview administered questionnaires on Construction Industry Federation of Zimbabwe registered companies that are resident in the province and on those that have undertaken or are undertaking construction projects within the same province. Construction companies in the Midlands province have overwhelmingly, albeit inappropriately, used the estimating technique as alluded to by 95% of the respondents. The outputs generated from use of this technique are significantly different from the actual outputs directly causing time overruns on the project sites. The other methods of time study at 33%, work sampling at 10% and synthesis at 5% have been sparingly utilized. The results from the use of time study and work sampling in combination with the estimating technique are within the allowable limits and hence these projects have no time overrun concerns emanating from the use of these techniques.

Keywords: Labour productivity, Cost and Time overruns, Work measurement techniques, Zimbabwe

1.0 Introduction

Improvements in construction productivity have a significant impact in improving a country's gross domestic product [10]. They further report that economic progress is dependent upon capital investment and economic stability is significantly affected by the rate of construction activity. In Zimbabwe, time overruns and high labour costs affected construction companies through reducing profitability and negatively impacting on the companies' reputation [20]. Since construction projects are based on repetitive processes, for example bricklaying and plastering, successful planning of these processes can result in time and cost savings over the duration of the projects [12]. To achieve this, companies have to undertake productivity measurement and improvements through implementation of various work measurement techniques. Work measurement is the periodic or continuous application of different techniques designed to establish the time for a qualified skilled worker to undertake a task at a defined rate of working or at a defined level of performance, time and quality being critical elements [1]. Increasing the overall productive use of labour hours, by application of process productivity measurement, analysis and improvement, results in accurate productivity standard output rates at task level

[13]. Productivity increases as the required skilled labour resources are minimized and non-productive time is reduced from the tasks within a construction project [4].

However, a major challenge facing the industry is that it is difficult to obtain a standard method to measure labour productivity as construction projects are complex in nature, having their own unique characteristics [27]. Productivity, especially in the construction industry, has been very difficult to measure and control and every error in productivity estimation causes an inverse effect in the actual cost and time of labour to perform a scope of work [4]. The average productivities are usually available as an aid for estimation, but these averages must often be modified in light of the special conditions of a job or site [14]. Therefore, it is firmly believed that going back to the basics of effectively measuring labour productivity at the task level would be necessary in facilitating improvements and also deal with those factors that affect the specific sites.

Productivity benchmarking and the computation of wage rates within the Zimbabwean construction industry are guided by the National Employment Council (NEC) for the Construction industry. Of concern is that the required output levels are substantially different from what the contractor organizations are using. This has affected project delivery by causing delays and high costs of labour [9]. This is despite the effect of known factors that have negatively affected the construction industry by reducing craftsmen productivity. Investigated factors that affect construction productivity include issues of technology utilization and availability of skilled labour [6]. In Zimbabwe, skilled labour migration to neighbouring countries has affected the country since the advent of the economic meltdown just after the turn of the millennium. This is supported by [7] when he reports that Zimbabwe has experienced brain drain especially to neighbouring South Africa. The unavailability of skilled labour was and probably still is a major challenge for the Zimbabwean construction industry [8].

This research is part of a broader study on the effectiveness of the work measurement techniques that are being utilized in Zimbabwe. Existence of variable techniques, and their inherent limitations and advantages the world over, has brought about a need to investigate and assess the techniques utilized by construction industry so as to improve labour performance on construction sites. Therefore, this study sought to investigate the work measurement techniques utilized within the Zimbabwean construction industry. Effective work measurement techniques and subsequent achievable standard outputs will greatly improve productivity, efficiency, profitability, growth and reputation for construction companies and also positively affect national construction performance.

2.0 Productivity and Productivity Measurement

The International Labour Office [17] defines productivity as the comparison between how much you have put into the projects in terms of resources and the result you get out of the project. Hence, construction labour productivity has to do with the efficiency of production, making a site more productive by getting more output for least cost in least time and up to required quality [2].

Time standard outputs are important for estimating and planning purposes, either to decide the labour strength necessary to produce a required qualitative output, or to forecast the possible output from labour force available [4]. Their accuracy and relevance are enhanced through continuous use of work measurement techniques. The assertion that labour productivity has a major impact on whether a construction project is completed on time and within budget is supported by [18]. Therefore, it is important for construction organizations through their head office and site management to effectively measure and improve the conditions that affect labour productivity on their jobsites. Further to this, [37] reports on the need to apply appropriate techniques to the type of work undertaken as this contributes to their effectiveness. The challenge within the Zimbabwean construction industry is that the existing databases at national level, from which construction companies can seek productivity data, are not periodically adjusted to suit changing trends. Thus a platform for extensive variability in cost estimating is created.

2.1 Work Measurement Techniques

This study considered time study, work sampling, estimating and synthesis for investigation and assessment.

2.1.1 Time study technique

Time study is a technique that uses stopwatches and or video cameras to determine productivity outputs [37]. However, there are numerous challenges encountered when using this technique. Lack of work-study experiences affected the use of this technique in developing countries [23]. The difficulties of using time study were summarized as follows [28]:

- a) The number of workers studied by one observer is limited which requires employment of several observers making manual study prohibitively expensive;
- b) Time study generated information is limited and
- c) Facts interpreted from the observers' notes may not cover sufficient details such as interdependencies among components, exact reasons for taking longer or shorter elemental times.

These will increase the variability and reduce accuracy. Time study should not be used to set standards for jobs in which the nature of the task is different each time and inexperienced personnel should not conduct time studies because errors in recording information or in selecting the work elements to include can result in unreasonable standards [22].

Managers disagree over the use of engineered work standards such as time study and activity sampling to increase productivity [22]. They argue that time studies dehumanize workers and that the costs of large staffs and the hidden costs of labour management conflicts outweigh the benefits of elaborate standards. Nonetheless, [28] allude to the fact that time study is the principle technique of work measurement and with the involvement of employees in defining their own work standards, this technique will increase productivity.

2.1.2 Work sampling technique

Work sampling is a technique that is purported to provide valuable information to a construction manager regarding areas of low productivity that need corrective action [30]. Work sampling was shown to provide important information about the characteristics of delays [31]. In USA, [24] statistically verified the effectiveness of work sampling in demonstrating true labour performance and also reported that it provides timely information to management in order to determine whether corrective action or detailed study is needed to achieve a higher degree of efficiency. In India, [19] further studied that work sampling had been accepted as a valuable method for assessing the productivity of workforce in construction sites. In Palestine, [10] utilized activity sampling to undertake productivity measurement benchmarking for block work in improving construction productivity. In Nigeria, [33] used activity sampling to determine the labour output of painting activity with a view to establish a standard for the financial value of a painter's daily output. In Canada, [32] report on a framework to develop crew level productivity analysis using work sampling as they allude to it being less costly, easy to adopt and able to avail quick information. Work sampling has received increased emphasis as managers struggle to control construction costs as its simplicity and low cost makes it a powerful technique for productivity improvement [3].

2.1.3 Estimating technique

Estimating has developed into various types, but in the context of this research, refers to analytical and comparative estimating. In analytical estimating the estimator should be familiar with and preferably skilled and experienced in, the work concerned [37] while in comparative estimating jobs are allocated a time interval and then a single time associated with that interval [11]. Researchers interested in estimating productivity can choose from an array of methodologies, each with its strengths and weaknesses [34]. However, many methodologies are not very robust to measurement error in application and this is particularly troublesome, because fundamentally the objective of productivity measurement is to identify output differences that cannot be explained by input differences (ibid). The author further says that misspecifications in portions of labour productivity and erroneous assumptions are other sources of error in estimating. This agrees with what [25] reports, that due to insufficient standard productivity measurement systems, the construction labour productivity has been declining over a decade. A case study was undertaken on the accuracy of experts' subjective estimates of durations of tasks [15], the study showed a mean error underestimate of about 1%, although the majority of tasks are overestimated. Such estimating data have the advantages of being easy to collect, understand, and communicate, but they provide no information for future improvement [5]. In addition, [4] argue that the limits of estimating are that the results are of special value in jobbing or repair work and planned maintenance of plant. Estimating, as a work measurement technique, requires considerable considerations of certain factors to achieve accuracy.

2.1.4 Synthesis Technique

According to [37] synthetic data is reliable and consistent since it is a result of many studies over a long period of time. Synthetic data can be used to establish time standards for short run work on which there would be insufficient time to conduct a direct time study, and to construct time standards for jobs not yet begun. Supporting this [4] reports that synthetics libraries require

Careful organization and constant revision, but its use may sometimes eliminate the need for prolonged studies. Synthetic data are used to establish the work content for job and batch production work and also for other work of a repetitive nature

3.0 Methodology

Methodology will be discussed under the following subheadings

3.1 Research Design

The study was descriptive as a general overview of the work measurement techniques utilized in the Midlands construction province was sought [26]. The study was carried out on construction companies that are, and those that have undertaken construction projects, within the Midlands province. The province registered significant growth in construction work as a result of massive investments in the mining and subsequent housing and infrastructure developments at Unki, Mimosa and Murowa Mines. According to [20], the construction sector has continued to maintain its growth momentum on the back of significant investments the mining industry since 2009. In addition, the Government initiated Community Share Trusts at Murowa, Zvishavane and Tongogara and these also translated into social infrastructure construction projects. There is also vast construction activity at the Midlands State University and other public sector construction projects within the province. The rise in construction tenders within the province has attracted construction companies from different regions within Zimbabwe.

Construction companies registered with Construction Industry Federation of Zimbabwe (CIFOZ) were considered. The CIFOZ list of 2013, which has a total population of 127 companies in categories A to H, was used as the sample frame. The grading of contractors in the CIFOZ database is based on the value of the works the various companies are restricted to undertake. This study considered three clusters, companies in category A, B and C. Category D to H companies were not considered on the basis of them undertaking works of small values. Category A companies have an unlimited cap while category B and C can undertake works up to a maximum of \$6 000 000.00 and \$3 000 000.00 respectively.

3.2 Sampling

A sample size of 30 construction companies was considered in this study. Only 6 companies are resident within the Midlands province and the number of those that have undertaken projects within the Midlands province is not readily ascertainable. In such instances, [29] advise of a sample size of a minimum number of 30 for statistical analysis and that this provides a useful rule of thumb. The final sample size can also be a matter of judgment rather than calculation [16]. Stratified sampling was used to categorize the companies into the CIFOZ grading clusters, with the 6 resident companies all considered in the study. Purposive and snowballing techniques were used to choose the subjects for the case of those companies that are not resident within the province but are undertaking or have undertaken projects within the province. This was partly

achieved through use of the National Social Security Association for the Midlands province database as all construction projects undertaken in this province are registered with them.

3.3 Data collection methods

Interview administered structured and semi structured questionnaires were used to investigate the general pattern regarding work measurement techniques used by contractors in the Midlands Province. Estimators, quantity surveyors, project managers, site agents, engineers or construction planners were targeted since they possessed the required knowledge and information in this area of study. Interview administered questionnaires were the first option but in instances where it was not possible, emailed questionnaires were followed up by telephone interviews.

3.4 Analysis of data

Qualitative data was categorized, allocating units of original data to appropriate categories, and recognizing relationships with and between them. Quantitative data was collated using a nominal scale for the work measurement techniques being utilized. Productivity outputs that were generated using these techniques were collected from respondents for trades of concrete work, bricklaying, plastering and screeding floors. Brick and cement based trades were selected as these are labour intensive and contribute significantly to time considerations of building projects. These were then compared to actual average productivity outputs on site with effects of factors that may have affected productivity accounted for. The accuracy of each technique was determined by the closeness of the generated productivity outputs to the actual outputs on project sites. This gave an indication of consequent time overruns due to the margin of these differences. Various researchers have set different allowable limits of accuracy. An accuracy that is less than 10% is acceptable [21]. This is further supported by an allowable accuracy of a range of -5% to +10%, as set by [36]. In addition, [12] deemed that an accuracy of -10% to +10% is acceptable when they were determining productivity rates for concrete work through case based reasoning. This study therefore considered a range of -10% to +10% and this was the basis of validating the existence of time overruns on construction projects.

4.0 Findings and Discussions

The findings of the study will be presented and discussed under the following subheading.

4.1 Demographics of respondents

The research achieved a 70% response rate. Out of these respondents, Quantity Surveyors were the majority constituting 52%, while Project Managers and Site Agents constituted 33% and 15% respectively. The study required respondents of this professional aptitude because they are critically involved in labour productivity concerns at tender and control the same during execution of projects. The respondents' experiences are evenly distributed with 57% having less than 10 years and 43% having 10 and more years' experience, reflecting on a construction

industry that is potentially lacking in experienced personnel, as reported by [7,8]. However, the response rate and the distribution of the professional aptitude respondents provide a strong base to deduce valid results for the study. In addition, 48% of construction companies which participated in the survey had more than 15 years construction industry experience while 81% had more than 10 years' experience. These companies were distributed as follows: Category A (62%), B (24%) and C (14%). Companies that have been in existence for a long time are expected to manage issues of productivity with aplomb.

4.2 Work measurement technique utilized

The work measurement techniques that are or have been utilized by construction companies in the Midlands province are presented in figure 4.1

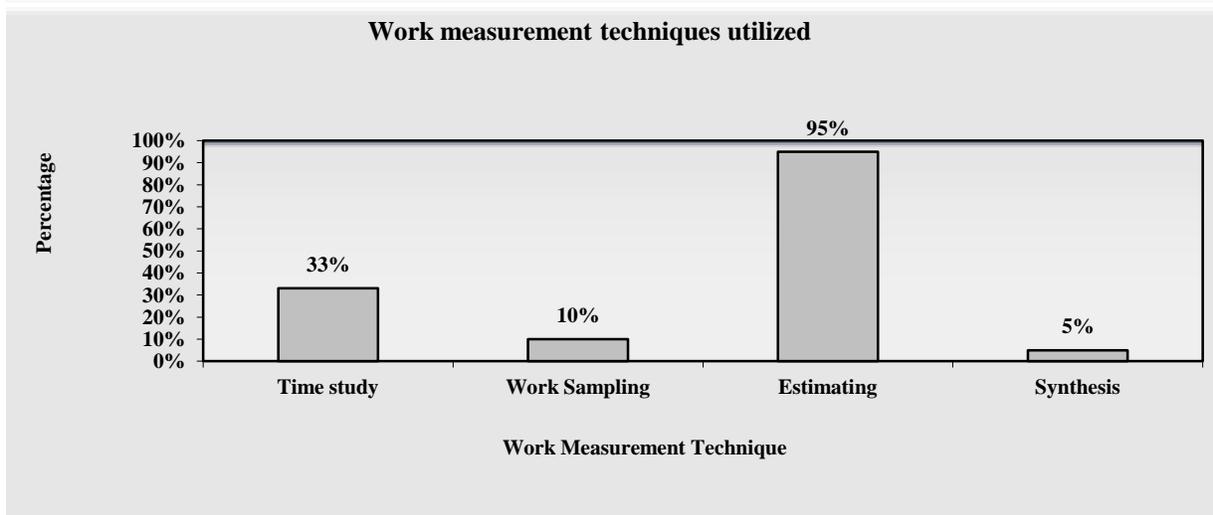


Figure 4.1: Work measurement techniques utilized

The results of the study show that all the construction companies recognize and use at least one work measurement technique. A few companies, 38%, with 63% of these being in category A, use more than one method, that is, a direct and indirect measurement method. This approach is considered to be the norm by [4,22,37]. It increases accuracy between the generated allowable and actual outputs of the work operations hence, at the least, inevitably arresting potential time and cost overruns. Although desirable, however, this approach is used by a few companies in Zimbabwe. These techniques are discussed in detail below.

4.2.1. Estimating technique

The estimating technique is the most preferred or used technique of work measurement with 95% of the companies that participated in the study using it. Of these, 70% are in Category A, and 15% in Category B and C respectively. The estimating technique is preferred because it is quick and less expensive to use when compared to the other techniques. In the majority of cases (65%), this technique has been used on its own and not supported by a direct method of measurement. However, the use of this technique for new works is at variance with observations made by [4,37] who noted that this method is suitable for maintenance work rather than new work since it

is the least accurate and it should be supplemented by time study or activity sampling. Additionally, [5] also report that estimating does not provide sufficient information for future improvement. This represents a drawback in its use and has the potential of generating inaccurate and biased results.

Respondents provided data on the differences between their estimated outputs and the actual outputs. The results mirrored a ratio of (-23.08%:+1.29%) in terms of overestimates compared to underestimates. These statistics surpassed the acceptable limits of $-/+10\%$. All the respondents that utilized this technique had estimated outputs which were considerably above the actual outputs. This meant that the estimated outputs were overestimated and supports the reason why they said their projects were suffering from time overruns.

4.2.2 Time study technique

Time study had the second highest percentage of utilization with 33% of the responses. Of these 72% are in category A and 28% are in category B. The results show that companies with higher grades are using the principle technique as alluded to by [28]. Only one organization undertakes time study individually and it has proved to be very accurate with no differences between their time study generated outputs and the actual standard outputs. However, 86% of these companies use time study concurrently with the estimating technique thus achieving an allowable ratio of (-8.92%: +6.38%). The companies that have utilized this had no significant challenges of time overruns attributable to use of this technique. However, the low levels of utilizing the time study technique concur with sentiments by [23,28] that the main difficulties in its use are that there was lack of work study experience and employment of several observers as is required. It is an expensive technique that relies on work study experienced personnel; yet the local building industry suffers from scarcity of labour experience [8].

4.2.3 Work sampling technique

Work sampling, having 10% of the responses, is lowly utilized. Though researchers in Africa and elsewhere that include [3, 10, 19, 32, 33] have strongly supported its relevance, the Zimbabwean construction industry has not reacted in the same way. This is contrary to the fact that it is less costly (compared to time study), and easy to adopt and able to avail quick information [4, 37]. The companies that use this technique are all in category A and this reflects on their experiences and apparent investment in effective work measurement techniques. They have also utilized it in conjunction with other techniques like estimating as suggested by [4, 22, 37]. The respondents also provided information on the technique generated outputs and the actual outputs and there was no significant difference but the number of respondents was too low for a valid analysis to be made.

4.2.4 Synthesis technique

Synthesis is the least utilized method with 5% of the companies using it. The Synthesis technique is therefore a product of the unbalanced use of estimating with the other methods. Since synthetic

data is calculated from many studies over a period of time, considering the responses and the challenges the construction industry has undergone, it likely that was used sparingly. This is compounded by issues of scarcity of work within the industry which would avail sufficient studies to be made to be able to utilize synthesis as a work measurement technique.

With the increase in complexity of construction projects and advent of newer designs, even in Zimbabwe, companies are required to predict data for work that they had never carried out but through use of synthesis, then accuracy is improved [37] . This is however not the prevailing case as the companies are mostly utilizing estimating for all types of work. This is also attributable to the low levels of experience of the construction professionals within the industry, as this technique would require high levels of expertise.

5.0 Conclusions and recommendations

Construction Companies in the Midlands Province have overwhelmingly used the estimating technique as alluded to by 95% of the respondents, which is an indirect method or an accountancy based method. Its use is marred by issues of it not being appropriate to the type of construction work and this has potentially affected its effectiveness with notable projects, within the same province, having failed or failing to meet project deadlines. The use of estimating, theoretically, has a direct contribution to the existent problem of time and cost overruns as this method is the most inaccurate of the considered techniques in this study. This was confirmed by the statistics on the differences between the generated outputs and the actual outputs on sites. These were above the maximum allowable percentage difference. Its continual use should be confined to the purposes it is best suited, for maintenance and repair works. It is however also important to understand the circumstances in which it is being used in Zimbabwe so as to take long term corrective measures. Time study and work sampling were the second and third most utilized techniques with 33% and 10% respectively. They were used in combination with the estimating technique and this generated differences that were within allowable limits. This approach is considered the most beneficial as concerns of time overruns are absolved. Synthesis had the least percentage of utilization with 5% and this reflected on low levels of experience within the industry.

Construction companies should seriously invest in adequate and appropriate work measurement techniques, both direct and indirect measurement techniques, so as to fully enjoy the benefits they present. Inclusive management styles and competent management of contractor organizations should be implemented. Full support should be rendered to those responsible in this aspect. This study has managed to highlight the techniques that are being used and how they have contributed to issues of time overruns. Further research on the actual impact of the techniques on project deliverables is pertinent to holistically ascertain how much the aspect of work measurement techniques affects successful delivery.

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