



## Cost of Quality in Construction Sector

*\*Recep Kanit, \*\*Latif Onur Uğur*

(\*Prof. Prof. Dr. Recep Kanit, Gazi University, Faculty of Technology, Department of Civil Engineering, Teknikokullar, Ankara/Turkey, rkanit@gazi.edu.tr)

(\*\*Assist. Prof. Dr. Latif Onur Uğur, Duzce University, Faculty of Technology, Department of Civil Engineering, Duzce, Turkey, latifugur@duzce.edu.tr)

### 1 ABSTRACT

In this study, to determine the quality management practices, to ensure lack of the regulation quality, the cost of quality is to determine the ratio of the total Project cost of the construction firms investigated. For this purpose, a questionnaire prepared and asked to the persons which Works in Total Quality Management departments of 54 construction firms from the members of Turkish Association of Contractors. According to the data obtained; all of these firms has quality management systems and certificates, they have quality control elements both in construction sites and their centers. Their ratios of receiving professional consulting services business making and during the construction process and making risk analysis are low. They have no special test system for choosing persons to their studies, their business, labor and equipment plans are not daily controlled. They don't granted to employees in the job training, their payments generally interruption because of the manufacturing quality... The biggest cost of quality seems in the production process, then construction site establishment, organisation, management activities takes important quality costs. Business making, contracting, production management and data generation process is understood that followed.

**Key Words:** Quality, Construction Industry, Quality Costs, Unquality Costs, Quality Management, ISO 9000

### 2 INTRODUCTION

Quality is the realization of the employer requests defined with specifications. Thus, the whole of the expenditure done with the aims of producing what the employer wants and presenting those products to the customer is referred to as the cost of quality. Genel anlamda, üretilen kalite, kalite maliyetleri ile dengelenmelidir. In general, the produced quality should be balanced with the quality costs. Therefore, it is important to know the quality costs.

Definition, identification and measurement of the quality costs are difficult to determine in construction production. However, Yapı üretiminde, kalite maliyetlerinin tanımlanması, belirlenmesi ve ölçülmesi güçtür. management of the quality management is a necessity for the construction industry. Bunu yaparken temel ilke, kaliteyi ilk ve tek defada hatasız üretmek olmalıdır. In doing so, the main principle is to produce quality at the first and only time without error.

Construction, in order to meet a specific need, is an engineering structure made in and/or on the ground, with the use of machine-equipment by using materials. It is constructed on a specific open place and is immovable. It is unique and unmatched in many ways. And the production methods change according to the place of production, ground type of that place, climatic condition, work force quality, and etc[1].

The construction production covers all of the activities in the process starting from the speculation about the work subject to the tender and continuing until the delivery of the structure performed. Along with the main profitability target of these activities, it should also be managed in a way to perform other targets emerging [2].

Construction production is provided as a result of fulfilling of many activities related to each other and connected to each other as well as the realization of a structure. İnşaat üretimi, sonucu itibariyle bir yapının gerçekleştirilmesinin yanı sıra, birbiriyle ilişkili ve birbirine bağlı birçok faaliyetin yerine getirilmesiyle sağlanır. In other words, the concept of quality construction in construction covers the quality of other activities realized in order to make this structure as well as the quality of the resulting structure at the end of production. This case is shown in Table 1 [1].

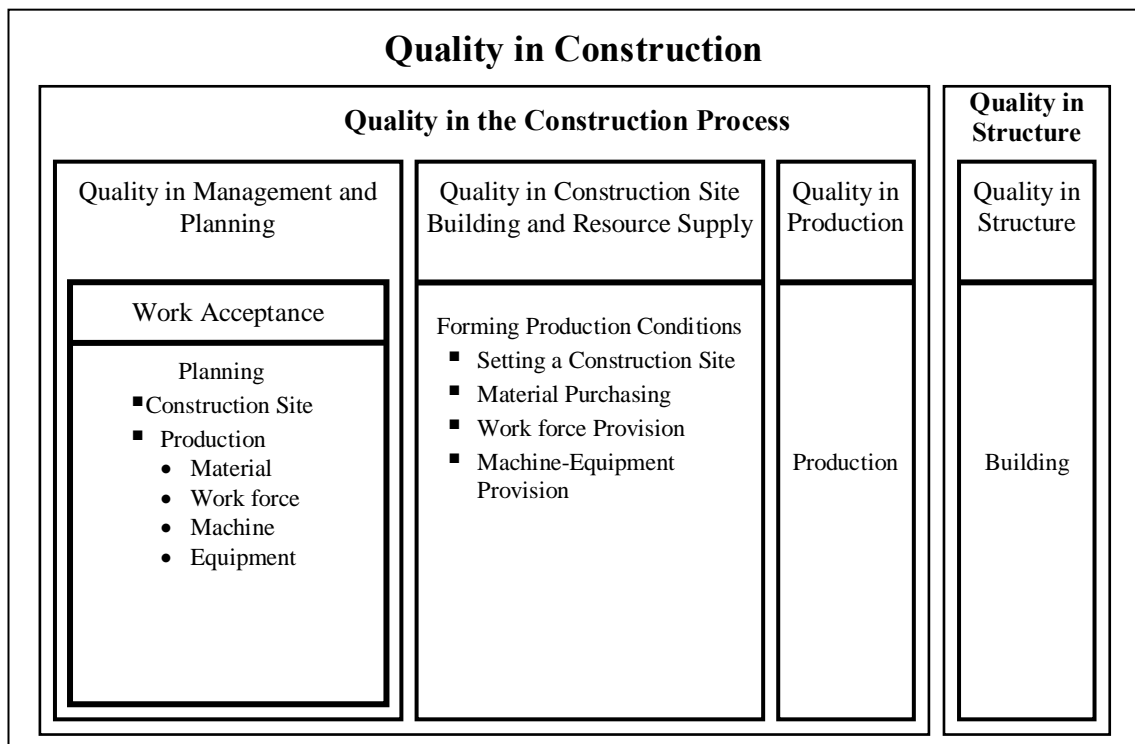


Table 1: Building Production Quality <sup>(1)</sup>

Generally, the order of importance of the quality elements of a construction such as functionality, aesthetics, affordability, durability and etc. can change according to the user and most of the time public authority decides on behalf of the user for which of the elements of this quality will take precedence. Besides, when it is mentioned about the construction quality, its characteristics regarding the construction of the following points come to mind. Bunlar;

These are:

- Performance - the functionality
- Features
- Reliability
- Conformity
- Resistance
- Utilitarianism
- Aesthetics and
- The display (perceived) quality <sup>[3]</sup>.

### 3 COST OF POOR QUALITY

If expenses caused by handling, changing, junking are considered, the philosophy behind poor quality is understood. As quality is defined as performing a work in way that it should be done, the cost of quality is ignored. However, there is a cost of poor quality. It is almost impossible to compete by price without actively taking the cost under control. In this sense, losses emerging as a result of poor quality are obstacles to an institution's own chance to compete that it creates by itself.

To give a more realistic definition of a poor quality would be, an important part of expenses that may arise as a natural result of developments under the responsibility of the manufacturer arise from the shortcomings in the understanding of service. The cost of poor quality is reflected directly to the expenses which are the expenses such as alteration, repair, renewal, junking and recovering that arise from the warranty coverage. Indirect expenses cover the issues such as legal operations, regaining the trust of the recipient and compensation. Improvement of the quality and the provision of an effective quality control may be defined as an issue that requires cost. On the other hand, the fact that carrying out a work in the right way from the start will prevent many indirect expenses stands before us. As control of the expenses arising from poor quality will reflect on productivity, it is certain that every effort directed at quality systems is a very fruitful investment for the future[3].

Now that the necessity of quality is accepted today, it would be more accurate to mention not the costs of expenses that would realize this but the market, prestige and the institutional cost of money lost on the markets because of poor quality. That is, the cost of poor quality is heavier [3].

#### 4 METHOD

In this study, it is aimed that the factors which affect the quality of the constructions as well as the cost of this quality are examined in the construction sector from the point that the company is informed about the construction work to the point where the data are collected and data banks are created. How the practice works in terms of the factors which affect the quality during the production process is searched and the quality costs of the fair-sized and large-scale companies which act as a subcontractor in the construction sector are assessed.

To this end, a questionnaire was prepared and the representatives of the companies in the construction sector were asked to respond to these questions. The questionnaire was applied to 18 construction companies in Ankara between 15th March 2007 and 3rd April 2007. The companies interviewed were selected among the members of the Turkish Contractors Association. In the pre-interview process, the respondents were informed about the subject in brief and the questionnaire was applied to the representatives who accepted the offer for an interview. Then, statistical analyses were conducted based on the responses of these representatives and deductions were made about the construction sector through the outcomes.

#### 5 FINDINGS

According to the survey results, all the firms to which the questionnaire was applied use ISO 9000 quality management system. From this point of view, it is considered that having an internationally recognised quality management system, having a quality document and applying such regulations are stipulated by application / eligibility requirements of the tenders both in Public Procurement Law and in the international regulations play a significant role. In line with this, that each company has employees who are responsible for the quality management was also determined by the data collected via the questionnaire. Furthermore, it was discovered that such employees responsible for the quality management are also assigned in the construction site. During the interviews made within the process of conducting the questionnaire, it was also discovered that in most companies, such employees are assigned with the tasks concerning quality control, work and occupational safety. The findings related to the applications made during the processes are listed below under each title.

##### 5.1 Work acceptance process

From the evaluation of the applications performed during the work acceptance process, it is understood that all of the companies carried out the bid price detection with professional teams but only 11 % of them took professional legal advisory service in the examination of the tender files. It was detected that work place examination and evaluation in terms of the provision of resources (labor, machinery-equipment, materials, sub-contractor, etc.), making evaluations and performing the necessity and economy analyses of the work in question has been executed but the risk analyses has been made only at the rate of 17 % (See Table 2).

I- Work Acceptance Process	Yes	No	% Yes
Were professional legal services taken for the examination of the tender file?	2	16	11
Was the construction site examined and evaluated?	14	4	78
Was an evaluation in terms of the provision of resources (labor, machinery and equipment, materials, sub-contractor, etc.) done?	13	5	72
Was the determination of the price of the tender offer made by a professional team?	18	0	100
Were the requirement and cost analysis of the work performed?	16	2	89
Was the risk analysis of the work performed?	3	15	17

Table 2 - Applications in the work acceptance process and their proportional distributions

## 5.2 Contract process

Upon winning the tender, at the stage of arranging the contract terms and their analysis, it is understood that the 61 % of the companies examined the contract text systematically in administrative, technical and legal terms but the remaining part of 39 % did not perform such an activity. According to the obtained results, none of the companies take professional aid for the examining of the contract text (See Table 3).

<b>II- Contract Process</b>	<b>Yes</b>	<b>No</b>	<b>% Yes</b>
Was the text of the contract examined systematically in terms of administrative, technical and legal aspects?	11	7	61
Was a professional help taken in order for the analysis of the text of the contract?	0	18	0

Table 3 - Applications in the contract process and their proportional distributions

<b>III- Site Foundation, Organization and Management</b>	<b>Yes</b>	<b>No</b>	<b>% Yes</b>
Was the Site layout (plan) arranged by taking into account the business type, size, construction period and climatic conditions?	18	0	100
Was the organizational structure of the site formed according to the characteristics of the work and the place?	17	1	94
Was a selection method in identifying a new technical staff for the work undertaken?	16	2	89
Were the skilled laborers and normal laborers detected through a knowledge-skill exam?	1	17	6
Were the site units organized according to the peak number of employees in terms of work force and the site organization plan?	12	6	67
Were the open and closed warehouses and their locations identified by taking into consideration the quantities and properties of the material?	11	7	61
Were the auxiliary energy, clean water and fuel units created?	3	15	17
Were precautions taken for the night-loading, unloading and transport?	6	12	33
Was an agreement with a health unit done within the scope of worker health?	16	2	89
Was hygiene and sanitation planning done for the workers' food and bodily cleanliness? Was an employee assigned for this?	18	0	100
Were the arrangements for the communication and recreation needs of the employees performed?	18	0	100
Were the internal and environmental safety measures in the construction site planned and applied?	17	1	94
Were construction site management measures taken by considering the fact that the duration of the work may extend?	16	2	89

Table 4 - Applications in the construction site establishment, organization and operation process and their proportional distributions

## 5.3 Site establishment, its organisation and operation

All applications made during the site establishment, organisation of its structure and operation are displayed in Chart 4. According to these data, all companies state that the plan of the site is organised according to the type, size, period of the work as well as the climate conditions; that a hygiene and sanitation planning is made for ensuring food and bodily cleaning for the employees; that an employee is assigned for this task; and that necessary arrangements were made for the communication and relaxation needs of the employees. It is understood that necessary tasks are mainly fulfilled: e.g. that the site is established according to the nature of the work and the features of the region; that election methods are used in order to determine new technicians for the task undertaken; that an agreement is made with a health unit for planning and ensuring

internal and environmental safety of the site; and that operational measures are planned by taking the fact that the construction period might extent into account. However, the other tasks are fulfilled at rather low levels: e.g. selection of operatives and unskilled workers with a test of knowledge and skills, creation of auxiliary power, clean water and fuel oil units, and measures for loading, unloading and transport other than the working hours.

#### 5.4 The manufacturing process

It expresses that all of the companies in the construction processes of their construction activities are selected according to the branches of specialization of the production and control engineers as the framework and the fine structure and on the basis of the subcontractors' qualifications. According to the given answers, to a large extent; monthly, weekly and daily work plans are made depending on the general work plan, machinery-equipment work plan and schedule are prepared; all of the workers are trained in terms of the importance of the work they do and its impact on quality, preventive measures are taken by searching for the reasons of non-conformities in the manufactures, the non-conformities are corrected and taken under record, precautions are taken in order for the manufactures in the suitable way for their properties and the planning of the subcontractor works are made, conformity of the manufactures is controlled and the improper ones are corrected.

Besides, it is understood that the activities of preparation and application of daily work orders, the preparation of general material provision program and transaction sheets on material basis, and the training of skill increasing at work for the craftsmen were not performed on the desired level. Applications carried out together with other matters and their rates of application are shown in Table 5.

<b>IV- Production Process:</b>	<b>Yes</b>	<b>No</b>	<b>% Yes</b>
Depending on the overall work program, were monthly, weekly and daily work programs carried out?	16	2	89
Were daily work orders prepared and applied?	2	16	11
Were general material provision program and work tables on the material basis prepared?	3	15	17
Were the machinery-equipment work plan and schedule created?	15	3	83
Were the manufacturing and control engineers chosen according to the fields of specialization such as coarse and fine structures?	18	0	100
Was the training of skill upgrading in the work applied for the craftsmen?	3	15	17
Were all the workers trained in terms of the importance of their work and its impacts on quality?	14	4	78
Were the reasons of the nonconformities in manufactures researched and preventive measures taken?	17	1	94
Were the conformity checks of the projects of the daily productions, work orders and manufacture descriptions done? And were they recorded?	12	6	67
Were the corrections of the ineligible products (walls, plaster, cement, tiles, etc.) done and recorded?	14	4	78
Were measures taken in order for the preservation of the manufactures in the way appropriate to their properties?	16	2	89
If a subcontractor was employed, was this subcontractor selected on the basis of qualification?	18	0	100
Was the planning of the works of subcontractor done and was the conformity of the products checked? Were the ineligible ones corrected?	17	1	94

Table 5 - Applications in production process and their proportional distributions

#### 5.5 Production Management

At the stage of management of the manufactures, all of the companies state that weekly evaluation meetings on the basis of production targets, precautions and needs are made and the results are reported. 94 % of the companies state that daily end of shift evaluation meetings are made while 72 % state that charts, tables and reports such as workplace efficiency chart, weekly status reports, monthly production targets tables, monthly temporal comparison reports, monthly used materials tables and monthly production progress report are prepared and applied (See Table 6).

<b>V – Production Management</b>	<b>Yes</b>	<b>No</b>	<b>% Yes</b>
Were charts, tables and reports such as workplace productivity chart, weekly status reports, monthly production targets tables, monthly temporal comparison reports, monthly used materials tables, and monthly production progress reports prepared and applied?	13	5	72
Were end of the shift daily evaluation meetings made? (Production targets, corrective and preventive activities, precautions to be taken for the following day)	17	1	94
Were weekly evaluation meetings on the basis of production targets, precautions and needs made and their results reported?	18	0	100

Table 6 - Applications in production management process and their proportional distributions

### 5.6 Admissions Process

During the temporary and permanent admissions of the manufactures to be made, all of the firms state that the products are controlled by examining one by one over their projects by the site manager in the context of preparation for temporary acceptance of manufacturing, preventive measures are taken for the finished products until the temporary admission, controls of whether lighting, heating, ventilation, clean-dirty water systems function or not and that the necessary corrections are made for the inconveniences. According to the answers given, 11 % of the companies were seen to be executed defective manufacture fine (a charge for defective manufacture) (See Table 7).

<b>VI - Admissions Process</b>	<b>Yes</b>	<b>No</b>	<b>% Yes</b>
In the context that the product is prepared for the temporary admission, was the control made by the site manager over its project by examining the products one by one?	18	0	100
Were protective measures taken for the finished products until the temporary admission? (Windows, fixtures, electrical switches, junction boxes, chimney covers, chimney caps, etc.).	18	0	100
Were the controls of whether the lighting, heating, ventilation, clean-dirty water systems function or not made and were the necessary improvements for the inconveniences made?	18	0	100
In the temporary admission, was any determination of incomplete and defective production made by the admission commission?	17	1	94
Was a fine for defective production (a charge for defective manufacture) applied?	2	16	11

Table 7 – Applications in the Admissions Processes and their proportional distributions

### 5.7. Data Generation Process

The applications in the studies, which were made with the aim of forming data for the future projects to follow after the admission process, and their rates, are shown in Table 8. Based on these data, it is

understood to a large extent that, when the tender price is being formed, the former data which the company formed in former works are made use of; data regarding the costs, materials, labor, machinery-equipment prices, input amounts in the unit products, material, labor, machinery-equipment price increases, monthly cash needs depending on the production amounts, monthly materials labor, machinery-equipment and subcontractor expenses, manufacture amounts, production time and labor needs, costs of the construction elements and unit construction site cost and materials relationship data are generated.

Also from the table, it is seen that out of the applications of data generation from total construction cost and construction site establishment cost, construction cost and labor, technical and administrative staff numbers, the cost of construction and daily construction site operation expenses, regarding the construction site establishment organization and operation, were performed at the rate of 72 %.

VII - Data Generation Process	Yes	No	% Yes
Regarding the costs; Were the data, which are of the relation between unit construction site costs and materials, such as material, labor, machinery and equipment prices, input amounts in the unit production, material, labor, machinery-equipment price increases, monthly cash needs depending on the manufacture amounts, Monthly material, labor, machinery-equipment and subcontractor costs, Manufacture amounts, construction periods and labor needs, the costs of Construction elements (the basic structural system, roof, etc.), created?	13	5	72
Regarding the construction site establishment, organization and operation; Were the data of total construction cost and construction site foundation cost, building cost and workforce, technical-administrative personnel numbers, building costs and daily construction site operation expenses created?	13	5	72
Were the data, created by the company according to the former works, made use of when the tender price was being formed?	16	2	89

Table 8 - Applications performed during the data formation process and their proportional distributions

### 5.8. Proportional effects of the processes on costs

Table 9 was formed with the gathering of the proportional inner costs of the processes, which are evaluated above with their components, to the total cost. As can be seen here; the largest cost provided for the quality is the production process with 0.3724 % and construction site establishment, its organization and operation with 0.2704 % and employment process with 0.0561 % follow this respectively.

Process	General cost rate (%)
Business Decision Process	0.0561
Contract Process	0.0153
Site Establishment, Organization and Management	0.2704
The Manufacturing Process	0.3724
Production Management	0
Admissions Process	0.0153
Data Generation Process	0

Table 9 – The rate of costs of processes within the construction activities to the general costs

## 6 RESULTS AND SUGGESTIONS

As a result of the evaluation on the applications made while the work is being undertaken, it is concluded that all the companies determine their price offers with professional teams and these teams are mainly comprised of their own employees. However, as a result of the evaluation of the tender files, it is observed that only 11% of the companies receive professional legal consultancy. It is considered that it would have positive outcomes for the companies to work with the legal consultancy firms which have expertise in the field. That the examination and evaluation of the construction site is conducted according to the norms including the local conditions in terms of the supply of the resources (labour force, machinery – equipment, materials, subcontractor, etc.) as well as necessity and economy analyses of the work is made are positive evaluations; it is also considered that more arrangements and applications can be made in the field so that more efficiency can be achieved (such as the creation of standard control forms, employment of experts, evaluations made by the people in charge according to certain procedures, etc.). Furthermore, that the risk assessments are conducted only with a ratio of 17 % indicates that the companies should pay more attention to this issue. Establishing risk management departments, employing competent workers, determining and implementing the relevant methods, creating the required data banks and supplying the required hardware and software can be listed as some of the practices in this respect.

It is concluded that during the organisation and analyses process of the terms and conditions of an agreement, 61 % of the companies have the agreement text examined in administrative, technical and legal aspects in a systematic manner whereas the remaining 39 % does not conduct such activities. This means that the risks that might jeopardize the high quality of the construction required in the specifications as well as the ones that might cause serious results with regard to the payments, responsibilities, risks, final and provisional acceptances are not ruled out. According to the findings, none of the companies receive professional assistance for the evaluation of the agreement text. This emphasizes the fact that sufficient importance is not attached to some disciplines in the construction process which actually has a multi-disciplinary nature.

All companies state that the plan of the site is organised according to the type, size, period of the work as well as the climate conditions; that a hygiene and sanitation planning is made for ensuring food and bodily cleaning for the employees; that an employee is assigned for this task; and that necessary arrangements were made for the communication and relaxation needs of the employees. It is understood that necessary tasks are mainly fulfilled: e.g. that the site is established according to the nature of the work and the features of the region; that election methods are used in order to determine new technicians for the task undertaken; that an agreement is made with a health unit for planning and ensuring internal and environmental safety of the site; and that operational measures are planned by taking the fact that the construction period might extent into account. However, the other tasks are fulfilled at rather low levels: e.g. selection of operatives and unskilled workers with a test of knowledge and skills, creation of auxiliary power, clean water and fuel oil units, and measures for loading, unloading and transport other than the working hours.

However, organising the plan of the site according to the type, size, and period of the work as well as the climate conditions, creating the organisational structure of the site according to the nature of the work and the features of the region, using election methods in order to determine new technicians for the task undertaken, selecting operatives and unskilled workers with a test of knowledge and skills, organising the units of the site according to the peak number of employees and site organisation plan set out in the labour force plan, determining open and closed stores and their places according to the quantity and properties of the materials, taking measures for loading, unloading and transport other than the working hours, making an agreement with a health unit for planning and ensuring internal and environmental safety of the site, and planning the operational measures by taking the fact that the construction period might extent into account do not cause substantial costs. On the other hand, making the duty descriptions of certain people more clear and creating and implementing the required procedures can be almost cost-free and implementing some certain quality measures will be an easy and positive action.

Furthermore, preparing and implementing the work orders on a daily basis, preparing transfer schedules based on the materials along with the supply schedule for the general materials, and making skills improvement trainings for the operatives more widespread will also be positive measures in order to increase the quality during the production process.

Increasing the preparation and utilization of graphs, charts and reports such as efficiency graphs of the workplace, status reports on a weekly basis, production targets charts on a monthly basis, time comparison reports on a monthly basis, material tables and production progress reports on a monthly basis will assist in achieving the quality goals.



When the bid price is formed, it is understood that the firms utilise the data they created in their previous works such as materials, workmanship, machinery – equipment prices, quantities of input in unit production, increases in the prices of materials, workmanship, machinery – equipment, monthly cash needs based on the production amounts, monthly costs of materials, workmanship, machinery – equipment, amount of production, production periods and needs of the labour force, costs of the construction products and the relationship of construction site costs and materials. According to the table, one can conclude that data are created with regard to the establishment, organisation and operation of the site such as the cost of the site establishment along with the total construction costs, the size of the workforce together with the construction costs, the number of technical – administrative staff, and daily operational costs of the site along with the construction costs are realised at a rate of 72 %. It will be possible to achieve the level of quality aimed by increasing this rate.

Not receiving professional legal assistance while studying the tender documents and not making the risk analyses of the work to be undertaken could be seen to be reducing the costs; however, the problems which might occur due to not taking such measures can have demolishing effects. Including competent employees to the staff of the company and receiving professional consultancy when required will definitely minimise some important risks in this regard.

That organising the plan of the site according to the type, size, and period of the work as well as the climate conditions, creating the organisational structure of the site according to the nature of the work and the features of the region, using election methods in order to determine new technicians for the task undertaken, selecting operatives and unskilled workers with a test of knowledge and skills, organising the units of the site according to the peak number of employees and site organisation plan set out in the labour force plan, determining open and closed stores and their places according to the quantity and properties of the materials, taking measures for loading, unloading and transport other than the working hours, making an agreement with a health unit for planning and ensuring internal and environmental safety of the site, and planning the operational measures by taking the fact that the construction period might extent into account do not cause substantial costs indicate that these can be realised at a great extent with a low cost thanks to the available equipment and personnel.

In the production management process, the ratio of costs of preparing graphs, charts and reports such as the efficiency graphs of the workplace, status reports on a weekly basis, production targets charts on a monthly basis, time comparison reports on a monthly basis, material tables and production progress reports on a monthly basis; making daily evaluation meetings after the working hours, making weekly evaluation meetings based on the measures and needs and reporting their outcomes to the ratio of general costs of the above mentioned activities does not have a contribution. At this point, by duly applying the previously accepted procedures, the companies will be able to reach their quality objectives and minimise their quality costs.

During the periods of provisional and final acceptances, with respect to the preparation of the production for the provisional acceptance, that the Site Manager examines and checks the manufactured products one by one according to the project does not cause any additional costs. The most important issue which affect the quality costs in this period has been to take protective measures until the provisional acceptance for the finished products. This is followed by the requirements for lightening, heating, air-conditioning, checking whether the clean-waste water plants work properly or not, taking necessary steps for defects, and being exposed to the faulty production penalty (requiring excellence). It seems possible to ensure minimisations in the costs thanks to the efforts to be made in this regard.

During the process of data creation, based on the information indicating the ratio of the issues and their costs which affect the quality costs to the ratio of overall costs, prices of materials, creating data with regard to the costs, i.e. workmanship, machinery – equipment, quantities of input in unit production, increases in the prices of materials, workmanship, machinery – equipment, monthly cash needs based on the production amounts, monthly costs of materials, workmanship, machinery – equipment, amount of production, production periods and needs of the labour force, costs of the construction products and the relationship of unit construction site area costs and materials; data with regard to the establishment, organisation and operation of the site, i.e. the cost of the site establishment along with the total construction costs, the size of the workforce together with the construction costs, the number of technical – administrative staff, and daily operational costs of the site along with the construction costs; and utilising the data created in the previous tasks undertaken do not cause any costs. Utilising such advantages, preparing and implementing the quality plans along with the harmonisation of the concepts of project management, construction management,

document management and the quality management will definitely have substantial benefits and will definitely have a positive contribution in the minimisation of quality costs.

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