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HUMAN RESOURCE PERFORMANCE MEASUREMENT FRAMEWORK FOR CONSTRUCTION PROJECTS AND COMPANIES

Zoran Stojadinović, Dejan Marinković, Branislav Ivković

Original scientific paper

A new approach for measuring the performance of employees in construction companies is presented. Two different methods are proposed. For employees directly engaged on a project, performance is measured by using different Key Performance Indicators on four different organisation levels. For employees not directly engaged on a project, performance is measured by using Responsibility Assignment Matrices that are quantified using the Quality Function Deployment methodology. In both cases the system returns non-dimensional evaluations for employees, which can be used as a management tool for efficient human resource management. The presented framework is designed for civil construction projects and companies but it is applicable to any industry.

Keywords: *human resource management, KPI, OBS, performance measurement, QFD, RAM*

Sustav za mjerenje učinka ljudskih resursa za građevinske projekte i tvrtke

Izvorni znanstveni članak

U ovom radu prikazan je novi pristup za mjerenje učinka zaposlenih u građevinskim tvrtkama. Dvije različite metode su predložene. Za zaposlene koji su izravno angažirani na projektima, učinak se mjeri pomoću različitih "Key Performance Indicators" na četiri različite razine organizacije. Za zaposlenike koji ne sudjeluju izravno na projektu, učinak se mjeri pomoću "Responsibility Assignment Matrix" koja je kvantificirana pomoću "Quality Function Deployment" metodologije. U oba slučaja dobivaju se bezdimenzijske ocjene za zaposlenike, koje se mogu koristiti kao alat za učinkovito upravljanje ljudskim resursima. Sustav je dizajniran za građevinske projekte i tvrtke, ali se može primijeniti i u drugim gospodarskim granama.

Ključne riječi: *KPI, mjerenje učinka, OBS, QFD, RAM, upravljanje ljudskim resursima*

1 Introduction

Employee performance measurement in construction companies is an important part of human resource management, because it allows making objective and timely management decisions. Performance measurement is a basis for performance based rewarding, which is one of the key components of strategic human resource management.

The first step of performance measurement is to determine which jobs individuals perform and to define measures that best represent the performance on these jobs (what to measure for which job). The second step is to define ways to quantify job performance measures (how to measure). The focus of this research is on the first step: to establish a framework that enables performance measurement for various jobs for all employees in a balanced and comparable way. Such a framework can then be used for performance based rewarding. Detailed analysis of quantifying measures is not the primary goal of this work: this task is a topic for further research.

When it comes to the nature of performed work, there are two different groups of employees in every construction company: employees who are directly engaged on projects and employees who perform tasks unrelated directly to specific projects.

For the first group, one of possible methods to measure and evaluate performance is to use Key Performance Indicators (KPIs). By selecting the appropriate set of KPIs it is possible to evaluate a wide variety of different jobs on projects, which makes them suitable for use in this study.

The problem with using KPIs, despite numerous studies, is the unsatisfactory level of objective metrics that is associated with the real on site performance [1]. Reliable metrics is a prerequisite for objective, unbiased and comparable performance measurement. This kind of performance measurement would be beneficial for any company which implements it. Besides introducing appropriate metrics, it is important to establish a valid relationship between different KPIs and different kinds of the work performed by the various project participants, all in accordance with the project Organization Breakdown Structure (OBS). Establishing this relationship is one of the goals of this research.

Performance of the second group of employees, the ones not directly associated with the project, is, most often, not clearly measurable, and KPIs cannot be used directly. This paper investigates the possibility of using a quantified Responsibility Assignment Matrix (RAM) in accordance with the Quality Function Deployment (QFD) methodology.

2 Literature overview

2.1 KPI and OBS

There are numerous separate studies in the field of project organization and the field of project success evaluation conducted using KPIs. However, the connection between these two areas and the potential that it offers in terms of employee performance measurement is not investigated enough.

Research in the field of KPIs is mainly related to proposing a representative set of KPIs that can be used for objective assessment of project success. A common method of finding a representative set of KPIs is interviewing experts and professionals using the Delphi technique. In this method, relative importance of the chosen KPIs is determined based on survey results. Over

20 different KPIs can be found in related research [2, 3, 4, 5].

We analysed the following examples. The first study relates to the research carried out in Australia [2] with the purpose of selecting relevant KPIs that can be applied on construction projects. Twenty five KPIs were identified and divided into four groups depending on the nature of KPIs (performance or relationships) and the quality of the evaluation (objective or subjective). The result of the study is a set of KPIs and a set of proposed measures for them. In the second study, conducted in the USA [3], fifteen KPIs were divided into two groups depending on their nature (quantitative and qualitative). Measures for assessing KPIs were not presented, except for a few selected KPIs within a case study. In studies conducted in Hong Kong [4] and Vietnam [5], KPIs are not grouped but measures are determined. Measures are objective (quantitative) and subjective (descriptive). A comparison of the results of these four studies is shown in Tab. 1, and the KPIs selected in each study are highlighted.

Table 1 Comparative results of four studies of KPIs and their measures

KPI CATEGORY	AUSTRALIA [2]	USA [3]	HONG KONG [4]	VIETNAM [5]
COST	Cost performance	$/unit	Variation actual/agreed	Variation actual/estimated
	Profit & financial objectives	Total Cost	Cost improvement	Material management - subjective scale
	Productivity	Resource Management	Subjective scale	
		Earned Man-Hours		
TIME	Time performance	Units/ManHour	Variation actual/agreed (%)	Variation actual/ estimated (%)
		On-Time Completion	Time improvement	
		Percent Complete	Subjective scale	
		Lost Time Accounting		
QUALITY	Quality performance	Quality Control/Rework	Rectifying defects (%)	Subjective scale
	Scope of rework	Punch List	Number of non-conformance reports	
	Number of non-conformance reports		End users satisfaction scores	
SAFETY& ENVIRONMENT	LTIFR million working hours	Safety		Subjective scale
	Environmental performance			
	Pollution occurrence			
INNOVATION	Innovation and improvement		Cost savings	
	Subjective scale		Number of innovation initiatives	
			Subjective scale	
COMMUNICATION	Effective communications		Reduction of written communication	Proj. team performance - subjective scale
	Harmonious working relationship		Variation of number of letters, emails etc.	
	Long-term business relationship		Subjective scale	
	Introduction of facilitated workshop		Top management commitment	
	Subjective scale			
SATISFACTION	Client's satisfaction subjective			Subjective scale
	Customer's satisfaction			
	Professional image establishment			
TRUST	Average duration for settling var. orders		Average duration of settling var. orders	Change management - subjective scale
	Litigation, dispute, claim occurrence and magnitude		Frequency of meeting others expectations	
	Trust and respect		Subjective scale	

The PMBOK Guide [6] defines the organization chart as any graphic display of project reporting relationships. It may be formal or informal, highly detailed or broadly framed, based on the needs of the project. An Organizational Breakdown Structure (OBS) is a specific type of organization chart that shows responsibility of organizational units for different work items. The organization chart is one of the three outputs of organizational planning.

We found virtually no investigation of the relationship between OBS and KPIs in current literature. An exception is presented in [7], where a Performance Management Support System (PMSS) was developed. It is a system for measuring employee performance based on the organizational chart of the project. It serves as a

support for the quality management system and management decision-making. The system measures performance of the project staff in three categories: cost, time and quality. The measure is estimated/performed for each category, multiplied by the weighting factor (values not listed in [7]). Each employee receives a Performance Factor (PF) grade, which depends on individual's performance (APF) and performance of the team the individual manages. Therefore, the organizational structure is taken into account for evaluating employee performance. The system is well designed and allows for various applications. The opportunity for improving the system lies in the fact that the performance measure is simplified (only cost, time and quality). Other categories (safety, innovation, communication ...) are ignored.

2.2 RAM and QFD

Separate studies can be found regarding the Responsibility Assignment Matrix (RAM) and the application of QFD methodology in construction. However, the connection between these two areas and the potential that it offers in terms of employee performance measurement is not investigated enough.

RAM is one of the standard tools for project management. The PMBOK [6] describes RAM as one of the three major outputs from organizational planning process. RAM is used for assigning roles and responsibilities to project participants. The studies in this area relate more to describing RAM as a management tool, and less to advanced applications on construction projects. For example, in one study that investigates project management practice in various companies RAM is mentioned as one of the tools that are rarely used in practice [8]. Elsewhere, RAM has been described as one of the fifteen possible views of the process model [9].

One exemption is a study that proposes an incentive pay system for the project management team [10]. The system represents an integrated use of RAM, fuzzy linguistic variables, and five project management process groups (initiating, planning, executing, monitoring and closing). Responsibility and performance are quantified either by crisp numbers (10, 7, 5, 3, and 1) or fuzzy intervals. Four models are discussed (with or without performance, crisp or fuzzy numbers, with or without weighting for process groups). The system has been applied to a practical case with 15 members of the project management team. The feedback indicated efficiency and effectiveness of the proposed methodology. It has been concluded that the choice between four discussed models depends on the specific situation and nature of work. The system is designed to distribute rewards within a group, but it could potentially be used for more complex purposes. Performance is evaluated in the interval $(0 \div 1)$, which does not allow for performance to be over 100 %. This paper researches the possibility of the wider application of this concept while using slightly different formulas to measure performance.

QFD has been defined by its originator Yoji Akao [11] as "a method for developing a design quality aimed at satisfying the customer and then translating the customer's demands into design targets and major quality assurance points to be used throughout the production phase". It is a highly effective and structured planning tool. QFD is usually used at early stages of a project, but using the same methodology as a decision-making tool at later stages also may be beneficial.

QFD methodology has been applied in the construction industry in many different ways. For example, Lee et al. [12], developed an automated system (SQFD) for measuring quality performance of the design/build contractor. In the same paper authors present an overview of QFD application in other areas of planning, design and tendering. QFD methodology can be used for the purpose of multi criteria choice of suppliers, taking into account cost and subjective factors and AHP method [13]. Another example is the model for the selection of contractors for specific renovation projects, which combines fuzzy theory and QFD methodology [14].

3 The proposed performance measurement framework

Investigations in the field of KPIs are certainly useful as their goal is adopting a standard set of KPIs, which could then be universally applied to all construction projects. In this way performance measurement can successfully be developed at the project level as a whole. However, the question is to what extent the proposed KPIs can be applied to assessing the performance of individuals. The problem is that the proposed KPIs are not equally related to all employees on a typical project. Project manager is not directly responsible for the physical execution of individual activities (time, cost, quality), and workers do not participate directly in communication and innovation. The missing link is the relationship between the individual KPIs and the performance measurement for different individuals and teams assigned to different jobs at different organizational levels.

Another problem is the performance measurement for employees in a construction company who are not directly engaged on a project (procurement, legislative, quality staff, planners etc.). Therefore, project KPIs cannot be directly used for the evaluation of their work. Instead of KPIs, the use of the RAM is recommended, with a modification that, in accordance with QFD methodology, numbers are used instead of symbols to indicate the level of responsibility.

The employee performance measurement framework, proposed herein, consists of two modules:

- MODULE 1 for employees directly engaged on projects. Performance is measured on separate organisational levels using KPIs.
- MODULE 2 for employees not directly engaged on projects. Performance is measured using the RAM and calculations based on QFD methodology.

3.1 Module 1 - employees directly engaged on projects

A review of four KPI-related studies shows that there is a common sub-set of KPIs highlighted in Tab. 1. Based on this level of consensus, the proposed model uses those common KPIs. In order to objectively evaluate the performance of all human resources on a project, a balanced use of KPIs in line with the organizational chart

of the project is proposed. Different sets of KPIs are defined for each level in the organizational chart, according to the different nature of work being carried out at each level.

The proposed module consists of four organizational levels:

- LEVEL A - PROJECT MANAGER
- LEVEL B - ENGINEERS (responsible for work packages and subcontractors)
- LEVEL C - FOREMEN (technicians)
- LEVEL D - CREWS (workers).

The proposed four levels are common for construction projects in Serbia, but more or fewer levels can be used as needed. A similar breakdown has been used in [15], where a competence based personnel selection method is discussed. Fig. 1 shows the organization chart, performance measurement levels and corresponding KPIs.

The proposed performance measurement sequence is D-C-B-A because evaluation consists of two categories: performance evaluation of own work and performance evaluation of the managed teams from the lower level. Both evaluations are accompanied with matching weights (shown in Tab. 3).

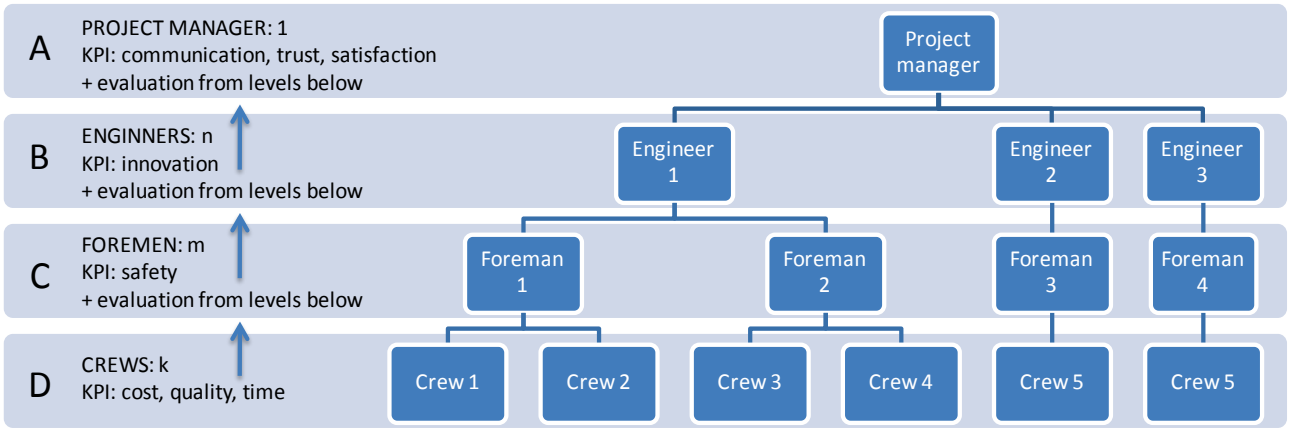

Figure 1 OBS (segment), performance measurement levels and KPIs for Module 1

Table 2 Organization levels, KPIs and measures

Level	KPI	Measure name	KPI measures (*g*) expressed as a percentage
D	Cost	*gc*	Estimated/actual cost
	Time	*gt*	Estimated/actual time
	Quality	*gq*	1 − (Cost of rework/estimated cost)
C	Safety	*gs*	1 − (Lost hours/estimated hours)
B	Innovation	*gi*	1 + (Cost savings/estimated cost)
A	Communication	*gcom*	Subjective scale (1÷10): performed/planned
	Client satisfaction	*gsat*	Subjective scale (1÷10): performed/planned
	Trust	*gtru*	Average time for settling disputes: performed/planned

Table 3 Recalculation of weights for each level

KPI	Weights names	Weights - *w*				
		Project	D	C	B	A
Cost	*wc*	0,131	0,339			
Time	*wt*	0,120	0,324	*w*D		
Quality	*wq*	0,130	0,337	0,757	*w*C	
Safety	*ws*	0,124		0,243	0,829	*w*B
Innovation	*wi*	0,105			0,171	0,615
Satisfaction	*wsat*	0,151				0,151
Communication	*wcom*	0,124				0,124
Trust	*wtru*	0,110				0,110

Performance measurement starts from the lowest organizational level D that represents workers organised in crews. For construction work team performance is more important than individual performance, so performance is measured on crew level. That way, the importance of teamwork is emphasised (another important component of human resource management). For crews, three aspects of performance are measured: cost, time and quality. The next level, C, represents the foremen who manage the crews. Evaluation of crew performance is a part of overall evaluation of foremen. This is very important because it prevents the possibility that foremen receive (good) evaluations regardless of the performance of their crews. This way, the foremen are automatically motivated to raise the performance of the crews they manage. Part of the foremen evaluation that relates to safety, is assigned regardless of the team. The next level, B, represents the engineers who are responsible for work packages and subcontractors. Besides the evaluation from lower levels, performance is measured in the field of

innovation (savings). Finally, the performance of the project manager is measured on level A. In addition to performance measurement of all subordinates, the project manager is evaluated in the areas of communication, client satisfaction and trust.

Table 4 Formulas for performance measurement for all levels

Level	Formulas		
D *k* crews	$GD_i = wc \times gc_i + wq \times gq_i + wt \times gt_i$ $wc + wq + wt = 0{,}34 + 0{,}34 + 0{,}32 = 1$		$i = 1, k$
C *m* foremen	$GC_i = ws \times gs_i + wD \times \overline{GD_i}$ $i = 1, m$	$\overline{GD_i} = \frac{\sum_j GD_j}{n(i)}$	$j \in crew(i)$
	GD_i - average evaluation of foreman *i* crews $n(i)$ - number of crews for foreman *i* $ws + wD = 0{,}24 + 0{,}76 = 1$		*crew*(*i*) is the set of crews for foreman *i*
B *n* engineers	$\overline{GB_i} = wi \times gi_i + wC \times \overline{GC_i}$ $i = 1, n$	$\overline{GC_i} = \frac{\sum_j GC_j}{n(i)}$	$j \in foreman(i)$
	$\overline{GC_i}$ - average evaluation of engineer *i* foremen $n(i)$ - number of foremen for engineer *i* $win + wC = 0{,}17 + 0{,}83 = 1$		*foreman*(*i*) is the set of foremen for engineer *i*
A 1 project manager	$GA = wcom \times gcom + wtru \times gtru + wsat \times gsat + wB \frac{\sum GB_j}{n}$ $wcom + wtru + wsat + wB = 0{,}12 + 0{,}11 + 0{,}15 + 0{,}62 = 1$		$j = 1, n$

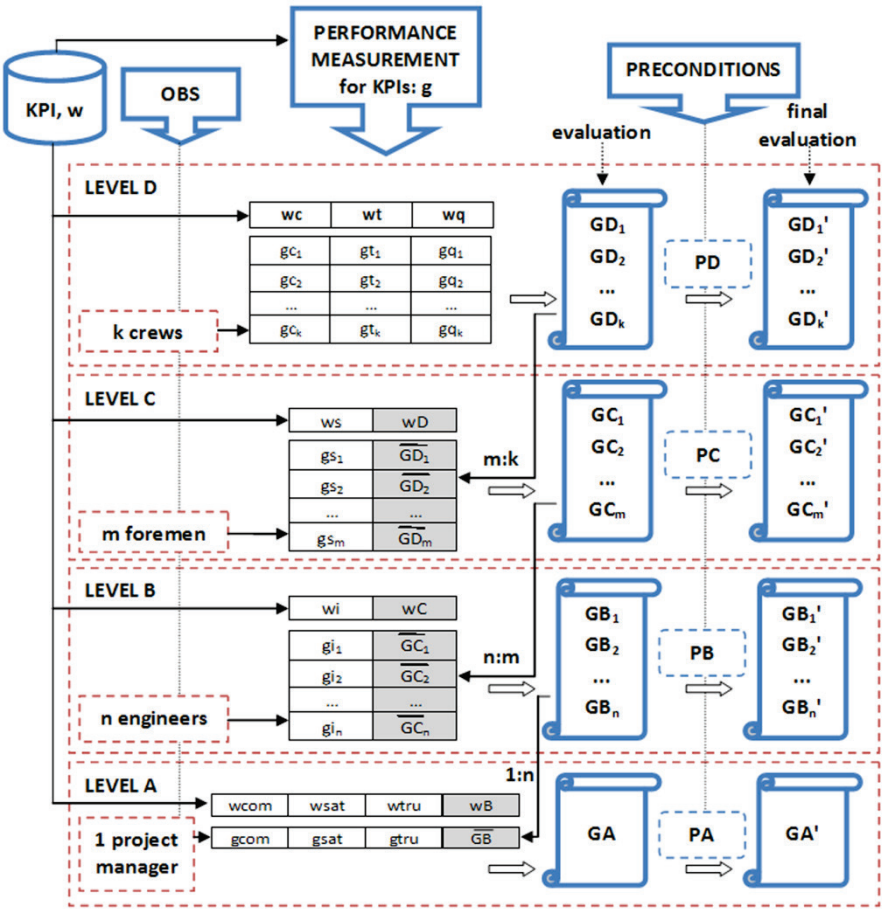

Figure 2 Employee evaluation procedure for Module 1

The emphasis of this study is the classification of KPIs in accordance with the nature of work and the organizational chart of the project. KPI measures are taken from previously mentioned studies with certain adjustments, although the definition of KPI measures is an important area of research that deserves special attention. KPI measures in this research are expressed as a percentage in order to be comparable (100 % - planned performance; over 100 % - better performance). It is important to emphasize that the quality of a performance

measurement system directly depends on (successful) KPI quantification. In order to make the system more unbiased descriptive marks (e.g. 1 ÷ 10) should be avoided in favour of numerical measures that can be obtained directly from executed works. There is also the possibility to define more than one measure for any KPI, with appropriate weights. Combining more measures for KPIs would make performance measurement more realistic. For example, a measure "estimated/actual spent hours" could be used for the time KPI in addition to the "estimated/actual time" measure. Tab. 2 shows the KPIs for each organizational level and the corresponding measures. This list can be adjusted in relation to specific project or company conditions.

Weights (w_i) for KPIs were also taken from one of the studies [2]. They are used to arrange the importance of different KPIs. Weights must be recalculated on each level by using proportions so the sum of weights is 1 on each level. Tab. 3 shows this recalculation.

Tab. 4 shows formulas for performance evaluation for all levels. $\overline{GD_i}$ is an average evaluation factor for crews which are managed by foreman i. Values Xd, Yd return the ordinal number of crews. Similar definitions apply for $\overline{GC_i}$, Xc and Yc.

Project manager	A
gsat	0,90
gcom	0,95
gtru	0,95
$\overline{GB}$	1,07
GA	1,02

Engineers	B1	B2	B3	B4	B5
$gi_1 : gi_5$	0,90	1,00	1,20	0,90	1,00
$\overline{GC_1} : \overline{GC_5}$	1,10	1,15	0,97	1,05	1,15
$GB_1 : GB_5$	1.07	1.12	1.01	1.02	1.12

Foremen	C1	C2
gs_1, gs_2	0,95	1,00
$\overline{GD_1}, \overline{GD_2}$	0,88	1,06
GC_1, GC_2	0,90	1,04

Crews	D1	D2	D3	D4	D5
$gc_1 : gc_5$	0,80	0,90	0,95	1,10	1,05
$gt_1 : gt_5$	0,85	0,95	0,90	1,20	1,10
$gq_1 : gq_5$	0,80	0,90	0,85	1,00	0,90
$GD_1 : GD_5$	0,82	0,92	0,90	1,10	1,02

Figure 3 Implementation example

Fig. 2 shows the complete employee evaluation procedure for Module 1. For each level, KPIs and corresponding weights are predetermined, in accordance with Tabs. 2 and 3. OBS provides the number of crews or individuals on each level (numbers k, m and n). Performance measurement is quantified using KPI measures (g) listed in Table 2. GD_i is an evaluation factor for each crew. Shaded areas mark performance factors taken from lower levels (m foremen manage k crews, n engineers manage m foremen, 1 project manager manages n engineers).

Fig. 3 shows an implementation example (only a part of an organization chart is presented). This example shows: 5 crews (D1:D5), two foremen (C1 leads 3 crews, C2 leads 2 crews), 5 engineers (B3 leads C1 and C2) and one project manager (A). Fig. 3 shows how individual evaluations effect final performance measurement. The poor performance of crew D1 led to bad evaluation of their foreman C1. The project manager received a good evaluation in spite of his own bad performance, because of the good performance of the engineers.

In order to objectively measure performance of project staff, it is necessary to introduce another coefficient that evaluates the fulfilment of necessary preconditions for each level (PA:PD). The purpose of this precondition coefficient is to ensure that employees can receive a good evaluation in the case when higher-level managers did not provide the necessary conditions to accomplish the planned tasks. Coefficient (P) is between 0 and 1 (1-all preconditions provided). At level D, PD represents the existence of all design details, materials, tools, free workspace etc. At level C, PC shows the lack of precise contract and design arrangements, adequate work force (number and composition), safety preconditions etc. At level B, PB quantifies influences from the project environment (quality of design, contract, permits, site space, traffic conditions, cooperation with the engineer and other authorities etc.). Coefficient PA quantifies aggravating circumstances on project level and enables comparing results achieved on projects of different complexity. Aggravating circumstances can be: poor design, poor financing, extreme weather and/or other conditions, poorly contracted project, and similar categories.

The mathematical interpretation follows the same logic as the performance evaluation process. For crew level D, preconditions depend on the same KPIs (cost, quality and time. The general formula is (1):

$$PD = wc \times PDc + wq \times PDq + wt \times PDt. \quad (1)$$

For example, PDt is the measure for time preconditions. It combines the precondition ratios for design details (available/total), free workspace (available/needed) and crew composition (1-optimal; 0,85-suboptimal; 0,7-not optimal) with appropriate weights. Similar formulas are used for levels C, B and A. The mathematical interpretation of measures for partial precondition coefficients needs to be carefuly developed so that it objectivly resembles the reality of construction projects. Precondition coefficients can change over time.

Final performance evaluation factors are calculated by using the following formula (2):

$$GX' = GX / PX \; ; X \in (D, C, B, A). \quad (2)$$

For each company KPIs, weighting sets and precondition coefficients can be modified after testing, according to specific circumstances.

3.2 Module 2 - employees not directly engaged on projects

Module 2 captures the performance of employees not directly engaged on projects. This group of employees perform a variety of different jobs. Performance measurement must be designed differently (without KPIs) because measurement cannot be directly linked to outcomes of project activities. We propose to use a Responsibility Assignment Matrix (RAM), where the RAM axes represent jobs and employees. In order to be used for performance measurement, RAM must be quantified in a certain way.

Module 2 concept consists of quantifying responsibilities and quantifying job importance. That way, using calculations based on QFD methodology, employee performance can be converted into points. This procedure can be carried out as follows:

1. Job identification is the first step in this module. If job systematization and a quality management system exist in a company, job identification is easy. If that is not the case, job identification can be carried out in a few iterations (for example: employees fill out forms, data is systematized and harmonized at company level).

2. Creating the responsibility assignment matrix is the next step. The matrix is filled out with different symbols that define the level of responsibility for particular jobs. A Responsibility, Accountable, Consultant, and Inform (RACI) format is often used to accomplish this task [9]. In this paper we will use the following three-step format: full responsibility, partial responsibility, and participation without responsibility.

3. Quantifying the responsibility assignment matrix is the key step because it enables converting employee performance into points. Quantifying the responsibility assignment matrix consists of transforming job responsibility into points and transforming the importance of jobs (for the company) into points.

3a. Quantification of responsibility means assigning numerical values to each symbol used in the scheme. For example:

- Full responsibility: $r = 9$
- Partial responsibility: $r = 3$
- Participation without responsibility: $r = 1$

3b. Quantification (ranking) of jobs means assigning importance of particular jobs for the company (w) to each job in a separate column. For example, the scale for job importance can be {1, 2, 3, 4, and 5}.

4. Points calculation is a 3-step procedure: calculation of maximum (Gmax), planned (Gplan) and performed (Gper) points.

The first step is calculating Gmax that stands for the sum of points for all jobs an employee can perform, given the job importance and job responsibility ("capacity of an employee"). The number Gmax (and the percentage ratio p) shows how much is each individual important for the company. Gmax can be used to determine the level of the base salary (higher score means greater significance of individuals for the company). Practically, a certain number of points (and salary level), employees can collect by performing a small number of significant jobs for which they are fully responsible, or a greater number of less significant jobs with reduced responsibilities. At this level, the validity of Gmax scores should be checked. For example: check if employees can really perform all assigned tasks, or check for employees with a low number of points for the salary they receive. The good side of the proposed system is that, just by introducing scoring, it provides internal fairness when determining salary levels. Fig. 4 shows the data structure of RAM for calculating Gmax.

$w_j \in \{1,2,3,4,5\}$		i=1,n			
$r_{ij} \in \{0,1,3,9\}$		employees			
		emp 1	emp 2	...	emp n
jobs	importance (w_j)	responsibility r_{ij}			
job 1	w_1	r_{11}	r_{12}	...	r_{1n}
job 2	w_2	r_{21}	r_{22}	...	r_{2n}
...	...	...	...	...	...
job m	w_m	r_{m1}	r_{m2}	...	r_{mn}
		$Gmax_1$	$Gmax_2$	...	$Gmax_n$	Σgmax
		p_1	p_2	...	p_n

j=1,m

Figure 4 Data structure of RAM for calculating *Gmax*

The formulas for calculating Gmax and p for each employee are:

$$G\max_i = \sum_{j=1}^{m} \left(w_j * r_{ij} \right), \tag{3}$$

$$p_i = \frac{G\max_i}{\sum G\max}. \tag{4}$$

According to the nature of the construction industry, the workload is distributed unevenly in time and scope. So, Gmax is a theoretical maximum of points that employees would receive for performing all jobs at the same time. Realistically employees will perform only a part of these activities in a time interval. Therefore, the assessment cannot be made on the basis of Gmax, but in relation to Gplan, which is a reduced number of points over the planning period (usually one month). To determine the planned number of points Gplan, the procedure is repeated in an identical manner with the same formulas, but only for the planned activities for the next month. A useful indicator for the company management is the ratio ΣGplan/ΣGmax that directly shows the overall level of employment of the company (all employees) in each month.

After that, performance can be evaluated for each job an employee performs (g_{ij}), compared to 100 % (100 % - planned performance). Measures for evaluating performance (g_{ij}) are hard to define explicitly (as in Module 1) because employees perform a large number of different jobs. Wherever possible, it is desirable to link the evaluation with KPIs and the performance on construction site. For example:

- The planning processes and bid preparation may be linked to KPIs (cost, time). The measures are similar to those in Module 1 and they actually reflect the validity of planning.
- Quality management tasks can be linked to KPIs (quality, communication, satisfaction).
- Legal department tasks can be directly linked to KPI (trust).).

- The work of the procurement department can be partially linked to KPI (cost, time).
- For jobs that cannot be directly linked to the projects, subjective assessment should be used (in relation to 100 %). Evaluation by immediate supervisor is most common.

Since these departments are usually engaged on more than project, it is necessary to calculate weighted evaluations. For that purpose the "project factor" (*PA* in Module 1) can be used. The formula for calculating weighted evaluations (for any measure *g*, in case of *n* projects) is:

$$\bar{g} = \frac{1}{n} * \sum_{i=1}^{n} \frac{g_i}{PA_i}. \tag{5}$$

After determining all g_{ij} evaluations (w_j and r_{ij} remain the same as in the previous matrix), employees receive an overall monthly performance factor *G*per. The *G*per factor should be viewed in relation to the monthly planned number of points *G*plan. Fig. 5 shows RAM with g_{ij} performance evaluations:

			i=1,n			
			employees			
			emp 1	emp 2	...	emp n
	jobs	importance (w_j)	responsibility r_{ij} ; performance g_{ij}			
j=1,m	job 1	w_1	r_{11} g_{11}	r_{12} g_{12}	...	r_{1n} g_{1n}
	job 2	w_2	r_{21} g_{21}	r_{22} g_{22}	...	r_{2n} g_{2n}
	...	...	...	...	...	...
	job m	w_m	r_{m1} g_{m1}	r_{m2} g_{m2}	...	r_{mn} g_{mn}
			$Gper_1$	$Gper_2$	...	$Gper_n$	ΣGper
			q_1	q_2	...	q_n	

Figure 5 RAM with g_{ij} evaluations

The formulas for calculating *G*per and *q* for each employee are:

$$Gper_i = \sum_{j=1}^{m} \left(g_{ij} * w_j * r_{ij} \right), \tag{6}$$

$$q_i = \frac{Gper_i}{Gplan_i}. \tag{7}$$

Based on ratio *q*, performance based rewarding can be implemented.

There is a clear analogy between the described procedure and the QFD methodology. The difference is that there is no mutual dependency among employees who perform their tasks. Dependence can be introduced at the level of individuals (for example, through assistants) but it is better to solve such relations by forming independent teams for different tasks.

Fig. 6 shows the complete performance evaluation procedure for Module 2.

5. Connecting points with salaries is the final step of Module 2. This is the most sensitive segment of the performance measurement system, and it should be approached with caution. In order to make sure that scoring is objective and credible, the system should be tested for several months before implementation.

Fig. 7 shows an example of a quantified RAM (year) from a case study. The first column shows the importance of each work for the company. For responsibility quantification, a (1, 3, 9) scale was used. Maximum number of points *G*max, and ratio *p* are shown at the bottom of the table. In this example, it is clear that two employees carry out 85 % of total work. After the quantification of RAM, the salary system in this company was reconstructed.

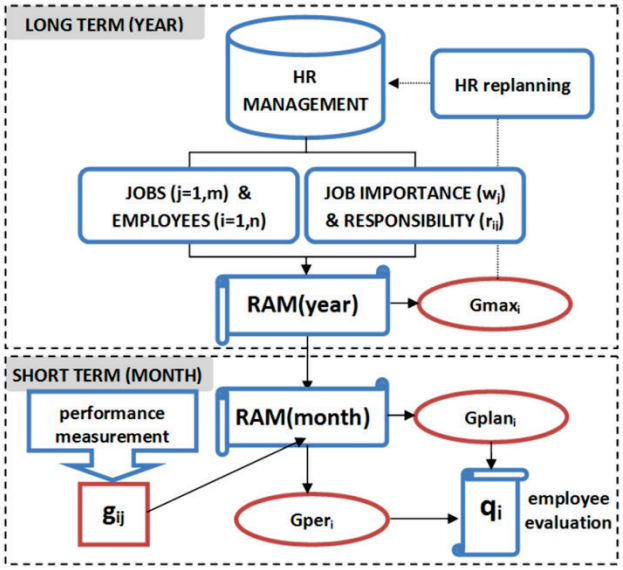

Figure 6 Performance evaluation procedure for Module 2

w_i	JOBS	EMPLOYEES				
		EMP 1	EMP 2	EMP 3	EMP 4	
	DESIGN	**RESPONSIBILITY r_{ij}**				
5	SHOP DRAWINGS	9	1		3	
5	CHANGE MANAGEMENT	9	1			
	TENDERING					
4	TENDER MANAGEMENT	9				
4	CONTRACTING		9	1		
5	PROCUREMENT	3	9			
3	QUANTITY CONTROL		9		3	
2	PAYMENT	9	1			
	CONSTRUCTION					
5	SCHEDULING			9		
5	SUBCONTRACTORS MANAGEMENT	9	3	1		
4	SITE MANAGEMENT	9		1		
3	PERFORMANCE MEASUREMENT		9			
3	DOCUMENTATION MANAGEMENT		9			
4	QUALITY CONTROL		9	1	1	
Full responsibility: r = 9	Gmax	240	225	58	28	551
Partial responsibility: r = 3	pi	44%	41%	11%	5%	
Participation without responsibility: r=1						

Figure 7 Case study of a quantified RAM

4 Conclusions, benefits and further research topics

The main benefit for a construction company is an objective performance measurement system for all employees. The framework proposed in this study is a way to perform such performance measurements. Company management can use the proposed framework as a management tool for allocating jobs or for implementing performance-based rewarding. Measurements are performed in real time, so it is possible

to immediately intervene with corrective measures, rewards/penalties or other control mechanisms. Performance-based rewarding can be easily implemented because evaluation factors are non-dimensional. Final evaluation can be linked to the base salaries and bonuses (positive or negative).

More benefits are achieved through higher motivation of employees. In the first cycle, the company makes a higher profit because employees are motivated (financially) to perform better than it was planned when preparing bids. Substantial benefits are gained in the second cycle. New bids are prepared with higher work standards so the company makes higher profit because of lowered costs (labour, rework, time, etc.). This way, the competitiveness of companies is increased, which is one of the main goals of strategic human resource management. This process tends asymptotically to optimal values when it is not possible to further improve performance. At some point, the performance standards cannot be further enhanced due to physical limitations. But at this stage, the company fully optimized its performance.

Another significant benefit for the company is a considerable increase in the quality of data obtained from completed projects. Evaluation of project staff leads to an evaluation of the project itself (*GA* factor from module 1). Unlike project evaluation through KPIs (1 ÷ 5 range), the proposed framework evaluates project success relatively in relation to planned values from the bid. Project evaluation is compared to number 1 (more than 1, a better result than planned). This kind of information is very useful for company management for negotiating new projects

Additional benefits for the company are:

- Identification of critical areas (for training, staff relocation, letting go etc.). Problematic or satisfactory areas easily come to light.
- Increased motivation through tangible and intangible rewards (bonuses or penalties), promotion of the best.
- Promotion of teamwork on projects (project staff evaluation is based on site performance). Creating a positive competitive spirit between crews, managers and projects.
- Evaluation is based on objective performance measurement, without subjectivism.
- The system is in line with major HR trends (strategic HR management, performance measurement, motivation and focus on people).
- Improved image of the company (top trends applied in practice).

The framework is designed for civil construction projects and companies that perform such projects, but it is applicable to any industry. In Module 1, the KPIs set should be adjusted to the nature of the industry in question. Module 2 can be implemented universally as it is proposed**.** The performance evaluation is fully comparable between modules because measures are non-dimensional. But the policy of bonuses should be developed and customized by every company in accordance with the nature and importance of individual jobs in question.

The most important direction for further research is detailed quantification of various KPI measures and precondition coefficients, because assigning objective and unbiased evaluations to employees in both modules is crucial for the overall quality of the proposed framework. Developing an appropriate software tool for the implementation of the proposed framework in practice is the next planned research step.

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Authors' addresses

Zoran Stojadinović, Ph.D., Assistant Professor
Faculty of Civil Engineering, University of Belgrade,
Bul. kralja Aleksandra 73, 11000 Belgrade, Serbia
(corresponding author)
E-mail: joka@grf.rs

Dejan Marinković, Ph.D., Teaching Fellow
Faculty of Civil Engineering, University of Belgrade,
Bul. kralja Aleksandra 73, 11000 Belgrade, Serbia
E-mail: dejan@grf.rs

Branislav Ivković, Ph.D., Professor
Faculty of Civil Engineering, University of Belgrade,
Bul. kralja Aleksandra 73, 11000 Belgrade, Serbia
E-mail: ibane@grf.rs