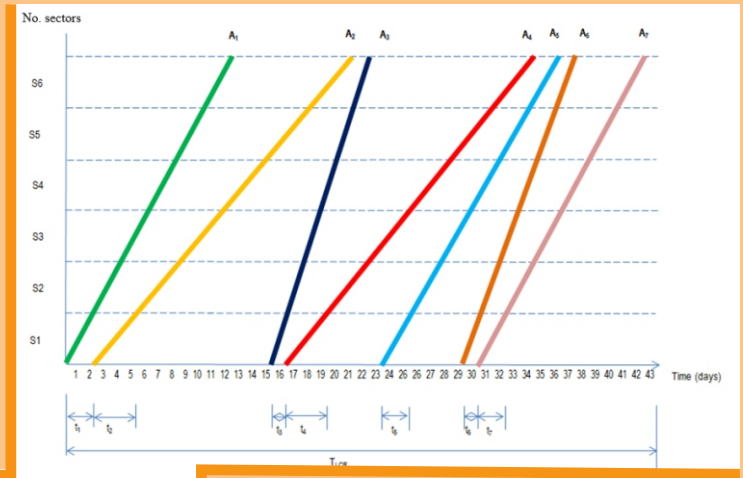
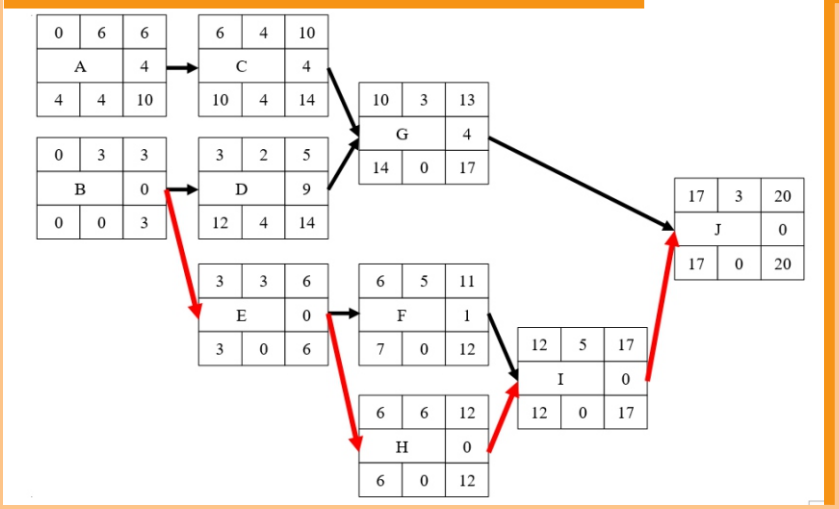
Livia ANASTASIU Maria-Nicoleta ROMAN-PINTICAN

MANAGEMENT IN CONSTRUCTIONS SCHEDULING THE PROJECT SITE ORGANIZATION





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SUMMARY

INTRODUCTION TO MANAGEMENT IN CONSTRUCTIONS

1. HISTORY

We all travel. The reasons are different: wishing to explore for new things, business, leisure, team spirit. Interested or not, it`s impossible not to notice houses, dams, castles, stadiums. Some of them we like, some seam disgusting. Nevertheless, we ask: how did they build them and why?

The construction field is practically identified with life on earth, because people have hardly adapted to the climate and safety conditions. First caves and huts kept them from cold and wild animals. The migrations have brought another challenge: defending the territories. With the emergence of the social classes, construction has become a way of displaying wealth.

The Industrial Revolution has replaced the craft workshops with serial production factories. The products had to be transported under conditions that should not affect their parameters. Horses and donkeys no longer met the demands, so transport means were invented to run on roads, and highways.

The discovery of electricity and the internal combustion engines produced a change in the way of executing the buildings. Machineries and equipment replaced the human work, where force and repetitive actions were needed.

 [1]

Today, modern technologies substitute the people's efforts and by their help, almost perfect constructions may be achieved. It`s normal: computer simulations provide the final image of a drawing. However, the Pyramids of Giza, the Parthenon of Athens or Stonehenge are flawless. The Pyramids from Egypt have almost 2.500.000 huge stone blocks, each weighing over 2 tones and were raised without cranes; moreover, they were transported to the construction site. If we think how 10.000 people have been coordinated for 20 years during this project, the enigmas are even more.

The Modern Age, where the individual has access to information (if there are criteria to filter them), allows specialists in every sector of economy to be aware of everything was discovered in his/her area of activity. The sources of information no longer have borders. It`s a proactive way for documentation. Best practices, as well as bad ones, help in delivering the projects in efficient conditions.

[1] https://markonart.com/product/mysterious-sphinx-vintage-egyptian-pyramids-art/, accesat în data de 23.10.2024

The construction projects have succeeded in combining the utility side with the design that gives freedom to imagination. It has come to the performance of recognizing a town by its buildings, perceived as icon: Eiffel Tower for Paris, Opera House for Sidney, Burj al Arab for Dubai or Guggenheim Museum for Bilbao.

 [2]

It`s also a trend in this sector, very technical. Nowadays we use modern technologies, gadgets inside and outside the buildings, "green buildings", and other ways to keep up with the time.

It`s obvious that these modern and sophisticated achievements have gathered what the humanity have accumulated in thousands of years. Today, it`s almost impossible to have a design office without computers equipped with updated software; the construction sites work with performing machineries; non-polluting materials; the operational staff working in safety, security and hygiene conditions, according to the regulations.

Jules Verne was considered the symbol of Sci Fi literature. His contemporaries perceived him as an imaginative person, but just a visionary. At the end of XIXth century, it was almost unbelievable to achieve the machineries described by him. And yet, today`s readers admire his ideas, but perceive them as ordinary and accessible.

The construction industry, the most pollution one in all economy, have been forced to adapt to the regulations imposed by international forums. The modern organizations use BIM (Building Information Model), drones, 3D scan and print, robots, and advanced technologies.

Can we still think that everything was said in our sector of activity, the construction one? Of course not, because the "dot.com" area makes it inexhaustible, whether we think of the shape, the height, the ground features, and others. Burj Khalifa, the tallest building on earth (828 de meters high) delivered on sand?

 [3]

[2] eceebbb1a0ff225c8a386759388721e7.jpg (980×736) (pinimg.com), accesat în data de 23.10.2024

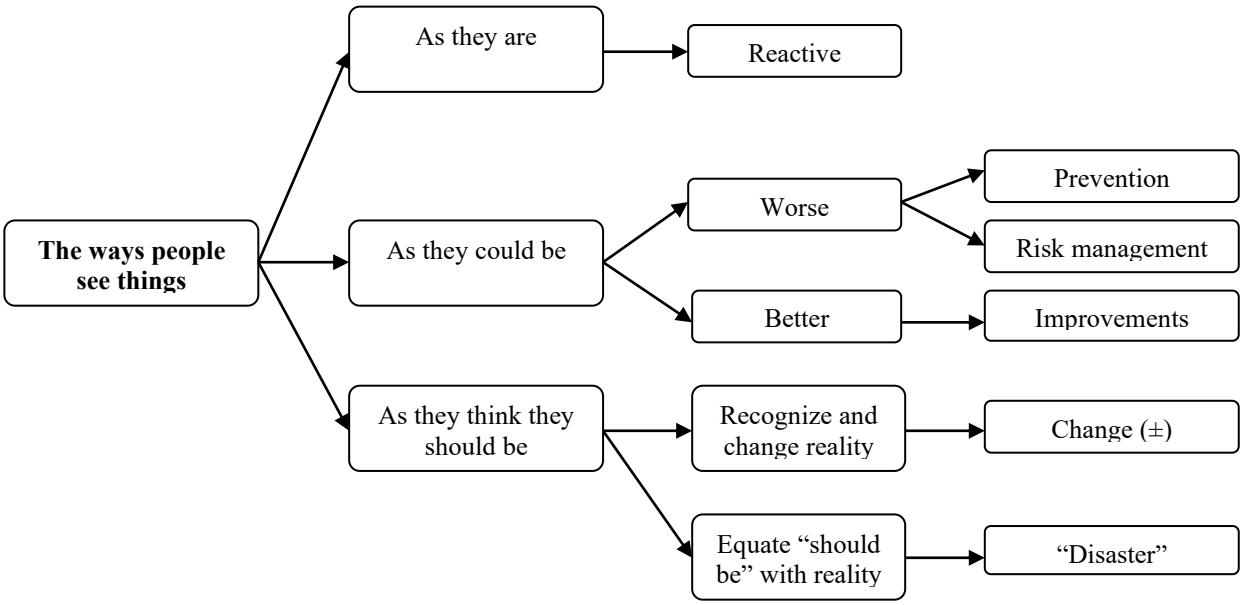
Who would have thought? The limits are only the intelligence, the imagination and the passion of those who want to leave masterpieces behind them.

2. THE FEATURES OF THE MANAGEMENT PROCESS IN CONSTRUCTIONS

Management has a history which is practically identified with that of mankind. In any society there were masters and servants. The subordinate relations have taken on very different forms, from despotism to cooperation relations and participative management.

The art of leading has no recipes or universal tips, like "Ten golden rules to be a good manager". Only principles can be listed, those which may have positive or negative effects of the way to lead people in order to complete the objectives.

The person who can make things happen is the manager. His/her personality influences the results of an organization. Depending on the individual`s personality, people see things differently:



An individual who sees things the way they are is a reactive one. He/she doesn`t plan things but takes them as they are. This person will not have the capability of innovating, or leading people to fight for competition.

Others see things as they could be, so they are proactive, because they think it could be worse or better than it really is. If they could be worse, they may prevent them, by designing risk plans. If they could be better, everything should be improved.

And there is another category of people, who see things as they think it should be. Some of them recognize the reality and plan to change it, finally with good or bad results. Others think reality is equal to their perceptions, so they don`t see the difference between their reality and the truth.

The construction domain is a dynamic one, even if it involves large durations for performing the projects. The environment where the companies struggle is competitive and changing, because the customers` tastes are in a permanent changing. A successful organization will be a flexible one, that will adapt to the market demands.

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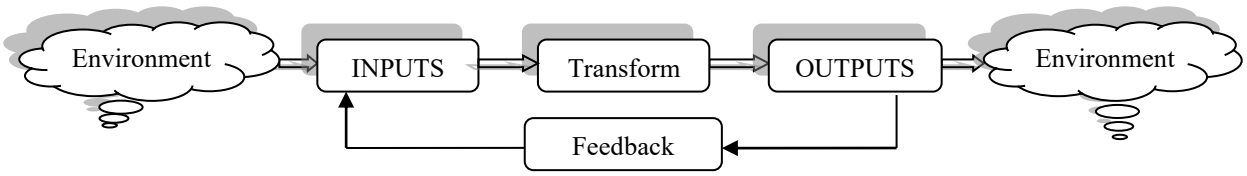
[3] Photo by: Wilerson S Andrade, Creative Commons Attribution Licence, https://timesofindia.indiatimes.com/travel/destinations/major-attractions-in-and-around-burj-khalifa/articleshow/39601994.cms, accesat în data de 23.10.2024

The modern theories of management are approaching the organization as an open system: the external environment provides the required resources (raw materials, financing, information, and, finally, human resources). All the resources undergo a transformation process that achieves the organization`s goal: to deliver products/services. When the environment`s energy goes inside the system, we have inputs. When it goes outside the system, we have outputs.



An open system will permanently interact with the environment in which it acts. The system attracts resources from the environment and monitors the way in which the environment reacts to its products.

The main benefit of a system is that, if it works, you can replicate it anywhere in the company, region, country, or world (e.g. McDonald, Starbucks).

The characteristics of an open system are:

- ♦ Negative entropy:
  Entropy is the quantitative measure of disorder of a system.
  Negative entropy is the capacity of the system to bring resources and new energies from the exterior environment in order to fight entropy.
- ♦ Complexity:
  Complexity is the capacity of complex systems to become more complex. In order to perform accordingly, specialized structures are needed for new organizational tasks.
- ♦ Synergy:
  Synergy is the capacity of the whole to represent more than the sum of its components, meaning that an organization may fulfill its objectives more effectively than if its parts (departments, offices) would act separately.

The main components of an organizational system are:

- Inputs, needed to get products and services: human resources, finance, materials, information, outsourcing;
- Throughputs or transformation processes: are the managerial and technological capabilities which, applied to inputs, transform them in outputs: individuals, teams, projects, processes, functions;
- Outputs: are tangible results like: products, services, or other activities of the organization (trained people, buildings, magazines, cars, etc.);
- Feedback: is the process through which, by the help of information concerning the results or the company`s present state, changes should be made for improving the processes.

At the end of the chain, another important aspect is the outcome of the organization, meaning the value added for the customer when using the outputs: employment, financial benefits, health, happiness, etc.

The organization is successful if it uses the resources efficiently and effectively:

- ➢ Efficiency is the capability of the organization to deliver in the external environment products/services according to the customers` demands, with less resources and waste (less costs) and maximum of profit. It may be calculated the ratio between the system`s inputs and outputs. It`s about doing things right (cheaper or faster). Briefly, efficiency is a quantitative indicator;
- ➢ Effectiveness is the internal capability of an organization to perform the right tasks for achieving the objectives. It`s about doing right things (positive results). Briefly, effectiveness is a qualitative indicator.

As we have noticed, the company is in permanent contact with the external and internal environment.

The external environment is represented, on one hand, by the resources providers, and on the other hand, by the consumer of the products and services of the company.

The internal environment is represented by the organization, which is a system of values, ideals, expectations, beliefs and mutual behavior rules, predominant among the members of the organization.

Hofstede once said: „Culture is learned, not inherited. It comes from the individual`s social environment, and not from its genes. Culture is different from the human nature and the human personality[4]".

In general, any planned action seeks to add value to the resources consumed for its achievement; a construction project fits into this pattern. The added value will help the investor develop and become a real player in this ruthless arena. But this is not the only reason. Let`s just think about the long-term investments in Dubai, a state which prepares for survival after the oil reserves are over. The investors, no matter if they are public or private, block their financial resources for future profits. Unfortunately, there are, also, negative examples.

[5]

[6]

[4] Hofstede, G., *Managementul structurilor multicolore. Software-ul gândirii*, Editura Economică, Bucureşti, 1996, pg. 21

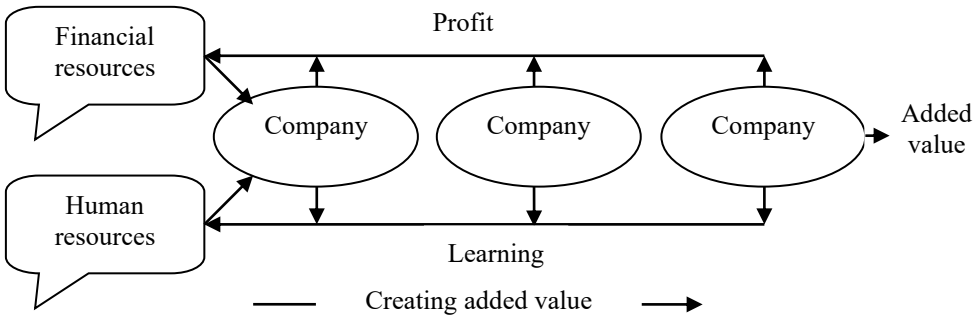
[5] https://www.cfr.org/media/30584/modal?anchor=slideshow-30584, accesat în data de 23.10.2024

[6] https://www.iproperty.com.my/guides/before-and-after-abandoned-olympic-venues-4100, accesat în data de 23.10.2024

Greece has spent almost 11 billion $ for organizing the Olympic Games in 2004. After more than 10 years, the state crossed several crises because it didn`t plan a strong strategy to exploit those investments.

Globalization influenced the way the businesses work. There are no borders for products or services, so the market for a specific area is practically endless. How will the customers choose? According to the perception of the value they add on their money spent, and not necessary on the price they pay. They value quality, materials, warranty, delivery terms, payment terms, social responsibility, or after-sale services. The product should be differentiated and unique (non-financial attributes), and the customer should be aware of it.

Here is a model to get added value[7]:



The financial resources are used for purchasing materials, equipment, machineries, technology or software for the company in a specific area. The human resources are hired from the environment, or also from specialized companies. In such situation, a chain of companies is cooperating for delivering the construction project. Other companies which may work together are financial funds, and others. The final product is the construction objective, which will be obtained through the transformation of the inputs. The profit, as part of the added value, will be invested by all the entities belonging to this chain in other resources, for a new project. The added value does not just stop to the companies that worked on the project completion. Such an investment can develop a geographic area, to attract new beneficiaries or to raise the incomes of the community in the area. New jobs are another consequence of this strategy.

A construction project is developed under principles which are the same for each domain of activity. Here are some of them, important for achieving the expected parameters:

* Delivering the project on budget and time schedule;
* Respecting the contractual terms;
* Respecting the regulations concerning the environment, the safety and security in work;
* Applying the principles of creating the teams: number, specialization;
* Fairness in evaluating, paying and motivating the personnel.

The management of the construction works differ from other types of works by the unique specificity: in most of the cases they are executed on a beneficiary`s command. In case of serial products, after their manufacturing, they are exposed in places designated for the purchase of the potential clients. The case of construction objects is different. The client is consulted (or, in the situation of blocks of flats or villas the demands are statistically analyzed), then an ante contract is made, after which the construction begins. In this case, the client`s demands will be found in all the management`s processes: planning, organizing, coordination and control[8].

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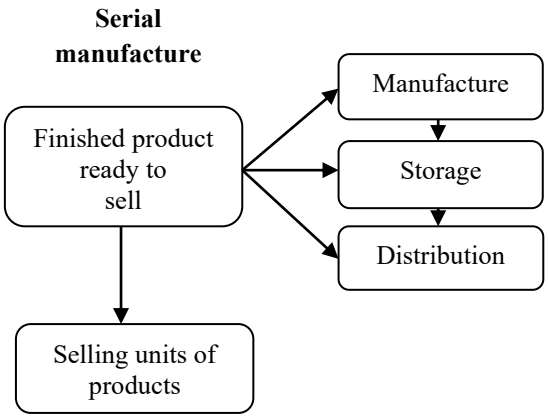
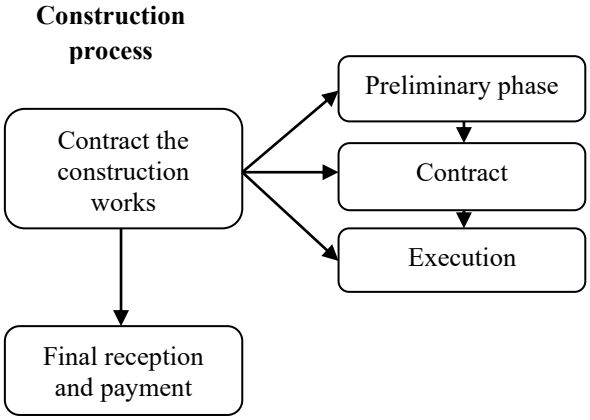
[7] Winch, W., G., *Managing Construction Projects*, 2nd Edition, Blackwell Science Ltd, USA, pg. 5
[8] Halpin, W. D., Bolivar, A., *Construction Management*, John Wiley & Sons Inc., 4th Edition, 2010, USA, pg. 9



The product, or group of products, is designed according to the consumer`s demands, the materials are purchased, also the equipment and machineries, and then the manufacturing phase begins. The finite products are stocked and distributed in warehouses or shops. The payment for the products will be made in the moment of selling them to clients.



The construction process begins with the preliminary design and its approval by the beneficiary.

The agreement between the two parties is concretized in a contract, in which is also stipulated the manner of execution the works and the payment. Finalizing the investment object means the reception and the final payment.

The resources involved in a construction project have different dimensions:

- Quantitative: type and number of equipment, materials, the capacity of the transportation and lifting devices;
- Qualitative: qualifications and specializations of the workers, nature and range of wages, techniques of motivating the workers, regulations for safety and work security, care for the environment.

An interesting approach may be searching for an ideal profile of a construction manager. The works in this area are unique in most of the cases, therefore the coordination will be different. Researchers suggested some benchmarks regarding the knowledge, skills and abilities of a project manager in constructions:

☑ Theoretical training in the construction area;
☑ Awareness of the market and its future trends;
☑ Intelligence;
☑ Communication skills;
☑ Firmness and fairness in decision making;

☑ Open to participative management;
☑ Personal example;
☑ Analytical thinking;
☑ Flexibility, innovation, adaptation.

One of these characteristics are native, others may be developed through education, individual study and experience.

3. PROPERTIES OF THE PRODUCT IN CONSTRUCTIONS

Any organization, no matter of its domain of activity, is focused in achievement of products and services. Their diversity comes from the resources involved (materials, human, financial, information) and by the way they are transformed in final products designated for the consumers.

The construction activity is a complex one, which delivers products (new buildings) or services (repair, refurbish or rehabilitation of existent buildings). These products have the following characteristics:

a. The product is fix and the process for achieving it is mobile

It`s a different situation from the usual production processes, which are manufactured on a fix technological flow containing the needed equipment for each operation. Because the final product, the construction, is not marketed in spaces designed for this purpose, all the resources are mobile and are moving for its execution.

The clients will also move for purchasing the product. Of course, the construction sector may exploit the virtual communication sources (professional sites, Internet, Facebook or Twitter), but only for the promoting phase. It`s difficult to imagine a client who will buy a house just by looking at blueprints.

b. The product is complex

The product encompasses very different resources: materials, personnel with different specializations, equipment and machineries that need training for their use. Consequently, all the management`s functions will be represented in its completion: accurate planning, efficient organize, maximum coordination and harsh control of the results.

As for organizing the teams for achieving the construction object, they will be specialized according to the type of activity, the materials used, the equipment and machineries needed. A very important element is the training and the specialization of the existing personnel.

c. The final product is unique

Even if it is a residential neighborhood, for which the resistance structure is the same for each block, the apartments may differ in terms of interior separations, the type and degree of finishing, or closures. A client may sign a contract before the reception of the building and so he/she might have the opportunity to choose according to his/her demands or budget.

But if we are referring to special constructions, such as factories, nuclear plants, highways or airports, there is practically no question of replying the same project.

d. The product is influenced by the geographical area

The location is important when a construction object is designed, because its implications are linked to the type of ground, the proximity to the resources used, the development level of the area, the incomes of the population, or its level of education. The expenses increase when the construction materials must be supplied from large distances or the labor force might be moved from their homes for a long period of time.

Climate conditions must be also considered, because most of the construction works are planned outdoors, either at temperatures below 0 degrees, or over 30 degrees, or in heavy humidity or wind conditions.

e. The product has a large value

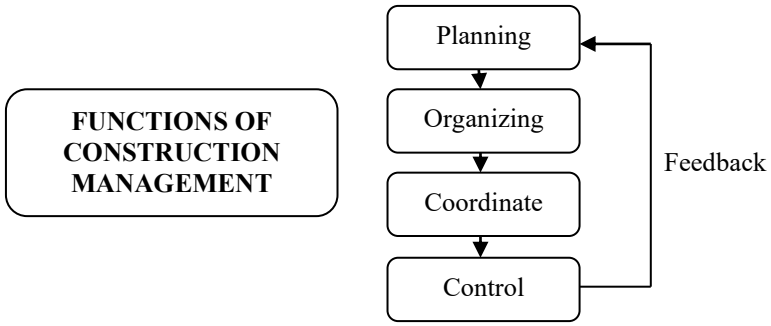
The value of the construction product consists of the sum of the resources embedded in its completion. These expenses are connected to the materials used, the number and specialization of the workers, the type and duration of the equipment and machineries used, the transportation means, and other expenses which may occur in the manufacturing process.
The technologies used have an important weight in calculation the construction value, mostly when special constructions are involved.

f. The warranty of the product is considerable

Regardless the type of the completed construction object, it is designated to the people`s use for a certain purpose: family, office spaces, production space, shop, facility, or other destinations. The safety must be at maximum level, so the warranty will ensure the best conditions.
The functional duration is large in this type of works (between 20 and 60 years), and this aspect is relevant also in the selling price.

4. THE FUNCTIONS OF CONSTRUCTION MANAGEMENT

The management in constructions is guided by the same general principles available to any field of activity, but with specific features.
These functions are: planning, organizing, coordinating and controlling.



a. Planning

According to the definition, "*the planning function means the assembly of working processes through which the main objectives of the firm and its components are determined, as well as the resources and the means required for their achievement".*

Considered as the most important function of management, planning answers to the fundamental question of any organization, which is: "What can be achieved on long term in the organization?", considering the available and potential resources.

During this phase, there are some aspects which require special attention and analyze in some aspects, such as:

- The resources that are available into the organization now of analysis;
- The evaluation of the previous results of the company`s activities, if the organization already exists;
- The evaluation of the situation of the company in the moment of the forecasting;
- Setting the scope and objectives resulted after the forecast.

As *objectives* of the planning, there are some examples:

a) Setting the final results to be achieved;
b) Specification and distribution of the activities planned for each department, division, or workshop of the company;
c) Designing policies of guidance and coordination;
d) Anticipating the problems and taking corrective measures;
e) Shaping and applying a system for economic and administrative control of the organization.

Planning considers the following aspects: trends, objectives, policies, programs, budgets, assignment of tasks, planning the activities, expanding and development, etc.

Under the conditions of transition to the market economy, one characteristic of the companies in the current period is to reconsider the approach of the planning function, meaning its fundament on market research, and on the effective demands of the consumers, using market tools, and by its full application to all the company`s departments.

b. Organizing

Organizing, as the management`s function, is "*the assembly of management`s processes though which the physical and intellectual processes and their components (moves, time, operations, tasks, works, etc.) are established*, *as well as their grouping on costs, teams, departments and the personnel involved according to economic, technic and social criteria, in order to meet the planned objectives in best conditions".*

After planning the scope and objectives, the organizing function answers to the question: "By which means will the company achieve the objectives?". Therefore, the following elements are established:

- The activities which will be needed to fulfill the objectives;
- Grouping the activities in a structure and setting a clear and logical succession;
- Distributing these groups of activities on jobs and giving these jobs to the existing or future personnel.

Based on the principles of this function, there are two types of organizing:

- Overall organizing of the company: this type of organizing will help the company in establishing the organizational structure and the informational system;
- Organizing the company`s departments: research development, production, commercial, marketing, human resources and others.

Modern management emphasizes the flexibility of the organization which performs in a competitive environment. A flat organizational structure, with less hierarchical levels, can adapt to the opportunities and threats coming from the external environment.

c. Coordinate

During this process, the work tasks are given to the people belonging to the organization. If their number is not enough, or if they don`t possess the required specializations, the manager has more options: recruiting personnel from outside the organization, rotating the staff, or training the existing personnel in order to meet the new technologies. Motivation is an essential process for achieving productivity and quality at a competitive level.

Motivation takes two forms:

- Positive motivation: based on increasing the satisfaction of the personnel who participates to the labor process, as a result of achieving the assigned tasks, by assuming that the level of the required tasks is accessible to most of the personnel;
- Negative motivation: based on threatening the personnel with the decrease of the benefits if the assigned objectives and tasks are not achieved as planned. Modern companies make a priority in using positive motivation, because the satisfaction for the job well done and the friendly environment in the working place will generate better results and benefits for the company.

d. Control

The control function is defined as "*the overall processes through which the company`s performance, systems and components are measured and compared to the objectives and standards initially set, in order to eliminate the identified deficiencies and to integrate the positive deviations*".

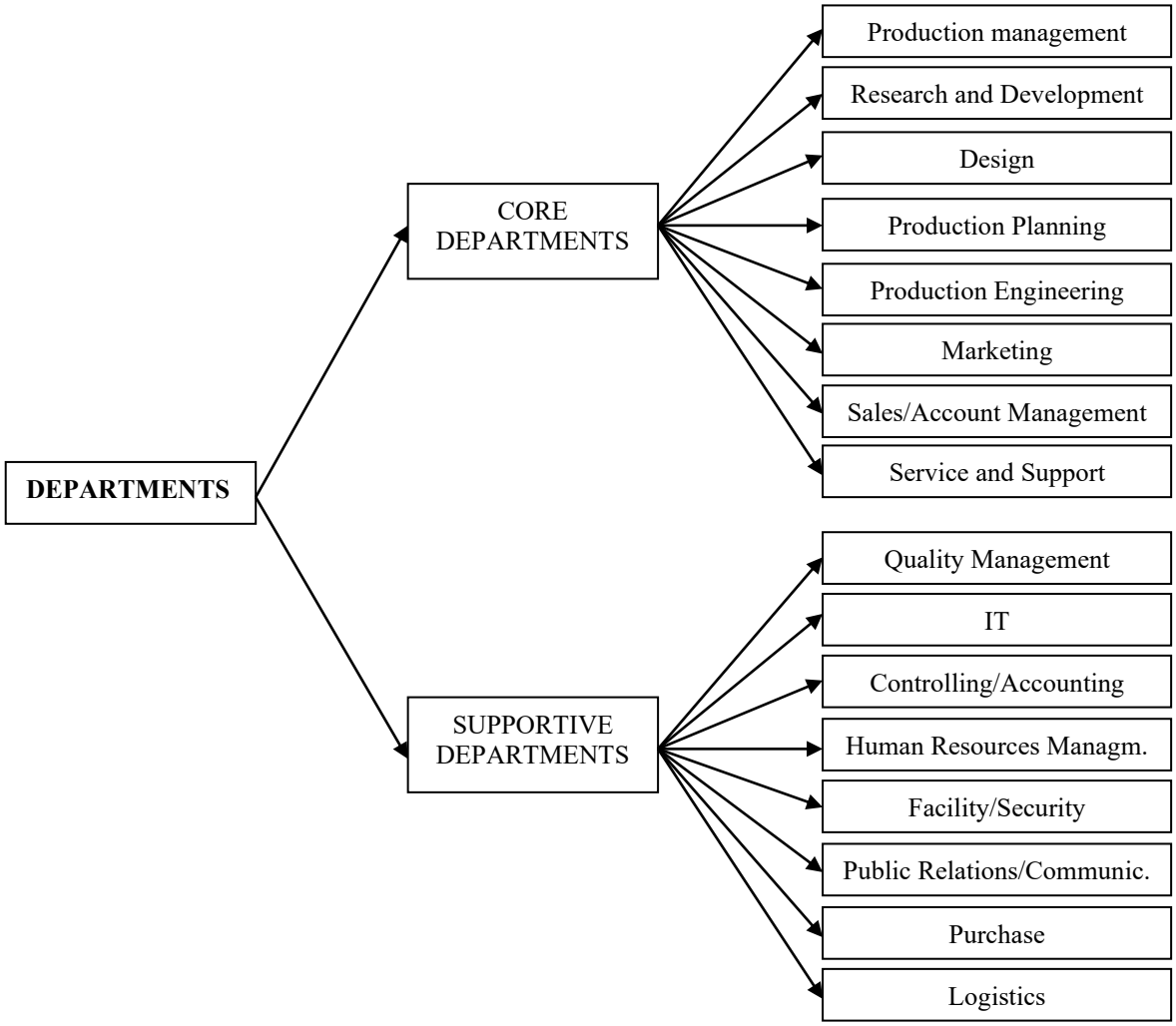
In order to achieve the expected results, the control function will answer to the question: "Which are the final results of the work and which is the level of the achievement of the planned objectives?"

A project is successful when the result of the actions is similar with what is planned to be done. There will be periodical checks, on physical stages of works, in order to find differences and make corrections in due time. Feedback provides information referring to the conditions in which the project is achieved, its indicators and the causes for low performance. These data will represent the fundament for future planning.

As a project management function, evaluation and control involve four phases:

- Measuring the results;
- Comparing the results with the initial objectives and standards, and emphasizing the deviations;
- Determining the causes which generated the deviations;
- Performing corrections, including, if possible, actions on the causes that generated negative deviations.

5. MANAGEMENT`S PROCESSES



The organization`s activities are numerous and very diverse. In order to have expected effects, activities of the management`s functions must be organized so that they may be coordinated, evaluated and controlled, for an efficient feedback.

Henri Fayol is the scientist who first noticed the need for such organizing, which, in his opinion was: technic, commercial, financial, accountancy, security and administrative.

The department is defined as "*the assembly of activities oriented on achieving some derived objectives, resulted from the overall activities of a company*".

The company`s departments exist for serving the strategy. Depending on the size and the activity, they may be organized as follows:

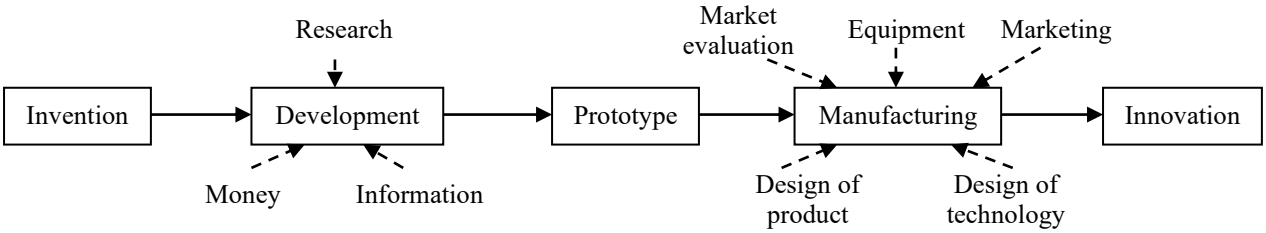
a. Research Development

Is the process of introducing the technical progress, for increasing the performances of the company through assimilating or improving the products, technologies, development of production capacities, etc.

The R&D department is responsible for implementing innovative solutions through the life cycle of the project, as follows:

- Research for new products: specifications, costs and schedule;
- Development of new products: depending on the results of the research, the staff will decide on the opportunity of the development;
- Updating the existing products: both for repairing the malfunctions and improving the performances;
- Innovation: is the most important element for the company to be competitive.

Not every invention is an innovation, unless it is confirmed by the market. The figure below shows the stages from a brilliant idea to profit for a manufacturing company:



In the construction industry, the research and development process will target the following issues:

- Standardization and prefabrication of the products;
- Consideration for the health and security of the personnel;
- Care for the environment and local communities;
- Concern for performance and quality rather than costs;
- Prevention of risks;
- Attention for new materials and technologies.

b. Production

Is the process of transforming the inputs (materials, semi fabricates or prefabricates) into outputs (construction objects, services).

This department is responsible with:

- Basic production, referring to the processes of transforming the resources, planning the production, monitoring the production, quality insurance and control;
- Auxiliary production, which is the secondary-industrial production (prefabricates, semi fabricates), maintenance, repair of machineries.

The production activity includes the succession of operations and terms of their achievement, setting the technical prescriptions and their timeline, the regulations, norms, standards, as well as safety and security norms and techniques of preserving the environment.

This process involves the following activities:

b.1. Activity of production preparation:
- Preparing the equipment, machineries and installations for performing the planned tasks;
- Ensuring the required conditions for the manufacturing technologies;
- Planning the rhythmical supply of the working areas with materials, devices, etc.;
- The preparation is influenced by the degree of novelty or innovation of the product to be manufactured: new product, updated product, or serial product.

b.2. Operative management of the production:
- „Breakdown" in time and space of the tasks included in the production plan;
- Designing operative manufacturing schedules on short period of times and on subunits;
- Providing the informational framework for launching and controlling the manufacturing programs.

b.3. Manufacturing:
- Applying the methods for organizing the fabrication of the company`s products as ordered;
- Applying the methods for work in correspondence with the production.

b.4. Technical Quality Control (CTC):
- Setting the methods for the technical quality control;
- Organizing the inter-operational and inter-phasic control;
- Organizing the activity of laboratories, probation stands, etc.;
- Checking of the raw materials, semi fabricates and subassemblies, as well as finite products, etc.

b.5. Maintenance and repair of the equipment and machineries:
- Organizing the activity in departments of maintenance and repair;
- Developing and fundament the plan of revision and repair;
- Planning the number of technical interventions;
- Organizing the activity of updating the equipment and machineries, etc.

b.6. Auxiliary production:
- Determining the needs of utilities (energy, fuel, tools, etc.) and their interdependency with the needs of the workshops;
- Organizing the activities of the company`s subsidiaries.

In this stage it`s important to show the methods to implement and apply the decisional system, which must be connected to the updated information.

The performances of the manufacturing process are depending on the activities of the commercial process (contracting the products), the human resources process (specialization of the personnel), and the financial-accountancy process (ensuring the financial means and planning the financial results.

c. Commercial

Is the process of connecting the company to the business environment. The company must be in permanent contact to the competition`s actions, to know the prices and quality of the products and to adapt its offers in order to be competitive.

Activities:

c.1. Supply:

- Centralize the need of material resources (raw materials, fuel, semi fabricates, prefabricates, energy) in order to manufacture the contracted production;
- Sign contracts with the suppliers;
- Perform calculations on stocks for the production department;
- Determine the norms of consumption for the supplied resources;
- Organize the qualitative and quantitative checks on materials involved in the manufacturing process, as well as the warehouse activities.

c.2. Marketing:

- Perform studies concerning the internal and external markets;
- Perform studies for fundament the overall strategy and the politics of the company`s development;
- Collect and process information in order to design production plans;
- Perform studies concerning the needs and behavior of the consumers, which will help the company in planning the production in connection with the market dynamics.

c.3. Sales:

- Perform studies on the internal and external market for finding potential clients for the company;
- Sign contracts for trading the company`s products;
- Calculate the size of stocks for the products;
- Organize the storage activities;
- Organize participation to fairs, exhibitions, advertising campaigns, etc.

d. Financial and Accounting

This process involves two distinct activities:

- Financial, referring to the design and the use of the financial resources of the organization;
- Accounting, referring to the reflection of the transforming process of the patrimonial elements, expressed in terms of values.

The particularities of the financial-accounting process:

- Calculate the cost and the price of the estimation, as well as the categories of costs and prices of the construction activity;
- Paying for the works according to their execution;
- Is the base for organizing the management for the production and the patrimony of the organization;
- Is in strong connection with all the other processes, for which it performs evaluation from the value perspective.

The factors that conditionate the choice of the financial means of the organization are referring to:

- The financial needs, meaning the tools to be used, which are set according to the actual financial state of the company;
- The legal form of the company;
- The size of the company;
- The financial organization of the company;
- The costs for financing the company.

There are two large groups of financial resources for a company: internal and external resources.

The internal resources, or the self-financing, represent the part of resources brought by exploiting the company and by the capital invested by the owner. The financial resources in this situation are: the profit and the depreciation of the fix assets.

The self-financing presumes the priority of actions focused on generating savings in a company. For achieving self-financing, the following techniques may be used:

- Re-investing the profit;
- Politics of using part of the profits;
- Using the cash-flow for financing future activities;
- Using some temporary resources.

If possible, self-financing is a good choice for a company. However, some financial restrictions may occur, in case of risky investments, if some external partners or stakeholders may be reticent.

External resources represent the total amount of contributions brought by the stakeholders, the credits, or other types of funds.

e. Human resources

Is the process that involves the recruitment, selection, retention, retribution, career development, motivation, evaluation, specialization and safety of the personnel of the organization.

People is the most valuable resource of a company. However, this input is not reflected in the firm`s balance sheet, but only in number, wages and taxes. Yet, when calculating the creditworthiness of an organization (in case of financing from structural funds or credits from banks), the human resources involved in the company`s activities play an important role.

The employees of the construction firms are a special category: they work in difficult climate conditions, the timetable is even 10 hours/day in peak times, they move from a site to another all over the country, away from their families. Therefore, the personnel fluctuation is higher than in other fields of activity.

COURSE 1
STRATEGIC PLANNING

1.1. INTRODUCTION

An organization`s strategically planning may be defined in an infinite number of ways, because it`s specific for each economic sector, each organization type, each company according to its size, and these elements are, basically, infinite.

Planning is the most important function of management, through which the organization anticipates the future actions, by setting the goals and objectives, along with the ways they are accomplished.

The main element of planning is the decision, belonging to the manager. The decisional process begins with the proposal of alternatives, the analyze of all possible choices, and then choosing the best solution based on the organization`s capabilities.

A sustainable economy is mainly based on quality, client-focus, performance, and rigorous planning. The construction industry is a non-typical case. The products and services are hard to be standardized in order to have strict procedures. The duration for executing a project is consistent, the working conditions are heavy, most of the activities are extra mural and are influenced by the climatic factors. Discipline in work is another problem in this industry. The company`s personnel is also different from other sectors: most of them are men, with strong personalities, therefore a specific management is required.

The construction business is very complex, because it`s specialized in more than one sector of industry:

- Building;
- Civil engineering;
- Repair and maintenance;
- Manufacturing of materials.

The World Crisis (2008-2010) forced the construction industry in finding methods for improving its standards: nowadays the construction companies' management is focused on productivity combined with qualitative indicators, reduced schedules by using modern technologies, attention in resources consumption, care for the environment. Flexibility and innovation are mandatory features for a performant management.

Globalization is another phenomenon which affects all types of business, including the construction sector. The companies are constantly seeking strategies for keeping or increasing the position in the market.

A model to develop the strategy is provided by Igor Ansoff, who conceived a matrix to represent the present and potential products and clients of an organization for a growth strategy. The study of the matrix parameters is the base for the decision making concerning the company`s strategy. By analyzing the matrix, the management can answer two key questions in any business "What will we sell?" and "To whom will we sell?"

	Existing products (clients)	Potential products (clients)
Existing markets	**Market Penetration**	**Product Development**
Potential markets	**Market Development**	**Diversification**

According to Ansoff theory, in case of an organization which exists in the business environment, four combinations of products (clients) and markets may be analyzed, and four growing strategies may be adopted:

a. Market penetration (Existing markets, existing products): it`s the safest strategy a company may adopt. The company aims to grow on its market segment, according to the existent products, by increasing its market share. This strategy is the least risky, because the company already has experience in delivering the products, has the required knowledge and abilities. However, this kind of strategy is efficient only till the market becomes saturated by the products, or till the competition grows in the sector.
   If the company chooses to use this strategy, it might follow some options:
   - Develop a PEST analysis to identify the opportunities and threats in the target market;
   - Change the traditional distribution channels (the company may try online or direct selling instead of intermediaries or agents);
   - Use market segmentation to analyze the potential clients, in terms of age, gender, level of education, etc.;
   - Use the marketing mix (5Ps) to analyze and reposition the product.

b. Market development (Potential markets, existing products): the company delivers the same products but wishes to extend in other markets. It`s difficult to get aware of new geographical areas, with their personalized features. Most of the time, the traditional products of the company must be adapted to those requirements, whether it`s concerning materials, technologies or human resources.
   If the company chooses to use this strategy, it might follow some options:
   - Develop a new marketing strategy for attracting new customers;
   - Use a BCG matrix to understand what products to develop, rebrand or, maybe, quit selling them.

c. Product development (Existing markets, potential products): the company wants to develop its existing products in the market where it performs. This is a client-oriented strategy, not a product-oriented one. The demands of the clients may lead to change on some features of the traditional products, or, if the company has capability, it may change the entire existing product range.
   If the company chooses to use this strategy, it might follow some options:
   - Invest in Research Development and innovation;
   - Studies on the customers` needs and the trends.

d. Diversification (Potential markets, potential products): the company wants to diversify, both by creating new products and by expanding in new markets. This is the riskiest of all four strategies, because, once adopted, it will change the products and the traditional markets. Such decision, called “suicide decision” in business, is recommended only when the company perceives an opportunity in the environment and if the company is flexible and “rich” enough to block enough resources in a short time. However, business requires brave managers (and, yet, realistic).

Michael Porter, the most famous guru in strategy, explains that the strategy business has four components[9]:

- Strategic planning generates results not just in the efficiency and effectiveness of a construction project. It is always mandatory in relation with competition in the market segment. Besides, the main question when a strategy is set is: "How can we be more performing than our competitors"?

  The construction companies which develop sustainable strategies provide flexibility in all the business components: they analyze the workforce competencies, are multi-task oriented, provide personnel training, and use outsourcing for the activities where the company doesn`t have competencies;
- Strategy means, among others, finding ways to gain competitive advantage through creating unique and inimitable value. Of course, it`s a short-term advantage, because it will take some time for the competitors to replicate the product, so it`s an opportunity for the company to create products with updated features;
- Strategy is always imposed by the market. Therefore, most of the competencies the company`s management may have will be analyzed, because they may not be suitable for competitive products, sometimes in terms of price, supply chains, distance from clients, appearance, or others.

  E-commerce forced the companies specialized in trading construction materials to adapt to this new style of supplying: web presentation, delivery online or direct to the construction site. In this situation, the price is dictated by the competition.

  There are a lot of situations when a compromise is made in quality in order to resist in the market. In case of construction companies, economy means pollution, inadequate measures for health and safety, and so on.
- A company is positioned in the market based on its strategic plans. All the activities that must be fulfilled must be strategic, because an organization performs as a system and benefits of synergy.

Sustainability mainly means wisely consuming of resources, in order to create heritage for the next generations. Therefore, in the construction companies` strategies, besides competitivity, they should focus on using "green" technologies, which provide products with high degree of independence over resources.

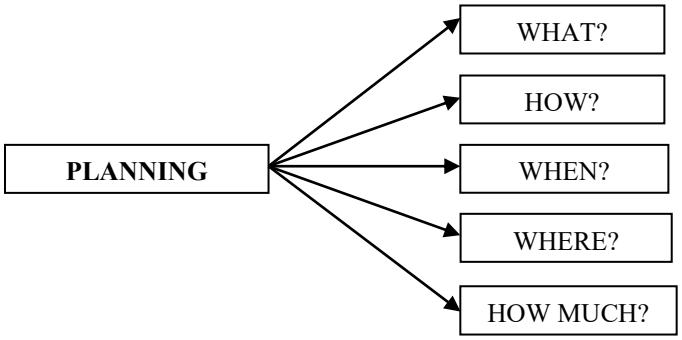
The planning function acts at all the organizational levels, because the top management establishes the overall strategically scope and objectives, while the departments set their own objectives accordingly.

The synergy principle, which is one of the fundamentals of the systemic theory of an organization, is the starting point for the strategic planning, because it involves all the departments of the organizational structure: R&D, manufacture, finance, accountancy, marketing, human

[9] Porter, M., "*What Is Strategy?*", Harvard Business Review, Nov-Dec 1998, pg. 61-78

resources, etc. Each of them is formulating their own strategy based on the overall strategy (which is the top management responsibility); through cooperation, they will build an integrated management.

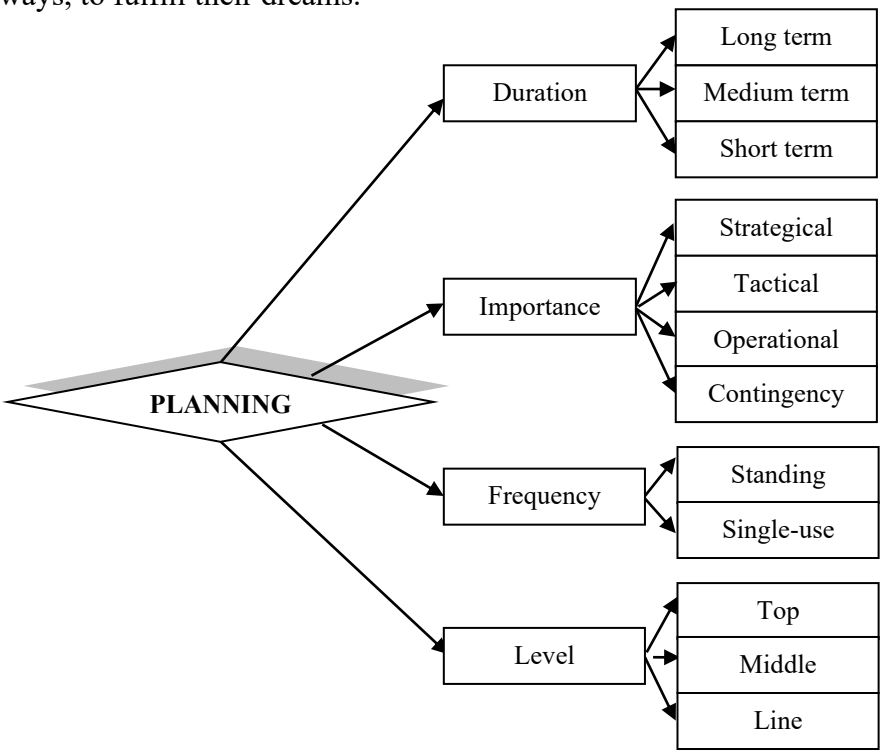
Planning answers to the following questions: what must be done, when, how, where, and how much?



WHAT?	The purpose: results of the project
HOW?	Methods to achieve the scope
WHEN?	The period to accomplish the project
WHERE?	Location of the project
HOW MUCH?	Costs, resources

1.2. TYPES OF PLANNING

Live is the fundament for all the management theories. They only systemize and create a logical frame of the way people lived, with happy or sad experiences which they faced when they tried, in their own ways, to fulfill their dreams.



An action, which may represent the start of a business, needs the determination of an entrepreneur. He/she is entirely involved in achieving his/her dreams, by risking time, money,

intelligence, effort, and most of the time the skills of the team which he/she will coordinate in this brave project.

The decisional system is the most important component of strategic management. It belongs to volunteer, experimented and empathic persons. The age of dictatorship is gone even in private companies. The employees are willing to understand the tasks of their jobs, but that`s not enough anymore. They also want to be involved in decision-making, because only that way they will really feel they are a part of the organization where they spend more time than with their families.

The life cycle of the organization reveals that the decisions are made on the whole period the company performs in the environment. According to its features, there are several types of planning:

a. Duration of planning:
   - Long term planning: is developed for more than three years. The decision-making is strategically planned, because it refers to the overall development of the organization in its sector. For a construction company, an example of this type of decision may be building "green" houses, which are energetically independent and use non-pollution materials and technologies.
   - Medium term planning: duration 1-3 years. The decisions involve the organization`s departments, which apply the strategically decisions. In our example, there may be marketing studies, research on the materials` properties, budget planning, required personnel, association or other types of cooperation between companies in the field.
   - Short term planning: shorter than one year. It refers to put into practice the long- and medium-term strategies, through certain and time-bounded actions. In our example, it might be planning the specific training for the personnel, recruiting specialists, contracts with the material and equipment suppliers, short-time financing, and others.

b. Importance of planning:
   - Strategic planning: it`s a long-term planning and is the responsibility of the top management. In this context, several strategic alternatives are chosen, they are analyzed and then comes the decision on one or more choices, by setting the scopes and objectives, along with the ways to accomplish them.
   - Tactical planning: supports the strategically planning and frames it in specific and relevant objectives. According to the market economy conditions, the tactical plans also show the capability of the organization to adapt to the business environment;
   - Operational planning: leans on the strategic and tactical planning and sets operational plans (daily, weekly, monthly, or quarterly) in order to achieve the objectives. All the organization`s departments are involved in this activity. Basically, they represent the actions and procedures of the line managers.
   - Contingency planning: is made for situations when events are disturbing the organizational plans and make them inoperable. Examples may be strikes, boycotts, natural calamities, or business crisis.

c. Frequency of planning:
   - Operational plans: also called Standard Operating Procedures (SOP), are frequent decisions which are taken often in the company`s life cycle, and usually are materialized in policies, procedures and rules which have to be respected by all the persons affected by them. Late-coming at work may be an example.

d. Single-use plans: they are unique decisions which are taken once in the company`s life cycle, and usually are strategic: the departments structure, the structure of the budget, criteria for evaluation and compensation of the personnel, and others. Mainly there are four types of single-

use plans: objectives, programs (plans of action for objectives), projects (jobs to be done for fulfilling the programs) and budgets (unit measures for completing the projects – money, hours, cube meters, etc.).

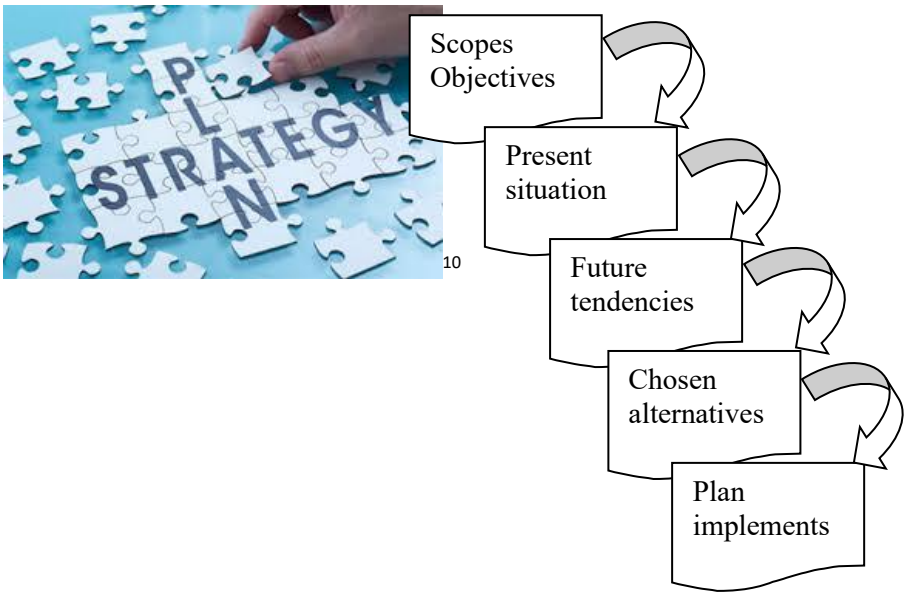
e. Level of planning:
- Top management: strategic, single-use and long-term decisions, made for setting the scope and general objectives of the company.
- Middle management: may be strategic decisions, in case of participative management, single-use, and involve the departments of the organizations, represented by their managers.
- Line (operational) management: are short time and operational decisions, because they are the responsibility of the managers who supervise the operational employees.

1.3. STAGES OF PLANNING

An unplanned investment may turn into failure, because there is a poor analyze of all aspects which affects it.

A simple explanation of the stages in planning may be assimilated to heading from a starting point of a road to the end of it. For example, we may choose some routes according to our resources: by plane, if we have enough money, by car if money is short or the final destinations doesn`t have an airport, by boat, and so on. It`s presumed that our decision of travelling is already made, our only choice will be the method to reach the final point.

In business, the management finds an opportunity and has to decide the methods to accomplish it. An effective strategic planning is realized in several phases:



[10]

☞ **Stage 1**: Setting the scopes and objectives

Any organization performs in a competitive environment, in which monopoly no longer exists. After an opportunity has been identified, the top management`s responsibility is to think of ways to put it into practice. In setting the scopes and objectives, the following aspects should be considered:
- The position in the market`s segment: e.g. To reach two steps higher if the business is successful. General Electric`s scope is to be number 1 or 2 in its sector. If not, the strategy

[10] https://successfultransitions.com/business_services.html, accesat în data de 23.10.2024

will be “Fix – Sell – Close”, meaning that they will have to fix the problems which generated a lower place in the sector. If this strategy is not working, they will try to sell the specific business from the portfolio at a good price. If this fails too, they will close the business for reducing the losses.
- Innovation: in order to be one step ahead the competition, the products/services have to be improved in terms of quality, design, post-warranty, or maintenance.
- Productivity: the organizations should adopt strategies to raise the yield and reduce the costs.
- Materials and financial resources: finding ways to reduce the consumptions, the expenses with the storage, the debts to suppliers, banks, taxes (e.g. Reducing the debts with 10%).
- Increasing the profit.
- Performance of the human resources, both managerial and operational: by modern methods of evaluation, training and personal development programs, reducing fluctuation and absenteeism.
- Social responsibility: enrollment in activities like care for the environment, charity or support for the local community.

☞ **Stage 2**. Evaluation of the present situation

The present situation should be considered and analyzed in relation to the competition. It may be assimilated with the foundation of a construction, because without a solid and real base, the whole building is uncertain.

An analyze cannot begin without knowing the mission and vision of the company, as a starting point in choosing a strategy.

The mission shows the purpose of the company in the business environment today: who it is, which is the area of interest. It answers to questions as: “What do we do?” or “What makes us different?” Depending on how the mission differentiates the company from the competitors and attracts more clients, it will become a strong strategic tool. A statement concerning the mission will describe the products/services, the target market, the organizational culture and the performance indicators.

The vision is the owner`s perception on the future of the organization. It will describe the future of the company and its effects on the future of industry or even society. It will answer questions like “Where do we aim to be?”

A SWOT analyze is developed in order to evaluate the internal status of the organization compared to the external environment. The strengths and weaknesses belong to the company, the opportunities and threats refer to the exterior.

Another phase is analyzing the key competencies of the organization.

☞ **Stage 3**. Planning the future trends

After the actual stage has been analyzed, the management will identify the factors which may block the achieving of the objectives listed in the first stage. Consequently, alternatives will be anticipated, and it will continue with work hypothesis for each. Practically, the strategic planning of a business is achieved similar with the military one. In fact, it`s about people`s lives too. It`s true, the failure of a business isn`t the end of life, like in the battlefield. Yet, the individuals involved have families, credits, so they made parallel long-term strategic plans. Therefore, it`s almost impossible to have only one plan, and no backup plans.

☞ **Stage 4**. Choosing alternatives and setting objectives

The alternatives in the decision-making process should have four characteristics:
- Authenticity: the managers must choose among at least two options, stated very clearly and with an equal degree of importance.
- Believability: a believable option must be based on relevant, representative and trustworthy evidence which rely on logic facts.

- Communicability: a strategic alternative has to be communicated in a way that all the implicated persons will understand it, accept and trust the judgment.
- Deliverability: an alternative may be interesting, but in order to have results, it may have deliverables which should be quantified.

After analyzing the alternatives, the managers will eliminate the unrealistic options and will choose the most suitable one. Then they will decide the future actions for accomplishing the proposed objectives.

☞ **Stage 5**. Implementation of the plans and results evaluation

The chosen alternative is operational, and it will be implemented based on the strategy. The evaluation is a continuous process which provides data on the evolution of the strategic plans on the course of their accomplishment.

There are some features of this stage:

- Motivational leadership: the leadership translates the strategy into action. A motivational strategy will be based on motivational theories which prove the connection between motivation and performance in work.
- Turning strategy into action: a strategic plan will prove its success when the actions taken will be measured in results, by involving right people with competencies which are able to support the strategy.
- Performance management: performance means outputs. They can be achieved only through integrated management, meaning the cooperation between departments, each of them delivering performance, giving and receiving feedback of the actions.

Even when the business is well planned, analyzed and implemented, it may fail because of causes which may depend or not on the managerial team which is responsible with its planning. The unstable economic environment, especially during world crisis, may affect all the fields of activity. The United Europe doesn`t bring only pluses for the member countries. An imbalance in an economy of a strong country will have huge impact on all the countries of the Union.

However, the strategic planning is the manager's job. The causes for unaccomplished strategic plans may be:

- Strategic planning is achieved only at departmental level, not in the integrated system of the organization.
- The managers involved in the strategic planning don`t clearly understand the formal aspects of planning.
- The planned objectives aren`t evaluated periodically, but only at the end of the process.
- The implementation methods are too expensive or too complicated for those responsible for putting them into practice.
- The data chosen for analyzing the alternatives are incorrect.
- The managers involved don`t delegate tasks, they spend time on routine tasks and don`t have time for strategic ones.

The strategic planning means:

- Clear scopes and objectives accepted by all the managers involved in the planning process.
- Correct setting of the tasks that contribute to achieving the scope and objectives.
- Setting the resources needed for the execution of the tasks (materials, money, equipment, informatic systems, etc.).
- Setting responsible objectives and also the persons responsible for each task.
- Setting evaluation criteria for accomplishing the tasks, measurable if possible.
- Setting a risk management plan.

COURSE 2
METHODS AND TECHNIQUES IN STRATEGIC PLANNING

2.1. INTRODUCTION

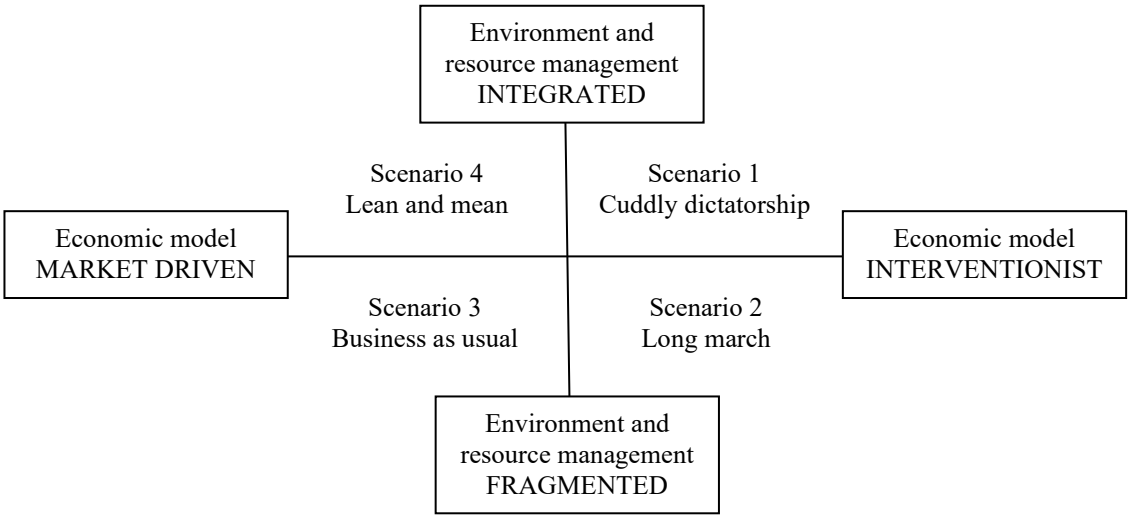
An initiative, no matter of its nature (public or private), is achieved through a project. The main features of a project are:

- A specific start and finish date;
- A life cycle, meaning different stages from beginning to end;
- A budget;
- A set of activities, which are successive, unique and non-repetitive;
- A set of resources;
- A set of responsibilities for the participants (managers and staff);
- A set of roles and relationships between the participants.

Strategy means planning the future, with accent on the forces that may change the long-term plans. In the construction industry, as in other industrial sectors, there are several techniques that involve factors which are affected by change:

- DEGEST: Demographic, Economic, Governance, Environmental, Societal, and Technological;
- PESTE: Political, Economic, Social, Technological and Ecological;
- STEEP: Societal, Technological, Economic, Environmental, and Political.

Based on STEEP technique, the researchers designed four scenarios of future trends in the construction industry. For a successful strategic planning, the management have to design the list of scopes and objectives for a construction project. Consequently, each item will be analyzed[11] :



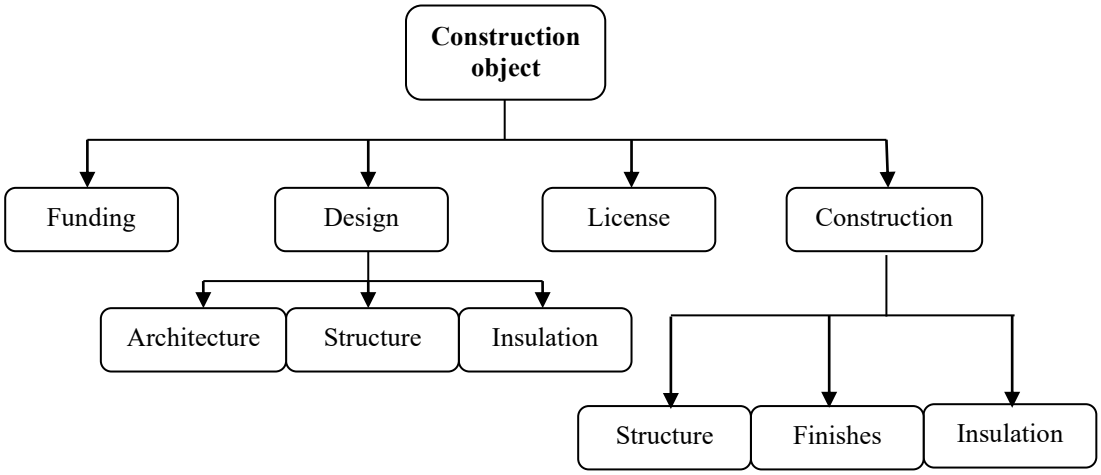
- Scenario 1: Cuddly dictatorship
  A future scenario might happen if the environment and resource management are integrated and the economic model is interventionist. This situation might occur in countries which are oriented on climate change effects. At a governmental level, there will be regulations for reducing the energy consumption and carbon emissions. Constructions will be focused on off-site activity, with modular designs manufactures off site and assembled on site. They will be cheaper and will be easily dissembled and moved on demographic or climate changes demand. The constructions will use modern technologies in design (3D modeling) and

[11] Erdogan, B., Abbot, C., Aouad, G., Kazi, A., *Construction IT in 2030. A Scenario Planning Approach*, Journal of Information Technology in Construction, ISSN 1874-4753, vol. 14, 2009, pp. 539-555.

nanotechnologies in maintenance (self-cleansing glass or self-repair concrete). They will use their own energy sources. A threat might be the skilled people for the new emerging technologies.

- Scenario 2: Long march
  It might happen in a fragmented environment and resource management with an interventionist economic model. The Great Recession (2008-2010) changed the economical chart of the world. There were a lot of alliances in the business environment in order to remain in the market. These companies will stay together if the interests are mutual, but with their own management style and politics. However, they will be forced by regulations to protect the environment.
- Scenario 3: Business as usual
  This scenario might happen in a fragmented environment and resource management with a market driven economic model, like it is today. The companies which survived Recession will struggle to continue doing business, focused on money, meaning the price of the constructions. The methods they will use for sustainable business will differ, according to their financial capabilities. This scenario will give hard times for small and medium enterprises.
- Scenario 4: Lean and mean
  A future scenario might happen if the environment and resource management are integrated and the economic model is market driven. The accent will be on resources with low energy consumption, which is a problem in the construction sector. The carbon emissions will be drastically reduced, dictated by international regulations. Only companies which will allocate money on R&D will survive.

For construction planning, we may use a Gozinto chart, which is a tree with successive levels of the activities needed to accomplish a project. The activities are detailed at a level they may be planned, organized, coordinated and controlled.



A construction project needs a budget. Financing is most often the main problem in starting a project. Therefore, the financing sources have to be identified and contracted before planning other activities. In this phase, we may think on non-reimbursable structural funds, investment funds, associations with individuals and companies, credits from banks, etc.

The next phase is the design of the construction, for which specialists are required: architects for design, professionals for the structure, insulation, or heavy works.

A planned project needs several licenses in order to be executed: urbanization certificate, building permit, notices (Sanitation, Electricity, Gas, Ministry of Water and Environment Protection, The State Inspectorate in Construction, Fire Safety, etc.).

When all these conditions have been fulfilled, comes the execution of the construction project: the structure, the finishing, insulation, roof, partitioning, heating, ventilation, and air conditioning (HVAC), and others.

The strategic planning process is based on making the best decisions for a certain event, situation, or overall strategy of a company. As explained above, the organization`s management will choose the best solution on medium and long term from all the alternatives identified.

Why do we plan the construction projects? There are some advantages for the contractors, like:

- Estimate the overall duration of the work completion;
- Foresight the impact of the construction works on the safety and quality of the environment;
- Evaluate the risks and opportunities;
- Ensure the monitoring and control of the works;
- Plan the material consumption;
- Reduce the loss of materials;
- Estimate the need of workforce and equipment.

The methods which may be used in the strategic planning for the decision-making process are[12] :

2.2. METHODS FOR STRATEGIC PLANNING

2.2.1. Methods for clarifying the problems

Any organization has to follow the decisions made by the management. A problem can be explained as the difference between "What is?" and "What should be?". There are some steps in clarifying this issue:

√ Analyze the present state: what you know now about the problem you have identified;
√ Find the issues which are missing in solving the problem;
√ Gather information about the problem;
√ Propose alternatives to solve the problem.

The management team has responsibility in setting the organization`s strategy. In order to achieve this action, the team will have to identify and then to clarify the problems which confront the organization.

The criteria for the evaluation of the strategic planning methods are:

- Relevance: analyze the degree in which the chosen method is suitable for clarifying the problems.
- Acceptance: refers to the conformity of the method with the country`s legislation.
- Cost: financial capability of the organization to apply the proposed method.
- Information: organization`s capability to provide useful data for the proposed method.
- Communication: the degree in which the personnel involved understands and accepts the proposed method.
- Sustainability: the possibility to apply the proposed method on future actions, combined with its improvement.

Because this method refers to the management team, some aspects must be clarified concerning the cooperation of its members, through the implication of all the team members in the decisional process. Basically, there are some alternatives concerning the team work:

[12] Nilsson-Axberg, *Forestry Sector and Forest Plantation in South and East South Asia*, Swedish University of Agriculture and Science, SIMS Report 34, Upsalla, pg. 34

a. Brainstorming:

This method was invented in the 1950`s by Alex Osborn, who was promoting manager at Madison Avenue.

It`s an informal approach of the decisional process, used when the present state is analyzed.

The members of the team involved in the project meet in order to achieve creative and rapid ideas. Their opinions are never criticized, in order to ensure the freedom of expressing the thoughts and to eliminate barriers of personality, hierarchic state, or discrimination.

b. SWOT Analyze:

	ADVANTAGE (for proposed objective)	**DISADVANTAGE** (for proposed objective)
INTERNAL (inside the organization)	**STRENGTHS (S)** ★…… ★…… ★…… ★…… ★……	**WEAKNESSES (W)** 👽…… 👽…… 👽…… 👽…… 👽……
EXTERNAL (outside the organization)	**OPPORTUNITIES (O)** ★…… ★…… ★…… ★…… ★……	**THREATS (T)** 👽…… 👽…… 👽…… 👽…… 👽……

When a certain strategy or objective is identified, the management team will develop an analyze of the strengths and weaknesses of the organization, correlated with the opportunities and threats coming from the external environment.

This matrix was initially developed for the business sector but is also useful for strategic decisions in areas like education, community, or others.

c. Problem (decision) tree:

For decisions linked to complex issues, this method identifies both the causes of the problem and its effects.

The main principle of this method is to identify a negative issue of a project and to transform it in a positive objective.

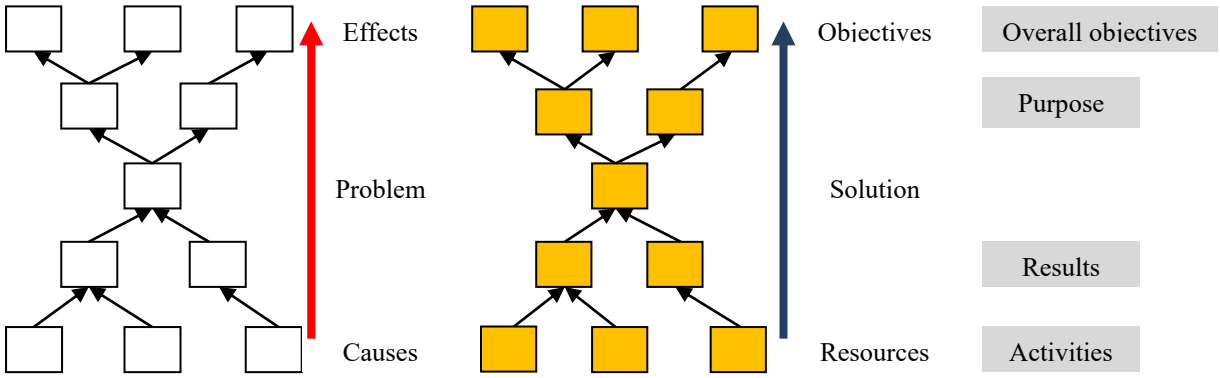
It`s an iterative method, which it`s repeated until the causes and effects of the identified problem become logical.

The roots of the tree (bottom of the drawing) represents the causes of the problem, the branches (fruits) are the problem`s effects.

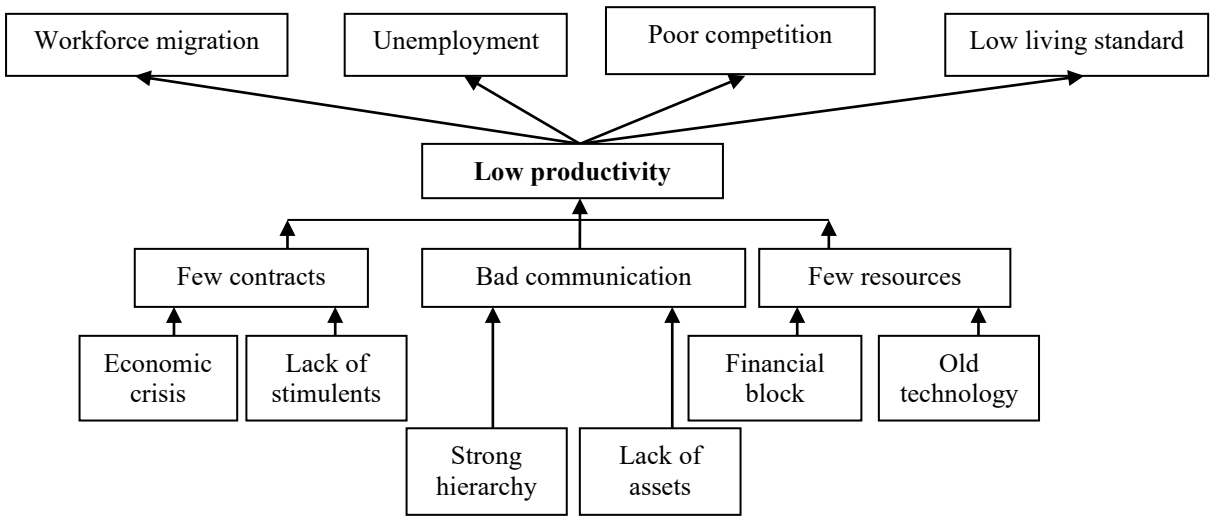
The steps in developing the methods are:

- Identify the problems that may exist when planning a project based on available information.
- Select a specific problem to analyze.
- Identify the causes and effects of the problem.
- Design the problem tree: causes will be placed below the problem; effects will stand above. If two or more causes produce the same effect, place them at the same level.
- Connect the causes and effects of the problem with arrows.

When designing the problem tree, for transforming a negative issue in a positive one, the causes will be the lack of resources, and the consequences will be the future achievable objectives (SMART). The strategy will have an overall objective, which will be materialized in specific objectives (purpose), which will lead to results provided by activities.



An example for the construction sector is presented below:



d. <u>The logical framework:</u>

By using this planning instrument, the management team establishes the cause-effect relations, when the latter is clearly defined[13].

This method is applied in circumstances when, in order to make a decision for a strategy, the company analyzes the historical data for similar situations.

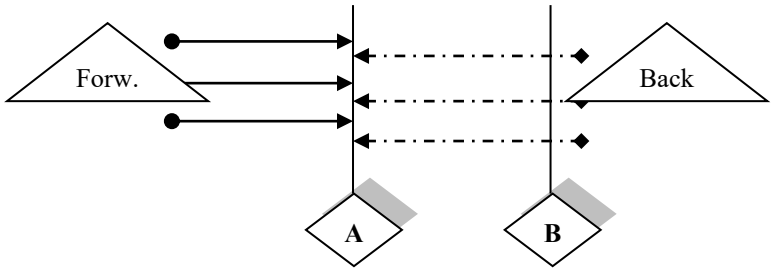
In this case, the CBR Index (case-based reasoning) is used, for problems which may be solved in the same way as they were previous done, with expected results.

The phenomena which may occur along the strategy process are analyzed, and for each alternative the management team will decide upon the ways to deal with.

[13] Begum, S.; M. U Ahmed, P. Funk, Ning Xiong, M. Folke (July 2011). "*Case-Based Reasoning Systems in the Health Sciences: A Survey of Recent Trends and Developments*". IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews 41 (4), pp. 421–434

e. The force field analyze:

Any strategy, when it`s implemented, is influenced by several forces, some of them obstructing, and others helping the project.



After identifying the forces which affect the strategy in a positive or negative way, in terms of numbers and types, the management team will establish the methods to exploit or block them, by giving them scores according to the degree of influence of these forces over the organization (0 for lack of control, 5 for maximum control).

TYPE OF FORCE	IMPORTANCE	CONTROL	TOTAL
DRIVING FORCES			
Force A: Use modern technology	3	4	7
Force B: Research new materials	2	2	4
Force C: Expend to new markets	4	2	6
Force D: Focus on green buildings	4	2	6
CONSTRAINIG FORCES			
Force E: Lack of specialized personnel	5	1	6
Force F: Environment regulations	4	0	4
Force G: Fluctuation of prices of houses	3	0	3
Force H: Fuel crisis	5	0	5

After analyzing the results, the management will choose to take actions on the high rated forces in the CONTROL box. Moreover, if there are forces which have influence on others, they might be the company`s priorities.

f. Comparison matrix:

The management team lists some alternatives of strategies which may develop on long term (alternative A, B, C, etc.). They will make a pair wise comparison (alternative A compared to B, A to C, B to C) and will choose the best option.

First, they will set the criteria based on the organization`s capability. The criteria are then rated according to their importance. The most used is the Likert scale:

Scale	Mean
-2	The worse
-1	Inferior
0	Satisfactory, not recommended
1	Good
2	Superior, excellent

The criteria are analyzed, and scores are given based on the importance on the future strategy. The more criteria are listed, the most accurate are the results.

CRITERIA	RATE	A		B		C	
		Score	Rate	Score	Rate	Score	Rate
C1	0.20	2	0.40	2	0.40	2	0.40
C2	0.15	0	0.00	2	0.30	2	0.30
C3	0.20	2	0.20	1	0.20	1	0.20
C4	0.10	2	0.10	-1	-0.10	-2	-0.20
C5	0.15	-2	-0.30	-1	-0.15	-1	-0.15
C6	0.20	-1	-0.20	-1	-0.20	-1	-0.20
TOTAL	1.00		**0.20**		**0.45**		**0.35**
RANKING		**3**		**1**		**2**	
CONTINUE?		**YES**		**NO**		**NO**	

g. Role playing:

It`s a technique to simulate the behavior of the participants in "What if?" situations, which may be sales meetings, negotiations, conflicts, etc.

A common situation may be the need to design a team for a new project.

[14]

In this method, the facilitator gives roles to persons in order to solve a problem and to overrun possible obstacles in fulfilling an objective. The game reproduces reality, therefore it`s a simulation.

2.2.2. Patterns review

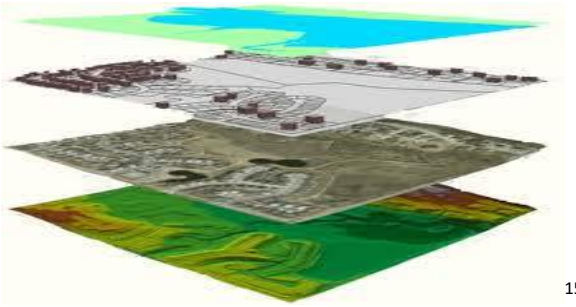
In the construction industry, the location of the buildings strongly affects the strategy of the organization. Therefore, the site plans, as well as overall plans, must be developed in order to have access to the required resources for completing a project in conditions of maximum quality.

These studies aren`t the responsibility of civil engineers and need a close cooperation with the specialists.

There are some possibilities of applying those methods:

[14] https://www.linkedin.com/pulse/step-1-creating-conops-create-working-group-naeem-m-ali-p-eng, accesat în data de 23.10.2024

a. Studying the maps and plans:

 [15]

These elements help the project managers, because a construction project is a very expensive one, and the preparing costs have a considerable amount in the overall price of the investment. The modern visualization systems GIS (Geographic Information Systems) ensure a great coverage of the area in which the building will be located.

b. Computerized simulations:
This method helps setting future strategies or future projects in construction, if uncertainty occurs.
The items considered may be geographical features of the area, climate conditions, or others.
For example, it may be useful in choosing the equipment for a specific area: concrete placement on site, earthmoving, coordination of cranes operations.

2.2.3. Methods of social, economic and environment analyze

These methods are based on economic sustainability, but they concern all the aspects which have influence on the environment and the people`s life in a specific area.
For economic analyze, the organization may apply some of the following methods:

a. Social evaluations:
There are studies and questionnaires which, through a specialized interpretation, provide information about the number of inhabitants in the area, the unemployment rate, the living standard, the birth rate, the level of education of the active population, and others.
These studies are costly, therefore the aspects which are the subjects of the analyze have to be carefully chosen, based on their relevance, in order to give accurate results when using them in the strategic planning.

b. Environment evaluations:
The construction works often use polluting materials and technologies. They have a bad impact on the environment, e.g.: noise, air and water pollution, solid and liquid waste, toxic gases, dust, mud, excessive energy consumption.
Sustainable strategies have to consider the level in which the activity may harm the environment and to propose methods to mitigate the effects, in a quantum the company affords.

[15] https://www.uwyo.edu/pie/research/gis.html, accesat în data de 23.10.2024

c. Cost-benefit analyze:

The strategies proposed by the company`s management have effects only if they are profitable. Ideas have to be realistic, because the final results affect all the stakeholders.

A cost-benefit analyze of each parts of the strategic objectives will highlight the amount of resources needed for their achievement. The company will develop a medium- and long-term projection of priorities and, based on the organization`s capabilities, it will choose one or more development solutions.

A business strategy relies on choosing the best alternative from a reasonable number of variants to be relevant. Therefore, one single method wouldn`t be enough for an effective strategic planning. Consequently, the management will combine more methods and ponderate them according to their importance.

In certain conditions, another method for decision making process is the decision matrix. It is a set of values which may be evaluated for a course of actions.

As an example, for the above methods, the management team may have five options, which will be evaluated according to social evaluation, environment evaluation and cost-benefit analyze. Scores are given for each option, and the highest total score will be the best option.

STRATEGY/ OPTION	SOCIAL EVALUATION	ENVIRONMENT EVALUATION	COST-BENEFIT ANALYZE	TOTAL SCORE
A	2	1	3	6
B	1	3	4	8
C	5	4	5	14
D	3	5	2	10
E	4	2	1	7

Where 5 is the highest score
1 is the lowest score

2.2.4. Anticipate the future strategies

Strategic planning is in fact a future vision of the company`s activity. Even if it`s a prediction, it`s a scientific process, which provides development poles on definite time periods. There are some quantitative and qualitative foresights:

a. Extrapolation of trends:

Past events may be extrapolated in the future by using statistical quantitative criteria. They may refer to the growth of the active population, migration from rural to urban areas, issues which, for the construction sector, may represent demands for dwellings or need for offices, sport halls, schools, universities, hospitals, etc.

This technique will also consider possible substitutes, such as dwellings outside towns, or refurbishment of decommissioned spaces.

Moreover, a correct extrapolation will also consider the weight of some factors that contribute to choose the future strategy.

b. Scenario method:

Unlike predictions, which often turn to quantitative statistics and probabilities, scenarios are qualitative approaches of a phenomenon that is projected into the future. It refers to strategic thinking, not planning, so it`s an option, not an action.

Opinions of the subjects asked how they perceive the future of the organization will be analyzed, quantified, and will provide a temporal image of the strategy.

As the construction industry is heavily affected by opportunities and threats due to the fast social, economic and environmental changes, it has to adapt its strategies to the future (foresight for 20-25 years).

c. Analysis of company`s history:

Knowing the company`s past performance is the step for its future development. Best practices are indicators of the way a certain problem was successfully solved. But negative results are as well credible sources concerning the approach of a phenomenon.

The competition is another source of information regarding the way they won or lost by adopting some business decisions.

This analyze must be followed by a SWOT analyze, and by interpreting it, the organization might take actions to maximize the strengths and opportunities and to mitigate the weaknesses and threats.

In the construction sector, an organization should consider the following elements:

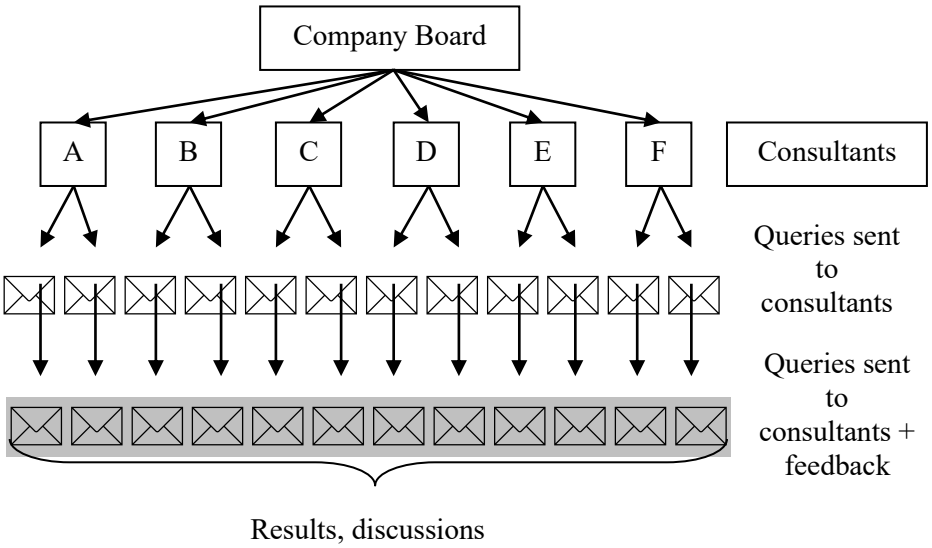
- Strengths: management skills, company`s brand, diversity in project types and expertise, etc.
- Weaknesses: relying on one client, acting in a restricted geographic area, specialized only in one domain (rehabilitation, modernization, plastering, etc.), lack of personnel`s key competencies, low participative management, employees specialized in only one field of expertise, etc.
- Opportunities: specialists to anticipate new trends in the consumers` tastes, flexibility in adapting to modern technologies, or using non-polluted materials, or building energy efficient constructions, etc.
- Threats: economic crisis, slowdown of the construction industry, changes in the regulations, ageing of the population, global warming, etc.

d. Methods based on collective views:

This method is based on the reasoning of the groups of persons who are tangential to strategic decisions.

One of these methods is Delphi, in which the issues connected to strategy are subject to the specialists` analyze. It`s an iterative process, where the persons involved, who don`t meet and don`t cooperate, offer solutions to strategic dilemma, by providing answers to questions stated by the company`s management.

Delphi Process



The organization`s management analyze the variants and send them back to experts with a new list of issues. This procedure continues till the dilemmas are solved.

An example may be the dilemma of a construction`s company management on how to minimize the risks of the business.

The variants proposed are:

- Improper planning and scheduling;
- Poor site management;
- Poor leadership;
- Reworks due to errors;
- Design changes;
- Disputes in sites;
- Poor supervision;
- Fluctuation in material costs;
- Additional works;
- Estimation failure.

After the first round, some issues may be insignificant for the experts. They will be eliminated, and the remaining issues will be reanalyzed, according to the feedback given by the company. The experts will give ranks to the variables and send them back to the company. After receiving feedback, the process reiterates until all the experts agree on the ranking of the issues.

COURSE 3
PROJECT MANAGEMENT IN CONSTRUCTIONS

3.1. INTRODUCTION

Management is the science that makes things happen. It`s easy to express, but very complex to accomplish. First comes the idea, the sparkle which will trigger the action. The ways to reach the expected result are various. There isn`t a single correct answer to a question. However, maybe, there is only one that is linked with the entrepreneur`s capabilities, where materials or people are involved, but most of the times the most important aspect for the chosen solution is the budget.

"Project management in constructions means the planning, organizing, coordinating and controlling of the project, from the beginning till its end, with the scope of meeting the client`s demands regarding the achievement of a viable project from functional and financial points of view, by respecting the quality standards, the costs and the agreed execution time".

Project management is a rather new specialization in management, born in the 1950s, which deals with allocation of the resources in a way to deliver a competitive project. No matter the area of activity, any planned action with a final result should be assimilated to the project concept. When planning is concerned, it means that a well-argued strategy will exist for achieving some SMART scopes and objectives (S = Specific, M = Measurable, A = Achievable, R = Realistic, T = Time-oriented).

The literature in the field abounds in definitions, more or less complicated, of a project. Here is a single example:

"A project is a temporary action destined to create a unique product/service, which depends on constrains as cost, time and scope[16]".

Some important elements of a project may be highlighted:

- Temporary character: any strategic project has a well-defined execution time, a starting and finishing time. The strategic planning is the one that imposes these targets;
- The product/service is unique: the uniqueness is given by its design, the materials and equipment used, the type and quality of the finishes, partitioning, utilities, etc.;
- Constrains: every project has a budget that has to be accurate, and most of the time is the major constrain. There are situations when the execution time is the main item, even before budget (let`s think of an office building or a mall, where the owner takes monthly rent). Yet, the destination of the building in the designing phase is equally important (there are huge differences when designing a block of flats, a highway, or a nuclear plant).

One possible definition of this notion may be: "The construction project is an action with a limited life cycle, destined to the building, rehabilitation or demolishing a construction objective, by performing variable and non-standardized works in a limited timetable, budget, and by compliance to the agreed quality standards".

A construction project is an application of project management, which is framed in its principles, but shows the following characteristics:

a. The construction`s project chart is a unique network: a construction company runs more projects at the same time, in many locations and/or with different resistance structures. In this situation, for each project a project team is allocated, with well-set responsibilities. The best option should be a matrix organizational structure.
b. The construction project is time bounded, according to the contract with the owner, therefore it has time limits for start and finish.

[16] Griffin, A., J., *Residential Construction Management: Managing According to the Project Life-cycle*, J. Ross Publishing, USA, 2010, pg. 3

c. The construction project`s objectives are quantifiable: besides duration, it has constrains of budget and quality.
d. The construction project is planned according to the organization`s capabilities, and the result is a construction objective, which may have one or more construction objects.
e. The construction project is achieved through cooperation of several actors: suppliers, clients, local authorities, investment funds, creditors, banks, etc. For acquiring the expected result (the construction objective), between the parties involved there should be coordination and efficient communication, because a wrong development of the project will generate malfunctions and conflicts.
f. The allocated resources are diverse both by their features and by their procurement means: materials (supplied from inside or outside the country, transported under conditions that should not affect the quality), human resources with different backgrounds, training and specialization, equipment and machinery needed to deliver the project.
g. Planning the duration of the activities should consider the logical sequence, along with the technical features, the size of the site, the number of available workers, the climate conditions, the environmental prescriptions, location, and others.

The best practices in civil engineering are a major source of inspiration for the organizations, because they prove that performance may be achieved in any domain, if strategically decision is adopted. The figure below presents a framework for transformation in construction area[17].

	Technology, materials and tools			**Processes and operations**		
Company level	Advanced building and finishing materials	Standardized, modular, and prefabricated components	(Semi)automated construction equipment	Front-loaded and cost-conscious design and project planning	Innovative contracting models with balanced risk-sharing	A common and appropriate framework for project management
	New construction technologies, e.g. 3D printing	Smart and life-cycle optimizing equipment	Digital technologies and big data along the value chain	Enhanced management of subcontractors and suppliers	Lean and safe construction management and operations	Rigorous project monitoring (scope, time, cost)
	Strategy and business model innovation			**People, organization, and culture**		
	Differentiated business model and targeted consolidation and partnerships	Sustainable products with optimal life-cycle value	Internalization strategy to increase scale	Strategic workforce planning, smart hiring, enhanced retention	Continuous training and knowledge management	High-performance organization, culture and incentive schemes
Sector level	**Industry collaboration**			**Joint industry marketing**		
	Mutual consent on standards across industry	More data exchange, benchmarking and best practice sharing	Cross-industry collaboration along the value chain	Industry-wide collaboration on employer marketing	Coordinated communication with civil society	Effective interaction with the public sector
Government	**Regulation and policies**			**Public procurement**		
	Harmonized building codes/standards and efficient permit processes	Market openness to international firms and SMEs	Promotion and funding of R&D, technology, adoption and education	Actively managed and staged project pipelines with reliable funding	Strict implementation of transparency and anti-corruption standards	Innovation-friendly and whole life cycle-oriented procurement

- Technology and materials:
  The construction industry is the most polluting one (almost 40% of solid waste comes from construction and demolition), the biggest consumer of raw materials (50% of the steel production, 3 billion tons of raw materials) and energy (25-40% of the global energy).
  The use of prefabricates is a benefit: less errors, shortage of the project`s duration, independence over weather conditions, labor safety, increase in productivity and quality, or less of pollution because they are manufactured indoors.

[17] Industry Agenda, *Shaping the Future of Construction: A Break though in Mindset and Technology*, World Economic Forum, 2016.

Examples:

- Broad Group China, in cooperation with ArcelorMittal used modular elements for buildings, moving 90% of the construction process in the factory. The effect was a 53 floors building executed in 19 days.
- Skanska, a Swedish company, invented the concept of "Flying factories", which are temporary plants near the construction site, which reduced the construction and labor costs to 50% and increased the productivity and quality with 40%.
- Komatsu uses drones and 3D scan to transmit the information to automatic bulldozers and excavators.

- Processes and operations:

The processes and operations become effective if all the stakeholders communicate and cooperate from the early stages of the project. This approach will lead to the mitigate of the risks. Best practices and lesson learned are other ways to improve the performance at all organization`s levels and departments.

The suppliers and subcontractors should be integrated in the project management process, in order to avoid delays, especially for the resources which cannot be purchased but in the moment of using them (concrete, components, etc.).

The lean management (zero wastes and high productivity) invented by Toyota may be applied to constructions, even if the operations are complex, and not standardized, like in the automotive industry. However, there are ways to improve the processes, with effects on costs, schedule, or quality:

- Dividing the construction into sectors may improve the schedule for the repetitive tasks. Moreover, the rhythm, or work pace of the flow line may be optimized, and consequently the resources may be managed more efficient.
- Just in time (JIT) supplying of materials and equipment: the suppliers will bring them exactly in the moment of usage, so expenses with storage and protection are almost null. It can be achieved only by perfect planning and cooperation with suppliers.

An important issue is the monitoring of the project. Some modern methods may be used: drones to measure the progress of the project, or simulations for detecting the possible changes and their effects on the development of the project.

- Strategy and business model innovation:

The construction companies may adopt methods to improve the operations and control the costs: acquisitions of manufacturing companies, or partnerships with providers of modern technologies (drones, 3D scan, etc.).

Innovative methods may be long term strategies, like the evaluation of the buildings` costs for the whole life cycle of the construction, and not only for the planning and execution phases.

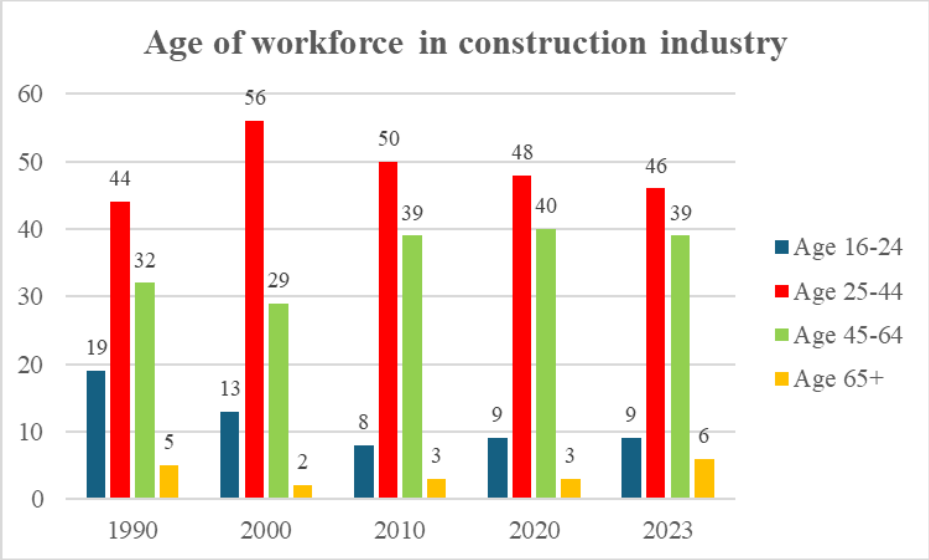
The construction companies may make associations with real estate firms to make survey on consumers regarding the materials, surfaces, design, lightning, appliances or costs, and adapt their offers accordingly.

Sustainability is another aspect: using recycled materials, low-energy technologies, biomass for producing energy, etc. The statistics show that only 20-30% of the materials from demolitions are recycled. The rest of 70-80%, such as lumber (40%), asphalt (14%), soil (11%), concrete/rocks/bricks (10%), drywalls (10%) and others (14%) may be transformed in fertilizers, gravel, road or wooden materials.

Another strategy that may be adopted by the companies is to become international, through cooperation with local firms.

- People, organization and culture:

The age of the working force in construction has decreased dramatically: in 1990 the average age was 36, while in 2023 was 43, and the trend is negative.



The workforce has to be planned strategically, because of the ageing and also the need for skills to handle modern technology.

The fluctuation of the labor force is another challenge: in 2023, 21.6% of the workers quit the organization, and created big problems in completing the projects.

The continuous training and a fair compensation system may help in creating a company culture and make the people loyal. A partnership with the universities might be a solution.

- Industry collaboration:

  The collaboration between stakeholders might improve the business strategies in constructions.

  Standardization of processes and procedures may provide control on costs, waste, or safety. It can be done by cooperation with other industries along the value chain of the project.

  Best practices should be spread. The Construction Industry Institute from USA collects the best practices and offers them to all its members.

  The public sector and the community should be also considered.

- Regulation and policies:

  The regulations insure the fact that the standards and codes will be respected. They have to be uniform for all the industry, like Euro code in Europe, and local norms for every country.

- Public procurement:

  The main clients of the construction companies are the government agencies (in 2023, from total contracts, the public ones represented 31% in UK, 44% in Germany and 57% in USA), therefore regulations have to be made for a fair bidding stage. A study made for the European Commission in 2023 showed that a probability of fraud and corruption was of 9-21% in the road and rail sector, 28-43% in water and waste, and 37-53% in urban and utility.

Project management is an old practice, maybe the oldest in the world. The purpose is to deliver a project according to the scope (to meet the customer`s demands), with the smallest budget, and as soon as possible. However, almost all of the megaprojects (even the well known Wonders) didn`t meet these indicators.

There are some unformal rules of project managers, never accepted by specialists, but hard to dispute:

- Law 1: No major project will be finished in the estimated time, scope, or budget, and the starting team will not be the finishing one.
- Law 2: If a project doesn't meet the three constraints, the longer you delay to fix it, the harder is to repair.
- Law 3: If you are confident that every people of the team understands and agrees what you decided, be sure that at least one person won`t.

3.2. CLASSIFICATION OF THE CONSTRUCTION PROJECTS

The construction sector is a very complex one, which is mainly confronting the clients` demands. The different personalities and features of individuals and groups provide the diversity of this industry.

However, some classifications of the projects may be done, based on several criteria, such as: destination, type of works, technologies used, and others.

a. By destination, the construction projects may be:
   - Residential buildings, which represent 30-35% of this industry. They are: single-family, multi-family, or blocks of flats. These are the most personalized buildings, because their destination is for family use. Practically, the project types are infinite and mostly unique. They may be designed by engineers or architects and developed by specialized companies or by the owner.
   - Industrial buildings, which represent 5-10% in this industry. They are: refineries, factories, nuclear plants, etc. The characteristic of these constructions is that there is a limited number of companies that can execute them, because of rigorous technical prescriptions. The architecture is almost insignificant related to other requirements, such as the dimensioning of the technological flows, or the level of pollution. They are generally located in urban areas.
   - Heavy buildings, which represent 20-25%: dams, tunnels, highways, airports, communication systems. Due to their features, the most important are: safety, comfort, special conditions. They are designed by engineers in cooperation with architects, because the safety of the construction is more important than the design.
   - Institutional buildings, which represent 35-40%: schools, universities, hospitals, theatres, warehouses, commercial buildings, stadiums, banks, offices, government buildings.

b. By the type of works, the projects are:
   - New construction works: investment objectives, construction objects, or parts of objects.
   - Changes to existing constructions: extensions, upgrades, or rehabilitation.
   - Maintenance or repair of existing constructions.

c. By the technologies used[18], the constructions may be:
   - Lightweight constructions, which don`t require special technologies. They are: lightweight structures for residential buildings, warehouses, platforms, small shops, small bridges, and others.
   - Heavy constructions, which require the use of heavy equipment and machinery: large bridges on pile foundations, tunnels, dams, highways, airports, harbors, etc.
   - Industrial buildings, which require special equipment and machinery: chemical plants, nuclear plants, refineries, steel or aircraft plants, etc.

d. By the execution time, the construction projects may be:
   - Long term projects: more than 10 years;
   - Medium term projects: between 3 and 10 years;
   - Short term projects: between 1 and 3 years;
   - Very short-term projects: less than 1 year.

e. By the value of the project:
   - Projects of very high value: over 1 billion $;
   - Projects of high value: between 100 million and 1 billion $;
   - Projects of medium value: between 10 million and 100 million $;
   - Projects of small value: less than 10 million $.

[18] Gahlot, P., S., *Construction Planning and Management*, New Age International Ltd, Delhi, 1992, pg. 19

The activities in constructions, as part of the global industry, have been classified by EUROSTAT (Statistical Office of the European Communities) in the NACE framework (Nomenclature Générale des Activités Economiques dans les Communautés Européennes), in the following categories[19]:

DIVISON		GROUP		CLASSES AND SUB-CLASSES	
SECTION F - CONSTRUCTION					
41	Buildings	41.1	Development of project designs	41.10	Development of building projects
		41.2	Construction of residential and non-residential buildings	41.20	Construction of residential and non-residential buildings
				41.20/1	Construction of commercial buildings
				41.20/2	Construction of dwellings
42	Civil engineering	42.1	Construction of roads and railways	42.11	Construction of roads and railways
				42.12	Construction of railways and underground
				42.13	Construction of bridges and tunnels
		42.2	Construction of utility projects	42.21	Construction of projects for fluid utilities
				42.22	Construction of utilities projects for electricity and telecommunication
		42.9	Construction of other civil engineering projects	42.91	Construction of projects for water
				42.99	Construction of other civil engineering projects
43	Specialized activities for constructions	43.1	Demolitions and site preparation	43.11	Demolitions
				43.12	Site preparation
				43.13	Test drilling and boring
		43.2	Electrical, plumbing and other construction installation activities	43.21	Electrical installations
				43.22	Plumbing, heat and air conditioning installations
				43.29	Other construction installation
		43.3	Building completion and finishing	43.31	Plastering
				43.32	Joinery
				43.33	Flooring, wall covering
				43.34	Painting 43.34/1. Painting 43.34/2. Glazing
				43.39	Other building completion and finishing
		43.9	Other specialized construction activities	43.91	Roofing activities
				43.99	Other specialized construction activities 43.99/1. Scaffolding 43.99/9. Specialized activities in construction (other than scaffolding)
SECTION M – PROFESSIONAL, SCIENTIFIC ANF TECHNICAL ACTIVITIES					
70	Head office activities; management consultancy activities	70.1	Head office and activities	70.10	Head office activities: supervising, coordination of other company`s units: headquarters, corporations, administrative offices, subsidiaries
		70.2	Management consultancy activities	70.22	Business and other types of management consultancy activities
	Architectural		Architectural and engineering,	71.11	Architectural activities 71.11/1. Construction activities 71.11/2. Urbanism and landscaping
					Technical consultancy and engineering activities 71.12/1. Design and technical consultancy

[19] The Standard Industry Classification (SIC) 2007 types of activities in the construction industry complied with the NACE classification

71	and engineering activities; technical testing and analyze	71.1	technical consultancy activities	71.12	activities 71.12/2. Technical and scientific consultancy activities 71.12/9. Other engineering activities (exclude design of industrial processes and production or other technical and scientific consultancy)
		71.2	Technical testing and analyze	71.20	Technical testing and analyze

3.3. STAKEHOLDERS ANALYZE IN THE CONSTRUCTION PROJECTS

The construction projects depend on some factors, and the most important are:

- The size of the project, which shows the number of activities to be accomplished, and each activity is defined by the quantity of works planned to be performed.
- Complexity, which is the quantification of variety of tasks to be done. A complex project is the one with diverse activities, compared with a simple project, which has more repetitive (or similar) activities.
- The quality of the task`s completion, which may be measured by fulfilling the standards and specifications.
- The productivity, which mainly measures the rate between the planned effort to manufacture a unit of quantity and the effort of the worker to fulfill this task.
- The time limit to finish the project, which depends on the speed to achieve its activities.
- The cost, which is the price the client will want to pay for the project plus the company`s profit.

One of the main characteristics of a construction project is its dependency of other entities involved, optional or legal, in order to achieve the objective, set by the managers, which is realizing the investment.

According to the systemic theory, an organization takes the resources from the external environment and transforms them into products or services, that are also delivered in the external environment of the organization. Therefore, it needs suppliers for resources (materials, prefabs, specialized employees, money, equipment, or machinery) and clients for its products or services.

Because a construction project is very complex, and destined to the local population, among aspects connected to business ethics, there are more issues dictated by regulations: citizen safety, protection of the environment, rational use of the resources, and others. Therefore, when a construction project is planned, the company has to analyze all the parties involved, which are the stakeholders.

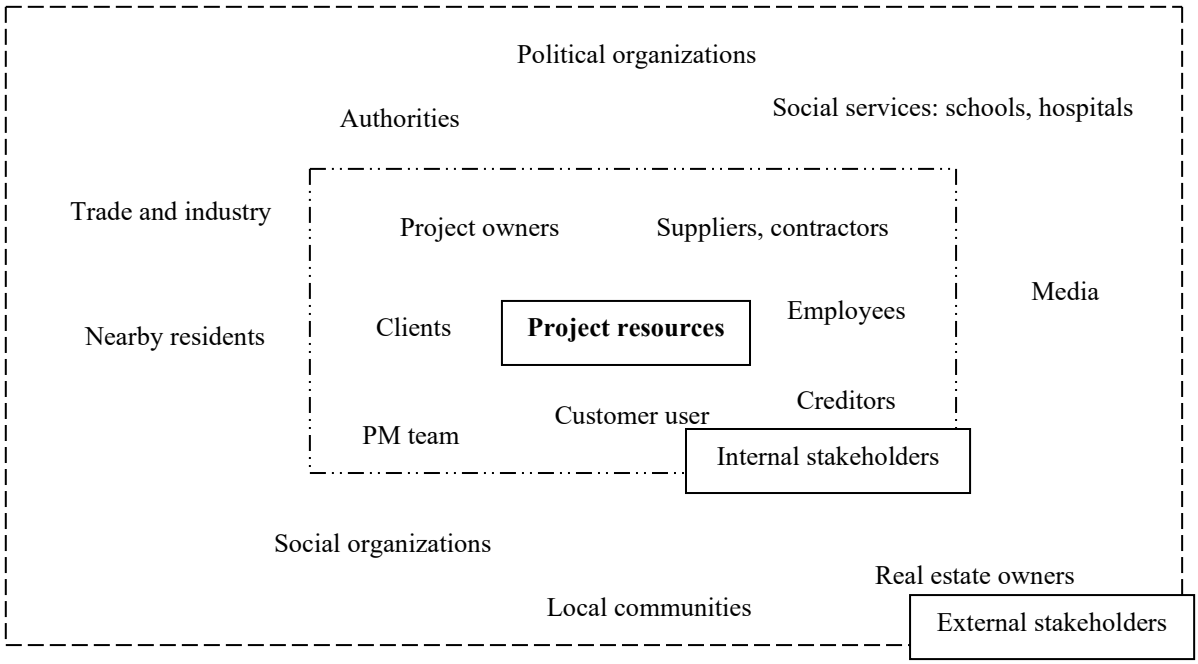
Stakeholders are groups, persons or organizations which have interests or are involved in the company`s projects.

Stakeholders` analyze means finding the people who will help on making the project successful. The benefits of developing a stakeholders` analyze are:

- Using the stakeholders opinions, the project can be protected from further problems at the early stage and save losses if changes will be required during its completion.
- The support of the stakeholders will benefit the project`s resources, in terms of price, quality, or time saving.
- By involving the stakeholders during the project stages, the advantages for the community may be stronger: employment, training for developing people`s skills, care for the environment, etc.
- Cooperation with the project`s stakeholders might be useful in anticipating the clients` expectations.

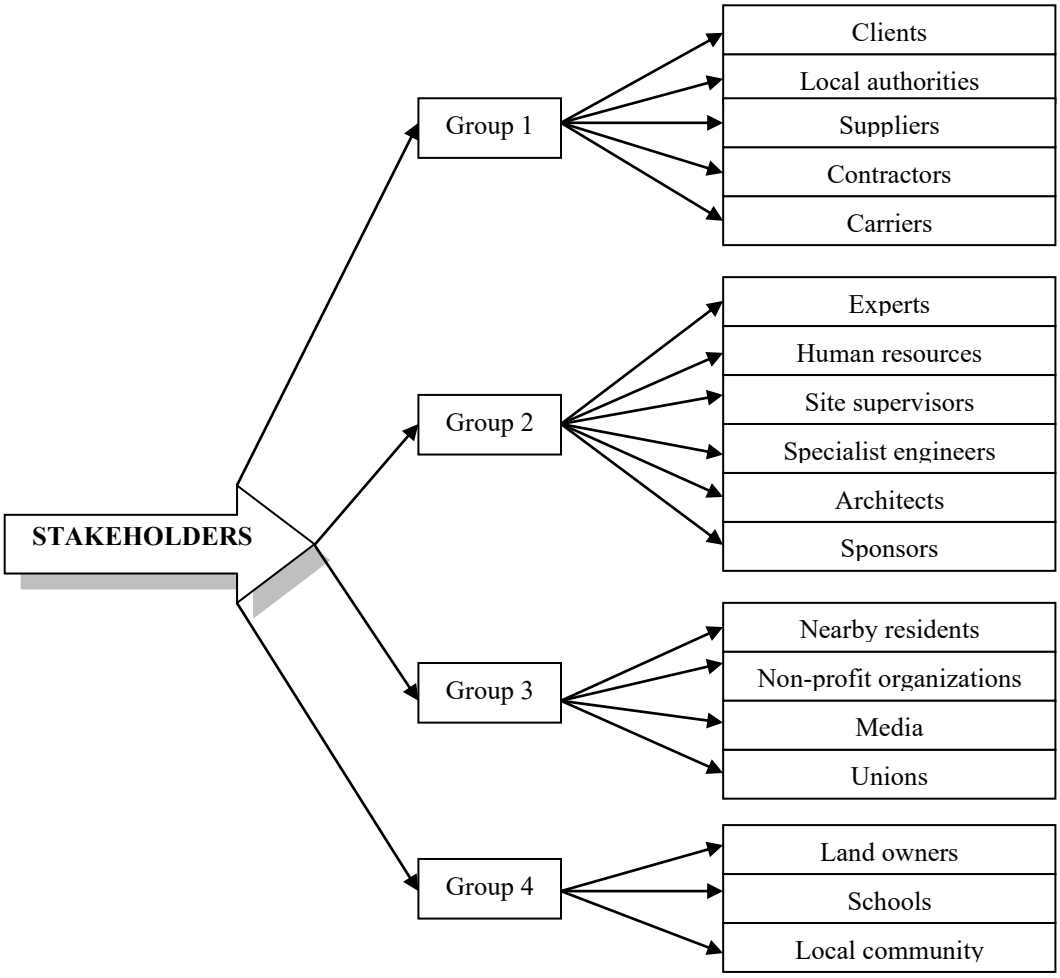
Stakeholders insure the inputs (resources) and outputs (products and services), as well as the feedback for the organization. Selling a construction project provides certain information on the

clients` demands and the market trends, and not just estimations, like when the project started. Based on the same logic, the inputs are evaluated more accurate after completing the project.



An organization which performs based on strategic planning has to develop a stakeholders` management, meaning an accurate analyze of the types and degree of importance (the degree in which they affect and are affected by a project), in order to quantify their level of involvement.

According to the impact of the stakeholders` influence on the construction project, they may be ranked by the following criteria:



a. By the level of involvement:
   a.1. Main stakeholders: are directly affected by the project`s achievement and implementation, both positively and negatively. They are the owners, investors, creditors, suppliers, clients, and the organization`s personnel. Basically, the company cannot operate without them, being totally dependent. The suppliers dictate the prices for materials or technologies, the creditors (individuals, investment funds or banks) provide financing in more profitable conditions, influencing the final cost of the project. The clients offer a price which they consider it`s fair based on the quality-price rate. The personnel rent their knowledge, abilities and competencies during their labor contract.
   a.2. Secondary stakeholders: are represented by individuals or companies which are indirect affected by the organization, only during the completion of the construction project. They are: local or governmental authorities, local communities, non-profit organizations, advertising and promotion companies, media, and others.
   a.3. Key stakeholders: may be main or secondary stakeholders, but only for a certain phase of the project and are strongly influencing its development.

b. By their importance, the stakeholders may be classified in four groups, beginning with the most important:
   b.1. Group 1:
      - Organization`s clients, which are the beneficiaries of the construction project. The construction company will be in connection with them during the project

development, because any malfunction which may occur may be more easily repaired. Moreover, they will have the possibility to choose some woodworks or plastering according to their tastes before the execution of the project, and receive advantages in time or money, because they won`t have to change them after moving into the building.

- Local authorities: they provide authorizations and endorsements for the legality of works. They may be: City Hall, Police, Fire Safety, Environmental Guard, Sanitary Division, Construction Inspectorate, and others.
- Suppliers of resources and utilities: they belong to the most important group because they have the power to impose the prices according to their number and negotiation power in the sector. The contracts signed with them will stipulate the price and the delivery time.
- Contractors: the construction works may be contracted by a general contractor, which may subcontract the works for which it doesn`t possess competencies or resources. All the changes that may occur during the execution of the construction works (cost, quality, timetable, transport) will affect the overall project.
- Carriers: wrong planning of the delivery of raw materials, semi-products, and prefabs or people and equipment may delay the execution of the works according to the plan and may lead to penalties.

b.2. Group 2:

- Human resources of the organization: they are an important group, because they are directly involved in the achievement of the construction project by their knowledge, competencies and abilities. In order to be performing, they will be planned, coordinated, evaluated and rewarded according to the achievements.
- Site supervisors: they represent the beneficiaries of the project and are responsible with the measurements and control during the development of the construction works in order to certify that they are performed according to the prescriptions.
- Architects, structural engineers and other specialists: they act not only in the designing phase, but are asked for expertise during all project development, for certifying the conformity of the works with the standards.
- Experts: for heavy buildings, or when there are special issues with no prescription in the project, they provide consultancy in their area of expertise.
- Sponsors: they are individuals or companies which contribute with resources (materials, human resources, money, technology, information) within the contract framework.

b.3. Group 3:

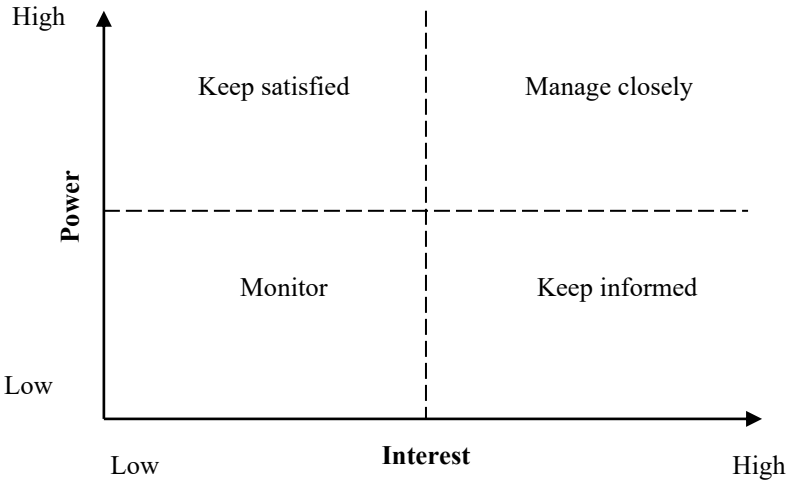
- Nearby residents: the site activity shouldn`t disturb individuals or organizations which live in the proximity, in terms of noise, pollution, dust, and others.
- Non-profit organizations: they are treated similar with the nearby residents.
- Advertising and media companies: are those which promote or inform the potential clients about the project. Both the beneficiaries and the contractors are interested in the project`s promotion, for a good image in medium and long term.
- Unions: in case of large companies, with strong unions, the relation with them should be a fair and friendly one, for avoiding strikes which may postpone the works and may lead to negative publicity.

b.4. Group 4:

- Land owners: the project`s management isn`t directly related to them, but the project may be in jeopardy if between the beneficiary and the land owner raise misunderstanding or mistrust.

- High schools, universities: even if they are not directly involved in the project, cooperating with them by site visits or presentations might be in benefit, because pupils or students may be the future clients, employees or partners.
- Local community: it`s not about those who stand in the proximity of the project, but about those who are informed via media about the quality of the works, the technologies used, or others.

Finding the project`s stakeholders is only one step in the analyze. The most important action is to prioritize their influence in the project`s development. Therefore, a grid has to be designed, according to their interest and power.



If the stakeholders have a low interest and low power in the project, it`s enough to monitor them, but no specific actions should be taken. If their interest is high but their power is low, the management should inform them on the objectives and the development of the project. If the stakeholders` interest is low and their power is high, they must be informed and consulted during the project`s development, in order to keep them satisfied. If their interest and power are high, they have to be involved in the project`s planning and progress because their influence is strong.

The key stakeholders may be involved in the project after evaluating their importance and by asking some questions:

?? What kind of influence, good or bad, do they have on the project`s achievement?

?? What is the company`s interest on involving them in the project?

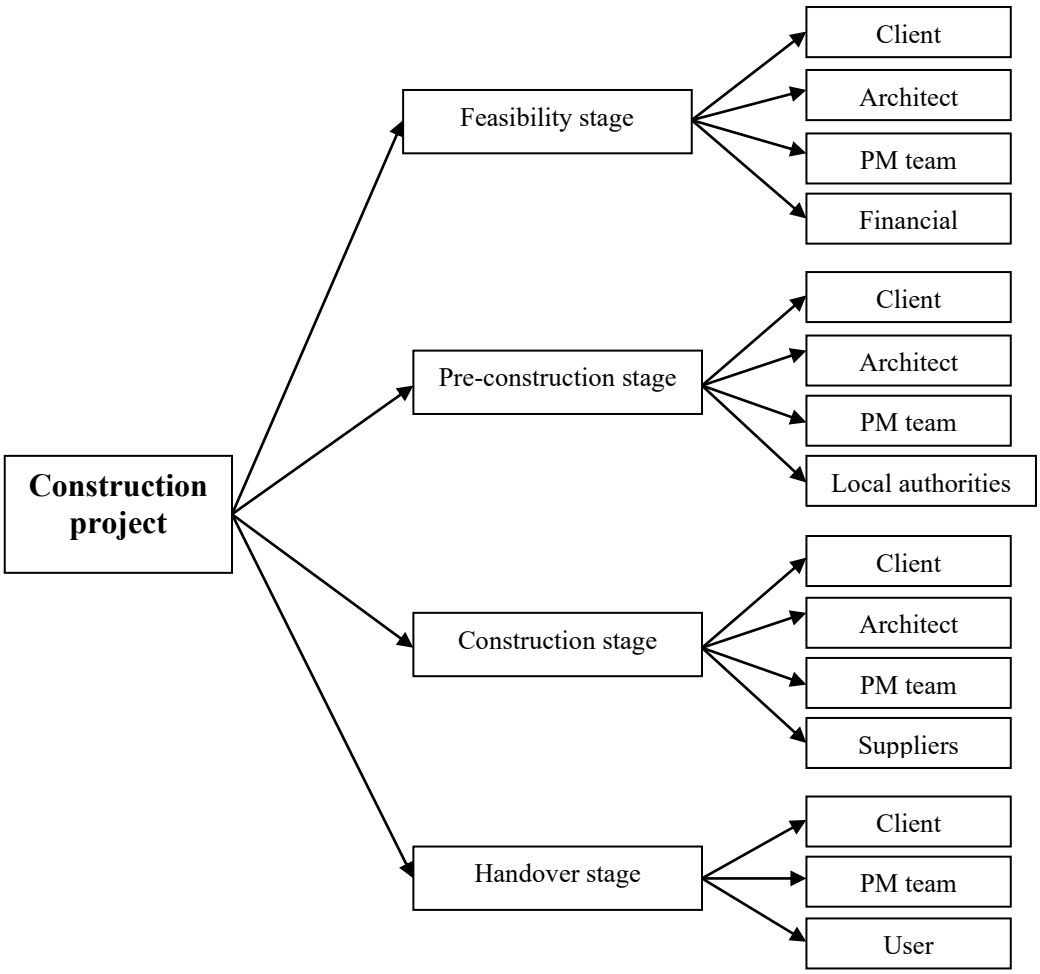
?? Which will be the communication channel with them and how often will they be consulted?

?? If they show hostility, how will this opposition be managed?

In construction projects there are some stages which involve the stakeholders:

- Feasibility stage: studies that prove that the project is viable in terms of deliverables and budget. They may be: risk studies, public consultation, geo-technical studies, environment impact assessment, health and safety studies, requirements and constrains, estimates of capital and operational costs (e.g. demolition costs), assessment of potential funding.
- Pre-construction stage: detailed design, preparation of tendering documents, tendering process. They may be: design management, tender action, pre-start meeting (with the contractors and consultants).
- Construction stage: the execution of the project.
- Handover stage: the completion of the project and the feedback.

For a construction project, the main stakeholders are :



- Client (customer): can be the project owner or the user of the project.
  The project owner is the person or company which provides resources and takes full authority of the project.
  The project user is the person or company which will use the project and will benefit of the project or the change brought by the project.
  Needs of the client:
  - Understanding and empathy;
  - Fairness;
  - Control;
  - Options and alternatives;
  - Information.

  Expectations of the client:
  - Completion on time;
  - Quality of work;
  - Respect of the budget;
  - Safety;
  - Flexibility.
- Project management team: are the project manager and the project consultants.
  The project manager is responsible for the project from planning to completing it.
  The project consultants are the professionals who advise the project manager according to their experience.
  Needs for project management team:
  - Co-operation: between all the project participants;

    - Reporting: all participants should report according to schedule (daily, weekly, etc.);
    - Control: the project management controls all the participants` activities based on budget, schedule and quality;
    - Communication: good communication flow between project manager, participants and client.

  Expectations of the project management team:
    - Safety: health and safety procedures;
    - Time: project delivered according to schedule;
    - Quality: quality of works;
    - Cost/payment: based on the contract.
- Project team members: design team, structure team and implementation team.
    - Design team: architect, designers and surveyors.

  Needs for the design team:
    - Client interpretation: based on the client`s needs;
    - Communication: with the project participants;
    - Budget: respecting the limits;
    - Reporting: the progress of works.

  Expectations of the design team:
    - Time: project development according to schedule;
    - Quality in design: quality delivered by all project participants;
    - Environment and safety: impact of the project on the environment.
- Structure (engineering) team: Civil, electrical and mechanical engineers.

  Needs for structure team:
    - Proper design: delivered by the designers;
    - Client`s objectives: understand the client`s requirements;
    - Communication: between participants;
- Implementation team: main contractor and subcontractors.

  Needs for implementation team:
    - Enough time for tender;
    - Project detail;
    - Trust;
    - Payment;
    - Communication.

  Expectations for implementation team:
    - Quality in supply;
    - Health and safety;
    - Time.

COURSE 4
TYPES OF CONTRACTS IN CONSTRUCTIONS

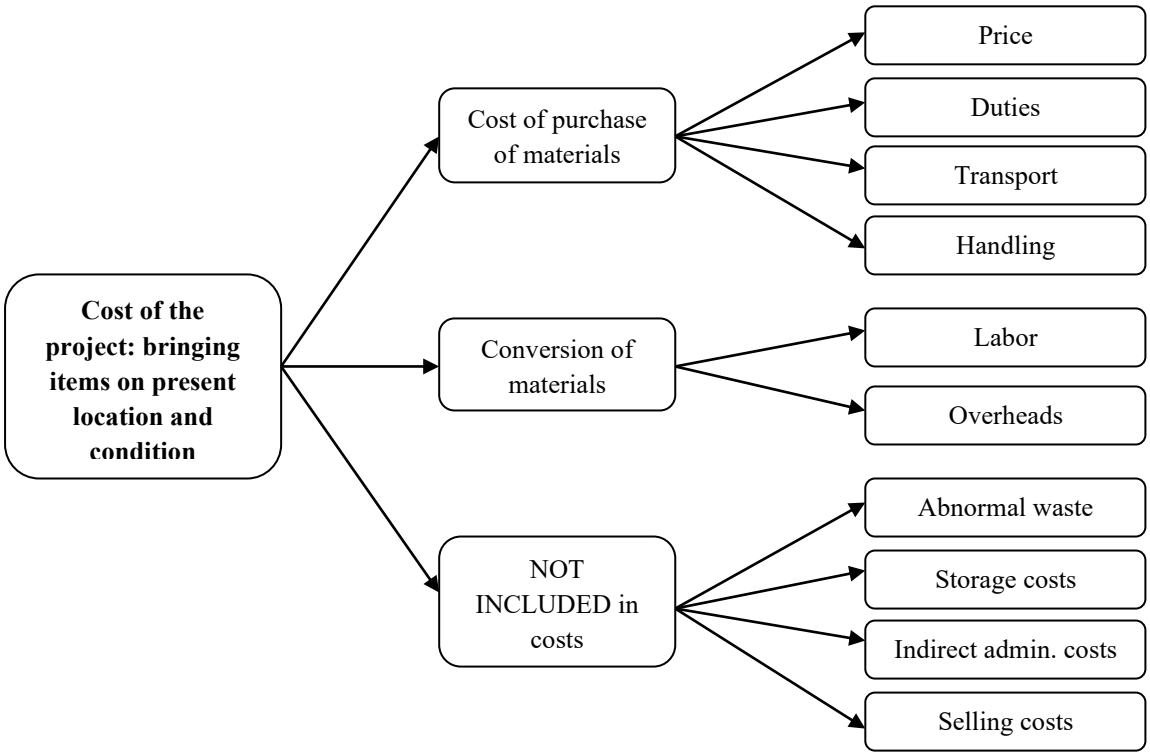
4.1. INTRODUCTION

A construction project is accomplished when an investor and a constructor sign an agreement. This deal works without problems till the project is developing according to plan. However, in complicated situation a legal base for discussion between the parties is mandatory.

[20]

Any construction project serves a beneficiary in some purposes: either the lowest bidding, the best value for the money invested, or the minimum risk involved. Therefore, there are a lot of strategies for achieving the project.

A simple definition: a contract is an agreement between parties which is enforced by law. All agreements are contracts if they are made by free consent of the parties, competent to contract, for a lawful consideration and with a lawful object. So, the contract is a legal document.



[20] https://www.haikudeck.com/ttulo-uncategorized-presentation-9ea19c23aa#slide12, accesat în data de 23.10.2024

Think about constructions like Wimbledon Stadium in UK or Opera House in Sidney. It took a lot of years to perform them and a lot of money involved. Therefore, the costs have to be based on estimates. The estimates should have three features:

- The estimates have to be fast to prepare: the offer for construction works might be asked in one or two days, so the estimator should have prices for parts of the buildings and just collide them according to the owners` demands.
- The estimates should be accurate: it should lead to profitability.
- The estimates should be easy to understand: they will be used by many members of the project team.

There is a major difference between the quantity takeoff and the estimate. The quantity takeoff is the process of measuring and quantifying every activity needed to deliver a project. Everything that has a cost has to be measured. The estimate is the process of costing all that has been quantified, including all the costs, like: fees and charges, materials and labor, overheads, contingency, and profit.

Costs we can bring to a constructions contract:

- Specific contract costs: site labor, material, depreciation of equipment, moving of plant, plant hire, design.
- General costs: insurance costs, overhead costs.
- Other costs under the contract terms.

Most of the contracts are between two parties: the owner and the contractor. Maybe the owner will sign with several contractors, so these too will be between two parties. But it often happens for the owner to ask a guaranty paper from the contractor`s bank, just to know that he has financing capacity to deliver the project, or to block money for non-performance works; in this case, the contract will have three parties.

All the contractors must know that they will have to fulfill three magic words: cost, quality and time.

There are some issues which will affect the quality of the contract and the trust between the client and the contractor if it`s a building or a rehabilitation project:

- The cost associated with all the works done must be very explicit.
- How the unknowns will be solved: after the project starts, there are lots of things which couldn’t be anticipated, and who will be responsible for them.

In the contract, parties make agreements concerning the duties of each other. Everything goes well as long as everybody respects the conditions. But when something goes wrong, and the parties fail on solving the problems, enforcement of law comes in the picture. And when problems occur, each party wants to pass the loss to the other. It`s not like a street fight, but it may come to it sometimes. It`s the time when law comes to solve the disagreement.

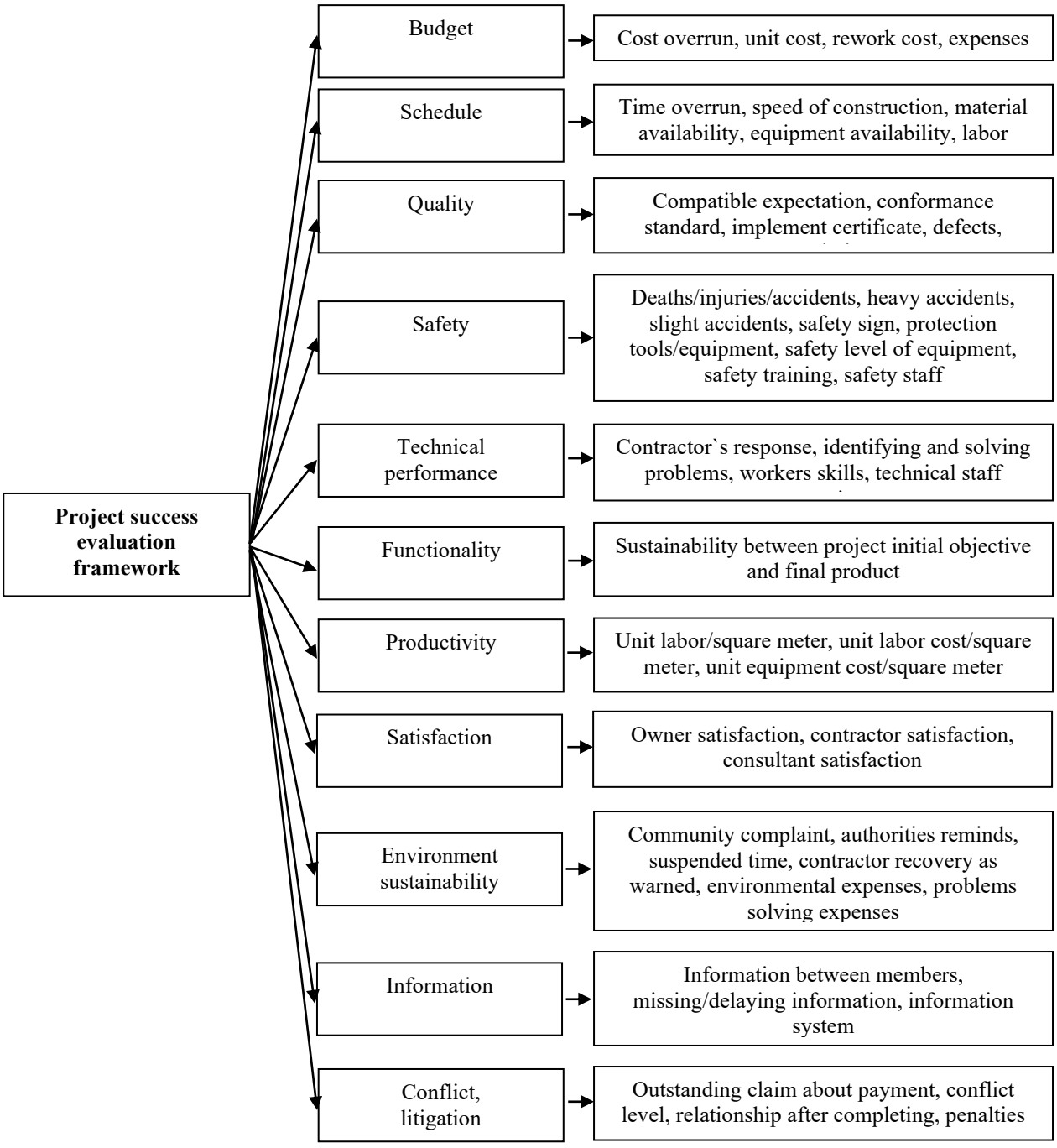
The construction contract is a legal act which stipulates, in a written form, the agreement between the contractor (investor, beneficiary) and the contractor (construction company, subcontractors, etc.).

There a lot of projects in civil engineering that require written agreements, framed into simple or complicated contracts:

- Whole building execution;
- Cleaning and maintenance;
- Renovation, repair and replacement;
- Internal furnishing and finishing;
- Rehabilitation;
- Demolition.

For projects with a minor complexity, the beneficiaries contact architects and construction engineers for design and execution, or they can realize the building by their own resources. However, for heavy buildings, specialists are required for each domain of expertise, meaning nuclear plants, airports, sport halls, stadiums, refineries, factories, and others.

The construction companies have to take a lot of circumstances in consideration when a possible contract of execution occurs. There are elements related to budget, schedule, quality of the works, safety of the personnel and community, the performance of the works, the functionality and productivity, and others.



In order to understand more clearly the power of a contract in construction, here is a simple example for realizing a dwelling[21],[13]:

CONSTRUCTION CONTRACT
NO. ……. / ……..

ART. 1. PARTIES OF THE CONTRACT

This agreement is made between S.C. …… with the headquarters in ……..., county ……, str. …….. no. …., registered in the Trade Registry by the no. ……, represented by ……., hereinafter called CONTRACTOR;
and
S.C. …… with the headquarters in ……..., county ……, str. …….. no. …., registered in the Trade Registry by the no. ……, represented by ……., hereinafter called OWNER.

ART. 2. OBJECT OF THE CONTRACT

The CONTRACTOR will provide for the OWNER a single-family dwelling located in ……., county ……, str. ……, no. ……, according to the Construction Authorization no. ……, and the project attached to the present contract, which is approved by the owner.

ART. 3. PRICE OF THE CONTRACT AND PROGRESS PAYMENTS

The price of the contract, paid by the owner, is …… lei (……. EURO) and will be paid in tranches, as follow:

- ….. % from the amount when the contract will be signed;
- ….. % from the amount at the completion of the substructure;
- ….. % from the amount at the completion of the superstructure;
- ….. % from the amount at the completion of the finishing;
- ….. % from the amount at the completion of the building;
- ….. % from the amount when the handover paper will be signed.

The price includes VTA. The payments will be made 5 days after the invoice is issued by the contractor.

The price agreed for the execution of the present contract at the date of its completion is fix and cannot be modified during its development, excepting the case when the owner choose a superior level of finishing or other features which are not included in the project. The change of the contract`s price will be expressed through an additional paper, with specifications on the extension of the term for the work completion, if necessary.

ART. 4. TERM OF COMPLETION

The term for the construction completion is of ….. months, from the date the present contract has been signed, according to the execution plan.

The delay of the completion of the works stipulated in the present contract entails penalties of ….. % per day, until the final handing over of the works.

ART. 5. THE COMMENCEMENT OF THE WORKS

The contractor will begin the execution of the work 15 days after the Construction Authorization is operational, but only after the payment of the first tranche, according to ART. 3.

[21] www.topfinante.ro/contract de antrepriza, retrieved 05.01.2017
[13] http://www.montrosecounty.net/DocumentCenter/Home/View/823, retrieved 15.05.2017

ART. 6. DOCUMENTS OF THE CONTRACT

The present contract will be developed based on the following documents which form an integral part of it:

- Zonal Urban Plan (PUZ);
- Project special provisions, if applicable;
- Blueprints provided by the owner;
- Addenda, if applicable;
- Change orders, if applicable;
- Modifications, if applicable;
- Written interpretation of the contract documents, if applicable;
- Technical Execution Plan;
- Construction Authorization no. ……. from ……..;
- Quality Plan;
- Site Location Plan;
- Architectural Plans;
- Resistance Drawings;
- Execution Chart;
- Payment bond, if applicable;
- Material bond, if applicable;
- Notice to proceed.

ART. 7. CONTRACTOR`S DUTIES

The contractor will procure the materials needed for the construction`s achievement and will execute the works according to the project approved by the owner (See Appendix 1 of the present contract). The contractor will repair the hidden defects according to the contract`s prescriptions.

The contractor shall supervise and manage the construction works. He will be solely responsible for all construction means, methods, techniques, sequences and procedures and for coordinating all portions of the works under the contract.

Unless otherwise specifically noticed, the contractor shall provide and pay for all labor, expertise, materials, freight/delivery equipment, tools, construction equipment and machinery, water, heat, utilities, transportation, and other facilities and services necessary for the proper execution and completion of the work.

The contractor shall always enforce strict discipline and good order among his employees and shall not employ on the work any unfit person or anyone not skilled in the task assigned to them.

The contractor warrants to the owner that all materials and equipment incorporated in the work will be new unless otherwise specified, and that all work will be of good quality, free from faults and defects and in conformance with the contract documents. All the works which will not be conformed to these standards may be considered defective.

The contractor shall pay all sales, consumer, use and other similar taxes required by law and shall secure all permits and licenses necessary for the execution of the work at the contractor`s expenses.

The contractor shall be responsible for the acts and omissions of all contractor`s employees and all the sub-contractors, their agents and employees and all other persons performing any of the work under a contract with the contractor.

The contractor always shall keep the premises free from accumulation of waste materials and debris caused by the contractor`s operations. This provision is imperative. At the completion of the work, the contractor shall leave the project`s site in a neat and orderly condition.

The contractor will turn the building to the owner at the prescribed term stipulated in ART. 4. from the present contract.

The contractor has the obligation to get all the authorizations needed for the execution of the present contract.

The contractor has the obligation to provide the guarantee for good execution of the works in the amount and conditions stipulated in ART. 10.

The contractor is responsible, in accordance with his obligations, for the hidden defects of the construction/facilities that occurred within 36 months of the reception of the works.

The contractor shall draw up and hand over to the owner, upon the completion of the works, the Technical Building Book, Chapter A and Chapter B (design and execution), in compliance with the provision of HG 273/2004 regarding the approval of the regulations for the reception of the construction and the installations.

ART. 8. OWNER`S DUTIES

The owner undertakes to pay the contractor the price stipulated in the contract, according to the prescriptions of ART. 3.

The owner is obliged to submit within 15 days from the date the contractor will announce the date for the reception of the construction`s completion and the handing over of the building.

The owner may establish, together with the contractor, any improvement works, only through an additional paper to the present contract.

The owner has the obligation to designate professional representatives (site supervisors) in order to follow the work execution, who within two days have the obligation to solve any problem at the contractor`s demand.

The owner will make periodic visits to the site to determine in general if the work is proceeding in accordance with the contract documents. Based on on-site observations, the owner representative will keep the owner informed of the progress of the work and will endeavor to guard the owner against defects and deficiencies in the work of the contractor. The owner representative will not be required to make exhaustive or continuous on-site inspections to check the quality or quantity of the work. He will not be responsible for construction means, methods, techniques, sequences or procedures, or for safety precautions and programs in connection with the work and will not be responsible for the contractor`s failure to carry out the works in accordance with the contract documents.

The owner shall provide labor and equipment to establish sewer, water, electric, and telephone lines as necessary.

ART. 9. PENALTIES FOR NON-FULFILLMENT OF THE OBLIGATIONS

The parties understand to fulfill all the obligations assumed through the present contract in good faith.

If, by its exclusive fault, the contractor don`t hand over the building to the owner within the term assumed in the present contract, the contractor will pay the owner penalties of …. % per day of delay, calculated at the value of the execution stage, which is not yet completed, till the date of fulfillment of the obligation.

If, for reasons attributable to it, the owner fails to pay, according to the assumed terms of the contract, the amounts stipulated in ART. 3., he shall be liable for late payment penalties of … % applied to the late paid amounts, calculated for each day of delay. The penalties will be charged until the date of full payment of the amount.

The penalties will be paid by the defaulting parties within 15 days of the date of fulfillment of the obligations for which they were calculated.

If the penalties will not be paid by the contractor within the specified period, the owner is entitled to use the banking guarantee letter of good execution of the project.

ART. 10. RECEPTION OF WORKS. CONTRACTOR`S GUARANTEES

In order to guarantee the entire and good faith fulfillment of the obligations stipulated in the present contract, the contractor will provide the owner a guarantee of good execution, expressed in Lei, representing 3% of the price, VTA excluded from calculus, to each invoice paid by the owner, both by deposits in a guarantee in a bank account, or by a banking guarantee letter. Within 90 days of each payment, the contractor will provide for the owner the proof of the provision of the guarantee.

The owner has the right to issue claims on the performance guarantee, to the extent of the damage caused, if the contractor does not execute, or inappropriately perform the obligations assumed by the contract.

The owner undertakes to return to the contractor the performance guarantee as follows:

- 70% of the guarantee account, based on the Handover Paper and the act which stipulates the corrections of the mentioned deficiencies, if necessary;
- 30% of the guarantee contract, at the end of the warranty period set out in the Final Reception Report.

The warranty period of the works is 36 months and starts with the reception date of the finishing of the works.

The contractor has the obligation to remedy the deficiencies or the hidden vices of the construction, found by the owner during the warranty period, within 30 days from the date of registration, but only if such hidden deficiency was discovered at the date the handover paper was signed.

ART. 11. REMOVAL OF THE CONTRACT

If the owner violates the obligations assumed under the contract, the contractor may request its removal, with the payment of penalties according to contract, after issuing a notice communicated to the owner with a grace period of minimum 15 days in fulfilling its duties after the notice. Same conditions apply when the contractor doesn`t respect its legal duties.

The termination of the contract will have effects only in the future and doesn`t affect the issues already accomplished by the parties until the date of termination.

The contract may be terminated in the situation when both of the parties agree on it, not just unilaterally.

ART. 12. DISPUTES

The disputes between the parties, meaning any misunderstanding or conflict which may occur in the course of or in connection to the fulfillment of the present contract, will be solved during its completion though direct negotiation. The disputes will be notified in writing. If, after 15 days from the start of these negotiations, the parties don`t reach consensus, the competent courts will solve the disputes accordingly.

Unregulated issues, or issues that may arise in the course of the contract, as well as the correct interpretation of some provisions, shall be settled in accordance with the Civil Code, the Civil Procedure Code and the Romanian Commercial Code, and with the special regulations regarding the civil and construction activities.

ART. 13. FINAL DISPOSALS

The contracting parties took note of the provisions of the Law no. 41/2005 on combating the tax evasion.

In the situation when the contractor will subcontract partially/totally the execution of the works that are parts of the present contract, its provisions shall be supplemented by the clauses of the respective subcontract. The completions thus made on the present contract will not lead to the increase of the price of the building, nor to the extension of the term of completion of the works and will not transfer to the subcontractor any of the contractor`s responsibilities or duties.

The law applicable to this document is the Romanian law. The disputes arising in connection with the conclusion, interpretation or execution of the present document will be settled by the Romanian courts of the common law.

The present contract settled in ….. specimens in Romanian, today, ……., of which ….. specimens for the contractor and ….. specimens for the owner.

The personal data of the owner will be stored and processed by the contractor S.C. ……., only for the purpose of running and completion of the building execution contract. Personal data will not be shared with the third parties.

The owner declares that he agrees to receive communication from the contractor S.C. …….. regarding the development of the building execution contract by any means of communication (email, post, fax, mobile, etc.).

OWNER	CONTRACTOR
S.C. ……	S.C. …….

Date

……..

In practice, the types of contracts between the parties may be infinite, but they can be framed in four categories: traditional contracts, cost plus contracts, management contracts, and other forms of contracts.

4.2. TRADITIONAL CONTRACTS

Traditional contracts are classic contracts agreed between the owner (beneficiary) of the building and the project`s contractor. The beneficiary may employ a project manager to represent his/her interests, in the agreed conditions, along the development of the contract.

For the designing phase, architects will be employed, and for the execution phase of the construction, the owner will approach contractors, sub-contractors, and supervisors for the project.

These contracts, suitable for residential buildings, are usually of small dimensions and low complexity, and they may be: lump sum contracts, quantity price contracts, and unit price contracts.

a. Lump Sum (Fixed price) contracts

This type of contract is recommended when the scope of the project is well defined beginning with the designing phase. The price of the project is fix; therefore, all the responsibility belongs to the contractor. The owner may pay incentives for early completion of the project, but as well receive penalties for late completion.

The architect or the design company provides blueprints for the beneficiary, and the building will be executed accordingly. They will also provide the task book (the document containing the conditions imposed by the owner for the construction achievement).

Based on those documents, the contractor (individual or organization) will develop the offer, in which he/she will estimate the total costs for the building completion.

The offer will represent the total price of the investment, which usually will be a fix one after the contract between the parties will be signed. The only entity which may change the price is the beneficiary, and just in case if, by mutual agreement with the entrepreneur, will ask for changes in the project`s structure.

The value of the contract may be divided into physical phases (milestones), for payment scheduling, in order to avoid financial bottlenecks.

The key components of the lump sum contracts are:

- Guaranteed price, schedule and performance.
- Price and schedule are risks assumed by Design Builder.
- Easy contract administration – no cost support need. He/she doesn`t have to go to the owner and show if, maybe, the price is lower, or bigger.
- Cost security for owner.
- All savings go to the Design Builder.

The client and the contractor will know from the beginning what will be the final value of the project, and it cannot be changed, unless some scenarios:

- There are industrial plants or debris on the land, and they must be removed.
- The client would have made changes to the project design, like moving some walls, or adding or removing doors and windows.

This agreement will put more pressure on the contractor. Therefore, when signing the contract, the parties will have advantages and disadvantages as well:

- Advantages:
  - Low risk of the owner;
  - Fixed construction cost;
  - Contractors try to complete the project faster.
- Disadvantages:
  - Changes are difficult to quantify;
  - The owner can reject change request;
  - The designs must be finished before starting the project.

b. Quantity price contracts

The project and the bill of quantities are the base for the calculation of the price of the building. In some situations, the beneficiary executes the construction by using its own resources but wants to contract some of its parts. Therefore, the owner`s request might be the price for the works quantities.

Hence, the entrepreneur will make an offer only for the part of the building which is the scope of the contract. Any change in the bill of quantities should be written in the additional paper of the initial contract. This action may occur when the quantity takeoff is incorrect, or if the owner has other demands concerning the materials or the technologies initially planned, or he/she wants other finishes, partitioning, etc.

c. Unit price contracts

When an investment is more complex, or when the beneficiary did not completely decide on the overall construction project, the project will be finalized during the works development.

In these conditions, the entrepreneur will receive the provisionally blueprint and an approximate bill of quantities. He/she will provide a unit price for the works only on these documents' basis.

An important issue is the fact that there are different unit prices per square meter for different buildings, even if the surface is identical. Think about two houses, one of 10x10 (100 m^2) and 40 m perimeter, and other of 20x5 (100 m^2) and 50 m perimeter. They will cost different, because of the number and size of the windows, the length of the gutter, the plastering, etc. However, the estimator may give unit prices for the columns, the beams or slabs, but certainly not for the whole building.

The invoices issued by the contractor for the works completed will include the value of the unit price applied to those measurements.

These types of contracts are suitable for public infrastructure projects (roads, highways, or railways) and not for building projects, because it`s hard to give a unit price for a square meter of construction, since only at the building completion the unit price will be accurate. Instead, it`s easy to pay a unit price for a completed kilometer of road.

For civil engineering projects, prices will be settled for certain chapters, such as: foundation, windows, partitioning, flooring, structures, then overhead costs will be added, and a price should be obtained.

- Advantages:
  - Contractor`s estimating risks are lower;
  - Allows the total price to be analyzed in detail;
  - Easier to identify problems that aren`t obvious at first sight.
- Disadvantages:
  - Contractors can twist the information;
  - Difficult progress payment;
  - Contractors can form a conspiring group and bid high for the project.

4.3. COST PLUS (COST REIMBURSABLE) CONTRACTS

This contract refers to the profit the contractor gets for completion of the project. It is based on a fee which the owner should pay to the entrepreneur for the activities set in the contract. Based on a mutual agreement with the owner, the contractor will pay all the costs related to the project`s resources needed for the building, and the owner will reimburse all the direct expenses, plus an amount of money for the contractor`s services.

The cost-plus contract is suitable when there are no certain data on the total cost of the project, or when the owner is not sure about the final design of the construction. It`s also suitable when the owner wishes to choose a contractor on qualification basis, and not on the lowest bidding.

Moreover, it`s recommended when risks may occur during the project`s execution: e.g. When a rehabilitation is required after huge damages (fire, earthquake, flood) and further works cannot be evaluated in advance.

The costs which will be subject of a cost reimbursable contract are:

- Direct costs: materials, human resources, equipment, suppliers, consultants, rented plant, sub-contractors;
- Overhead costs (indirect costs): usually are a percentage of the labor costs, and include insurances, office rental, blueprint multiplication, office utilities, manufacturing facilities, contractor`s plant;
- Fee: it`s a fix cost and usually is a percentage of the labor cost.

This type of contract has advantages, but also disadvantages as well during its development, such as:

- Advantages:
  - The contractor will be focused on quality, instead of quantity and price;
  - The contractor will not have interest in reducing the labor costs and qualification, which will lead to best performance;
  - All the expenses based on invoices will be paid;
  - The contractor`s risks are minimal.
- Disadvantages:
  - The final cost of the project is uncertain; therefore, the owner will know the price of the project only in the end;
  - Disputes may occur between the parties concerning the costs of the resources;
  - The project`s timetable may be changed during the project`s completion.

The mutual trust between the parties stands as base to the choice of the reimbursable cost contracts, which may have the following types: cost plus fee, cost plus percentage of costs, cost plus fixed fee, guaranteed maximum price (GMP), or target value.

a. Cost plus fee contract:
   The contractor will calculate the labor costs of the project and will agree with the owner on a fee as a percentage of these costs.
b. Cost plus percentage of costs contract:
   The contractor will evaluate all the project`s costs and will negotiate with the owner on a percentage of the overall costs.
c. Cost plus fixed fee contract:
   The direct and indirect costs are calculated, and a fixed fee is added to them.
d. Guaranteed maximum price (GMP) contract;
   It is also called construction manager – at risk – contract.
   The principle of this contract is that the owner will cover all the contractor`s expenses related to the project, plus a fixed fee (which is normally between 10% and 20%), and excluding the overrun costs, but not exceeding a maximum price. The owner has the right to check the books of the project at any moment he chooses, or make the project audit in each stage, for ensuring the validity of data provided by the contractor.
   The risks concerning this contract are charged to the contractor. Therefore, there are some methods to reduce the risks, like:
   - To calculate higher price for the building and ensure more profit, but keep in mind the risk of losing the contract in a bidding competition;
   - To transfer the risks to the sub-contractors, if they are in charge with specific construction works or consultancy;

- To perform an accurate estimation of the project, eliminating the further risks of miscalculation or overhead costs;
- To make an agreement with the owner about the shared profit if the project may be cheaper than the initial evaluation.

e. Target value contract:
This type of contract may be suitable in situations when the beneficiary hasn`t an overall image on the project and asks for changes during its completion. Therefore, the contractor`s fee is difficult to evaluate, so they may agree for the payment of a fix amount based on the initial estimation, and along the project`s development, it may be adjusted according to the construction`s real expenses.

4.4. OTHER FORMS OF CONTRACTS

The constructions have various features, depending on their purpose or the beneficiaries which decide to invest their money in this sector. Based on the diversity of the domain, there may be other forms of contracts:

a. Partnership
The beneficiary agrees on sharing the profit resulted after trading the building. The contractor will be selected after bidding or after negotiation, or when between the parties there is a business background. The offer will provide a financial evaluation of the project which will be detailed on expenses chapters. By analyzing the offer, the parties will agree on the profit rates participation according to the money invested by each entity.
The advantage of this type of agreement is that both the owner and the contractor, as partners, have mutual interests in managing the resources, which are also major sources of expenses.

b. Offer in two phases
In order to achieve complex projects, traditional contracts are not suitable because of their excessive specialization of the construction works. Therefore, choosing the entrepreneur and the agreement on the value of the contract will be performed in two phases.
During the first phase, the investor decides on a limited number of specialized companies, able to complete the project and to make an offer on the estimated price. After analyzing the offer, the beneficiary will choose the contractor, based on pre-established criteria, known by all the bidders.
The second phase, which is the decision upon the contractor, is the phase where the contractor cooperates with the designer for setting the optimum methods for achieving the construction project: choosing the materials, equipment, technologies, and sub-contractors, if necessary.
After all these elements are mutual agreed, the final price of the estimation is performed, which will be base for finalizing the contract between the parties.

c. Serial contracts
This variant is chosen when the beneficiary decides to realize more projects of the same type (e.g. sports halls, schools, shops in different locations).
The bidding procedures will establish a sole contractor to execute the similar projects, of course with special attention on inflation, if they are developed on a long timetable, or other elements which differ in terms of location (type of ground, closeness to the resources, climate factors, or others).

4.5. MANAGEMENT CONTRACTS

The market economy involves a harsh competition between the entities that wish to invest in a certain field of activity, even if they don`t possess the needed competencies for performing the projects.

Globalization is another challenge, because today the products and services are borderless. The presence of multi-national companies is common on each part of the globe. Moreover, it`s not unusual for companies with several areas of expertise to be important actors all over the world.

It`s obvious that these huge companies don`t have global expertise in all the activities of their portfolio, therefore they will approach specialists or consultants for the activities for which they don`t have competencies.

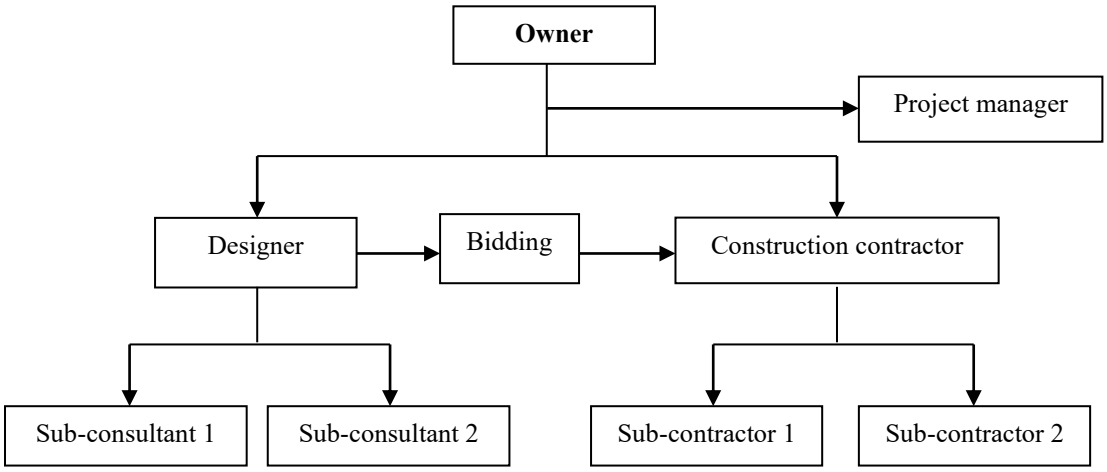
The construction projects, which involve complex aspects connected to their value, innovation concerning construction materials, equipment, machineries or site technologies, but also the degree in which the affect the environment, must be treated with special attention and concern.

Therefore, a successful construction project will be approached on an integrated management basis: beginning with pre-feasibility and feasibility studies, and continuing with issues related to quality management, risk management, conflict management, communication management, control, and others.

From this point of view, there are three types of contracts: design-bid-build contract, design-build contract, and construction manager at risk contracts.

a. Design – bid – build contract

It`s the most common type of contract (75% of the construction projects are of this category). This is a contract signed between three parties: the owner, the designer and the builder; it may have a project manager to keep the contract in its timetable and budget and to advise the owner in all aspects regarding the planning, organizing and control of the investment.



Initially, the contract is negotiated between the owner and the designer. The designer, maybe in cooperation with sub-consultants, will provide the blueprints of the building and the specifications, known as construction documents. Then the bidding takes place. The builders evaluate the documents and give prices for the foundations, structure, finishes, etc., and for the overall project. Based on the prices and the builders` competencies, the owner, maybe with the help of the project manager, will choose the general contractor for the project. If the general contractor doesn`t have the capability to complete the project, he will hire specialized sub-contractors.

If a project manager is part of the construction project, the designer and builder will be subordinated to him, and will not approach the owner.

Characteristics:

- Three linear phases: design, bid and contract;
- Three players: designer, builder, owner;
- Two contracts: Owner & designer; Owner & builder.

Responsibilities:

- Owner: program, finance, management;
- Designer: prepare plans and specs;
- Builder: prime and sub-construction.

The benefits of this type of contracts are:

- The owner is in full control of the project, from choosing the designs to bidding for the builder and the project completion;
- It`s the most widely used form of contracts because of the clearness of agreements and subordination between parties;
- It`s based on competitivity, as the builders make their offers using the same data, meaning the drawing and specifications;
- Very useful for iterative projects (e.g. schools, retail stores, food chains).

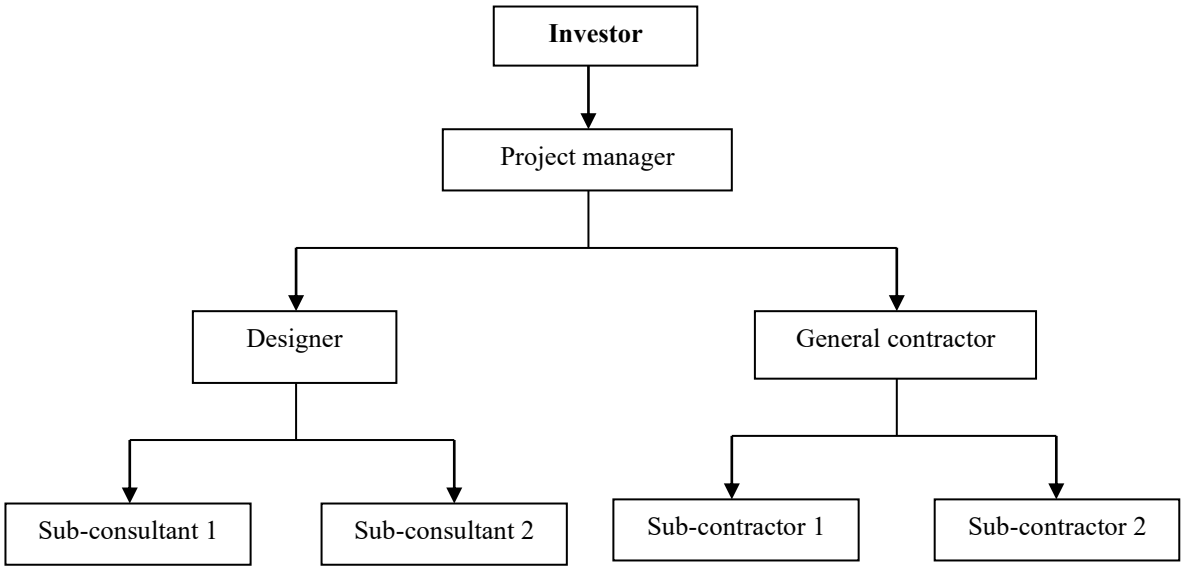
The drawbacks of this type of contracts are:

- Long schedules for the design to be completed and after which the builder may make an offer. As seen in the figure above, the builder doesn`t cooperate with the designer and cannot begin the construction, unless all the drawing is done;
- The builder should check the designers` calculations, because most of the time they differ from the site reality;
- The lack of cooperation between parties lead to hostility and even legal disputes which are time and money consuming and may jeopardize the project.

b. Design – build contract

When the completion of the projects requires many contractors, very difficult to manage in case of ample projects with important financial resources and time, the best option is the design – build contract.

The owner hires a project manager, who will be responsible with choosing the parties for the investment`s development.



Design Build Outline:

- In order to win a Design Build contract, the designer and the general contractor will have to go through an RFQ/RFP process: first the RFQ (Request for Qualification), in order to qualify the team of architects and constructors. The owner will approach maybe 15 companies on recommendation (with the help of consultants), he/she will check them all and select a short list of 3 which will have to state an RFP (Request for Proposal). They will have to come with a proposal and give it to the owner, to see if they can win it.
- Owner performance requirements: when the company will get the RFP, it will have criteria in it: bridging documents, prescriptive documents or a loose pack that gives a focus of what they are looking for: height of the building, number of students in a university, air conditioning capacity, number of rest rooms. But it`s not totally designed. This will be its job to design it and to submit.
- Best Value Method: they will take each company`s RFP and they will score it. Ex. from a total point of 50: mechanical design 8, electrical 7, etc. This is the technical score. They will take this score (maybe 44 out of 50), they will divide the money offer to the company`s score and that will be the final score. In the competition with two other companies, which gets the higher score wins.
- Technical Sheet: no name of the company on it, equal opportunity for each company.

Technical Proposal Scoring	
The Technical Proposal will be scored as follows:	
DESCRIPTION	**AVAILABLE**
Executive summary	0
Foundations	15
Superstructure	20
Roofing	5
Insulation	5
Finishing	10
Project Functionality and Added Value: innovation, creativity, passion	15
Schedule	5
Deviation from RFP	0
Oral presentation	5
SUBTOTAL	80
Best and final offer (if necessary)	20
TOTAL	**100**

- Asking questions;
- Role playing: the owner will join everybody in the room for discussions (mechanical, electrical, dry wall) because the companies want to provide the best innovative solution to the owner, and in the end the project will get the integrated best value design.
- Download and sharing;
- Research the owner: how they think.
  Characteristics:
  - Integrated process design construction overlaps;
  - Fast track: you don`t have to have all drawings and details from the beginning, you may start foundations for example, because they know you will have everything when the phase of the construction occurs;
  - Entity can take on many forms;

- Two players, 1 contract.

Responsibilities:

- Owner: program, performance requirements, financing;
- Design-builder: design construction. It may include programming and post construction.

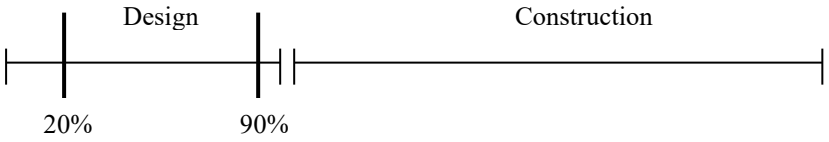
It takes a lot of time selecting the design-build contractor; most of the time is based on recommendation, history and performance. It`s different from the bid contract, because there you will know who`s the cheapest.

The good thing from the owner`s point of view is that the contractor has full responsibility in performing the project, he/she has no one to lean on and say he couldn`t do it because of other entities.

The main figure in this contract is the design builder. He is seen like a Master Builder. Let`s think of Leonardo da Vinci who was one of them. He did the drawings, he built itself (Sistine Chapel).

Principles of the design build contract: This will start with the vision of the client. This will be the concept of the project. It will be split in two parts: the budget part and the design part. Then it comes the documentation phase (structure, design) which is the architect`s responsibility. After that comes the execution of the project, the constructor`s responsibility.

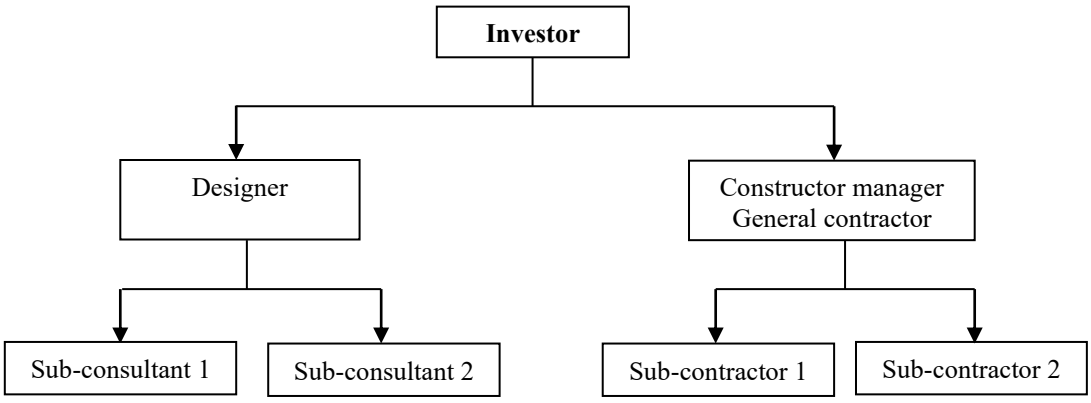
Most of the owners agree on bridging documents from architects: if they will ask for the bridging documents after 20% of their completion, 80% will be perfect for negotiation between the constructor and the architect on perfect solutions. But when the owner asks for bridging documents after 90% of completing the design, it will be no time for innovation.



All owner wants, the owner gets: removing a wall, a door or a window, even the bathroom. The contractor will have a transparent profit of, let`s say, 10%, so if this change will cost for example 50.000 $, the real cost for the owner will be 55.000 $.

c. Construction manager at risk contracts

It`s another way to approach a contract between the investor and the parties involved.



Basically, it`s similar with the design – bidding – build contract, but the difference is that the contract might start early, because the general contractor might start the execution of the project when the drawings are not completely done.

The general contractor will give support in the early stages of the project, by helping the designer with technical solutions. The owner feels that he has control on the project, because he gets feedback from the general contractor, who acts also as a consultant.

The constructor manager may also give consultancy on costs, because he may analyze the alternative provided by the designer, and from his experience, he may think of a cheaper solution to a problem. He can also come with innovation and creativity, which gives extra value to the construction project.

Characteristics:

- 3 linear phases: design, bid, build;
- 3 players: owner, designer, constructor manager;
- 2 contracts: owner – designer; owner – constructor manager.

Responsibilities:

- Owner: program, financing;
- Designer: all normal services;
- Constructor manager: preconstruction and project management, design coordination, subprime.

4.6. THE BIDDING PROCESS

The bidding is based on the project estimation. Therefore, the estimator should carefully study the drawings which show the design, the location, the dimensions of the construction and some details.

This is a very important process because the estimation is based on the Project Manual (Caiet de sarcini) which has the needed information for bidding and delivering the process with specific materials, technologies, and others.

The drawings and the Project Manual will be basis for the contract between the parties involved. Any error in the estimation will represent extra costs for the contractor. The estimation is also important for controlling the execution of the project in specific conditions of time and costs.

Based on the quantity takeoff, the estimation will provide the costs for the constrution and the time schedule for performing it. A sample of costs for a small dwelling can be seen below:

Type of Cost	Amount (Euro)
Permits	4.500
Site organization	2.500
Sewer and water system	9.000
Sidewalks and garrage (2)	12.000
Foundations	45.500
Frame	86.600
Exterior and interior brick walls	48.400
Insulation	12.000
Drywalls	23.000
Roofing	17.200
Windows	24.000
Doors	25.500
Floor coverings	28.000
Cladding	16.000
Painting	18.000
Plumbing	24.000
HVAC	21.000
Electrical	17.000
Landscaping	6.000
TOTAL	**440.200**

The costs in a project contain two items:

- Direct costs: all expenses related to the physical part of the project. They may be materials, labor, equipment, or any other subcontracted items (transport, cleaning, prefabs, and others).
- Indirect costs : are the costs that support the construction activity. They can be: office, vehicle, insurance, overhead, supervision.

The tender is a written offer to execute specified work within a certain time under certain conditions of contract between the contractor and the client for a certain amount of money.

The client and the contractor are bind together through a contract. The contractor agrees to deliver services to the client (owner of the investment), and the client agrees to pay the contractor for the works done in the conditions stipulated. So the tender is not a contract, but a paper submitted by the client to let the contractors bid for the works in certain conditions.

The notice inviting tender (NIT) shows the intention of the client to go public. It`s a public document announcing the project and inviting the interested parties to bid. All the quantities of work, as well as the technologies, have to be stated. In this phase, the costs are not pre-estimated, but calculated in detail.

Intra in contul tău INFO CENTRUM pentru informatii privind procedura (Despre organizator, Cum sa aplici, Acces la caiet de sarcini)

Descriere contract licitatie SEAP
"READILITARE, EXTINDERE, MODERNIZARE, ECHIPARE STRUCTURĂ EDUCAŢIONALĂ – GRDADINIŢA CU PROGRAM PRELUNGIT NR. 3 - ŞIMLEU SILVANIEI, JUDEŢUL SĂLAJ"
Data publicarii: 2019-11-28 | **Data licitatiei**: 2019.12.16 | **Tip contract**: Lucrari

II.1) Obiectul achizitiei

II.1.1) Titlu

"READILITARE, EXTINDERE, MODERNIZARE, ECHIPARE STRUCTURĂ EDUCAŢIONALĂ – GRDADINIŢA CU PROGRAM PRELUNGIT NR. 3 - ŞIMLEU SILVANIEI, JUDEŢUL SĂLAJ"

II.1.2) Cod CPV principal

45000000-7 Lucrari de constructii (Rev 2)

II.1.3) Tipul contractului

Lucrari / proiectare si executare

II.1.4) Descriere succinta

- Obiectul contractului care se va încheia presupune realizarea lucrarilor de interventie in vederea reabilitarii, extinderii, modernizarii, echiparii structurii educationale Gradinita de copii cu program prelungit nr. 3 Simleu Silvaniei in conformitate cu DALI NR PROIECT 53/2015. Numar de zile pana la care se pot solicita clarificari inainte de data limita de depunere a ofertelor/candidaturilor: cu 10 zile inainte de data limita depunerii ofertelor. Termenul-limita in care autoritatea contractanta va raspunde in mod clar si complet tuturor solicitarilor de clarificare/informatiilor suplimentare este cu 6 zile inainte de data limita depunerii ofertelor. La nivelul Devizului general au fost estimate cheltuieli diverse si neprevazute in suma de 398.371,85 lei fara TVA. Sumele aferente acestor cheltuieli nu sunt incluse in valoarea estimata a contractului.

II.1.5) Valoarea totala estimata

Valoarea totala estimata: 3.012.107,78 Moneda RON

II.1.6) Informatii privind loturile

Contractul este impartit in loturi: NU

Sursa: SEAP (www.e-licitatie.ro)

The general content of a NIT:

- The name of the client inviting tender;
- Pre-qualifications (if any);
- Nature of work;
- Estimated cost;
- Time of completion;
- Conditions of the contract: general and specific conditions;

- Details of the Ernest Money Deposit (EMD): while submitting the tender, the contractor may have to deposit some money (about 2% of the estimated cost), as a guarantee of the earnestness of the bid, for preventing an unfair bid. The money will be forfeited by the client if the contractor wants to withdraw of the bid after the opening. This is a penalty, because the client had costs for preparing the bid.
- Details of the Security Deposit (SD) and performance guarantee: SD is deducted from the payments, to use them in case of repairs during the defect liability period. After that period, if no defects arise, the client will refund the money to the contractor.
- Last date of submission;
- Date, time, and place of the tender opening.

The nature of work, the estimated cost and the time of completion are the main reasons for the bidder to decide if the contract can be achieved. For example, big contractors may refuse small contracts, or small contractors may not have the capacity to fulfill big contracts.

After the bidding process is finished, the client will give a Letter of Intent (LOI) to the bidder to announce the winner and ask him to sign the contract. He invites the bidder to make a performance guarantee deposit (about 5% of the awarded value). There may be a difference between the estimated and the awarded value, because the bidders may have complains concerning the documents (quantities, prices, or technologies) and they may clarify them in a given time. All these aspects may modify the estimation. The mobilization and the starting time of the works are also part of the LOI.

The evaluation of the bids:

- The bids may be evaluated on the lowest cost alone;
- The technical competence, reputation, or recommendation may be part of the evaluation process. In this case, the bidder has to submit documents.
- The bids may contain two parts: technical and financial bids, which are opened separately. First, the technical requirements are analyzed, then the financial envelope is opened for the bidders who were technically qualified.

EXAMPLE:

Consider a project estimated to 1.000.000 Euro, with 4 bidders:

No.	Bidder	Financial Bid
1	A	950.000
2	B	870.000
3	C	640.000
4	D	760.000

a. If the evaluation is based on the lowest price, the winner is obvious Bidder C.
b. If the evaluation considers both the technical and financial requirements, the table will be as follows:

No.	Bidder	Technical Bid Score	Financial Bid
1	A	80	1.110.000
2	B	75	980.000
3	C	45	850.000
4	D	60	1.000.000

The technical score was calculated on a scale from 1 to 100, based on criteria.
For the evaluation, the client may set some criteria:
   - The technical score should be bigger than 50. In this case, Bidder C is out of the bid.
   - Only for qualified bidders based on technical score, the cost should be the only criteria of selection. In this case, Bidder B is the winner.

c. If both the criteria are important, weight should be given. Technical score have to be more than 50, and the winning bid will be calculated as a composite score (50% for technical and 50% for financial).

The financial bid have to be transformed in scores. The lowest bid can be scored 100, and the others proportionally.

No.	Bidder	Technical Bid Score	Financial Bid	Marks awarded to cost
1	A	80	1.100.000	87.76
2	B	75	980.000	100
3	C	45	850.000	-
4	D	60	1.000.000	97.96

Bidder C is rejected.
Bidder B is rewarded 100.

Bidder A is rewarded: $100 - \frac{110-98}{98} \times 100 = 87.76$

Bidder D is rewarded: $100 - \frac{100-98}{98} \times 100 = 97.96$

Then the composite score is calculated: 50% for technical, 50% for financial.

No.	Bidder	Technical Bid Score	Marks awarded to cost	Composite score
1	A	80	87.76	83.88
2	B	75	100	87.50
4	D	60	97.96	78.98

Bidder A: 80 x 50% + 87.76 x 50% = 83.88
Bidder B: 75 x 50% + 100 x 50% = 87.50
Bidder D: 60 x 50% + 97.96 x 50% = 78.98
The winner is Bidder B.

If both the criteria are important, weight should be given. Technical score have to be more than 50, and the winning bid will be calculated as a composite score (80% for technical and 20% for financial).
The financial bid have to be transformed in scores. The lowest bid can be scored 100, and the others proportionally.

No.	Bidder	Technical Bid Score	Financial Bid	Marks awarded to cost
1	A	80	1.100.000	87.76
2	B	75	980.000	100
3	C	45	850.000	-
4	D	60	1.000.000	97.96

Bidder C is rejected.
Bidder B is rewarded 100.

Bidder A is rewarded: $100 - \frac{110-98}{98} \times 100 = 87.76$

Bidder D is rewarded: $100 - \frac{100-98}{98} \times 100 = 97.96$

Then the composite score is calculated: 50% for technical, 50% for financial.

No.	Bidder	Technical Bid Score	Marks awarded to cost	Composite score
1	A	80	87.76	81.55
2	B	75	100	80.00
4	D	60	97.96	67.59

Bidder A: 80 x 80% + 87.76 x 20% = 81.55
Bidder B: 75 x 80% + 100 x 20% = 80.00
Bidder D: 60 x 80% + 97.96 x 20% = 67.59
The winner is Bidder A.

COURSE 5
ORGANIZATIONAL CHARTS

5.1. INTRODUCTION

Any project, no matter of its scope, is put into practice by a team with strong established responsibilities. A successful project targets many aspects, such as budget, duration, quality and many others.

All the elements that define a project gravitate around people, organized in such a way to accomplish the proposed objectives. Therefore, putting them in a certain hierarchical position, giving them tasks and responsibilities, and monitoring and controlling them, rely on choosing the right people for the right jobs.

Definition: "The organizational structure of a company is the ranking of the personnel, represented by authority levels, communication flow, and rights and duties of its members[22]".

So, the main idea of the structural organization is the departmentalization, meaning grouping the people together into logical units in order to determine who does what and to whom they will respond. The designing of the organizational structure depends on the strategy implemented by the company`s management, the objectives and the adopted tactics.

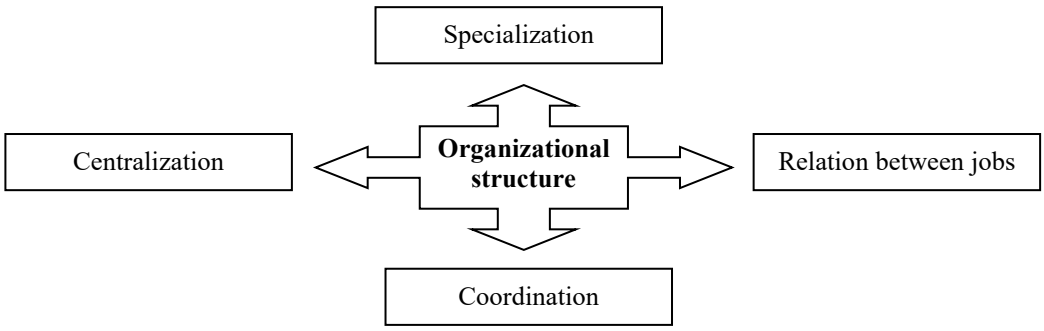
The organizational structure is changing according to the company`s evolution and development in time and space. For example, when a firm is born, usually, the owner is the person who establishes the strategy, but also the one who works effectively for achieving the products/services. The personnel are reduced in number and has multiple responsibilities, and the jobs aren`t well defined. The organizational chart is flat, and the communication is direct and informal.

If the organization will plan its development strategies, maybe through differentiation, the organizational structure will change: it will be taller, with more levels, departments will be designed for important functions or more departments will form groups in order to ensure the control.

Changes may occur in the job designing as well: depending on resources available for the company, the jobs will become more specialized, and the personnel will be selected according to the competencies required by the job analysis.

The communication in such a structure is very formalized, both horizontal and vertical. Information goes with rather small speed, and the same is the feedback. The politics and procedures are rigid and become part of the organizational culture.

In order to design the organizational structure, there are four principles that may be considered:



a. Specialization: is the breaking of the job tasks into specialized component parts, for which competent individuals are needed, in order to generate efficiency and effectiveness in achieving the objectives set by the strategy;

[13] www.businessdictionary.com/definition/organizational-structure.html, accesat în data de 20.12.2012

b. Coordination: is the process by which the departments, as separate units, are managed in such a way that the organization will be able to act as a whole. The methods suitable for coordination are hierarchy and authority. In fact, the number and the type of the departments depend on the decision made by the company`s management on the method of coordination.

c. Centralization: refers to the level where the decisions are made on long, medium, or short term. A centralized-based organization is focused on the power pole in the top, and the inferior levels (no matter if they are middle or operational levels), are fulfilling the tasks. Participative management is almost inexistent. A non-centralized organization is less bureaucratic and formalized, and the tasks and responsibilities may be delegated to departments through competent employees.

d. Relation between jobs: consider the subordinate relationships between superiors and subordinates (vertically) and cooperation between departments (horizontally). Moreover, there is a difference between the operational jobs (productive) and the supporting ones, which help the operational personnel in carrying out their tasks.

The organizational charts are of many types, as shown below. Each company has its own characteristics, so there are some steps in choosing the best organizational chart for a certain firm or project:

- Defining the overall scope and objectives of the company;
- Developing a WBS (Work Breakdown Structure) for the activities associated to each objective, and identifying the departments involved in the activity;
- The WBS is divided into work packages;
- The work packages will be analyzed to find what competencies are required to achieve them;
- A multi-criterion analyze will be developed to find which of the organizational structures will fit best.

When designing an organizational chart, there are some key jobs that should exist, based on the company`s domain of activity. For a construction firm, the main managers that will lead the departments, are as follows:

- The Supplying (Purchasing) Manager: is responsible for the supplying of materials and supplies needed for projects and daily consumption. The purchase will be done only after comparing more variants according to price, quality, terms of delivery, etc.
- The Engineer (Production) Manager: is responsible for the planning of the construction project.
- The Financial Manager: is responsible for the cash-flow of the company and for finding sources to develop the projects: money for materials, salaries, equipment, headquarter expenses. The offices subordinated to the Financial Department may be: Finance, Accountancy, and Administrative.
- The Marketing Manager: is responsible for the market research, marketing strategies, sales, advertising, promotion, pricing, and product development.
- The Project Office Manager: is responsible for the overall scheduling and managing the projects. In cooperation with each project manager, he/she will allocate resources based on schedule and decide the priorities, if more projects are running, and the resources are scarce. They have to make everything possible to complete the projects in the conditions imposed by the contract.
- The Research Development Manager: is responsible for finding new materials, new technologies, or new products.
- The Human Resources Manager: is responsible for staff recruiting and training, record keeping, compensation and benefits, insurance, and employee relations.

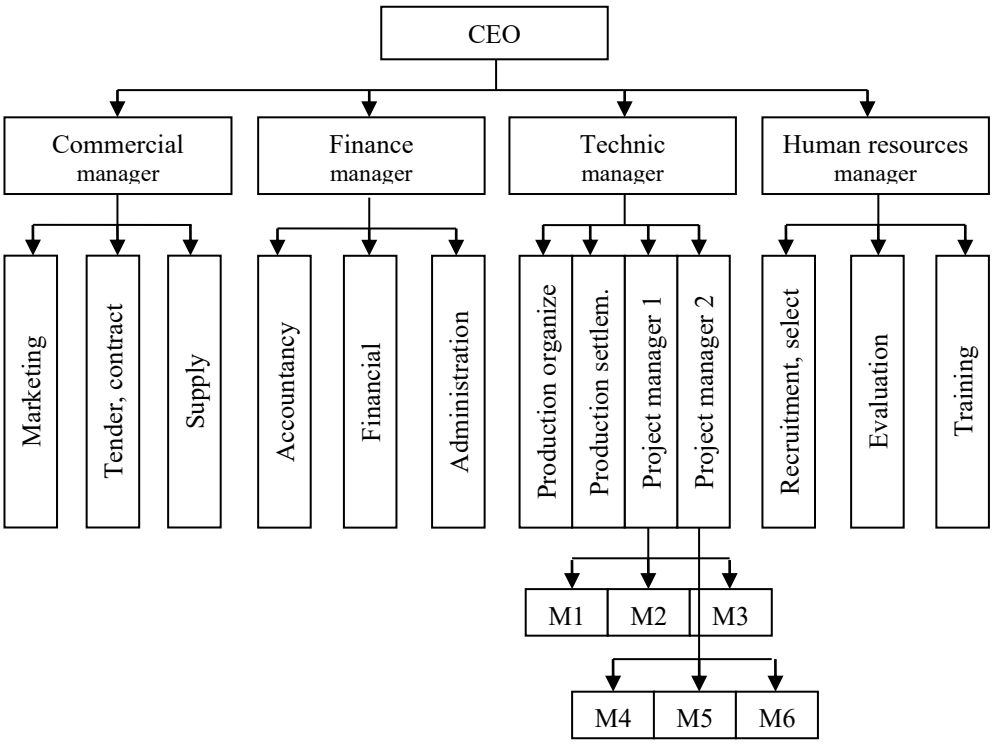
5.2. FUNCTIONAL (HIERARCHICAL) ORGANIZATIONAL CHART

This organizational structure is suitable for large companies, with many hierarchical levels and strong specialization of the departments and employees. Each team member is placed according to competencies (expertise) and is integrated into a team with similar activities or job tasks.

Strategically planning, as well as control, are ensured by the CEO (Chief Executive Officer), who distributes or delegates tasks and responsibilities to the deputy managers, assimilated to top management of the organization. They, in turn, lead the department managers (assimilated to middle management), which may be divided into offices. The middle managers lead the next level, which is the operational (or line) management, which is in direct relationship with the productive (operational) employees.

The number of levels differ based on the organization`s area of activity, the degree of specialization, the company`s size, or the existence of participative management.

There is no template in representing this type of organizational structure. Here is an example of a private company, with only few functions and hierarchies:



As suggested by the name, the organization designs its hierarchical levels by its functions: production, trade, research and development, financial, accountancy, or human resources. The level of responsibility and authority is based on the distance from the top management.

The functional structure has pros and cons as well:

a. Advantages:

- Insures the usage of features (computers, soft, database, etc.) by all the company`s departments;
- Specialized employees may provide support and expertise for all the activities;
- The members belonging to the same department may improve their competencies by sharing knowledge and learning from each other;
- The company has an overall vision upon all the present projects and may develop long term strategies by using the maximum of the employees` competencies;

- The company may design a career development plan for the personnel, or training programs for applying new technologies, or, maybe, thinking of new businesses in its portfolio;
- The organization may set standard procedures for all departments, so that the company may perform as a whole, based on synergy.

b. Disadvantages:

- The hierarchical pyramid has more levels, which obstructs an efficient vertically communication;
- The overall view on the company minimize the attention on a specific project, situation in which there is less interest in resources allocation, evaluation process, monitoring or control;
- The functional chart is not centered on the client`s demands. The department`s members are focused only in fulfilling their jobs;
- Non-loyal competition may occur in resource allocation, when more projects are being developed in the same period;
- The project-based teams aren`t aware of the management`s priorities, so when the resources are short, it`s a source of conflict;
- The decision-making process is slow, because of the communication between the levels of authority;
- The appraisal of the personnel which is involved in more projects at the same time is often difficult.

5.3. DIVISIONAL ORGANIZATIONAL STRUCTURE

When a company performs on several areas of activity, or in more geographical regions, it`s recommended that each division should have its own organizational structure.

Let`s think about General Electric, a corporative company in USA, which has in its portfolio more than150 areas of activity and has subsidiaries in more than 100 countries. It is specialized in energy distribution (solar and nuclear), manufacture of industrial and medical equipment, car and steam engines, aircraft engines, aviation services, and others. Moreover, it has businesses in investment and capital funds. General Electric`s high performances are widely recognized, because for more than 60 years it is among the 10 companies in the world in their specific sectors of activity.

It`s obvious that such a multi-national company is organized in a specific way for having an effective management. The control cannot be globalized, because of the diversity of domains and the geographical spreading. Usually, the company`s location is decided by the clients` locations, in order to adapt to the consumer's preferences. Therefore, for each field of activity there will be a department structure, which may be extended even on continents, countries, or regions.

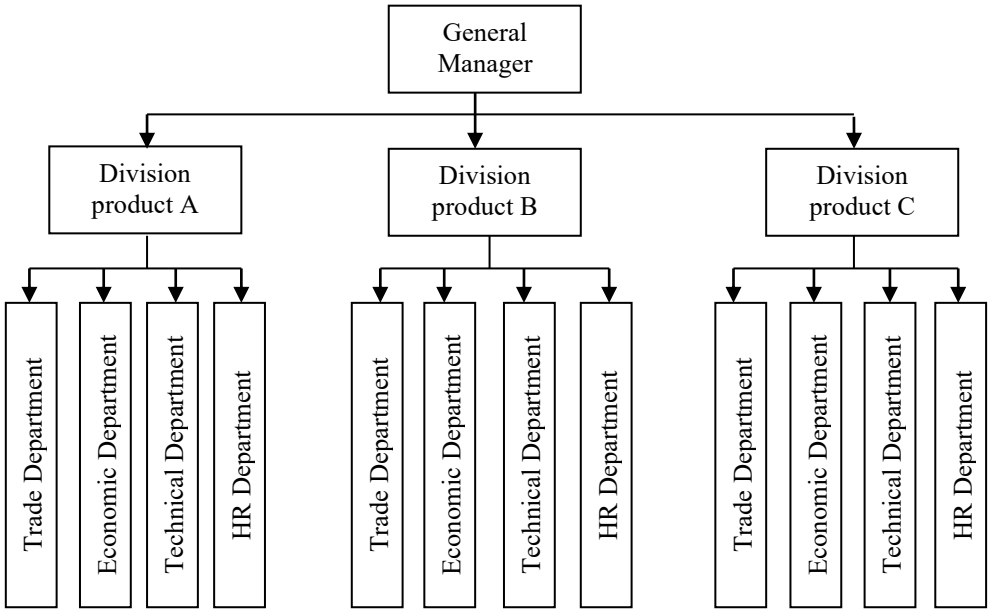
The divisional structure may be developed based on several criteria:

a. By product: the company has several types of products in its portfolio, which deserve various raw materials, prefabs, technologies, and human resources. In this case, the divisions will be the products, and the departments will be designed for each of the specific products (E.g. Apple, Pepsi Co, Procter&Gamble). The companies which are using this form of organizations are focused on the performance of the business unit, and not the overall success of the firm;

b. By market: if the markets that trade the products/services differ, even if they are located in the same country or region, the organizational structure should be split into divisions, which will represent the market segments;

c. By geographical zones: it`s the case of multi-national corporations, which deliver products and services in several countries, therefore they should design the structural organization accordingly.

This is an example of divisional chart:



This type of structural organization has pros and cons as well:

Pros:

- The divisions work best in an unstable environment;
- The divisions work as individual companies and are self-managing their resources;
- The divisions have specialization in a certain product; therefore, they may develop superior competencies;
- The divisions know very well the specificity of the market in which they perform.

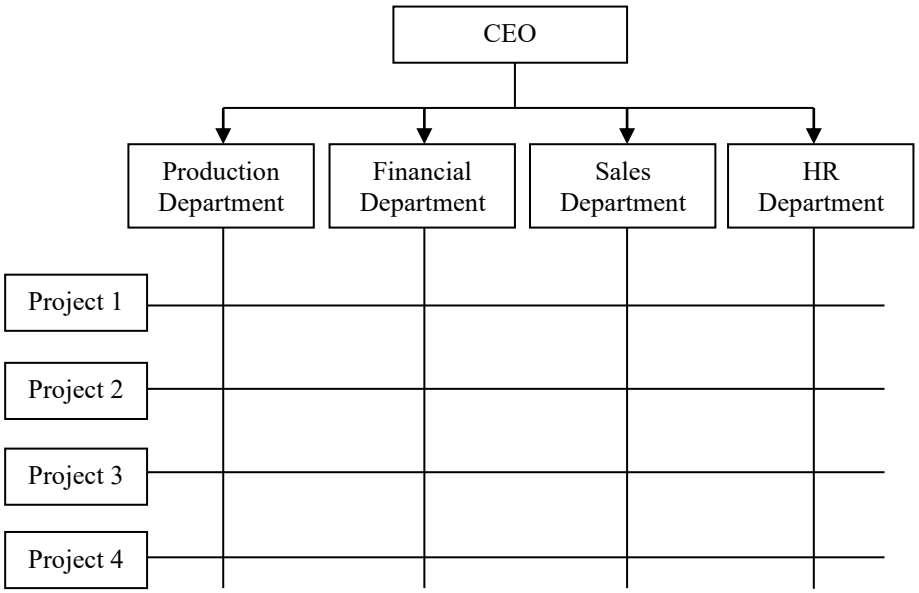
Cons:

- The overall image of the company is diluted concerning the general management of the company;
- There is a raise in costs of location, compensations, or equipment;
- There is a limited communication between divisions.

5.4. MATRIX ORGANIZATIONAL STRUCTURE

It`s mostly used for complex projects, which involve all the organization`s functional departments in their development. The hierarchy levels are drastically diminished compared to the functional organizational structure, and the responsibilities are distributed to the departments` managers.

As shown in the figure above, in this type of structural organization the department members are subordinated both to the general manager and the project manager



There are some advantages and disadvantages of the matrix organizational structure:

a. Advantages:

- The organization`s activities are project-based; therefore, the departments are not involved in the overall strategy, but on specific tasks, according to their members` specializations;
- The project managers will set their own performance standards, they are empowered with the resource allocation, and these aspects represent an advantage because they are the ones who know the project best;
- The project managers are in direct connection with the clients, who will be the beneficiaries of the organization`s products/services, so any demand coming from them (of, course, by respecting the terms of the contract) will be more efficiently and effectively fulfilled;
- The project teams are better motivated because such organization allows participative management and it`s very formal and rigid.

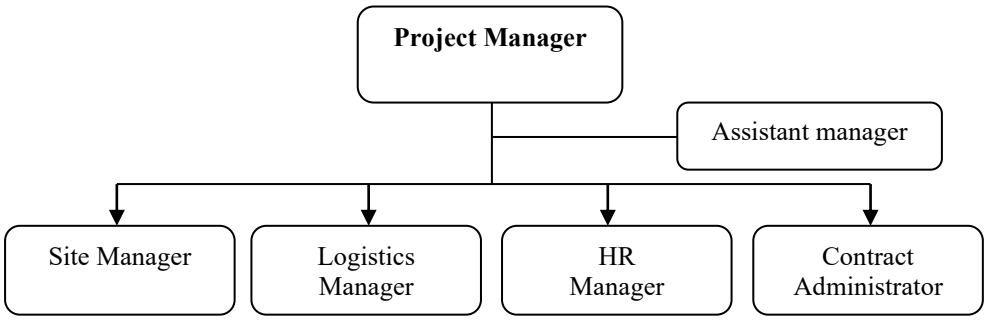
b. Disadvantages:

- When more projects are developed in parallel, conflicts between managers may occur, because of the allocation of resources, which most of the time are limited in an organization;
- In a matrix organization, the hierarchy may change, and some animosity may interfere between the project managers and the department managers, which may last even after the project`s completion.

In the civil engineering area, a project team may have a variable number of members, according to the project`s size[23] .

It`s the case of a project with a sole construction site. When a complex project is involved, with several sites, then the logistics management department, the human resource department and the contract administration might be common for all small projects, or might serve one or more construction sites, based on their size and complexity.

[23] Barbu, N., Managementul proiectelor de construcţii, Ed. Codecs, Bucureşti, 2000, pg. 24



The responsibilities for each entity are:

a. The project manager:

The project manager is responsible with the performance indicators of the project. He/she has authority coming from the management functions: planning, organizing, coordination and control.

b. The site manager:

Is subordinated to the project manager and is empowered by him/her with all the aspects connected to the project execution. He/she is responsible with: execution terms, coordination of the teams, quality of works, cooperation with the other members of the project team, efficient communication, or others;

c. The logistic manager:

Is the person involved in the supplying of the site with the required material resources.
He/she has responsibilities in the relationships with the suppliers of materials and equipment, the management of stocks, the supply of the construction site according to planning, the quality and quantity of the materials according to the project specifications, the communication with the site manager, etc.

d. The human resources manager:

Is the person empowered to ensure the project members needed to perform the works. For occupying the jobs according to the specified activities, the team of the human resources department has the following responsibilities: recruitment, selection, and the performance evaluation.

e. The contract administrator:

Has responsibilities connected to the execution of the project along its schedule: draws up reports, keeps the permanent connection with the beneficiary, prepares the invoices for payments, solves, by the support of the team, the complaints or the changes requested by the beneficiary.

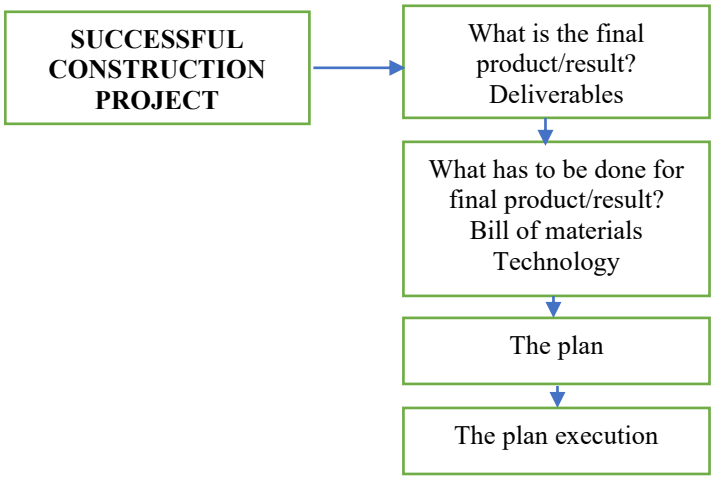
f. The project`s assistant manager:

Represents the interface between the project manager and subordinates. He/she insures the vertical communication between them. Moreover, he/she addresses secretarial issues, such as the company`s contact with the outside environment.

COURSE 6
PLANNING THE CONSTRUCTION WORKS

6.1. INTRODUCTION

Every project is successful if it meets its purpose, translated into objectives for the management team.



Planning is part of the decision-making process. Based on the fact that a project is performed and controlled by a lot of people, the project managers may deliver four different plans: one for the boss, one for the client, one for subcontractors and one for him/her, to have the idea of what`s really going on in the project. Each of them may have different targets. Sometimes he/she forgets what plan to give to whom.

As long as a project is based on assumptions, they may not work. So, we have to plan.

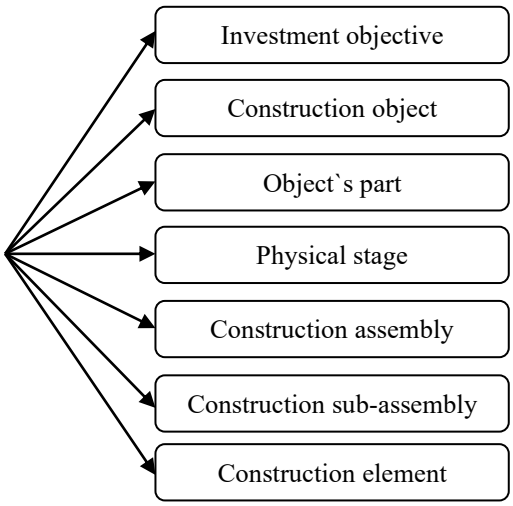
Steps in planning the project:

- Set the goals: where the organization wants to go. E.g.: maximize profit, minimize costs, manufacture new products, etc.
- Determine the objectives: the expected end result of an activity (planned target of performance). The objectives should be SMART. E.g.: Increasing profit by 10%.
- Establish the strategy to reach the objectives: the planning premises, meaning the conditions of the way the project manager wants to operate. He/she should analyze the internal or external conditions of the organization.
- Determine the alternative courses for achieving the objectives.
- Evaluate the alternatives, rank them and select the course of action for the best alternative(s).
- Prepare the derivative plans for the chosen alternative.
- Set the activities needed to accomplish the plans, then make a cost and time analysis for the operations.
- Establish the team for performing the project, in terms of knowledge, skills and abilities, with attention to security and safety in work.
- Provide follow-up of the course of action.

After signing the contract, which is based on estimation (project price), the construction may begin. The execution phase mustn`t be chaotic, because the contract stipulates the price, the duration of the project, and the quality requirements. Each delay or defect may bring penalties and bad references for the contractor.

Based on the technical criterion, the construction works may be classified in the following categories:

[24]



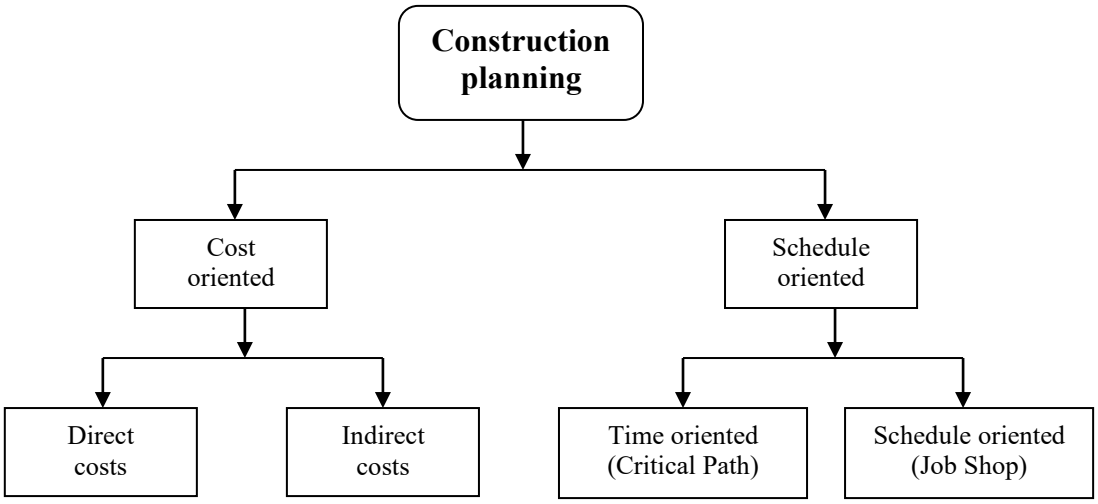
a. The investment objective is the set of construction objects which may be grouped into functions and/or services and are designed to ensure the functionality of the overall project. In practice, an investment objective may be a residential district, a factory, or a recreation center;
b. The construction object is a stand-alone building, bounded by the other construction objects according to its independent utility. The construction objects may be: a block of flats within a residential district, the workshops of a factory, or the tennis halls, aerobic halls or SPA for a recreation center;
c. The object`s part is a component of the construction object, which may be spatially and functionally bounded, and it`s executed in several distinct stages. Examples may be the sub-structure, the superstructure, glazing, closures, finishing, and others;
d. The physical stage is a division of the object`s part which has partial or total independent functionality, it is measurable and is the basis for the agreements between the beneficiary and the contractor. The execution of foundations, as part of the sub-structure, is considered a physical stage;
e. The construction assembly is a group of sub-assemblies which operate homogeneously and are identified in the construction site by a certain category of works or a certain specialty. An assembly of water treatment plants or a residential complex fall within this classification;
f. The construction sub-assembly is the part of a construction object and includes similar elements that may be executed by personnel with the same specialization, in a single technological execution phase. It may represent elements of finishes, installation, semi or prefabs, and others;
g. The construction element is the smallest part of a construction object, with clear shape and dimensions and well-defined functional role. It contains articles of works from the norms, which are required for the execution of the construction element. This category includes, for example, the execution of columns (with the articles of works as formworks, reinforcement, supporting activities, concrete pouring, and formworks dismantle), roofing, or others.

6.2. PLANNING MANAGEMENT

Planning management in construction is based on the same principles as for any other domains of activity, meaning that a well-managed construction project will meet the required scope, time, money and quality.

[24] https://www.facebook.com/346857775512901/photos/1778590399006291/?_rdr, accesat în data de 23.10.2024

For designing a construction plan, there are two approaches: the cost-oriented approach and the schedule-oriented one[25] :



Supposing that the client is interested in building an independent dwelling, for family use, the main constrain of the project should be the price. Accordingly, the project will be cost-oriented, meaning that the contractor should analyze the structure of the costs (direct and indirect costs) and reduce it to the minimum limit, but not by affecting the quality.

If the client is interested in building serial houses, or a campus, his/her interest would be to achieve the investment very fast, because the further incomes will come from rent. In this situation, the main constraint will be the schedule of the project. The contractor may have two choices:

- Time oriented project: by analyzing the critical path, the contractor will focus on the critical activities that might delay the completion of the project;
- Schedule oriented project: the project will have a series of identical buildings, so called "Belt System Constructions", with the same dimensions and using the same types of resources (materials, workers, technologies), so they may be performed in parallel. Timing and synchronizing are critical.

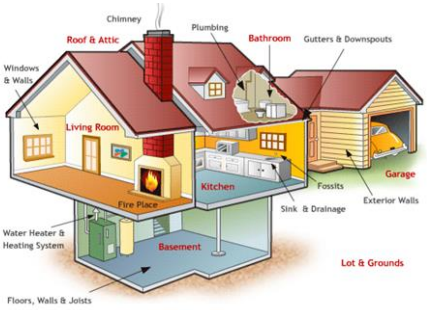
Planning a construction project means planning the activities involved in terms of duration and designing a sequence of their completion. An activity might have a sole task, or it`s a series of interdependent tasks.

Planning a project means to answer a few questions: WHAT to do (Work Breakdown Structure), HOW to do (Specifications of the project), WHO is responsible (Organization Breakdown Structure), and HOW MUCH will cost (Cost Breakdown Structure). Combining the answers to these questions, the conclusion will be WHEN is the project delivered completely.

Work Breakdown Structure (WBS)

The reason for doing a project is to produce deliverables. A lot of project managers miss the essence of a project because they don`t set SMART manageable objectives that provide control of the results, mainly if the project is developed on a long period of time.

[25] Vattai, Z. (2012), *Flow-Shop Schedules in Construction*, International Scientific Conference. People, Business and Environment, Lednice, Czech Republick.



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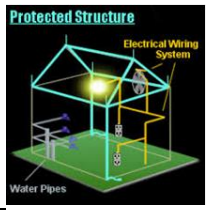
Final deliverable


27



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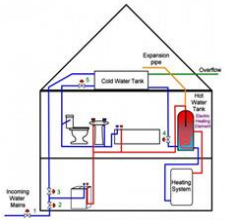

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Framework structure
- Framing Studs → Framing materials deliverable
- Work package → Framing labor

Electrical system deliverable
- Wire → Electrical materials delivrable
- Work package → Electrical labor

Plumbing system deliverable
- Pipe & Fitting → Plumbing materials deliverable
- Work package → Plumbing labor

Outside finishing deliverable
- Outside Finishing → Outside finishing materials deliverable
- Work package → Outside finishing labor

Inside finishing deliverable
- Inside Finishing → Inside finishing materials deliverable
- Work package → Inside finishing labor

If the company has operating contracts, won in competition, the manager may group activities into packages which may be repetitive in further biddings.

If the project manager will not have a detailed work flow of the construction projects, there will be a lot of risks involved in its completion:

- Unpredicted profitability: only projects with measurable deliverables may be evaluated in terms of profitability.
  The working hours are part of the direct costs, so their quantifying will influence the profit of the project.
  External influences, like bad communication with the owners, suppliers or sub-contractors, may lead to unfulfillment of the objectives and losses.
- If the project is not delivered in the conditions of the contract (quality, budget, and schedule), the contractor will lose credibility in the business market, and will take a lot of effort to recover it.

WBS is the first step in a project`s planning phase. It is a hierarchical partition of the work flow to be executed in a project in orde

r to create the required deliverables.

[26] https://www.eaglepremierinspections.com/whatweinspect, accesat în data de 23.10.2024
[27] https://uk.pinterest.com/america91/, accesat în data de 23.10.2024
[28] https://franklinlightningrod.wordpress.com/2009/01/24/c-how-a-lightning-protection-system-works/, accesat în data de 23.10.2024
[29] https://plumbingimmediately.co.uk/loft-water-tank-leaking/, accesat în data de 23.10.2024
[30] https://ro.pinterest.com/ideas/certainteed-max-def-weathered-wood/909261497455/, accesat în data de 23.10.2024
[31] https://walkergeneralcontractors.ca/services-vancouver/basement-renovations-vancouver/, accesat în data de 23.10.2024

It`s the project`s "TO DO" list, made top-bottom.
Why is WBS important in project planning?

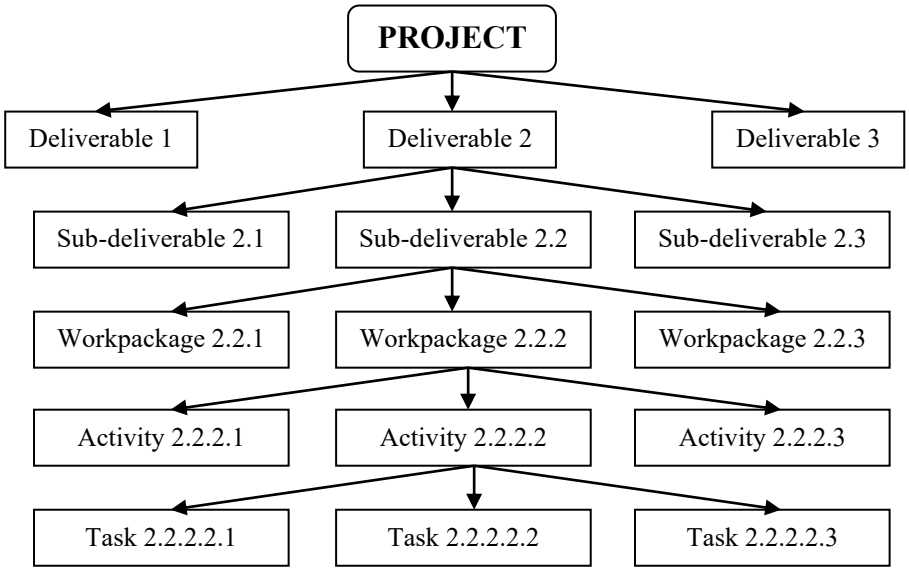
- It defines in a suggestive way what is to be done in the project and which is the logical order of performing the activities and tasks;
- It determines the amount of resources to be allocated and the time for supplying them for performing the project`s activities and tasks;
- It determines what skills do the personnel need for fulfilling the tasks;
- It determines what responsibilities should be delegated for completing the project in terms of budget, time, and quality.

The Work Breakdown Structure is a very important document of the project for some reasons, such as:

- It provides information for all the project`s participants (project team, stakeholders), for a clear understanding of the scope and objectives;
- It helps in identifying the project`s milestones;
- It is the starting point for the project`s scheduling;
- It`s a source of information for the project`s risk analyze.

Before scheduling, a Work Breakdown Structure (WBS) has to be designed. It`s a team effort and involves all the participants. It`s top-down, not bottom-up, starting with the project's outputs. It`s not a schedule, but a tool to design the schedule. The project is broken into phases, with at least 2 levels of details, so that the project manager can monitor it. The lowest level of breakdown and detail is called work package. They will be estimated (time, cost, resources). Bringing them back to the top will provide the total cost and time for the project. Every work package will need a person responsible for it. The project`s HR structure will come out. Moreover, every work package has deliverables (products, etc.).
The 8/80 Rule: no work package will be less than 8 hours and more than 80 hours.
It involves elements:

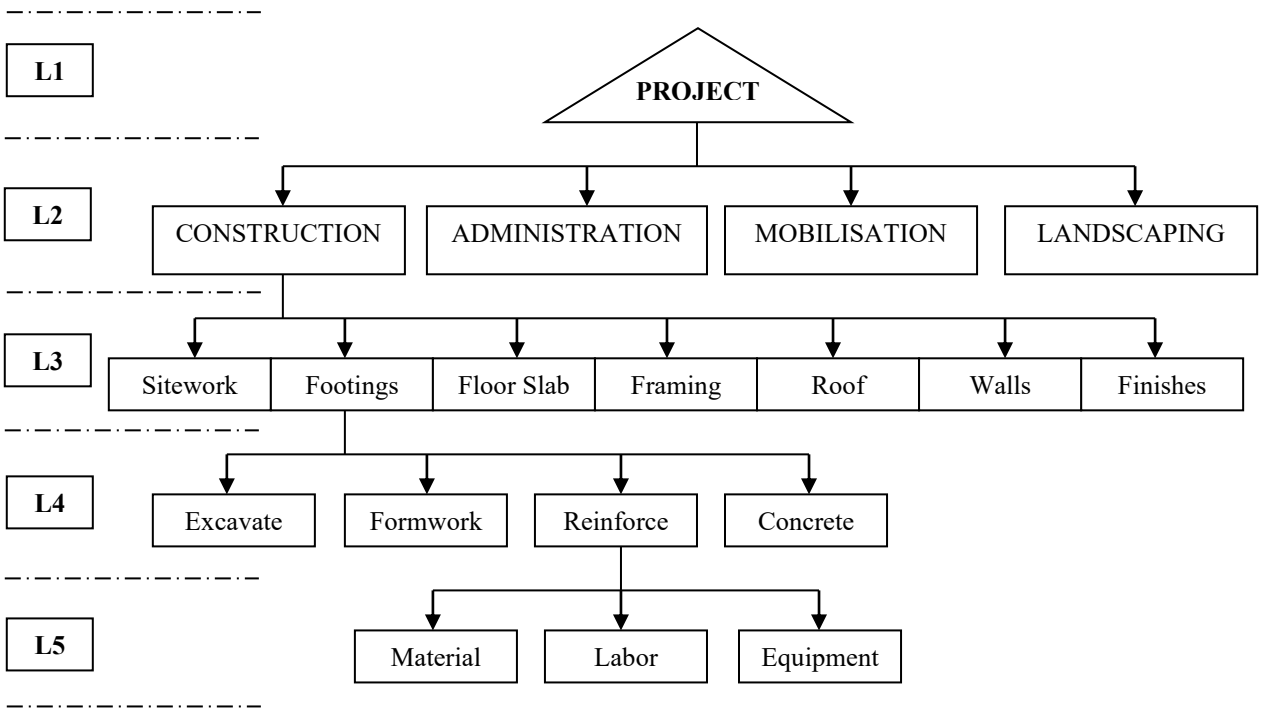
- Input: the scope of the project;
- Input: requirement documentation;
- Technique: the deliverables;
- Output: the WBS;
- Output: the scope baseline;
- Output: documentation update.



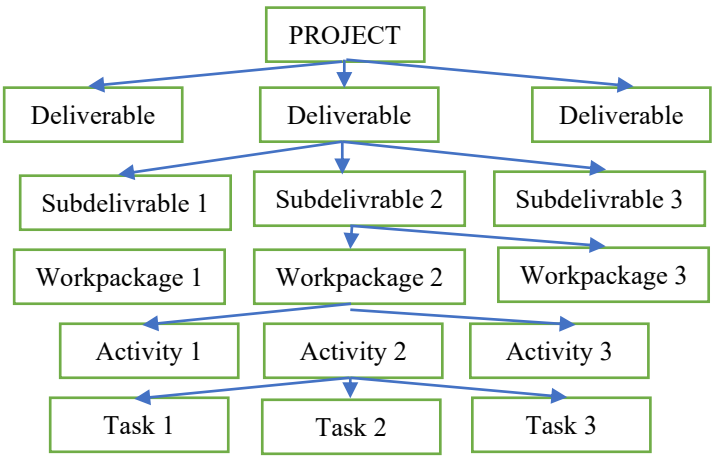
If, for example, you want to build a school, meaning the scope of the project, you will have to analyze the documentation and only after you will be able to set the deliverables of the project,

which may be the school building, parking, restaurant, campus, etc. Then you will design the WBS, which will contain the organigram of activities (tasks) or sub-activities (sub-tasks) for each deliverable.
Each activity is broken into sub activities (milestones).

When scheduling the activities, in order to have an overall vision of the whole project, the planner should design a Work Breakdown Structure (WBS), which is a hierarchical drawing of the detailed activities grouped in measurable levels.



L1 (Level 1): Total project
L2 (Level 2): Sub-project
L3 (Level 3): Category of work
L4 (Level 4): Work package
L5 (Level 5): Resources



Each of the questions will lead to a certain structure of the project, and will end with a schedule, like follows[32] :

[32] www.springer.com/cda/content/document/cda.../9783642170911-c1.pdf?SGWID

a. Work Breakdown Structure (WBS):
   WBS is the division of the project in work packages and elementary activities that may have a final result. The construction company should design work packages and give them codes, if they repeat the same activities in multiple projects, so the managers may give cost and schedule for each.

b. Organization Breakdown Structure:
   The work packages will show the activities needed to be executed in order to complete the project. The next stage will be the analyze of the human resources required for the project execution.
   The Work Breakdown Structure is the basis for the level of specialization and authority of the personnel:
   - Project management team: Project manager, Site manager, Scheduler, Site inspector;
   - Engineering: Project engineer, Architect, Civil engineer;
   - Manpower: Foreman, Workers with different specializations;
   - Subcontractors: Electrical, Plumbing, Structure;
   - Material and equipment suppliers.
   -

c. Cost Breakdown Structure:
   The costs will represent the budgets of the work packages and will be categorized as direct and indirect (overhead) costs. In order to be standard costs for certain work packages, they will include only the expenses related to the project, and not the overhead costs of the company (office expenses for utilities, staff salaries, taxes, or other expenses).

d. Schedule:
   After knowing the activities of the project, the personnel involved and the project`s budget, the person (or team) responsible will plan the activities to fulfill the project.

The task represents the frame required for planning the construction activities. It means the setting of activities and start and finish times, and also the allocation of resources needed for each activity.

Fortunately, many tasks may be repetitive in different parts of the construction. For example: the activities needed for the execution of the first floor of a block of flats is iterated, maybe with small differences, to the upper floors. As a positive effect, the planner shouldn`t analyze each activity, but only the ones with differences.

Performing a task requires time and resources, including manpower, equipment and machinery. The time needed for completing the task is called task duration. The start and the finish of a task represent milestones and show the progress of the project.

There is a natural hierarchy of activities. For example: executing a column is divided in sub-activities, referring to formwork positioning, fitting the reinforcement, pouring the concrete, and formwork removal. The sub-activities may be divided even more. E.g.: Cleaning the formwork may be divided in:

- Transportation of the formwork from the warehouse to the cleaning platform;
- Fixing the formworks on the platform;
- Washing the formworks with water;
- Cleaning the concrete deposits from the formwork surface;
- Lubrication of the reusable formworks with oil for another use;
- Transport of the formwork from the platform to the warehouse.

Defining the tasks will serve as a base to the programming, for planning communication and for monitoring the construction project, it will also be a milestone for partial payments from the beneficiary and to the suppliers.

Example:

Let`s take an example of a construction project that involves the execution of three blocks of flats.

The construction project has identical blocks of flats. The project manager will give codes: B.1. for block no. 1, B.2. for block no. 2, and B.3. for block no. 3.

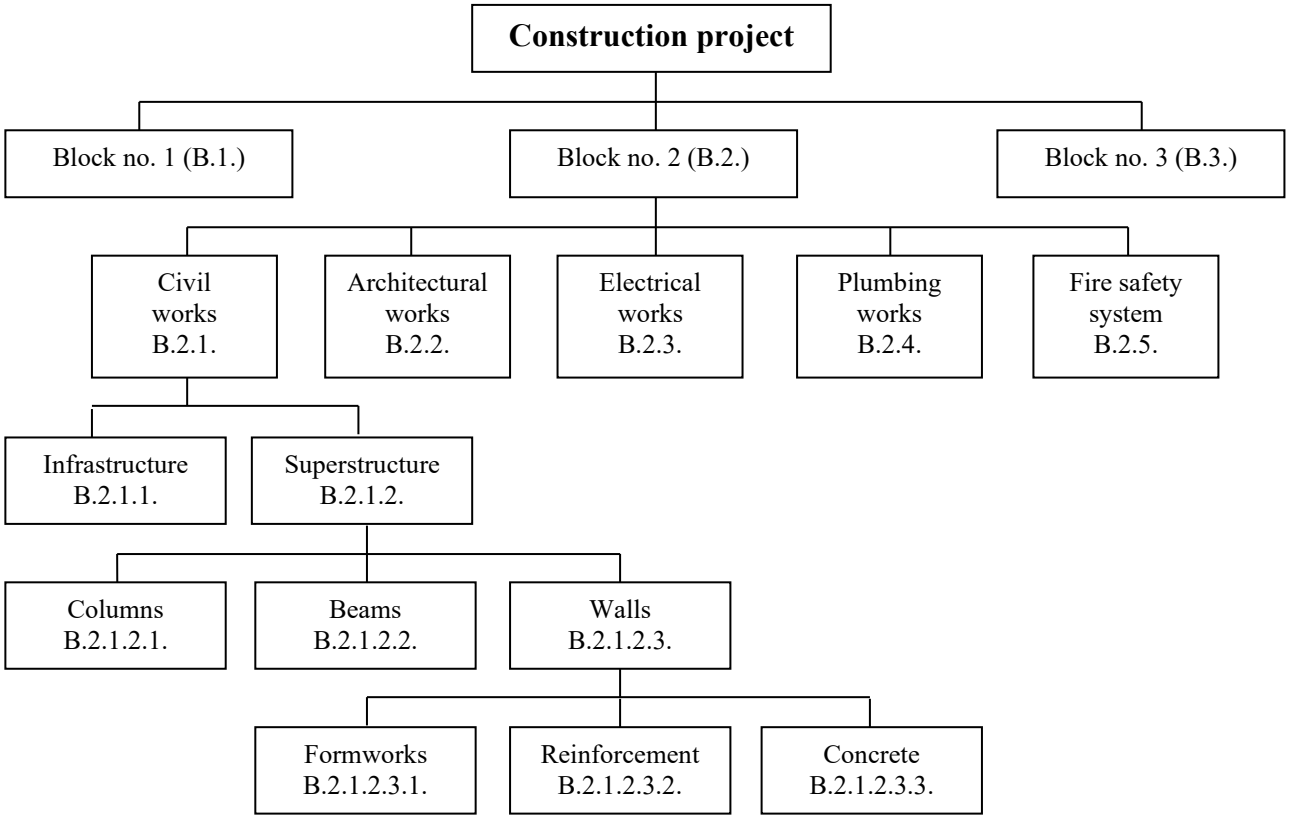
For each one, the same works should be performed. We will analyze block no. 2, with work codes as follow: B.2.1. for civil (structural) works, B.2.2. for architectural works, B.2.3. for electrical works, B.2.5. for fire safety system, and so on.

For the civil works, they may be separated in some categories: sub-structure (B2.1.1.), superstructure (B.2.1.2.), roof (B.2.1.3.), finishing (B.2.1.4.), and others.

The superstructure may be divided in floors, and for each floor the categories of works may be: Columns (B.2.1.2.1), beams (B.2.1.2.2), walls (B.2.1.2.3), and slab (B.2.1.2.4).

The works for the walls may be: formworks (B.2.1.2.3.1.), reinforcement (B.2.1.2.3.2), and concrete pouring (B.2.1.2.3.3.).

As seen below, the works are put in sequence, in the logical order of performing them.



The scheduling process is finalized in two documents:

a. Calendar plan

This type of drawing delivers the time scheduling of the construction works in their logical sequence. Because the construction activities are developed in long periods of time, their programming may be expressed in days, weeks, months or years.

In order to be used by more project members, with different jobs, the calendar plan will have both the planning of activities and the resources involved.

No.	ACTIVITY	RESOURCES NEEDED	Programming (days, weeks, months, years)						
			1	2	3	4	5	6	7
1.	Earthworks	1 topometer Eng.							
2.	Manual digging	2 unskilled workers							
3.	Mechanized digging	1 excavator							
4.	Foundations	3 unskilled workers 2 concreters							

Which is the importance of this document?

- It is designed before the start of the project;
- It`s an estimation of the project`s duration;
- It develops a plan for the resources needed in the project: materials, manpower, financial, and technology;
- Estimates the need for financial resources for relative short periods of time;
- Represents a basis for signing the contracts with the suppliers, sub-contractors and beneficiaries;
- It`s a method of evaluation of the activities along their accomplish, and not only at the end of their execution, therefore the managers may interfere at any moment in the project for rescheduling.

The calendar plan is suitable in many stages of the construction project and helps the company`s departments for planning the resources, as follows:

- The project management officer (PMO) may have an overall image of the project before the start and may prioritize the resources, especially when the company develops more projects at the same time;
- The site manager will schedule the on-site activity and will have milestones which will be base for rescheduling, if some of the activities have delays;
- The logistic manager will supply the needed materials and equipment according to the plan, along with their transporting means. Moreover, he will sign contracts with the equipment suppliers, if they will be rented.

b. Resources plan

The resources plan is similar with the calendar plan, but this document details the resources planning on specialization, types of equipment and machinery, and others. The graphical representation provides an image of their activities in days, weeks, months or years, with reference to the number of existing items.

RESOURCES	PROGRAM (days, weeks, months, years)						
	1	2	3	4	5	6	7
Topometer engineer	1	1					
Unskilled workers			2	2		3	3
Concreters						2	2
Excavator					1		
TOTAL	**1**	**1**	**2**	**2**	**1**	**5**	**5**

The resource plan is an important planning document in a construction projects for some reasons:

- It allows the project manager to plan the human resources for many projects at the same time. It is also suitable for budget analyze and allocation of funds along the development of the project;

- The site manager will have the possibility to monitor the human resources, to control and evaluate them;
- It`s very useful if the company uses sub-contractors, so they may schedule their activities during the development of the project.

6.3. TYPES OF SCHEDULING IN CONSTRUCTIONS

The construction field is part of the engineering area; therefore, it operates with accurate data. The investments in this economy sector have an important value, and also a big duration of completion. So, any action should have a rigorous programming, with well-defined start and finish times, as well as a detailed budget at such a level that all the planned objectives should be achieved.

The specialty literature abounds in types of programming, which may be used simultaneous, or just some of them should be operational. The more they are applicable, the easiest will be to monitor the projects.

Here are some examples:

a. Coordinated investment program

An investment plan is designed in order to analyze the possible advantages and disadvantages after its further completion. Using this program, the management of the company may establish:

- The scope of the project;
- The main suppliers of resources;
- The main clients of the products/services;
- The budget needed for the investment;
- The time schedule of the project;
- The sources for financing the project;
- The planning of the activities.
-

b. Planning the works before the bidding

Any contract has two main elements: the budget and the schedule of the activities. These items are stipulated in the offer provided by the organization which shows interest in executing a certain project. Therefore, based on the data from the task book, the company participating to the bidding will develop an appraisal of the important chapters of the estimation.

This type of programming will emphasize only the duration of the main categories of works: site organization (… months), substructure (… months), superstructure (… months), finishes (… months), frame enclosure and internal walls (… months), etc.

c. Planning the works after signing the contract

The bidding will decide the winner of the contract, and then the agreement will be signed by all the parties. A global planning isn`t enough, because this is the moment when the parties agree upon the start and finish time of the construction objects, along with their budgets.

It`s very important to perform an accurate particularization of the program, because both the beneficiary and the builder should be aware of the level of resources (materials, human, financial, technological) which they may rely on different stages of the construction project.

The resources are planned along the whole duration of the project development, they are agreed by all the participants, and these documents will represent the base for the evaluation of the physical stages of the construction and the planning for the scheduled payment.

d. Monthly planning of the construction works

A complex construction project is developed for a long period of achievement; therefore, a global planning is not relevant. Based on this statement, the planning should be detailed in operational plans, scheduled by years (if necessary), and by months, in order to organize the resources needed to accomplish it, and, eventually to recover any kind of delays in the project activities.

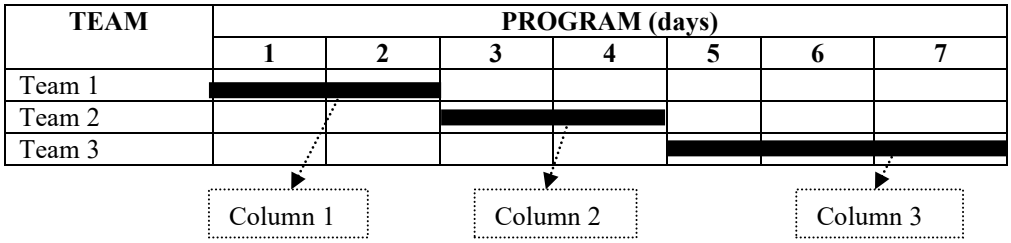
The design of this type of planning oversees the site manager, who has a global image of the whole activity.

e. Weekly planning of the human resources

This planning is designed by the site manager or the foreman of the construction site, who supervises more worker teams. The manpower will be scheduled based on the technological flows and their logical orders.

This type of program depends on the number and the quality of the available personnel of the company.

For example, let`s take the case of putting the formworks for columns execution of a construction:



The teams are located at each column.

Team 1 will work for 2 days on column 1, then it will move to column 4, then to column 7, and so on.

Team 2 will work for 2 days on column 2, then it will move to column 5, then to column 8, and so on.

Team 3 will work for 3 days on column 3, then it will move to column 6, then to column 9, and so on.

6.4. PRINCIPLES OF SCHEDULING

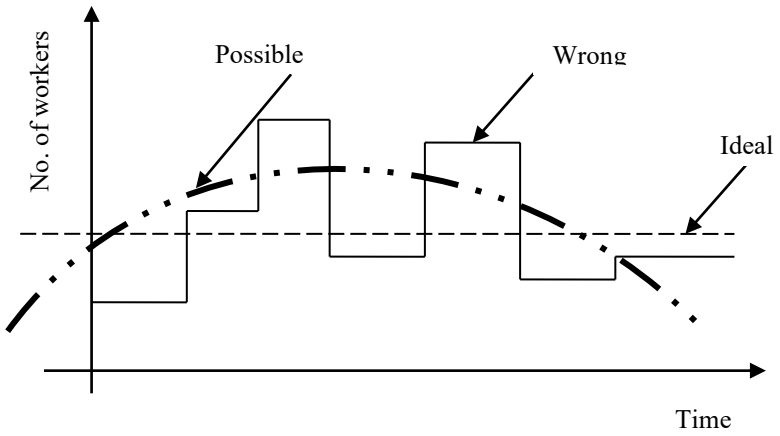
An important aspect is the fact that different types of connections may be designed and each of them has multiple implications for the works scheduling:

- **a.** There are activities whose technical and physical order cannot be changed. E.g.: the pouring of concrete cannot be performed before formwork and reinforcement;
- **b.** There are activities that require preliminary activities in a continuous open location, even if they don`t have a logical connection. E.g.: the formworks may be placed at the beginning of an excavated trench, even if the digging equipment continues the excavation. The formworks shouldn`t exceed the digging, but both activities may begin and stop independently;
- **c.** Some precedent activities are not technically necessary but are imposed through implicit decisions given by the construction planning. E.g.: two simultaneous activities may require the same equipment (crane); therefore, one activity must follow a precedent one in order to be sure that they are not planned at the same time.

There are some principles of scheduling the construction works:

1. Optimum level of detail:
   The project may be split into activities, to a level that they can be monitored and controlled. The level of detail depends on the company`s capability to execute them according to the project`s specifications.
   If the company has big expertise or the activities are rather easy to perform, the level of detail will be reduced.
   For complex projects, the level of detail will be thorough, because it involves the monitoring and control of important resources.

2. Continuity in resources utilization
   This principle is mainly operational for equipment and human resources.
   When scheduling a construction project, a flat diagram is recommended, because discontinuity means extra expenses. However, peak times require heavy hiring and renting. If they are wisely planned, the company may agree with the suppliers for a correct price.
   Uniformity in resources utilization



   The figure represents the case of the human resources for a certain physical stage of a construction.
   The ideal situation is when the workers, grouped in specialized teams, have the same number of people along the project development. Of course, practically this aspect is not possible, because each activity requires different human resources.
   When planning the activities, it`s not recommended to allocate non-balanced number of workers, because it involves changes in the site organization (more warehouses, platforms, lockers), and this will also have impact on the project`s expenses.
   The most feasible will be a lean allocation of resources, where the company`s management is able to schedule the procurement of materials and organize the on-site activities without damaging the quality of works.

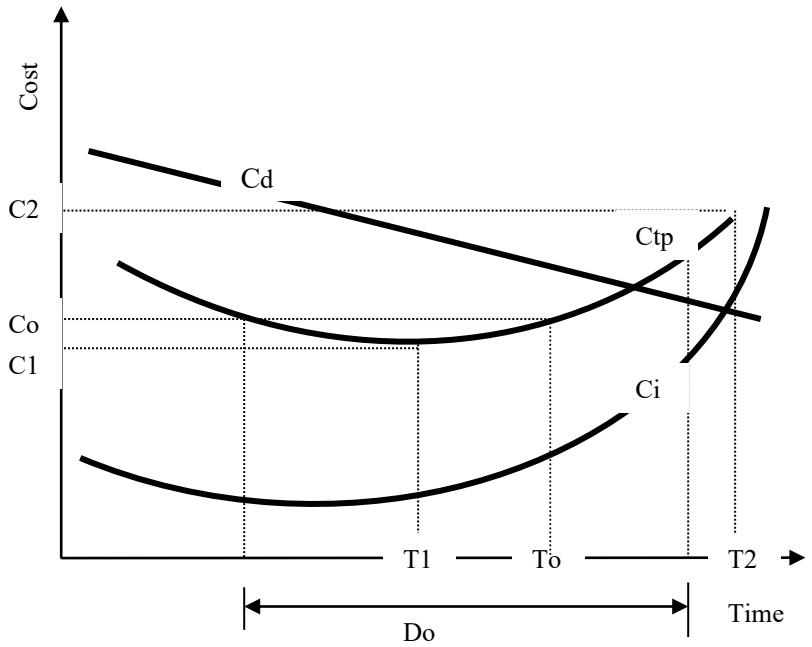
3. Minimizing the completion time of the project
   This principle refers to the activity duration and the overall timetable of the project.
   Reducing the duration of the projects isn`t always a benefit.
   For example:
   - The extension of the timetable will increase the costs, especially the indirect ones. It may occur if there is more leading staff, less workers, less equipment or machineries, or small deposits;

- Shortening the duration may also be a bad choice: too many equipment or machineries may disrupt the development of the project, too many workers may generate chaos, tensions, or lack of coordination. Moreover, a crowded site makes the monitoring and controlling almost impossible.

A construction project, as any other type of project, is based on the calculation of the budget needed for the planning of the resources involved in its achievement.

Costs represent a combination of expenses which will occur along the project`s completion: taking over the site, site organization, construction execution, project closure. However, there is more about expenses: during peak times additional personnel is required, in case of cash-flow issues the company needs credits from banks, or unexpected expenses for equipment or machineries defects.

The profitability of a construction project is affected by direct and indirect costs. The inter-dependency between them is represented in the figure below:



C_0 = optimum costs
C_1 = costs connected to accelerate duration
C_2 = costs related to extended duration
C_i = indirect costs
C_d = direct costs
C_{tp} = global production costs
D_0 = optimum scheduling duration
T_1 = accelerated duration (the shortest possible) – overloaded area
T_2 = extended duration (the longest possible)
T_0 = optimum time

As represented in the figure, the direct costs, which quantify the development of the project (materials, human resources involved in the project, equipment, machineries, transport) have a descendent evolution. At the beginning of the project, the direct expenses are high, because they involve all the start-up costs. As the activity is structured, the resources planning should be done in such a way that the resources will be stored on site for maximum 3 days.

Unlike the direct costs, the indirect (overhead) costs (management, contingency, bank credits, taxes, insurances, rents, and others) are small at the beginning of the project, but they increase with the project development, and the big load will be in the final stage. The office activity related to the project (reports, interest rates for loans, new sources of funding due to financial bottlenecks,

negotiations, software needed to complete the project, etc.) generate additional expenses towards the end of the project. If the completed project is to be sold later, the costs related to advertising are also a source of important expenses.

The optimum duration is the one where the costs are constant, in which the working space is used rationally, without periods of overloading or non-use. This type of resource planning should help the company`s management in avoiding production delays, financial bottlenecks, which are the main sources of costs increasing, decreasing the quality of the project, and, finally, bad publicity.

COURSE 7
METHODS OF SCHEDULING THE CONSTRUCTION WORKS

7.1. INTRODUCTION

Time management is part of management science, of capital importance in a construction project. There are some aspects to support this theory:

- ☑ The workers are often paid hourly, and then time management can control wages costs. The personnel should be aware of the productivity indicators used for measuring their performance, including the duration of the activities;
- ☑ The delays in finalizing the construction project have influence both on the contract (penalties for each day of delay) and the potential projects, because of bad publicity;
- ☑ Most of the time, the construction activities are inter-dependent in terms of scheduling. For example, the drywalls cannot be put into position till the installations are finalized, or the painting cannot be applied till the internal walls are put into position.

An accurate planning of the construction works may be accomplished by splitting the construction object into component parts, through such a level of details that its completion may be realistic and achievable.

The construction works are very complex, because they are performed on a long-term scheduling. They are influenced by several factors, such as:

- The type of activity: simple or complex;
- The activity`s duration;
- The resources involved;
- The season, in terms of: temperature, humidity, wind power, etc.;
- The working conditions: height, underground, polluting environment;
- Constraints regarding the supplying, the payment of the invoices, the finishing time, or others.

No matter of the method of estimation used, the main item for planning is the activity`s work norm. The labor time is the time allocated to a worker in a shift in order to fulfill the labor task at standards.

The labor norms in constructions are multiple, because what a planner estimates are the activities, which are very diversified. The labor norms may be classified by several criteria, as follows:

a. By the level of applicability:
- Local norms, which are calculated locally and may be applied for a specific construction site for a complex project, with personalized resources and in specific labor conditions;
- Global norms, applicable to all construction sites of the project.

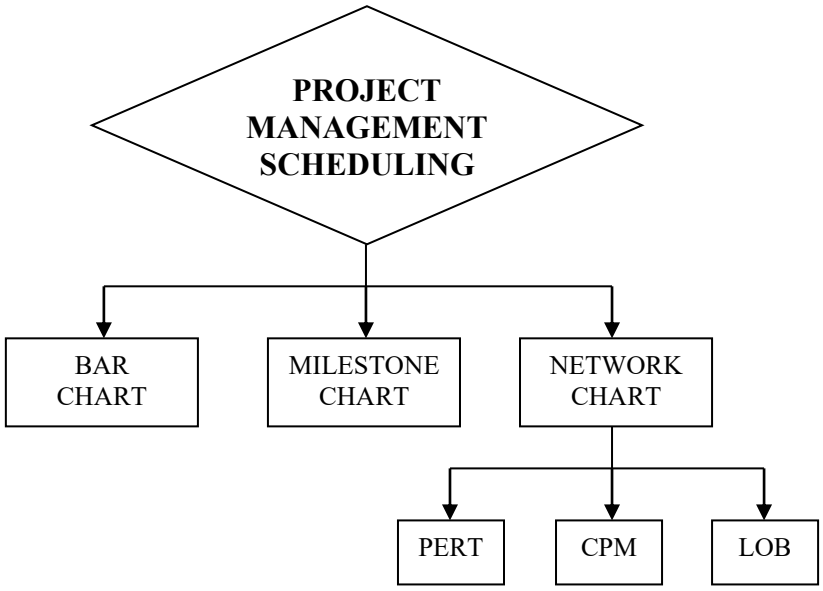
b. By the degree of complexity:
- Elementary norms: they refer to a single activity;
- Composed norms: they quantify complex processes, involving several elementary norms in constructions.

c. By the content of the labor norm:
- Quantitative feature: the volume of labor needed to accomplish an activity;
- Qualitative feature: qualification or specialization of the workers who will perform for the activity`s completion;
- Technological feature: description of the operations which should be achieved for a certain activity.

In order to plan the execution duration of a construction project, the manager should estimate the achieving time for each activity. There are two main calculus methods:

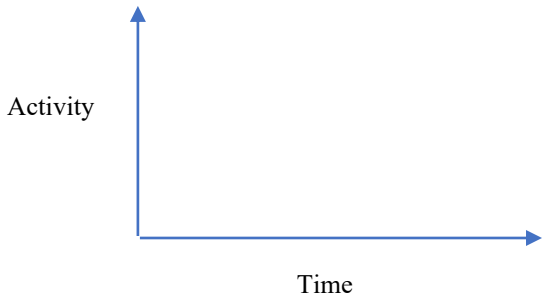
- Deterministic method (assimilated to the Critical Path): the duration of a project is determined through calculation;
- Probabilistic method (assimilated to PERT, which is the abbreviation of Program Evaluation and Review Technique): is based on the calculation of the average duration of an activity, but also taking in consideration the factors which may disturb the proper development of it in normal conditions.

In constructions project management, there are several scheduling methods deriving from the deterministic or probabilistic ones, such as:



7.2. BAR CHART SCHEDULING (GANTT CHART)

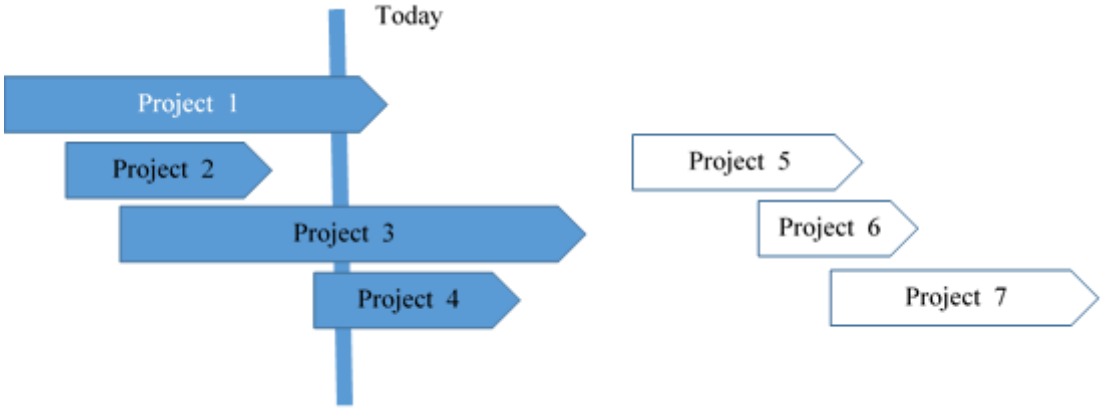
Henry Gantt (1861-1919), mechanical engineer and management consultant, has invented in 1910 the principle of scheduling which carries his name. This type of representation used in the construction projects is also called the duration-activity chart, because these are the two variables calculated.



The Gantt Chart is a graphical drawing of the succession of activities, in their logical order, on a horizontal axis, by giving durations to activities, categories of works, or chapters of works. Each bar of the chart has a certain length assimilated to the computed duration of the activity (days, months, weeks, or years).

This is a picture that represents the progress of the project in terms of resources: money, time, teams, stuff, etc. It shows what you should have done and what you have done.

It can be designed for a project or for a group of projects of a company that may be delivered simultaneously.



As can be seen, today the company has 3 projects in progress and 3 projects in the future. Will the resources be enough for performing them? The management will have to make decisions after analyzing the capability to perform all or a part of them.

Advantage: easy, cheap, good visualization of entire project

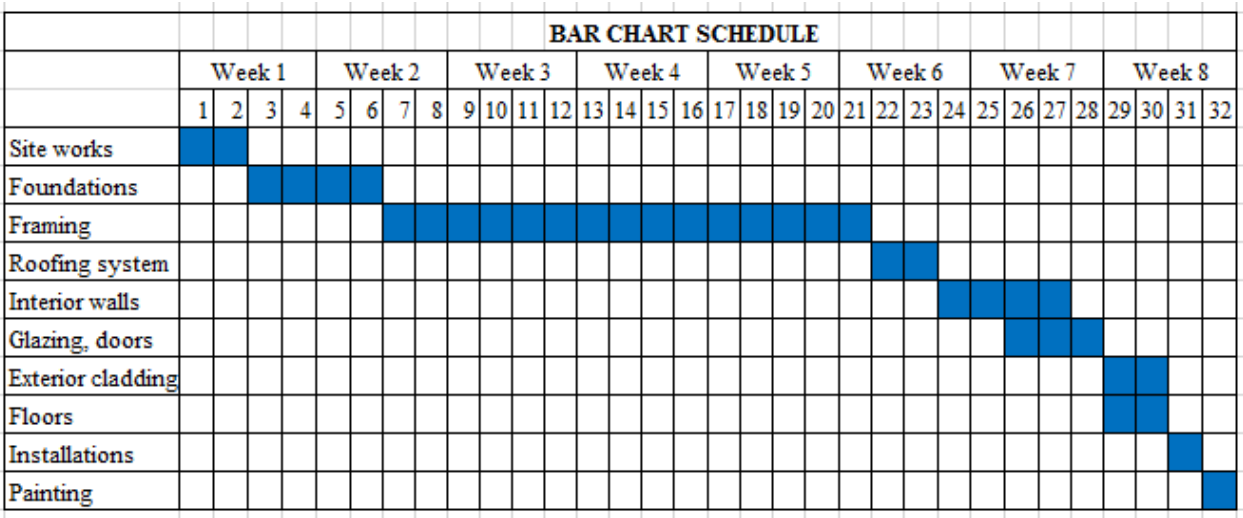
Disadvantages: lack of detail, difficult to review the project, activity inter-relationship not seen, time uncertainty not considered, critical activities not identified, no cost optimization.

For a certain project, we can draw the Gantt Chart for all activities, according to their dependencies.

It`s a dynamic document, so it must be adapted according to the project`s constrains: time, scope and quality.

Steps:

- List the tasks that must be performed to deliver the project;
- Assign one or more people (teams) to complete each task;
- Determine the task sequence and the time required for task completion;
- Mark major milestones to indicate critical schedule points.



The minus of this planning is that it gives only a rough idea of the project development, but doesn`t show the inter-dependencies between activities.

This chart is useful when a construction project has a small number of activities (maximum 40), and only for the global planning of a construction objective detailed on objects or work categories. Moreover, it`s suggestive for the project manager who is planning also the financial flow according to the contract.

7.3. MILESTONE CHART

The milestone chart represents the groups of activities or the significant events of the project. It is designed similar with the Gantt Chart, but it was developed for enabling the managers to supervise more complex projects at the same time.

In this scheduling technique, the milestones show both the start and the finish time of a certain group of activities. They are graphical tools used for visualization of the project's progress and to control the intermediate stages fulfillment.

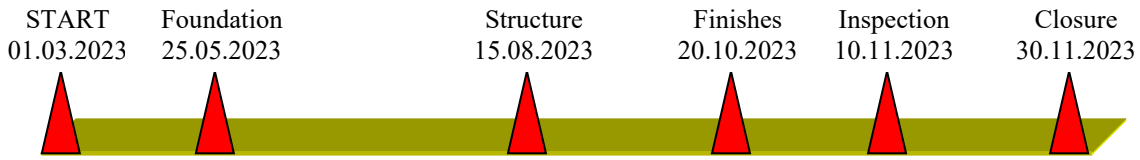
A milestone is an important element that occurs in the development of a project and each changing in its scheduling will have effects on other group of activities. Deliverables with deadlines may be projects` milestones.

Milestones may be use for some purposes:

- They give the manager a snapshot of the progress of the project;
- They will show what`s coming up next in the development of the project (next week, next month or next year);
- They may represent a payment schedule.

A few examples of milestones: completion of blueprints, client approvals, tendering the construction project, starting and completion of foundations, starting and completion of the structure, repair of defects, etc.

Milestones are represented by triangles. In scheduling, they are known as ″tasks of zero duration″, because they are not activities, but reference points of starting and finishing stages of the project.



The project manager may have an overall image of the project`s development, and may control the completion of the stages which, most of the times coincide with the payments provided by the owner.

This graphical representation may be used by the stakeholders as well, because they are interested just in the progress of the project, and not necessary on the completion of each activity or groups of activities.

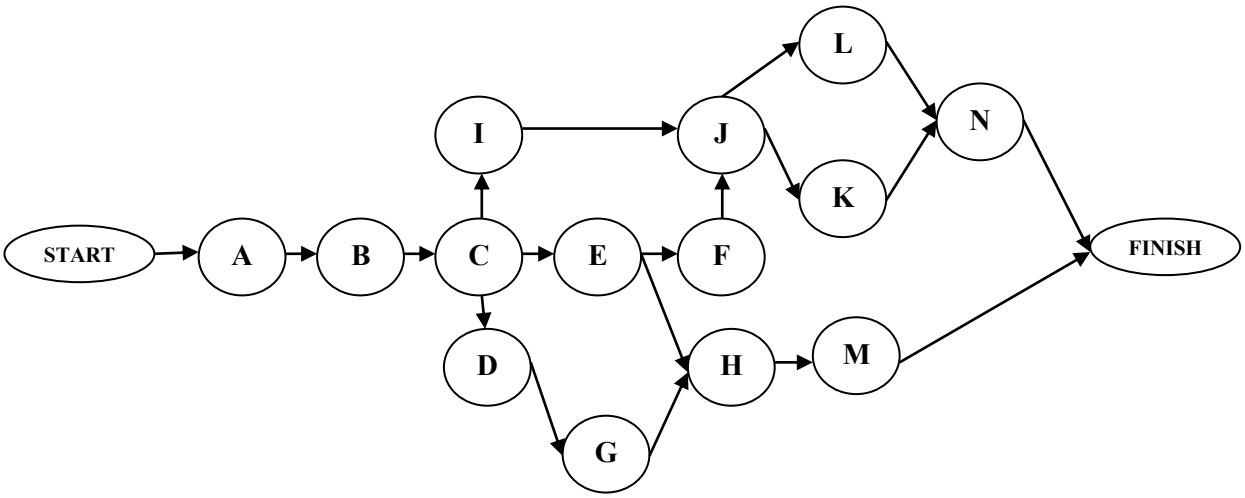
7.4. NETWORK CHART

For a construction project, the activities for completing it are inter-dependent, meaning that they must be performed in a logical succession. Therefore, when scheduling, the predecessors have to be accurate set.

No.	Activity code	Name of activity	Predecessor	Estimated duration
1.	A	Excavation for foundations	-	2
2.	B	Executing the foundations	A	4
3.	C	Executing the structure	B	10
4.	D	Put up the roof	C	6
5.	E	Exterior plumbing	C	4
6.	F	Interior plumbing	E	5
7.	G	Lay the thermo system	D	7
8.	H	Exterior painting	E,G	9
8.	I	Electrical works	C	7
10.	J	Interior walls	F,I	8
11.	K	Flooring	J	4
12.	L	Interior paintings	J	5
13.	M	Exterior fixtures	H	2
14.	N	Interior fixtures	K,L	6

By interpreting the data, the information are as follows:

- The excavation (A) doesn`t depend of any activity.
- The foundations (B) cannot start till the excavation (A) is finished. However, they may start with a delay at the same time with the excavation, if there is free work front.
- The structure (C) may begin after the foundations (B) are executed.
- The roof (D) may be executed after the structure (C) is done.
- The exterior plumbing (E) may start after the structure (C) is done.
- The interior plumbing (F) may start after the exterior plumbing (E) is finished.
- The thermo system (G) may be placed after putting the roof (D).
- The exterior painting (H) depends on the finish of two activities: exterior plumbing (E) and thermo system (G).
- The electrical works (I) may start after finishing the structure (C).
- The interior walls (J) may start after the interior plumbing (F) and electrical works (I) are finished.
- The floors (K) may be put after finishing the interior walls (J).
- Interior paintings (L) may begin after finishing the interior walls (J).
- The exterior fixtures (illuminate M) may begin after finishing the exterior painting (H).
- The interior fixtures (N) may begin after the floors (K) and interior paintings (L) are finished.



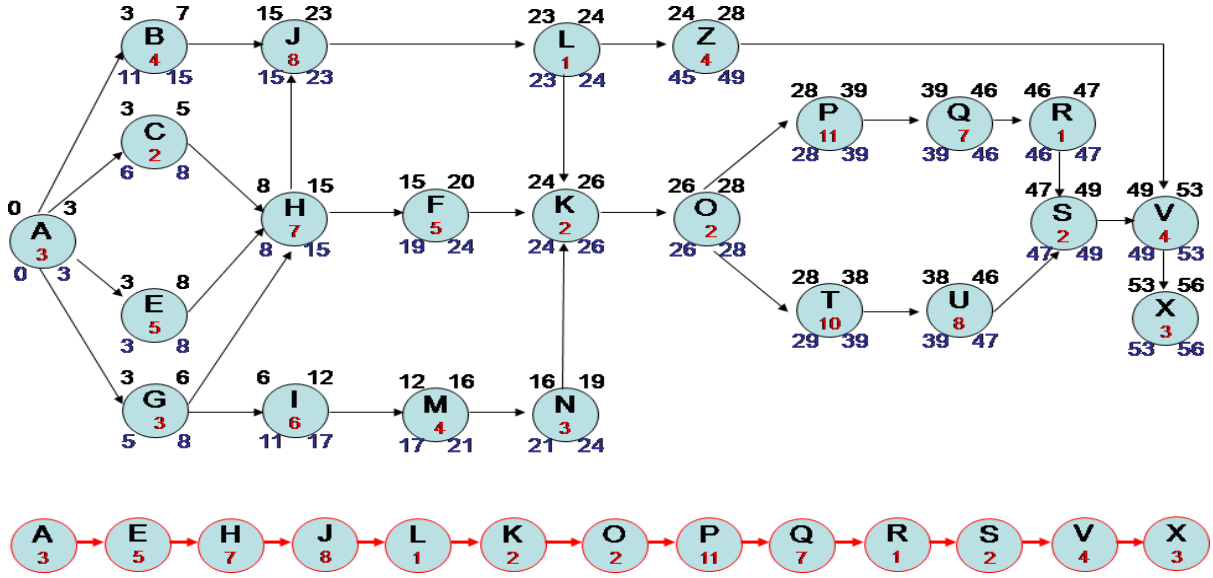
If the activities are successive, the whole duration of the project is:
T = 2 (A) + 4 (B) + 10 (C) + 6 (D) + 4 (E) + 5 (F) + 7 (G) + 9 (H) + 7 (I) + 8 (J) + 4 (K) + 5 (L) +
+ 2 (M) + 6 (N) = 79 days
However, if the activities may be performed simultaneously, the duration will be shorter.
There are several paths to calculate the duration:

1. T = 2 (A) + 4 (B) + 10 (C) + 7 (I) + 8 (J) + 5 (L) + 6 (N) = 42 days
2. T = 2 (A) + 4 (B) + 10 (C) + 7 (I) + 8 (J) + 4 (K) + 6 (N) = 41 days
3. T = 2 (A) + 4 (B) + 10 (C) + 4 (E) + 5 (F) + 8 (J) + 5 (L) + 6 (N) = 44 days
4. T = 2 (A) + 4 (B) + 10 (C) + 4 (E) + 5 (F) + 8 (J) + 4 (K) + 6 (N) = 43 days
5. T = 2 (A) + 4 (B) + 10 (C) + 4 (E) + 9 (H) + 2 (M) = 31 days
6. T = 2 (A) + 4 (B) + 10 (C) + 6 (D) + 7 (G) + 9 (H) + 2 (M) = 40 days

The longest path will be the realistic duration of the project, in our case 44 days. That means that the economy of time (and implicit labor costs) will be 35 days, which represent 44% faster by using the network diagram with predecessors.

a. CRITICAL PATH METHOD (CPM)

It`s the most common approach for estimating the finish time of a project, using mathematical methods.



It was first used in USA in 1957 for the planning of construction works in the chemical industry.

It`s a scheduling method which analyzes each of the activities, in their logical succession, with a fix starting and finishing time, and with computing the floats resulting from the network diagram of the project.

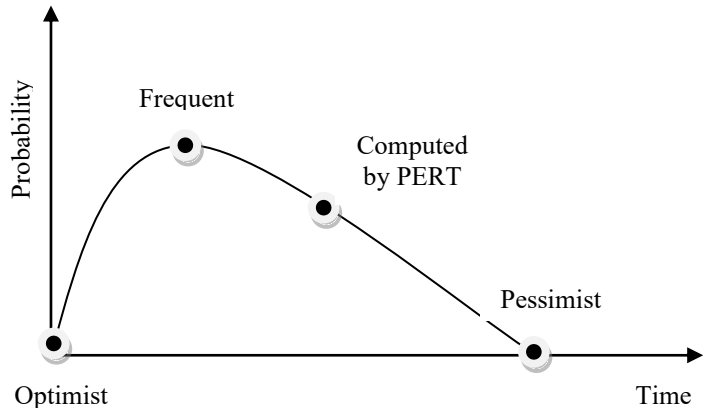
The total and the free float represent the difference between the early and the late start time, respectively the early and late finish time.

The activities which are not part of the critical path have some floats. The lack of free or total floats provide information for the managers regarding the critical activities, which, by having delays, may jeopardize all the following activities.

b. PERT SCHEDULING

The name of this method is the abbreviation of Program Evaluation and Review Technique (PERT).

It is generally used for projects with non-repetitive activities. This type of scheduling is relevant only if combining it with Gantt Chart or CPM. The benefit of PERT is that the costs and durations may be reduced for a construction project, because the activities may be thoroughly detailed.



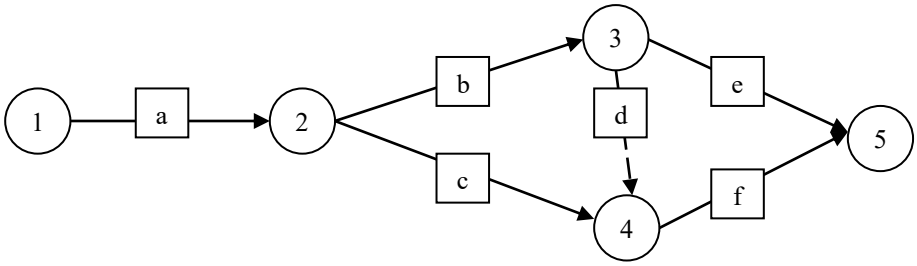
It`s a mathematical method of determining the duration, based on empirical estimation of the start and finish time of the project`s activities. Two elements represent the basis of this type of scheduling: the activity and the event.

The event is a decision point or the fulfillment of an activity. For example, organizing a bidding for a construction project may be an event.

The activity is an action taken in a project which consumes time, or a task which has to be accomplished. In our example, designing a task book is one of the activities which are part of the event called bidding.

The PERT method is a graphical representation of the project`s development in a logical and time-oriented order. This network diagram may be drawn in two styles:

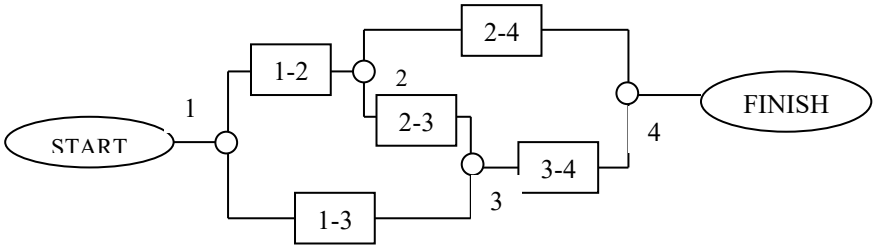
b.1. PERT Network based on the project`s events (stages):



The events (1,2,3,4,5), which are in fact the construction`s stages, are represented by circles, and the activities performed to complete the stages are represented by arrows (a,b,c,d,e,f). The length of the arrow is drawn arbitrary, without having connection with the duration of the activity.

Activity (d) is a dummy one and is not really existing in the succession of the project`s activities. It is represented only to determine the predecessor activities. Its duration is null.

b.2. PERT network based on project`s activities:



The activities are represented by rectangular (1-2, 1-3, 2-3, 2-4, 3-4), and the events by points (1,2,3,4).

This method is used when the durations of the project`s activities are known by practice. Consequently, the project manager estimates the duration of an activity by the formula:

$$t_p = \frac{x + 4z + y}{6}$$

Where: t_p = the estimated time
x = the optimistic time
y = the pessimistic time
z = the most likely time

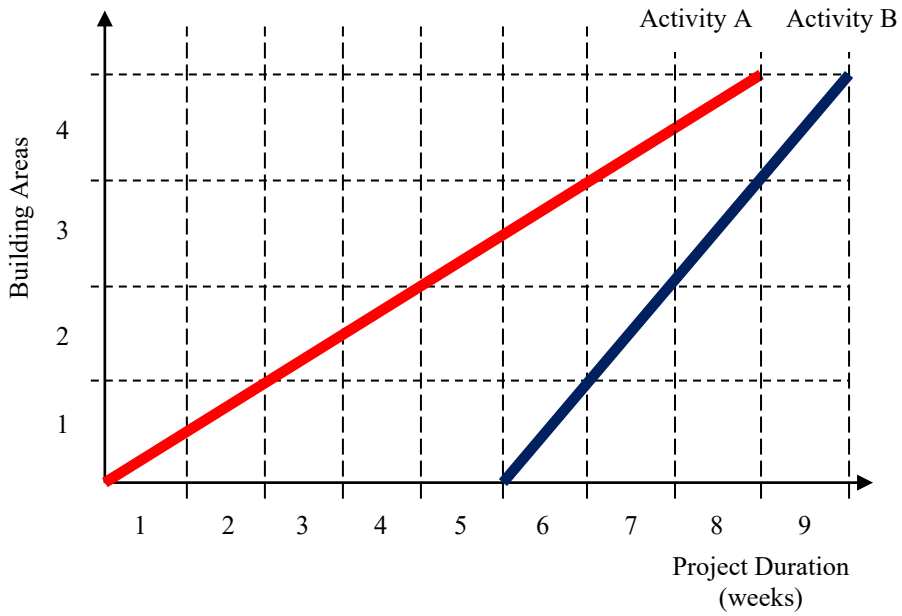
c. FLOW LINE SCHEDULING

This method of scheduling is used in construction projects where the activities are repetitive, such as roads, tunnels, or high-rise buildings.

It was developed by Goodyear Company in 1940, and then adopted by US Navy in 1950. Formerly used in the manufacturing industry, it was used in the construction sector for scheduling iterative tasks.

It`s a graphical representation of repetitive activities of a construction project, if identical teams of the same specialization may perform at the same time in multiple areas of a construction site.

The project timeline is drawn on the x-axis of the diagram, while the working areas are along the y-axis.



As seen in the figure above, Activity A lasts 8 weeks. The productivity for the team performing in each area is 2 weeks per area.

The activity B lasts 4 weeks and has a productivity rate of 1 week per area for the team performing in each area.

Activity A will be finished after 2 weeks on Area 1. The front is free, so Activity B may begin. However, continuity for Activity B is not possible, since after finishing Area 1, the team will have to wait three weeks till Area 2 is free.

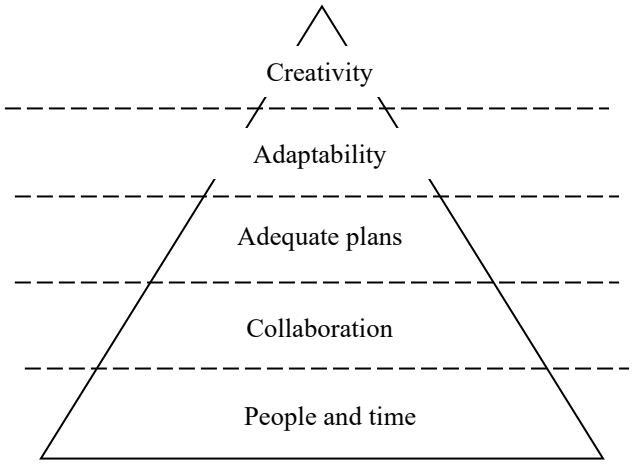
Therefore, the scheduling of Activity B will be done top-bottom, meaning that, in order to avoid disruptions, the early time to finish will be week 9, so the early time to start Activity B will be week 6.

7.5. CRITICAL CHAIN METHOD (CCM)

This method was invented by Elyahu Goldratt in 1997 and changed the behavior of the companies in the competitive environment. It was shortly adopted by important companies, such as Boeing, Tata, Mazda, or Seagate.

The Maslow Pyramid ranks the people needs in five categories: basic, safety, belonging, esteem and self-actualization.

Adapted for projects, the pyramid will look as follows:

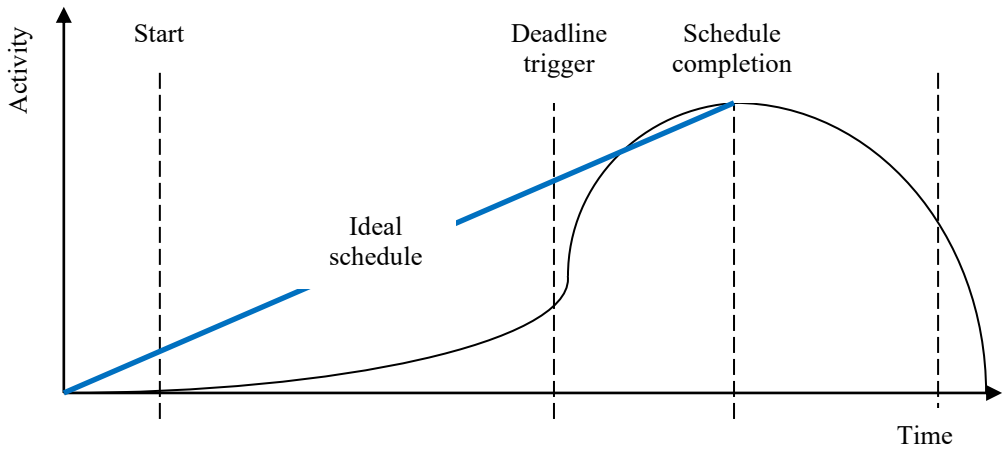


Any project needs resources (time and people) to fulfill it. People have to communicate and collaborate, because a project is a team effort. If the projects become more complex, the company has to revise the initial plans and adapt them to the current situation. Therefore, all the resources involved must be adapted to the present demands.

The project`s resources are always limited, so the people (managers, staff and workers) must be creative to keep the project on track.

The Critical Chain Method is based on the theory of constrains. According to Parkinson Law, the time to complete a task is the finishing time, not the start and finishing time.

Goldratt also invented the term of "The Student`s Syndrome":

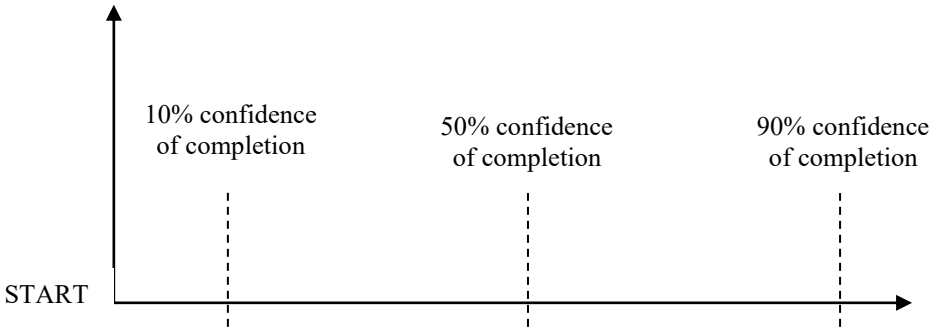


The students tend to postpone the study for projects or exams, no matter how much time they have. In the figure above, they have 7 days to accomplish a project. In an ideal situation, if they should spread the subject in 7 parts, the effort to accomplish the activity should be balanced.

However, if they know they have enough time, they will make a small effort the first 4 days, and then, the next 3 days they will work day and night to recover the lost time. The results will usually

be a lot of mistakes, bad results, and less of energy for the following exams. So, no matter how much time they have, they will start late and will exceed the schedule.

The same happens in project management. No matter how much time a manager allocates for a task, it`s never enough. This was the starting point of Goldratt`s idea, that, if an employee will start a task with a big delay, and he will still accomplish the job, but with a small delay, meaning that he has extra time allocated. Moreover, if a project has multiple tasks, it may be assumed that all of them have spare time.



According to Goldratt, the project manager should schedule each task at half of the computed duration and aggregate all the other halves of each task into a buffer at the end of the schedule. This buffer will be consumed along the project, if the deadlines are in jeopardy.

The main principle of the critical chain schedule is the aggregation of risk, meaning that if the project has a large pool of risk, the costs will be lower, and they may be kept that way until the buffer is empty.

When scheduling the project`s activities based on CCM, the planner will have to find the critical path, if the activities are performed in parallel. Then the activities` durations are reduced to half and the safety time will be deposit in the buffer.

The project`s buffer will protect the critical path and will be placed at the end of the last critical task.

The feeder buffer will protect the non-critical path and will be placed at the end of the last non-critical task. However, the feeder buffer duration must not exceed the critical path, so the amount will take this case into account.

There are some principles in using CCM:

- There are no milestones in scheduling, because most of the time they are not met.
  When analyzing a task, the manager assumes that each task will be performed in half time of the initial scheduling, and if something goes wrong, he/she will allocate the safety time only for activities that have delays.
  The statistics show that, at the end of the project, there will be an average of 25% economy of time.
- Contingency: when giving a duration to a task, frequently the people are observed and asked to describe the actions needed to be performed, along with the duration of each action.
  However, people aren`t honest in evaluating their work and tend to protect themselves from penalties if they don`t meet the deadlines. Therefore, they try to extend the time for completing their tasks. A more complicated situation occurs when teams must be scheduled in a project.
- People tend not to report the early completion of a task, because they don`t receive benefits or other incentives. But if there are delays on a task, the worker will pass them to next tasks.
- Only the project manager will allocate the safety time from the buffer, meaning that he/she will monitor and receive daily feedback on the progress of the project.

- Multitasking is the main danger of a project. A fragmented working day is time consuming because the worker will have to switch from one area to another, to prepare the working front, or to remember where he left earlier.
  In CCM, the worker or team will perform the same job till its completion.
  However, it`s complicated for the company`s management, who will have to invoice even for partial works. So, the tendency is to put the workers to perform something and to be able to invoice something. If, for example, the term of the contract stipulates that the owner will pay for works in progress, the manager has two choices:
    - To finish all the interior paintings (2 months duration) and invoice null in the first month and all in the second month;
    - To work 3 weeks of the first month on interior paintings and 1 week on exterior cladding, so he may invoice both works.

  In the Critical Chain Method, only the first variant is permitted.
  Another choice is to hire more workers to complete both tasks. It`s risky if this isn`t based on the calculation of the optimum number of workers. If the area is too crowded, the effect of this action will be reverse: they will annoy one another, and the productivity will decrease.

However, in order to be certain that the buffer will be enough for all situations, some contingency durations generated by contingency costs should be considered, such as:

- Incomplete designs;
- Construction disturbances: accidents, breakdowns;
- Changes in market conditions;
- Estimating errors;
- Technological changes;
- Omissions;
- Unusual schedule risks: unavailable materials, labor or equipment; uncertainty in contractor stability; unavailable facilities.

How will this method work?
In a simple project, with a team that will execute three activities, one possibility is to perform the first one till its completion, then the second, and finally the third.

Activity A
Activity B
Activity C

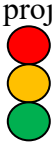
The CCM will reduce the duration at half and will schedule the team to perform part of each activity, in order to invoice each activity in progress.
The result will be a buffer of safety time.

Buffer
Lag

However, moving from one sector to another to perform the multitasks, there is a lag in completing the project tasks. Still, there is a buffer which may be used by the project manager if delays occur.
Based on the principle of eliminating multitasking for the team members, the buffer increases because there is no lagging.

First, the team will finish activity A, then it will move to the next sector to perform activity B, and finally it will execute activity C. No invoice will be issued until each activity will be finished.
If the same team will work for all the project`s activities, there is no problem in scheduling. But in complex projects, there are specialized teams for each task. In our example, that means that the

team responsible for activity B should wait till activity A is finished, and the team responsible for activity C should wait till all predecessors' end. Therefore, the manager will have to choose the appropriate method of scheduling accordingly.
If using the CCM, the amount of the buffer will give information on the actions to be taken by the project management:



ACT! Buffer used more than 66%
PLAN! Buffer used up to 66%
WATCH! Buffer used up to 33%

7.6. LEAN CONSTRUCTION

The principle of lean construction is to provide maximum value for the client with minimum waste.

Staying in contact with the client will ensure both the quality of the project and the demands of the beneficiary in terms of functionality, gadgets, etc. The contractor can also advise the customer based on his/her previous experience.
Phases on lean construction:

- Identifying the client`s values:
  By understanding the client`s values, the contractor can plan the processes to achieve them. He/she will identify the activities needed to fulfill the project and will choose the suitable materials, technologies and workforce.
- Waste minimizing:
  There are eight major categories of waste which should be minimized or eliminated in the project`s activities:
  - Defects: everything which is not performed as required should be repaired.
  - Overproduction: it occurs when the workers finish their tasks earlier than planned and have to wait for the next task.
  - Waiting: this delay appears when the supplying with materials doesn`t respect the project`s schedule. It also occurs when the workforce is wrong planned, and the sectors are not empty when a team is scheduled there.
  - Not utilizing talent: it occurs when the workers don`t have the needed knowledge and skills to perform the tasks.
  - Transport: wrong planning of the materials and equipment for the work site (too soon or too late).
  - Inventory: the materials and equipment should arrive "just in time", not "just in case".
  - Motion: the workers should perform the jobs during the working schedule and not lose time in getting to the location or taking the needed materials and equipment.
  - Excess processing: it occurs when more than one process generates wastes.
- Achieving flow for work processes:
  Each activity should be scheduled in a logical flow, in connection with the overall project. No task should start or finish earlier or later than schedule. Therefore, communication is essential between all the participants to the project, both managers and workers.
- Using pull planning and scheduling:
  Pull planning is performed by communication between the contractor and all the subcontractors for perfect alignment of activities` sequences.
- Perfecting the processes through continuous improvement:
  The previous experience stands as base for new projects in order to find ways to improve the processes and eliminate waste. Innovation should be encouraged.

COURSE 8
CALCULATION OF DURATIONS FOR THE CONSTRUCTION WORKS

8.1. INTRODUCTION

A construction project has specific features which differentiates it from other projects. One of them is the relatively long duration of execution, that involves activities connected in a logical and realistic way.

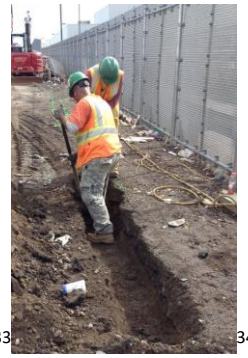
For an accurate estimation of time, the manager, who usually is responsible for the schedule of the projects, will group the simple activities in complex packages, in order to have efficiency in the monitoring of their progress.

Here are some examples of complex activities, which, by their completion in a logical order, will lead to the achievement of a certain element of construction or a chapter of works:

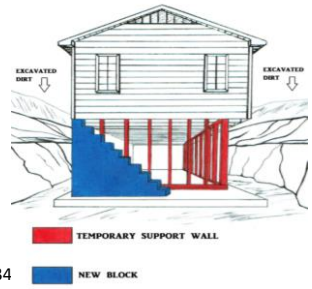
a. Execution of foundations

 [33]

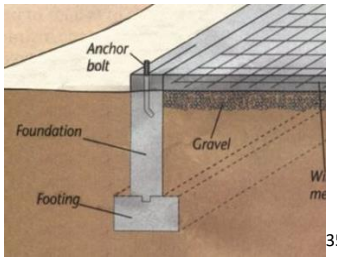
Mechanized digging

 [34]

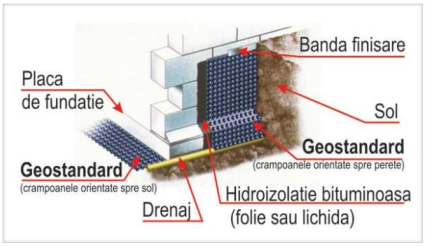
Manual digging

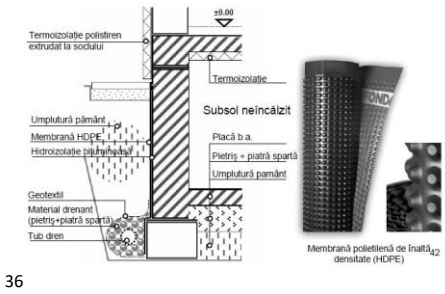


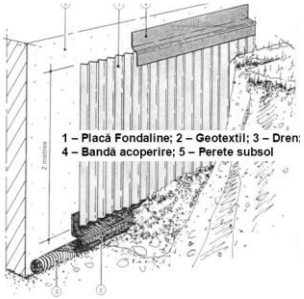
Support wall


[35]

Concrete pouring




[36]



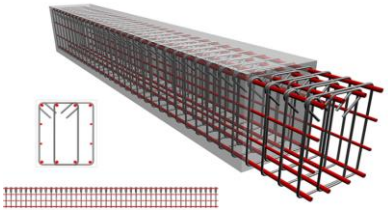
Insulating the foundations

[33] https://www.perrinconstructionredding.com/blog/2019/4/17/essential-steps-to-a-successful-excavation-project, accesat în data de 23.10.2024
[34] https://www.flickr.com/photos/mtacc-esa/25961088535/in/photostream/, accesat în data de 23.10.2024
[35] https://grahamsmallman.wordpress.com/2016/09/24/wisdom-is-supreme/, accesat în data de 23.10.2024
[36] https://casaideala.wordpress.com/cu-ce-si-cum-construim/, accesat în data de 23.10.2024

c. Execution of beams

 [37]

Formwork and support

 [38]

Beam reinforcement

 [39]

Concrete pouring

c. Site organization

 [40]

Access road

 [41]

Lockers, offices

Material warehouse

In order to estimate the duration for execution a construction objective, all the activities have to be evaluated, no matter if they are simple or complex.

The parameters of the construction activities may be differentiated according to their types, as follows:

a. Parameters of organizational and office activities:

- Are specific for the non-productive staff, meaning the site manager, the foreman or the team leaders;
- There are no standardized norms, because each project has different approaches;
- The activity duration (t_i) is expressed in working days and is evaluated from the experience of previous works;
- Depending on the level of complexity and the activity duration, the cost of the activity (c_i) will be calculated as a component of the estimate.

[37] https://www.google.com/imgres?imgurl=https%3A%2F%2Flntsufin.com%2Fstorage%2Fmediafiles%2Fcatalog%2Flive%2F16101-6128%2Foriginal%2F16101-6128_image_1.jpg&tbnid=1pAFHmqt0VlpeM&vet=1&imgrefurl=https%3A%2F%2Flntsufin.com%2Fproduct%2Fsuraksha-shuttering-plywood-film-faced-2440-x-1220-mm-12-mm%2F16101-6128&docid=8ORF1OE3ahE_FM&w=250&h=166&hl=en-US&source=sh%2Fx%2Fim%2Fm1%2F4&kgs=a1f1fd4b87b14171&shem=isst, accesat în data de 23.10.2024

[38] https://debug.pi.gr/default.aspx?ch=15, accesat în data de 23.10.2024

[39] https://www.camfaud.co.uk/managing-a-pump-pour/, accesat în data de 23.10.2024

[40] https://www.google.com/imgres?imgurl=https%3A%2F%2Flookaside.fbsbx.com%2Flookaside%2Fcrawler%2Fmedia%2F%3Fmedia_id%3D666061023438258&tbnid=Z822rUD2t3In5M&vet=1&imgrefurl=https%3A%2F%2Fwww.facebook.com%2Fp%2FJmdr-infra-projects-pvt-ltd-100081892631415%2F&docid=euXI5HG5WByapM&w=276&h=183&hl=en-US&source=sh%2Fx%2Fim%2Fm1%2F4&kgs=18c9c10406756ece&shem=isst , accesat în data de 23.10.2024

[41] https://2249-ao.all.biz/limpesa-refeitrios-s5286, accesat în data de 23.10.2024

b. Parameters of production activities:

- Are based on the Standard Norms of Estimate;
- Will be normed based on the quantities of works performed (Q_i), as follows:
  - For simple activities, the bill of quantities will express the quantity of works to be executed (Q_i).
    For example, the execution of formworks for a column with dimensions (L x l x h)
    0.50m x0.50m x3.00m,
    Q_i = 6.00 MP;
  - For complex activities, the quantities of works Q_i will be calculated for each type of activity.
    E.g.: the execution of a column with dimensions (L x l x h)
    0.50m x0.50m x3.00m

The simple activities of the complex activity are: formworks, reinforcement, and concrete pouring:

- Formworks: Q_{i1} = 6.00 square meters of formworks
- Reinforcement: Q_{i2} = 30.00 kg reinforcement
- Concrete: Q_{i3} = 0.75 cube meters of concrete

- The duration of the activity (t_i) is calculated for each activity (simple or complex) based on the quantities of works needed (Q_i), The value will be expressed in days, weeks, months or years.
- The number of workers (N_m) needed for manual processes will be established based on the quantities of works (Q_i) and the duration of the process (t_i), as follows:
  - For simple activities, N_{mi}
  - For complex activities, $N_{mi} = N_{mi1} + N_{mi2} + \ldots$.
- The number of equipment (N_u), needed for mechanized processes, will be established based on the quantities of works (Q_i) and the duration of the process (t_i), as follows:
  - For simple activities, N_{ui}
  - For complex activities, $N_{ui} = N_{ui1} + N_{ui2} + \ldots$.

The resources which have to be scheduled in the construction projects may be of two types: the building materials, the project staff, and the prefabs are considered passive resources, while the workers and equipment are active resources. The active resources are the most important, so they should be scheduled very accurate.

The duration of a construction project depends on some items, as follows:

- The costs/value of the construction
- The type of the construction:
  - The product: dwelling, skyscraper, plant, etc.;
  - The technical parameters: height, spans, floor area, etc.;
  - The quality of the project and the execution;
  - The complexity of the construction.
- The location.
- The productivity:
  - Managerial productivity: motivation, abilities, systems;
  - Organizational productivity: structure, style, informational systems;
  - Labor productivity: motivation, skills, work systems;
  - Technology productivity: equipment (age, level of technology).
- Type of contract:
  - Risk allocation: e.g. Inflation;
  - Tenderer selection method: Open, Prequalification, Selection, etc.;
  - Management structure: Traditional, Design build, etc.;
  - Payment: Fixed price, Cost plus, etc.

In practice, in the construction industry, there are three distinctive situations for which the activities` parameters are calculated, as follow:

8.2. CALCULUS OF ACTIVITY`S PARAMETERS WHEN THE DURATION (t_i) IS IMPOSED

It`s one of the most common constrains in the construction projects, because the beneficiary wants to make profit from the investment as soon as possible, and to get the return of the investment very quickly.

In this situation, the most important element to win the contract might be the finishing time of the project.

In order to get the list with the resources needed, the first step is the analyze of the activities which will be performed and splitting them in simple or complex ones, for an accurate monitoring.

The manager, together with the project team, will compute the resources involved, based on the constraining element, (t_i). The number of workers (teams) (N_{mi}) and the number of equipment needed to achieve the project (N_{ui}) will be estimated, using the following formulas:

$$t_i \text{ (days)} = \frac{Q_i \times NT_i}{8 \times N_{mi} \times \rho_{pi}}$$

$$N_{mi} = \frac{Q_i \times NT_i}{8 \times t_i \times \rho_{pi}}$$

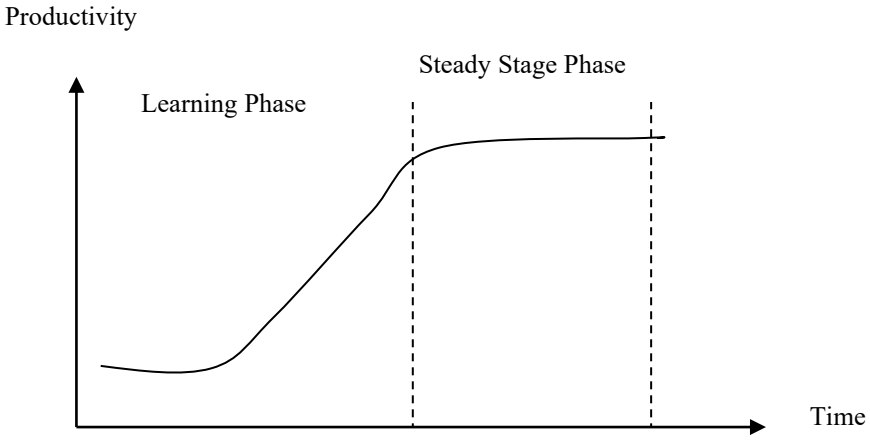
Where:

- Q_i is the quantity of works from the quantity take-off;
- NT_i is the team norm taken from the Norm Indicators for the process "i". It`s measured in hours for each specialized team recommended by the Indicator. When the Indicator doesn`t provide this data, the manager will calculate local norms.

These formulas are adequate for almost all the activities. The planner will decide on the number of specialized crews and will have the freedom to modify it according to the project`s specifications and time constrains.

The calculus by the formula above is only an approximation, for some reasons:

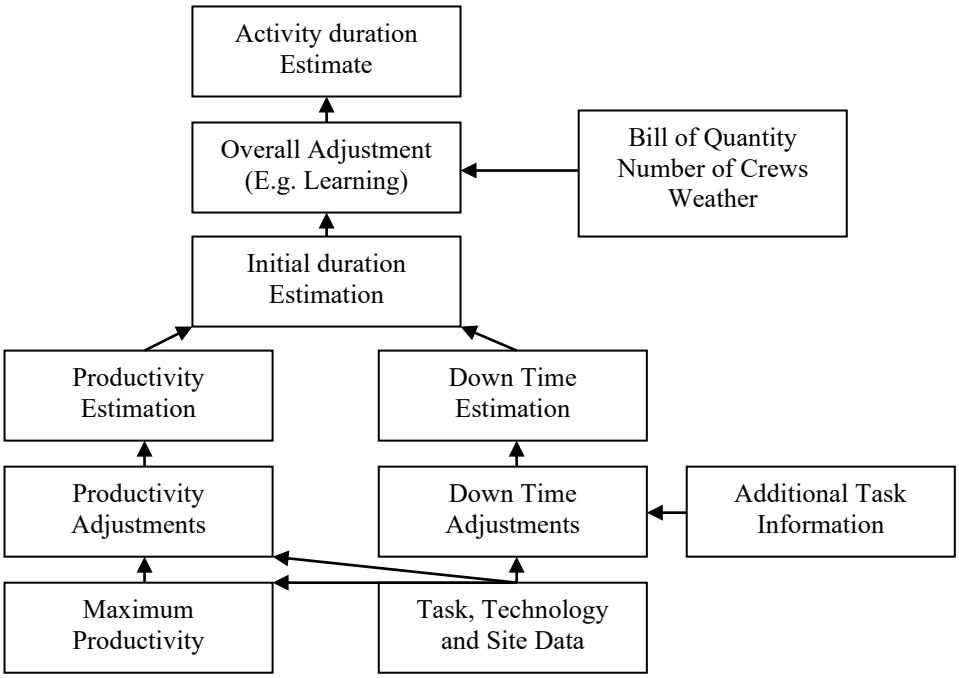
- The Norm Indicator provides the team`s productivity in normal working conditions. But each project has its main features, like: the proximity to the resources, the technology used for completing the activities, and so on. Therefore, the norms will be adjusted accordingly;
- The productivity rate differs according to the specialization of the team members, like in the figure below:



At the beginning of the specialization, the team will work slow, they will learn what to do and how to do, in terms of quality and time (learning phase). In time, the productivity increases, and they will perform better. The planner will have to take this situation very seriously.

- Weather is another important factor in the scheduling process. Since the norms will give the productivity for normal conditions, the planner should adjust them based on the historical data of the weather forecast (rain, snow, heat, wind, etc.). He/she will have to give extra days if the schedule meets these weather constrains.

When scheduling the activities` durations, all these aspects must be analyzed and adjusted according to the project`s specifications (https://theconstructor.org):



a. For manual processes:

a.1. Simple processes

$$t_i \text{ (days)} = \frac{Q_i \times NT_i}{8 \times N_{mi} \times \rho_{pi}} \text{ (imposed)}$$

$$N_{mi} = \frac{Q_i \times NT_i}{8 \times t_i \times \rho_{pi}}$$

Where:

- Q_i is the quantity of works from the quantity takeoff;
- NT_i is the duration norm coming from the Norm Indicator, for the process "i". It is quantified in hours for each crew recommended by the Norm Indicator. When it doesn`t provide these data, the project manager will calculate local norms;
- $Q_i \times NT_i$ represents the total volume of workmanship for a specific article of the estimation;
- 8 (or, if case requires, 10, 12, 16 or 24) is the number of hours for one, two or three shifts and stands as base for the timekeeping of the specialized crew of workers, depending on the type of the performed activity. The working conditions or the weather will impose that value;
- ρ_{pi} is the index of achieving the norm, planned for the activity "i". Its value (sub or supra unitary) will correct the norm according to the comparison between the yield based on the Norm Indicator and the effective yield of the workers. If the value is sub unitary, it means that the technology chosen or the planned number of

workers doesn`t allow the achievement of the activity with that yield. Similarly, the norm will be corrected by supra unitary ρ_{pi} if the planner notices a higher yield than that from the Norm Indicator;

- $8 \times t_i \times \rho_{pi}$ is the volume of work achieved by the crew of workers in a normed working day (8-hour shift with a yield similar with the one in the Norm Indicator).

a.2. Complex processes

The planner will compute the number of workers for each activity, by the formulas:

$$N_{m1} = \frac{Q_{i1} \times NT_{i1}}{8 \times t_i \times \rho_{pi1}}$$

$$N_{m2} = \frac{Q_{i2} \times NT_{i2}}{8 \times t_i \times \rho_{pi2}}$$

$$N_{mi} = \sum N_{mi1} + N_{mi2} + ...$$

b. For mechanized processes

b.1. Simple processes

$$t_i \text{ (days)} = \frac{Q_i \times NTU_i}{8 \times N_{ui} \times \rho_{pi}} \text{ (imposed)}$$

$$N_{ui} = \frac{Q_i \times NT_i}{8 \times t_i \times \rho_{pi}}$$

Where:

- NT_i is the norm of time for the equipment, taken from the Norm Indicator for the specific article;
- ρ_{pi} is the yield of the equipment, compared with the one from the Norm Indicator;
- $Q_i \times NTU_i$ is the total number of hours for the equipment;
- $8 \times Nu_i \times \rho_{pi}$ is the amount achieved by N_{ui} in a working day (8 hours).

b.2. Complex processes

$$N_{ui1} = \frac{Q_{i1} \times NT_{i1}}{8 \times t_{i1} \times \rho_{pi1}}$$

$$N_{ui2} = \frac{Q_{i2} \times NT_{i2}}{8 \times t_{i2} \times \rho_{pi2}}$$

$$N_{ui} = \sum N_{ui1} + N_{ui2} + ...$$

These estimations are achieved, as mentioned, in limiting conditions, in which the duration (t_i) to execute the construction project is imposed.

After calculating the number of workers (or equipment) needed to perform the activities in an imposed duration, the following analyses are made:

☑ Checking the working front regarding the needed conditions to achieve the activity: the possibility of access, the existence of utilities, its release by the previous crew of workers, and others;

☑ Checking the saturation degree of the enclosure: according to the type of action for the activity, each worker needs an average of 10 m^2 of maneuvering space;

☑ Checking the possibility of access for the equipment needed for a specific activity in the working area.

If, by making the checking, the planner notices that the activity cannot be performed in optimum conditions of productivity, quality and safety, changings will be made, like:

✯ If the area is supersaturated with workers, the planner will choose to schedule two or three shifts;

- ✯ The working schedule may be changed from 8 to 10 hours, depending on the season or the weather conditions of the zone;
- ✯ If none of these variants are possible, an agreement with the beneficiary will allow for a changing in technology: more performant equipment, semi or prefabricates, mechanization for activities which can be done like that, etc.

8.3. CALCULUS OF THE PARAMETERS OF AN ACTIVITY WHEN THE NUMBER OF WORKERS (CREWS) (N_{mi}) IS IMPOSED:

Another constraining situation occurs when the construction company has a limited number of workers to complete a certain project. The duration for achieving the activities will be calculated according to this constrain.

a. Simple processes:

$$N_{mi} = \frac{Q_i \times NT_i}{8 \times t_i \times \rho_{pi}}$$

$$t_i = \frac{Q_i \times NT_i}{8 \times N_{mi} \times \rho_{pi}}$$

b. Complex processes:

$$N_{mi1} = \frac{Q_{i1} \times NT_{i1}}{8 \times t_{i1} \times \rho_{pi1}}$$

$$N_{mi2} = \frac{Q_{i2} \times NT_{i2}}{8 \times t_{i2} \times \rho_{pi2}}$$

$$N_{mi} = \sum N_{mi1} + N_{mi2} + \ldots$$

If the time to achieve the construction objective is too large, some corrections can be done, like follows:

- ✯ If the working area is supersaturated with workers, the solution might be to work in two or three shifts;
- ✯ The working schedule may be changed from 8 to 10 working hours, depending on the season and the climate characteristics of the area;
- ✯ If none of these variants are possible, an agreement with the beneficiary will allow for a changing in technology: more performing equipment, semi or prefabricates, mechanization for activities which can be done like that, etc.

8.4. CALCULUS OF THE PARAMETERS FOR AN ACTIVITY WITH NO CONSTRAINS

This is an ideal situation, when the beneficiary of the construction project doesn`t impose a limited duration for the achievement of the objective, and the contractor doesn`t have limitations regarding the number of workers.

However, even without constrains, the project manager will consider a minimum duration. Like in previous hypothesis, the construction works may have simple and complex activities and processes.

a. Simple processes:

$$t_i = \frac{Q_i \text{ x } NT_i}{8 \text{ x } N_{mi} \text{ x } \rho_{pi}}$$

The planner will choose the number of workers N_{mi} for a saturated working area. Then he will compute the duration for the simple activity t_i .

If possible, the duration should be minimized by changing the technology or by using materials that might shorten the duration of execution.

b. Complex processes:

If complex processes occur, formed by several simple activities (Q_{i1}, Q_{i2}, ...), first of all the planner will decide for the leading process, which is the most important one in term of resources, and then he will calculate the secondary processes.

For the leading process, the planner will compute the duration of execution t_{ic}, considering the available number of workers N_{mic}, on specializations.

$$t_{ic} = \frac{Q_{ic} \text{ x } NT_{ic}}{8 \text{ x } N_{mic} \text{ x } \rho_{pic}}$$

Then the planner will set the number of workers for each simple process, using as reference duration the time for execution of the leading process t_{ic}.

$$N_{mi1} = \frac{Q_{i1} \text{ x } NT_{i1}}{8 \text{ x } t_{ic} \text{ x } \rho_{pi1}}$$

$$N_{mi2} = \frac{Q_{i2} \text{ x } NT_{i2}}{8 \text{ x } t_{ic} \text{ x } \rho_{pi2}}$$

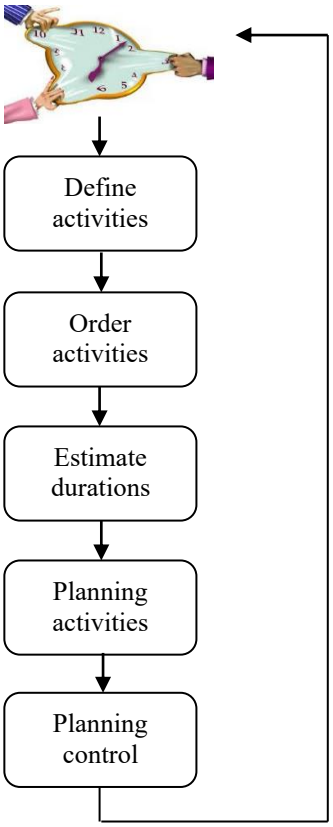
$$N_{mi} = \sum N_{mi1} + N_{mi2} + \ldots$$

If the working area is supersaturated, the number of workers will be shortened for the leading process N_{mic} and the calculation will be reiterated with this number.

COURSE 9
DRAWING UP THE TIMETABLE

9.1. INTRODUCTION

The main idea in planning the activities of a construction project is developed from its definition: a construction project is a temporally action designated to get products and/or services.



Defining the activities is the first step in determining the duration for achieving the project. It is also the starting point for calculation the budget, in terms of resources like materials, human resources, technology and others.

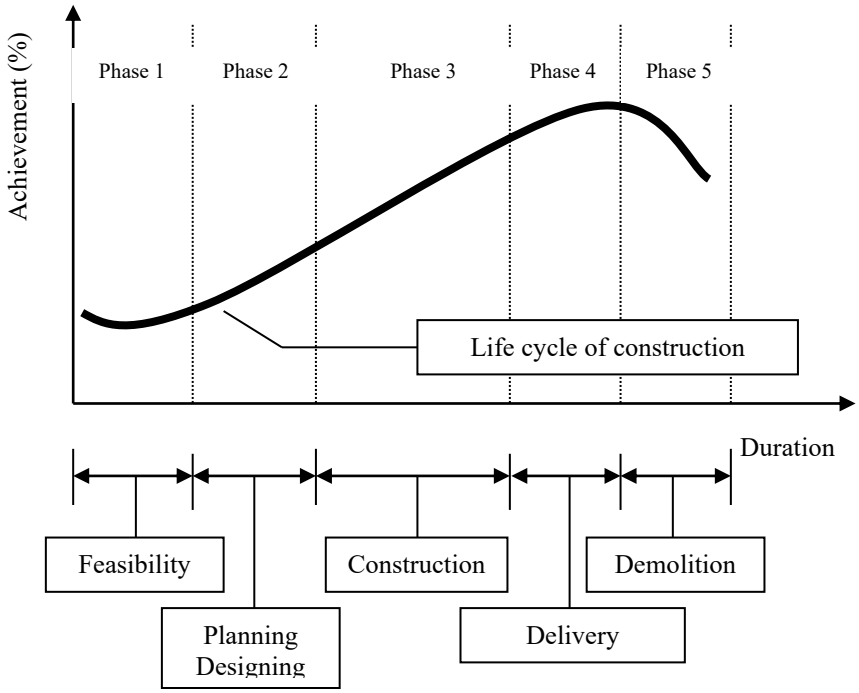
After defining the activities, they have to be scheduled in a logical order for an accurate planning of the project.

The durations for each activity should be computed in connection with the project`s constrains, as shown in the previous chapter. The sum of the activities` durations will set the total duration of the development of the project.

Drawing the timetable means the planning of all activities needed for the project accomplish. Then the plan should be adjusted by considering all the aspects regarding the location, the suppliers, and so on.

9.2. THE LIFE CYCLE OF A CONSTRUCTION

The construction projects lean on the overall principles of management, based on the product`s life cycle. A graphical representation is very suggestive for supporting this management concept:



- Phase 1: Defining the project

  After performing the feasibility studies, the investor decides on the type of the building he/she wishes to achieve. The team will establish the location, the destination, the structure, the level of finishing and other features. This phase will end with the concept of the overall project of the objective.

- Phase 2: Designing and planning the investment

  This is the beginning of the investment phase, in which, through negotiation, the designing and execution contracts will be awarded by bidding or direct custody. The result of this phase will be signing the contracts (with contractors and sub-contractors if necessary).

- Phase 3: The execution of the construction

  The construction activity begins with the supply of the main resources needed for achieving the project. The process of achieving the project will be developed according to the planning agreed and accepted through the contract. The phase will end by the final reception of the project.

- Phase 4: Delivery of the project

  The construction, already received, will get the planned destination and will be exploited according to the demand and regulations.

- Phase 5: Demolishing or rehabilitation

  After the calculated life cycle of the construction have expired, the objective has to be demolished or modified.

  From this point of view, "the life" of a construction may be classified in two categories:

  - "The physical life", meaning the time between the moment when the building is achieved and the one when the building doesn`t fit the resistance prescriptions. However, because the building has important schedule and costs, the investor is interested in extending its service life. Consequently, he/she may adopt measures such as:
    - Structural rehabilitation: restoring or increasing the structural capacity of some construction elements;

- Functional rehabilitation: partitioning according to the new requirements of the project.

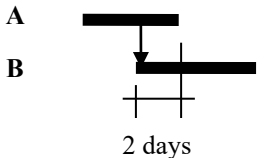
- "The economic life", meaning the time between the moment of the construction and that of economic depreciation.
  - Economic depreciation occurs when a building needs changes in order to satisfy the exigency of its users;
  - Technical depreciation occurs when some construction elements no longer satisfy the requirements of safety in its exploiting (degradation, damage, and others);
  - Moral depreciation occurs when the building as a whole, even if it`s satisfactory in terms of resistance, no longer meets the actual needs of design or comfort of the users.

9.3. SETTING THE ACTIVITIES AND THE TYPE OF LINKS

When planning the activities for a construction project, there are three types of links between them:

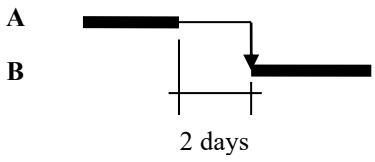
a. Finish to Start Dependency
This graphical design shows that Activity B cannot begin unless Activity A is finished.

For example, pouring the concrete cannot begin unless the formworks and the reinforcement are finished.
The activities may have some leads or lags depending on the processes involved:



Excavating (A)
Formworks for foundation (B)

The workers don`t have to wait till all the excavation is done (Activity A) but can start placing the formworks for the foundations (Activity B) as soon they have enough working area to perform, repenting safety conditions (e.g. 2 days lead).



Concrete slab pouring (A)
Wall finishing (B)

For better understanding, let`s say we have five activities.

Activity	Predecessor	Duration
A	-	2
B	A (FS)	4
C	B (FS +2)	3
D	C (FS – 1)	5
E	D (FS)	1

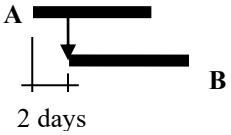
If we draw the timeline, it will look like:

A																
B																
C																
D																
E																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

b. Start-to-Start Dependency

In this type of dependency, activities A and B may begin at the same time, or with a lag of few days.

Formworks on sector 1 (A)
Formworks on sector 2 (B)



Manufacture of rebars (A)
Placing rebars (B)

For better understanding, let`s say we have five activities.

Activity	Predecessor	Duration
A	-	3
B	A (FS)	2
C	B (SS +1)	4
D	C (FS – 1)	5
E	D (SS – 1)	7

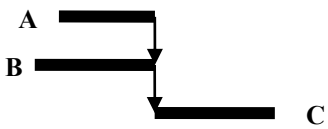
If we draw the timeline, it will look like:

A																
B																
C																
D																
E																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

c. Finish-to-Finish Dependency

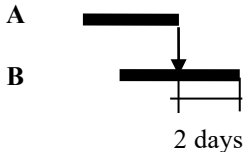
Activities A and B will be finished in the same time, or with a lag of few days, so the next activity (C) should begin.

As an example, concrete will be poured only after the formworks and reinforcement in beams and slab are done.



Formworks and reinforcement of beams (A)
Formworks and reinforcement of slab (B)
Pouring concrete in beams and slab (C)

The finish-to-finish dependency may have some lag, as in the situation of putting drywalls in a building. First the metallic structure must be fixed (Activity A); placing the drywalls (Activity B) mustn`t wait until Activity A is finished but may begin with a lag of 2 days.



Fix the skeleton (A)
Place drywalls (B)

For better understanding, let`s say we have five activities.

Activity	Predecessor	Duration
A	-	1
B	A (FS)	2
C	B (FS +1)	4
D	C (FF + 1)	3
E	D (FS)	5

If we draw the timeline, it will look like:

A																
B																
C																
D																
E																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

9.4. TABLE WITH THE DEPENDENCY BETWEEN TASKS

A construction project requires a correct planning, elaborated in concordance with the tasks that are involved in the delivering process. Therefore, dependencies of the activities (tasks) may be grouped in some categories:

a. By the type of the tasks:
- Technological dependencies, in which the tasks are inter-conditioned and in succession (E.g. pouring concrete cannot be scheduled unless the formworks and reinforcement are completed);
- Organizational dependencies, which are needed for the site organization (E.g. the resistance structure cannot be performed unless the crane is located).

b. By conditioning:
- Conditioned tasks;
- Unconditioned tasks.

c. By the type of dependency:
- Rigid dependencies, which are compulsory and cannot be changed during the work flow;
- Elastic dependencies, which are optional.

d. By the structure of the dependency:
- Finish-to-Start dependency;
- Start-to-Start dependency;
- Finish-to-Finish dependency;
- Start-to-Finish dependency.

Understanding the type of the dependency is important in establishing the duration of execution for a construction project. Planning the tasks has implications also on the allocated resources. Therefore, the steps in planning will be:

- Detailing the tasks;
- Calculating the durations for each task;
- Allocating resources (materials, human resources, technology);
- Determining the predecessors and successors;
- Establishing the types of dependencies between tasks;
- Computing the lags between tasks.

No.	Name of the task	t_i (days)	Resources needed	Predecessors	Type of dependency	Lag t_i (days)
1.	Marking the plan	1	2 carpenters	START	-	-
2.	Site organization	2	2 carpenters 2 unskilled 1 bulldozer	Marking	F - S	-
3.	Mechanical digging	3	1 excavator	Marking	F - S	-
4.	Manual digging	4	4 unqualified	Mechanical digging	F - F	2
5.	Foundations	3	2 carpenters 2 smiths 2 concreters 2 unskilled	Mechanical digging Manual digging	F - S	-
6.	Footings	4	2 carpenters 2 smiths 2 concreters 2 unskilled	Foundations	F - S	-
7.	Fillings	2	4 unqualified	Footings	F - S	-
8.	Slab 0.00 level	4	2 carpenters 2 smiths 2 concreters 2 unskilled	Fillings	F - S	-
9.	Columns sector 1	2	2 carpenters 2 smiths 2 concreters 2 unskilled	Slab	F - S	-
10.	Columns sector 2	2	2 carpenters 2 smiths 2 concreters 2 unskilled	Columns sector 1	S - S	-
11.	Beams sector 1	4	2 carpenters 2 smiths 2 unskilled	Columns sector 1 Columns sector 2	F - S	-
12.	Beams sector 2	4	2 carpenters 2 smiths 2 unskilled	Columns sector 1 Columns sector 2	F - S	-
13.	Slab floor 1	4	2 carpenters 2 smiths 2 unskilled	Beams sector 1 Beams sector 2	F - S	-
14.	Concrete pouring in beams and slab	1	2 smiths 2 concreters 2 unskilled	Slab floor 1	F - S	-

9.5. GANTT CHART

This empirical method, based on the project manager`s experience, uses bars to represent the planning of the construction works in their logical succession, through dependencies.

No.	Name of task	Resources	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
1	Marking the plan	2 carpenters																																	
2	Site organization	2 carpenters																																	
		2 unqualified																																	
		1 buldozer																																	
3	Mechanical digging	1 excavator																																	
4	Manual digging	4 unqualified																																	
5	Foundations	2 carpenters																																	
		2 smiths																																	
		2 concreters																																	
		2 unqualified																																	
6	Footings	2 carpenters																																	
		2 smiths																																	
		2 concreters																																	
		2 unqualified																																	
7	Fillings	4 unqualified																																	
8	Slab 0.00 level	2 carpenters																																	
		2 smiths																																	
		2 concreters																																	
		2 unqualified																																	
9	Columns sector 1	2 carpenters																																	
		2 smiths																																	
		2 concreters																																	
		2 unqualified																																	
10	Columns sector 2	2 carpenters																																	
		2 smiths																																	
		2 concreters																																	
		2 unqualified																																	
11	Beams sector 1	2 carpenters																																	
		2 smiths																																	
		2 unqualified																																	
12	Beams sector 2	2 carpenters																																	
		2 smiths																																	
		2 unqualified																																	
13	Slab floor 1	2 carpenters																																	
		2 smiths																																	
		2 unqualified																																	
14	Concrete pouring	2 smiths																																	
		2 concreters																																	
		2 unqualified																																	

When representing the Gantt chart, there are two main parts: the left one, containing the list of activities, which are usually grouped in their logical and chronological order of completion. It also shows the resources needed to perform the tasks. The right part is the planning of the tasks, represented by bars. The length of the bar is expressed in time units: hours, days, weeks, months, or years.

There are advantages and disadvantages when drawing this type of planning a construction project.

Advantages:

- The drawing is easy to understand;
- The progress of the works shows the delays, if there are any;
- The relation between tasks are explicit;
- Deadlines are clear;
- It can be used both for monitoring and control.

Disadvantages:

- No quantities of works are shown;
- No production rates are visible;
- It`s not possible to see the sub-activities of an activity;
- No forecasts on the production rates are possible.

In order to draw the Gantt Chart, some steps should be followed:

- Identify the tasks which have to be performed for delivering the project. Use the WBS for this phase, then estimate the duration for each task;
- Establish the relationship between the tasks: finish-to-start, start-to-start, finish-to-finish;
- Revise the chart as often as needed.

The Gantt chart is designed after using a certain method of planning, like PERT or Critical Path Analyze. Critical activities will be highlighted, as well as the resources that might be optimized.

COURSE 10
CRITICAL PATH METHOD (CPM)

10.1. INTRODUCTION

In a competitive market, the organizations use the opportunities existing in the sector where they perform. They must be flexible in order to be able to adapt to the challenges coming from the environment. Therefore, in the last years, the companies moved from a function-based organizational structure to a project-based one.

Every organization has as its main objective to achieve success through the activities it carries out. But it depends entirely on the strategy that sets the goals. The 80:20 Rule (Pareto Principle) states that 80% of the efforts are focused to get 20% of results. In terms of project management, one may consider that the manager spends 80% of the working time for solving 20% of the important tasks of the project[42].

Project management has become a critical success factor for the organizations, no matter the area of activity. One of the elements that define a competitive project is the duration to achieve it. Different models of representation have been applied for optimizing this parameter. Morgan R. Walker and James E. Kelly are the inventors of the Critical Path Method in 1957.

For better understanding the terms of this management`s concept, there are some definitions of CPM.

"In project management, the critical path is a chain of elements of a network with the longest global duration, which determines the shortest durations of the activities that are involved in the project's completion[43]".

"The Critical Path Method is the technique of project analyze through determining the longest sequence of activities in a network of tasks of a project[44]".

"The activity is a set of specific tasks or a single task, required to be executed for achieving a certain project. All the activities are interconnected, and these links are called conditionalities of the project[45]".

The critical path, as suggested by the name, is the route between the critical activities, the ones with no time floats, meaning the longest path between the project`s activities. In fact, it`s a sequence of activities, whose durations will give the total maximum time for completing the project.

This method of scheduling the construction projects, especially for repetitive and routine tasks, has pros and cons:

a. Pros:

- A complete list of activities is carried out, for all the tasks to be achieved from the beginning of the project. Therefore, all the company`s departments should cooperate in order to meet the project`s goals;
- The duration of all tasks is computed, on work phases or physical stages;
- By determining the critical path, the project manager may analyze every constrain that may occur along the project, even before its start. This is a real advantage, especially for situations when more tasks depend on the same resources (workers, equipment or machineries);
- The relation between cost and time for achieving the project may be optimized. In case of limitations of the budget, the duration will be adapted accordingly;

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[42] Stelth, P., Guy Le Roy, "*Project`s Analysis through CPM (Critical Path Method)*, School of Doctoral Studies (European Union) Journal, July 2009, No. 1, pg. 11

[43] www.businessdictionary.com/definition/critical-path.htm, accessed 12.11.2012

[44] www.iiuedu.eu/press/journals/sds/sds1.../05_SECC_01.pdf, accessed 12.11.2012

[45] Archibald, R., Villoria, R., *Network-based systems (PERT/CPM)*, Wiley, New York, 1966

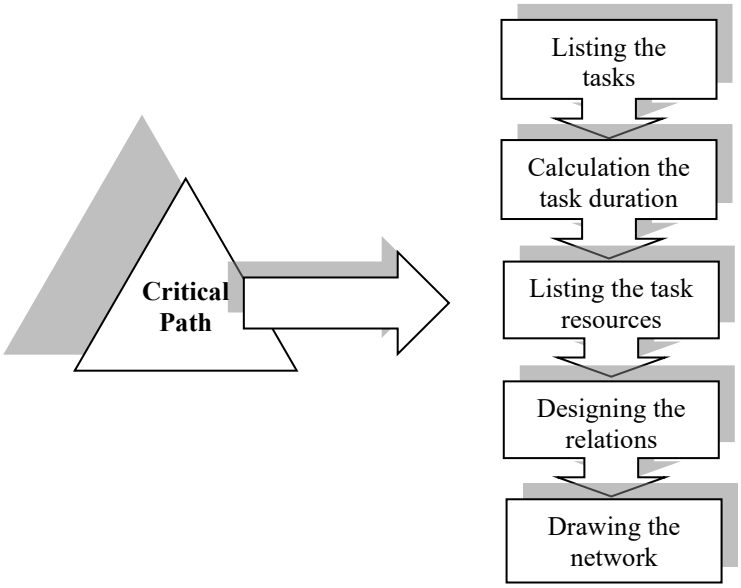
- The diagram of activities may be changed anytime along the project development, when critical situations occur. However, for this type of events, a reschedule is required for the whole chain of activities which are planned to be completed after the incident;
- In large projects, there may be more critical paths. In this situation, the diagram will help the managers to focus on the action plans of all these issues.

b. Cons:

- The critical path is rather difficult to design for large projects which don`t have routine or repetitive activities. The diagram will become complicated when there are too many links and dependencies;
- When there are more critical paths, it`s hard to estimate which are the strongest constrains, especially when these paths are performed in parallel and the organization has a limited amount of resources to be used at the same time;
- As the project evolves, some critical moments may occur, therefore the manager and his/her staff will have to review the diagram constantly;
- For projects with a long execution duration (more than 3 years), the organization`s personnel might fluctuate, which cannot be planned. In such critical situations, the company needs time to replace the human resources, because the newcomers will have to be trained and integrated. These activities are not found in the initial schedule.

10.2. PHASES OF THE CRITICAL PATH

In order to plan the project using the Critical Path Method, some phases have to be completed, as follows:



The first phase is to establish the tasks needed for the project completion. They may be divided in sub-tasks if the scheduling is more suggestive.

The next step is to calculate the duration for each task or sub-task, using the formula explained on the previous chapter. The duration will depend on the number of teams and equipment afforded by the organization.

The resources will be listed for each activity, in order to link them with the project`s budget and quality.

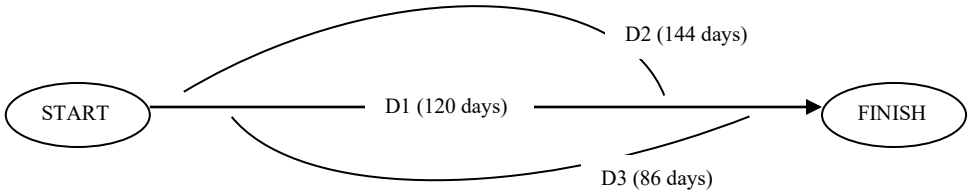
A very important phase is establishing the dependencies between the tasks, especially when the same resources have to be used. Then the diagram will be drawn.

All the elements will be gathered in a table:

Activity Code	Activity description	Estimated time	Predecessor	Resources
A				
B				
C				
D				

The construction sector is one for which the duration of execution may be a big one, and the resources involved are various and in large amounts. Moreover, all the materials, equipment, machineries and human resources will move on the construction site, so the scheduling will have to coordinate their allocation.

The Critical Path Method is used to determine the optimum completing time of the project. Considering that the project may be scheduled by grouping the activities for each physical stage, there may be more than one parallel critical paths.



The critical path is the longest duration of the project`s completion, and the critical activities are the one that cannot be delayed, because if it happens, all the activities which will follow will have incorrect start and finish times.

There are some words used as basic terminology in CPM scheduling:

- Activity (or task): A discrete scheduled component of work to be performed during the course of a project.
- Milestone: A significant event in the project schedule, such as an event restraining future work, or marking the completion of a major milestone.
- Planned duration: The total number of working days estimated to complete a schedule activity.
- Resource estimates: The estimated quantity (and types) of resources required to perform each schedule activity.
- Logical relationships: A dependency between two schedule activities, or between a schedule activity and a schedule milestone:
  * Predecessor: An activity required to be completed prior to the start of a (successor) activity;
  * Successor: An activity that follows the start/completion of a (predecessor) activity.
- Float: The number of days an activity can be delayed before impacting a successor (or the end date of the project).

The Critical Path Method operates with some items:

a. Graphical representation of activities

* Variant1 1: Activities on Node (AON)

t_i^m	t_i	t_t^m
A		R_t
t_i^M	R_l	t_i^M

A – [illegible]ity

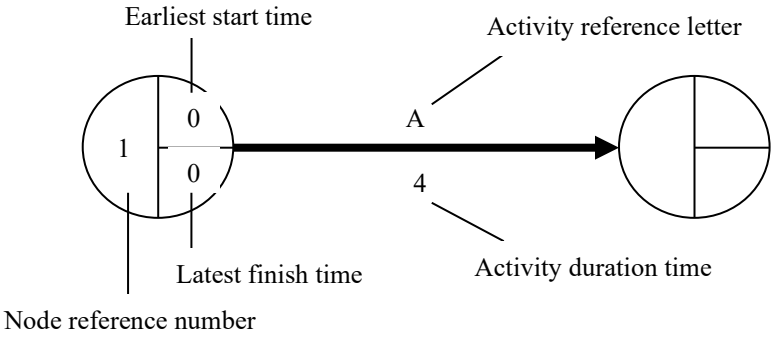
t_i – Duration of the activity

$R_{t,l}$ – Total/free float (slack)

$t_{i,t}^m$ – Minimum time to start/finish of an activity

$t_{i,t}^{M}$ – Maximum time to start/finish of an activity

* Variant 2: Activities on Arrows (AOA)



b. The network diagram

In order to design the network diagram, a table will be used to list all the activities to be scheduled, their durations of execution, as well as the predecessors ant the types of dependencies between them.

The question is: how long is the duration of completing the project? This will be given by the length of each path of the network.

A path through a project network is one of the routes from START to FINISH. The length of the routes is the sum of the estimated durations of all the activities belonging to the route.
The critical path is the length of the longest path through the project network.

The following example refers to the construction of a dwelling:

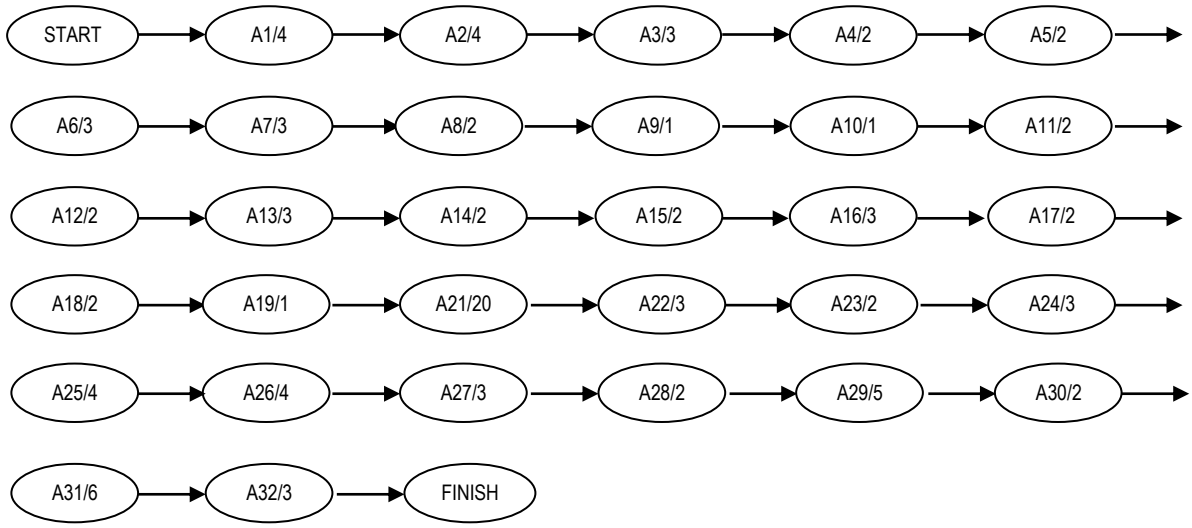
No.	Name of activity	Symbol	t_i	Predecessor	Dependency
1.	Masonry for walls sector 1	A1	4	START	
2.	Masonry for walls sector 2	A2	4	START	
3.	Rebar manufacturing for columns	A3	3	START	
4.	Rebar for columns sector 1	A4	2	A1	F-S
5.	Rebar for columns sector 2	A5	2	A4	S-S
6.	Formworks for columns sector 1	A6	3	A4	F-S
7.	Formworks for columns sector 2	A7	3	A5	F-S
8.	Concrete in columns	A8	2	A6,A7	F-S
9.	Formwork removal in columns sector 1	A9	1	A8	F-S
10.	Formwork removal in columns sector 2	A10	1	A8	F-S
11.	Formworks for beams sector 1	A11	2	A9	F-S
12.	Formworks for beams sector 2	A12	2	A10	F-S
13.	Rebar manufacturing for beams	A13	3	A11,A12	F-S
14.	Rebar in beams sector 1	A14	2	A13	F-S
15.	Rebar in beams sector 2	A15	2	A13	F-S
16.	Formworks in slab	A16	3	A11,A12	F-S
17.	Reinforcement in slab	A17	2	A16	F-S
18.	Props for supporting formworks	A18	2	A16	F-S
19.	Concrete in beams and slab	A19	1	A17,A18	F-S
20.	Concrete hardening 1	A20	3	A19	S-S
21.	Concrete hardening 2	A21	20	A19	S-S
22.	Roof	A22	3	A20	F-S
23.	Formwork and props removal for slab	A23	2	A21	F-S
24.	Glazing	A24	3	A22	F-S
25.	Thermal installations	A25	4	A24	F-S
26.	Sanitary installations	A26	4	A25	F-S
27.	Drywalls	A27	3	A26	F-S
28.	Doors	A28	2	A25	F-S
29.	Interior painting	A29	5	A28	F-S
30.	Scaffolding	A30	2	A22	F-S

31.	Thermo system	A31	6	A30	F-S
32.	Exterior painting	A32	3	A31	F-S

This list has to be detailed in such a way that the activities should be evaluated from the duration and the needed resources points of view.

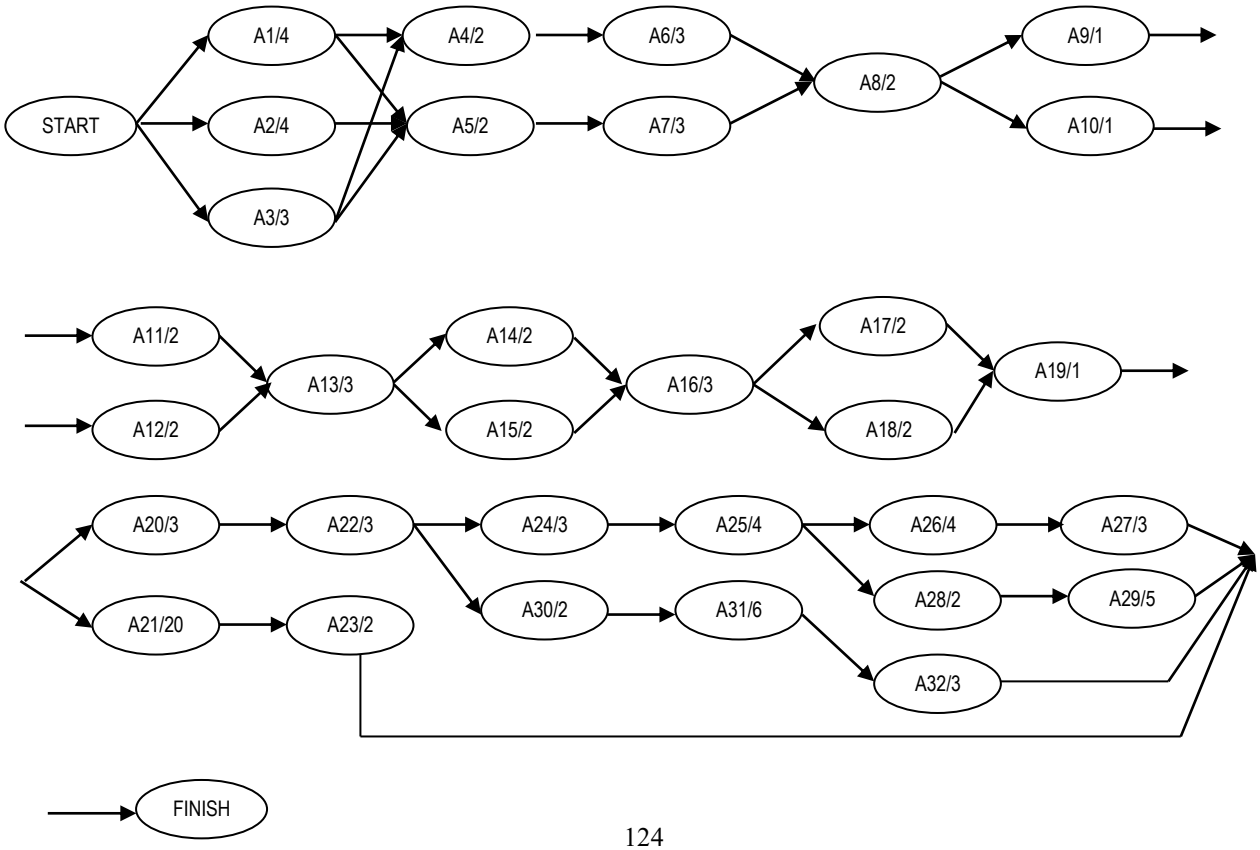
Too small details lead to less control and has effects on the expected performances; in reverse, too many activities will harden the process of planning the resources and will delay the documents` approval by excessive bureaucracy.

In parallel, the activity planning will be presented in two variants: without using the Critical Path Method and by applying this method. The differences concerning the durations of execution will be observed.



In this variant, the tasks are achieved one after another, therefore the total duration of execution is obtained by summing all the durations (T=101 days).

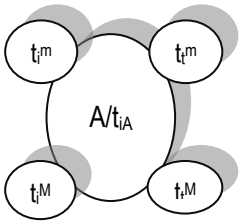
Planning by using the CPM is reducing the duration of the project achievement, because the tasks may be planned in parallel (t=47 days).



As it can be noticed, by applying CPM the duration for achieving the construction project is reduced with 54%, a very important issue for winning a contract.

c. Dates and time floats of activities

- Minim (early start and finish)
  - Early start $t_i^{m}{}_{(i)}$
  - Early finish $t_t^{m}{}_{(i)}$
- Maxim (late start and finish)
  - Late start $t_i^{M}{}_{(i)}$
  - Late finish $t_t^{M}{}_{(i)}$
- Floats:
  - Total $R_{t(i)}$
  - Free $R_{l(i)}$
- Graphical representation



or

t_i^m	t_i	t_t^m
A		R_t
t_i^M	R_l	t_t^M

Calculation of dates:

The CPM algorithm consists of two phases:

- Forward pass determines the Early Start (ES) t_i^m and Early Finish (EF) t_t^m of the activities.
  Forward pass calculation assumes that all the activities will start as soon as possible. Each activity will start as soon as the predecessor finishes.
  The process begins with the first activity at time zero.
  Because all previous activities must be finished before a successor, early start of a given node is the maximum of early finishes of previous nodes. Briefly, the forward pass determines the shortest time to complete a sequence of tasks.
  The minimum duration (ES and EF) is calculated from START to FINISH.
- Backward pass determines the Late Start (LS) t_i^M and the Late Finish (LF) t_t^M of the activities.
  Backward pass calculation assumes that all the activities will start and finish as late as possible. Each activity will finish as the earliest of its successors starts.
  The process assumes that all predecessors will also finish as late as possible.
  Because previous activity must finish before any following activity, late finish of a given activity is minimum of late starts of the successors. Briefly, given a final completion time of a sequence of tasks, the backward pass allows calculating the latest point in time the sequence has to be initiated. Both notions are quite common-sense reasoning that we use all the time for daily life tasks (e.g. we use the forward pass to figure out what is the earliest time we could meet someone, or use the backward pass to know what time we need to leave for arriving on time).
  The maximum duration (LS and LF) is calculated from FINISH to START.
  The formulas for the calculation of the activities` durations:

$t_i^m{}_{(i)}$	ES	= max $[t_t^m{}_{(i-1)}]$	ES for activity (i) is the maximum EF of the previous activities
$t_i^M{}_{(i)}$	LS	= $t_t^M{}_{(i)}$ - t_i	LS for activity (i) is LF for activity (i) minus duration of (i)
$t_t^m{}_{(i)}$	EF	= $t_i^m{}_{(i)}$ + t_i	EF for activity (i) is ES for activity (i) plus duration of (i)
$t_t^M{}_{(i)}$	LF	= min $[t_i^M{}_{(i+1)}]$	LF for activity (i) is the minimum LS for the next activities

Calculation of the float

The float, or slack, is the amount of time that a task can be delayed without jeopardizing the whole project.

- The total float (R_{ti}) is the time a task may be delayed without delaying the finishing time of a project, determined by calculating Early durations (t_i^m and t_t^m).
  The total float is associated with the critical path of the project.
- The free float (R_{li}) is the time the task may be delayed without delaying the start of next task at the early start time (t_i^m).
  $R_t \geq R_l$
  The float allows the manager to prevent the project`s delays, giving flexibility to performing the tasks. It`s also a strategy to negotiate the duration of the project with the owner.

The formulas for the calculation of the activities` floats:

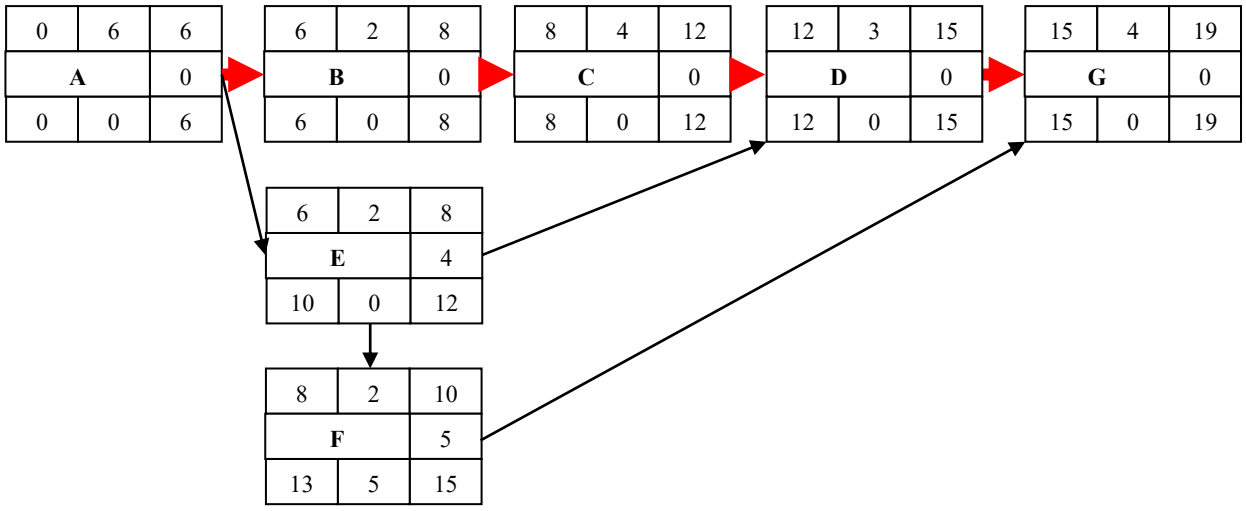
$R_{t\,(i)}$	TF	$= t_t^{M}{}_{(i)} - t_t^{m}{}_{(i)}$	TF for activity (i) is LF minus EF of activity (i)
$R_{l\,(i)}$	FF	$= [t_i^{m}{}_{(i+1)}] - t_t^{M}{}_{(i)}$	FF for activity (i) is minimum of the difference between ES for next activity and LF of activity (i)

For a better understanding of the calculation of duration using CPM, here is a simple example with few activities:

Activity Code	Description	Estimated Time	Predecessor
A		6	START
B		2	A
C		4	B
D		3	C,E
E		2	A
F		2	E
G		4	D,F

Let`s take the below representation of the activity for the Critical Path:

t_i^m	t_i	t_t^m
A		R_t
t_i^M	R_l	t_t^M



For activities performed in succession, the total duration is:

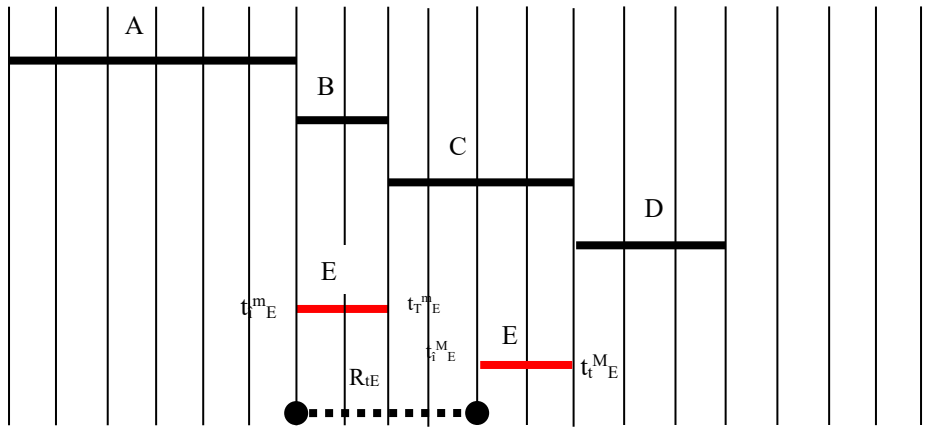
T = 6 (A) + 2 (B) + 4 (C) + 3 (D) + 2 (E) + 2 (F) + 4 (G) = 23 days

The possible paths of the project are:

1. 6 (A) + 2 (B) + 4 (C) + 3 (D) + 4 (G) = 19 days
2. 6 (A) + 2 (E) + 3 (D) + 4 (G) = 15 days
3. 6 (A) + 2 (E) + 2 (F) + 4 (G) = 14 days

The critical path is A – B – C – D – G.

In order to clarify the terms of free and total float, let`s analyze Activity E from the Critical Path above:



In our example, Activity E lasts 2 days. Activity D, which lasts 3 days, may start after the finish of Activities C and E.

Activity E starts after the finish of Activity A, meaning any time after day 6, but no later than day 10, because it lasts 2 days and has to be finished till day 12.

Consequently:

$t_i^{m}{}_{(E)} = 6$

$t_t^{m}{}_{(E)} = 8$

$t_i^{M}{}_{(E)} = 10$

$t_t^{M}{}_{(E)} = 12$

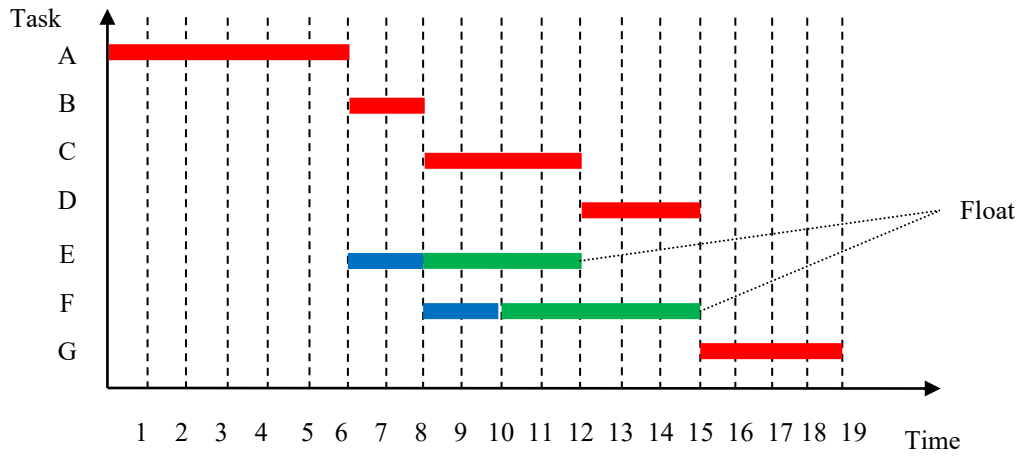
$R_{t(E)} = 12 - 8 = 4$

$R_{l(E)} = \min(12, 8) - 8 = 0$

Any method of scheduling the construction works may be used also for staffing and re-scheduling. In our example above, we will gather the data in the following table:

Task	Duration	Precedence	Staff needed	ES	EF	LS	LF	Slack time	Critical
A	6	-	2	0	6	0	6	0	Yes
B	2	A	4	6	8	6	8	0	Yes
C	4	B	4	8	12	8	12	0	Yes
D	3	C,E	1	12	15	12	15	0	Yes
E	2	A	2	6	8	10	12	4	No
F	2	E	1	8	10	13	15	5	No
G	4	D,F	2	15	19	15	19	0	Yes

If we draw the Gantt Chart, it will look like follows:



We have three such days:

- Tasks B and E simultaneous: 4 workers + 2 workers = 6 workers
- Tasks C and E simultaneous: 4 workers + 2 workers = 6 workers
- Tasks C, E and F simultaneous: 4 workers + 2 workers + 1 worker = 7 workers
- Tasks C and F simultaneous: 4 workers + 1 worker = 5 workers
- Tasks D and F simultaneous: 1 worker + 1 worker = 2 workers

The maximum staff will be 7 workers on the site.

The staff utilization will be calculated with the formula:

$$\text{Staff} = \frac{Duration\ of\ task\ x\ staff/task}{Maximum\ staff\ x\ project\ duration} =$$

$$= \frac{6\ x\ 2+2\ x\ 4+4\ x\ 4+3\ x\ 1+2\ x\ 2+2\ x\ 1+4\ x\ 2}{7x\ 19} = 0.40 = 40\%$$

Where the maximum staff is the very busy day with total of workers.

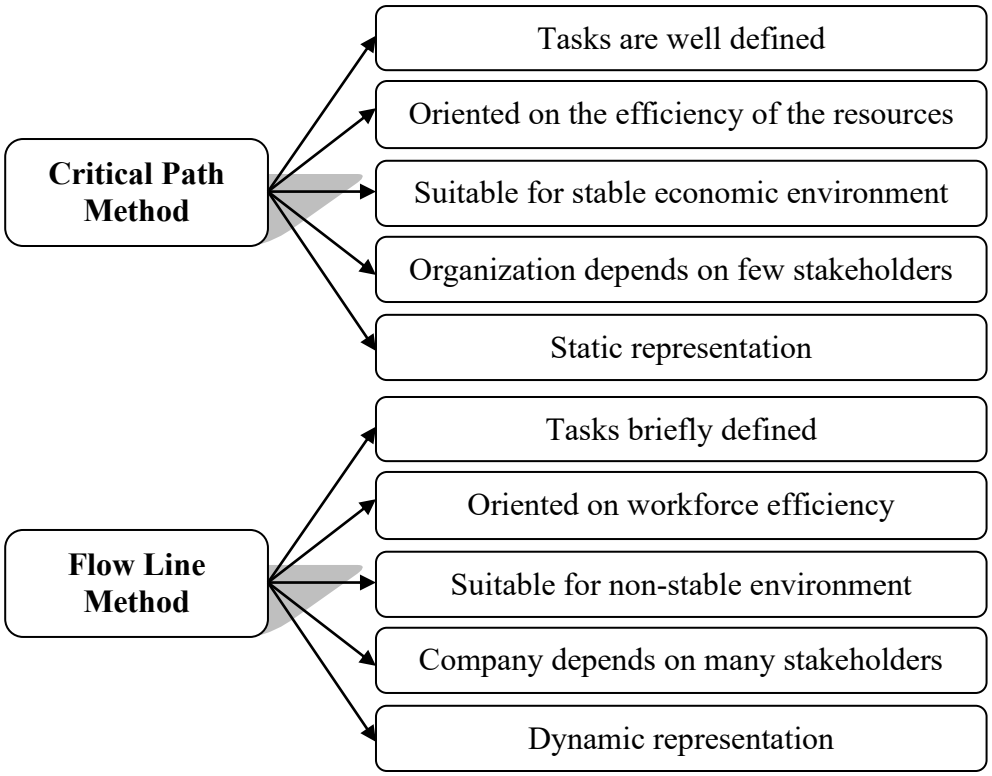
That means that the capacity of the workers is used only on a rate of 40%. In order to improve the schedule, the project manager will have to think of revising the norms or shortening the slacks. In this case, tasks E and F must be corrected.

COURSE 11
FLOW LINE SCHEDULING

11.1. INTRODUCTION

The Flow Line Scheduling (or Line of Balance LOB) is also called Spaghetti Diagram. It`s a location-based planning used to coordinate the crews so that they will continuously move from area to area throughout the building without idle time for workers and equipment. The crews will complete the work at one area and then start working at the next location without interruption.

There are differences between the Critical Path method and the Flow Line method, presented below:



Unlike a Bar Chart, which shows the duration of a particular activity, a LOB Chart shows the rate at which the work that makes up all of the activities has to be undertaken to stay on schedule, the relationship of one trade or process to the subsequent trade or process is defined by the space between the lines.

The schedule is represented by a line which shows that the activities stay "in balance", meaning that the flows of repetitive activities are not obstructed and can be performed according to plan.

This type of scheduling has advantages and disadvantages as well:

Advantages:

- The project manager may understand very clear the amount of work in a specific area at a specific time and allows permanent control of the project`s constrains and resources;
- The resources can be optimized for repeated activities;
- The crews involved will perform a single type of tasks, will not have multiple specializations, therefore they will not interrupt the activity by moving from one area to the other and will not change their equipment;
- The project manager can prioritize the tasks which are using the same resources with the highest consumption;
- As all information is available for each activity, the project manager may optimize the cost and time;

- The scheduling may be modified, updated and changed quite easy.

Disadvantages:

- The method is rather complex and requires experience in civil engineering planning;
- Project managers have the tendency to overload the workers with tasks. The norms calculate also the breaks, meaning the amount of time the workers move from one area to the other. But the flow line scheduling eliminates that time from the norm (usually the norm will be 33% bigger, but the manager can increase it to 50% or even 75%). The effects may be fatigue or indifference, if increasing the norm is not followed by raising the wages;
- It`s difficult to coordinate tasks that are depending on the same resources;
- The schedule is centered on tasks performed by company`s specialized workers. The rest of the activities will usually be outsourced. In this situation, calculating the duration will not be on the contractor`s control, which can harm the total time of achieving the project;
- The overall project`s schedule is difficult to perform, like in CPM, because the flow line is divided only by location.

This resource-balance method is suitable for complex processes, with repetitive activities and specialized teams for each task. For complex activities, they will be devised in simple activities, for which specialized crews can be allocated. For example, for scheduling the execution of beams (complex activity), it will be split in simple activities (formworks, reinforcement and concrete pouring), performed by specialized crews (carpenters, iron workers, concreters).

The line represents the execution of a task by the same crew, continuously, by moving from one area to another. The area (sector) represents the division of a building where the same crew performs the same task. The flow line schedule will determine the suitable crew size and the number of crews to employ in each repetitive activity.

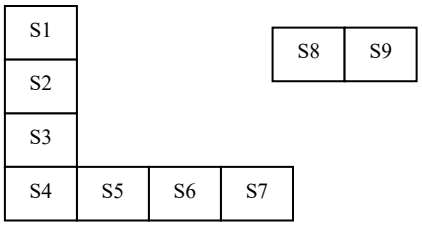
Examples:

- A group of 9 similar dwellings

S1	S2	S3
S4	S5	S6
S7	S8	S9

The planner will calculate the duration for one area (sector) t_i^l, where "l" is the area and "i" is the activity.

- Blocks of flats with the same dimensions:



The principles of the flow line scheduling:

a. Continuity: the crews move continuously from one area to another, without interruptions and delays. The productivity rate and the yield of resource usage are increased; therefore, the expenses decrease;
b. Uniformity: involves same volumes of works per time unit. Uniformization may be achieved by allocating same productivity indicators for each area of work;
c. Rhythmicity: splitting the working location in equal areas (sectors) with equal quantities of work;
d. Synchronization: means the immediate loading of all new areas (sectors) with specialized crews, with respect of the technological succession of the working processes.

Parameters used in scheduling the construction works:

- Quantitative parameters:
  - Quantity of works per object – from the quantity take-off;
  - Quantity of works per area – if splitting in areas (sectors) is possible;
  - Volume of works per object;
  - Volume of works per area (sector);
  - Number of workers per crew;
  - Number of crews per object.
- Spatial parameters:
  - The site location: space fenced and flagged;
  - Working location: the space where a working process is taking place;
  - Working area (sector);
  - Working level: part of the construction object limited by height.
- Time parameters:
  - The working rhythm: the duration of execution of the working process per area (sector);
  - The line path: the period between the beginning of two successive working processes on the same area from technological point of view.

The flow line scheduling has the following representation:

- The y-axis displays the locations for the project;
- The x-axis displays the days, weeks or months depending on the calendar settings;
- The graph displays the flow of crews through locations with particular productivity rates;
- Each line represents one crew or task as they move through the building;
- The slope of the lines marks their stated productivity rate. If it`s possible, the dotted line indicates their measured, actual rate;
- When two lines cross each other, means that two crews are scheduled in the same location;
- The gaps in the graph represent under-utilized locations.

In order to schedule the duration of a project using LOB methods, the following steps should be developed:

1. Drawing the logic diagram: all the repetitive activities will be graphically represented for visualizing the big picture and the slopes of each activity.
2. Computing the duration of each activity.
3. Choosing the buffer (lag) time between activities for eliminating the overlays.
4. Computing the output rate of the project based on the required completion rate.
5. Complete the table.

Activity	Manhours/unit	Workers/team	Theoretical team size "G"	Actual team size "Ga"	Actual output rate "Ra"	Activity duration/unit "D"	Time from start to last "T"	Maximum buffer time
1	2	3	4	5	6	7	8	9
A								
B								
C								
D								
E								
F								
G								

- Column 1: The name (or code) of the activity.
- Column 2: Man-hours/unit recommended by the norms.
- Column 3: Number of workers/team recommended by the norms.
- Column 4: Theoretical team size for completing the project in a specific duration of time.

$$G = \frac{R \, x \, Manhours/unit}{No \, of \, working \, hours/man/week}$$

- Column 5: Actual team size based on theoretical estimation
  G_a = Multiple of G
  It will be multiple of the number of workers/team. The same number of workers is not an option, even if the rate is 1.00, because for performing faster, the number of workers per team (meaning the number of teams) should be bigger.
- Column 6: Actual output rate based on actual team size
  $R_a = R \times \frac{Ga}{G}$
- Column 7: Activity duration per unit
  $$D = \frac{Manhours/unit}{No \, of \, workers \, per \, unit \, x \, No \, of \, working \, hours \, per \, worker \, per \, day}$$
- Column 8: Time from start of first unit to start of last unit
  $$T = \frac{(n-1) x \, No \, of \, working \, days \, per \, week}{Ra}$$
- Column 9: Maximum buffer time, which is the time between the finish of an activity and the start of the next one. It is estimated from experience

Example:

A construction project refers to 10 identical individual dwellings which require five activities to be performed for each unit (dwelling). The activities are repetitive for each unit.

The target output rate (R) will be 2 units per week. The working time for a week is 8 hours per day, 5 working days.

Activity	Manhours/team	Workers/team	Theoretical team size "G"	Actual team size "Ga"	Actual output rate "Ra"	Activity duration/team "D"	Time from start to last "T"	Maximum buffer time
1	2	3	4	5	6	7	8	9
A	100	3						
B	300	7						
C	400	9						
D	25	2						
E	200	5						

- Column 4:

$$G = \frac{R \, x \, Manhours/unit}{No \, of \, working \, hours/man/week}$$

$$G_A = \frac{2 \, x \, 100}{8 \, x \, 5} = 5.00$$

$$G_B = \frac{2 \, x \, 300}{8 \, x \, 5} = 15.00$$

$$G_C = \frac{2 \, x \, 400}{8 \, x \, 5} = 20.00$$

$$G_D = \frac{2 \, x \, 25}{8 \, x \, 5} = 1.25$$

$$G_E = \frac{2 \, x \, 200}{8 \, x \, 5} = 10.00$$

Activity	Manhours/team	Workers/team	Theoretical team size "G"	Actual team size "Ga"	Actual output rate "Ra"	Activity duration/team "D"	Time from start to last "T"	Maximum buffer time
1	2	3	4	5	6	7	8	9
A	100	3	5.00					
B	300	7	15.00					
C	400	9	20.00					
D	25	2	1.25					
E	200	5	10.00					

- Column 5:

  Ga = Multiple of G

  G_a(A) = Multiple of 3; the closest multiple of 5 is 6 → G_a(A) = 6

  G_a(B) = Multiple of 7; the closest multiple of 7 is 21 → G_a(B) = 21

  G_a(C) = Multiple of 9; the closest multiple of 9 is 27 → G_a(C) = 27

  G_a(D) = Multiple of 2; 2 is not an option → G_a(D) = 4

  G_a(E) = Multiple of 5; the closest multiple of 5 is 10 → G_a(E) = 10

  If G differs in decimals (ex. 10.34 for E), the result G_a(E) will be 10.

Activity	Manhours/team	Workers/team	Theoretical team size "G"	Actual team size "Ga"	Actual output rate "Ra"	Activity duration/team "D"	Time from start to last "T"	Maximum buffer time
1	2	3	4	5	6	7	8	9
A	100	3	5.00	6				
B	300	7	15.00	21				
C	400	9	20.00	27				
D	25	2	1.25	4				
E	200	5	10.00	10				

- Column 6:

  $R_a = R \times \frac{Ga}{G}$

  $R_a(A) = 2 \times \frac{6}{5} = 2.40$

  $R_a(B) = 2 \times \frac{21}{15} = 2.80$

  $R_a(C) = 2 \times \frac{27}{20} = 2.70$

  $R_a(D) = 2 \times \frac{4}{1.25} = 6.40$

  $R_a(E) = 2 \times \frac{10}{10} = 2.00$

Activity	Manhours/team	Workers/team	Theoretical team size "G"	Actual team size "Ga"	Actual output rate "Ra"	Activity duration/team "D"	Time from start to last "T"	Maximum buffer time
1	2	3	4	5	6	7	8	9
A	100	3	5.00	6	2.40			
B	300	7	15.00	21	2.80			
C	400	9	20.00	27	2.70			
D	25	2	1.25	4	6.40			
E	200	5	10.00	10	2.00			

  The actual output rate represents the slope of the line. It`s obvious that for activity D the slope is very abrupt because there are only 2 teams of 2 workers to perform the activity in the target rate of two units.

  In order to be parallel, the R_a for each activity should be around 2.00.

- Column 7:

  $D = \frac{Manhours/unit}{No\ of\ workers\ per\ unit\ x\ No\ of\ working\ hours\ per\ worker\ per\ day}$

  $D_A = \frac{100}{3\ x\ 8} = 4.16$ (days)

  $D_B = \frac{300}{7\ x\ 8} = 5.36$ (days)

  $D_C = \frac{400}{9\ x\ 8} = 5.56$ (days)

  $D_D = \frac{25}{2\ x\ 8} = 1.56$ (days)

$D_E = \frac{200}{5 \times 8} = 5.00$ (days)

Activity	Manhours/team	Workers/team	Theoretical team size "G"	Actual team size "Ga"	Actual output rate "Ra"	Activity duration/team "D"	Time from start to last "T"	Maximum buffer time
1	2	3	4	5	6	7	8	9
A	100	3	5.00	6	2.40	4.16		
B	300	7	15.00	21	2.80	5.36		
C	400	9	20.00	27	2.70	5.56		
D	25	2	1.25	4	6.40	1.56		
E	200	5	10.00	10	2.00	5.00		

- Column 8:

$T = \frac{(n-1)x\,No\ of\ working\ days\ per\ week}{Ra}$

$T_A = \frac{(10-1)x5}{2.4} = 18.75$ (days)

$T_B = \frac{(10-1)x5}{2.8} = 16.07$ (days)

$T_C = \frac{(10-1)x5}{2.7} = 16.67$ (days)

$T_D = \frac{(10-1)x5}{6.4} = 7.03$ (days)

$T_E = \frac{(10-1)x5}{2.0} = 22.50$ (days)

Activity	Manhours/team	Workers/team	Theoretical team size "G"	Actual team size "Ga"	Actual output rate "Ra"	Activity duration/team "D"	Time from start to last "T"	Maximum buffer time
1	2	3	4	5	6	7	8	9
A	100	3	5.00	6	2.40	4.16	18.75	
B	300	7	15.00	21	2.80	5.36	16.07	
C	400	9	20.00	27	2.70	5.56	16.67	
D	25	2	1.25	4	6.40	1.56	7.03	
E	200	5	10.00	10	2.00	5.00	22.50	

- Column 9:

The buffer should be equal to the medium of activities` duration, which is 5 days.

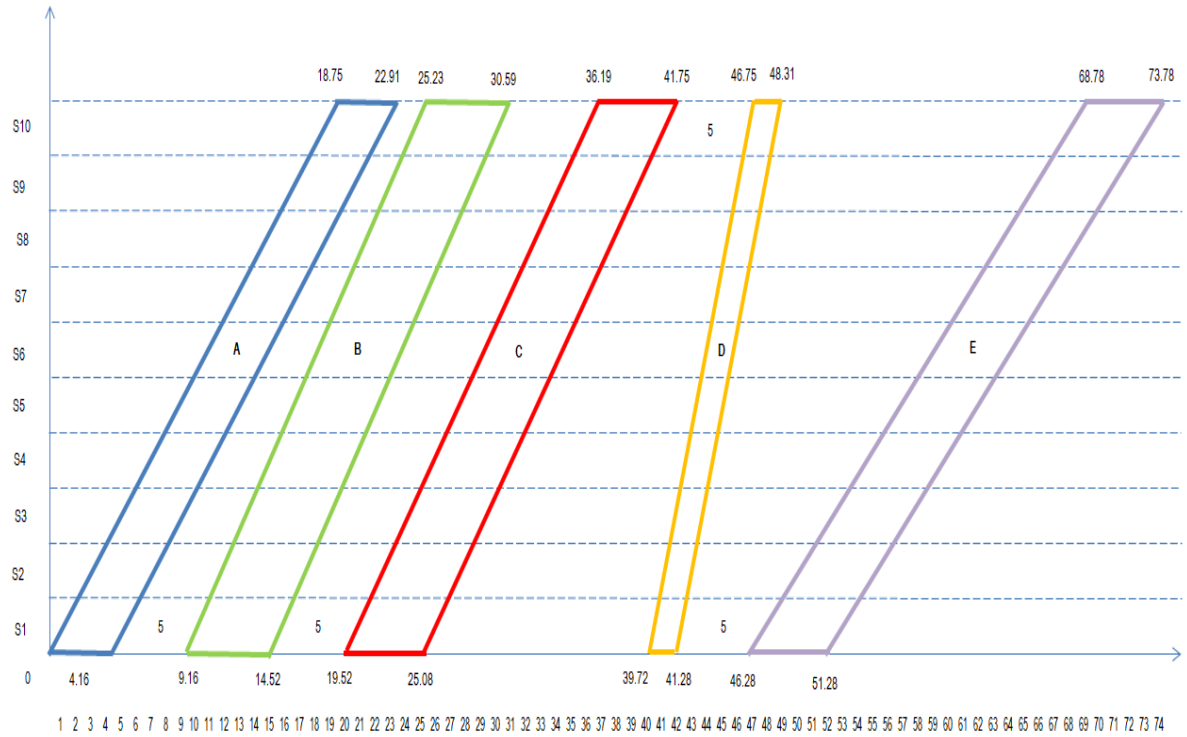
Activity	Manhours/team	Workers/team	Theoretical team size "G"	Actual team size "Ga"	Actual output rate "Ra"	Activity duration/team "D"	Time from start to last "T"	Maximum buffer time
1	2	3	4	5	6	7	8	9
A	100	3	5.00	6	2.40	4.16	18.75	5
B	300	7	15.00	21	2.80	5.36	16.07	5
C	400	9	20.00	27	2.70	5.56	16.67	5
D	25	2	1.25	4	6.40	1.56	7.03	5
E	200	5	10.00	10	2.00	5.00	22.50	5

For drawing the LOB, the columns that will be used are: (1), (6), (7), (8), and (9).

Activ	Ra	D	T	B	t_1	t_2	t_3	t_4
1	6	7	8	9				
A	2.40	4.16	18.75	5	0.00	18.75	18.75 + 4.16 = 22.91	0 + 4.16 = 4.16
B	2.80	5.36	16.07	5	4.16 + 5 = 9.16	9.16 + 16.07 = 25.23	25.23 + 5.36 = 30.59	9.16 + 5.36 = 14.52
C	2.70	5.56	16.67	5	14.52 + 5 = 19.52	19.52 + 16.67 = 36.19	36.19 + 5.56 = 41.75	19.52 + 5.56 = 25.08
D	6.40	1.56	7.03	5	46.75 - 7.03 = 39.72	41.75 + 5 = 46.75	46.75 + 1.56 = 48.31	39.72 + 1.56 = 41.28
E	2.00	5.00	22.50	5	41.28 + 5 = 46.28	46.28 + 22.50 = 68.78	68.78 + 5 = 73.78	46.28 + 5 = 51.28

- t_1 is the time to start the activity in Sector 1.
  For A, t_{1A} is moment 0. $t_{1A} = 0$ days.
  For B, t_{1B} is the finish of A in Sector 1 plus the estimated buffer. $t_{1B} = 4.16 + 5 = 9.16$ days.
  For C, t_{1C} is the finish of B in Sector 1 plus the estimated buffer. $t_{1C} = 14.52 + 5 = 19.52$ days.
  For D, t_{1D} is t_{3C} minus t_{1C} plus the buffer minus T_D. $t_{1D} = 41.75 + 5 – 7.03 = 39.72$ days. As can be seen, the duration of activity D is shorter than the predecessor (C). In order to avoid the disruptions, the planning begins from above, when activity C finishes, then adding the buffer. The start of activity D will be the finishing date of C minus the total duration of D (for all sectors).
  For E, t_{1E} is the finish of D in Sector 1 plus the estimated buffer. $t_{1C} = 14.52 + 5 = 19.52$ days.
- t_2 is the time to start the activity in Sector 10.
  For A, t_{2A} is T_A. $t_{2A} = 18.75$ days.
  For B, t_{2B} is t_{1B} plus T_B. $t_{2B} = 9.16 + 16.07 = 25.23$ days.
  For C, t_{2C} is t_{1C} plus T_C. $t_{2C} = 19.52 + 16.67 = 36.19$ days.
  For D, t_{2D} is t_{3C} plus the buffer. $t_{2D} = 41.75 + 5 = 46.75$ days.
  For E, t_{2E} is t_{1E} plus T_E. $t_{2E} = 46.28 + 22.5 = 68.78$ days.
- t_3 is the time to finish the activity in Sector 10.
  For A, t_{3A} is t_{2A} plus D_A. $t_{3A} = 18.75 + 4.16 = 22.91$ days.
  For B, t_{3B} is t_{2B} plus D_B. $t_{3B} = 25.23 + 5.36 = 30.59$ days.
  For C, t_{3C} is t_{2C} plus D_C. $t_{3C} = 36.19 + 5.56 = 41.75$ days.
  For D, t_{3D} is t_{2D} plus D_D. $t_{3D} = 46.75 + 1.56 = 48.31$ days.
  For E, t_{3E} is t_{2E} plus D_E. $t_{3E} = 68.78 + 5.00 = 73.78$ days.
- t_4 is the time to finish the activity in Sector 1.
  For A, t_{4A} is t_{1A} plus D_A. $t_{4A} = 0.00 + 4.16 = 4.16$ days.
  For B, t_{4B} is t_{1B} plus D_B. $t_{4B} = 9.16 + 5.36 = 15.52$ days.
  For C, t_{4C} is t_{1C} plus D_C. $t_{4C} = 19.52 + 5.56 = 25.08$ days.
  For D, t_{4D} is t_{1D} plus D_D. $t_{4D} = 39.72 + 1.56 = 41.28$ days.
  For E, t_{4E} is t_{1E} plus D_E. $t_{4E} = 46.28 + 5.00 = 51.28$ days.

The diagram looks like below:



For optimizing the diagram and reducing the delays between activities, their durations should be similar. In this example, Activity D is the one with the most abrupt slope, so the solution may be to increase its duration to around 5 days, like the other ones, and to make the line parallel with the others.

Moreover, the buffers are not mandatory, if the experience of the manager in previous projects proves so.

11.2. TYPES OF FLOWLINES

Concerning the construction projects, the following types of lines may be described:

a. Elementary flow lines (sole activity)
  a.1. Simple
    a.1.1. Rhythmic (LESR)
    a.1.2. Non-rhythmic (LESN)
  a.2. Divided (LED)
b. Complex flow lines (multiple activities)
  b.1. Rhythmic (LCR)
  b.2. Non-rhythmic (LCN)

11.2.1. Elementary flow lines

This flow line is designed for a sole activity, which will be repeated on a specific area (sector).

These flow lines may be classified in some categories: simple flow lines (a single crew is scheduled), or complex flow lines (for a specific activity more crews with the same specialization will be scheduled).

No matter the type of flow line (simple or complex), they may be rhythmic (if the duration of execution is identical for each sector) or non-rhythmic (if the durations are different for different sectors).

The differences concerning the durations for achieving activities depend on some elements: the size of the sector, the number of workers of a crew, the working conditions on the sector, and others.

a. Simple flow line

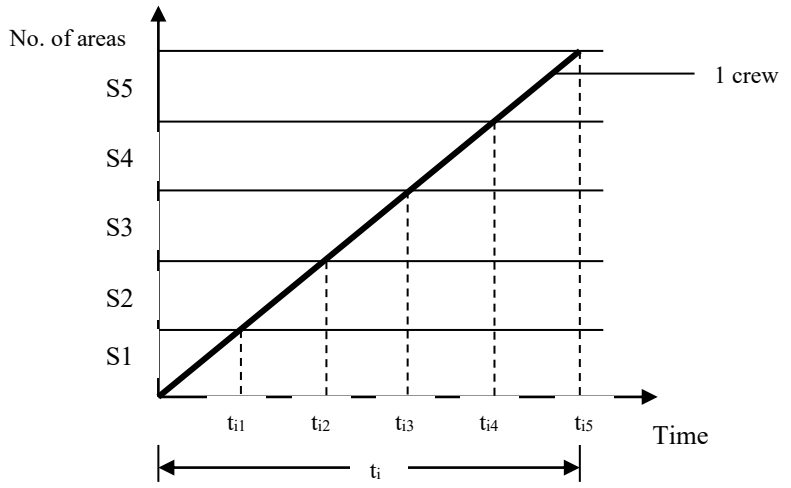
a.1. Simple rhythmic flow line:

A simple process is achieved by successive move of the specialized crews from one sector to another, until the construction object is finalized.

This situation may happen at the execution of drywalls, curtain walls, glazing, paintings, etc.

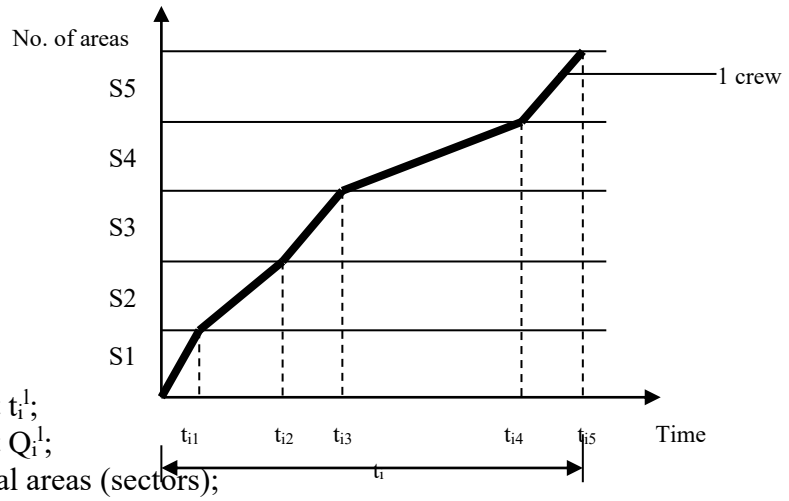
Advantage: the continuity of the activity of the crews.

Disadvantage: big execution scheduling.



- Identical (equal) sectors;
- Equal quantity of works;
- Equal t_i^l ;
- Equal Q_i^l per sector.

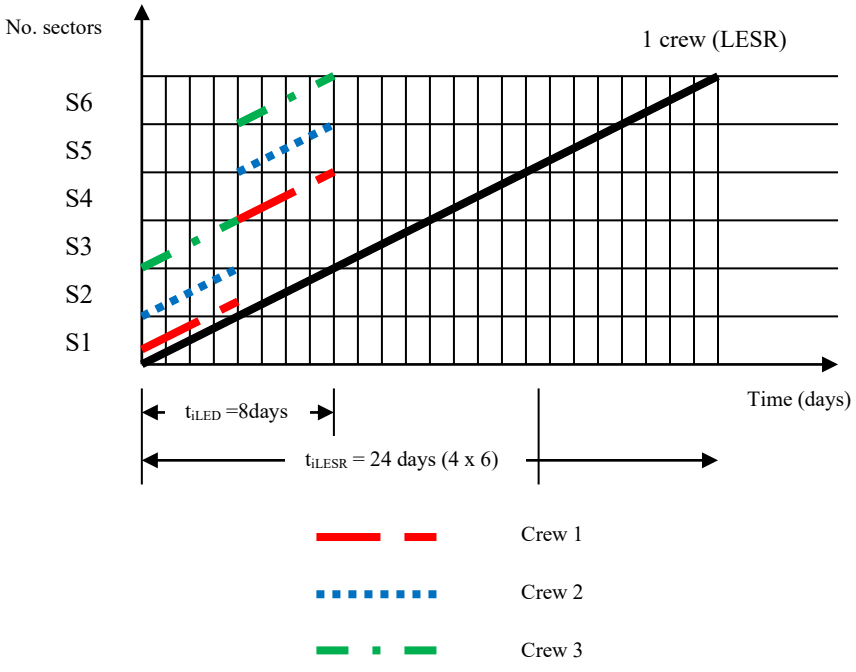
a. 2. Simple non-rhythmic flow line:



- Different t_i^l;
- Different Q_i^l;
- Non-equal areas (sectors);
- In practice is very rare, the tendency is for rhythmic flow line.

a.3. Divided flow line

The simple process is executed simultaneously in all sectors, depending of the number of crews available. Crew 1 works on sector 1, then moves to sector 4. Crew 2 works on sector 2, then moves to sector 5. Crew 3 works on sector 3, simultaneously with crews 1 and 2, then moves to sector 6.



- It`s based on LESR and it`s suitable when t_i is too big and must be shortened;
- The number of crews depends on the surface and shape of the building;
- The continuity of the crews must be insured;

- The coefficient of rhythmicity ki = $\frac{t_{il}}{N_{ei}}$

11.2.2. Complex flow line

The complex flow line, or Spaghetti Diagram, is a group of elementary lines perfectly synchronized.

The continuity is insured by permanently creating free working areas for the crews which finish a simple process on an area. The uniformity presumes the execution of a constant volume of works in a time unit. Synchronization means the immediate load of all working area created in the building.

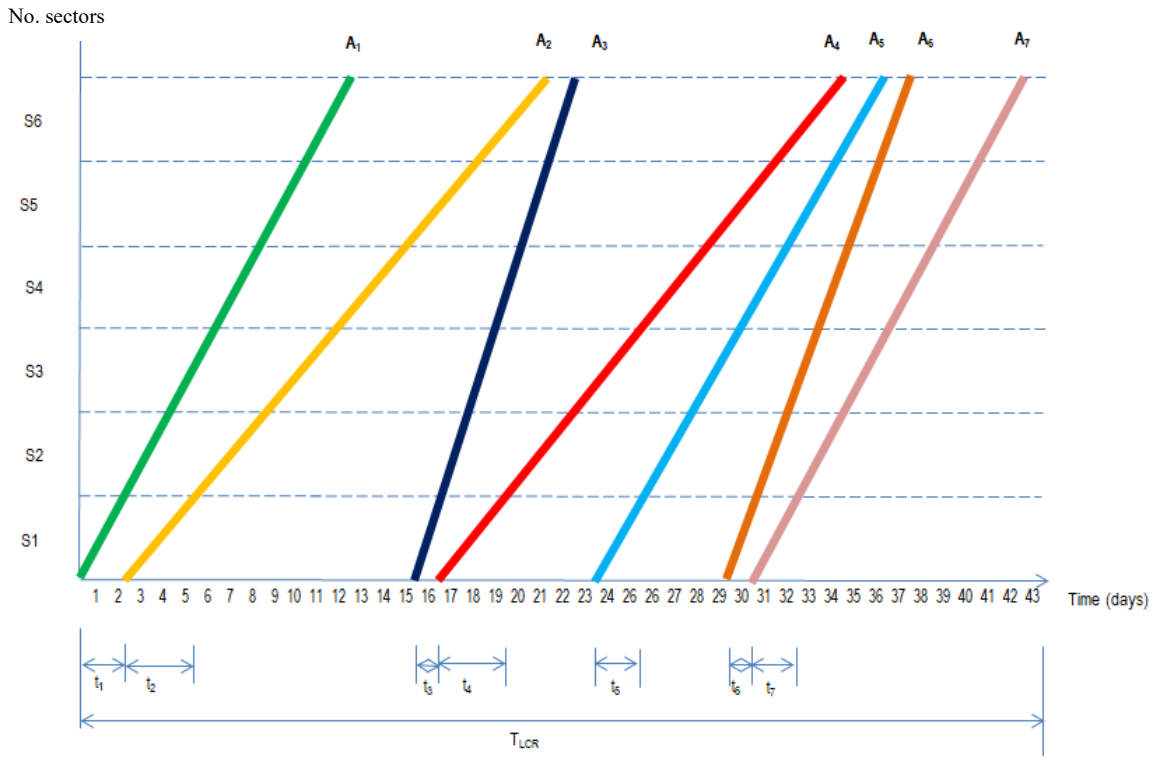
The main rule: two simple processes mustn`t overlap.

The graphical representation of a complex flow line is also called histogram. The histogram is the figure that represents the evolution of a process that has operations which are repeated in successive cycles.

The example below presents the calculus of the execution duration of a project which needs 7 activities planned on 6 sectors, in continuous flow.

Seven crews will be scheduled for each activity. The crew responsible with activity A will finish its tasks on sector 1, then will move to sector 2, and so on, till will finish, in our case, in 12 days (2 days x 6 sectors).

a. Simple complex flow line:



Ex: A1 $t_1 = 2$ days
A2 $t_2 = 3$ days
A3 $t_3 = 1$ day
A4 $t_4 = 3$ days
A5 $t_5 = 2$ days
A6 $t_6 = 1$ day
A7 $t_7 = 2$ days

$t_i < t_{i+1}$ $(t_1 < t_2) \rightarrow$ synchronization on sector 1

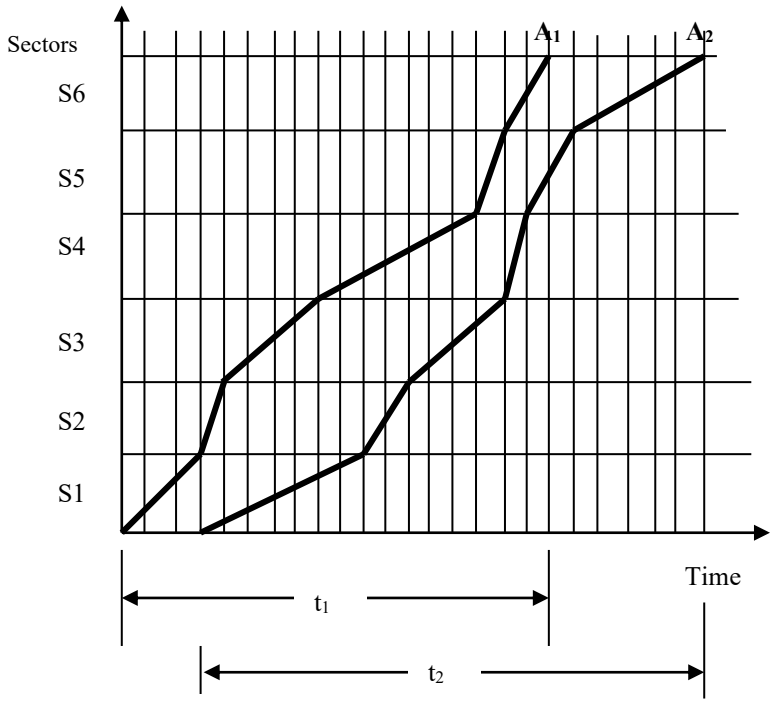
$t_i > t_{i+1}$ $(t_2 > t_3) \rightarrow$ synchronization on sector 3

$t_i = t_{i+1}$ → synchronization on all sectors

- The duration of A1 is 2 days per sector. That means that A1 will be finished in 12 days (2 days x 6 sectors);
- A2 may begin on sector 1 after 2 days, on day 3. It will last 18 days (3 days x 6 sectors), meaning it will be finished on day 20 (2 days + 18 days);
- A3 may begin after 5 days, on day 6. As may be seen, sector 1 will be finished in 1 day, meaning that on day 7 the crew can move to sector 2. But this is not free, because crew 2 is not ready (A2 lasts 3 days). So, crew 3 should wait 2 days till the area is free, and the continuity is broken. Therefore, if the next activity (A3 in our case) is shorter than the predecessor, in order to ensure continuity, it has to be scheduled from top to bottom. In our case, A2 is finished on day 20. A3 lasts 1 day per sector, so it will be finished on day 21. Backward calculus will show that crew 3 should begin on day 15 (day 21 – 1 day x 6 sectors).

b. Non-rhythmic complex flow line

This type of schedule is suitable when the durations of execution of one or more activities differ from one sector to another. This situation is quite unlikely on a construction site, because of the lack of control on the productivity rate.

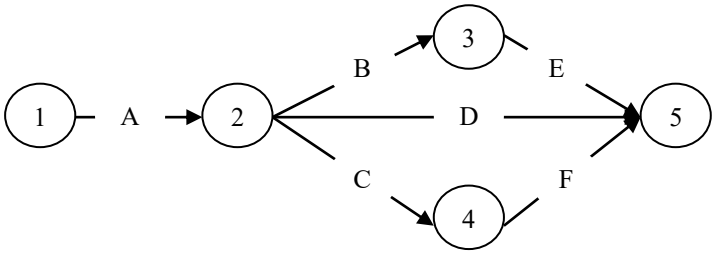


COURSE 12
PERT METHOD

12.1. INTRODUCTION

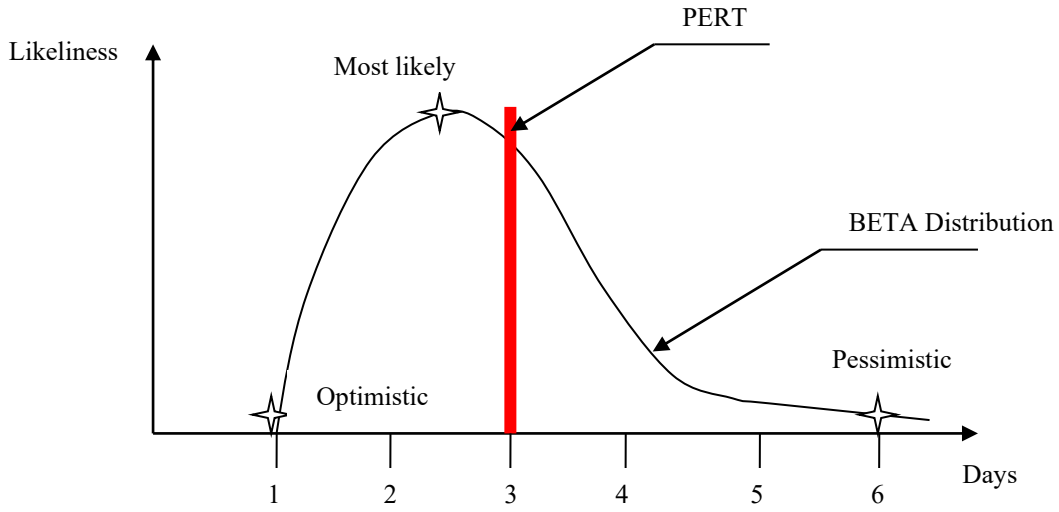
PERT, a network diagram method, is the abbreviation for "Project Evaluation and Review Technique" and is a project management tool for evaluating the duration of a project in uncertain conditions. In construction industry, this type of scheduling is suitable for large projects.

PERT is designed like a diagram, which doesn`t show the inter-dependencies between activities, but the events are represented by resources: cost, time, technology, etc. The nodes represent the events, and the arrows represent the activities required for achieving the event.



The assumption is that, for non-repetitive activities, the manager should make 3 scenarios (optimistic, pessimistic and most-likely), due to unpredictable situations that may occur during the project completion: personnel supply (absenteeism, sickness, vacations, strikes), climate conditions (snow, rain, flood).

Since it`s a probabilistic method, the manager of the project will use three types of activities` durations:



- The optimistic time "a": the fastest time for performing an activity, meaning nothing will go wrong. It is presumed that all the resources are available, and all the predecessors are delivered as planned.
- The most likely time "m": the estimated time based on previous experience.
- The pessimistic time "b": the longest time of an activity, assuming that everything will go wrong, including the availability of resources and delays of predecessors (but excluding the calamities).
- The expected time "μ" (or weighted average) will be calculated by the formula:

$$\mu = \frac{a+4m+b}{6}$$ (mean duration)

The expected duration is the average value of a probability distribution defined by the three estimates: a, m, and b. The expected duration is always constant.

The activities don`t have the same weight in a project, because if the duration has a "most likely" situation, it should have the highest weight. It can be two times or four times more important than the others.

Usually, the "most likely" time is weighted 4 times more because it is expected to happen far more than optimistic and pessimistic time.

12.2. PROPERTIES OF PERT METHOD

The PERT method is based on the normal distribution theory, assuming that the probability of completing the project is normal distributed. It operates with three values:

- The mean value (or "μ").
- The standard deviation ("σ") which shows how widely the observed values "μ" are distributed;

  $\sigma_t = \frac{b-a}{6}$

  The larger the standard deviation is, the less precise is the estimation (the optimistic and pessimistic times are very different in value).
- The variance "v" or "σ^2"

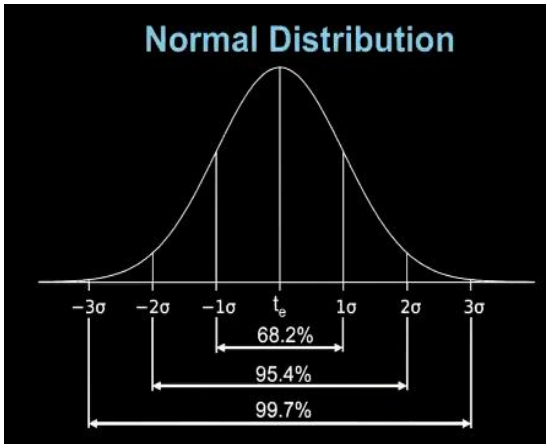
  $v = (\frac{b-a}{6})^2$

  The variance for all the critical activities will be calculated. They will be summed, so the project variance will be obtained.

  Then the standard deviation of the project can be calculated from the variance:

  $\sigma_p = \sqrt{\sigma^2}$

The normal distribution has the same distribution to the right and to the left of the mean value. The entire area of the normal distribution is 100%. Usually, 99,70% of the standard deviations are normally distributed between -3σ and +3σ. Between -σ and +σ, the area is 68,20%, and between -2σ and +2σ the area is 95,40%.



The problem to which the PERT Method answers is: What is the probability to complete a project in "X" number of days?

Advantages:

- Suitable for large projects;
- The Critical Path is visible;
- It helps the management to perform activity analysis;
- Leads to better coordination of resources;

- Based on What-If Analysis.

Disadvantages:

- The analysis is subjective;
- It`s focused only on time, not resources, especially when more projects use the same resources simultaneously;
- It may be inaccurate, due to the prediction of the durations;
- It`s expensive.

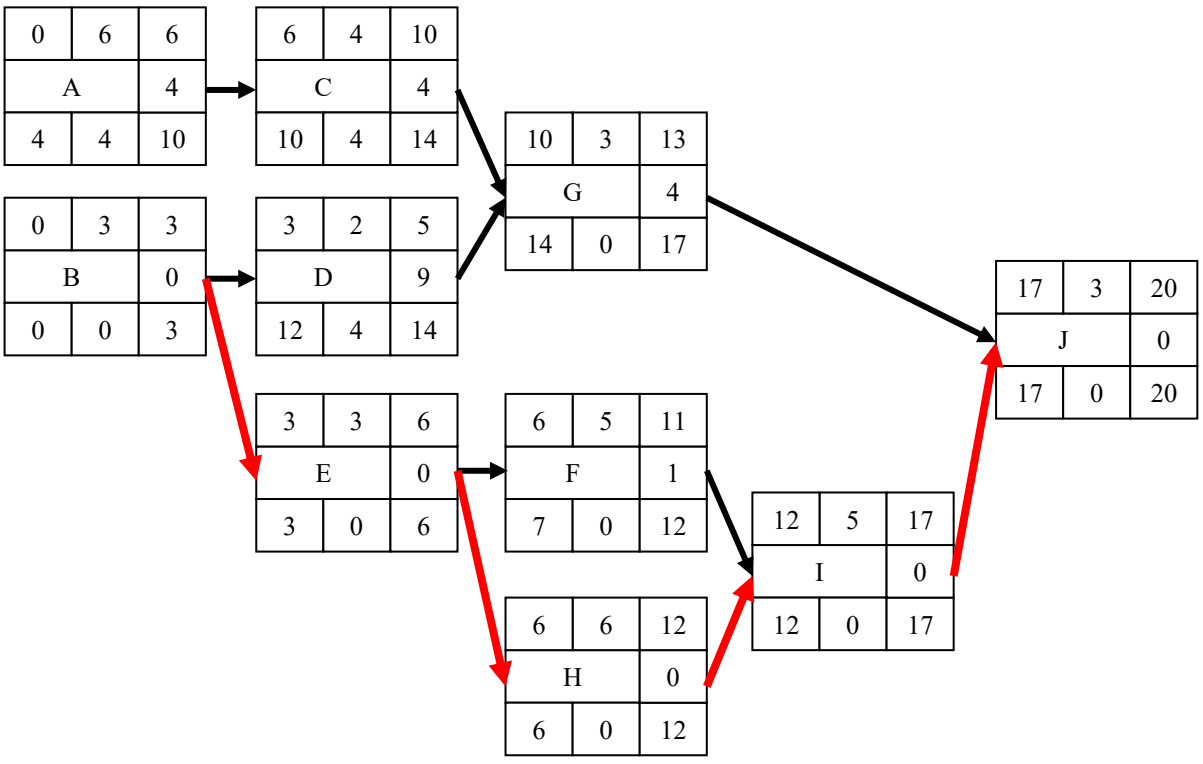
PERT method may be developed in 5 steps:

- Step 1: Identify the activities of the project.
- Step 2: Determine the sequence of the activities.
- Step 3: Design the network diagram.
- Step 4: Estimate the duration for each activity: optimistic, pessimistic, most likely and expected time.
- Step 5: Identify the critical path.

An example of using PERT method in scheduling:

The Critical Path for the project will be designed by using the expected time for each activity of the project. The duration of an activity will be the expected value (**μ**).

Activity	Predecessor	a	m	b	μ	Variance (σ_p^2)
A	-	5	6	7	6	0.11
B	-	1	3	5	3	0.44
C	A	1	4	7	4	1.00
D	B	1	2	3	2	0.11
E	B	1	2	9	3	1.78
F	E	1	5	9	5	1.78
G	C,D	2	2	8	3	1.00
H	E	2	6	10	6	0.69
I	F,H	2	5	8	5	1.00
J	G,I	2	2	8	3	1.00



The median duration of an activity is calculated by the formula:

$\mu = \frac{a+4m+b}{6}$

$\mu_{(A)} = \frac{5+4x6+7}{6} = 6$ $\mu_{(B)} = \frac{1+4x3+5}{6} = 3$ $\mu_{(C)} = \frac{1+4x4+7}{6} = 4$ $\mu_{(D)} = \frac{1+4x2+3}{6} = 2$

$\mu_{(E)} = \frac{1+4x2+9}{6} = 3$ $\mu_{(F)} = \frac{1+4x5+9}{6} = 5$ $\mu_{(G)} = \frac{2+4x2+8}{6} = 3$ $\mu_{(H)} = \frac{2+4x6+10}{6} = 6$

$\mu_{(I)} = \frac{2+4x5+8}{6} = 5$ $\mu_{(J)} = \frac{2+4x2+8}{6} = 3$

The critical path of the project is B-E-H-I-J. But, of course, we may have two or more critical paths. If that is the case, we will calculate the variance for each path. We will choose the one with the greater variance (by summing the variances of each activity of the critical path), because there will be a greater spread of the normal distribution curve.
The project will be finished in 20 weeks, which is the mean normal duration.

In the example, the variance is:

$v = (\frac{b-a}{6})^2$

$v_{(A)} = (\frac{7-5}{6})^2 = 0.11$ $v_{(B)} = (\frac{5-1}{6})^2 = 0.44$ $v_{(C)} = (\frac{7-1}{6})^2 = 1.00$ $v_{(D)} = (\frac{3-1}{6})^2 = 0.11$

$v_{(E)} = (\frac{9-1}{6})^2 = 1.78$ $v_{(F)} = (\frac{9-1}{6})^2 = 1.78$ $v_{(G)} = (\frac{8-2}{6})^2 = 1.00$ $v_{(H)} = (\frac{10-2}{6})^2 = 0.69$

$v_{(I)} = (\frac{8-2}{6})^2 = 1.00$ $v_{(J)} = (\frac{8-2}{6})^2 = 1.00$

The variances for the critical activities are:

Activity	a	m	b	μ	Variance (σ_p^2)
B	1	3	5	3	0.44
E	1	2	9	3	1.78
H	2	6	10	6	0.69
I	2	5	8	5	1.00
J	2	2	8	3	1.00
TOTAL	8	18	40	20	4.91

Project variance = $\sigma_p^2 = 0.44 + 1.78 + 0.69 + 1.00 + 1.00 = 4.91$ weeks

Standard deviation: $\sigma_p = \sqrt{4.91} = 2.22$ weeks ~ 2 weeks

As explained above, 99.70% of the expected time will be between -3σ and +3σ, meaning 6 weeks. So, we may be 100% sure that the project can be completed in 20 + 6 = 26 weeks. It can be assume that there is a probability of 95% (between -2σ and +2σ) that the project can be delivered in 20 + 4 = 24 weeks.

In the current project, the standard deviation might be 2 weeks, meaning that we could be in trouble (68% chance) if we plan to deliver the project in 22 weeks.
Some possible situations may be analyzed.

a. We can assume that the project will be finished in 20 weeks. However, the pessimistic duration is 40 weeks. Which will be the probability of fulfilling it in 23 weeks?
   The probability can be expressed as:
   $P(x \leq 23) = P[z] = P[\frac{x-\mu}{\sigma}]$
   Where $z = \frac{Due\ date - Expected\ Date}{\sigma_p} = [\frac{x-\mu}{\sigma}]$
   Due date is the date we want to finish the project (23 weeks)
   Expected date is the mean value (20 weeks)
   x = 23
   μ = 20

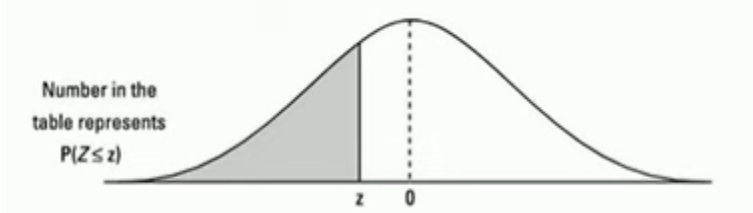
$\sigma = 2.22$

$z = \frac{23-20}{2.22} = 1.351$

$P[\frac{23-20}{2.22}] = 1.351$

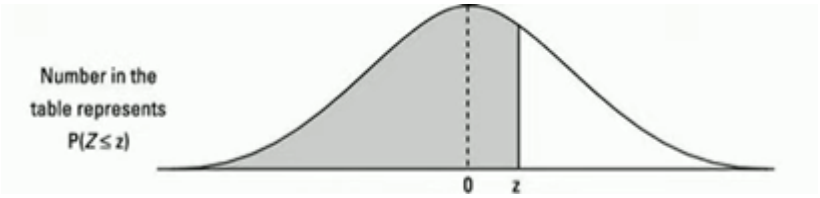
$P[z \leq 1.351]$

The normal distribution table (z table):



STANDARD NORMAL DISTRIBUTION: Table Values Represent AREA to the LEFT of the Z score.

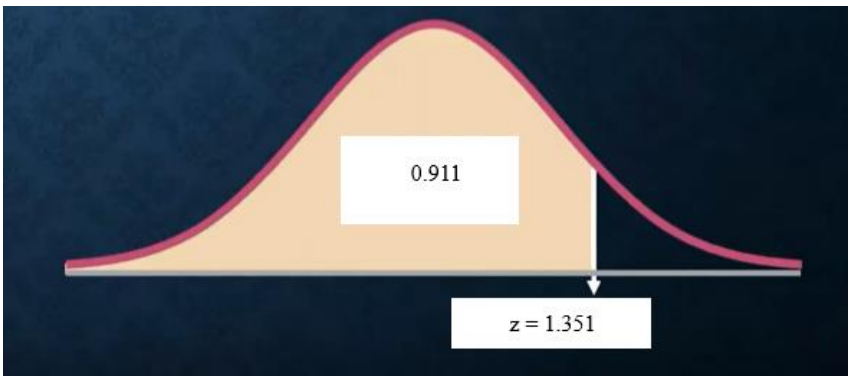
Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
-3.9	.00005	.00005	.00004	.00004	.00004	.00004	.00004	.00004	.00003	.00003
-3.8	.00007	.00007	.00007	.00006	.00006	.00006	.00006	.00005	.00005	.00005
-3.7	.00011	.00010	.00010	.00010	.00009	.00009	.00008	.00008	.00008	.00008
-3.6	.00016	.00015	.00015	.00014	.00014	.00013	.00013	.00012	.00012	.00011
-3.5	.00023	.00022	.00022	.00021	.00020	.00019	.00019	.00018	.00017	.00017
-3.4	.00034	.00032	.00031	.00030	.00029	.00028	.00027	.00026	.00025	.00024
-3.3	.00048	.00047	.00045	.00043	.00042	.00040	.00039	.00038	.00036	.00035
-3.2	.00069	.00066	.00064	.00062	.00060	.00058	.00056	.00054	.00052	.00050
-3.1	.00097	.00094	.00090	.00087	.00084	.00082	.00079	.00076	.00074	.00071
-3.0	.00135	.00131	.00126	.00122	.00118	.00114	.00111	.00107	.00104	.00100
-2.9	.00187	.00181	.00175	.00169	.00164	.00159	.00154	.00149	.00144	.00139
-2.8	.00256	.00248	.00240	.00233	.00226	.00219	.00212	.00205	.00199	.00193
-2.7	.00347	.00336	.00326	.00317	.00307	.00298	.00289	.00280	.00272	.00264
-2.6	.00466	.00453	.00440	.00427	.00415	.00402	.00391	.00379	.00368	.00357
-2.5	.00621	.00604	.00587	.00570	.00554	.00539	.00523	.00508	.00494	.00480
-2.4	.00820	.00798	.00776	.00755	.00734	.00714	.00695	.00676	.00657	.00639
-2.3	.01072	.01044	.01017	.00990	.00964	.00939	.00914	.00889	.00866	.00842
-2.2	.01390	.01355	.01321	.01287	.01255	.01222	.01191	.01160	.01130	.01101
-2.1	.01786	.01743	.01700	.01659	.01618	.01578	.01539	.01500	.01463	.01426
-2.0	.02275	.02222	.02169	.02118	.02068	.02018	.01970	.01923	.01876	.01831
-1.9	.02872	.02807	.02743	.02680	.02619	.02559	.02500	.02442	.02385	.02330
-1.8	.03593	.03515	.03438	.03362	.03288	.03216	.03144	.03074	.03005	.02938
-1.7	.04457	.04363	.04272	.04182	.04093	.04006	.03920	.03836	.03754	.03673
-1.6	.05480	.05370	.05262	.05155	.05050	.04947	.04846	.04746	.04648	.04551
-1.5	.06681	.06552	.06426	.06301	.06178	.06057	.05938	.05821	.05705	.05592
-1.4	.08076	.07927	.07780	.07636	.07493	.07353	.07215	.07078	.06944	.06811
-1.3	.09680	.09510	.09342	.09176	.09012	.08851	.08691	.08534	.08379	.08226
-1.2	.11507	.11314	.11123	.10935	.10749	.10565	.10383	.10204	.10027	.09853
-1.1	.13567	.13350	.13136	.12924	.12714	.12507	.12302	.12100	.11900	.11702
-1.0	.15866	.15625	.15386	.15151	.14917	.14686	.14457	.14231	.14007	.13786
-0.9	.18406	.18141	.17879	.17619	.17361	.17106	.16853	.16602	.16354	.16109
-0.8	.21186	.20897	.20611	.20327	.20045	.19766	.19489	.19215	.18943	.18673
-0.7	.24196	.23885	.23576	.23270	.22965	.22663	.22363	.22065	.21770	.21476
-0.6	.27425	.27093	.26763	.26435	.26109	.25785	.25463	.25143	.24825	.24510
-0.5	.30854	.30503	.30153	.29806	.29460	.29116	.28774	.28434	.28096	.27760
-0.4	.34458	.34090	.33724	.33360	.32997	.32636	.32276	.31918	.31561	.31207
-0.3	.38209	.37828	.37448	.37070	.36693	.36317	.35942	.35569	.35197	.34827
-0.2	.42074	.41683	.41294	.40905	.40517	.40129	.39743	.39358	.38974	.38591
-0.1	.46017	.45620	.45224	.44828	.44433	.44038	.43644	.43251	.42858	.42465
-0.0	.50000	.49601	.49202	.48803	.48405	.48006	.47608	.47210	.46812	.46414



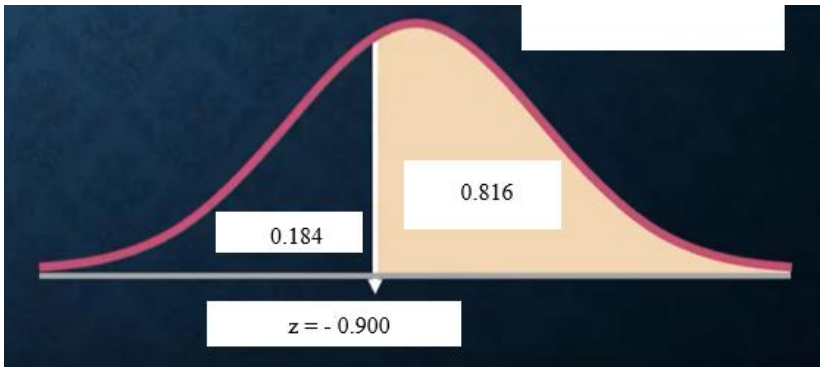
0.0	.50000	.50399	.50798	.51197	.51595	.51994	.52392	.52790	.53188	.53586
0.1	.53983	.54380	.54776	.55172	.55567	.55962	.56356	.56749	.57142	.57535
0.2	.57926	.58317	.58706	.59095	.59483	.59871	.60257	.60642	.61026	.61409
0.3	.61791	.62172	.62552	.62930	.63307	.63683	.64058	.64431	.64803	.65173
0.4	.65542	.65910	.66276	.66640	.67003	.67364	.67724	.68082	.68439	.68793
0.5	.69146	.69497	.69847	.70194	.70540	.70884	.71226	.71566	.71904	.72240
0.6	.72575	.72907	.73237	.73565	.73891	.74215	.74537	.74857	.75175	.75490
0.7	.75804	.76115	.76424	.76730	.77035	.77337	.77637	.77935	.78230	.78524
0.8	.78814	.79103	.79389	.79673	.79955	.80234	.80511	.80785	.81057	.81327
0.9	.81594	.81859	.82121	.82381	.82639	.82894	.83147	.83398	.83646	.83891
1.0	.84134	.84375	.84614	.84849	.85083	.85314	.85543	.85769	.85993	.86214
1.1	.86433	.86650	.86864	.87076	.87286	.87493	.87698	.87900	.88100	.88298
1.2	.88493	.88686	.88877	.89065	.89251	.89435	.89617	.89796	.89973	.90147
1.3	.90320	.90490	.90658	.90824	.90988	.91149	.91309	.91466	.91621	.91774
1.4	.91924	.92073	.92220	.92364	.92507	.92647	.92785	.92922	.93056	.93189
1.5	.93319	.93448	.93574	.93699	.93822	.93943	.94062	.94179	.94295	.94408
1.6	.94520	.94630	.94738	.94845	.94950	.95053	.95154	.95254	.95352	.95449
1.7	.95543	.95637	.95728	.95818	.95907	.95994	.96080	.96164	.96246	.96327
1.8	.96407	.96485	.96562	.96638	.96712	.96784	.96856	.96926	.96995	.97062
1.9	.97128	.97193	.97257	.97320	.97381	.97441	.97500	.97558	.97615	.97670
2.0	.97725	.97778	.97831	.97882	.97932	.97982	.98030	.98077	.98124	.98169
2.1	.98214	.98257	.98300	.98341	.98382	.98422	.98461	.98500	.98537	.98574
2.2	.98610	.98645	.98679	.98713	.98745	.98778	.98809	.98840	.98870	.98899
2.3	.98928	.98956	.98983	.99010	.99036	.99061	.99086	.99111	.99134	.99158
2.4	.99180	.99202	.99224	.99245	.99266	.99286	.99305	.99324	.99343	.99361
2.5	.99379	.99396	.99413	.99430	.99446	.99461	.99477	.99492	.99506	.99520
2.6	.99534	.99547	.99560	.99573	.99585	.99598	.99609	.99621	.99632	.99643
2.7	.99653	.99664	.99674	.99683	.99693	.99702	.99711	.99720	.99728	.99736
2.8	.99744	.99752	.99760	.99767	.99774	.99781	.99788	.99795	.99801	.99807
2.9	.99813	.99819	.99825	.99831	.99836	.99841	.99846	.99851	.99856	.99861
3.0	.99865	.99869	.99874	.99878	.99882	.99886	.99889	.99893	.99896	.99900
3.1	.99903	.99906	.99910	.99913	.99916	.99918	.99921	.99924	.99926	.99929
3.2	.99931	.99934	.99936	.99938	.99940	.99942	.99944	.99946	.99948	.99950
3.3	.99952	.99953	.99955	.99957	.99958	.99960	.99961	.99962	.99964	.99965
3.4	.99966	.99968	.99969	.99970	.99971	.99972	.99973	.99974	.99975	.99976
3.5	.99977	.99978	.99978	.99979	.99980	.99981	.99981	.99982	.99983	.99983
3.6	.99984	.99985	.99985	.99986	.99986	.99987	.99987	.99988	.99988	.99989
3.7	.99989	.99990	.99990	.99990	.99991	.99991	.99992	.99992	.99992	.99992
3.8	.99993	.99993	.99993	.99994	.99994	.99994	.99994	.99995	.99995	.99995
3.9	.99995	.99995	.99996	.99996	.99996	.99996	.99996	.99996	.99997	.99997

$P[z \leq 1.351] = 0.911$

Where they meet is the value 0.911 (91%). That means that there is a probability of 91% of completing the project in 23 weeks. You have to worry that you will have approx. 9% probability to fail.



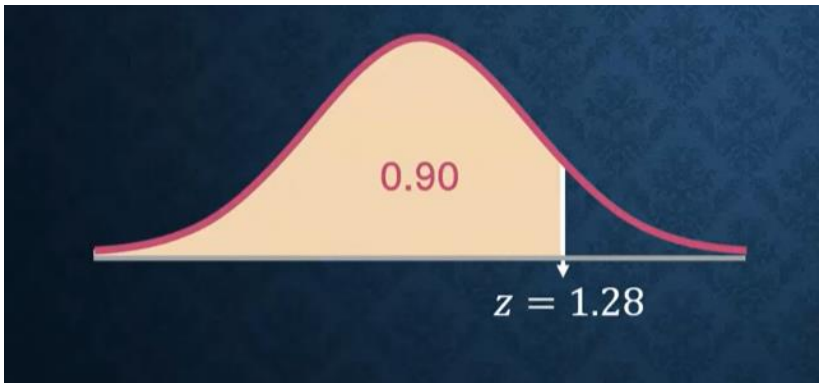
b. Which will be the probability to complete the project in more than 18 weeks:
If the z value is negative, the spread is on the left of the mean value. If it`s positive, the spread of the probability will be on the right of the mean value.
In any case, the table with the normal distribution shows the probability in the left of the value for which we make the calculation.
$z = \frac{18-20}{2.22} = -0.900$, which is
P[z > -0.900] = 1 – P[z < -0.900] = 1 – 0.184 = 0.816



It is a probability of 82% for completing the project in 18 weeks.

c. Which will be the probability to complete the project in 20 weeks?
$z = \frac{20-20}{2.22} = 0.0$
The probability is 50% to complete the project in 20 weeks. That means that there is a probability of 50% deliver the project in the median time.

d. How many weeks are needed for completing the project with a probability of 90%?
The calculus is reverse.



By analyzing the table, it can be seen that it corresponds to z = 1.28 (0.89973).

$z = \frac{x-\mu}{\sigma}$

$1.28 = \frac{x-20}{2.22} \rightarrow$ x = 22.84 weeks.

That means that if the project manager will plan the duration, for 90% chances to complete all activities, the works will last 22-23 weeks.

So, instead of giving a SWAG answer to your boss and take the risks, you can give an accurate answer.

In practice, there are situations when the investor will offer a bonus for the contractor, if he will complete the project earlier than planned and agreed by the parties.

That situation will require a project acceleration. The question is: how many resources may be supplemented and with what costs?

The solution is the crash of the activities and the time-cost tradeoff, known as the range estimation.

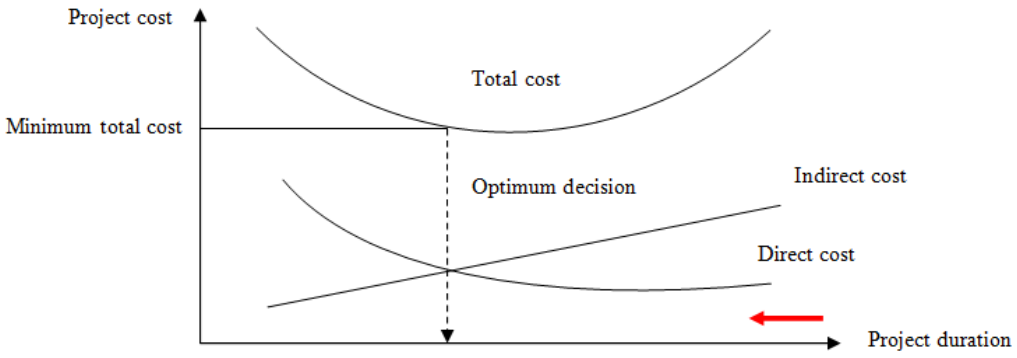
Crashing an activity means taking special costly measures to reduce the duration of an activity below its normal value. This might need additional workforce, time-saving materials, special equipment, etc.

12.3. CRASHING ACTIVITIES IN PERT

This method is also called project acceleration.

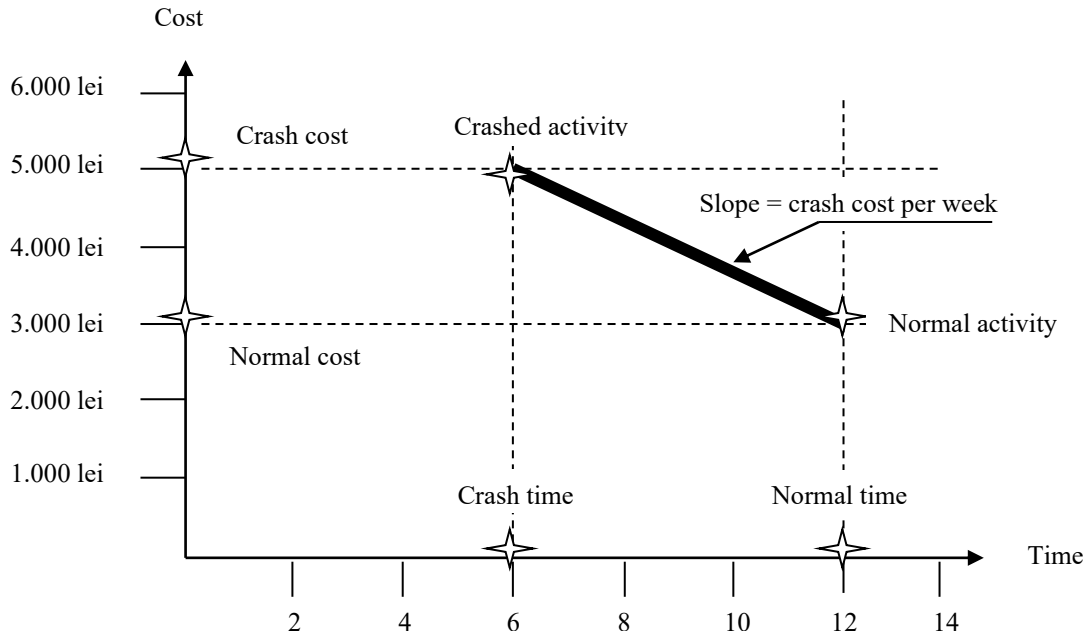
The construction projects involve big expenditures, in terms of time and money, therefore the activities should be planned in such a way that generates minimum costs and schedule. These items are strongly depending on the resources allocated to each individual activity.

The duration of an activity can be reduced by allocating as much resources as possible, especially for critical activities. The benefits may be quantified in money earned by the contractor if the project is delivered earlier.



As can be seen, during the evolution of the project the direct costs go down and the indirect costs go up. The total costs are sum of the direct and indirect costs. By reducing the duration of the individual activities, the total cost of a construction project can be reduced to an optimum level.

Crashing means the reducing of the duration to an optimum amount by allocating more resources.



The crash slope of an activity is the extra cost needed for shortening the duration. From the project`s activities, the first to be crashed should be the one with the lowest cost slope.

As suggested by the figure, the normal activity should be crashed from 12 days to 6 days. Obvious, the crash cost will be 5.000 lei, more than 3.000 lei, the normal cost. The cost of the crash will be 5.000 lei – 3.000 lei = 2.000 lei.

For crashing the activities, the following steps should be taken:

- Identifying the critical path(s) of the project;
- Determining the costs for each activity;
- Calculating the cost slope for each activity;
- Ranking the critical activities in the ascending order of the cost slope and crashing the activities according to the ranking;
- Activities can be crashed to their minimal duration;
- Calculating the project`s revised cost;
- Repeating the previous steps till the optimum cost and duration is achieved.

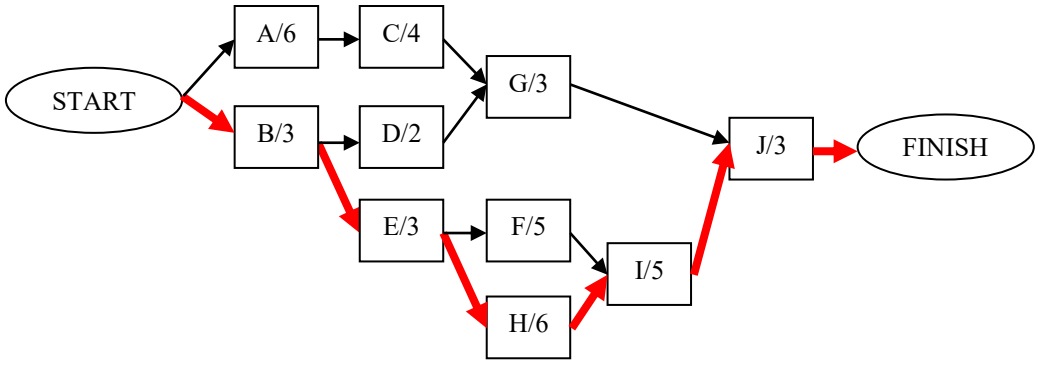
For exemplification, the above project will be analyzed:

The owner wants to shorten the project and offers bonus 1.500 Euro for each week the project is delivered earlier.

We can use it for CPM too, not only for PERT.

Activity	**Predecessor**	**Required time (weeks)**		**Cost (EURO)**	
		Normal	**Crash**	**Normal**	**Crash**
A	START	6	4	12.000	13.000
B	START	3	2	8.000	9.000
C	A	4	2	10.000	14.000
D	B	2	2	7.000	7.000
E	B	3	1	5.000	9.000
F	E	5	4	11.000	14.000
G	C,D	3	2	9.000	16.000
H	E	6	4	10.000	14.000
I	F,H	5	3	8.000	10.000
J	G,I	3	2	15.000	18.000
TOTAL CRITICAL		20		95.000	115.000

The network diagram:



The project manager will have to examine each activity and calculate which are the costs (additional resources needed) to complete the project earlier.
If the activities are performed one after the other, the total normal time will be 40 weeks.
The critical path has to be determined.
The activities may have the following sequences:

- A-C-G-J: 6 + 4 + 3 + 3 = 16 weeks
- B-D-G-J: 3 + 2 + 3 + 3 = 11 weeks
- B-E-F-I-J: 3 + 3 + 5 + 5 + 3 = 19 weeks
- B-E-H-I-J: 3 + 3 + 6 + 5 + 3 = 20 weeks

The critical path is B – E – H – I – J.
For shortening the schedule, extra costs will be added to some activities.
The only activity that cannot be crashed is D.
In order to calculate the cost of crash per week, we use the formula:

$$\text{Cost/week} = \frac{Crash\ cost - Normal\ cost}{Normal\ time - Crash\ time}$$

$$\text{Cost/week (A)} = \frac{13000 - 12000}{6 - 4} = 500 \text{ Euro}$$

$$\text{Cost/week (B)} = \frac{9000 - 8000}{3 - 2} = 1.000 \text{ Euro}$$

$$\text{Cost/week (C)} = \frac{14000 - 10000}{4 - 2} = 2.000 \text{ Euro}$$

$$\text{Cost/week (E)} = \frac{9000 - 5000}{3 - 1} = 2.000 \text{ Euro}$$

$$\text{Cost/week (F)} = \frac{14000 - 11000}{5 - 4} = 3.000 \text{ Euro}$$

$$\text{Cost/week (G)} = \frac{16000 - 9000}{3 - 2} = 7.000 \text{ Euro}$$

$$\text{Cost/week (H)} = \frac{14000 - 10000}{6 - 4} = 2.000 \text{ Euro}$$

$$\text{Cost/week (I)} = \frac{10000 - 8000}{5 - 3} = 1.000 \text{ Euro}$$

$$\text{Cost/week (J)} = \frac{18000 - 15000}{3 - 2} = 3.000 \text{ Euro}$$

Activity	Predecessor	Required time (weeks)		Cost		Cost per week	Weeks to decrease
		Normal	Crash	Normal	Crash		
A	START	6	4	12.000	13.000	500	2
B	START	3	2	8.000	9.000	1.000	1
C	A	4	2	10.000	14.000	2.000	2
D	B	2	2	7.000	7.000	-	-
E	B	3	1	5.000	9.000	2.000	2
F	E	5	4	11.000	14.000	3.000	1
G	C,D	3	2	9.000	16.000	7.000	1
H	E	6	4	10.000	14.000	2.000	2
I	F,H	5	3	8.000	10.000	1.000	2
J	G,I	3	2	15.000	18.000	3.000	1
∑		20		95.000	115.000		13

We analyze the cheapest activities to crash per week. They are: A (500 EURO), B (1.000 EURO), E (2.000 EURO), G (7.000 EURO), and I (1.000 EURO).
The cheapest activity to crash is A. The first impulse is to crash it. But it must belong to the Critical Path, and it`s not, so the overall duration of the project will not decrease.
The next cheapest is B, and it belongs to the Critical Path.
We can crash B with 1 week. When it`s completely crashed, in the table we will mark it with (*).
If we reduce B with 1 week, the Critical Path will last 19 weeks.
Let`s check if the Critical Path is the same:

A-C-G-J: 6 + 4 + 3 + 3 = 16 weeks
B-D-G-J: **2** + 2 + 3 + 3 = 10 weeks
B-E-F-I-J: **2** + 3 + 5 + 5 + 3 = 18 weeks
B-E-H-I-J: **2** + 3 + 6 + 5 + 3 = 19 weeks

The Critical Path is still B-E-H-I-J.
The next critical activity that belongs to the Critical Path is E. It can be reduced with 2 weeks. First, we will reduce E with 1 week.

A-C-G-J: 6 + 4 + 3 + 3 = 16 weeks
B-D-G-J: **2** + 2 + 3 + 3 = 10 weeks
B-E-F-I-J: **2** + **2** + 5 + 5 + 3 = 17 weeks
B-E-H-I-J: **2** + **2** + 6 + 5 + 3 = 18 weeks

The Critical Path is still B-E-H-I-J.
We will reduce E with one more week.

A-C-G-J: 6 + 4 + 3 + 3 = 16 weeks
B-D-G-J: **2** + 2 + 3 + 3 = 10 weeks
B-E-F-I-J: **2** + **1** + 5 + 5 + 3 = 16 weeks
B-E-H-I-J: **2** + **1** + 6 + 5 + 3 = 17 weeks

The Critical Path is still B-E-H-I-J.
The next activity is G, but it doesn`t belong to the Critical Path.
The next critical activity that belongs to the Critical Path is I. It can be reduced with 2 weeks.
First, we will reduce I with 1 week.

A-C-G-J: 6 + 4 + 3 + 3 = 16 weeks
B-D-G-J: **2** + 2 + 3 + 3 = 10 weeks
B-E-F-I-J: **2** + **1** + 5 + **4** + 3 = 15 weeks
B-E-H-I-J: **2** + **1** + 6 + **4** + 3 = 16 weeks

As can be seen, there are two Critical Paths: A-C-G-J, and B-E-H-I-J.
In order to continue crashing, we must find an activity that belongs to both Critical Paths. A, which is the cheapest, is not an option. The only one is activity J, which may be crashed with 1 week.

A-C-G-J: 6 + 4 + 3 + **2** = 15 weeks
B-D-G-J: **2** + 2 + 3 + **2** = 9 weeks
B-E-F-I-J: **2** + **1** + 5 + **4** + **2** = 14 weeks
B-E-H-I-J: **2** + **1** + 6 + **4** + **2** = 15 weeks

Since A-C-G-J and B-E-H-I-J are still critical, and no other activity is common, it means that we cannot crash more. The result is that the project can be ready with an economy of 6 weeks. All other activities are useless to crash, because they don`t belong to the critical path.

Duration	Activity Crashed	Direct Cost	Bonus	Total cost
20 (normal)	-	95.000	0	95.000
19	B*	95.000 + 1.000 = 96.000	- 1.500	94.500
18	E	96.000 + 2.000 = 98.000	- 3.000	95.000
17	E*	98.000 + 2.000 = 100.000	- 4.500	95.500
16	I	100.000 + 1.000 = 101.000	- 6.000	95.000
15	J*	101.000 + 3.000 = 104.000	-7.500	96.500

Therefore, the activities which can be crashed are: B (-1); E (-2); I (-2); J (-1).

By crashing the activities, the project paths look like follow:

Project Paths	Normal duration	B*	E	E*	I	J*
A,C,G,J	16	16	16	16	16	15
B,D,G,J	11	10	10	10	10	9
B,E,F,I,J	19	18	17	16	15	14
B,E,H,I,J	20	19	18	17	16	15

All the costs for crashing the critical activities are:
- Activity B: 1.000 EURO
- Activity E: 4.000 EURO
- Activity I: 1.000 EURO
- Activity J: 3.000 EURO

The total extra costs for finishing the project 5 weeks earlier are 9.000 EURO (average of 1.800 EURO/week).
The project manager has three choices:
- To ask at least extra 2.000 EURO/week and finish 5 weeks earlier;
- To take 1.500 EURO/week and finish 2 weeks earlier, but having no profit;
- To work according to schedule.

The project manager has another option: to crash two different activities from both critical paths, which will have the same effect on the duration of the project.
In this example, we can take:
- Activity C from the critical path A,C,G,J.
- Activity H from the critical path B,E,H,I,J.

It`s all about money. Crashing two activities at the same time generates extra costs. Therefore, a financial analysis is mandatory.

Crashing C and H at the same time:

Duration	Activity Crashed	Direct Cost	Bonus	Total cost
20 (normal)	-	95.000	0	95.000
19	B*	95.000 + 1.000 = 96.000	- 1.500	94.500
18	E	96.000 + 2.000 = 98.000	- 3.000	95.000
17	E*	98.000 + 2.000 = 100.000	- 4.500	95.500
16	I	100.000 + 1.000 = 101.000	- 6.000	95.000
15	J*	101.000 + 3.000 = 104.000	-7.500	96.500
14	C	104.000 + 2.000 = 106.000	-9.000	97.000
14	H	106.000 + 2.000 = 108.000	-9.000	99.000

As it can be observed, crashing both activities with 1 week generates extra cost of 4.000 EURO (2.000 EURO for C and 2.000 EURO for H). The bonus given is of 1.500 EURO per week, which means that the company has a loss, and not a benefit.

Rule of thumb: when deciding to crash activities, the project manager has to begin with the cheapest activities that belong to the Critical Path, and the same algorithm should be applied when the project has two or more Critical Paths.

COURSE 13
DESIGN OF THE SITE ORGANIZATION

Any construction project is achieved according to the blueprints provided by the designer and/or the engineers specialized in the structure calculus. The project will be developed on the beneficiary`s land, or, if he/she doesn`t own it, on an area landed or under concession.

The objective of the site organization is to ensure all the technical and logistic conditions for developing the construction project based on the contract agreements.

The site organization for a construction project serves some purposes:

- To optimize the time, cost, transport and material logistic;
- To maximize the work safety and the work and operation efficiency;
- To minimize accidents, materials loss, or any kind of waste.

The design of the site organization is influenced by a lot of factors:

- The characteristics of the construction site: soil, size, inclination, infrastructure, neighborhood, traffic, vegetation, legal issues;
- The characteristics of the building: site, function, complexity, structure, materials;
- The characteristics of the contractor: capital, business strategy, risk strategy, machineries and equipment used.

The community affected by the construction works is warned to stay out of the site, because they are exposed to multiple risks: violation of private property, accidents, etc. Moreover, in the neighborhood some activities may be performed, without generating accidents, pollution and others.

For the personnel hired for the construction project, the site organization is designed to protect their health and safety from some perspectives:

- ☠ Traffic inside the site: the pathways shall be placed so as not to affect the workers` activities;
- ☠ The material and waste facilities: will be placed according to the available regulations in constructions;
- ☠ The existence of drinking water, lockers, toilets, will provide the hygiene conditions for the personnel.

The site organization project is a technical-economic documentation, developed by the designer in cooperation with the general entrepreneur; it contains written and drawn documents according to the activities of the construction project, together with the estimation which will show the expenses needed for its completion.

When preparing the project for the site organization, two phases are being carried out:

a. Preliminary phase: the designer develops a general scheme of site organization, based on the pre-estimation. Usually, this phase takes place during the tender preparation stage and includes general elements based on the pre-estimation and on provisional constructive solutions;

b. Final phase: the construction company details the solutions of the preliminary phase based on the general scheme of the site organization. The entrepreneur analyzes the general estimation which contains the resources required, together with the schedule of works, then develops written and drawn documents, graphs, diagrams and tables that will facilitate the planning of the site activities by avoiding interruptions and by respecting the start and finish terms, as follows:

- Execution of the basic constructions that are dimensioned and located to facilitate the work on site and to reduce the manufacturing expenses. There will be access routes to the building (and its parts), to the main road; there will be access to the utilities, by planning additional expenditures if the roads don`t exist on the site or they are at significant distances;

- The location of the main equipment (generally the crane) with respect for the norms of work safety;
- Dimensioning the lockers and other facilities designated for accommodation of the personnel on short periods or on the whole development of the construction project (warehouses, toilets, showers, cafeteria, etc.);
- Sizing the storage of materials, based on the planning of their cyclical supply. If possible, the destination of the warehouses and platforms will be changed according to the technological flows, of course for space-saving reasons;
- Using mobile or demountable site organization items, also for reasons of ergonomics;
- Planning the transport of resources to the location, including the workers, if they must be moved daily or weekly.

The site organization project is as important as the investment itself, because it is supporting all the manufacturing and auxiliary activities from the technical and technological points of view.

The preparation of the site organization project is based on general and location information, namely:

- Geotechnical study, according to the regulation NP 074/2007, for preventing the degradation in time of the construction or for avoiding accidents caused by unbalancing of equipment or means of transport;
- Climatic and hydrologic study, that provide data related to the duration and frequency of the frost periods, the level of ground waters, the flows of watercourses from the area or neighborhoods;
- Analyze of the distance from the material resources needed for the project completion;
- Analyze of the access routes to the location: roads, railways, river or sea transport;
- Existence and quality of the utilities in the area: electricity, gas, water, telephone;
- Study concerning the number and quality of the workforce in the area, in case that, in peak times, supplementary personnel is needed.

The technical-economic documentation that is the fundament of the site organization project, is approved by the contractor`s management and it`s not the beneficiary`s responsibility. He/she is responsible with the payment of the works, as a percent of the general estimation. The value is set as a negotiation between the investor and the contractor.

The site organization project is not generally valid, but specific for each type of works related to the building. Consequently, based on the documentation, the works that may be performed are[46] :

- Administrative buildings: dwellings, bedrooms, food court, food deposits, offices, locker rooms, sanitary facilities, etc.;
- Auxiliary buildings, which serve the construction process: carpentry workshops, blacksmiths, locksmiths, prefab facilities, aggregate sorting plants, concrete and mortar stations, etc.;
- Buildings that serve the production: warehouses, platforms for materials, fuel warehouses, limestone warehouses, castles or water basins, unloading and storage ramps, etc.;
- General constructions and installations, roads, provisional garage lines, crane tracks, electrical networks, water and sewerage networks, provisional electrical and thermic plants, etc.;
- Installations and site organization works needed to perform the construction works in cold weather and artificial light.

Depending on the usage duration of these construction objects, as well as the stage of endowment of the site, the site organization facilities are:

a. Definitive constructions: those that are used for the whole site`s functionality and keep their location, but not necessary the destination;
b. Temporary constructions: those that may be demountable, fix or mobile. They may move from a construction site to another, or in case of fix ones, they may be demounted when the site is

[46] http://www.stiucum.com/management/managementul-proiectelor/Lucrarile-de-organizare-a-sant84339.php

closed. In order to locate them, a preliminary authorization is required, and if they change their location, the authorization is no longer valuable, and it has to be renewed.

After the agreement between the two parties has been signed, the general contractor summons the beneficiary and the designer on site. The beneficiary will deliver the land through a protocol which will state the fact that the location is clear, both for the construction and the site organization, by ensuring free access to it ; however, if the land is occupied with old buildings or other objects that obstruct the future activity, the beneficiary will be in charge to release it. At that moment, the general contractor issues "the order of starting the works".

The site organization project is the technical-economic documentation, delivered by the designer, in form of a general outline, which will be detailed by the general contractor.

The site organization project is delivered in 2 phases:

- Phase I: is materialized in a "General site organization outline" delivered by the designer, and based on the technological solutions written in the order note;
- Phase II: delivered by the general contractor based on the "General site organization outline" and the execution project. In this phase, the solutions provided by Phase I will be detailed.

The site organization project – Phase II, contains drawings, graphs, and tables that express the following aspects:

- Execution of the basic buildings in a logical succession of works, with priority to those that will reduce the site organization costs (access routes to the construction object, underground works, etc.);
- Maximum usage of the buildings designated for accommodation, canteen, storehouse, warehouse;
- Sizing the manufacturing plant to take minimum space;
- The use of mobile and demountable devices by the general contractor;
- Adopt the most economic methods to transport the workers.

The amount of site organization value represents a percent from the total estimation. This rate may be used for executing:

- Administrative buildings, dormitories, wagons, containers, canteens, first aid rooms, toilets;
- Auxiliary constructions: carpenters, locksmiths, blacksmiths, prefab platforms, concrete central stations, etc.;
- Construction designated to help the manufacturing: warehouses, storehouses, loading and storage ramps;
- Constructions and installations of general use: crane tracks, electric and sewerage networks.

After signing the contract by the beneficiary and the general contractor and the acceptance of the payment for the construction works, the general contractor will open and equip the site, by releasing "The Order of Starting the Construction Works".

Before the site opening, the general contractor calls the beneficiary and the designer to the site location, where the beneficiary will give the construction site to the general contractor through a protocol, together with the location for the site organization, which will be free of objects or networks which may obstruct the activity in normal conditions. Moreover, the designer provides the main site landmarks and the metric levels materialized on the ground. On this occasion, the general designer presents the execution project, by providing all the necessary explanations.

In order to track the correct delivery of the project, by mutual agreement, the beneficiary together with the general contractor and the general designer will draw up a chart to state the physical execution stages to which the designer will be mandatory present to the construction site.

For the site opening, the general contractor takes a number of measures to allow the beginning of the preparatory works (fencing the land, clearing the land and cutting the trees, if necessary, demolishing the old buildings if they exist on the location, evacuating the resulted wastes, land leveling, etc.) These works should be finished very quickly, except for constructions that may be used for site organization.

After the execution of the main organizational works, the contractor will mark the land for the future construction, by recording the activities in a protocol for each construction object. He/she will also mention the delays, if there are any, and the reasons for the delays. Moreover, the physical stages will be mentioned, as base for the future payments.

The site organization project has three sections: the technology section, the scheduling section, and the site organization section.

1. Technology section (development of technological sheets):

For each execution process, the following items will be determined:

- How to receive the materials on site;
- Means of local transportation (for equipment, tools);
- Equipment and machineries on site:
  - Formworks: types of formworks;
  - Concrete: pumps, vibrators;
  - Prefabs: cranes, lifting devices.

2. Scheduling section:

Scheduling means drawing up the calendar (based on the finishing time agreed with the beneficiary).

After drawing the calendar, the contractor will elaborate plans for the resources needed (materials, workforce, equipment).

The planning ends with centralizing the resources plans in order to check if the contractor has the capacity to perform the project. For peak periods, where the contractor might have problems, some changes should be made.

3. Site organization section:

There are some types of site organization objects:

- Definitive: objects to be used throughout the duration of construction site;
- Provisional: are built immediate after the site opening, based on prior authorization, and when they are out of use, their demolish is mandatory, but without the need of a new authorization. They may be:
  - Demountable;
  - Mobile;
  - Fixed.

The demountable and mobile objects will be moved from one construction site to another. The fixed objects will be abandoned or demounted.

For a legal regulation of the norms related to the site organization project, the contractor will respect the Governmental Decision 28/09.01.2008, which includes the site organization in the general estimation, as follows:

GENERAL ESTIMATION

Regarding the expenses needed to achieve ……

In Thousand Lei/Thousand Euro, conversion of … Lei/Euro from (day/month/year) …

Crt No	Name of chapters and sub-chapters of expenses	Value (without VTA)		VTA	Value (with VTA)	
		Thousand lei	Thousand euro	Thousand lei	Thousand lei	Thousand euro
1	2	3	4	5	6	7
CHAPTER 1. Expenses for buying and arranging the land						
1.1.	Buying the land					
1.2.	Arranging the land					
1.3.	Arranging for land protection and bringing it to the initial state					
	TOTAL CHAPTER 1.					
CHAPTER 2. Expenses for providing needed utilities for the construction object						
	TOTAL CHAPTER 2.					
CHAPTER 3. Expenses for design and technical support						
3.1.	Land surveys					
3.2.	Taxes for notices, agreements, authorizations					
3.3.	Design and engineering					
3.4.	Organizing the procurement procedures					
3.5.	Consultancy					
3.6.	Technical support					
	TOTAL CHAPTER 3.					
CHAPTER 4. Expenses for basic investment						
4.1.	Constructions and plumbing					
4.2.	Assembling technological machineries					
4.3.	Equipment, technological and functional machineries with assembly					
4.4.	Equipment without assembly and means of transport					
4.5.	Features					
4.6.	Intangible assets					
	TOTAL CHAPTER 4.					
CHAPTER 5. Other expenses						
5.1.	Site organization					
	5.1.1. Construction works					
	5.1.2. Expenses connected to the site organization					
5.2.	Commissions, rates, taxes, cost of the credit					
5.3.	Unpredicted and diverse expenses					
	TOTAL CHAPTER 5.					
CHAPTER 6. Expenses for technological test and deliver to the beneficiary						
6.1.	Training the personnel					
6.2.	Technological tests					
	TOTAL CHAPTER 6.					
GRAND TOTAL						
FROM WHICH C+M						

Depending on the size of the construction project, but also on the financial capability of the investor or the contractor, some responsibilities should be established regarding the following items of the site organization[47] :

a. Investor:
- Provides the conditions of health and safety in work;
- Provides a qualitative construction product;
- Allocates enough resources for allowing the contractor to design the site organization in conditions of security in work.

b. Contractor:
- Designs the escape routes, access routes, safety areas, ramps, space for load and unload, etc.;
- Ensures the equipment and tools for work safety, the safety data sheet, the training of the workers for safety in work;
- Ensures the slopes for the excavator;
- Places the visual and auditive safety signals;
- Provides the reflective warning equipment;
- Provides the working place with security and safety;
- Locates the first aid pickets, or, depending on the size of the site, the required medical personnel.

c. Employees:
- Respect the safety in work norms;
- Provide the security equipment, the safety for using the equipment, materials, semifabs or prefabs;
- Immediate repair or replace of the broken tools or equipment;
- Stop the activity of the employees with health problems;
- Announce the hierarchic boss of any situations that may jeopardize the personnel`s health and safety.

d. Site`s management:
- Trains the personnel in issues connected to the health and safety in work;
- Evaluates the level of risk for the activities that cannot be avoided;
- Sets the additional measures of safety for activities with high degree of risk;
- Performs periodical and permanent training of the personnel.

e. Architects, specialized engineers:
- As early as the project phase, the architects will explain to the investor the risks that may arise in terms of security and safety;
- Design the utilities and the buildings that will ensure the work safety of the personnel;
- Inform the contractors and subcontractors of issues connected to safety in case of a project with such problems.

f. Jobsite engineers, staff in charge with work safety:
- Identify the sources of risks in work;
- Provide advice of effective help in situations related to such risks and incidents at work;
- Analyze the number and type of accidents in work and find solutions for avoiding or eliminating them;
- Train the operative personnel for risk prevention.

The site organization begins before the construction works start. It is the stage in which the legal papers are prepared according to the regulations, like follows:

- Plan to ensure the safety and security in work;
- File to register the work accidents;
- File with the work safety sheets;

[47] Construction Site Safety Handbook, 2005, published by The Real Estate Developers Association of Hong Kong and The Hong Kong Construction Association

- Documentation for the training procedures;
- File with the work safety tools and equipment;
- Book of labor protection.

For small size construction sites, the site organization in achieved in the following conditions:

- The materials with a high degree of danger will be stored accordingly, by respecting the safety and security regulations;
- The operative personnel will have protection equipment;
- Periodical technical check of the equipment and machineries required for the construction activity;
- Providing the site with fences and signaling systems;
- Measures to prevent accidents caused by the fall of heavy objects from a height;
- Providing secured scaffolding for work at height;
- Maintaining cleanliness on the site;
- Providing first aid locations;
- Providing fire dips, escape routes, etc.;
- Scheduling periodical inspection of electrical installations;
- Locating the equipment and access routes for trucks, concrete mixers and other heavy vehicles in areas that shouldn`t affect the safety of the workers;
- Checking the location of the lifting equipment;
- Respecting the regulations of chemical, noise pollution, etc.

Briefly, the expenses concerning the site organization of a project refer to:

- Lockers for the personnel;
- Technological platforms, including their decommissioning;
- Toilets and sanitary rooms;
- Car wash ramps;
- Warehouses for materials;
- Foundations for tower cranes;
- Lighting and power grids;
- Access roads and railways;
- Connections to utilities;
- Fences;
- Presentation panels;
- Fire pickets;
- Expenses for dismantling the site organization, including expenses needed to restore the occupied lands to their initial state, at the completion of the construction works;
- Expenses related to the site organization, like:
    - Obtaining the construction/dismantling of the site organization;
    - Placement fees;
    - Renting traffic signs;
    - Temporary disruption of access roads or water distribution, sewerage, thermal agent, electricity, natural gas, etc.;
    - Assistance contracts with the local police;
    - Temporary contracts with energy, water and sanitation suppliers;
    - Ecological deposit fees;
    - Local taxes;
    - Rents for temporary occupation of the public zone;
    - Costs of electricity and water consumed within the site during the execution of the construction works;
    - Costs of transporting non-domestic workers and/or their accommodation;
    - Guarding the site;
    - Salary for authorized fireman;

- Costs of ensuring the safety and health of the workers during the execution of the construction works.

An important issue on the construction site is related to the fire safety. The fire hazard intensity may be classified as follows:

No.	Fire hazard level	Fire intensity (kW/m)	Fire flame height (m)
1.	Low hazard	Less than 400	0 – 1.5
2.	Medium hazard	400 – less than 1000	1.5 – 7
3.	High hazard	1000 – less than 2000	7 – 14
4.	Very high hazard	Grater than 2000	> 14

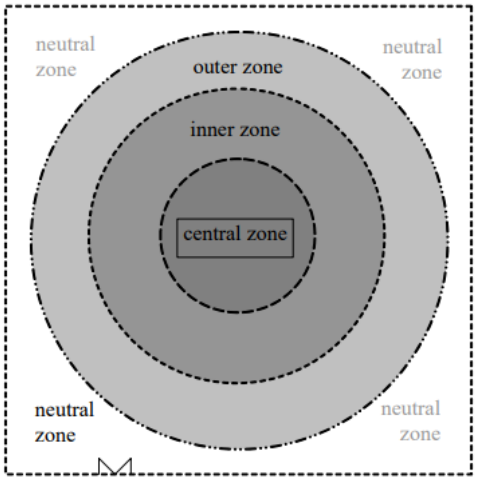
The facilities in the site that have to be monitored for fire safety may be:

Facility	L (m)	l (m)	Movable or fixed	Hazard source	Hazard level	Vulnerability class
Electric generator	2	1	Movable	Yes	High	Safe
Labor services	7	3	Movable	No	-	Very dangerous
Concrete plant	10	6	Movable	No	-	Dangerous
Job office 1	12	5	Movable	No	-	Very dangerous
Job office 2	5	12	Movable	No	-	Very dangerous
Steel storage	8	20	Movable	No	-	Safe
Fuel storage	2	1	Movable	Yes	High	Safe
Tower crane	8	8	Fixed	No	-	Safe
Construction building	26	50	Fixed	Yes	Medium	Safe

COURSE 14
CALCULUS OF THE BUILDINGS AND UTILITIES FOR THE SITE ORGANIZATION

 [48]

An efficient site organization has a positive influence on the productivity of the entire project, from the supplying of the materials to their handling and the workers` safety.
The site area is split in some zones:



[49]

[48] https://www.esedirect.co.uk/articles/post/site-organisation-for-construction.aspx, accesat în data de 23.10.2024

[49] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://s3.studentvip.com.au/notes/23946-sample.pdf, accesat în data de 23.10.2024

- The central zone: it includes the construction project to be built. In the center will be located some equipment (tower cranes, lifting/bearing equipment, scaffolding). Most of the time, this zone is identified in accordance with the operating radius of the central tower cranes. The central zone is the primary area of works/performances (building processes).
- The inner zone: is close to the central zone and is designed for loading/unloading (pick-up) areas and active (short term) stores, deposits (e.g. prefabricated elements/units/blocks of load-bearing structure, masonry blocks, roofing structure), together with main temporary access roads.
- The outer zone: is located in the reaching area of the main tower cranes. The auxiliary plants, workshops, yards are placed, together with the auxiliary stores and deposits (e.g. steel yard, wood yard, stores for on-roof HVAC devices, sealing/proofing materials, etc.).
- The neutral zone: is located inside the boundary fences of the construction site, usually out of reach of the main cranes, surrounding the building area. It accommodates auxiliary temporary structures such as site offices, parking lots, on-site production plants (e.g. batching plant), workshops, laboratories, equipment stores, earth/topsoil deposits, contaminated/waste water tanks, temporary waste material deposits (e.g. "dead concrete"), hazardous material stores or containers, etc.

The psychical characteristics of the site are affecting the design and the method adopted. A site investigation will set where to place the accommodation, storage, access roads, or plant. For example, limited access will restrict the dimensions of the facilities brought on site, and will have consequences on the costs. Sites with tall buildings in the surroundings will limit the size of plants, or cranes. Sloping sites will obstruct the choice of tower crane, or rail-mounted crane.

The site layouts will be designed both for people and equipment, and will consider some important aspects:

- The movement of people, plant, and equipment.
- Accommodation for:
    - Administration offices: they are the information and control center of the site and should be placed so as to facilitate checking, supervision, and security on site. They can be ready-made and equipped mobile accommodation, or existing buildings on site.
    - Toilet and mess facilities: depend on the number of operational people, and the location (local or remote).
    - Parking facilities: should be located close to the site offices.
    - Subcontractor accommodation: they may have their own, or may be rented from the contractor.
    - Accommodation for client`s agent: they may be architects, quantity surveyors, or consultants.
    - Site clerk`s accommodation: should be located near the entrance of the site so the clerk can check and inspect deliveries and direct them to specified areas.
- Work activity areas:
    - Repair and cleaning areas for formworks;
    - Steel reinforcing storage;
    - Working area.
- Site access: vehicle deliveries, etc.
- Control of site activities.

The factors that may influence the size of the warehouses needed to store the materials in the site organization may be:

- Economic buying of materials: a contractor may buy in large (bulk) quantities to reduce the material costs. This strategy requires big dimensions for storing area;
- Changes in the production programs: if the initial planning is modified, the supply with materials should be adapted;

- Late delivery from suppliers: for preventing the postponing of activities because of the lack of materials, the contractor can supply the materials in advance and store them in designated areas;
- Limited period of availability of some materials.

Some documents should be completed on the site, concerning the supply with materials:

- Materials received:

MATERIALS RECEIVED				
Job:		Address:		
Date	Material code	Name of material	Supplier	Remarks
Signature:				

- Materials returned:

Supplier`s copy

MATERIALS RETURNED

_____
_____
_____

No. …..
Project:
Date:
Refer: Mr. ……..

PLEASE RECEIVE THE UNDERMENTIONED MATERIALS:

Reasons to return

1. _____
2. _____
3. _____
4. _____
5. _____

Your delivery note no. _____ Date _____

Received on behalf of the above supplier: _____

Note:

The constructions which are parts of the site organization may be classified in the following categories:

14.1. TYPES OF SITE ORGANIZATION BUILDINGS

These buildings are mandatory for each construction site. They are temporary buildings required for the execution in normal conditions of the final works. Here is a list of the site organization buildings:

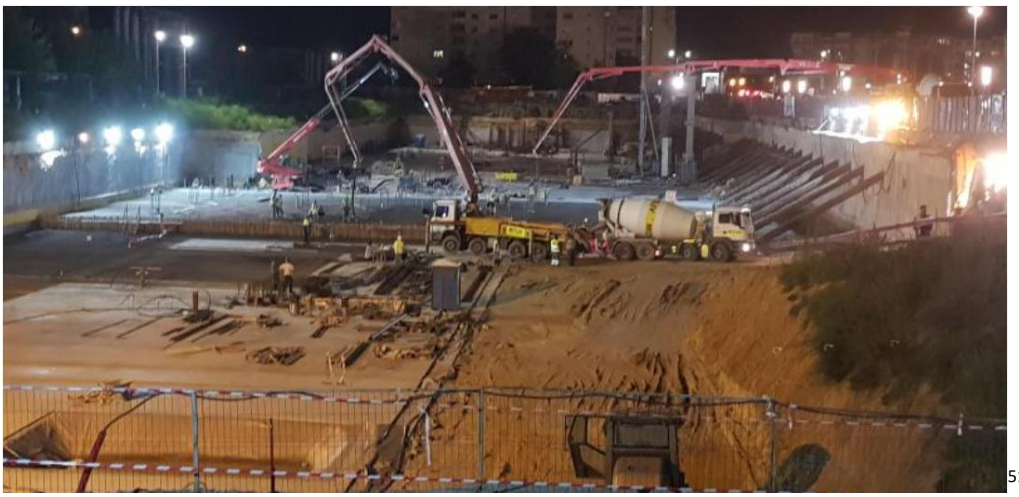
a. Technological buildings:

a.1. Material deposits:

 [50]

- They have to be protected against bad weather;
- They will be located near the structure, in the central zone of the site;
- They will be guarded;
- They are designed for all main materials;
- The cement, plaster and lime will be packed in paper bags and require dry deposits. These materials will not be stored for a long time inside the site; therefore, their supplying should be carefully planned;
- Aggregates like sand or ballast, require a clean surface so that the residues do not mix with them;
- The bricks and other container materials should be placed so that there would be maneuver space between them. They also should be protected against weather conditions: humidity, frost, excessive sun exposure. They should be covered with foil.

a.2. Space for concrete delivery:

 [51]

[50] https://www.facebook.com/warehousechicago/, accesat în data de 23.10.2024

[51] https://www.google.com/imgres?imgurl=https://media.licdn.com/dms/image/v2/C5122AQEfKfVgSdAoDg/feedshare-shrink_800/feedshare-shrink_800/0/1582063021099?e%3D2147483647%26v%3Dbeta%26t%3DUfZY8H5er77OB-fckFq242krsMD9iaizeVDUPUf4i9U&tbnid=6_OWtC0Pwp6T1M&vet=1&imgrefurl=https://ro.linkedin.com/in/liviucocosila&docid=QnkvCHdwu_Cg8M&w=800&h=388&hl=ro-RO&source=sh/x/im/m1/4&kgs=3d9584eb26cb55e8, accesat în data de 23.10.2024

- The vertical transport of the concrete is provided by buckets lifted by cranes, or concrete pumps. The unload time will be maximum 30 minutes. The falling height of the concrete should be: maximum 3 m for elements with maximum 1 m width; maximum 1,50 m in other situations, including surface elements like beams or foundations;
- The maximum durations recommended are: 30 min for unloading; 50 min for preparing and pouring in summer; 70 min for preparing and pouring in winter;
- The height for concrete pouring will not exceed 3 m. For walls, the pouring will be performed in horizontal layers of 30-50 cm depth, and in columns for 1 m area;
- Pouring concrete in beams or slabs will begin after 1-2 hours before pouring the concrete in columns or other supporting elements. Concrete for beams and slabs will be poured at the same time. The concrete for beams will be poured in 30-50 cm horizontal layers;
- For formworks removal, the minimum time will be 2 days for lateral surfaces. For inferior surfaces, the minimum time will be 5 days, but keeping the props. For props removal, the minimum time will be 10 days;
- The formworks for structural elements should be removed after performing test to show the resistance of the concrete. They may be removed if the resistance is: 50% maximum spans of 2 m; 70% for spans between 2 m and 8 m; 90% for spans larger than 8 m. If tests cannot be possible, the limit time will be:

Formwork removal (days)			
Temperature Celsius	Span of the element (meters)		
	< 2.00	2.00-8.00	> 8.00
5	10	20	35
15	6	12	22
25	5	8	16

The order for the formworks removal is: the lateral sides of the beams; the columns that aren't solicited; the slabs with small spans; the beams. However, some props should be not removed until the complete hardening of the concrete: one for 120 m^2 of slab, one for 3 meters of beam, if the upper slab is supported by it.

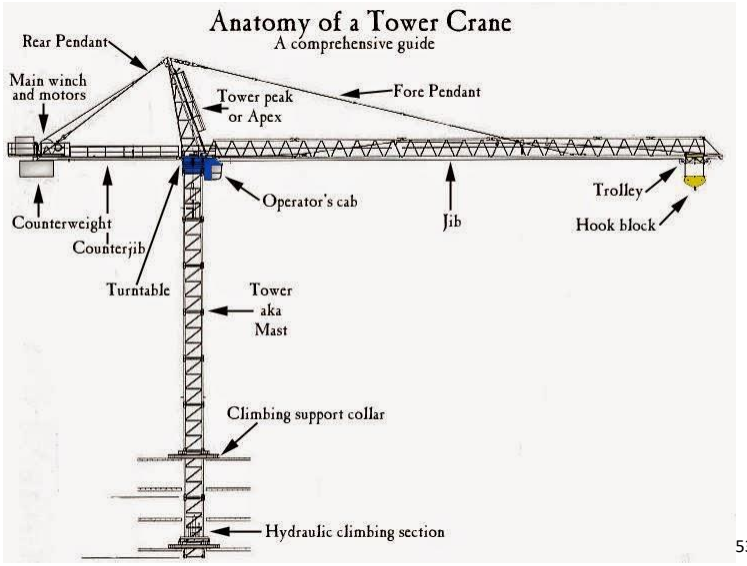
a.3. Spaces for manufacturing semi fabricates:

 [52]

[52] https://www.google.com/imgres?imgurl=https://p.turbosquid.com/ts-thumb/k1/2YeK3s/dOT9alca/constructionsiteobjects/jpg/1332262623/600x600/fit_q87/d2ae823cbc6ce762ae7ff3590854acf5f88825dc/constructionsiteobjects.jpg&tbnid=exPyaINiNTc-LM&vet=1&imgrefurl=https://www.turbosquid.com/de/3d-models/max-construction-site-object/661747&docid=bPR1mxMcQ0NIMM&w=600&h=450&hl=ro-RO&source=sh/x/im/m1/4&kgs=37888d6c166ed11b, accesat în data de 23.10.2024

These may be big formwork panels, reinforcement cases, etc.

a.4. Location for the tower crane:



[53]

In order to use the tower crane on the site, several documents are needed:

- The list of mounting documentation, written and drawn papers;
- The execution project for the tower crane`s foundation;
- The mounting project of the tower crane;
- The demounting project of the tower crane;
- Geological study concerning the nature of the soil;
- Documents for the works that become hidden;
- The warranty certificate of the materials used for the crane`s foundation;
- The Topo report on checking the tower crane location;
- The certificate of checking the protection against the voltage stresses;
- The certificate of checking the insulation of the cables;
- The welding joints verification bulletin (if applicable);
- The time for the theoretical and practical preparation of the tower crane assembly;
- The tower crane assembly technology.

[53] https://www.facebook.com/photo/?fbid=534654556968352&set=pcb.534655743634900, accesat în data de 23.10.2024

a.5. Deposits (platforms) for demolition materials: wood, steel, plastic, etc.

b. Temporary buildings for people

The temporary facilities for people will require enough space for indoors activities of the project team: managers and workers.

Area estimates for temporary facilities (average m^2)	
Craft change house per worker	1.02
Time office per office worker	8.70
Project manager	12.00-25.00
Construction manager	9.00-14.00
Mechanical/Electrical/Civil Engineer per Engineer	9.00-11.00
Purchasing (total)	46.00-84.00
Schedule and Cost Control (total)	28.00-93.00
Accounting (total)	37.00-80.00
First Aid and Safety per Office	17.00-19.00
Estimator	11.00

b.1. Lockers

[54]

[54] https://www.equipmentrentalpros.com/office-trailer-rental/in.php, accesat în data de 23.10.2024

b.2. Offices

 [55]

b.3. Resting spaces: huts, trailers – if they work outside their residence

 [56]

b.4. Repository for tools and small materials

 [57]

[55] https://www.usinenouvelle.com/expo/espaces-modulaires-economiques-proeco-p219084.html, accesat în data de 23.10.2024

[56] https://www.caravans.nl/avento/avento-mezzano-385-2xtreinzit-hefdak-tent-950839.html, accesat în data de 23.10.2024

[57] https://sailvega.wordpress.com/interior-images-of-the-historical-vessel-vega/, accesat în data de 23.10.2024

b.5. Ecologic toilets

 [58]

b.6. Fire pit: sandbox, extinguisher

[59]

b.7. Notice board panel:

[58] https://www.technava.gr/partners/jets-vacuum-as-environmental-industrial/, accesat în data de 23.10.2024
[59] https://fireprotectionireland.ie/, accesat în data de 23.10.2024

The size is 60x90 cm, according to Law 50/1991. The details of the panel: identification data; address of the building; the owner of the investment; the general designer; the construction company which will execute the project; the duration of the project`s execution; the number of the construction authorization; the start data of the works; the deadline of the project; the future image of the building.

b.8. Fencing:

[60]

b.9. Areas considered dangerous: will be marked with signs and inscriptions

[61]

c. Utilities

c.1. Access routes: close to the temporary buildings (easy access).


[62]

[60] https://www.tasconcorp.com/experience/safety, accesat în data de 23.10.2024
[61] https://vectorportal.com/es/vector/herramientas-vector-silhouettes.ai/5112, accesat în data de 23.10.2024
[62]https://www.google.com/imgres?imgurl=https://loveincorporated.blob.core.windows.net/contentimages/gallery/e9822601-9614-4dbf-a69a-31d603459477-29-valuemegaprojects-sydney.jpg&tbnid=brwcv8ITom4TfM&vet=1&imgrefurl=https://www.lovemoney.com/galleries/85899/the-worlds-

If the site is located inside the town, the routes should not disturb the traffic, and not exceed the allowed size. Downtown, the supply of the site will be developed at night.
The site organization should include water and electric networks.

14.2. PRINCIPLES OF DESIGNING THE FACILITIES

14.2.a. The site facilities should be recoverable to the greatest extend possible, because they are temporary.
14.2.b. If it`s possible, the site will use final works as site organization.
14.2.c. The facilities should be as simple and cheap as possible.
14.2.d. Signals and security: located near the fences and gates, especially for special constructions (e.g. airports), where restrictive areas should be provided, only for authorized staff. E.g.: surveillance cameras, special security, alarm, projectors. The fence should be minimum 1.80 m height and to provide physical and visual protection.

14.3. DESIGNING THE SITE ORGANIZATION FACILITIES

a. Design of the deposits

- Maximum quantity to be stored: 2-3 days;
- Required area;

$$S_{nec}\ (m^2) = \frac{Q_{stoc}}{q_{normat}} \times k_{sc}$$

q_{normat} = The quantity stored, in m^2, which is in fact the storage norm
k_{sc} = Traffic space coefficient (between deposits, between stacks of materials)
= 1,3 – 1,5

- Constructive solution;
- Location;
- The stock of materials depends on the number of days for storage:

$Q_{stoc} = t_{stoc} \times q_{max/zi}$
Q_{stoc} = Quantity to be stored per day in the deposit
t_{stoc} (days) = Duration for which the stock is calculated (2-3 days)
$q_{max/zi}$ = Maximum consumption of materials per day

- Constructive solutions: for the routes – layer of ballast (15 cm) rolled on ground, opened platforms, etc.
-

b. Places for preparing the semi fabricates, receiving the concrete.
The order of choosing them is:

- Required area for raw materials deposit;
- Required area for the processing space;
- Deposit area for the final product;
- Required area for traffic spaces.

c. Designing the facilities for people (lockers, offices)

- Required area: 1 – 1,7 m^2/worker;

S_{nec} = Max. no. workers x S_{normat}

- Maximum number of workers – from the scheduling
- S_{normat} – Minimum normed area required

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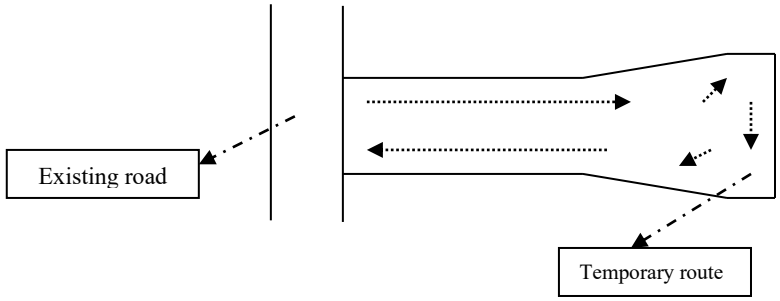
bestvalue-megaprojects-of-all-time&docid=PeQBNm4KDERfnM&w=940&h=625&hl=ro-RO&source=sh/x/im/m1/4&kgs=b70a73d88be3bb26, accesat în data de 23.10.2024

- Constructive solution;
- Containers, with all the facilities: water, electricity connected to the site`s network;
- Caravans;
- Demountable barracks;
- Location.

d. Access route: for materials supply. If the route is not designed for the access of trucks or platforms, the costs will increase, because smaller transports will be needed. Therefore, the best way to use the access routes is of the definitive ones. If it`s not possible, the following principles will be applied:
- Choosing the shortest route;
- The route should be rain and winter proofed;
- The route will have only one track in the site: 3 meters width (and space for return), or two tracks (6 m width);



- Constructive solution:
- Layer of cylindered ballast of 15 cm on a layer of cylindered soil, after removing the vegetal layer;
- If the site lasts for a long period of time (more than a year): prefabricates, reused slabs, mounted on a ballast layer;
- Mandatory: roadside gutters, drainage slopes.

e. Water supply

Water is used for preparing the concrete, mortars, adhesives or other construction materials. It may be provided by connecting to the local network or by drilling a small depth well equipped with hydrophone and submersible pump.

No.	**Name of activity**	**Average consumption of water (l/m^3)**
1	Mechanical washing of aggregates	710 – 5000
2	Preparation of mortar	170 – 300
3	Extinguish of lime	2500 – 3500
4	Preparation of concrete	200 – 300
5	Watering the concrete	200 - 400

- Required flow (l/sec)

  $A = A_{th} + A_i + A_{PSI}$
- For technological and industrial water (e.g. for concrete, formworks)

  $A_{th} = \sum_{i=1}^{n} A_i x k_s$

  i = Overlapping processes with water consumption

A_i = Required water for process "i" (l/sec)
k_s = Coefficient of simultaneity, subunit (0,5 – 0,8)

$$Ai = \frac{Q_{si} \text{ x } a_i}{8 \text{ x } 3600} \text{ x } k_n \text{ (l/sec)}$$

3600 = seconds
8 = hours/shift
Q_{si} = Quantity for process "i" per shift
a_i = liters of water per unit measure
k_n = coefficient of non-uniformity, above unit (1,2 –1,5)

- Drinking water (lockers, offices)

$$A_p = \frac{N_{max} \text{ x } a_p}{8 \text{ x } 3600} \text{ x } k_n \quad \text{(l/sec)}$$

N_{max} = Maximum number of workers in a peak day
a_p = 3 l/shift (for 1 worker)

- Firefighting water (PSI norms – number of hydrants)
- Sources for water supply:
  - Inside town: connect to local network;
  - Outside town:
    - River catch: pumps, reservoirs (technological water);
    - For big construction sites (more than 1 year): water catch from deep wells, groundwater (industrial water);
    - Tank transport.
- The network route (the shortest route)
- Constructive solution
  - Underground: 78-80 cm depth (below freezing depth)
  - PVC tubing
  - Terminals
    - Site well, exterior tap for drinking water, tap for industrial water;
    - Sanitary groups;
    - 3 fire pit hydrants, according to fire safety standards.

f. Electricity network

The electricity network is used for the operation of equipment and tools, as well as for artificial lightening. It is achieved by connecting it to the existent network or by using an electrical generator of minimum 3 KW.

- Installed power (KW)

$$E_{th} = \sum_{i=1}^{n} k_{sth} \, x \, e_i \quad \text{(KWh)}$$

E_{th} = Energy for technological needs
k_{sth} = Coefficient of simultaneity (subunit), because it`s unlikely to work all at the same time
e_i = Installed power for equipment "i"

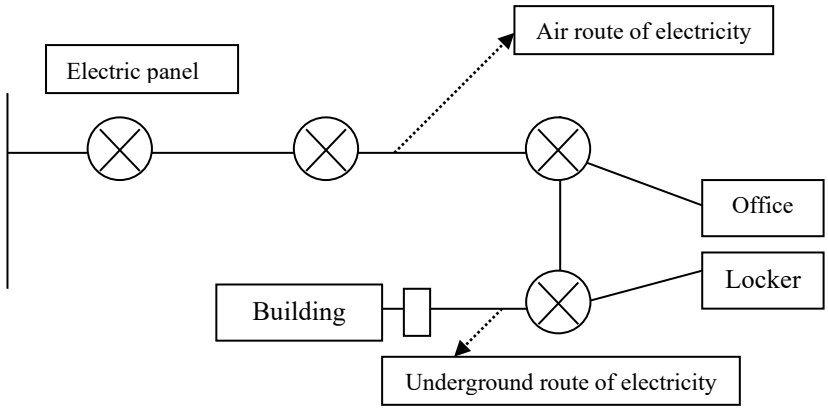
$$E_{il} = \frac{1}{1000} \left(\sum e_{il\,\text{int}} + \sum e_{il\,ext} \right) \text{ x } k_{sil}$$

e_{il} (Wh)
k_{sil} = Coefficient of simultaneity

$$E \text{ (KWh)} = (E_{th} + E_{il}) \text{ x } \frac{1{,}1}{cP}$$

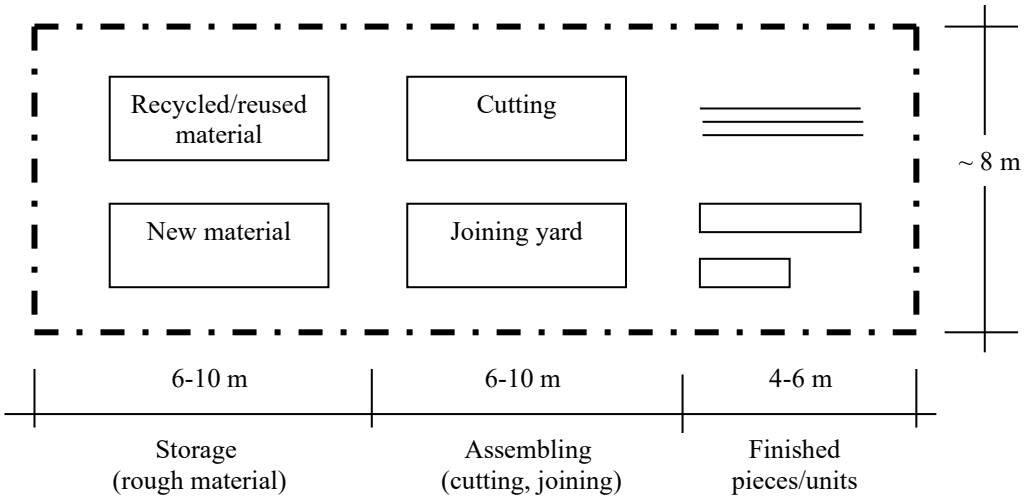
cP = Power factor (0,75)
1,1 = Coefficient that considers the loss of power in the network

- Power supply sources:
  - Inside town: connection to the low power grid;
  - Outside town: connection to the low/high power grid, if it passes near (maximum 1 km), or mobile electricity generators



Some of the main site organization buildings are designed and placed as follows:

a. Wood yard
Its significance is vanishing due to more and more wide-spread use of formwork systems. Only irregular or unusual forms in architecture may revitalize its use.

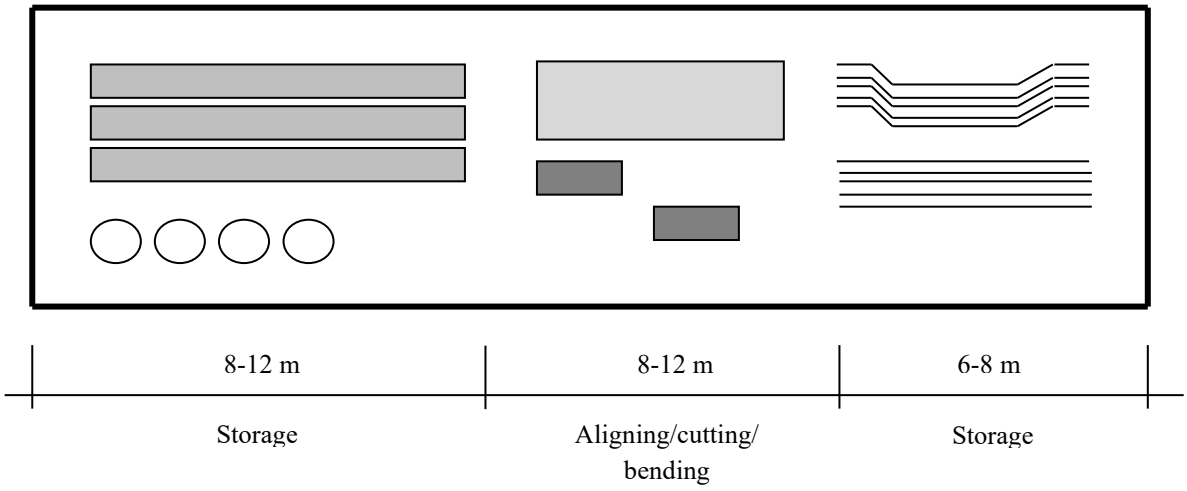


- Storage: on slippers (e.g. on concrete beams) laid on spacers (ventilation/airing) – "lumber piles":
  - Lumber (6 m);
  - Log (rarely!) (4-10 m).
- Cutting: power-saws under shelter:
  - Band-saw;
  - Circular saw (properly located for to cut any sizes of log or timber).
- Assembly: in joining yard.
- Infrastructure:
  - Electric power supply: buried cable;
  - Water supply: fire plug (hydrant);
  - Road and surface:
    - Gravel-typed dry/hard surface;
    - Access for transportation;
    - Fencing/enclosing needed.

b. Steel yard

The central steel yard (reinforcement processing plant) as industrial supply is tending to be typical.

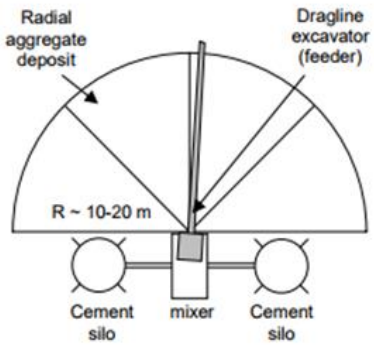
Here is an example of on-site steel yard.



- Storage: transport and storage:
- Straight rods and bars (length ~ 12 m);
- Rods and bars cut and bended (confected);
- Rolls of wires (e.g. for stirrups and for bonding).
- Cutting and bending: bending equipment and power tools.
- Assembly: on workbench.
- Storing pre-assembled reinforcement elements: on the ground or on wood holders (spacers).
- Infrastructure:
  - Electric power supply: buried table;
  - Water supply: fire plug (hydrant);
  - Road and surface:
    - Gravel-typed dry/hard surface;
    - Access for transportation;
    - Fencing/enclosing needed.

c. Batching (concrete mixing) plant:

On-site batching (radial or tower-system) plants are typical rather at distant, ("greenfield") investments. At municipal (in-city) sites is less frequently applied.



- Functional units:
  - Mixer, stand, dozing partition;
  - Cement silos;

    - Radial deposits for fractions of aggregates (+ dragline excavator/feeder).
- Infrastructure:
    - Electric power supply (high consumption, separated supply);
    - Water supply (high/intensive consumption).
- Road and surface:
    - Access around the aggregate – deposit must be provided;
    - Receiving cement transport – parking/loading bay;
    - Supply, reach/access/service of mixer – height of stand;
    - Hard surface (cover) under aggregate – deposit.

d. Traffic management on site:

On average, each year, about 7 workers die as a result of accidents involving vehicles or mobile plant on construction sites. A further 93 are seriously injured.

Accidents occur from groundwork to finishing works. Managers, workers, visitors to sites and members of the public can all be at risk.

The regulations say that the construction site should be organized so that vehicles and pedestrians can move around safely. The routes should be suitable for persons or vehicles that are using them, in suitable positions and enough in number and size.

The term "vehicles" includes: cars, vans, lorries, low-loaders and mobile plant such as excavators, lift trucks and site dumpers, etc.

The construction site vehicle incidents should be prevented by the effective management of transport operations throughout the construction process.

The key issues in dealing with traffic management on site are:

d.1. Keeping pedestrians and vehicles apart

Most of the construction transport accidents result from the inadequate separation of pedestrians and vehicles. This can usually be avoided by careful planning, particularly at the design stage, and by controlling vehicle operations during the construction works.

The following actions will help keep pedestrians and vehicles apart:

- Entrances and exits: provide separate entry and exit gateways for pedestrians and vehicles;
- Walkways: provide firm, level, well-drained walkways that take a direct route where possible;
- Crossing: where walkways cross roadways, provide a clearly signed and lit crossing point where drivers and pedestrians can see each other clearly;
- Visibility: make sure that drivers driving out onto public roads can see both ways along the footway before they move onto it;
- Obstructions: do not block walkways so that pedestrians must step onto the vehicle route;
- Barriers: think about installing a barrier between the roadway and walkway.

d.2. Minimizing vehicle moving

Good planning can help to minimize vehicle movement around the site. For example, landscaping to reduce the quantities of fill or spoil movement.

To limit the number of vehicles on site:

- Provide car and van parking for the workforce and visitors away from the work area;
- Control entry to the work area;
- Plan storage areas so that delivery vehicles do not have to cross the site.

d.3. People on site

Employers should take steps to make sure that all the workers are fit and competent to operate the vehicles, machines and attachments they use on site by, for example:

- Checks when recruiting drivers/operators or hiring contractors;
- Training drivers and operators;
- Managing the activities of visiting drivers.

People who direct vehicle movements (signalers) must be trained and authorized to do so.

Accidents can also occur when untrained or inexperienced workers drive construction vehicles without authority. Access to vehicles should be managed and people alerted to the risk.

d.4. Turning vehicles

The need for vehicles to reverse should be avoided where possible as reversing is a major cause of fatal accidents.

One-way systems can reduce the risks, especially in storage areas.

A turning circle could be installed so that vehicles can turn without reversing.

d.5. Visibility

If vehicles reverse in areas where pedestrians cannot be excluded, the risk is high, and visibility becomes a vital consideration.

Following situations should be avoided:

- Aids for drivers: mirrors, cameras or reversing alarms that may help drivers see movement all-round the vehicle;
- Signalers: who can be appointed to control maneuvers and who are trained in the task;
- Lighting: so that the drivers and pedestrians on shared routes can see each other easily. Lighting may be needed after sunset or in bad weather;
- Clothing: pedestrians on site should wear high-visibility clothing.

d.6. Signs and instructions

Make sure that all drivers and pedestrians know and understand the routes and traffic rules on site. Use standard road signs where appropriate.

Provide induction training for drivers, workers and visitors and send instructions out to visitors before their visit.

e. <u>Protecting the public:</u>

The law says that you must conduct your business without putting members of the public at risk. This includes the public and other workers who may be affected by your work.

The project client should provide information about:

- Boundaries;
- Adjacent land usage;
- Access;
- Measures to exclude unauthorized persons.

These aspects will influence the measures contractors take.

Each year, two to three children die after gaining access to building sites, and many more are injured. Other members of the public are seriously injured by:

- Materials or tools falling outside the site boundary;
- Falling into tranches;
- Being struck by moving plant and vehicles.

The safety key issues are:

e.1. Managing site access:

The site boundaries should be defined physically, where necessary, by suitable fencing. The type of fencing should reflect the nature of the site and its surroundings.

Determining the boundary is an important aspect of managing public risk. Following actions should be taken:

- Plan the form of the perimeter;

- Provide the fencing;
- Maintain the fencing.

Questions you should ask yourself:

- What is the nature and type of the construction work?
- How heavily populated the area is?
- Who will need to visit the site during the work?
- Will the site attract children?
- What are the site characteristics (e.g. existing site boundaries, location, proximity to other buildings)?

Typically, in populated areas, this will mean a two-meter high small mesh fence or hoarding around the site.

The main contractor must take reasonable steps to prevent unauthorized people accessing the site.

- People may be authorized to access the whole site or be restricted to certain areas;
- You must explain relevant site routes to authorized people and undertake any necessary site introduction;
- You may need to supervise or accompany some authorized visitors while they are on site or visiting specific areas.

e.2. Hazards causing risk to the public:

Many hazards have the potential to injure members of the public and visitors. Consider if they exist on your project and how you will manage them.

- Falling objects: you should make sure objects cannot fall outside the site boundary. On scaffolds you can achieve this by using toe-boards, brick guards and netting. You may also need fans and/or covered walkways.
- Delivery and other site vehicles: Make sure pedestrians cannot be struck by vehicles entering or leaving the site. Obstructing the pavement during deliveries may force pedestrians into the road, where they can be struck by other vehicles.
- Scaffolding and other access equipment: prevent people outside the boundary being struck while they are erecting, dismantling and using scaffolding and other access equipment.
- Storing and stacking equipment: you can reduce the risks associated with the storage of materials by storing materials within the site perimeter, preferably in secure compounds or away from the perimeter fencing.
- Openings and excavations: people can be injured if they fall into excavations, manholes, stairwells or from open floor edges. You`ll need to put up barriers or covers.
- Other hazards, such as:
    - Slips, trips and falls within pedestrian areas;
    - Plant, machinery and equipment;
    - Hazardous substances;
    - Electricity and other energy sources;
    - Dust, noise and vibration;
    - Road works.

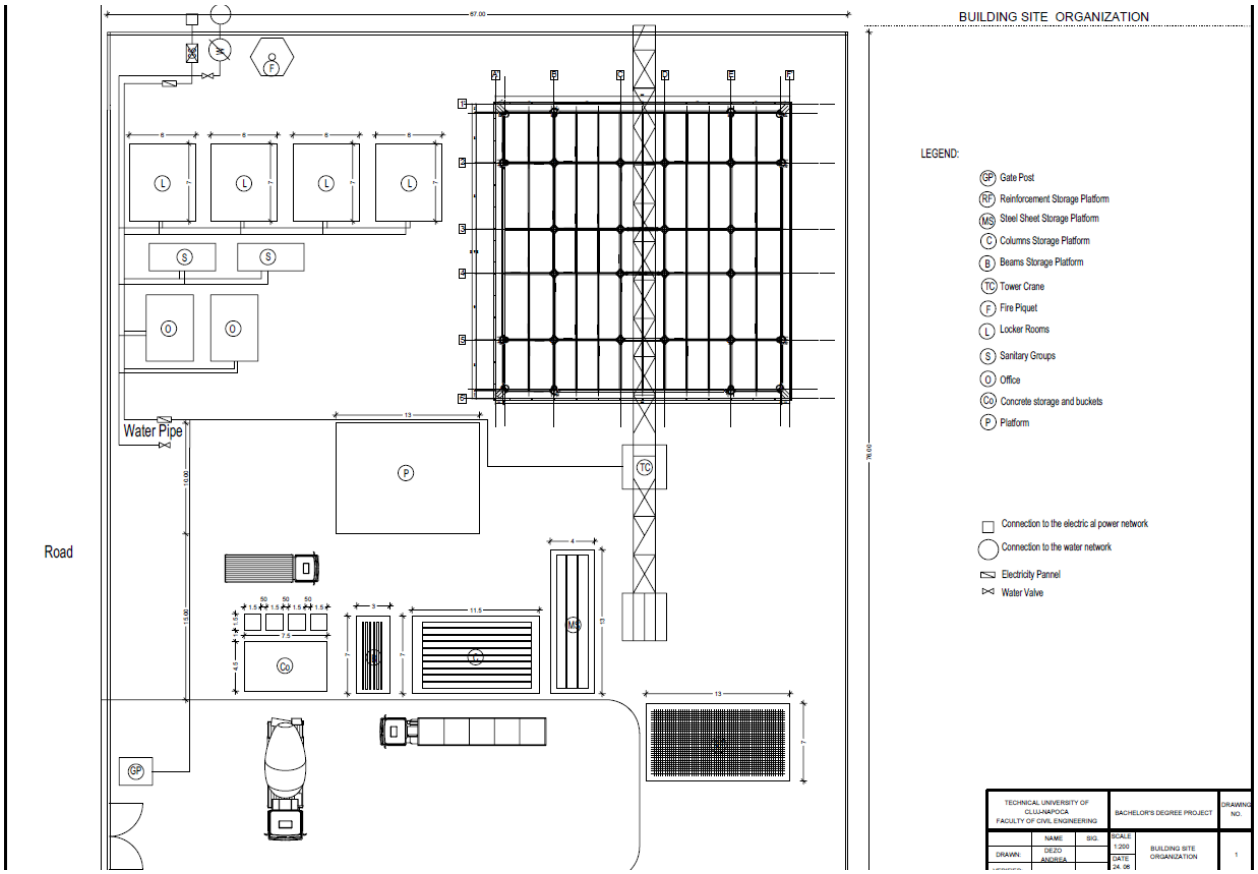
e.3. Vulnerable groups:

The elderly, children and people with certain disabilities may need special attention. Work in premises such as schools and hospitals need careful planning.

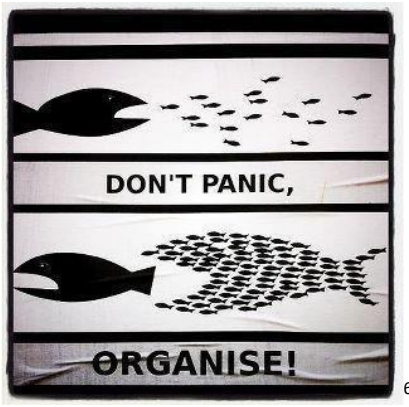
Some children are drawn to construction sites as exciting places to play. You must keep them out of the site and away from danger.

For children safety, the safety solutions may be:

- Secure sites after finishing working hours;
- Barrier off or cover over excavations and pits;
- Isolated and immobilized vehicles and plant, or, if possible, locked in a compound;
- Stored building materials (such as pipes, manhole rings, cement bags) so that they cannot topple or roll over;
- No access ladders from excavations and scaffolds;
- Hazardous substances locked away.



CASE STUDY
INVESTMENT PLAN FOR CIVIL ENGINEERING COMPANY „ABC" S.A.[63]



[64]

1. OBJECT OF ACTIVITY

- Civil and industrial buildings;
- Rehabilitation of roads and platforms;
- Capital repairs for constructions and equipment`s foundations;
- Technological design and expertise to strengthen damaged structures;
- Thermo insulations and partitioning;
- Waterproofing in various constructive solutions;
- Special waterproofing works for concrete; preparation, delivery and concrete pouring, mortars, concrete and reinforced concrete elements: pavements, edges, slabs, tiles, fireplace caps;
- Negotiation, bidding, contracting, designing, executing and service for various investment works, current and capital repairs for fixed assets, pipelines and fittings.

2. ORGANIZATIONAL STRUCTURE

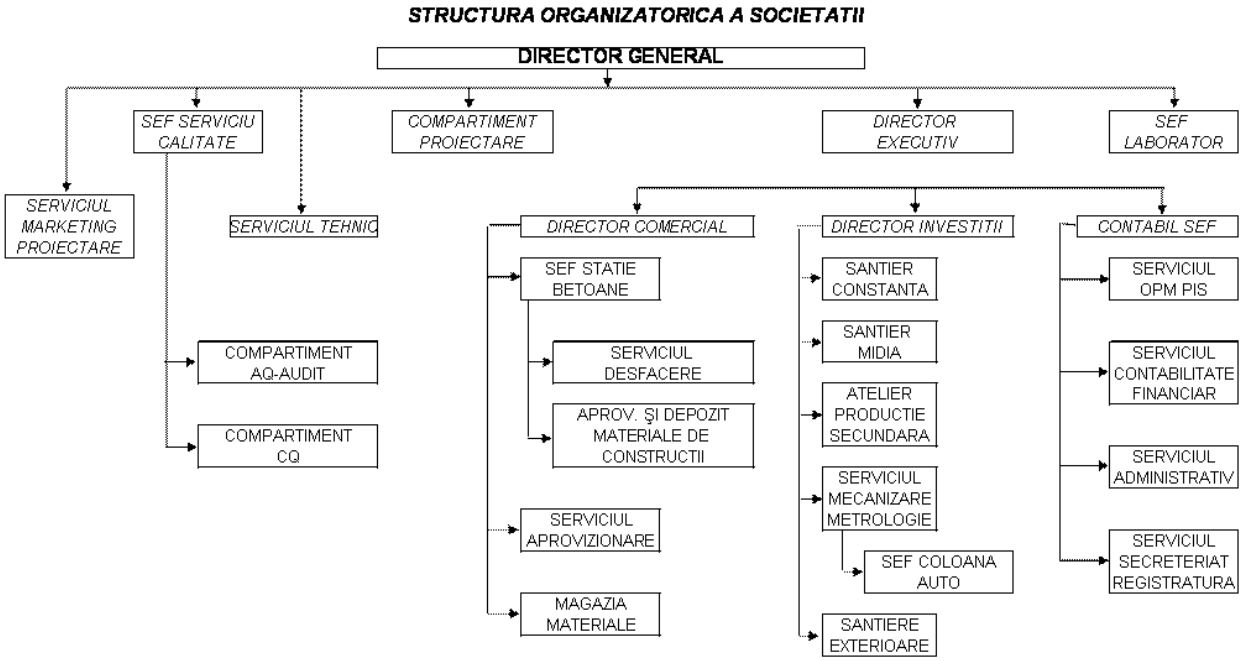
The company „ABC" S.A. is a legal entity with entirely private capital, constituted based on Law No. 31/1990 concerning the establishment of the commercial companies, republished.

The organization and operation regulation of the company is the most important document developed at the company`s level. The document describes the functioning mechanism by determining the responsibilities of the departments, along with the tasks, competencies and responsibilities of each existing function.

[63] http://www.scritube.com/management/STUDIU-DE-CAZ-AL-REALIZĂRII-IN75974.php, accesat în data de 23.10.2024

[64] https://mastodon.social/@charogg, accesat în data de 23.10.2024

In case of the company „ABC” S.A., there is a functional organizational structure. This occurred due to the diversification and the increase of the company`s activity.



The main feature of the functional organizational structure is that the job holder receives tasks both from the hierarchical managers and the functional departments. This dual subordination is the possible reason for the occurrence of malfunctions in the operation of the company because of the issuance of inadequately correlated or even contradictory decisions, the ambiguity of defining the managers` responsibilities, or the lack of decision making and action.
The company has the following departments:

- Design Department:
  - Is subordinated to the General Manager;
  - Deals with the development and improvement of the manufacturing processes;
  - Designs and improves the construction projects, by methods to increase the productivity in work and to reduce the physical effort.
- Quality Department:
  - Is subordinated to the General Manager;
  - Deals with the qualitative control for materials and other products from the suppliers;
  - Examines in a documented, comprehensive and systematic manner the construction works the company is performing.
- Marketing – Contracts Department:
  - Is subordinated to the Sales Manager;
  - Establishes the quality requirements, as an optimum result between the beneficiary`s needs and demands;
  - Develops marketing surveys and studies;
  - Tracks the development of the contracts with the beneficiaries;
  - Tracks the evolution and the structure of the production, the evolution of prices and the profitability indicators.
- Sales Department:
  - Is subordinated to the Sales Manager;
  - Delivers the final product to the beneficiary;
  - Provides information on how to use the product.

- Material Supply and Storage Materials Department:
  - Is subordinated to the Sales Manager;
  - Provides all the material and technical elements required to achieve the planned objectives by obtaining high profits and small costs;
  - Storage ensures the optimum conditions for materials in terms of safety of the batches used in the manufacturing process.
- Secondary Production Department:
  - Is subordinated to the Executive Manager;
  - The supply and manufacturing activity are checked and correlated in order to ensure the continuity and rhythmicity of the manufacturing process.
- Financial Accounting Department:
  - Is subordinated to the Accountant Manager;
  - Is in charge with the tracking of the inputs of materials;
  - Ensures the control of the stock movement, sets the volume of the circulating means and the rotation speed of raw materials;
  - Highlights the transportation and storing expenses;
  - Analyzes the economic activity of the company by detailing the production expenses, the productivity, the evolution and structure of the unit prices;
  - Analyzes the evolution of incomes, expenses, financial results in the last years, the evolution and structure of the net patrimony, the structure of the assets, the evolution of the permanent capital, the availability of cash.
- Personnel – Payroll Department:
  - Is subordinated to the Human Resources Manager;
  - Ensures the function of the departments in the organizational structure;
  - Manages the data related to the activity of the human resources and their payroll;
  - Ensures the development of personnel policies based on the laws and regulations for promoting the professional competencies;
  - Coordinates the activities of training, integrating and promotion of the employees, as well as coordination the activity of developing the personnel's skills.
- Administrative Department:
  - Is subordinated to the Executive Manager;
  - Develops strategies in administrative function to effectively running of the organization;
  - Supervises and manages administrative operations of the department;
  - Develops and implements administrative functions to monitor business operations;
  - Develops inventory control management systems for the inventory department;
  - Assists and supports front desk management in handling visitors and clients;
  - Assists and supports financial department in preparation of budget and other reports and statements.

3. THE EXISTING TECHNOLOGICAL EQUIPMENT

The development, diversification and improvement of the construction equipment allowed the transition from the mechanization of isolated processes with big volume of work to the complex mechanization of the construction works.

The type and number of the equipment in the construction site is calculated in the designing phase and is revised annually; their procurement is paid form the company`s investment funds. The machinery endowment is a ratio between the inventory value of the equipment park and the value of the works from the annual plan.

The number of company`s equipment is calculated based on several factors, as follows:

- The increase of the volume of the construction works;
- The structure of the works;
- The level of mechanization of the construction works;

- The introduction of new machineries to replace manual operations.

The size of the equipment park of a construction company is determined based on the volume, the features of the construction works and their duration of execution.

The company „ABC" S.A. has heavy and medium equipment, as well as small mechanization machineries.

The heavy equipment is used for the mechanized execution of earthworks, foundations, mounting construction elements, and installations.

No.	Name of company`s main equipment and machinery	UM
A. EQUIPMENT		
1.	Excavator with picon P550	2 pieces
2.	Bulldozer 650 CP-1550 CP	4 pieces
3.	Roller cylinder	2 pieces
4.	Auto Crane KATO	2 pieces
5.	Wheel crane 16.5 tone	2 pieces
6.	Crane HT 125	3 pieces
7.	Loader Kawasaki	3 pieces
8.	Trailer	2 pieces
9.	Compressor	2 pieces
10.	Forklift	2 pieces
11.	Electro compressor	3 pieces
12.	Welding convertor	3 pieces
13.	Turbosol plastering machine	1 piece
14.	Rotary hammer	5 pieces
15.	Concrete truck	1 piece
B. MANUFACTURING PLANT		
1.	Concrete plant	6.600 m^2
2.	Industrial production plant	5.000 m^2
3.	Fuel station	400 m^2
C. MEANS OF PRODUCTION		
1.	Van Volkswagen	3 pieces
2.	Dumper	2 pieces
3.	Concrete mixer	4 pieces
4.	Semitrailer for transport of cement	2 pieces
5.	Tractor	2 pieces
6.	Truck R8135	3 pieces

Excavator
picon P550

Bulldozer
650CP

Roller
cylinder

Auto crane
KATO NK400

Wheel crane

Telemac crane
HT 125

Loader
Kawasaki

Trailer

Compressor

7

Welding
convertor

75

[65] https://www.automobileromanesti.ro/Altele/Promex/, accesat în data de 23.10.2024
[66] https://www.deere.asia/en/dozers/650j-crawler-dozer/, accesat în data de 23.10.2024
[67] https://www.utilben.ro/detalii-produs/second-hand/cilindru-compactor-terasier-bomag-bw-216-d-h-5-455705, accesat în data de 23.10.2024
[68] https://commons.wikimedia.org/wiki/File:Kato_NK_400E_.jpg, accesat în data de 23.10.2024
[69] https://www.mirservice.ro/ht-125/, accesat în data de 23.10.2024
[70] https://www.truck1.ie/buy/construction-machinery/mobile-cranes/telemac-ht-125-a8428454.html, accesat în data de 23.10.2024
[71] https://www.veritread.com/specs/construction/wheel-loaders/kawasaki/115z7, accesat în data de 23.10.2024
[72] https://dir.indiamart.com/rourkela/logistics-service.html, accesat în data de 23.10.2024
[73] https://masif.ro/compresor-de-aer-fini-supertiger-312m-50-l-2-2-kw-10-bar-284-l-min/?gad_source=1&gclid=Cj0KCQjw782_BhDjARIsABTv_JDZWUi1gQMdNCFMUPkluztQ2kiF270IzUnF6Z8gEWE6c9Ob8APpMc8aAohwEALw_wcB, accesat în data de 23.10.2024
[74] https://dhl-freight-connections.com/en/logistics-dictionary/forklift/, accesat în data de 23.10.2024
[75] https://www.indiamart.com/proddetail/plaster-spraying-machines-for-conventional-mortars-4780182255.html, accesat în data de 23.10.2024

Forklift

Turbosol plastering machine

[76]


[77]


[78]

Concrete truck

Dumper

Tractor

[68]

[79]

4. ORGANIZING THE CONSTRUCTION ACTIVITY

4.1. Basics for drawing up the site organization project

The organization of a new site requires dealing with problems referring to ensure conditions for performing the main activity, mainly the designing of new locations, utility networks, transportation routes, workshops, prefabricated plants, concrete plants, quarries and ballast platforms.

The full or partial solutions of the problems concerning the site organization works are planned from the design stage, when the site organization project is elaborated, depending on the existing and specific conditions of the investment.

The site organization project is a technical-economical documentation, delivered by the designer in form of a general scheme of organizing, which is detailed by the general contractor. It consists of written and drawing documents, showing the organization solutions for providing the needed conditions for the construction objectives and works, for which there have been allocated funds.

For the site organization, the following information and data are required:

- The geological, climatic and hydrological situation: the structure of the soil, the level of the groundwater, the available water flows, the number of frosty days;
- The location of materials in the area;
- The availability and the state of communication roads, electricity and other facilities in the area.

[76] https://www.indiamart.com/proddetail/transit-concrete-mixer-11401390133.html, accesat în data de 23.10.2024
[77] https://anayurtgazetesi.com/haber/10866803/damper-kopruye-carpt, accesat în data de 23.10.2024
[78] https://www.agriaffaires.ro/second-hand/tractoare-agricole/45351018/international-454.html, accesat în data de 23.10.2024
[79] https://www.acicluj.com/productie-industriala.html, accesat în data de 23.10.2024

The diversity of the construction works requires a solid analyze for the design and choose of the solutions regarding the elements for the site organization. Consequently, some aspects should be considered:

☑ Minimum installation time on site;
☑ Maximum reuse of temporary facilities;
☑ High recovery rate, expressed by the ratio between the volume of recovered elements and the total volume of temporary facilities, quantified in money;
☑ Diversified use of temporary facilities, in terms of destination, function, capacity, or others;
☑ Cost of manufacturing the facilities for the site organization, recommended to be as low as possible, and choosing definitive solution, if they are available.

According to these characteristics, the following site organization elements may be used in a construction project:

- Definitive: objects that may be used during the whole duration of the project on the same working area;
- Temporary: demountable objects, mobile or fix, which will be abandoned or demounted at the end of the site works.

Even if they are supporting the construction activities, the site organization works should have a low cost for not affecting the total price of the construction objective. Therefore, for site organization projects, priority should be given to the following items in the execution process of the construction:

☛ Definitive works of roads, streets or alleys. These works will be performed after the completion of all the underground works that are crossing or are located under the road system. By using definitive roads from the site organization stage, the cost of the site organization project is reduced.
☛ Sources and definitive network facilities planned so that their use in the site works should not delay the deadline of the investment.
☛ Manufacturing capacities of the units, polygons, plants or workshops for auxiliary production.
☛ Availability of accommodation spaces for personnel in the area, if the construction project location is far from their homes.
☛ The capacities of related investment objectives and the common works.

The project dealing with the organization of an area or an industrial platform is known as a coordinating organization project. The project that solves the site organization works for a construction investment objective is named site organization project.

The technical-economical documentations prepared for each objective represent execution details. The site organization projects deal with the overall concept of the site organizing, focusing on the technologies and planning of the main works, measures and evaluation of the works and site organization expenses, planning the site organization, cooperation with the site units, location of the site organization works, the definitively or provisionally of such works.

The coordinating organization project must be updated by analyzing each change that may occur by removing or placing investment objectives in the area or in the industrial platform where they act. These are developed by the general designer of the area or the platform, in cooperation with the general contractor and with the specialized contractors.

4.2. Opening and setting up of the site

After signing the contract and the permission for financing the construction works, the general contractor will open and set up the site, by issuing "The order of work start".

Prior to the opening of the site, the general contractor calls the beneficiary and the designer. The beneficiary gives to the contractor, on a basis of a report, the location of the work, as well as the space needed for the site organization, that will be free of any objects or networks which may obstruct the execution of the works in normal conditions. Moreover, the designer gives the main landmarks of the location and the main levels materialized on the ground.

On this occasion, the general designer will explain to the contractor all the aspects related to the execution of the project. In order to track the right execution of the project, the three parties involved (beneficiary, general contractor and designer) will draw up a statement that sets the physical stages of execution, upon which they will be mandatory present.

Thereafter, the general contractor will organize his activity according to the schedule, he/she will appoint the site manager, will assign the engineers and foremen responsible with the execution of the construction works, the technical and normative staff, the accountants, the economists and the administrative staff.

For the site opening, the general contractor should apply a series of measures to permit the start of the preparatory works (fencing the location, grubbing up if necessary, cleaning, demolishing the old buildings that may exist on the land destined for the construction, evacuating of the wastes, land leveling, and others). These works will be achieved at the beginning of the execution of the project and should be finished as soon as possible, unless the buildings planned to be demolished do not obstruct the execution of the basic works and may be used as site organization buildings (offices, warehouses, accommodation spaces, etc.), which may generate savings of the funds allocated for these facilities.

After carrying out the main site organization works, the general contractor will draw the shape of the building and the execution process begins. The effective date of the start of the works for each object will be recorded in a report written by the site manager. When the starting date is after the imposed schedule (attached to the contract), the report will list the causes for the delays.

The site manager has to keep a clear and accurate evidence of the physical stages executed for setting the payments for the works executed by the contractor.

4.3. Social-administrative site facilities

The execution of the construction works will take place on a relatively long period of time and requires a big consumption of labor. The personnel involved need decent conditions of work and living. Consequently, the following social-administrative site facilities will be planned:

- ☑ Fixed constructions, which are placed in the area of the construction company. These are permanent facilities and form the technical and material basis of the firm;
- ☑ Constructions that are part of the investment objective to be executed and which may serve as temporary facilities for the organization, during the execution of the investment works and which finally become fix assets of the beneficiary;
- ☑ Rent or take-over of some existing buildings in the site area, that will be used only temporary by the contractor, with or without improvements, and which will be returned to the owner at the end of the construction works;
- ☑ Fix buildings for the site organization, which, at the end of the construction works will be handed over to the beneficiaries or other organizations and will become part of their patrimony;
- ☑ Facilities of the site organization, mobile or demountable, belonging to the contractor, which will be moved to another site after the project is finished;
- ☑ Temporary buildings, usually fix, for the site organization, which will be demolished at the end of the project.

Solving the problems generated by the sizing of the social and administrative facilities is conditioned by:

- Factors that depend especially on the characteristics of the investment objective (the volume and the structure of the needed workforce);
- The duration for achieving the works, which is different from a project to another and is detailed in the investment scheduling chart;
- The location of the investment objective, which may benefit of some advantages, such as facilities of the area or recruiting of neighborhood staff.

The sizing of accommodations destined for the personnel will be based on the following elements:

- The total staff of the site in peak times;
- The staff who doesn`t need accommodation, because they live in the area or in the surroundings;
- Surface or volume indicators, calculated for each facility (dormitories, laundry, bathrooms, dining rooms, dispensaries, offices, canteens).

$S = (N_t - N_e) \times I \qquad [m^2, m^3]$

Where

S	Space for serving the site staff
N_t	Total site staff
N_e	Staff from the area or neighborhood
I	Surface or volume indicators for facilities

The calculation is performed for each space for serving the site staff. Because the expenses for building the temporary facilities don`t generate revenues, and the recoverable values at the site closure don`t exceed 15-25% of the investment, the company`s strategy should consider their limitation, because they have influence on the final cost of the construction works.

4.4. Organization of the technical material supply of the site and the development of the supplying plan for the company "ABC" S.A.

The technical material supplying of the sites represents one of the basic components of the organization of the construction manufacturing and it consists of an assembly of activities for planning, organizing, commercial, and finance-accountancy, which ensure the required manufacturing means for the unfolding interruption of the production process, in conditions of respecting the deadlines of commissioning or putting into issue of the investments, and of achievement of some basic parameters regarding the production`s quality and some prequisite efficiency indicators.

Supplying is a complex process, by which materials, equipment, devices, machineries and mechanized means arrive on the construction site at the planned time. For achieving its scope, supplying should begin in the preparation stage of the execution, with 6-9 months before the start of the works and should be continuous along the development of the project.

The consumption norm for supplying with the planned materials has three components:

- The net consumption, representing the maximum quantity of materials for the planned construction project;
- The technological wastes, which are the quantities that are lost in the process of transformation the raw materials into finite products. During this process, a part of the materials remains in a form of waste, which may be used in the manufacturing process, or will be delivered to third parties. Another part is totally lost and can no longer be recovered;
- Non-technological wastes that come from: transportation, handling, storage, or other non qualitative or dimensional aspects.

Recent studies and research reveal the fact that in the activities of transport and handling, around 38% of the construction workers are involved. A significant aspect is that almost two thirds of them have a lower qualification. In the transportation and supplying processes taken place near the construction area, the share of the workers is higher than the media and may exceed 50% in some organizational conditions. In this situation, a major objective in the process of material supplying is represented by the increase of the work productivity through an intensive mechanization of handling and transport.

Another important factor in the material supplying process is related to the reduction of non-technological wastes through improving or even radical changes of transportation technologies, which should be mutual agreed by the material manufacturers, the transporters, and the beneficiaries.

The company`s management was focused on equipping the site with items for reducing the duration of achieving the project: special tank wagons, pneumatic unload systems, silos for storage, performing systems for loading cement from plants.

The main changes in the supply of materials and semi fabricates may be summarized in some guidelines:

- ☑ Development of cooperation in the supplying process, starting with the suppliers, or at least the central warehouses of the company and the manufacturing plant;
- ☑ Providing equipment for loading, such as containers, for ensuring the materials delivery on the construction sectors in concordance with the planned activities, based on the scheduling graphs (decade, day, or even hour);
- ☑ Reorganizing the warehouses and storing spaces for reception, deposit and handling the materials, calculated in cargo units;
- ☑ Optimizing the relationships between suppliers, carriers and beneficiary, through reducing the costs for the consumer.

The plan for material supply is developed based on the economical documentation of the objective and the site organization project. Accordingly, reception documents are made for each material, at the construction object level. These papers are centralized at the site level in the form of reception documents, for each material, by summing them on object, including those required for the site organization. The results represent the consumption of materials, which will be centralized in a table for the entire objective.

However, the material resources, as obtained by centralization on objects, should be processed at the site level as follows:

- ➲ The materials which are part of semi fabricates, prefabricates, and the steel fabrications for the secondary industrial production should be considered;
- ➲ The materials should be grouped by their destination and routing.

An important issue is determining the required materials for the objects for which the economic documentation is not yet available. In this case, the calculation of the material consumption will be based on:

- ➧ The informative list of materials from the companies that develop the design for these objects;
- ➧ The list of materials from similar works previously executed;
- ➧ Determining the quantity of materials based on consumption index.

The material supplying plan is developed on standardized documents, by considering the difference between the moment of supplying the material and the consumption, established for each material, depending on some technical economical parameters, such as:

- ☑ The size of the preliminary stock at the beginning of the year;
- ☑ The maximum allowable stock;
- ☑ The mean of transport used for the supply;
- ☑ The transport distance from the suppliers to the contractor.

This plan should include separately the materials required for works executed from own resources or in subcontracting. Based on the supply plan, orders are issued, which are sent to the supplier with the following specifications:

- The delivery term;
- The delivery location;
- The way of reception;
- The method of payment for the selling-buying process.

The supplier will send the delivery contract or the delivery notice to be signed, and the buyer will confirm the reception of the order.

The delivery of the materials from the supplier to the buyer is, in most cases, provided by the supplier. There are situations in which the buyer undertakes the transport by its own means or rented ones. The supplying process is considered to have been completed when the materials arrived in the site`s warehouses and were received quantitative and qualitative.

4.5. Types of warehouses of raw materials existing in the construction site of "ABC" S.A.

In order to execute the construction works, on the company`s construction site we may find the following deposits

4.5.1. Open warehouses – platforms:

In general, the materials whose properties cannot be sensible influenced in a relatively short period of time by the action of weather agents, will be stored on open platforms.

The storage area of the platforms may be arranged differently in relation to the duration of the operations, the nature of the stored materials, the resistance of the ground, and others. The following types of platforms may be used:

- Ground platforms, leveled and compacted;
- Ballasted and cylindered platforms, with a layer of ballast of around 15 cm thickness;
- Slag platforms, with a layer of slag of around 10-15 cm thickness;
- Platforms made of boulders or rough stone;
- Platforms made of macadam;
- Platforms made of simple monolith concrete, casted as tiles directly on the ground, without foundation or on a foundation made of ballast, crashed stone, rough stone, or boulders;
- Prefabricated concrete platforms, made of hexagonal, rectangular or trapezoidal tiles which have been refurbished, placed on a bed of sand with 5-10 cm thickness.

For construction sites destined for short time works (under one year), ground platforms with improvements are used. For construction sites destined for medium time works (1-10 years), the contractors will use platforms of boulders or crashed rock, simple concrete or prefabs; for long time sites (over 10 years), the most used platforms will be of simple macadam, monolith concrete, or asphalt.

The open warehouses will have frontal or partition walls for increasing the storage capacity. They will be equipped with support or stacking devices. On these platforms, equipment and machineries will be mounted for handling the materials: tower crane, wagon lines, beams, or rolling bridge.

For unloading and storing the materials, if possible, the company will respect the track gauge, so that the storage will be at minimum 2.40 meters from the rail axis for packaged materials, and at least 3.50 meters for bulk ones.

The rough stone will be placed on stacks of parallelepiped shape, with a height of 1.50 or 1.80 meters.

 [80]

The sand, the gravel and the crashed stone will be stored in piles with regular geometric shapes, for permitting the measurement and determination of their volumes.

[80] https://ziare.com/afaceri/constructii/afacerile-cu-piatra-naturala-de-neclintit-pe-timp-de-criza-1299545, accesat în data de 23.10.2024

 [81]

The burned lime brought on the site will be immediately extinguished after its arrival and will be stored in pits where, after several months, will be transformed in lime paste. The limestone warehouse consists of a lime storage facility, devices for lime extinguish and the storing pits. Usually three pits will be made: one for storing old limestone, and two others for alternating consumption and filling.
The bricks and the small blocks of masonry will be stored on leveled platforms.

 [82]

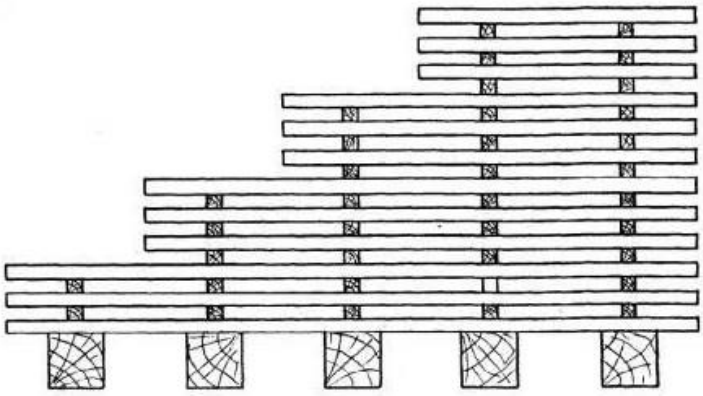
The timber will be stored in stacks sorted by size, quality, type of wood, and destination. The length and the width of the timber stacks will be calculated based on the size of the stored stock.

 [83]

[81] https://www.google.com/imgres?imgurl=https://frankfurt.apollo.olxcdn.com/v1/files/b43umtt8xgqv3-RO/image&tbnid=YAsXF3vicRB87M&vet=1&imgrefurl=https://www.olx.ro/d/oferta/vand-nisip-agregate-pamant-IDgUrv9.html&docid=l7lxjvCRMQ4mqM&w=809&h=587&hl=ro-RO&source=sh/x/im/m1/4&kgs=47688454bf746b58, accesat în data de 23.10.2024

[82] https://www.bca.ro/galati, accesat în data de 23.10.2024
[83] https://www.temporar.silvapit.ro/cherestele.html, accesat în data de 23.10.2024

The timber is stored crosswise, the air space between planks should be equal with the width of the plank if the material is manufactured soon, and with 70-10 interstices for dry material.
The height of the stack is recommended to be 1.50-2.00 meters.


[84]

The timbers of different length will be stored separately.

The steel bars for concrete, the profiled steel, the steel and cast-iron pipes, as well as the metal sheets, should be placed on stacks of 3-10 meters width and maximum 1.50-meter height, on wooden soles. For avoiding the corrosion of the steel construction elements on the effect of atmospheric conditions, they will be protected from weathering in sheds, and if storing them for a long time, they will be covered with a protection layer.


[85]

The prefabricated elements from reinforced concrete shall be stored on sorts, with interspaces between rows, placed on the same vertical axis.

[84] https://civilblog.org/2014/10/28/how-to-store-timber-on-site/, accesat în data de 23.10.2024
[85] https://buildeasy.co.in/, accesat în data de 23.10.2024

4.5.2. Covered warehouses – sheds

[86]

They are made of a light roof with one or two slopes, supported by columns, without walls or partially closed with light protection walls.

The floor is made of timber, concrete or leveled ground, usually raised above the ground. The most usual solution is:

- Steel structure from thin sheet profiles, made of sections and assembled pieces;
- Prefabricated reinforced concrete foundations, 95% recoverable;
- Demountable roof of corrugated sheet or PVC tiles.

4.5.3. Closed warehouses – storerooms

High value materials, as well as the ones that may be damaged due to the weathering, will be stocked in closed warehouses.


[87]

The constructive solution for the resistance structure of the warehouses may be similar to the sheds; for the closing elements, corrugated board panels should be used, fixed in frames made of thin sheet profiles.

For thermally insulated warehouses light thermally insulated panels will be used, made of autoclaved cellular concrete (BCA) blocks. The floors will be prefabricated concrete slabs, made of monolith concrete or asphalt.

[86] https://ro.pinterest.com/pin/570901690244339434/sent/?invite_code=4b13e96fb0964d6b9d87c04ed2f97233&sfo=1, accesat în data de 23.10.2024

[87] https://www.shutterstock.com/image-vector/isolated-big-hangar-on-white-background-23892877, accesat în data de 23.10.2024

4.5.4. Special warehouses

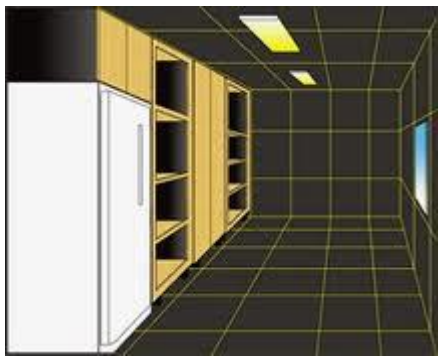
The special warehouses have a specific destination, and consequently they have their own operating technology. These facilities are part of the closed warehouses and they store materials with special features. These warehouses include:

- Warehouses for bed covers, pillows or blankets, made of light bricks; the interior space is unheated, without thermal insulation, but with a good protection against dust;
- Warehouses for fuels, built on site, on a location protected of fire.

[88]

The storage of the fuel is done in large metal tanks placed on over ground concrete foundations; the small tanks will be buried and covered with a thin layer of ground. These warehouses are equipped with air vent, and the electric lighting is made with bulbs and switchers placed outside the building.

- Food deposits



They have shelves and special boxes with a good ventilation.

4.6. Organization of the workforce at "ABC" S.A.

For a good organization of the manufacturing processes and for ensuring efficient use of the workforce, production staff should be organized in teams, like follows:

- The minimum group, defined as the smallest workers group that may execute independently an elementary manufacturing process;
- The team, which gathers more minimum groups with the same specialization, that is responsible with achieving an elementary manufacturing process;
- The specialized brigade, which is the group of workers specialized for executing simple processes, and has more teams, each of them executing the same simple process;
- The complex brigade, which is the group organized for achieving a complex process, composed of teams of different specializations corresponding to the simple processes that form the complex process;

[88] https://taner.com.mx/galeria/, accesat în data de 23.10.2024

- The group of complex brigades, associated for executing a stage of the construction object, an object, or the whole construction objective.

Principles of organizing and using the workforce

For achieving performing results in the manufacturing process, and for efficiency in the use of the workforce, the following actions may be taken:

- ☑ The construction works may be performed only by specialized teams;
- ☑ Each group or team should be organized on specializations; each specialized brigade will execute a simple process from a complex one;
- ☑ The number of teams of the specialized brigade or the complex brigade, organized for the execution of a certain process, stays constant. The changes in the capacity of the brigade is not made by changing the number of teams, but by changing the number of workers that form these teams;
- ☑ For planning the number of groups of workers, the management should consider the balance between the manufacturing capacity of the groups. In case of the complex brigades, the team that executes the manufacturing process is the base unit of the brigade and shall be sized according to the volume of works to be performed; the working capacity of the other teams will be correlated with the production capacity of the main team;
- ☑ The involvement of the workforce in the manufacturing process is achieved by implication of the workers in the company`s results. In this situation, the principle of paying the workers in concordance with the results will stimulate the increasing the productivity and the specialization. Incentives are even bigger if they are applied to more workers, because it stimulates the team spirit and cooperation.

4.7. The compensation politics at company "ABC" S.A.

At the basis of the compensation system stays the principle of paying for quantity, quality and importance of work. The compensation system conceived like this stimulates the involvement of the manufacturing personnel in training and performing results.

For delivering equity for the compensation system, as an active factor for achieving productivity, the following principles should be applied:

- The compensation should be proportional with the volume of works or the production achieved;
- Equal compensation for equal performance;
- Compensation should be different based on the personnel`s skills;
- Compensation should be different based on the quality of work;
- Compensation should be different based on the working conditions.

4.7.1. Compensation of the workers

The compensation of the workers in the construction sector is based on the compensation tariff networks and the qualification tariff index:

- The compensation tariff networks set the hourly wages of the workers for the unskilled, skilled and specialized work;
- Framing the workers in different categories is based on the qualification tariff index. They include the classification of the works on qualification and conditions of framing the workers in these categories. The index set the knowledge and skills for the qualified workers. For unskilled workers there are no qualification tariff index. The same is for specialized workers.

The framing categories for the qualified workers highlight aspects related to the level of knowledge, the qualification degree and the required experience for executing the works with diverse degrees of complexity in good conditions; for unskilled workers they are based on the difficulty of the tasks.

Framing the workers into categories is performed for each unit by specialized staff, based on their knowledge and skills.

The base for the compensation of the construction workers is the normed work; under certain conditions, they may also benefit of bonuses and allowances for heavy conditions, experience, managing the teams, etc.

4.7.2. Norms for the construction works

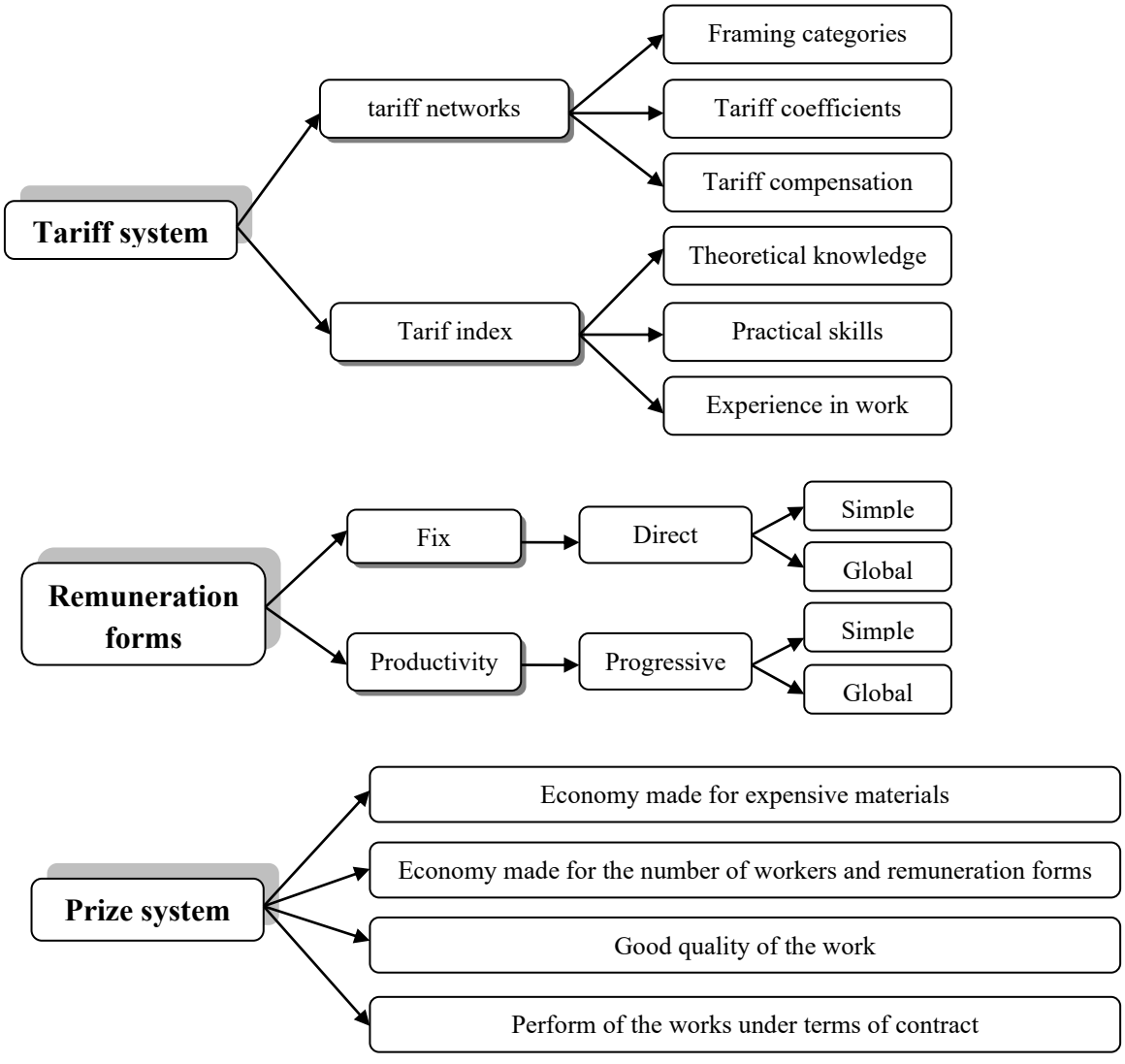
The norms for the construction works establish the quantity and quality of the works needed for executing the construction works in normal rhythm and intensity under specified technical economic conditions.

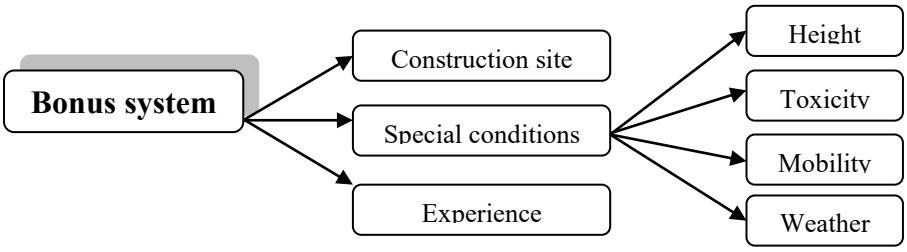
The work norm is defined as the task assigned to a person that has the required qualification, in order to perform an activity or to fulfill a job under specified conditions.

4.7.3. The compensation system in construction

The main forms of the compensation system of the manufacturing personnel in constructions are: the tariff system, the remuneration forms, the prize system and the bonus system.

The tariff system aims to make a differentiated assessment of the quality of work based on the needed qualification and the importance of the industry. In order to perform an accurate assessment, the sectors of economy are ranked on groups. The construction industry is included in groups 3 and 4.





The tariff index for qualification is set for the entire construction sector, according to the level of qualification required for the different types of works. The main criteria applied for the framing of the workers are: theoretical knowledge, practical skills, and the experience in work. Other aspects considered are the quality of the works performed and the achieved economy of materials.

The tariff network is the main element for compensation. It sets the number of framing categories and the hourly or monthly retribution for each degree of qualification.

In addition to the tariff retribution, the workers may benefit of:

- Prizes for outstanding work achievements, representing up to 1% of the planned compensation fund;
- Bonus for hard work conditions;
- Bonus for extended schedule of 10 hours;
- Bonus for nightshift hours.

The compensation based on the amount of work in the construction industry may be achieved by two methods:

- Compensation based on the working time, called fix remuneration. It`s suitable when the wages are calculated according to the effective working time for a specific task, which has a previous calculated tariff;
- Compensation based on the volume and the quality of the works performed, called progressive remuneration. It is based on working norms which will determine the quantity of works needed for each construction object, and also the specialization needed for achieving it. The workers` compensation will be calculated by multiplying the quantity of works with the tariff retribution of the task, according to the qualification tariff index.

4.8. Methods of scheduling the investment works at "ABC" S.A.

The efficient use of the investment funds involve a thorough analyze of all expenses incurred in the achievement of the future objective, together with setting an optimum duration for fulfillment of each activity and the entire construction objective.

For scheduling the execution of the construction works in optimum conditions, the Critical Path Method may be used, for ensuring the time planning of the activities, so that the future objective should be completed in the shortest period of time.

Planning the construction works may be achieved by the following methods:

4.8.1. Critical Path Method

For achieving a construction investment, some works have to be performed, which may be grouped in activities. Each activity is identified through a start and finish time. Therefore, conditioning between activities are highlighted, when they are dependent.

For applying the Critical Path Method (CPM), some data should be provided by the project planner:

- The name of the activity;
- The symbol of the activity;
- The succession of the operations, by specifying the start and finish time;
- The duration of the activity;
- The resource consumption for achieving the activity.

The elements that identify each activity may be represented more suggestive through a graph. A graph is a logical assembly, perfectly coordinated, by which the activities of a project may be linked in a specific order. For designing the graph, the planner begins with the first activity and, based on the start and finish time, the next activities will be drawn.

When using the graph for scheduling the project by the Critical Path Method, some principles should be applied:

- Every activity is oriented from the initial event to the final one;
- The activities will be provided in a network, according to the order resulting from the relations that exist from the start and finish time;
- One activity must have only one initial node and one finish node;
- A node from inside the network should make a link between one or more predecessor activities and one or more successor activities;
- The activities that are not conditioned, meaning they may be performed simultaneous, will be drawn parallel on the graph;
- The activities with no consumption of material and human resources, but with time consuming (such as concrete hardening), are called fictive activities, or waiting activities, and are represented in dashed lines.

If all the times for achieving the activities are rigorously observed, the duration of the execution of the whole project is given by the length of the Critical Path. The activities placed on the Critical Path don`t have floats, so they are called critical activities. Any delay of these activities will generate the delay of the overall project.

4.8.2. Planning the construction using PERT Method

PERT Method is suitable for construction works which have uncertain durations. In this case, three possible situations might be considered: optimistic, pessimistic and probable duration; the latter should stay between the former two. Setting the optimistic and pessimistic durations is done by practical experience, statistical values from similar situations, and economical computing.

By determining the optimistic and pessimistic durations, the company may calculate the probability of achieving each activity and the overall construction project. If the chances of completing the project stays around 50%, it means that, in conditions of a good management, the objective will be targeted as in the planned schedule. Values being under 25% show that the terms of accomplishment are very tight, the schedule is restrictive and there is risk of exceeding the timeline. If the probability of completion is over 60%, the activities have a great number of floats and the schedule is easy to accomplish. In both cases, the timeline should be revised, and the durations should be rescheduled.

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