COMPARISON OF THEORETICAL MAN-HOUR VALUES AND PRACTICAL MAN-HOUR VALUES IN TURKEY

[1]AYNUR KAZAZ, [2]TURGUT ACIKARA, [3]BAYRAM ER

[1,2,3]Civil Engineering Department, Akdeniz University, Turkey
Email: [1]akazaz@akdeniz.edu.tr, [2]tacikara@akdeniz.edu.tr, [3]bayramer@akdeniz.edu.tr

Abstract—In construction projects most of the resources are used in the construction phase. Therefore, the cost and time of each construction activity are the main determinants of the total project cost and time. In this aspect, for an effective project management it is crucial to calculate the cost and time of activities accurately. The main data for calculating the time and accordingly the cost of an activity is the labor productivity rate. Since, labor productivity is affected by many factors; its value rate varies from region to region. This circumstance, forced academicians and industry participants to measure labor productivity rates for a specific region. One of the commonly used terms for expressing labor productivity in construction industry is the man-hour value. This value is simply defined as the time required for a labor to finish unit work amount and is widely used by planning engineers for cost and time analysis. Although, the Ministry of Environment and Urbanization publishes every year the man-hour values for many construction activities; it is believed that these values are not appropriate for all regions in Turkey. In this study it was assumed that labors can better evaluate the time they require to finish unit work amount compared to on site measurements. In this context, actual man-hour values of specified construction activities were determined by interviewing 126 labors employed in Antalya, Turkey and compared with those values of the Ministry of Environment and Urbanization. The results revealed that, there are significant differences between these man-hour values and for an accurate calculation the values of the Ministry of Environment and Urbanization must be updated for each region in Turkey.

Index Terms—Construction Labor Productivity, Construction planning, Man hour values, t- test

I. INTRODUCTION

Time, cost and quality are the 3 main conflicting constraints of a construction project. In this aspect, the primary goal of project management is to manage these constraints within the project's scope. Especially, in today's competitive environment finishing a project in the shortest time with lowest cost and highest quality became an important goal for the project managers [1]. To achieve this goal, the resources used in construction activities must be utilized effectively throughout the project life. Construction activity resources are categorized under 3 groups named as labor, material and equipment [2]. Since labor is affected by many internal and external factors, it has the most uncertain nature among these resources. Even under the same working conditions, the productivity rates of labor may vary [3]. In construction industries of many developed and developing countries, labor productivity is one of the main factors causing time and cost overruns [4]-[8]. The labor cost of a project comprises approximately 20 to 50% of the total cost [9]-[11]. Therefore, an increase in labor cost will also increase the total cost of the project significantly [12]. In other words, improving the labor productivity is one of the effective ways of cost reduction [8]. Similarly, labor productivity has also a significant impact on project time. As known construction projects constitutes of many dependent and successive activities. Therefore, any delay in these activities will also cause a delay in the succeeding activity and accordingly, in the total project time. To prevent time and cost overruns in a construction project, labor productivity rates should be periodically monitored throughout the construction phase. For this purpose labor productivity and labor efficiency variances must be expressed with numerical values. The man-hour value is a widely used term in the literature and construction industry for expressing labor productivity. In this study man-hour values of 5 different construction activities were investigated. For this purpose 126 craft workers employed in 5 different construction project in Antalya were interviewed by assuming that they can better estimate their productivity rates compared to on site measurements. Then the results of the survey were compared with the man-hour values published by the Ministry of Environment and Urbanization and the differences between practical and theoretical values were discussed.

II. MAN-HOUR VALUES AND UNİT PRİCE ANALYSİS

Man-hour value is simply defined as the time required for a labor to finish unit work amount. A construction project involves numerous activities that have different characteristics. To calculate the total time and cost of a project the time and cost of each activity must be considered. Man-hour values are the main data used by the planning engineers in the design phase. These values are used for establishing the schedule, determining the number of craft workers and estimating the labor cost. In addition, man-hour values are also a common measurement method for evaluating the productivity rates during the construction phase. In this sense, periodically measurements of man-hour values will provide a

comparison of labor productivity rates in different times and accordingly, will ease determining the reasons of the fluctuations. Labor productivity is affected by many internal and external factors which make it inconstant throughout the construction phase [2]. Therefore, labor productivity has a complicated non-linear characteristic in the construction industry. In this context, classical statistical methods such as normal distribution are not appropriate to explain labor productivity [14]-[15].

As mentioned before, man-hour values are used for expressing the labor productivity rates. Therefore, the dynamic nature of labor productivity also makes the man-hour values dynamic. This dynamic nature complicates the estimation of the man-hour values. In this aspect, expressing the man-hour values by a constant number is not acceptable for the planning engineers in this dynamic nature [16]. Regarding this issue, different comparative studies were conducted in UK, Germany and France [17]-[20]. The result of these studies revealed that the man-hour values predicted by the planning engineers from these 3 countries differ significantly in some activities such as reinforcement fixing, formwork erecting and concrete pouring. Also in the Turkish construction industry the man-hour values depends on the experience of the planning engineers and hence, significant differences may be observed among the same activities. Imitation of man-hour values obtained from the previous projects is another method used for estimating the labor productivity rates. However, the project specific characteristics of each project will also cause differences between the man-hour values of a specific activity in this method. Although man-hour values are inconstant, planning engineers rarely update labor productivity rates [21].

In Turkey, unit price analysis published by the Ministry of Environment and Urbanization are used for preparing the tender documents of public projects. Similarly these analysis are also used in private projects with some modifications since there does not exist any alternative resource [3]. In these analyses besides material and labor cost, also the man-hour value of each activity is calculated. Although man-hour values are region dependent, unit price analysis published by the Ministry of Environment and Urbanization embraces all regions of Turkey by neglecting the regional differences[23]. In addition, the Ministry of Environment and Urbanization only updates the cost data of the analyses without changing the man-hour values. This circumstance makes these analyses outdated and accordingly inapplicable for the Turkish construction industry [3].

III. METHODOLOGY

Construction projects involve numerous different activities and in this context approximately 1400 construction activities were analyzed by the Ministry of Environment and Urbanization [3]. Therefore, comparing the practical man-hour values of all activities with those of the Ministry of Environment and Urbanization would be unpractical. In context of the study, 5 different activities namely erecting flat surfaced formwork for concrete and reinforced concrete, erecting curved surfaced formwork for concrete and reinforced concrete, bending and fixing the ribbed bars with diameter of 8-12 mm, scaffold installation and soldier pile installation were investigated. These activities are labor intensive and common almost in every construction project. In Table 1 the name of the activities and their codes are shown.

TABLE I
Task names and their codes in UPA

Task code in UPA	Title of activity
21.011	Erecting flat surfaced formwork for concrete and reinforced concrete
21.021	Erecting curved surfaced formwork for concrete and reinforced concrete
23.001/2	Bending and fixing the ribbed bars with diameter of 8-12 mm
21.065	Scaffold installation
14.023/2	Soldier pile installation

The necessary data for estimating the practical man-hour values of the activities were obtained by interviewing 126 craft workers employed in 5 different projects. After these interviews minimum, mean and maximum man-hour values for each activity were determined. During the calculation of mean values the same number and qualification of craft workers determined in UPA were used. The procurement time was neglected and only working and idle durations were included to the man-hour values. One sample t-test was used for the statistical analyses of the obtained data. This test allows comparing a simple value with the mean value of a sample data. In other words, one sample t-test is used for comparing the observed and expected values. In this study, man-hour values obtained from the interviews and UPA were accepted as observed and expected, respectively.

IV. DISCUSSION OF RESULTS

In Table 2 the number and qualifications of craft workers together with their man-hour values of each activityare comparatively shown. For example, according to UPA to erect 1 m2 flat surfaced formwork both 1 skilled and 1 unskilled labor have to work 0,75 hours which makes the total time 1,5 hours. On the other hand, the survey result revealed that the actual time needed for the same activity was 1,13 hours. Indeed, all of the expected man-hour values of the investigated activities were higher than the observed ones. In other words, craft workers had a higher productivity rate compared to expected ones. The main reasons of these differences are the low wage policy and inflation in Turkey [2].

Table II.
Comparison of Theoretical and Practical Man-hour values

Task code in UPA	Title of activity	Labor	Theoretical man-hours value for a craft worker	Total theoretical Man-hours value	Practical man-hours value for a craft worker	Total practical Man-hours value	Unit
21.011	Erecting flat surfaced formwork for concrete and reinforced concrete	1 skilled worker	0.75	1.50	0.52	1.13	(Hour/m^2)
		1 unskilled worker	0.75		0.61		
21.021	Erecting curved surfaced formwork for concrete and reinforced concrete	1 skilled worker	1.50	3.00	1.34	2.71	(Hour/m^2)
		1 unskilled worker	1.50		1.37		
23.001/2	Bending and fixing the ribbed bars with diameter of 8-12 mm	1 skilled worker	25.00	125.00	8.35	25.61	(Hour/ton)
		1 helper	60.00		9.18		
		2 unskilled worker	40.00		8.08		
21.065	Scaffold installation	1 skilled worker	0.225	0.55	0.22	0.39	(Hour/m^2)
		2 unskilled worker	0.325		0.17		
14.023/2	Soldier pile installation	1 skilled worker	1.05	2.10	1.04	1.96	(Hour/m^2)
		1 unskilled worker	1.05		0.92		

In Table 3 the results of the one sample t-test are shown. As seen from the table, in 3 activities the gaps have been proved to be not statistically significant ($p>0,05$). In other words, there is not a statistically significant difference between the observed and expected man-hour values. In this context, the UPA of these activities should be revised instead of renewing. On the other hand, the gaps have been proved to be statistically significant ($p<0,05$) in the other 2 activities.

This result revealed that the expected man-hour values of these 2 activities have lost their validity and currency which means that their UPA must be renewed. As seen from Table 3 the observed man-hour values of "bending and fixing the ribbed bars with diameter of 8-12 mm" and "scaffold installation" activities are almost 5 and 1,5 times higher than the expected ones, respectively. The reason why the UPA of these two activities loosed their validity and currency is that the Ministry of Environment and Urbanization neglects the technological and methodological advancements in the construction industry and only updates the material and labor costs every year without changing the man-hour values.

In addition, the man-hour values estimated by the craft workers for the same activity had also varied. For example, the maximum rate of "erecting flat surfaced formwork for concrete and reinforced concrete" is almost 7 times higher than its minimum rate (Table 3). Indeed, the differences between the craft workers' estimations increase as their standard deviation increases. These variations can be explained by differences of some factors such as motivation, wage, working conditions, region etc.

Table III.
One sample t-test results

Task code in UPA	21.011	21.021	23.001/2	21.065	14.023/2
Title of activity	Erecting flat surfaced formwork for concrete and reinforced concrete	Erecting curved surfaced formwork for concrete and reinforced concrete	Bending and fixing the ribbed bars with diameter of 8-12 mm	Scaffold installation	Soldier pile installation
Productivity rate in UPA	1.50	3.00	125.00	0.55	2.10
Average of Craft workers productivity rates (ACPR)	1.13	2.71	25.61	0.39	1.96
Minimum rate	0.48	0.84	8.00	0.24	1.37
Maximum rate	3.20	4.57	48.00	0.58	2.37
Difference	0.37	0.29	99.39	0.16	0.16
Standard deviation	0.691	1.15	10.73	0.114	0.462
Lower Limit of 95 % confidence of ACRP	0.89	2.10	20.00	0.32	1.573
Upper Limit of 95 % confidence of ACRP	1.47	3.31	31.20	0.46	2.355
p-value	0.057>0.05	0.380>0.05	0.000<0.05	0.003<0.05	0.600>0.05

CONCLUSION

In construction projects it is crucial to estimate labor productivity rates accurately to prevent unexpected time and cost overruns. In Turkey, planning engineers widely use the UPA data published by the Ministry of Environment and Urbanization. However, in these UPA only the material and labor cost data is updated every year without changing the man-hour values. In addition, these data embraces all the regions by neglecting region specific characteristics. In this study, it was argued that UPA of the Ministry of Environment and Urbanization are outdated due to the technological and methodological advancements in the construction industry and therefore, their man-hour values have to be updated. In this study, practical man-hour values of 5 different construction activities were estimated by interviewing 126 craft workers employed in 5 different construction projects in Antalya and compared with the UPA values. The results revealed that the expected man-hour values of all the activities were higher than the observed ones. However, 3 of them were still statistically valid while 2 of them invalid. In other words the man-hour values of "bending and fixing the ribbed bars with diameter of 8-12 mm" and scaffold installation" activities must be renewed. In addition, since this study was conducted in a specific region in Turkey, the results also proved that man-hour values vary for region to region. As a summary, for an accurate time and cost estimation the UPA data must be updated by considering regional differences.

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