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# THE CONTRIBUTION OF DATABASES TO THE PLANNING OF CONSTRUCTION WORK WITH THE CONSEQUENT ACHIEVEMENT OF THE REQUIRED QUALITY LEVEL

BY

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**Abstract.** Quality is a requirement of the 21st century, ranging from education to construction. Hence, this paper aims to treat in a theoretical but especially in an applied manner the set of concepts which lead to the achievement of quality in construction.

The article is structured in five sections, followed by the resulting conclusions at the very end. The first section deals with the introductory elements of this article.

The second section refers to the definition of the concept of quality in construction. The third section concerns the definition of the concept of planning in construction, as a necessity to reach the quality level required by the Romanian legislation. The fourth section deals with the elements of a database design for a construction project, its stages and the information that is processed. The fifth section refers to the case study that presents the elaboration of the project plan and the logical matrix of a project.

**Keywords:** quality in construction, planning, logical framework, project plan, database

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## 1. Introduction

It is well known that quality in the construction field is a requirement without which this economic sector cannot exist. It has to be strictly fulfilled according to the norms, it has to be controlled and checked in order to ensure both the existence over time of a sustainable construction and to ensure its operation without risks and/or major incidents, throughout the life cycle of the construction, regardless of its function.

In a detailed manner, the quality consists of:
- the quality of the designs developed by the design engineers
- the quality of the actual construction on site
- the professional execution of the construction
- proper compliance concerning the maintenance procedures

## 2. Quality regulation of construction work in Romania

When we talk about quality in construction in Romania, we are talking about the whole quality system, regulated by the legislator and implemented in practice. The quality system in construction is regulated by Law 10/1995 regarding the quality in construction, republished, with subsequent amendments [L10/1995, on quality in constructions, with subsequent amendments, art.5].

According to this law, "The quality system in construction is the set of organizational structures, responsibilities, regulations, procedures and means, which contribute to the quality of construction in all stages of design, construction, operation and post-use."[L10/1995, on quality in constructions, with subsequent amendments, art.8]. To be specific, the quality system is made up of the regulatory section, the section relating to the certification of conformity of construction products, the section relating to the verification and technical assessment of projects, and the section relating to the quality of the construction work carried out [L10/1995, on quality in constructions, with subsequent amendments, art.9].

Furthermore, this law states that the quality system in construction has the purpose of implementing procedures for the realization of constructions with an appropriate quality level [L10/1995, on quality in constructions, with subsequent amendments, art. 3].

The adequate quality level is further defined as the fulfilment of requirements concerning: mechanical strength, stability, fire safety, ensuring hygiene requirements, safe operation, noise protection and saving energy (thermal insulation) [L10/1995, on quality in constructions, with subsequent amendments, art. .5]

For each direction of action, starting from the basic regulation - Law 10/95 on quality in construction, packages of regulations have been developed to

provide details and milestones for meeting the requirements (e.g. package of regulations for the market of construction products, package of regulations for state control over the performance of construction works [HG907/2016, with subsequent amendments])

## 3. Construction planning - an important component of the construction process

*3.1. Concept presentation*

Several definitions and interpretations have been given in the literature to define the project concept. By analyzing the various definitions, we conclude that the project is basically a collection of interrelated activities that we want to carry out to create a new product.

The characteristics of any project are the duration of time, limited between the starting date and the closing date of the project, the timeframe in which the project must be completed and the level of quality it must fulfill.

In order to meet the quality requirements, any construction project is divided into simple and complex activities. Carrying them out, while complying with the requirements of the quality law, requires rigorous coordination by specialist engineers.

The coordination of these activities - and therefore the coordination of the project team - can be done, realistically, only on the basis of planning, within the project. Planning the activities, identifying the links between them and the actual execution of the activities, makes up the project planner.

The planning activity of a project must act in the following directions:

1. Setting the minimum quality level to be achieved - this will influence the resources involved in the project, the construction time and the construction technology
2. Identifying the activities in the project (contracting, design, construction, acceptance)
3. Centralization of the resources involved, with reference to the quantities of materials, workmanship, transport costs and use of machinery
4. Centralization of the total costs resulting from the project
5. Centralization of the total duration of the project from the conceptual design to the closing of the project, after the warranty period has expired. [HG907/2016, with subsequent amendments]

Figure 1 illustrates the elements that make up and influence project implementation. It is observed that the durations of design, construction and acquisition, with or without the installation of equipment and fittings, are also resource-generating (the need to achieve a shorter duration may lead to the use of more complex production technologies or may require the allocation of more resources).

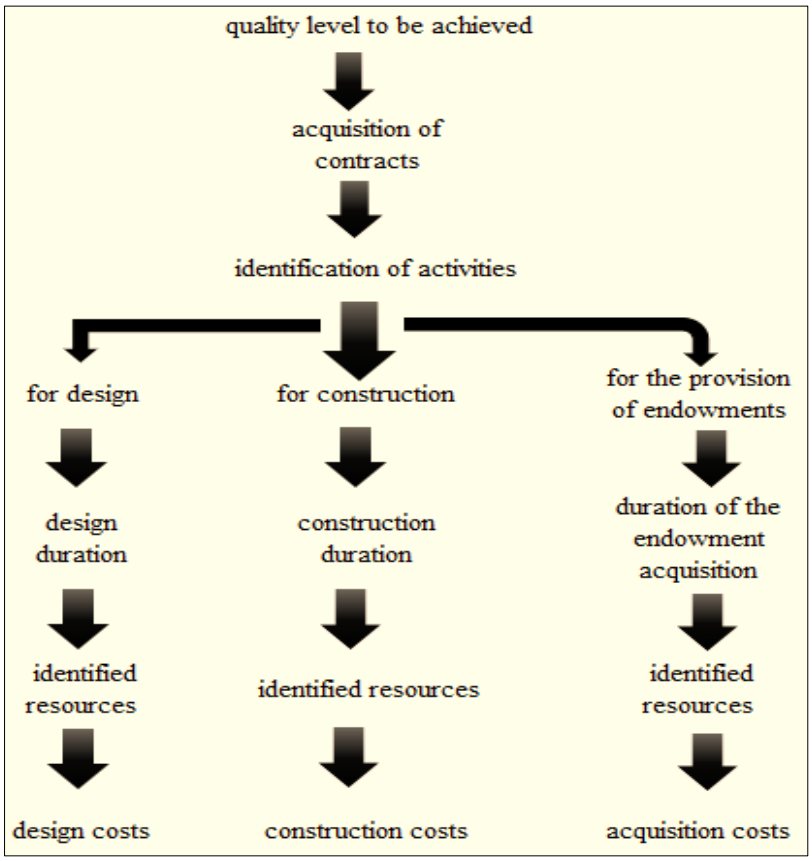



Fig. 1 - Identifying the elements for planning various stages of project management

Logically planned activities make up the project plan. In addition to the project plan, for the management of a project planning, the Logical Framework Matrix (MCL) is also used to manage the planning of a project.

On the basis of the project plan and the LCM, the necessary charts for the implementation of the project are drawn up, such as the execution chart, the site supply chart, the human resources allocation chart, the financial or cash-flow chart. In the case of a large number of activities, their planning is carried out using existing applications/software and databases, customized for each project.

*3.2. Presentation of the project plan and the logical framework method - main tools in the planning process*

*3.2.1. Project plan presentation*

The project plan is drawn up for all the main or secondary, adjacent activities that make up the project. From the study of bibliographical sources, correlated with practical experience, we can say that a project can be planned in

steps, stages, which together make up the project plan. In this sense, the main chapters of the Project Plan are:
1) Presentation of the general objective and of the specific objectives to be achieved
2) the establishment of the minimum and desired level of quality to be achieved
3) the order of implementation and achievement of the main objectives
4) identification of secondary objectives resulting from the main objective
5) identification of the activities and actions to be carried out to achieve the objectives
6) setting the time frames for the main objectives, then the secondary objectives, then the identified activities and linking them in both directions of the described flow
7) establishing the project team and identifying its members
8) determining the necessary resources
9) establishing the costs of the activities and comparing them with the projected budget (or based on the costs, drawing up the budget forecast)
10) establishing the necessary procurement schedule
11) identification of project risks and elaboration of the risk scenario, with identification of measures to improve them
12) establishment of legal documents, protocols to be signed for the opening, running and closing of the project
13) project management (elaboration of procedures), including the elaboration of procedures for monitoring changes to the Project Plan, which occur during project implementation and for establishing the communication path in the project
The project plan can be prepared with several annexes detailing the issues involved. It is also possible, at the end, to make a centralization of it, in the form of a calendar.

*3.2.2. Presentation of the Logical Framework Approach (LFA)*

In the literature studied, the logical framework of the project is presented in several forms, having the same basic features. We consider representative, the presentation of LFA by Radulescu Corina and authors, [Radulescu Corina et al, Project planning and management, U.T.Press, Cluj-Napoca, 2017, ISBN 978-606-737-256-4, p 138-140], where it is presented as an analytical method, through which an overview of it is achieved, both vertically, between the upper and subordinate levels and horizontally, on the same level, establishing verification indicators – Table 1.

Regardless of how LFA is organized (within its defining limits), its role is to create a logical flow of project development. The project goal concerns the mentioning of specific objectives in the Project Plan. For these, indicators must be identified that demonstrate the degree of achievement of each objective.

The results are the materialization of the end of each stage of design, execution, delivery. The results also include the completion of each stage of

control by the competent bodies (e.g. State Building Inspectorate). Another result will be the product or part of the product that will be addressed to the beneficiary or the target group for which the project was developed.

**Table 1**

*LFA elaboration of the project [source: Radulescu Corina and authors, page 139]*

| | 1. Logic of the intervention / Description of the project | 2. Objective verification indicators (IVO) | 3. Sources and means of verification | 4. Risks and assumptions |
|---|---|---|---|---|
| General objective | | | | |
| The purpose of the project | | | | |
| Result | | | | |
| Activities | | Tools | Costs | |
| | | | | Preconditions |

The activities are generally the key, defining activities for the good functioning of the project. Hypotheses refer to the external factors that can influence the project without being able to control them directly.

Based on the LFA, the Logic Matrix (Fig 2) is drawn up, which allows to allocate responsibilities in the project and to count the progress of the project during its development. It also helps to anticipate project phases. It is a useful tool for project thinking in conjunction with the Project Plan and the other techno-economic analyses that are carried out in the project.

## 4. Database design for a construction project

*4.1. General elements on Databases*

The database The database is an accumulation of stored information, called "records", linked to each other and divided into sections characterized by a specific feature (e.g.. Database for the preparation of a quotation, with sections: unit prices, recipes, standards etc.).

The database consists of records. Each record represents the sum of the characteristics of an activity called "subject" - e.g. the subject is "execution of one square meter of plaster", which includes the materials used, labor, equipment and tools used for the execution of that square meter. Each included feature is referred to as a "field". Each feature of the subject has the same number of fields - the maximum number - so that some features have some fields left blank, so that the structure of the subject is homogeneous.

*4.2. Stages of database design*

As a general rule, in order to create a database, the database structure is first generated with the required fields. The most commonly used in construction are relational databases, in which they are organized as tables in which the records are arranged horizontally (representing rows) and the fields are arranged vertically (representing columns). In this way, databases are created for drawing up estimates or for making graphs representing the design and construction time of an investment. In the same way, databases are also organized to plan and organize a project (a database of tools and equipment in a warehouse at a construction site can be created).

Once the requirements have been analyzed and finalized, the total number of records and the total number of fields required are determined. The next step is to develop the logic diagrams, which is the conceptual modelling. In this step the records are divided into tables. Also here the major topics, called "entities", are created, such as orders, work contracts, estimate 1, estimate 2, etc.

After the database structure has been generated, it is filled with the information collected for each subject. For a database it is important that records or fields are not duplicated, as this generates errors.

## 5. Presentation of the case study

As a case study, the project plan is presented for the design and execution of a socio-cultural objective with a mixed function (indoor swimming pool, together with accommodation, kitchen and dining room) for tourism.

Being an investment objective with many distinct components - eight design contracts, fourteen supply contracts for equipment and facilities and six construction contracts on site - a database was created to allow the tracking of the indicators to be fulfilled. Prior to this stage, the project plan and the Project Logical Framework Matrix were drawn up - these highlighted the main elements of the database.

*5.1 Presentation of the Project Plan*

The main chapters of the Project Plan are are presented below, as follows:

1) General objective: development of tourism in the area, considering the difficult access conditions; the area is connected to utilities; geothermal and wind energy will be used.

2) Specific objectives: creation of a number of jobs, occupation of the land (initially it is virgin, unequipped land); creation of the possibility to practice swimming.

3) Minimum quality level: as established by the quality law [1], projected quality level: 3-star tourist location, according to specific legislation;

4) Order of implementation and achievement of the main objectives: establishment of the project team, carrying out studies for the creation of a first budget forecast; contracting and elaboration of the project; obtaining the necessary approvals and agreements; establishment of the final budget;

negotiation and contracting of the actual construction works; in parallel contracting of suppliers for the purchase of the appropriate machinery, equipment and fittings, according to the project;
5) Identification of secondary objectives, resulting from the main objective: establishment of the accommodation conditions for the personnel involved in the work, temporarily, or for the entire period of construction of a part of the construction; ensuring health and safety conditions at work.
6) Identification of the activities: consultancy activity, design activity, construction activity, activity for the purchase of machinery, equipment and fittings and collection of the necessary data to establish the durations and deadlines for each activity;
7) Establishment of durations and deadlines for each activity, followed by cumulation, for the main objectives, then for the secondary objectives and their correlation in both directions of the described flow.
8) Establishing the resources required, resulting from each activity; drawing up estimates with the quantities required and unit prices
9) Establishing the final costs of the activities, following the negotiation and comparing them with the forecast budget; in this case, a budget reserve was obtained and stored for the following situations
10) Establishment of the necessary acquisition schedule
11) Identification of project risks: for the elaboration of the feasibility study, a risk scenario was drawn up, highlighting the risks as well as the measures to improve them; also in the studies chapter, a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis was drawn up.
12) Establishment of legal documents, protocols to be signed for the opening, running and closing at the end of the project: service contracts were signed, which included the training of operators who will serve the swimming pool and will work with the equipment and machinery installed in the technical room, contracts for the execution of construction works and supply contracts that included the purchase, installation of equipment where appropriate and maintenance of equipment and machinery, post warranty for a period of 24 months;
13) Project management (development of procedures), including the preparation of procedures for monitoring changes to the Project Plan that occur during the implementation of the project and for establishing the communication path in the project.

*5.2. Presentation of the Matrix of the logical framework of the project*

To manage the project, the Project Logic Matrix (Table 2) was developed and an existing database for three main sections was used:
- planning of execution times and checks in decisive phases, without which the project cannot proceed;
- the estimation of the design and works estimates
- management of the invoices made, in relation to the contractual clauses and the quantities executed

**Table 2**

*Presentation of the Logic Matrix for the studied objective*

| | Project description | Target monitoring indicators | Sources and means of verification | Risks and assumptions |
|---|---|---|---|---|
| General objective | Tourism development - design and execution of a socio-cultural objective with mixed function (indoor swimming pool, thermal water, together with accommodation, kitchen and dining room) for tourism. | Functioning of the built target, on time | Permanent technical quality control | Lack of macro-economic predictability |
| Aim of the project | Job creation<br>Swimming<br>Relaxation | Number of jobs created, according to the project<br>Operation of the installations in the technical room of the pool and the basin | Technical verification with specialized personnel<br>Verification of employment contracts | Compliance with specific legislation and design requirements; natural hazards |
| Result | Elaboration of studies and project<br>Construction and operation of the site<br>Hiring of staff for the jobs created<br>Presence of tourists | Compliance with the deadlines for the completion of the project and construction works; compliance with the deadlines for the supply of equipment | Technical verification with specialized personnel<br>Verification of employment contracts<br>Verification of tourist accommodation records or number of receipts paid by external tourists | Natural hazards/disasters - earthquake, pandemic, which restrict access of specialized staff during the project implementation period;<br>Restriction of tourist access |

| | Project description | Target monitoring indicators | Sources and means of verification | Risks and assumptions |
|---|---|---|---|---|
| | | and machinery<br>Tourist attendance at least 70% all year round<br>Hiring of staff on time | visiting the swimming pool | |
| Activities | Activity 1 - study preparation<br>Activity 2 - design<br>Activity 3 - execution of construction works on site<br>Activity 4 - purchase of machinery, equipment and facilities | Resources<br>Qualified personnel, staff training, operation of machinery and equipment, adequate supplies, Creation of facilities | Costs<br>Own budget, design costs, supply, execution of works, adjacent costs | Assumptions:<br>staff serving the target are well trained<br>Tourists respect the rules for using the swimming pool |

*5.3. Presentation of the database for planning the stages of the project activities*

*5.3.1. Natural language case study requirements*

It was intended to create a database for this construction project. For this particular reason it was necessary to store data on the minimum quality level to be achieved, as this will influence the resources involved in the project, the construction time and the technology used.

The activities in the project were identified, meaning contracting, design, construction and acceptance. It was necessary to take into account the resources involved, i.e. quantities of materials, labor for the work, expenses for transport and use of machinery. We had to take into account the total duration of the project from the conceptual design to the closing of the project, after the warranty period had expired.

*5.3.2. Glossary of terms*

The terms used are defined in the table below (Table 3).

**Table 3**
Glossary of terms used

| **Term** | **Description** | **Reference** |
|---|---|---|
| Contracting | Concluding a contract. | Quality level |
| Activity | Accomplishing tasks towards a certain result. | Contracting |
| Design | The process of developing a project. | Activity |
| Building | Forming a whole by assembling its component parts according to a predetermined plan. | Activity |
| Provision of facilities | Supply of products. | Activity |
| Quality level | Level of safe operation of the building. | Contracting |
| Duration | Time in which a task is performed. | Design, Construction, Supply of equipment |
| Resources | Items needed to perform the task. | Design, Construction, Supply of equipment |
| Costs | Amount of money needed to carry out a work. | Design, Construction, Supply of equipment |

*5.3.3. Operational requirements*

- Enter an activity for a quality level, with all its data (the operation is to be performed (about 20 times a day)
- Display all the information about the quality level (about 40 times/day)

*5.3.4. Choosing a design strategy*

In this case, a mixed strategy was chosen. The combination of requirements and strategy resulted in the initial Entity - Association Diagram (DEA)

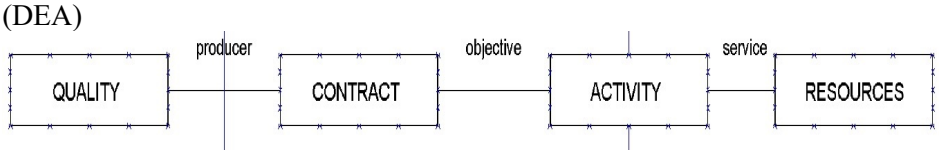



Fig.2 - Entity diagram - Initial associations

*5.3.5. Refining the entity diagram - Associations, iterative*

In this step, the interdependence relationships of the measurable characteristics of the analyzed parameters are established. They are shown in Figures 3 and 4.

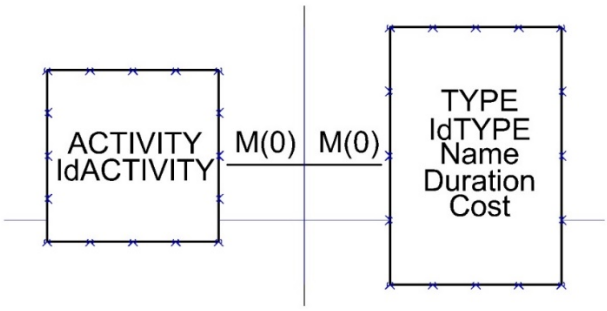



Fig. 3 - Refined scheme (I)

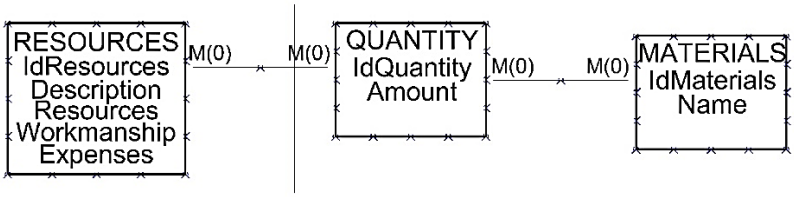



Fig. 4 - Refined scheme (II)

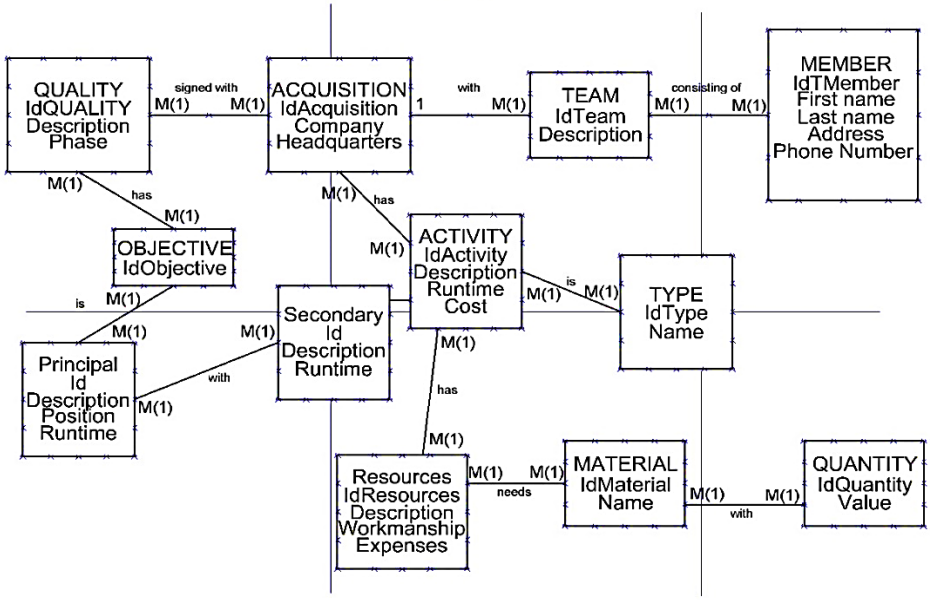



Fig. 5 - Entity Diagram - Final Associations

Subsequently, the final Entity - Associations Diagram is drawn up, which includes all data (Figure 5)

*5.3.6. Restrictions (Business Rules)*

For the development of the scheme in Figure 5, the constraints were established:

- (R1) setting durations for the main objectives, then the secondary objectives, then the identified activities and their correlation
- (R2) centralizing the total duration of the project from the conceptual theme to the end of the project, after the guarantee period has been used up.

In the last step the entities and relationships were separated or merged, as appropriate, resulting in the scheme/algorithm below, shown in Figure 6

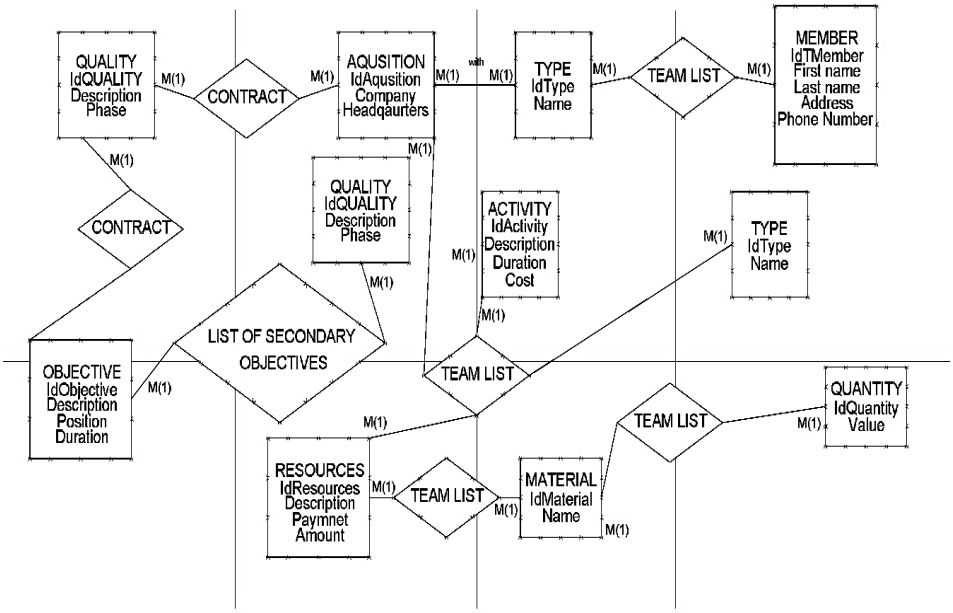



Fig. 6 - Restructuring the Entities - Associations Diagram

## 3. Conclusions

Construction projects are complex because of their specificity. The minimum level of quality required is justified primarily by the safe operation of the construction.

To achieve this level of quality, several parameters need to be managed. The management of these parameters would not be possible without rigorous planning of all activities. As each project contains a large number of activities, the design and use of a database is a tool to help monitor the activities. Each

activity carried out properly will contribute to the expected quality level to be achieved.

With regard to the case study, the project manager and the project team monitored, through this database:

- project delivery times, technical specifications and equipment as well as construction times so that the participating companies did not create time synergy or hinder other technological flow - there were also adjacent activity flow charts
- the progress of contracts concluded and payments made
- establishment of deadlines for checking the quality level together with the institutions authorized for this purpose (State Building Inspectorate)

In the first stage, data from the eight design contracts were introduced into the database. The first was writing the technology project [HG907/2016, with subsequent amendments], which aggregated the technology sheets and provided the primary design data. This was divided into more than one hundred activities. Each activity was broken down into secondary activities.

Initially, there were several proposals for technological solutions on the basis of which, with the help of the database (bid values and estimated deadlines were entered), the resulting budget and the total construction completion time were simulated. The database contributed to the choice of the optimal solution.

Then, along the way, the deadlines for the delivery of documents and their completions and the related payments were more easily correlated in order to obtain the necessary approvals and authorizations to start construction on site.

The total construction duration was composed of the sum of the construction durations of the six construction contracts, on site. As the six companies had no contractual relationship with each other, the project plan and the database facilitated the correlation and interleaving of construction durations and deadlines for control in the determining phases (defined by Law 10/1995 on quality in construction). The restrictions (R1) and (R2), imposed for the creation of the database, were also useful.

In addition, with the help of the database, alarm signals were raised and various situations were identified on the construction site, such as certain delays that were resolved in time without harming the project.

The fourteen supply contracts for equipment and fittings required an advance payment to be made at the time of contracting in order to release the order on the production line. With the help of the database the existing cash-flow was managed and based on the estimated time, Tx, for the assembly, both the time of the order launch and its payment were ordered and controlled.

Subsequently, with the help of the database, the delivery terms were managed, with the consequence of establishing the storage period and the storage place of each equipment until its assembly.

Valid for all contracts, the prices initially introduced were reference prices, thus making it easy to monitor and compare, over the three years of the entire project, the evolution (increase) of the project prices and the increase of the total cost of the project.

Each building project is a one-time action [5] only the quality level does not change. Although it may include similar activities to other construction projects, however, a project does not have the same working conditions, or the same site conditions for the forthcoming construction. Thus, the planning of multiple activities - and the use of databases - is undertaken to develop the appropriate directions of action and the most suitable strategies, for solving problems that may arise.

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## CONTRIBUTIA BAZELOR DE DATE LA PLANIFICAREA LUCRARILOR DE CONSTRUCTII CU CONSECINTA OBTINERII NIVELULUI DE CALITATE IMPUS

(Rezumat)

Calitatea este o cerință a secolului XXI, în orice domeniu, de la educație la construcții. Din acest punct de vedere, lucrarea se inscrie în a trata teoretic dar mai ales aplicativ ansamblul de concepte ce duc la obținerea calității în construcții.

Articolul este structurat in cinci secțiuni, urmate de concluziile care rezultă, la finalul articolului. Prima secțiune se referă la elementele introductive privind acest articol.

A doua secțiune se referă la definirea conceptului de calitate în construcții, în contextul legislației din România.

A treia secțiune se referă la definirea conceptului de planificare în construcții, ca o necesitate pentru atingerea nivelului de calitate inpus de legislatia română. De aici, mai

departe, implicit, apare necesitatea utilizării bazelor de date, în special în etapa de planificare.

A patra secțiune se referă la elementele proiectării unei baze de date, pentru un proiect de construcții, etapele care se parcurg și informațiile care se procesează.

A cincea secțiune se referă la studiul de caz care prezintă elaborarea planului proiectului și a unei matrice logice, a unui proiect – unelte principale în cadrul proiectului, pentru planificarea activităților unui obiectiv de investiții. Tot aici este prezentată baza de date, utilizată pentru monitorizarea activităților proiectului.