Waste time activity determination to improvement process in the Construction environment

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Abstract. Waste effects inter-reliant with productivity, the Waste measurement is essential in the management of production systems, because it is an effective way to evaluate their performance. Main aim for this paper is diagnoses the waste time factors and examined to eliminate them in the implementation the tests assess the performance of the process accomplished by finding the waste time on the two case studies, the observations have been taken in Baghdad using forms developed by researchers specifically designed based on the fundamentals of work-study methods and Work measurement techniques including (Activity sampling observations sheet, the flow process chart, and foremen survey form.) the wasted time causes defined clearly inclusion the performance of general efficiency .also determining the Invaluable and unnecessary activities ratio that contribute in the waste of implementation . a general regression model had been made for these factors showing the power of their association. The calculations shown the Mismanagement of the site and Choosing an inefficient contractor is most significant, while the conduct of activities the direct work is 56%, and the unnecessary activities by 25.75%, that’s the activity type should target for mitigation to increase the efficiency of the construction process from Wasted Tim reduction.

1. Introduction

In the past, construction specialists had identified waste as fully linked to the amount of debris removed from the construction site's activities.[1] Nowadays waste is known by different definitions are probably all the work that has exhausted sources and costs a fee of materials or equipment, workers or investment and was not essential in the construction process, that means a loss in performance time due to the lack in productivity and profits margin. Also the performance index will be decreased for the project.[2] constructions contain a repetitive circle of successive activities, one of which depends on the completion of another, such as columns and floor plates, and because each construction project is unique waste has become a common issue and widespread if not controlled.[3] by The National Institute of Standard and Technology 25% -50% of waste factors were materials delivering, moving and labours mismanagement.[4] The waste also associated with "excessive movements and activities, mistakes, delays. workers equipment . practically that about 46 per cent of the workers time is to carry out activities of value and 54 per cent of it for non -value activities . in the USA for example, the waste cost up to 8 per cent of the project’s total cost, so reducing these activities will increases the chances of improving on the Performance process,[1] Many project managers believe that waste is
inevitable and unavoidable generated with all activities during the construction process and cannot be prevented so they add it to the total project cost. [5]

2. Literature review
Generally, waste in construction is directly referred as a waste of material while waste in performance activity time is not diagnosed as waste. Many of construction project in Iraq usually, taking time more than their requirement and overrun project time is common issues in it the activities such as waiting time, idle inspection delays materials transporting and others are not determined as waste. These which is called non-value-adding activities(NVAA) are intangible and often invisible causes by lack of performance improvement. One cause why waste is not accurately predictable is the absenteeism of The suitable tools for waste measuring. (Thus to get the highest profit margin and keep the project on the planned schedule and budget the significant to eliminating wastes and thereby improved productivity in Iraqi construction projects.[6] Waste elimination in construction is a theoretical description study of the prioritization of waste reduction in the product development system to improve construction project performance it is worked out a model to determine the priorities of the waste and linked to each other and their causes and calculate the impact of this pairing and arranged according to the definition of priorities to know the direct and indirect relationships trying to obtain a comprehensive model. [7] The researchers have used one of the techniques of artificial intelligence to create an effective model for the optimal accessibility of the time and cost of projects to assist decision-makers in the planning stage three different indirect cost rates; sensitivity analysis was conducted to make the model suitable for various projects[8] The main reasons for delaying the implementation of projects are due to social and cultural reason [9] addressed the problem of factors affecting the delay in construction projects in Indonesia and analyzed these factors by conducting a questionnaire after dividing them into categories and organizing. Waste in construction simply can be classified into three main components labours, machinery, and materials waste. One of the objectives of waste restrict is to increase productivity and develop resource allocation management within construction firms’ projects managers fail to diagnostic the waste exactness that’s because of the Absence the accuracy tools to measuring. waste correctly [10] Three main classes of construction waste are founding (materials., Time value), loss. Which are related to (transformation aspect, flow aspect, value aspect) respectively, should be in construction concentrated on the most important waste to the improvement of construction processes[11]. Waste is described as any activity in a process that requires time and cost and does not give value to the service /product from the client point of view in the construction carries out three types of value-related activities first, value-adding activity (VAA) transferring the crude material into what the client needs, second, Non-value adding necessary activity(NVANA) a profligate activity but required, in real construction processing, the third one, is a Non-Value Adding unnecessary activity(NVAUA), clear waste that should be completely reduced.[12]

3. Research methods
The work studies are brilliant means used to develop methods of implementation in the constructions work to get the best economical way, depending on the optimal use of resources by the time limit frame ceiling. Data collection methodology contained:
1. determine the proportion of wasted time in NVAUA.2. Analysis of the causes of these activities, factors. 3. The diagnosis of opportunities to reduce such wastage. different mechanisms and tools were involve based on the type of project and the validity of the observation and research needs of the data in detail as following described.

3.1 Method study and Recording techniques
Depending on the nature of the construction work itself leads to ways of improvement as long as the re-planning processes are not urgent and ill-considered, the difficulty is to determine any possible method To be the most useful to define the method of the problem (work samples) as a statistical record of a certain number of Random observations during the specified periods for a group of workers or machines,
or both, calculate the ratios to stop and record each observation of what happens at that moment, and the percentage of observations recorded in a particular activity is a measure of the percentage of the time. [13][14][15]. To record activities on a plan of the area and this is one of the most suitable methods used in the constructions. a group of symbols placed for recording is displayed in Table (1) and is known as ASME symbols (the American Society of Mechanical Engineering). [16]

**Table 1. ASME symbols**

| Sambal | Operation | Inspection | Transport | Storage | Delay |
|--------|-----------|------------|-----------|---------|-------|
|       |           |            |           |         |       |

This technique was used in the first case study Road pavement project, no need appeared to plan (diagram) outlining of the work area because of, the movement of the concrete paver is distributed on many streets within the wide area. The researchers used the (process chart man-machine type) Due to the absence of sequence in the movement of the mechanism was used in the first project to monitor the movement of the and adapted to the type of machine to record what happens to the machine and operator). The observations recorded in this form for each operation with its time and whether it is productive or not. This chart provides the delay appears during the works and why, as well as the main problems of implementation). for example, Figure (1.) shows excessive movement and delays Investigated by the crane.

**3.2 Activity Sampling Procedure**

More than one round conducted to find out what the researchers lack tools and the clarifications the needs to help in designing the optimum form sheet for this case, based on the Activity Sampling Observation Sheet described in figure (2.) which the form adopted was subsequently extracted from it.

**Figure 1.** delays Investigated by the crane. **Figure 2.** Activity Sampling Observation Sheet.[15]
after some modifications, the following steps were taken to implement the activity sample Procedure.[14]

4. Case studies Characteristics

First Case study: project A/ Donor: Mayoralty of Baghdad/Project Department project828 section development –new assign 80 kilometers of Road pavement.

Second Case study: project B / Donor: Baghdad Investment Commission/ Republic of Iraqi (Iraq gate Residential) a Residential of forty-seven high-rise buildings with sixteen Floor per building It is one of the largest residential projects on the level of the capital Baghdad sited in the heart of the capital (on the area of total land about twelve dunums).

4.1 Observations sample size

Regarding the random error represents the measured mean deviation from the real mean, that occurs on many occasions in the field the account repeats which is a line resulting from the frequency of taking the same reading many times which is that a measurable where the proportion of unproductive workers schemed graphically shows their distribution "normally" and it is statistically possible to extract the number of observations require detracted from the normal distribution equation and the compensation of the standard deviation values and the z value in the binomial distribution equation to get the following equation number .1 Thus the researchers depended on it. to determine the required sample size of observations

\[ N = \frac{(2\alpha/2)^2p(1-p)}{L^2} \]

\[ EQ.\ 1 \]

\[ EQUATIONS \]

\[ N= \text{count of observations required}, \]

\[ P= \text{Percentage of activities (typically considered from pilot studies 0.50)}, \]

\[ L= \text{Ratio of accuracy required (0.05)}, \]

\[ Z_{\alpha/2}= \text{obtain from statistics tables depending on confidence 95\% usually taken as 1.96. at } \alpha = 0.05. \]

By applying those values, can get 384 of observations, which is the minimum number of observations required,

4.2 Preparing data registration forms

first case study project A (the road- pavement site) to create the forms The researchers discover that some modifications and changes should be conducted On the forms for the collection of information to serve the research goals., these additions are shown in the figure (3. ) which is subsequent, The researchers added a column (Delay –minutes) that includes in the waste time in minutes and for each cause of delay was seen put a measure of the intensity of that reason by another column called the (factor weight). Another addition the researchers hold on the form is to change the type of effectiveness from productive activity or not productive replaced with (VAA, NVANA or NVAUA). To be able to extract the percentages of activities and the indicator of project efficiency as explained in the analysis of the data .at the second case study, a (Residential buildings project) Data for this study were collected using adjustment sheet also, this time Three columns have been added to the Activity sampling observations sheet shown in figure (4.) The same fields for activity classifications (Activity type) A.T and factors weights measured for the severity of the effect of the causes were added to obtain a unified method of observation data results. The time for recording observations is divided into four rounds during an hour every fifteen minutes, complete a monitoring course by the researchers to register and record in front of all the time the cause and degree of its effect.
Figure 3. Flow process chart modified one.

Figure 4. Activity Sampling adjusted the sheet.

5. Execute Study for project A and B

The activity item monitored for project A consists of the processing, supplying and transportation and Brushing of hot mix asphaltic concrete pavement thickness of 10 centimetres with spraying the (Bituminous Tack coat and prime-coat) layer under the technical specifications of the road work (AASHTO m-82-2004). the production average per day is equipped at a rate of 3000 square meters this for the modified surface layer does work steamroller flattened it with two types tired-roller and one wheel/drum roller with a water tank see figure 5. While for project B The researchers collected 200 observations during 38 round four rounds an hour for four days. By monitoring for activity (Cement plastering for walls, Porcelain: for wall/for the floor, Marble: 30*200*1500 mm size, using for windows sill, fixing by mortar (1:2) see figure 6.
6. Finding from project A and B Sites by Calculating Total Overall Results
When all the observations recorded for ten days by both projects sites A for six days and B for four days, a separated sheet was prepared to precis and calculate the work rate for each day by applying the equation number .2 below. This operation conducted to all value activity categories.

\[ \text{Activity Percentage} = \frac{(\text{Day } 1 + \text{Day } 2 + \text{Day } 3 \ldots \text{activity total}) \times 100}{\text{Total activity observations}} \] \quad \text{EQ.2 [14]}

The efficiency rate of the construction process calculated using equation number .3

\[ \text{Process Efficiency (PE)} = \frac{(\text{Value added activities}) \times 100}{(\text{Total observations})} \quad \ldots \ldots \text{EQ.3 [17]} \]

The efficiency rate of the construction process was 56%, this is a rather remarkable, because of the researchers is purposely adopted at the observations procedure pick up the distinct construction site and precluded an efficient contractor to test. Table (.2) describe all activity compression.

| Table 2. Value perspective of observed activity. |
|------------------------------------------------|
| | Project A | Project B | Total Observations | Percentage (%) |
| 1 | No. observations | 200 | 200 | 400 | 100% |
| 2 | VAA | 98 | 127 | 255 | 56.25% |
| 3 | NVANA | 50 | 22 | 72 | 18.00% |
| 4 | NVAAU | 52 | 51 | 103 | 25.75% |

Process efficiency = 56%

indications that the direct work of the activities is 56%, the necessary activities were 18%, and the unnecessary activities are 25.75%, this is the target type for mitigation by adopting a new implementation methodology to increase the efficiency of the construction process and reduce Wasted time with increased productivity as a means of continues improving at construction operations.

The factors items observed in the two case studies, Table .3 main factors cause waste activity in the project. shows the classification adopted by the researchers for the connected of analysing the results to the model and linking the factors caused by their roots.

| Table .3 Main sources for wasting activity in sites A and B. |
|-------------------------------------------------------------|
| The main factor causes waste time | Associating | Group | Code |
| 1- Choose an inefficient contractor | Owner | A | X2, X5 |
| 2- Mismanagement of the site and supervision and control of the conduct of activities | Contractor | B | X1, X11, X13 |
| 3- Lack of experience in specialized work | Contractor | C | X4, X10 |
| 4- Poor planning of the project by the contractor | Contractor | D | X3, X6, X9, X12 |
| 5- Poor qualifications of the contractor's technical staff | Contractor | E | X7, X8 |

7. Statistical Analysis Regression Model of Data Observations
The model used multivariate regression to deal with the type of data observed as each day there is a combination of factors called Xn causing waste time activity during implementation and to determine which factors are more important than others and the strength of the correlation between them to choose Content analysis (using BIM SSPS.V25) statistical Package for social sciences and discusses results statistical program was used for this purpose. The researchers used the Artificial Neural Technique to represent the model of regression because this does not require the establishment of a statistical
hypothesis null or alternative to know the type of relationship whether it's linear or not, but considers it variable and the fact that this technique is accurate and paints a precise regression model to take all the factors together and all the variables without being enslaved. In figure 7 the model shows that the most important factor is the 100% mismanagement of the site by the contractor ($x_{11}$, group B) and the following importance after that factor $X_2$, with 86.7%, which is within the reason for the selection of an ineffectual contractor by the owner.

![Normalized Importance](image1)

**Figure 7** Normalized Importance for the regression model.

All the results of this model and the forms of relationships between each variable and the form of the Neural Network are summarized at figure 8.

![Artificial Neural Network](image2)

**Figure 8** The Artificial Neural Network of the regression model

the correlation between the factors and their impact is highlighted by the lines that link the darker layers of them shows that the link here is high and vice versa the model of analysis is characterized by the high accuracy of the analysis of network regression because it takes all the variables and processes it once which as the data divides in this model for the processing cases training model was 90% of samples and 10% as testing samples and the number of units involved 13 factors and one hidden layer consisting of 9 units was grated. Table 4 shows the sequence of the relative importance factors derived from the
model regression of factors contributing to a waste of time note that the strength of average overall relative error for model equal 0.728.

Table 4. Importance of wasting activity factors in projects A and B.

| Group | Independent Variable Importance                              | Code | Importance | Normalized Importance |
|-------|---------------------------------------------------------------|------|------------|-----------------------|
| B     | Transport the machine for another position.                  | X1   | 0.058      | 45.5%                 |
| A     | the equipment Maintenance                                    | X2   | 0.071      | 56.2%                 |
| A     | Fill the steamroller with water                              | X3   | 0.110      | 86.7%                 |
| C     | Waiting for the temperature of the asphalt to decrease.      | X4   | 0.068      | 53.4%                 |
| A     | Waiting for materials supplied by the truckload.             | X5   | 0.075      | 59.0%                 |
| D     | Waiting Others to complete their work                        | X6   | 0.086      | 67.8%                 |
| E     | Inexperienced workers re-working                              | X7   | 0.046      | 36.1%                 |
| E     | Take the test samples for the lab.                           | X8   | 0.077      | 60.5%                 |
| D     | Waiting for truckloads to arrive                             | X9   | 0.054      | 42.2%                 |
| C     | set up a cleaning cracking window sill to put the mortar.    | X10  | 0.060      | 47.4%                 |
| B     | Mismanagement site of truck operators conflict               | X11  | 0.127      | 100%                  |
| D     | Lack of electricity and water supply services                 | X12  | 0.101      | 79.4%                 |
| B     | Idling of workers                                             | X13  | 0.067      | 52.8%                 |

8. Conclusions

Where all those involved in this sector aim to reduce the completion time of projects to reduce costs and improve efficiency and maintain the quality of the work done. the researchers have been created a system of dividing categories for the observed factors to include the reasons seen within these factors and according to their dependency, for example when the owner chooses an ineffectual contractor include categories of factors such as observation on the site A and B, which is the equipment maintenance and the lack of material supply. by reducing the percentage of unnecessary activities that Caused by this waste time, the efficiency of the performance of the construction process increased. the researchers concluded that Iraq involved the most developed countries that the Mismanagement of the site Waiting for materials, re-working, idling Time for inspecting the works characterized the researchers with this result of exploiting the unnecessary activities and without a great cost can achieve the biggest goal of all the executors which is to deliver projects in a shorter period and efficiently and with a perfect means put everything in its place and every action has its value in the site factors affecting the waste of time are the mismanagement of the site by the contractor, the delay in the arrival of materials, the loitering of workers, the re-establishment of the work due to the lack of technical expertise and waiting for others to perform their work. As showed the results of the regression model analysis that the rising index for important contribution to waste time of execution poor site management and this is one of the most important factors of realism where the iterative nature and the effectiveness of the construction used to put management plans in a minute for her performance where the interrelationship between activities and its disappearing of proper planning will lead to low quality and it takes extended duration, for implement. This study has found that generally no criteria to measure the performance of the workers in the construction sites to determine efficiency and eliminate waste by effort Forms designed by researchers in this paper could also be adopted for the purpose of assessing performance, diagnosing negative factors and excluding activities that reduce productivity in order to obtain optimal performance.
and increase the profit margin for participants as result to control waste time activities and increase productivity.

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