# LEONARDO DA VINCI ToI PROJECT

# TRAIN-TO-CAP

**Strengthening of European Union Funds Absorption Capacity for Infrastructure Construction Projects**

**2010-1-PL1-LEO05-11469**

# MANUAL "DELAYS AND DISRUPTIONS IN CONSTRUCTION PROJECTS"


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**PREFACE**

This book and training course are the results of the project no. 2010-1-PL1-LEO05-11469 entitled ”Strengthening of European Union funds absorption capacity for infrastructure construction projects”, implemented within the framework of Leonardo da Vinci Programme – Transfer of Innovation.

The Polish Association of Construction Industry Employers, Poland was the project promoter.

The project partners were:

- The Chartered Institute of Building – United Kingdom;
- ERBIL Project Consulting Engineering CO. Ltd – Turkey;
- Training 2000 – Italy;
- Civil Engineering Faculty– Warsaw University of Technology – Poland.

The aims of the project were to:

- Minimise problems connected with disputes and claims in construction projects regarding infrastructure;
- Increase transparency of procedures in risk management and claims and disputes processes;
- Increase access to training through the MOODLE platform.

The main result of the partnerships' works within the TRAIN TO CAP project is a blended learning training set containing: training courses on MOODLE (Multi Object Oriented Dynamic Learning Environment) platform concerning risk and dispute management in infrastructure construction projects and three textbooks:

- PROCUREMENT STRATEGY IN CONSTRUCTION
- DELAYS AND DISRUPTIONS IN CONSTRUCTION PROJECTS
- MANUAL FOR TUTORS

The project products are prepared for: qualified engineers, managing directors, project managers, construction managers, engineers (FIDIC), and other managing staff from construction companies, government agencies, local authorities who are able to manage international projects and act in any European country.

TRAIN TO CAP as a blended learning course was created in order to increase the professional knowledge, skills and background of employees dealing with European construction projects. Understanding and gaining the specific skills minimises risks and disputes during conducting construction and infrastructure projects on European Union market. Gained knowledge and usage of specific terminology allows avoidance of unnecessary problems with management and communication during the lifetime of projects. These aspects are directed to strengthen effective European Union funds absorption in the field of infrastructure projects.

The project products are available in four language versions: Polish, English, Turkish and Italian. TRAIN TO CAP course is to be used as a basis for organisation of trainings for the engineering staff at construction companies, local government organisations, and local authorities and for postgraduate students as well.

More information about the project and the online course is on TRAIN TO CAP website: www.traintocap.eu.

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# CHAPTER 1
# INTRODUCTION

## OBJECTIVES OF CHAPTER 1

The primary objective for this chapter is to introduce construction contracts and standard contracts currently used in the global and European construction market.

## LEARNING OUTCOMES FOR CHAPTER 1

The primary learning outcome for this chapter is for the reader to become familiar with the contract term, different types of contracts, contract changes, variations and claims and disputes.

## 1.1. Introduction

The term *Contract* used in construction management is often defined as: "An agreement entered into by two parties under the terms of which one party agrees to perform a specific job for which the other party agrees to pay. Contract documents attached to and/or stated in the agreement form integral parts of the contract".

In order to ascertain the presence and validity of a construction contract, some specific criteria have to be met:

- **The parties to the contract** must be competent and legally capable of playing their intended part.
- **The subject matter of the contract** must be lawful and definite in respect of requirements and duties of each party. For example a contract violating municipal regulation is not binding and is void in courts. Also uncertainty in respect of what is wanted may result in the contract being not enforceable by law.
- **Proposal and acceptance**: There must be a proper proposal by one party and its absolute and unqualified acceptance by the other party. The proposal is not binding without a clear acceptance and is not binding beyond its date of validity.
- **Free consent of parties to the contract:** Consent is said to be free when it is not caused by force, or undue influence or fraud or misrepresentation.

The construction contract is unique in that it seeks to provide for a specific remedy in the event of any breach of the terms and conditions within its framework and/or for a contractual entitlement in respect of specified events. Therefore, it is essential that the parties and those who represent them fully comprehend the terms of the contract and the remedies available to them under it.

The genesis and development of the standard form of construction contract was and remains based on the need to redefine and reapportion the risk ascribed to the respective parties by the applicable law.

In terms of nature of works, needs of the clients and different allocation of risk, the main standard contract forms currently used in the global and European construction industry are:

1. Fédération Internationale des Ingénieurs-Conseils (FIDIC) – International Federation of Consulting Engineers. The standard forms published by FIDIC are probably the most well-known and widely used internationally. All of the FIDIC forms adopt English as the official and authoritative text, although translations into several other languages have been made in most cases. The FIDIC forms include both general conditions and particular conditions. The general conditions are intended to be used in an unmodified form on each project. Any modifications or additional provisions which are considered necessary in order to deal with issues which are specific to a particular jurisdiction, to a particular governing law or to a particular project will be made or included in the particular conditions.

2. The Joint Contracts Tribunal (JCT) is the UK's largest producer of standard form contracts, guidance notes and other standard documentation for use in the construction industry. The committee which is responsible for drafting the JCT contracts is made up of key construction industry executives representing bodies such as the British Property Federation, the Royal Institute of British Architects and the Royal Institute of Chartered Surveyors. The JOT publishes a wide range of contracts primarily for building projects such as retail, office, leisure and warehouse developments. Their 1998 suite of contracts was fully repackaged and reissued in 2005. Further updates of the 2005 forms were issued in 2007 and 2009.

3. The New Engineering Contract (NEC) is a suite of contracts which is published by the Institution of Civil Engineers as an alternative to other more conventional standard forms. The main form of engineering and construction contract was first released on a consultative basis in 1991 and has subsequently been superseded by the first edition (1993), the second edition (1995) and the current (third) edition (2005). The main form of engineering and construction contract is comprised of a set of core conditions, which are designed to be supplemented by one of the main payment options "A" to "F" and various secondary options. The intention is to provide users with the flexibility to amend the basic terms to suit individual projects. One of the main differences between the NEC forms and other more conventional standard forms is the NEC's emphasis on "partnering". The NEC forms are designed to promote co-operation and reduce confrontation, recognising that, in the absence of good project management, large or complex projects are less likely to be successful. The parties are obliged to act in accordance with the contract and "in a spirit of mutual trust and co-operation". There is an emphasis on communication, co-operation, programming and clear definition of the information needed to make the contract work. The NEC forms have been endorsed by the Office of Government Commerce in the UK and have become the preferred choice of contract for construction projects procured by the UK public sector. In addition to the main form of engineering and construction contract, the NEC suite includes various related and ancillary contracts, including the Short Contract; the Professional Services Contract; the Term Service Contract; the Term Service Short Contract; the Engineering and Construction Subcontract; and the Framework Contract.

4. Other:
   a. World Bank Forms of Contracts.
   b. Institution of Mechanical Engineers (IMechE) and Institution of Engineering and Technology (IET) have developed four standard forms of contract relating to supply

of electrical and mechanical plant goods and the provision of engineering consultancy services (MF/1, …, MF/4).

c. Institution of Chemical Engineers (IChemE) has published a series of standard form contracts for use on chemical process plant projects (Red Book, Green Book, Burgundy Book, Yellow Books).
d. Institution of Civil Engineers (ICE) publishes a range of contracts for use in civil engineering works (ICE Conditions of Contract: measurement version, term version, target cost version and ICE Design and Construct Conditions of Contract) – mainly used in the UK.
e. Leading Oil and Gas Industry Competitiveness (LOGIC – previously CRINE) issues a range of standard contracts (Three standard forms include: General Conditions of Contract for: Construction, for Design and for Marine Construction). Forms are primarily used in the UK offshore oil and gas industry but with appropriate modification have been used internationally.

By including a mechanism to give one party a certain remedy if a specified event arises, the risk of that event, which would otherwise remain with that party, is transferred to the other party. However, whether the remedy sought is in respect of a breach of the contract terms and conditions or for the occurrence of a specified event, all construction contracts place an obligation on the party who wishes to avail themself of that remedy to follow a set procedure.

All international form contracts deal with specific procedures including the risk and consequences of the changes, variations and upgrades etc.

## 1.2. Variations

One of the common features of construction contracts is that the design of the work contracted for may require variation as the work proceeds. The magnitude of variations tends to be greater in engineering works, reflecting the greater element of the unknown in such operations. But it is still a rare event for even the smallest of building jobs to be completed exactly according to the original contract provisions. Strictly the contractor is not bound, without express provision, to execute more than the contract work; and the employer will be in breach of contract if they omit a part of the work included in the contract without a contractual provision enabling them to do so. Construction contracts, therefore, provide that the employer (or their agent) may require alterations, additions or omissions to the contract work and bind the contractor to carry them out (see JCT, cl.3.10; ICE, cl.51, FIDIC cl. 13).

When there has been a departure from the work specified in the contract, it is necessary to decide whether there is, in law, a variation under the contract; if there is a variation, whether the contractor is entitled to be paid extra; and if so, the amount of the extra payment.[1]

## 1.3. Change and variation control[2]

The project manager should carry out the following tasks to control variations:

1) Monitoring and controlling variations which result from changes to the project brief to be avoided whenever possible (Figure) or design/schedule modification (e.g. client's request, architect's or site instructions) must follow a procedure which:
   a) identifies all consequences of the variation involved;

[1] John Uff "Construction Law" Tenth Edition, 2009

[2] Code of Practice for Project Management for Construction and Development, Fourth Edition

b) takes account of the relevant contractual provisions;
c) defines a cost limit, above which the client must be consulted and, similarly, when specifications or completion dates are affected;
d) authorises all variations only through the appropriate change procedure.

2) Identifying, in consultation with the project team, actual or potential problems and providing solutions which are within the time and cost limits and do not compromise the client's requirements, with whom solutions are discussed and approval obtained.
3) Checking the receipt of scheduled and/or ad hoc reports, information and progress data from project team members.

The main effect on the reduction of claims or variations is to ensure the brief is clearly defined, and the contract documents and drawings accurately and completely reflect the detail.

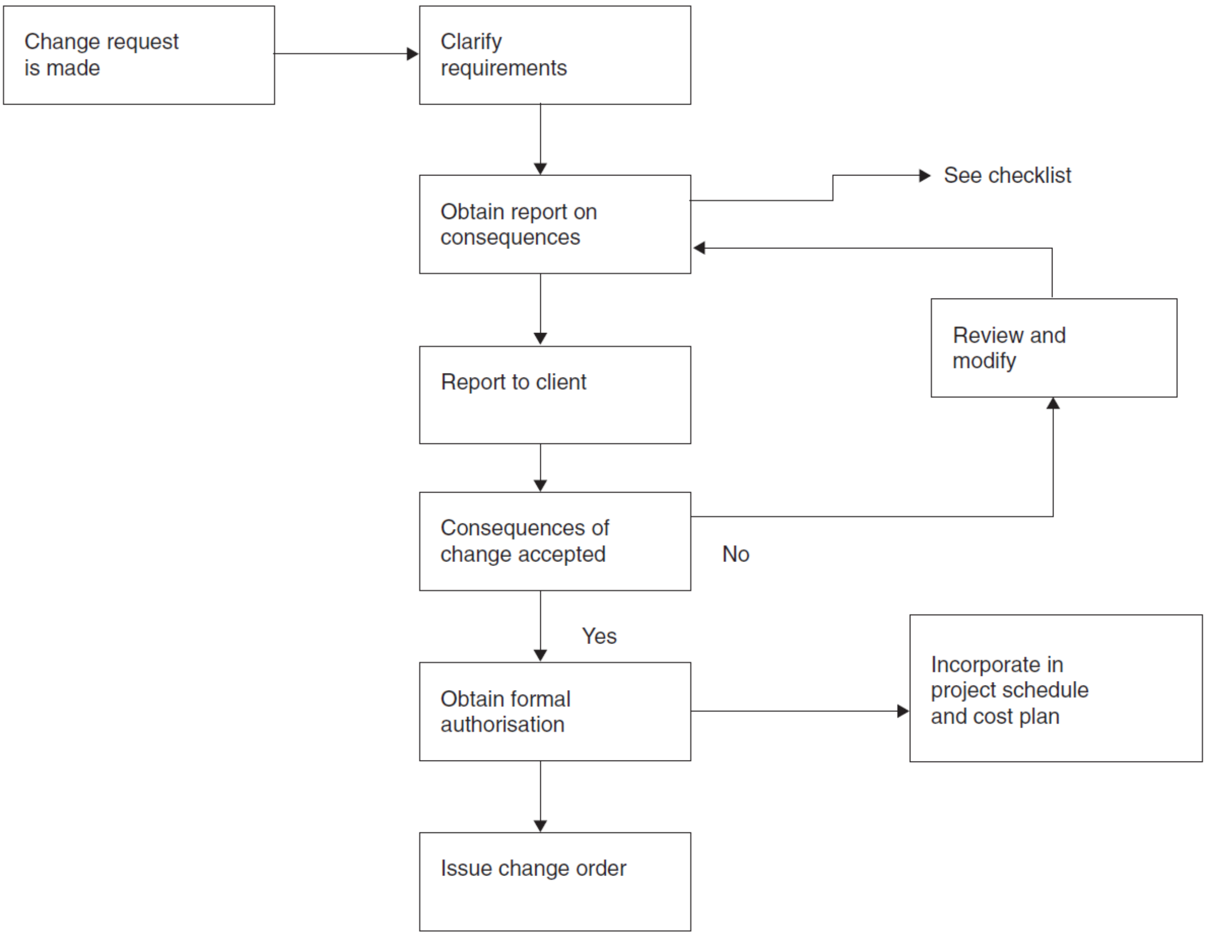


**Figure 1.1.** Changes in the client's brief.

Managing change control at design development stage is far more effective than managing the process when construction is in progress. Circumstance-driven changes, mistakes or unknowns have to be effectively managed on the basis that in many instances time is more expensive than the material change. Some form of authorisation needs to be agreed (financial limits) so that instructions can be given without having to refer every change back to the customer for approval.

The project manager will need to maintain a register of changes and variations, cross-referenced to contractor's RFI (request for information) notices, and possibly contract claims.

The register should include budget costs and final costs for reporting to the client on a regular basis.
Accurate, detailed daily diaries will need to be kept, complete with plant, labour and material deliveries so that consequential costs can be identified. In dealing with the effects and costs of variations, the project manager will need, where possible, to agree costs before issuing an instruction. It is also wise to agree, again where possible, that work will be undertaken with no overall effect on the schedule. It is vital to carefully record events and situations at the time. Procedurally, the project manager must inform both the design consultants and the main contractor that all variation instructions must be in the correct written form and *must* only be issued via the project manager (unless the project manager is the appointed contract administrator to the main contractor). To avoid unnecessary complications in agreeing valuations and accounts, it is imperative that the variation instructions are issued from one source. Design consultants must raise (in writing) RFI to the project manager who will in turn issue the instructions to the contractor. *All* variations *must* have an instruction (in writing) against them in order to be valued.

**Table 1.1.** Changes in the client's brief: checklist

| **Activity** | **Action by** |
|---|---|
| 1. Request for change received from client | Project manager |
| 2. Client's need clarified and documented | Project manager |
| 3. Details conveyed to project team | Project manager |
| 4. Review of technical and health and safety implications | Consultants and project manager |
| 5. Assessment of programme implications | Planning support staff and project manager |
| 6. Evaluation/calculation of cost implications | Quantity surveyor |
| 7. Review engineering services commissioning | Commissioning manager |
| 8. Preparation of report on effect of change | Project manager in consultation with consultants |
| 9. Reporting to client | Project manager |
| 10. Consequences accepted/not accepted by client | Project manager |
| 11. Non-acceptance: further review/considerations as per items 4–6 and action items 7 and 8 | Project manager assisted by consultants |
| 12. Further reporting to and negotiation of final outcome with client | Project manager assisted by consultants |
| 13. Agreement reached and formal authorisation obtained | Project manager |
| 14. Incorporation into project programme and cost plan (budget) | Project manager and quantity surveyor |
| 15. Change order issued | Project manager and client |

### 1.4. Change management

Change in a construction project is any incident, event, decision or anything else that affects:
1) the scope, requirements of the project;
2) the value (including project cost and whole-life cost) of the project;
3) the time milestones (including design, construction, occupation);
4) risk allocation and mitigation;
5) working of the project team (internally or externally);
6) any project process at any project phase.

### 1.5. Changes during the design development process

The procedure outlined is used to control the development of the project design from the design brief to preparation of tender documents. It will include:
1) addressing issues in the design brief;
2) variations from the design brief, including design team variations and client variations;
3) developing details consistent with the design brief;
4) approving key design development stages, namely scheme design approval and detailed design approval.

The procedure is based on the design development control sheet. The approved design will comprise the design brief and the full set of approved design development control sheets. The procedure comprises the following stages:
1) The appropriate member of the design team addressing each design issue in the development of the brief, co-ordinated by the design team leader.
2) Proposals developed are discussed with the appropriate members of the project's core group through submission of detailed reports/meetings coordinated by the project manager. Reports should not repeat the design brief, but expand it, address an issue and prepare a change.
3) The design team leader co-ordinates preparation of a design development control sheet, giving:
   a) design brief section and page references;
   b) a statement of the issue;
   c) a statement of the options;
   d) the cost plan item, reference and current cost;
   e) the effect of the recommendation on the cost plan and the schedule;
   f) a statement as to whether the recommendation requires transfer of client contingency (i.e. a client variation to the brief) and if so the amount to be transferred.
4) The design team report section of the control sheet is signed by:
   a) the design team member responsible for recommendations;
   b) the quantity surveyor (for cost effect);
   c) the design team leader (for co-ordination).
5) The design team leader sends the design development control sheet to the project manager who obtains the client's approval signature and returns it to the design team leader.
6) The quantity surveyor incorporates the effect of the approved recommendation into the cost plan.
7) The project manager incorporates the effect of the approval recommendation into the master schedule.

| | | |
|---|---|---|
| **Client name:** | | |
| **Project name:** | | |
| **Sheet no.** | | |
| **Design team report** | | |
| Design brief section: | | |
| Issue: | | Pages: |
| Options considered: 1. | | |
| 2. | | |
| 3. | | |
| Recommendation: | | |
| Cost plan item: | | |
| Ref: | | |
| Current cost: | | |
| Effect of recommendation on costs/schedules: Increase/decrease | | |
| Application for transfer of client contingency: | Yes/No | Amount: |
| Architect/services engineer/structural engineer: | | Date: |
| Quantity surveyor: | | Date: |
| Design team leader: | | Date: |
| **Client approval** | | |
| Design development/Client contingency transfer approved (delete as applicable) | | |
| Position | Signature | Date |

**Figure 1.2. Design development control sheet**

## 1.6. Example of change management process

1) Identification of requirement for change.
2) Evaluation of change.
3) Consideration of implications and impact including risks.
4) Preparation of change order.
5) Reviewing of change order: client's decision stage.
6) Implement change.
7) Feedback including causes of change.

### 1.7. Assessment and management of variations

1. The project manager is responsible for ensuring that there is early warning, hence creating the possibility of alternative action/methods to prevent delay and additional costs.
2. A schedule should be prepared, stating the grounds for extension, relevant contract clauses and forecast of likely delay and cost.
3. The involvement and possible contribution to the solution of problems of other parties affected should be established.
4. A procedure will need to be available for extension approval. If relevant, the disputes procedure may be invoked.
5. Applicable procedures are covered under standard or in-house forms of contract relevant to the specific project.

### 1.8. Change management design

1. Reviewing with the design team and other consultants any necessary modifications to the design schedule and information required schedules (IRS) in the light of the appointed contractors'/subcontractors' requirements and reissuing revised schedule/IRS.
2. Preparing detailed and specialist designs and subcontract packages including bills of quantities.
3. Making provision for adequate, safe and orderly storage of all drawings, specifications and schedules including the setting up of an effective register/ records and retrieval system.

The project manager must ensure that the client is fully aware that supplementary decisions must be obtained as the design stages progress and well within the specified (latest) dates in order to avoid additional costs. Designs and specifications meeting the client's brief and requirements are appraised by the quantity surveyor for costs and are confirmed to be within the budgetary provisions.

Handling changes will require a series of actions. The project manager will be responsible for these activities:

1. Administering all requests through the change order system (see Table 5.3 and Appendix 17 for checklist and specimen form).
2. Retaining all relevant documentation.
3. Producing a schedule of approved and pending orders which will be issued monthly.
4. Ensuring that no changes are acted on unless formally decided.
5. Considering amendments and alterations to the schedules and drawings within the provisions of the applicable contract/agreement.
6. Initial assessment of any itemised request for change made by the client taking due account of the effect on time.

Action by consultants in relation to variations will include the following items:

1. Securing required statutory/planning approvals and cost-checking revised proposals. Confirmation of action taken to project manager.
2. Design process and preparation of instructions to contractors involved.
3. Cost agreement procedure for omissions and additions, i.e. estimates, disruptive costs, negotiations and time implications.

### 1.9. Claim procedures

In all construction contracts, claims and the right to claim play a significant role in the contractual relationship between the employer and the contractor. Curiously, for such a fundamental aspect of the contract, no express definition appears in the typical standard form of construction contract and it is rare to find a definition of 'a claim' in reference texts or authorities on construction contracts. A claim is defined in The Oxford Companion to Law as a general term for the assertion of a right to money, property, or to a remedy. Strictly speaking then, whenever for example the contractor applies for his monthly interim payment for the original scope of the works, or whenever for example the employer writes to the contractor requiring him to remedy defective work, it would be a claim under this definition. In construction contracts, a claim is generally taken in practice to be an assertion for additional monies due to a party or for extension of the time for completion.

Although some claims can be avoided by proper planning and risk management, claims are usually a result of unexpected circumstances, not described in contract documents. Claims in general, are almost inevitable since it is practically impossible to foresee every event that might occur during the construction period and to plan in advance for the consequences of such events – even if great emphasis is placed on risk mitigation and transfer. If that concept is accepted, then it is necessary to incorporate into the contract a mechanism for implementing changes which are found to be necessary or desirable during the construction period.[3]

### 1.10. Disputes[4]

The construction industry is a fertile breeding ground for disputes. They cannot be avoided entirely and it would be foolish to suggest that they could. Among other things, there may be design faults, there can be defective work or materials, the cost of variations may cause dismay, money can be wrongfully withheld, loss and expense for delay and prolongation, or extensions of time to defend against liquidated damages for late completion may be claimed.
On the other hand, the high cost of energy-sapping defended litigation can often be avoided by sensibly planning your dispute resolution procedures before contract and as well as by the proactive management of the process of resolution once a dispute has arisen.
Mediation, conciliation, expert determination, adjudication, arbitration, and, of course litigation, are all possibilities to be considered. Two of these: mediation and conciliation are often referred to as ADR (alternative dispute resolution). That in itself does not mean much without recognising to what it is an alternative. The essential difference between orthodox dispute resolution and ADR is that in ADR the parties make their own settlement agreement, which is only binding so long as they want it to be, and in orthodox dispute resolution the decision is made for them by a third-party and it is final and binding on them. There is a grey area in all this and that is in expert determination and adjudication in which the decision can be final and binding, or it can be final and binding unless disputed in another forum, or it could be non-binding depending on how (and under what law) it is structured.
Apart from reference to the courts by litigation (which in every common-law country is a unilateral act, open to anyone who thinks they have had a right infringed) all the other methods of dispute resolution require an agreement. Naturally, it is easier to agree a method of resolving a dispute before it has arisen rather than after. However, irrespective of whether there is an agreement in place, it is always open to either party to suggest an alternative means of dispute resolution that will save both parties time, cost, and frustration, and to enter into an agreement for that, at any time.

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[3] Nael G. Bunni "The FIDIC Forms of Contract" Third Edition, 2005

[4] Extracted from Pickavance, Keith, 'Dispute resolution without tears', Times of The Islands, (Spring, 2005). http://www.timespub.tc/2005/04/transforming-waste-into-wonder/ (accessed 31 July 2009).

### 1.11. Disputes resolution methods

#### 1.11.1. Non-binding

In non-binding processes the dispute resolver helps the parties to agree their differences. These are entirely private processes, conducted without prejudice to the rights of either party and there is nothing stopping either party from shifting its ground during the process. Indeed, if it is to be successful, it is essential that they do. If they do not succeed in reaching a settlement there is nothing to prevent either party from dealing with the same dispute through another forum at a later date and nothing that has been discussed in the ADR process may be used in evidence can usually be used elsewhere. The dispute resolver will agree a procedure with both parties; he will read the parties' respective position statements and any documents provided in support. He will consult with the parties privately, and with both together. Although essentially a non-binding process, it is always open to both parties to agree that the final settlement should be binding. The parties agree to share the costs of the dispute resolver and to pay their own. This is an excellent method of dealing with disputes, because it encourages the parties to talk to each other; if successful it helps to preserve working relationships and, even if unsuccessful, it helps the parties to focus on the real matters in which they are in dispute. In many contracts, ADR is required at some stage and in England court-ordered ADR forms a part of the civil procedure rules of the courts.

#### 1.11.2. Mediation

Without express permission, the mediator will never disclose what has been said to him by either party to the other. A mediator does not have to have a detailed understanding of the facts or the law of the matters in dispute, but it often helps. He will not advise the parties of their rights nor generally will he advise the parties of the strength of their case, but he will help each to see the weaknesses of their own and the strengths of their opponent's position. In doing so he will draw them closer with a view to executing an agreement to settle their differences. In general, mediation can be completed in two to three days. In very large cases with many issues it might take a week or more but that is unusual.

#### 1.11.3. Conciliation

Conciliation as a similar process to mediation but the conciliator takes a more active role in the settlement of the dispute than does the mediator. A conciliator necessarily has to have a detailed understanding of the facts and law of the matters in dispute. The conciliator will express an opinion on the relative merits of the parties' respective cases. He will try to persuade them of his views and, in doing so, will attempt to guide the parties into an agreement compatible with the parties' rights under the contract. Conciliation can be expected to be a little shorter than mediation simply because the conciliator is able to focus the parties' attention on the issues and drive the process in a way that is unavailable to a mediator. In general, conciliation can be completed in one or two days. As with mediation, in very large cases with many issues it might take a week or more but that is unusual.

#### 1.11.4. Non-binding or final and binding

Unlike ADR, in which the parties make their own decision, the essence of these decision-making processes is that a third party is introduced to make the decision for them. Because the process is consensual, it is always a private process. However, depending on the rules of engagement agreed between the parties, the information that becomes available may not be privileged and the decision made may not be binding on the parties, leaving them free to revisit the dispute in another forum. The parties are free to agree who should pay the dispute resolver's costs and how the party's costs should be dealt with, although it is usual for each side to pay their own costs.

### 1.11.5. Expert determination

Expert determination is quite different from any other method of dispute resolution. In this forum the expert is appointed for his knowledge and understanding of the particular issues in dispute in the field in which he is an acknowledged expert. The expert will agree a procedure with both parties; he will read the parties' respective position statements and any documents provided in support. There is usually no provision for the parties to change their position or amend their case during the process. He will consult with the parties privately, and may consult with both together, but he is under no obligation to do so unless it is made a term of his appointment. He is given the role of investigator. He is required to find the facts and law in relation to the issues in dispute, to make his own enquiries, tests and calculations and to form his own opinion and decide on the merits of the parties' position. Depending on the issues, expert determination can involve much research and a hearing and can take anything from a week to several months.

### 1.11.6. Adjudication

**An overview of adjudication**

Adjudication is intended to be quicker and less expensive than court proceedings. Therefore the parties must be prepared for a degree of 'rough justice'. The adjudicator has very wide powers. He can use his initiative and can request further documents from any party, meet and question them, visit the site, appoint experts to help him if necessary (e.g. technical assessors, legal advisors, etc.), issue directions and timescales. He can adjudicate, with the consent of all parties, on 'related disputes' under different contracts. He can award interest payments.

**What can be referred to the adjudicator?**

Virtually all kinds of dispute or difference may be referred to the adjudicator provided they arise 'under the contract' (the contract can be written, oral or partly oral). These would include: failure to issue notice of sums due or notice of withholding payment, value of interim payments, value of variations, extension of time, loss and expense, set-off and contra-charges, workmanship, whether or not an instruction was reasonable, etc.

**Who pays for the cost of adjudication?**

It is usual that each of the parties must bear their own costs in submitting and presenting their cases. However, under some circumstances a 'costs paid by loser' approach may be undertaken.

**How is the adjudicator's decision enforced?**

The adjudicator's decision is intended to be binding pending final determination by legal proceedings or arbitration, or by mutual agreement in settlement. Several court cases have shown that the courts intend to support both the Act and the adjudicator by enforcing awards. It may well be that the mere presence of an adjudication resource will concentrate the minds of those on either side whose stance is less than reasonable and so enable the parties to go forward with providing the client's end product – the completed project – on time and free of major disputes.

In England and Wales and in several Commonwealth countries, adjudication has recently been given statutory authority. Under the law of those countries that adopt this process it is generally the rule that either party to a specified type of construction contract has the right at any time to submit any dispute or difference to the adjudication of a third party. However, even where the statutory right is limited to particular types of contract there is nothing stopping the parties from agreeing by contract to follow the same process in regard to contracts which are outside the law.
Adjudicators are often appointed for their knowledge and experience of the type of matters in dispute, although it is not essential. While the idea of adjudication is that there should be a decision, in the event that the parties do not like the result there is nothing to prevent them from running the case again in another forum; the rule of *res judicata* does not apply to adjudication. The adjudicator will agree a procedure with both parties; he will read the parties' respective referrals and any documents provided in support. He may also require a hearing and will often conduct conference calls with the parties.
The adjudicator's decision is binding until either party decides to refer the same dispute to arbitration or litigation, in which case the decision is binding until an award or judgment is handed down. When the legislation was first enacted in England in 2000, the adjudicator was empowered to make his own enquiries of the facts and law. It was thought that he might act pretty much like an architect or engineer under a construction contract and that few parties would take the adjudicator's decision as final and binding, so it was not initially thought necessary for the adjudicator to act within the rules of natural justice.
Five years on and several hundred enforcement cases later, it became clear that parties who have been unhappy with the outcome have sought to overturn the decision on the basis of the adjudicator's misconduct rather than have the case rerun in arbitration or litigation. As a result the courts have imposed the obligation on adjudicator's to act within the rules of natural justice. They must hear both sides. The parties must have an equal opportunity to make their own case and to respond to the case against them, although they may not alter or amend their submissions. This is a tall order in the limited time available to make the decision. They must be impartial but they do not have to be independent. They may only enquire into the facts and the law of the cases that are put to their decision. They may not go outside the parameters of the parties' submissions to make good any deficiencies.
Unless the referring party agrees to extend the period for the decision by up to 14 days, or both parties agree to extend the period the decision beyond that the dispute resolution process must be conducted and the decision given within 28 days of referral. The adjudicator has no power to order discovery or to take evidence on oath unless the parties give it to him by agreement and if either party request it, he must give reasons for his decision. It all seems to work very satisfactorily.

### 1.11.7. Litigation

Litigation is the dispute resolution process run by the civil courts of the state. It is free to every individual who has a grievance to resolve. Judges tend not to be technical people although in some courts they are specifically selected for their technical ability (e.g. the English Technology and Construction Court). On the other hand, judges often have the power to appoint technical assessors or experts to assist them and will almost always do so if the parties request it. Notwithstanding that the court and the judge are provided by the state, litigation is often a very expensive process. This is often simply because of the complicated rules of procedure, which a reluctant but wily litigant can often exploit to put off the hearing of the case for years, including amending its case from time to time.

There are also restrictions on who can appear in the courts on behalf of a litigant. In large cases the costs can run to many thousands of pounds per day during a hearing, which may take many months or even years before the dispute reaches that stage.

Litigation is a public process (justice must be seen to be done) and the public are encouraged to sit in on the proceedings to hear of the matters in dispute. Judges must give reasons for their decisions and important decisions are published and recorded in law reports.

### 1.11.8. Arbitration

An arbitration agreement is written into all standard forms of building and civil engineering contract. It is a private process and nobody is permitted to know of the matters in dispute or the decision unless the parties agree otherwise. The arbitrator's decision is final and binding and can be enforced in many countries by virtue of the New York convention. Arbitrators, like judges, must be independent and impartial. They must scrupulously follow the law of the contract and the rules of natural justice to provide a speedy and efficient decision on all the issues submitted to jurisdiction. The arbitrator may not go outside that limitation to decide things that were not part of the reference. Subject to the arbitration agreement, the parties may adopt specific procedural rules which dictate the powers of the arbitrator or the procedure to be followed. If this is not done, the powers of the arbitrator are set out by statutory instrument.

In domestic disputes it is normal for the reference to be to a single arbitrator, but in international disputes it is more common for each party to appoint their own arbitrator and for the arbitrators to appoint a chairman or umpire, forming a three-man tribunal.

Arbitration can be very time consuming and expensive or it can be quick and cheap depending on the parties and the case-management skills of the arbitrator. There is usually nothing to stop a party from amending its case subject to paying the costs of the other side. Generally, the arbitrator has the powers of a high court judge in regard to the taking of evidence on oath, subpoenas for evidence, discovery and so on. He can order a party to pay the costs of interlocutory matters and can determine who should pay his fees and whether the losing party should pay the winning party's costs, in whole or in part, with or without interest and on what basis. The arbitrator must give reasons for his decision if either party requests it.

### 1.11.9. Final and binding

In the following tribunals the facts once found cannot be reopened by any court: the matters are *res judicata*. Appeal on a point of law is always available from a domestic arbitral tribunal to the court and from a lower court to a higher court. However, statute has tended to limit the right of appeal from an arbitrator's award in other than a point of law of public importance in order to give the parties a greater sense of finality.

## 1.12. An example of legal aspect of the UK

### 1.12.1. Housing Grants, Construction and Regeneration Act 1996, Amended 2009

The Housing Grants, Construction and Regeneration Act 1996 is applicable to all construction contracts entered into after 1 May 1998. The intention behind introducing the reforms pinned around improving cash flow, reducing confrontation and facilitating 'fair play' in the payment mechanisms. In order to enhance the effect of this, a number of amendments (initially proposed in 2004) have been introduced from September 2009 focusing on increased

transparency and clarity, encouraging parties to resolve disputes by adjudication and improving the right to suspend performance under the contractual arrangements.
The Act is applicable to all construction operations including site clearance, labour only, demolition, repair works and landscaping. However, off-site manufacturing, supply and repair or plants in process industries, domestic construction contracts, contracts not in writing and certain other activities including PFI contracts (but not the construction contracts entered into as a result of PFI) have been excluded from the purview of this Act.
The two key areas affected by this Act are the payment procedures and the adjudication in case of disputes.

### 1.12.2. Payment under the Act

The Act requires that every construction contract must contain the following elements:
1) payment by instalments;
2) adequate mechanism to determine what amounts of payments are due and when;
3) prior notice of amounts due and make up;
4) prior notification (seven days) of intention to withhold payment (set-off), giving grounds and amounts;
5) suspension of work (not less than seven days' notice) for non-payment of payments due;
6) all 'pay when paid' clauses outlawed except in the instance where a third party on whom the payment depends becomes insolvent;
7) in the absence of minimum requirements as specified by this Act, the government scheme comes into operation as a default clause.

### 1.12.3. The government scheme for payment

The government scheme for payment provides for:
1) monthly interim payment;
2) due date for interim payments is seven days after the end of the relevant monthly period or from making a claim, whichever is the later;
3) final due date for interim payment is 17 days from due date;
4) notice of amount due should be given not later that five days after due date;
5) notice of intention to withhold payment should be given not later than seven days before final payment date.

### 1.12.4. Adjudication under the Act

The Act makes it a statutory right to refer any dispute for adjudication. It stipulates that all contracts must contain an adjudication procedure that complies with the Act:
1) Either party can give notice of adjudication at any time regarding any dispute or difference arising under the contract.
2) The contract must provide a timetable for appointment of adjudicator and referral of dispute within seven days of initial notice.
3) The adjudicator must reach decision within 28 days of referral (up to 42 days if the referring party agrees).
4) The adjudication period can be extended only if parties agree, or on the adjudicator's instigation with the consent of the referring party.
5) The adjudicator is enabled to take necessary initiatives in ascertaining facts and law.
6) The decision of the adjudicator is binding until the dispute is finally determined by legal proceedings or arbitration or by agreement.
7) The parties have the option to agree to accept the adjudicator's decision as final.

8) The government scheme comes into operation as a default mechanism if the minimum requirements as stipulated by the Act are not met.

### 1.12.5. The government scheme for adjudication

The government scheme for adjudication provides for:
1) Written notice of adjudication stating:
    a) nature and description of dispute and parties involved;
    b) details of where and when dispute has arisen;
    c) nature of redress sought;
    d) names and addresses of parties to contract.
2) The appointment of an adjudicator within seven days of notice.
3) The same seven days in which to submit full documentation (referral notice).
4) Oral evidence limited to one representative (may or may not be a lawyer).
5) The adjudicator's decision within 28 days from referral notice or 42 days with the referring party's permission.
6) Parties are equally responsible for payment of the adjudicator's fees (unless otherwise determined by the adjudicator).
7) Reasons for the adjudicator's award have to be provided if requested.
8) The decision by the adjudicator is binding pending any final determination by legal proceedings or arbitration, or by mutual agreement in settlement.
9) Parties have to comply with the adjudicator's decision immediately.

### 1.13. Literature and further reading for chapter 1


1. Nael G. Bunni "The FIDIC Forms of Contract" Third Edition, 2005
2. The Global Construction Practice, Booklet, Herbert Smith
3. John Uff "Construction Law" Tenth Edition, 2009
4. Chartered Institute of Building (2010) Code of Practice for Project Management for Construction and Development (4th edition), Wiley Blackwell
5. Pickavance, Keith, 'Dispute resolution without tears', Times of The Islands, (Spring, 2005). http://www.timespub.tc/2005/04/transforming-waste-into-wonder/ (accessed 31 July 2009)

## 1.14. Set of exercises for chapter 1

**Exercise 1.1:**
Define the term *contract* used in construction management

**Exercise 1.2:**
List at least two main standard contract forms currently used in the global and European construction industry.

**Exercise 1.3:**
Variation can be in the form of alterations, additions or omissions to the contract work. True or false?

**Exercise 1.4:**
At what stage is managing change control more effective?

a) Design development
b) Construction is in progress

**Exercise 1.5:**
List at least three disputes resolution methods.

# CHAPTER 2
# IDENTIFICATION OF RISKS IN CONSTRUCTION PROJECTS AND NEEDS FOR CHANGE

## OBJECTIVES OF CHAPTER 2

This module defines the risks, risk management, changes and needs for change at the beginning of the construction projects.

## LEARNING OUTCOMES FOR CHAPTER 2

By understanding the precautions that can be taken with respect to risks and changes participants will learn to avoid the problems that may occur in construction work.

## 2.1. Introduction

Risk and uncertainty are usual in all construction work no matter what the size of a project. Size can be one of the major causes of risk, so changes can occur in political or commercial planning. Other factors carrying risk include the complexity of the Project, location, speed of construction and familiarity with the type of work. Road and reservoir maintenance work and most building refurbishment are examples of smaller but risky projects.
Risk analysis can be qualitative and quantitative. Firstly the sources of risk must be identified. Secondly their effects must be assessed or analysed. Risk management requires management responses and policies to reduce and control the main risks identified in the analysis. Risk management is most valuable early in a project proposal, while there is still the flexibility in design and planning to consider how the serious risks may be avoided. Not all can be avoided, for instances in the predictions of the demand for the service or product, and the risks can change. Risk management should, therefore, be continued throughout the life of a project. It should influence each stage of commitment by the client, especially at these three stages:

- in deciding the project “master plan” or brief resulting from the evaluation of various schemes in the project appraisal stage,

- in preparing the final proposal for funding,

- in deciding the contract strategy and basis for awarding contracts

The principals of risks are as follows while solving them:

- The greatest uncertainty is in the earliest stages of a project, which is also when decisions of greatest impact are made. Risk must be assessed and allowed for at this stage.

- The client's departments and advisors should operate as a single team to avoid the institutional risk of incomplete commitment and inconsistent decisions.

- Delay in completion can be the greatest cause of extra cost and of loss of financial return and other benefits from a project. The first estimate of cost and benefits should be based on a realistic programme for a project. On this basis the potential effects of delays can be predicted realistically.

- All too often risk is either ignored or dealt with in an arbitrary way: simply adding a 10% probability onto the estimated cost of a project is typical. This is virtually certain to be inadequate and cause expensive delay, legal action and perhaps bankruptcy.

- Risks can change during most projects. Risk management should therefore be a continuing activity throughout the life of a project.

- Much can be learned about the implications and management of project risk without extensive numerical analysis. Risk analysis is essentially a brain-storming process of compiling realistic forecasts and answers to "what happens if ?" questions.

- Joint ventures and consortia are means of sharing resources and risks but should be based on partnership and commitment.

- Quantitative techniques can be used to analyse probabilities and the sensitivity of predictions or uncertainties in estimates to give a much more accurate assessment of risks.

- Competitive tendering together with traditional contractual arrangements limit the realistic management of risk. The pressure is always on those bidding for contracts to keep their tender prices as low as possible, which can put both them and their clients at great financial risk if things go wrong.

- Risk techniques are widely used in other industries and these techniques can easily be accessed by small companies through the internet.

- The evaluation of risk requires analysis of variable factors. The analysis should be carried out by project planners and cost estimators. The need for judgment should not be used as an excuse for failing to give adequate consideration to project or contract risk.

- Flexibility in project design and the risk of later changes should be considered in detail before completing proposals for allowance.

- On most construction projects, the client is mistaken if he uses single figure estimates of cost and time for appraisal and funding decisions. Ranges of estimates should be used, including specific unexpected probabilities and tolerances uncertainty.

- Giving importance to contract strategy based upon systematic consideration of risk can achieve significant cost savings for a project. Traditional arrangements are no longer the best basis for managing today's high risk projects. The proposals for funding a project should therefore include recommendations on contract strategy.

- For high risk contracts, Project sponsors should specify the allocation of risk when inviting bids and require tenderers to state their provision for risk in their bids. Project sponsors should also consider selecting the contractor on the basis of minimum acceptable risk rather than lowest price. Risk analysis allows such a criterion to be used.

- Public authorities should review the cost effectiveness of their policies and procedures for dealing with risk. Project managers should be given the authority to manage project risks and restrictions on the choice of contract arrangements. Tendering procedures should be removed where they lead to inefficiency.

- Clients and all parties involved in construction projects and contracts benefit greatly from reduction in uncertainty prior to their financial commitment. Money spent early buys more than money spent late. Willingness to invest in anticipating risk is a test of a client's wish for a successful project.

**2.2. Identification of requirement for change**

In construction projects, a change means an alteration or a modification to pre-existing conditions; assumptions or requirements and some of the rules are being changed. It can be caused by either internal or external factors. Different changes may have different effects or consequences on the project.
What are these changes? A change that occurs during a project can be a "gradual change" or a "radical change", depending on the degree of severity and importance. A gradual change, also known as incremental change, happens slowly over a prolonged period and its intensity is low. A radical change is sudden, dramatic and has a marked effect. Gradual changes often occur during the design development stage, where many decisions are fine-tuned and refined progressively. Radical changes occur more often at post fixity or post design development phases. Project changes can also be classified as "anticipated changes" and "emergent changes". Anticipated changes are planned in advance and occur as intended. On the other hand, emergent changes arise spontaneously and are not originally anticipated or intended. Another way to view project change is through its necessity. In this way, project changes can be classified as "elective changes" and "required changes". An elective change is where one may choose whether or not to implement; and a required change is where there is no option but to make the change.

The causes of project change may originate from either external or internal pressures that are being applied to the project. External causes may be due to technological changes, changes in customer expectations, changes in competitor's activities, changes in government and policies, changes in the economy and finally demographic changes in society. Internal causes may result from changes in management policy, changes in organisational objectives and changes in the long-term survival strategy of the organisations involved. At a more detailed level, the causes of construction project change are usually generated from either design or construction activities. The design generated causes include design changes, design errors, omissions and operational improvements. Construction driven causes are often linked to the unsatisfactory site conditions that hinder good workmanship, material handling and plant operation. The design and construction issues must be considered in conjunction with how the team is managed, co-ordinated and communicated with to reduce problems resulting from insufficient work separation, insufficient construction planning and disturbance in personnel planning.

External causes:

- Economic;
- Environmental;
- Technological;
- Regulatory.

Internal causes:

- Organisational level;
    - Organisational culture;
    - Ineffective decision-making;
- Project level;
    - Design improvements;
    - Inadequate skills and knowledge amongst the team;
    - Weather conditions;
    - Late change of client brief;
    - Designer change of mind;
    - Design errors;
    - Inadequate knowledge of the site conditions;
    - Revised design parameters;
    - Minor field-originated changes;
    - Contract disputes;
    - Confusion in project goal, scope, and resources.

Any one or a combination of the above factors may result in changes to the design and construction of a building.

While some changes may bring benefits to a project, most changes, if not managed properly, can result in cost and time overruns. The major cost due to change is the cost of rework or revision of work. Rework is the unnecessary effect of re-doing a process or activity that was incorrectly implemented in the first place and can be created by defects or variations. The cost of rework in construction projects can be as high as 10-15% of contract value. Rework is an example of a direct effect of project change. In addition to direct effects, project changes can also bring some indirect effects, which will ultimately have an impact on project cost and schedule.

Direct effects:

- Addition of work;
- Deletion of work;
- Destroying work already done;
- Rework;
- Specification change;
- Time lost in stopping and restarting current tasks in order to make the changes;
- Revisions to project reports and documents;
- Reorganising schedule and work methods to make up lost time.

Indirect effects:

- Need for communicating change to all project members;
- Dispute and blaming amongst project partners;
- Loss of productivity due to reprogramming; loss of rhythm, unbalanced groups and acceleration;
- Change in cash flow, financial costs, loss of earnings;

- Increased risk of co-ordination failures and errors;
- Lower morale of work force;
- Loss of production, therefore increased sensitivity to further delays.

Changing the project brief has, often negative, impact on project cost, time and quality, however, literature review and case studies show that changing the project brief better enabled client organisations achieve their expectations and enhance the performance of their projects. There are four underlying principles for the success of the work.

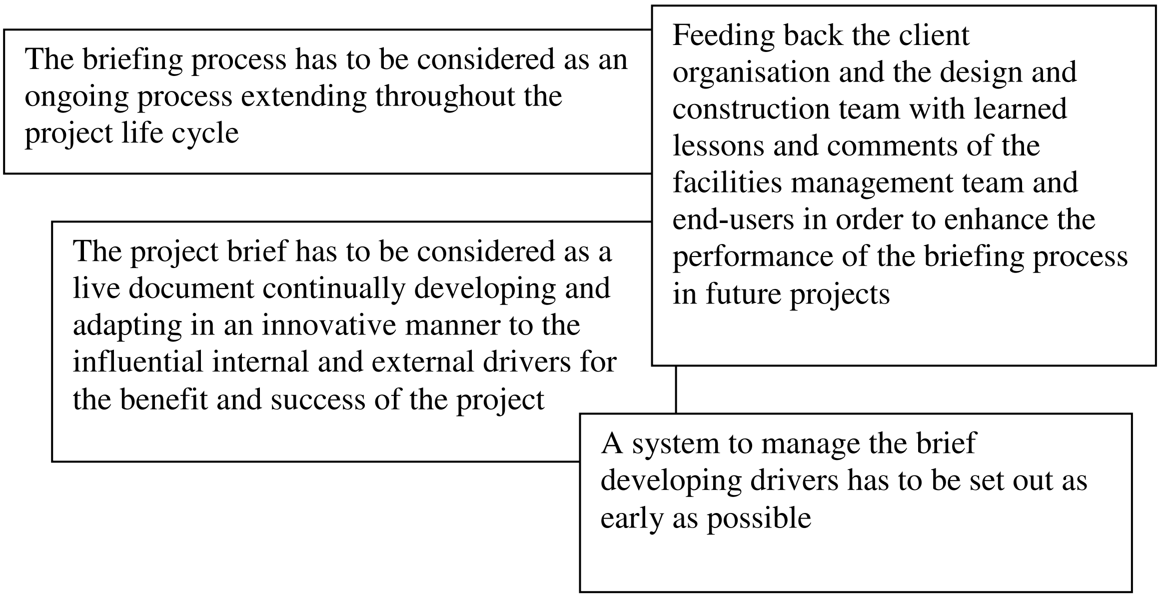



Figure 2.1. Principles for the success of the work

The first stage of change orders is the feasibility stage, where the client requirements are first identified, studies that enable the client to decide whether to proceed and select the probable procurement method are prepared and the strategic brief is identified. Evaluating the project brief at this stage represents the basis to compare subsequently developed brief versions.

At the second stage, it evaluates the brief development at the end of the detailed proposals stage where the information becomes more concrete and the pace of change is reduced as well as the detailed proposals are prepared. This stage should reflect the influence of internal and external drivers on design since clients' ideas develop as the design alternatives are seen.

Third stage comes at the end of the tender action stage, which represents the end of the pre-construction period and the beginning of the construction period, the tender documentation is ready, potential contractors and/or specialists for the construction of the project are identified and evaluated. In addition, tenders are obtained, appraised and recommendations are submitted to client. Evaluating brief development takes a particular importance because the cost of change or modification after this stage is expensive.

The fourth stage evaluates the brief development at the end of the construction to practical completion stage. Implications of the drivers that affected the project brief during construction in terms of cost, time and quality, should be reflected in the developed brief. This construction stage represents the stage that witnesses most frequent development of the project brief. This can be attributed to the industry's fragmented nature, long investment term, risk exposure, time consumption, and a lot of other internal and external influences.

The fifth stage comes at the practical completion stage, where the final inspections and settlement of the final account occur. Evaluating brief development at this milestone provides the client organisation, design team and construction professionals with learned lessons and feedback from the end-users and facilities management team, all of which play an important role in improving the briefing process for future projects.
Most of the changes/variations occur due to changes in the client's requirements, revisions or modifications in the original design by the designer (Architect/Engineer/Superintending Officer/Project Director and/or amendments or changes in the statutory provision or requirement.

If there is no variation provision in the contract, then any change would require the agreement of the contracting parties, be it between the Employer and Contractor or Contractor and Sub-contractor. The contracting parties would need to renegotiate the contract price and/ or rates (and possibly even time, as the case may be), each time a change occurs.

The engineer can comment on the following:

- Increase or decrease the quantity of any work included in the contract;
- Omit any such work;
- Change the character or quality or kind of any such work;
- Change the levels lines position and dimensions of any part of the works; and
- Execute additional work of any kind necessary for the completion of the works

In the original contract the following changes can be made:

- Quantity increase and/or decrease;
- Addition or omission;
- Change in character, quality and/or nature;
- Change in levels, elevations, layout and dimensions;
- Demolition or removal of any part of the works, equipment, materials/goods not desired by the employer;
- Change in contractor's temporary work, working method and/or construction plant by employer;
- Postponement of any part of the works by employer;
- Employer's requirement to complete the works or any part/section earlier than its completion time.

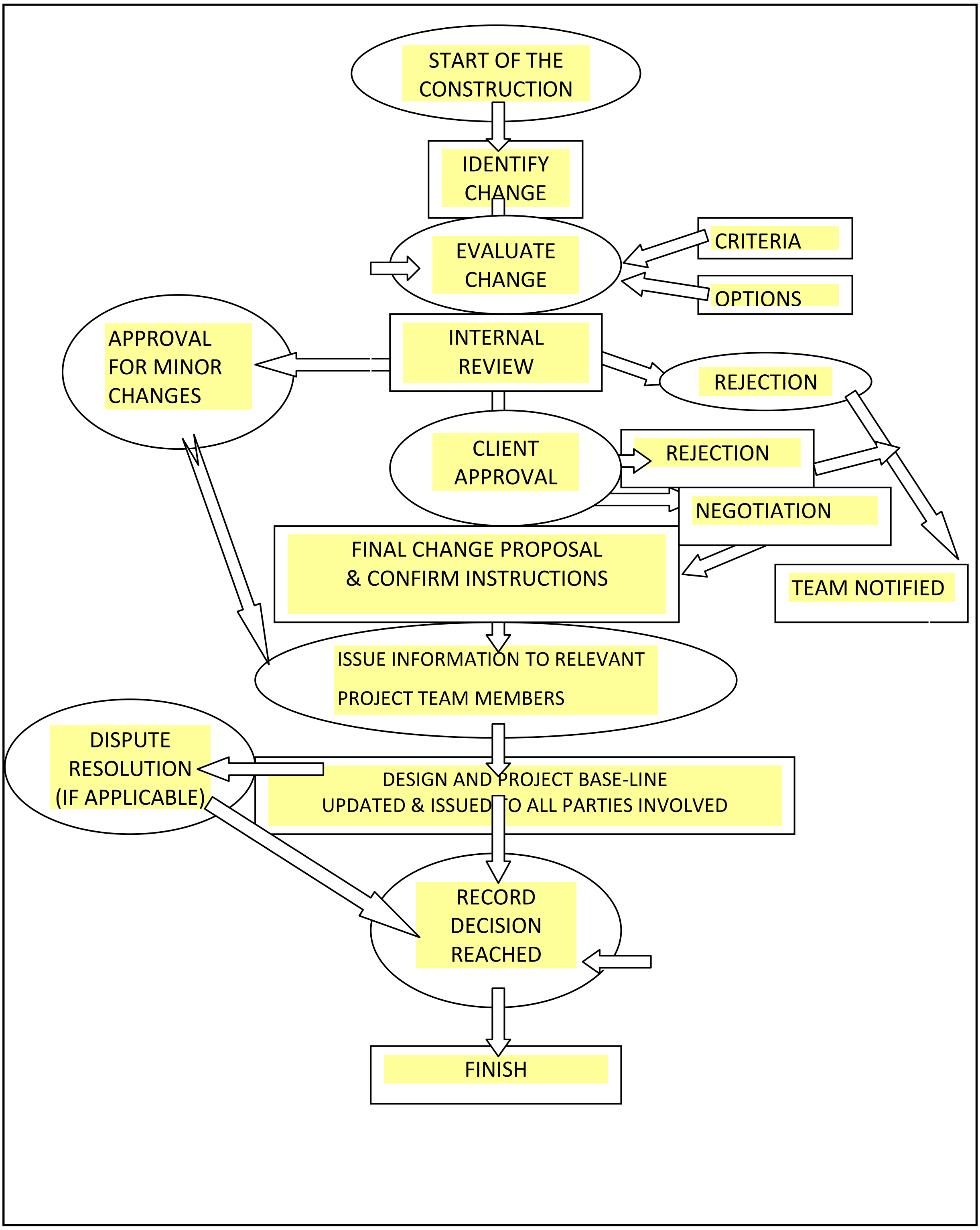



Figure 2.2. Stages of the project vs. disputes

With respect to changes, in the first part of the contract, it relates to changes to the contract documents which make it necessary to alter or modify the design, quality or quantity of the works or removal from site of any executed works or materials/goods brought to the site. In the second part, it relates to additional, alteration or omission of obligations or restrictions in regards to:

- Access to site;

- Use of any specific part(s) of the site;
- Limit working space;
- Limit working hours;
- Execution or completion of the work in any specific order.

However, sometimes client-contractor relationships do come to an end. Clients may be faced with a requirement for a new contractor, an additional contractor, or a different type of agency, and divergences appear or disagreements occur which simply cannot be recovered. In those circumstances clients will call competitive pitches. A competitive pitch can be part of the process of ensuring that marketing budgets create maximum value for the brand concerned. They can be required to provide more effective creative and/or media communications solutions, more harmonious or constructive working relationships, or to produce greater cost-effectiveness. They can also enable more successful contractors to grow and challenge for more business, so ensuring vitality of the contractor sector, providing new resources and wider choice for clients.

However a huge amount of time and money is invested and often misapplied on pitching, by both client and contractor. If the process is faulty, it can lead to unproductive solutions that have to be undone at further expense and disruption to the brand. The increasing involvement of procurement in the area of agency relationships, while often enriching the process with additional expertise, can sometimes add a further layer of complexity to the pitch process.

### 2.3. Literature and further reading for chapter 2


1. The WFA web site: www.wfanet.org
2. The EACA web site: www.eaca.eu
3. WFA/EACA guidelines on CLIENT-AGENCY RELATIONS and best practice in the PITCH PROCESS
4. http://onlinemanuals.txdot.gov/txdotmanuals/cah/changes_to_contract.htm
5. http://www.bne.uwe.ac.uk/cprc/publications/mcd.pdf
6. http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.1995.tb00086.x/abstract
7. http://www.mbam.org.my/mbam/images/MBJ4Q08/@ENTRUSTY%20%2882-92%29.pdf
8. Engineering construction risks: a guide to project risk analysis and risk management, Edited by Peter Thompson and colleagues, Centre for Research in the Management of Projects University of Manchester Institute of Science and Technology: John Perry and colleagues, School of Civil Engineering, University of Birmingham
9. http://www.medwelljournals.com/fulltext/?doi=jeasci.2009.170.176, Journal of Engineering and Applied Sciences, Year: 2009, Volume: 4, Issue: 3,Page No: 170-176, Variation Orders in Construction Projects, Randa S.M. Jawad, Mohd. Razali Bin Abdulkader and Abang Abdullah Abang Ali
10. Drivers for dynamic brief development in construction, Ayman A.E. Othman, Tarek M. Hassan and Christine L. Pasquire
11. Project management: techniques in planning and controlling construction projects, H. N. Ahuja,S. P. Dozzi,S. M. AbouRizk

## 2.4. Set of exercises for chapter 2

**Exercise 2.1.**

1. The causes of project change may originate from either external or internal pressures that are being applied to the project. Which one of the following is not an external cause?
a) Regulatory
b) Environmental
c) Contractual
d) Economic
e) Technological

**Exercise 2.2.**

Define the term "RISK" with a text please.

**Exercise 2.3.**

According to the internal causes of the project change, please define which is true and false:
a) Inadequate skills and knowledge amongst the team
b) Confusion in project goal, scope, and resources
c) No changes in the design project
d) Weather conditions
e) Proper decision-making

**Exercise 2.4.**

Which is not an effect for a change in the project?:
a) Destroying work already done
b) Change in cash flow, financial costs, loss of earnings
c) Type of the procurement
d) Increased risk of co-ordination failures and errors
e) None

**Exercise 2.5.**

In the original contract which change/changes cannot be made:
a) Quantity increase or decrease
b) Change of client
c) Change in contractor's temporary work, working method and/or construction plant by employer
d) Demolition or removal of any part of the works, equipment, materials/goods not desired by the employer
e) Employer's requirement to complete the works or any part/section earlier than its completion time

**Exercise 2.6.**

Please fill in the blanks.
"The project brief _______to be considered as a _______ document continually developing and adapting in an innovative manner to the influential internal and external drivers for the _________________of the project."
a) has not, useless, failure and unsuccessful
b) has, useless, benefit and success
c) has not, live, failure and success
d) has, important, failure and unsuccessful

e) has, live, benefit and success

**Exercise 2.7.**
Define the direct and indirect effects of change in a text please.

**Exercise 2.8.**
Which one of the following is not a principal of risk while solving it:
a) The greatest uncertainty is in the earliest stages of a project, which is also when decisions of greatest impact are made. Risk must be assessed and allowed for at this stage,
b) The client's departments and advisors should operate as far as possible from each other to avoid the negotiations and arguments,
c) The first estimate of cost and benefits should be based on a realistic program for a project,
d) All too often risk is either ignored or dealt with in an arbitrary way : simply adding a 10% probability onto the estimated cost of a project is typical,
e) Joint ventures and consortia are means of sharing resources and risks but should be based on partnership and commitment.

**Exercise 2.9.**
Fill in the blanks please,
"For _____ risk contracts, project sponsors should specify the allocation of risk when inviting bids and require tenderers to state their provision for risk in their bids. Project sponsors should also consider selecting the ______ on the basis of ________acceptable risk rather than ____________price. Risk analysis allows such a criterion to be used."
a) low, contractor, maximum, highest
b) high, project manager, minimum, lowest
c) low, inspector, maximum, lowest
d) high, contractor, minimum, lowest
e) low, contractor, minimum, highest

**Exercise 2.10.**
Define the meaning of a change in a construction project giving an example, please.

# CHAPTER 3
# MANAGING CHANGES IN CONSTRUCTION PROJECTS

## OBJECTIVES OF CHAPTER 3

The end users of the module are construction engineers and project managers engaged in construction projects. This module allows the participant to understand the fields of contract risk, the risk evaluation methods, risk mitigation and claim management in construction projects.

## LEARNING OUTCOMES FOR CHAPTER 3

This module will appeal to a wide range of professionals responsible for construction project implementation. Participants will gain specialised knowledge of risk evaluation, the approach to risk mitigation and the claim procedures.

## 3.1. Introduction

The construction work is a unit of individual projects, which are different in size, length and complexity. And, project change is one of these common specialities. During a construction project many decisions have to be taken based on incomplete information, assumptions and personal experience of the construction professionals. Changes and adjustments at a later stage are obvious. Managing change effectively is essential and very important at this stage for the success of the project. If changes are not managed appropriately, they can cause project delays and overspending.

In almost all construction projects, changes or variations are common occurrences during the design and construction phases. It is therefore not surprising that in most construction contracts, standard forms or bespoke, the provision for a variation clause in the contract has become a standard, if not compulsory feature.

Effective evaluation of project success should include:

(1) **Clear goals,** essential to identify potential incompatibilities among project goals and objectives and to provide a framework for design of project evaluation.

(2) **Baseline data,** needed as an objective basis for evaluating change caused by the project and encompassing as long a pre-project period as possible (including a detailed historical study).

(3) **Good study design,** to demonstrate the effects of restoration projects in complex environments.

(4) **Research for a long term,** to detect effects evident for years following project completion; in general, monitoring should continue for at least ten years, with surveys conducted after each flood above a predetermined threshold.

(5) **Willingness to acknowledge failures,** or rather to recognise that each restoration project constitutes an experiment, so that a failure can be just as valuable to the science as a success, provided we can learn from it (which requires objective, robust post-project evaluation).

## 3.2. Changes at construction and development stage

Immediately after the contract is awarded, the construction phase begins. In cases where detailed drawings and technical specification were available as a part of the tender document, the contractor proceeds with the construction. During the construction it may occur in practice that some requirements resulting from the drawings and technical specifications are divergent,

in some cases the site conditions might differ from those taken into consideration in the design, or other circumstances influencing the assumption of the project have been met. In such cases right analysis is required to elaborate the best solution to be implemented in the contract, taking into account technical, financial, and time aspects. As a result some changes or variations might be required to be implemented in the contract to the construction or construction process, sometimes with some influence for time for construction and project cost.
In practice some ambiguities or discrepancies can be found out within three essential contract documents:

- Design (drawings);
- Technical specifications;
- Bill of Quantities (BoQ).

The documents forming the contract are to be taken as mutually explanatory of one another. If any ambiguity or discrepancy occurs, one of the contract party or project manager (engineer in FIDIC contracts) should conduct the procedure to clarify this ambiguity or rectify the discrepancy and issue any necessary clarification or instruction.

### 3.3. Changes to technical solutions

The changes/variations to technical solution may occur as necessary or as recommended at the stage of construction. They may result as consequences of:

- unforeseeable physical conditions encountered on site (underground structures and services, geological conditions, hydro-geotechnical conditions);
- limited access to the site in size and time aspects;
- different technology to be used for execution of permanent works due to knowledge, possibilities and experience of the contractor;
- optimizing of equipment in number, parameters and capacity;
- optimizing the construction materials (especially in earth works, concrete and asphalt recipes.

Each change/variation may include:

- changes to the quantities of any item of work included in the contract;
- changes to the quality and other characteristics of any item of work;
- changes to the levels, positions and/or dimensions of any part of the works;
- omission of any work unless it is to be carried out by others;
- any additional work, plant, materials or services necessary for the permanent; works, including any associated tests on completion, boreholes and other;
- testing and exploratory work;
- changes to the sequence or timing of the execution of the works.

Analysing the proposed change or variation of technical solution, the following main aspects need to be taken into consideration:

- technical parameters of change/variation versus client's requirements;
- cost of change/variation;
- influence of change/variation on the time schedule;
- influence of change/variation on operation costs;
- influence of change/variation on maintenance conditions.

### 3.4. Changes due to technology development

The changes/variations may occur as necessary or as recommended due to new technologies on the market, and can be adopted to temporary works and to permanent works as well.
New technology can influence any of the following fields of construction projects:

- equipment to execute the works;
- technology of work's execution;
- materials for works;
- equipment/plant parameters;
- new equipment/plant solutions;
- new technology/process (like water, wastewater, solid waste treatment);
- measure, operation and control system.

### 3.5. Changes due to unforeseen conditions

During the execution of works it happens from time to time that physical conditions on the site encountered by the contractor differ from those specified by the client in the tender dossier. It is obvious that such conditions, not known up to that time, were not taken under consideration and estimated in the tender's BoQ.

#### *3.5.1. Definition of "Physical conditions"*

"Physical conditions" means natural physical conditions and manmade and other physical obstructions and pollutants, which the contractor encounters at the site when executing the works, including sub-surface and hydrological conditions but excluding climatic conditions.

#### *3.5.2. Notification on "Physical conditions"*

If the contractor encounters adverse physical conditions which he considers to have been *"unforeseeable"*, the contractor shall give notice to the engineer as soon as practicable.

This notice shall describe the physical conditions, so that they can be inspected by the engineer, and shall set out the reasons why the contractor considers them to be unforeseeable. The contractor shall continue executing the works, using such proper and reasonable measures as are appropriate for the physical conditions, and shall comply with any instructions which the engineer may give.

#### *3.5.3. Consequences of "Physical conditions"*

If and to the extent that the contractor encounters physical conditions which are unforeseeable, gives such a notice, and suffers delay and/or incurs cost due to these conditions, the contractor shall be entitled to:

- an extension of time for any such delay, if completion is or will be delayed,
- payment of any such cost, which shall be included in the contract price.

However, before the additional cost is finally agreed or determined, the engineer may also review whether other physical conditions in similar parts of the works (if any) were more favourable than could reasonably have been foreseen when the contractor submitted the tender. If and to the extent that these more favourable conditions were encountered, the engineer may proceed to agree or determine the reductions in cost which were due to these conditions, which may be included (as deductions) in the contract price. However, the net effect of all adjustments and all these reductions, for all the physical conditions encountered in similar parts of the works, shall not result in a net reduction in the contract price.

### 3.6. Changes due to clients new needs and requirements

To prepare and implement the construction project takes time. From design to completion of works and put them into operation client has to wait average from three to five years. During this period of time the assumptions taken as a starting point of the project, market requirements or client's expectations and requirements may change and differ from those analysed and taken into elaboration of the project at commencement. Sometimes the reason for the change is a new point of view of the client arising during the construction period and the desire to better match the project functions and parameters to contemporary market requirements.

### 3.7. Changes due to the law and market conditions

#### *3.7.1. Changes due to the law*

The period of construction works in construction project varies on average from two to four years. During such a period of time it is possible that the changes can be noticed in laws:

- the laws in the country;
- the country's technical standards;
- building, construction and environmental laws;
- laws applicable to the product being produced from the works;
- other standards specified in the client's requirements applicable to the works or defined by the applicable laws.

All these laws shall, in respect of the works, be those prevailing when the works are taken over by the client. References in the contract to published standards shall be understood to be references to the edition applicable on the date of tender submission unless stated otherwise.
If changed or new applicable standards come into force in the country after the date of tender submission (i.e. during the contract implementation), the client shall take a decision whether compliance is required or not.
In FIDIC contracts in such a case the contractor should give notice to the engineer and (if appropriate) submit proposals for compliance. In the event that:

- the engineer determines that compliance is required, and
- the proposals for compliance constitute a variation,
- then the engineer shall initiate a variation.

The contract price shall be adjusted to take account of any increase or decrease in cost resulting from a change in the laws of the country (including the introduction of new laws and the repeal or modification of existing laws) or in the judicial or official governmental interpretation of such laws, made after the date of submission the tender, which affect the contractor in the performance of obligations under the contract.

#### *3.7.2. Changes due to the market conditions*

In the case of construction projects, which often take several years to complete, issues related to time, value for money, current market condition, and price-level acquire tremendous significance, as transactions are taking place at different times, and it stands to reason that the financial position is viewed as on a certain cut-off date.
The rises or falls in the cost of labour, goods and other inputs to the works can be observed. Dependent on market conditions, are not only the increase or decrease of prices of labour and materials can be observed, but the shortage of materials and extended time of their delivery the

contractor can take place. These have influence on contract budget and on time for completion as well.
The amounts payable to the contractor shall be adjusted for rises or falls in the cost of labour, goods and other inputs to the works, by the addition or deduction of the amounts determined by the formulae prescribed in the contract, if any. To the extent that full compensation for any rise or fall in costs is not covered by the provisions of the contract, the contract price (Accepted Contract Amount) shall be deemed to have included amounts to cover the contingency of other rises and falls in costs.
Also the time for completion can be influenced by the shortage of materials, and appropriate steps to limit the time extension or increase the contract price should by carefully analysed to find out the optimal, from the client point of view, solution.

### 3.8. Changes to time schedules

Changes to time schedules are normal procedure to reflect the actual progress by introducing the latest influences on the works and other contractor's obligations.
Changes and updating of time schedule can be defined as planning and programming of the remaining portion of an activity job by introducing the latest information available.
The contractor shall submit a revised time schedule whenever the previous one is inconsistent with actual progress or with the contractor's obligations.

#### *3.8.1. Entitlement to extension of time*

The Contractor shall be entitled to an extension of the time for completion if and to the extent that completion is or will be delayed by any of the following causes:

a) a variation or other substantial change in the quantity of an item of work included in the contract,
b) a cause of delay giving an entitlement to extension of time,
c) exceptionally adverse climatic conditions,
d) unforeseeable shortages in the availability of personnel or goods caused by epidemic or governmental actions, or
e) any delay, impediment or prevention caused by or attributable to the employer, the employer's personnel, or the employer's other contractors.

#### *3.8.2. Delays caused by the contractor*

At any time when:

a) actual progress is too slow to complete within the time for completion, and/or
b) progress has fallen (or will fall) behind the current time schedule,

Due to the responsibility of the contractor, then the contractor shall submit a revised time schedule and supporting report describing the revised methods which the contractor proposes to adopt in order to expedite progress and complete within the time for completion.
Unless the project manager/engineer notifies otherwise, the contractor shall adopt these revised methods, which may require increases in the working hours and/or in the numbers of contractor's personnel and/or goods, at the risk and cost of the contractor.

### *3.8.3. Scope of changed time schedule*

Each time schedule shall include:

a) the order in which the contractor intends to carry out the works, including the anticipated timing of each stage of design (if any), contractor's documents, procurement, manufacture of plant, delivery to site, construction, erection and testing,
b) the sequence and timing of inspections and tests specified in the contract,
c) a supporting report which includes:
    - a general description of the methods which the contractor intends to adopt, and of the major stages, in the execution of the works, and
    - details showing the contractor's reasonable estimate of the number of each class of contractor's personnel and of each type of contractor's equipment, required on the site for each major stage.

## 3.9. Changes of contract costs

The changes of contract costs should reflect the amounts payable to the contractor for:

1. The work instructed as a variation or adjustment – the appropriate price has to be agreed between the contractor and project manager/engineer.
2. The cost related to unforeseeable physical conditions – if the contractor encounters physical conditions which are unforeseeable and incurs cost due to these conditions, the contractor shall be entitled to payment of any such cost, which shall be included in the contract price.
3. Volume of works as a result of measurement of executed works in measurement contract – contract price has to be agreed or determined by evaluating each item of work, applying the measurement agreed and the appropriate rate or price for the item. Any quantities which may be set out in the BoQ or other schedule are estimated quantities and are not to be taken as the actual and correct quantities of the works which the contractor is required to execute and be paid for.
4. Changes of scope of works in lump sum contract – the adjustment of contract price subject to change of scope of works has to be agreed between the contractor and project manager/engineer, there is no measurement in this type of contract.
5. Adjustments to changes in legislation – the contract price shall be adjusted to take account of any increase or decrease in cost resulting from a change in the laws of the country (including the introduction of new laws and the repeal or modification of existing laws) or in the judicial or official governmental interpretation of such laws, made during the contract, which affect the contractor in the performance of obligations under the contract. If the contractor incurs (or will incur) additional cost as a result of these changes in the laws or in such interpretations, made during the contract, the contractor shall be entitled to payment of any such cost, which shall be included in the contract price.
6. Adjustments for changes in cost – the amounts payable to the contractor shall be adjusted for rises or falls in the cost of labour, goods and other inputs to the works, by the indexing. The adjustment to be applied to the amount otherwise payable to the contractor, as valued in accordance with the appropriate schedule and certified in payment certificates, shall be determined from formulae in the contract for each of the currencies in which the contract price is payable. No adjustment is to be applied to work valued on the basis of cost or current prices.

## 3.10. Cross cultural communication and management

### *3.10.1. The importance of communications*

Effective verbal and written communication does not come naturally for most people. Some who are adept at the spoken word may have trouble writing a clear, concise letter. Others can write a beautifully constructed manuscript, yet have difficulty in communicating the same ideas in speech.
People often feel they understand one another perfectly, when, in reality, they do not. They are operating in what psychologists call "pseudo-communication." They use the same words and phrases but interpret them differently depending upon their own background. National origin, gender, culture, education and past experiences all play a role in the "understanding" reached.

### *3.10.2. Communication principles*

Nowadays, the need for communication skills has become hugely important. Communication plays a vital role in the global world. The world ‘communication’ has been derived from Latin *communis* which means ‘common’. Communication involves an exchange of ideas, information, attitudes, feelings, beliefs or impressions. However, this process requires understanding between its participants as an idea is always intangible and abstract. The message has to be encoded in words, signs or symbols and has to be brought to life in a concrete and accurate way in order to be understood correctly. This may be problematic task and cause many difficulties. Furthermore, communication does not involve only words but all nonverbal signs, such as gestures, voice, pitch and facial expressions. As a result, all factors involved in communication have to be taken into account. The message cannot be spelt out or written without consideration of its understanding. As Peter Ustinov said ‘*Communication is the art of being understood’*. That is why it is vital for participants to pay attention to the proper selection of words and the nonverbal aspects of communication. As an example, a high-pitched or raised voice, tense facial muscles or knitted eyebrows may mean anger, confusion, disgust, hate and so forth. In written communication these nonverbal factors are important too. Cluttered text, long paragraphs, no use of white space in the page, poor layouts of business letters or overload of information are significant errors. They can cause lack of interest in the reader.

### *3.10.3. Effective communication*

How to communicate effectively? Firstly, awareness and respect of others’ feelings should be preserved. Communication is not only passing information, it is a complex process where two sides should be satisfied with the result. That’s why it is important to be sincere, avoid anger or negative words, but be polite, reliable and respectful. Secondly, the message should be simple, direct, precise and short. For clarity, the research about another side is essential to avoid misunderstanding.
Another factor is conciseness. A long winded message is a time robber, especially in business when time is money. What is required are accuracy and limited use of relevant worlds. Furthermore, use of facts, figures, examples, charts are essential to remember and understand the message easily. Those tools of communication should be used with correctness, adapting proper world, intonation and relevant information. Effective communication involves two-sides and their satisfaction. As a result, the participants should keep a thoughtful approach to communication related to numerous factors such as price, delivery time, specifications and so

forth with mutual benefits and real facts. The process of communication is complex and all above should be used simultaneously.

### *3.10.4. Intercultural communication*

The need for intercultural communication is as old as human kind. From tribes, travelling traders and religious missionaries, there was always a necessity to encounter different people from another. It is an old process, however, technology, new means of transportation and communication has accelerated intercultural contact.

People differ all around the world, in Paris they eat snails, while in other part of the world put poison on them; some people speak Hindi, others speak Polish; some people eat dogs, for others they are pets. Where are all discrepancies from? It is culture that can deliver answers to this and others questions about what the world looks like and how people communicate. '*There is not one aspect of human life that is not touched and altered by culture*' (Hall, 1977). In modern society people communicate in different ways. Culture helps to define the correct and proper message that can be sent to people from another country, as the communicative behaviour depends largely on the cultural background that we are from.

The world 'culture' comes from 'cultura' – the Latin word which is related to worship or cult. In the broadest meaning it is associated with human interaction. In a more specific sense, it is knowledge, experience, beliefs, attitudes, values, meanings, and religion, social hierarchies, notion of time and so forth, acquired and used to interpret experience and generate social behaviour. There are numerous definitions of culture, however, most of them characterise culture with some main points. Culture is not inherited or innate; it is acquired by learning and experience. Another characteristic is that culture is shared, it is not specific to individuals but for members of group, organisation or society. Furthermore, culture is transmitted from generation to generation; it is a cumulative process and is based on symbols.

### *3.10.5. Communication at domestic and international level*

Communication in the international arena it is not an easy process and there are many problems that can result in the failure to transfer meanings effectively. How people convey information is essential, what Hall calls a 'context' which is a key in explaining communication discrepancies? In high-context cultures, such as Arab countries, messages are often implicit and coded. In contrast, in low-context cultures, Anglosas countries, the message is explicit and words are used precisely. This division indicates styles which are preferable in high and low context societies. In the first case people prefer to have close personal relations and big information networks. Communication with them should be based firstly on building good relationships and gaining trust. Voice intonation, timing, facial expression and non-verbal communication are very important. In low-context societies meetings are mostly to obtain objectives. There are no closer relations, so communication is formal and direct.

Cultural diversity may cause many problems, such as lack of cohesion that results in inability to communicate efficiently or effectively. Those issues are derived from people's attitudes. An example may be preconceived stereotypes, for example engineers from economically advanced countries often see themselves as more knowledgeable than others from less developed countries. As a result, status related problems may occur, as one side is regarded as more competent than the other. Potential problems may be inaccurate biases. For example in some countries decision-making process involve long consultation with many people (e.g. in Japan), while in more individualistic countries decisions are taken quickly and by smaller group of people. Another example that may lead to miscommunication is language. In the

U.S. a ‘fortnight’ means four days, whereas in in Britain it means two weeks. Different perceptions of time may cause numerous misunderstandings. In many developed countries time is money, while in other countries the perception of time is more flexible. Another issue is associated with the way that particular situations can be interpreted. For example, Chinese people nod their heads during negotiation but this does not have to mean they agree with what is being said. In some cultures which are always very polite and attentive people may indicate that they agree when they actually do not.

### *3.10.6. Communication barriers*

*Language*
Even when non-native speakers know the language of communication but still cannot be fluent and confident enough. This can result in not asking questions or making statements with wrong meaning. Even more it can be noticed in written communication where problems arise with translation of information from one language to another.
*Cultural barriers*
For instance, non-native speakers use exaggerated politeness, they code the main message, while many American writers are more direct and blunt.

*Perception*
Is a person’s view of reality; how people see reality can vary and may influence their communication and decision making process.
Closely related to communication is negotiation, which is the process of bargaining with one or more sides to achieve a solution that is acceptable to all. In this process planning is very important, where the objectives should be identified, how these aims can be reached, and when dealing with different cultures the strategy should be precisely altered to negotiating across cultures. Research about the country, its culture and customs should be carried out in order to avoid mistakes or offence. In some countries it is essential to first build interpersonal relationship through lunch, informal talks, receptions and then after getting to know the partners the stage of doing business can be started. At this stage parties exchange task-related information and gain information about each other’s objective. Afterwards the persuasion process begins. The success of this stage often depends on mutual understanding of each other’s position, the ability to identify similarities and differences and with regards to those create new positions. Moreover, the good will of both sides is an essential factor to achieve a satisfactory mutual solution. The final stage of negotiation is the agreement. Some of the countries want to resolve each issue, others prefer to remove them from the bargaining table and focus on different matters. Even at this stage cultural differences may affect effectiveness.
It is important to take into consideration some factors while negotiating or cooperating with different cultures, like communication patterns, time orientation, customs and social behaviour. Talking about these factors in construction management, formal and informal aspects of cross-culture communication need to be taken into consideration for good understanding and mutual respect of business parties. These reflect not only the formal part of contracts, like contract agreement, minutes of meeting, current correspondence and implementation of issues agreed, where the three main issues referred to cross-culture managing are of essential importance (acceptance of different culture, established rules from the very beginning, and making agreement during face to face meeting) but also in habits and behaviour like politeness or punctuality in official and everyday contacts.
Unquestionable benefits from respect of cross-culture differences for success in business are:

- Mutual respect;
- Good understanding;

- Good cooperation.

### 3.11. Preparation of change order

Contract quantities or alterations in the work may be amended, in writing and at any time, to satisfactorily complete the project. As agreed in the original contract, the contractor will perform the work as increased, decreased, or altered. Amend the contract work by change order (CO) whenever a significant change in the character of the work occurs or a time extension is granted. Ensure that the CO is approved before beginning the changed or altered work.

Prior to developing a CO, work with the contractor to define the scope of the problem that requires a change to the contract. Evaluate possible solutions with the contractor. Include cost breakdowns and price justifications for any added items. Unit prices that are comparable to bid prices for the same character of work are acceptable without additional justification. Obtain assistance from the construction division, field engineering branch, design division, or the district construction office, as needed. Obtain contractor agreement regarding the scope of work and basis of payment for the CO.

Prepare COs when contract revisions, additions, or deletions to the work are necessary. COs may be required due to:

- an error or omission in the contract;
- differing site conditions;
- adding a specification;
- adding new items of work;
- resolving a dispute;
- changing the sequence of work; or
- other contract changes.

Ensure that any COs meeting either of the following conditions are signed and sealed by a licensed professional engineer:

- proposing major modifications to the TCP or
- modifying structural designs.

In general, change orders deal with three aspects: legal, cost and management. In this respect, we refer to legal aspects such as contract change, clause interpretation, substantiation and management of claims. In this approach, changes are looked at as a major source of construction claims and disputes. The major legal aspects are:

- Selecting the best delivery system (contract format)
- Drafting and interpreting changing clauses
- Documenting changing orders to be ready in case of litigation

| | | | |
|---|---|---|---|
| Project no. | Date: | No. | |
| **Client:**<br>**Project:** | | | **Distribution:** |
| Subject – definition of change: | | | WHAT |
| Identified by: | | | WHO |
| Reasons for change: | | | WHY |
| Discretionary | | Non-discretionary | |
| **Cost implication:** | | | |
| **Time implication:** | | | |
| Recommended action: | Project manager | | .........Date |
| Client decision required by: | Date: | | |
| Forwarded to client: | Date: | | |
| Client's decision: | Date | | |
| Projected schedule and cost plan (budget) amended on | Project manager | | |

Figure 3.1. Change order request form

| Project: | | | Client: | Job Id: | File reference: | | |
|---|---|---|---|---|---|---|---|
| Request Id: | Date | Initiated by: | Description of change | Client decision required by: | Client decision obtained by: | Client decision | Client decision Id no.: |
| | | | | | | | |

Figure 3.2. Change order register

### 3.12. Implement change

The organisation must be determined that will most effectively meet the needs of a project and also the characteristics of the project must be considered. The most important characteristics are:

1. Objective: What is the project designed to achieve? The organisation must enhance the probabilities that the project will meet its original objectives without compromise;
2. Schedule. The duration of the project and its target dates must be met. The organisation must work efficiently enough that its functioning will not hinder the Schedule;
3. Complexity. The technological requirements determine to a large extent what sort of organisation is compatible;
4. Size and nature of the task. A project involving thousands of workers and several years duration will have an inherently more complex organisational structure than a six-month, small-scale undertaking;
5. Resources required. Every project requires unique materials and individuals who form the organisation to carry it to completion;
6. Information and control systems. According to the peculiarities of the project, each organisation will produce suitable information to control effectively the project duration and cost in different ways for the various management personnel.

### 3.13. Feedback including causes of change

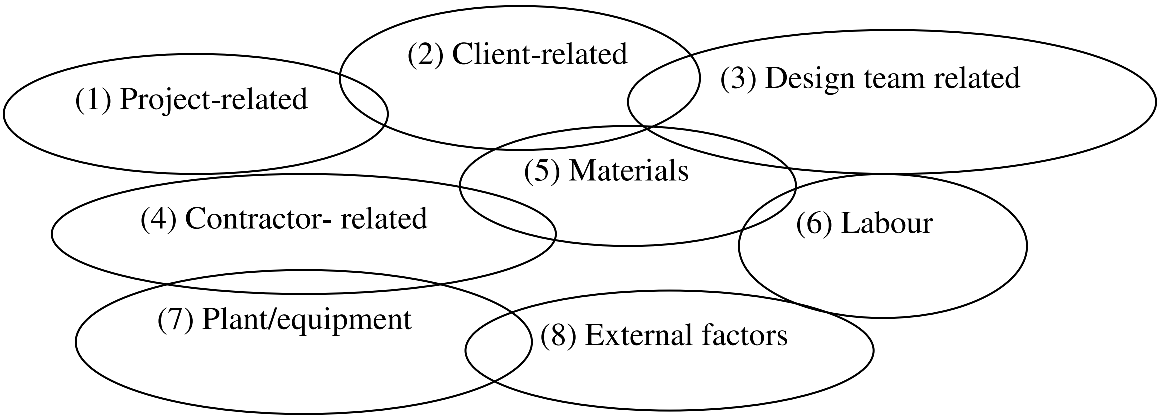
The success of a construction project, to a large extent, is determined by the ability of the project team to manage the inevitable changes during the project. Construction activities are complex processes involving many uncertainties. Changes can be caused by any or a combination of factors.

Project productivity and efficiency are influenced by the size of change order, relative size of project, timing of change order, complexity of change work, effectiveness of management, etc. And, the loss of productivity due to change was caused by the loss of learning curve effect, site congestion, trade stacking, schedule compression, overtime, over-manning, multiple-shift work, staff morale and motivational problems, and resource problems. The loss of productivity will be due to the need for reprogramming, loss of rhythm and unbalanced groups as a result of changes. Risk-related effects: in addition to the immediate consequences, project changes can also increase the risk of further disruptions.

Because in order to catch up with the delays caused by change, some tasks have to be accelerated and some floats of the original schedule are lost. Other effects: the relationship between the client and contractor is usually formalised by a contract. Project changes often result in alterations to the contractual terms and conditions. Differences in understanding of causes of change would lead to claims and counter claims. The general occurrences of claims and disputes are due to the fact that a project change is usually a result of a combination of causes rather than a clear-cut individual factor. A client and a contractor can often agree on what the change is.

However, they do not agree on the exact causes of the change and the responsibilities for the causes. If such a disagreement cannot be resolved through consultation, claims and disputes will be the result. Project changes often lead to higher workload and the need for rescheduling of work. Working overtime and/or managerial pressure are usually required to get the project back on track. One of the consequences of this is damage to staff morale and staff fatigue, which in turn results in low productivity and poor quality of work.

Change of causes can be classified in eight main categories:




The categories reflect both key participants (client, designer and contractor) and main components (material, labour and equipment) of construction projects.

**Taxonomy of change effects**

| | | | |
|---|---|---|---|
| **Level 1** | | **Time effect** | |
| **Level 2** | **Time extension** | **Loss of productivity** | **Increased Risk** |
| **Level 3** | **Addition of work** | **Productivity degradation** | **Acceleration measures** |
| | **Deletion of work** | **Procurement delays** | **Interruption of flow of work** |
| | **Rework/redesign** | **Logistic delays** | **Loss of float** |
| | **Work duration extension** | **Unbalanced rhythm** | **Increased sensitivity to further delays** |

| | | |
|---|---|---|
| **Level 1** | **Cost effect** | |
| **Level 2** | **Direct cost increase** | **Indirect cost increase** |
| **Level 3** | **Waste on abandoned work** | **Interrupted cash flow** |
| | **Demolition costs** | **Increased retention/contingency sum** |
| | **Increase in overheads** | **Overtime costs** |
| | **Additional equipment and materials** | **Litigation costs** |
| | **Additional payment to contractors** | |

| | | | | |
|---|---|---|---|---|
| **Level 1** | | **Relationship and people effect** | | |
| **Level 2** | **Relationship related** | **Working conditions** | **Staff Related** | **Quality** |
| **Level 3** | **Claim and dispute** | **Revision to work method** | **Loss of learning curve** | **Quality degradation** |
| | **Arbitration and litigation** | **Site congestion** | **Lower morale** | **Damage to reputation** |
| | **Team change** | **Poor safety conditions** | **Staff turnover** | |
| | **Poor coordination** | | | |

Source :Taxonomy for change causes and effects in construction projects
Ming Sun , Xianhai Meng

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### 3.15. Set of exercises for chapter 3

**Exercise 3.1.**
Which one of the following is not a factor for an effective evaluation of project success:
a) Clear goals, identification of potential incompatibilities among project goals and objectives providing a framework for design of project evaluation.
b) Baseline data, needed as an objective basis for evaluating change caused by the project and encompassing as long a pre-project period as possible (including a detailed historical study).
c) Good study design, demonstrating the effects of restoration projects in the complex environment.
d) Undertake for a long term, detection of effects evident only years following project completion.
e) None.

**Exercise 3.2.**
The changes/variations of technical solution may occur as necessary or as recommended at the stage of construction. Accordingly, which one of the following is TRUE or FALSE?
a) Unforeseeable physical conditions encountered on site (underground structures and services, geological conditions, hydro-geotechnical conditions).
b) Limited access to the site in size and time aspects.
c) Different technology to be used for execution of permanent works due to knowledge, possibilities and experience of the contractor.
d) Change of project manager and the subcontractors.
e) Optimising the construction materials (especially in earth works, concrete and asphalt recipes).

**Exercise 3.3.**
The contractor shall be entitled to an extension of the time for completion if and to the extent that completion is or will be delayed by causes. Under what circumstances is it not accepted as a cause:

a) Variation or other substantial change in the quantity of an item of work included in the contract.
b) A cause of delay giving an entitlement to extension of time.
c) Proper climatic conditions.
d) Unforeseeable shortages in the availability of personnel or goods caused by epidemic or governmental actions.
e) None.

**Exercise 3.4.**
Contract quantities or alterations in the work may be amended, in writing and at any time, to satisfactorily ________________ the project. As agreed in the original contract, the ________ will perform the work as increased, decreased, or altered. Amend the contract work by ______________________ whenever a significant change in the character of the work occurs or a time __________ is granted.
Please fill in the blanks:
a) cancel, client, change order, limit
b) complete, manager, contract, extension
c) cancel, architect, change order, offer
d) complete, contractor, change order, extension
e) None.

**Exercise 3.5.**
Prepare Change Orders (COs) when contract revisions, additions, or deletions to the work are necessary. COs may not be required due to:
a) An error or omission in the contract.
b) Differing site conditions.
c) Adding a specification.
d) Adding new items of work.
e) None.

**Exercise 3.6.**
The organisation must be determined that will most effectively meet the needs of a project and also the characteristics of the project must be considered. Accordingly, which one of the following is wrong?
a) Objective: What is the project designed to achieve? The organisation must enhance the probabilities that the project will meet its original objectives without compromise.
b)Schedule. The duration of the project is not important and it can be as long as the contractor wants without any limitation.
c) Complexity. The technological requirements determine to a large extent what sort of organisation is compatible.
d) Size and nature of the task. A project involving thousands of workers and several years duration will have an inherently more complex organisational structure than a six-month, small-scale undertaking.
e) None.

**Exercise 3.7.**
Fill in the blanks please choose from proposals: a), b), c), d) or e):
Change of causes can be classified in 8 main categories:
1. ______ related,
2. Client related,
3. ______ team related,
4. ______ related,
5. Materials,
6. Labour,
7. Plant/Equipment,
8. ____ factors.

a) Office, client, contractor, external.
b) Personnel, client, contractor, internal.
c) Project, design, client, internal.
d) Project, design, contractor, external.
e) None.

**Exercise 3.8.**
Define the meaning of changes/variations in the construction projects in a text please.

**Exercise 3.9.**
Analysing the proposed change or variation of technical solution, which one of the following main aspect need not be taken into consideration:
a) Technical parameters of change/variation versus client's requirements.
b) Cost of change/variation.
c) Influence of change/variation on the site manager.
d) Influence of change/variation on operation costs.

e) Influence of change/variation on maintenance conditions.

**Exercise 3.10.**
Please define the following as TRUE or FALSE:
Each change/variation may include:
a) Changes to the quantities of any item of work which is not included in the contract.
b) Changes to the quality and other characteristics of any item of work.
c) Changes to the levels, positions and/or dimensions of works which is not in the scope of the existing work.
d) Omission of any work unless it is to be carried out by others.
e) Any additional work, plant, materials or services necessary for the permanent works.

# CHAPTER 4
# PROJECT COST CONTROL: EVALUATION, DELAYED PAYMENTS

## OBJECTIVES OF CHAPTER 4

This chapter presents cost control of projects in construction industry. Different stages are presented: evaluation at the inception stage, calculation in the design phase and calculation in the construction phase of project. Many estimation methods are shown: single-rate approximate estimating, multiple-rate approximate estimating, and analytical estimating. This chapter also presents the structure of costs for construction projects and methods of cost control. The last subchapter is about the legal and contractual consequences connected with delayed payments.

## LEARNING OUTCOMES FOR CHAPTER 4

After reading this chapter you will be more familiar with methods of cost estimation and cost control of construction projects. You will know several estimation methods, which of them can you use in which phase of the project and how to use them. You will know how to calculate costs according to the structure of costs for construction projects. You will be familiar with basics of the consequences of delayed payments, especially in case of the projects co-financed by the EU.

## 4.1 Introduction - Overview of estimation methods

Cost estimating is essential for cost planning and budgeting, both of which lay the basis for cost monitoring and control, as explained in the following chapters. Cost estimating takes place in the project life cycle, that is to say, in all stages of the project development.
Methods for cost estimating vary as the project evolves from the early stages of conception to the construction phase, and then to the operation phase. In principle, as the project develops, more information becomes available thus estimating methods ought to be more accurate. Accordingly, estimating methods may be grouped as follows (the expected precision of project's investment costs calculation is indicated in brackets):

- Estimation methods at the inception stage (30% to 50%);
- Design phase estimation methods (15% to 30%);
- Construction phase estimation methods (5% to 15%).

The fundamental difference between methods included in the first two classes and those included in the last class above is that the former depend on reliable historical cost data whereas the latter follow an analytical approach based on the costs of resources required for project completion. Moreover, the accuracy of estimation during the design phase increases as more information on the project is released by the design team. Table 4.1 below lists a few methods currently used in construction and classify them according to the project phase for which they are appropriate. Note that the design phase is divided into three sections for three stages of design development.

Table 4.1. Estimating methods. [15]

| Classes of estimating | Estimating methods | Inception phase | | Design phase | | Construction phase |
|---|---|---|---|---|---|---|
| Guess estimating | "Blue sky" | ■ | | | | |
| | Cost comparison | ■ | | | | |
| Single-rate approximate estimating | Cost per unit | ■ | ■ | | | |
| | Floor area method | | ■ | ■ | | |
| | Building volume method | | | ■ | | |
| | Storey enclosure method | | | ■ | | |
| Multiple-rate approx. estimating | Elemental cost plans | | ■ | ■ | | |
| | Approximate quantities | | | ■ | ■ | |
| Analytical estimating | Unit rate estimating | | | | | ■ |
| | Operational estimating | | | | | ■ |

Although guess-estimating may not be considered a methodology for estimating, it is sometimes useful for a preliminary educated guess on the approximate amount of investment required for the project.

## 4.2. Single rate approximate estimating

### 4.2.1. Cost per unit

The cost per unit is commonly used by national and international bodies [15] such as education services, health services and office building investors at the inception stage of project development. It is adequate for preliminary estimating of some type of building facilities for which there is recent comparable unit data available. The total cost of the project will be given by:

**Total cost = cost per unit x number of units**

Units to consider will be dependent of the type of building, for example, theatre seat, car park place, hotel bedroom, hospital bed space, etc. Obviously, for unit cost data to be reliable, it must come from a significant number of buildings of the same type, and ought to be updated to take into consideration cost depreciation over time. The method is very easy to use but may be rather imprecise even for the inception stage, for which a poor degree of precision is expected (say, 30% to 50%). For this reason, it is sometimes recommended that ranges of values instead of single values may be used for unit costs.

However, clients tend to use it very often for budgeting purposes. For example, if a client has a certain amount of money to spend in a facility, then it may be possible to consider the likely number of functional units to provide within the target cost available. Conversely, if the client decides to build up a hotel of 50 bedrooms, and historical data shows that for similar quality standard the cost of a bedroom is, say, between € 15 000 and € 20 000, then the client knows that the expected budget for the project ranges between € 750 000 and € 1 000 000.

### 4.2.2. Floor Area Method

The floor area method is very popular in many European countries because of its simplicity. It is also adequate for preliminary estimating but obviously needs some more information from the project than the cost per unit method described above. The total cost of the project will be given by:

**Total cost = cost per square meter x total project area.**

In order to use the method, the building must be first measured by its internal dimensions at each floor level. No deductions are made for internal walls, ducts, lifts or stair cases. The costs of previous similar buildings are used to establish a sound cost per square meter that can be used for calculation of the total project cost by using the above expression.
Adjustments may be made to historical data for location and inflation. Subjective judgement may also be needed for establishing the adequate cost per square meter to use. For example, the standard of finishes, the shape of the building and the number of storeys may possibly unbalance average data collected from similar buildings.
In a more comprehensive version of the method, different types of floor areas and corresponding costs per square meter are taken into consideration. Table 4.2 depicts the breakdown of a dwelling, measured areas for each floor type and corresponding historical costs per square meter. This requires more information on the project, obviously coming from a later stage of design than above, and implies the availability of historical data in a more detailed fashion than just a global figure per square meter as in the standard version of the method. But it can lead to much better results and avoid some subjective judgements. In a way, this variant of the cost per square meter method may be considered a multiple rate estimating and be included in the second class of Table 4.2.

Table 4.2. Dwelling project breakdown.

| Type of areas | Quantity ($m^2$) | Cost/$m^2$ (€) | Total cost (€) |
|---|---|---|---|
| Basement for car parking | 1 100 | 350 | 385 000 |
| Ground floor common access areas | 350 | 400 | 140 000 |
| Common floor areas | 900 | 600 | 540 000 |
| Apartment areas | 4 000 | 740 | 2 960 000 |

In current construction practice, separate assessments are usually made for some works that, due to their great variety and cost, may significantly alter the total building cost appraisal. This is the case of foundations, external works, incoming services, drainage etc. Therefore, costs considered in Table 4.2 above do not include those works.
Parallel to the floor area method which is building specific, single rate estimating methods may be used for certain external works, especially in road and railway projects. The advantages and limitations of these methods are identical to those described above. Similarly, instead of using a single rate value, distinct rates for specific works may be adopted. Table 4.3 shows an example of a municipal road project where the main works and rates are identified.

Table 4.3. Municipal road project breakdown. [15]

| Type of works | Quantity ($m^2$) | Cost/$m^2$ (€) | Total cost (€) |
|---|---|---|---|
| Land acquisition | 70 000 | 7,5 | 525 000 |
| Earth movements | 95 000 | 3,2 | 304 000 |
| Paving | 60 000 | 30,0 | 1 800 000 |

Civil engineering works like earth supporting structures and bridges may be valuated separately because the variability of associated costs is likely to distort the final cost appraisal.

## 4.3. Multiple rate approximate estimating

### 4.3.1. Elemental cost plans

Despite their simplicity, single rate estimating methods may not be sufficiently precise even for preliminary project phases. A way to improve precision to the cost per square meter method has already been mentioned above: By adopting a convenient breakdown of project components, multiple cost rates instead of one may be used to generate a comprehensive cost plan and eventually lead to a closer estimation of the project cost.

Actually, elemental cost plans are often used for approximate estimating. The first step is to decide on a convenient cost breakdown structure (CBS) for the project under consideration. This may be different according to each project participant, the stage of project development and the availability of historical data, as discussed before. The second step is to forecast the cost for each element of the cost breakdown. This may be calculated in two ways:

- By measuring the approximate size of each element and applying a unit rate, like the cost per square meter, as in the example of Table 4.2;
- By calculating the proportion of the total cost for each element on a similar project and using this ratio to divide the total cost for the proposed project into its elemental breakdown.

Table 4.4 shows a typical example of the second approach above. In this example, the design budget of an office building project is stipulated from the preliminary estimate of the project. The cost breakdown adopted was by design components, each of which represents a known percentage of the total building cost. Finally, the design budget for each design component is calculated by applying a fee to the cost of the corresponding component. In Table 4.4, the fee for the architecture design is multiplied by the total building cost less the foundation cost estimate, i.e., 100% - 15% = 85%. In the same Table, the fees for the thermal insulation design and the acoustical insulation design are lump sums, thereby estimated through a different approach.

Tables 4.5 and 4.6 [15] illustrate another example of the use of ratios in elemental cost planning. Firstly, the CBS of a former warehouse is depicted in Table 4.5. The cost of a proposed warehouse similar to the previous one may be estimated by using identical rates as shown in Table 4.6.

Table 4.4. Design budget for an office building project.

| Estimated total building cost<br>€ 4 000 000 | | | | |
|---|---|---|---|---|
| Design component | Ratio (%) | Component cost (€) | Percentage for design (%) | Design budget (€) |
| Architecture | 85% | 3 400 000 | 3,92% | 133 280 |
| Foundations | 15% | 600 000 | 5,33% | 31 980 |
| Structure | 25% | 1 000 000 | 4,84% | 48 400 |
| Water distribution and internal drainage | 6% | 240 000 | 6,28% | 15 072 |
| Electrical installation and telephone | 18% | 720 000 | 5,15% | 37 080 |
| Heating ventilation and air conditioning | 25% | 1 000 000 | 4,84% | 48 400 |
| Gas supply | 2% | 80 000 | 7,53% | 6 024 |
| Thermal insulation | | not applicable | | |
| Acoustical insulation | | not applicable | | |
| External works | 5% | 200 000 | 6,48% | 15 552 |

Table 4.5. CBS of Upstream warehouse.

| Upstream Warehouse built in 2001 with 2 500 m2.<br>Total cost: 1 000 000 | | | |
|---|---|---|---|
| Element | Element cost (€) | Ratio (%) | Cost/$m^2$ (€) |
| Preliminaries | 100 000 | 10% | 40 |
| Foundations | 100 000 | 10% | 40 |
| Concrete frame | 200 000 | 20% | 80 |
| External walls and roof coverings | 60 000 | 6% | 24 |
| Internal walls | 40 000 | 4% | 16 |
| Windows and external doors | 30 000 | 3% | 12 |
| Carpentry and internal doors | 70 000 | 7% | 28 |
| Internal finishes | 90 000 | 9% | 36 |
| Sanitary appliances, water distribution and drainage | 30 000 | 3% | 12 |
| Electrical installation and telephone | 60 000 | 6% | 24 |
| Heating ventilation and air conditioning | 120 000 | 12% | 48 |
| External works | 100 000 | 10% | 40 |
| TOTALS | 1 000 000 | | 400 |

Table 4.6. CBS of Downstream warehouse.

| Downstream warehouse to be built in 2004 with 3 750 m2.<br>Total estimated cost: | |
|---|---|
| Element | Element cost (€) |
| Preliminaries | 150 000 |
| Foundations | 150 000 |
| Concrete frame | 300 000 |
| External walls and roof coverings | 90 000 |
| Internal walls | 60 000 |
| Windows and external doors | 45 000 |
| Carpentry and internal doors | 105 000 |
| Internal finishes | 135 000 |
| Sanitary appliances, water distribution and drainage | 45 000 |
| Electrical installation and telephone | 90 000 |
| Heating ventilation and air conditioning | 180 000 |
| External works | 150 000 |
| TOTALS | 1 500 000 |

The figures in Table 4.6. may possibly need adjustments to consider inflation and significant specification changes, like improved quality of finishes, distinct external works and number of sanitary appliances. Moreover, identical cost structures for both warehouses are feasible only for similar project characteristics otherwise the pattern of cost distribution may vary significantly. For example, when comparing two buildings of similar floor area, one with rectangular shape and the other irregular, the wall/floor ratio may lead to rather different cost distributions. Another example is when comparing warehouses with very distinct floor areas for which the same ratio may also be very different even if their shape is similar.

### 4.3.2. Approximate quantities

Approximate quantities are used in construction for a number of reasons. Firstly, they allow for preliminary cost assumptions prior to the design phase completion. Secondly, they use actual project data instead of historical data which may not be available or adequate for the proposed project. Thirdly, they help checking the output of analytical estimating as discussed below.

For the aims of preliminary estimating, the approximate quantities method concentrates on a small number of items of grouped work components. The basic rule is that 20% of typical work items roughly add up to 80% of the project cost. A simple example is the concrete frame of a building: because the cost of slabs may contribute for a significant part of the frame cost, slabs would be measured and priced at a composite rate including formwork, steelwork, shuttering and concrete. Composite rates for typical building items can be found in price books or may be computed from rates in priced bill of quantities.

Accordingly, assuming that the cost of slabs of a concrete frame building is as much as 60% of the estimated cost of the whole building structure, if the approximate measurement of total slab volume is 1 600m3 and a composite rate of € 300/m3 is used, then the estimate for the building structure will be roughly € 480 000. Now, if the structure is expected to contribute to say 25% of the project cost, then a budget of € 1 920 000 would appear to be reasonable. This would then be compared to the result of similar calculations performed for other building components.

As design proceeds, more data on the project becomes available, therefore allowing additional measurements and the refinement of estimation. At the later stages of design, approximate measurements become detailed measurements and the cost of project components may be estimated with an increasing degree of accuracy. After design completion, the design team releases the detailed measurements of the project and market rates may be used to gauge an estimate with a reasonably high degree of precision (say 15% or less). Rates may be obtained in priced bill of quantities or in price books.

## 4.4. Analytical estimating

### 4.4.1. Key aspects of analytical estimating

Analytical estimating involves three key features: detailed measuring of project works, evaluation of resources required to perform those works and resource cost assessment. Instead of using pre-established rates as above, analytical estimating aims at computing actual costs for each construction work. This can only be done in the scope of a given production organisation which means that analytical estimating is specific to construction companies.

Most countries across Europe have adopted comprehensive measuring systems for construction projects. In the United Kingdom for example, the Standard Method of Measuring of Building Works (SMM) and the Civil Engineering Standard Method of Measurement (CESM) are currently used for building and civil engineering projects respectively. For example in Portugal, there is not a uniform standard and many construction clients have developed a specific one for tendering their projects. However, the classification system developed by the *Laboratório Nacional de Engenharia* Civil (National Laboratory of Civil Engineering – LNEC) is widely adopted in both public and private building projects.

In Poland numerous regulations and documents apply to the cost estimation, for example:

- Ordinance of the Ministry of Infrastructure, from 18 May 2004 (Journal of Law 04.130.1389) titled: "Determining the methods and preparation of cost estimate of the investor base, calculate the planned costs of design and planned construction costs specified in the functional plan"
- Catalogues of Material outlays (KNR) – giving the advise about materials quantities as well as labour and machinery hours needed to produce unit of work (i.e. painting of 100 m2 of walls or digging 1 m3 of excavations)
- Sekocenbud, updated quarterly – one of the price lists for building materials, labour costs and machinery costs.

In Turkey, unit prices for building (superstructures) construction are given by the Ministry of Public Works, for Road & Highways Construction by General Directorate of Highways and for infrastructure construction by Bank of Provinces and for the special type of costs, they are calculated by the construction companies or clients. The ministries and directories publish these unit prices for the construction sector each year with new modified prices. There are powerful software programmes for the estimation of costs of construction that are being used by the contractors and clients.

Generic computer aided building cost estimation models are used in Turkish construction sector projects for feasibility and schematic design phases. The designs are based on the building functional elements method and a building cost estimation model is based on functional elements which work on a cost database. Underlying principles and basic steps of cost estimation based on functional elements are explained by means of computer-based cost estimation process. In order to automate the manual building cost estimation process, the software based on functional elements is developed. Making use of both public sector and current market prices in the cost estimation process, increasing number of projects stored in the database for more accurate results, estimating costs of different types of projects and estimating the structural functional

element percent more precisely are suggested for future research. As the number of similar projects in the database is increased, the accuracy of the cost estimation is also increased.
As industrial and technological development directly affects the construction sector, projects are getting more complicated and their scales are getting larger. Hence it is becoming more difficult to complete projects within quality standards, budgeted cost limits and on time. In order to use the limited resources in a rational way, it is necessary that cost estimation should be done efficiently in each phase of the process. As the level of details differentiates in each phase of the project, the cost estimation models applicable for each phase shall be different as well. A model can be chosen which is consistent with the detail level of the decisions in each phase. On the other hand, participants of the building construction process need and use cost estimation for different purposes. Owners want to know how much the profit will be or how much capital is required for the project. The owner tries to estimate the roughest cost rapidly. On the other hand, the designer needs the cost estimation to determine which schematic design alternative is the most suitable solution. Finally, the contractor needs more detailed and reliable cost estimation in order to determine the tender price and to manage cash flow.
Automation software (such as Microsoft Excel™) with wide range of built-in function and formulas, what-if analysis, vast graphical reporting facilities are used commonly in the construction sector in Turkey. Spread sheet + add-ins supplies integration and data transfer facilities for widely used CAD, accounting, scheduling and high-level cost estimation packages are also very common. In-house cost estimation applications based on expert programming of database management systems (such as Lotus Notes™, Oracle™) are the other systems used in design development and construction documentation phase. The third one is the on-the-shelf cost estimation packages. These are also called integrated or high-level systems. They are mainly used by general contractors to prepare estimates for bidding, preparing interim payment lists and by owners to evaluate or compare contractors' bids and interim payment lists. Entering BoQs, standard or user defined cost resource databases and reporting facilities are the most important part of those systems.
Turkey is in a phase of constructing and building up the country in terms of infrastructure and superstructure constructions, the cost estimation methods are used widely and professionally in each level of the constructions.

In Italy the law on public tendering states that the cost of a project is determined using analytical estimation, applying for each category of work the unit price obtained by the current price list of the contracting authority or, in absence of the corresponding item in the price lists, from other official price lists currently used in the area.
Each region has drawn up its own reference price list which is updated annually and is the reference for projects drawn up in that area.
Together with the price list, criteria for measurement of each category of work are defined.
For any items missing, the price is determined by the following analytic method:

a) Listing the quantity of material, labour, freight and transportation, necessary for the realisation of individual quantities of each item, and applying their prices derived from basic official price lists or price lists of local chambers of commerce or, failing that, by current market prices;
b) Adding a further variable percentage ranging from thirteen to seventeen percent, depending on the importance of the nature, duration and specific needs of individual works, for general overheads;
c) Finally, by adding a rate of ten per cent for contractor profit and risk.

The presence of different price lists for each region can lead to difficulties for companies participating in tenders as often in neighbouring regions there are significant differences in description of items and unit prices.

There is a need to unify and standardize the regional price lists in terms of methodological approach and analysis in order to make them comparable across the country.
To achieve this goal, the Institute ITACA (Institute for Innovation, the Transparency of Contracts and Environmental) in late 2011 adopted the document "Guidelines for the establishment of a regional reference price list in public procurement - part I: Setting Methodology. Chamber Works".
The activities developed within the working group, "Tender specifications and price lists" coordinated by the Region of Liguria, has been widely shared both by experts from all regions and representatives of industry (professionals, contractors, production companies, unions and public institutions).
The proposed scheme adopts the UNI 11337/2009 "Construction and civil engineering works. Criteria coding works and construction products, activities and resources ", which aims to create a unique system of coding and achieve a high degree of commonality in the recognition of subjects, objects and activities of the domain of constructions, by a common and shared language.

The evaluation of resources required to perform each identified project work is possibly one of the most difficult estimating tasks because it depends on the establishment of realistic production standards. In principle, this is specific to each contractor's organisation, because it is expected to vary according to the production means involved. Relevant data may be gathered from previous projects through the monitoring system which is normally put into practice in each construction site. This creates a feedback information process as illustrated in figure 4.1. below.

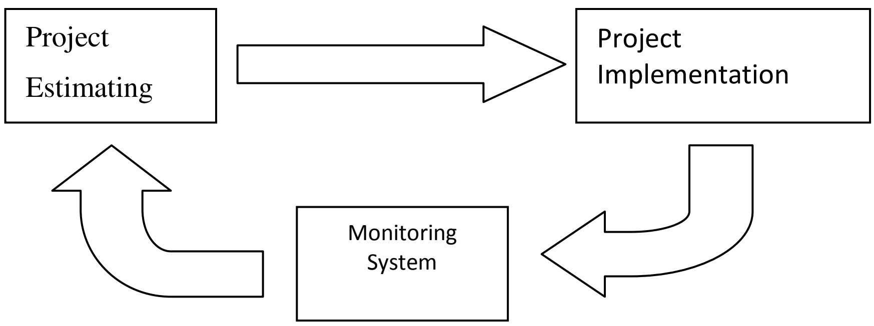


Figure 4.1. The typical feedback production information process.[15]

The monitoring may be done for bonus or other purposes, but quantities of work and the time expended in performing construction activities are recorded, and this is the information passed back to the estimating department.
In order to make this information usable for estimators, it must be formatted according to the current measuring systems adopted in the BoQ. However, information collected on construction sites may be difficult to use by estimators for the following reasons:

- It varies widely from site to site, affected by specific characteristics of each project;
- It is often not compatible for future estimating needs because of the unique circumstances under which each task has been carried out;
- A substantial number of similar task recordings are needed for establishing reliable average labour and plant outputs; this may be difficult to achieve in small and medium companies;
- Historic data may not be easily comparable because production means change over time;
- The site recording systems may not be reliable.

Alternatively, estimators may adopt published data on production standards collected from the industry. Data is worked out from a large number of observations in several construction sites and is organized into typical construction sites according to a specified measurement system. In the UK for example, published standards may be structured under the SMM or CESMM format or both, as in the sample depicted in Figure 4.2. In Portugal, the classification system developed by LNEC for building projects is widely adopted as in the example shown in Figure 4.3 (compare productivity differences between data presented). Nowadays, software companies throughout Europe have developed computer applications for estimation based on this type of data.

| PRICING INFORMATION | | | | | | BAR REINFORCEMENT | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Fixing times (total hrs/t) | | | |
| Bar size (mm) | Mass (Kg/m) | Waste (%) | Wire (Kg/t) | Spacers (nr/t) | Unload bars (hrs/t) | Foundations | Slabs & beams | Links | Site Cut & bend |
| 6 | 0,22 | 4,0 | 14 | 60 | 3,7 | 40 | 42 | 56 | 28 |
| 8 | 0,39 | 3,5 | 13 | 55 | 3,4 | 33 | 35 | 48 | 23 |
| 10 | 0,61 | 3,0 | 11 | 50 | 3,2 | 28 | 29 | 40 | 20 |
| 12 | 0,88 | 2,5 | 9 | 45 | 3,0 | 24 | 25 | 36 | 17 |
| 16 | 1,57 | 2,5 | 8 | 40 | 2,8 | 22 | 24 | 32 | 15 |
| 20 | 2,46 | 2,5 | 7 | 35 | 2,5 | 20 | 22 | | 14 |
| 25 | 3,85 | 2,5 | 5 | 30 | 2,3 | 18 | 21 | | 13 |
| 32 | 6,31 | 2,0 | 4 | 25 | 2,2 | 16 | 20 | | 11 |
| 40 | 9,86 | 2,0 | 3 | 20 | 2,0 | 14 | 19 | | 10 |
| 50 | 15,4 | 2,0 | 3 | 15 | 1,8 | 14 | 18 | | 10 |

Figure 4.2. Production standards for bar reinforcement (adapted from BROOK,1998).

It must be noted that production standards in figures 4.2 and 4.3 exclusively refer to labour and plant actually involved in production and may be used for direct cost calculation only. Site on-costs must be assessed separately. This approach seems to best suit current cost estimating procedures and provides a better understanding of the cost structure of BoQ items than if resources of other types were included. Furthermore, published standards like the ones above relate to specified working and management conditions on site which have to be compared to the ones forecast for the project under consideration.

Accordingly, production standards for both labour and plant are likely to be influenced by a whole range of project characteristics. When deciding on a standard output, the estimator needs to take into consideration all influencing different factors in order to get the best possible output for the project under consideration. Some of the characteristics that need to be considered include:

- Location and accessibility of the work;
- Amount of repetition;
- Intricacy of the design;
- Need for special skills;
- Quantity of work involved;
- Quality of materials and standards of workmanship;
- Working environment such as safety, temperature, etc.

### 4.4.2. Unit rate estimating

Unit rate estimating applies unit rates to the measured quantities in bills of quantities (BoQ). Unit rates comprise all elemental cost items, namely labour, materials, plant, subcontracts and overheads. The calculation of unit rates for each item of the BoQ essentially requires collating cost information, assessing labour and plant outputs and evaluating project overheads. BoQs are usually prepared in accordance with some agreed rules of measurement, as explained in the previous section of this chapter (for example KNR or SECOCENBUD in Poland).

| PRICING INFORMATION | | | | | BAR REINFORCEMENT | | | |
|---|---|---|---|---|---|---|---|---|
| Type of element | Cut and bending (hrs/10Kg) | | | | | | | |
| | 6 | 8 | 10 | 12 | 16 | 20 | 25 | 32 |
| Spread footings | 0,560 | 0,532 | 0,504 | 0,476 | 0,448 | 0,420 | 0,392 | 0,364 |
| Thin walls | 0,414 | 0,355 | 0,315 | 0,283 | 0,255 | 0,229 | | |
| Thick walls | 0,355 | 0,315 | 0,310 | 0,259 | 0,362 | 0,310 | 0,259 | |
| Small columns | 0,666 | 0,599 | 0,532 | 0,466 | | | | |
| Medium columns | 0,592 | 0,562 | 0,532 | 0,503 | 0,474 | 0,414 | 0,355 | |
| Large columns | 0,518 | 0,492 | 0,466 | 0,440 | 0,414 | 0,362 | 0,310 | 0,259 |
| Small beams | 0,666 | 0,599 | 0,562 | 0,532 | 0,503 | | | |
| Medium beams | 0,592 | 0,562 | 0,532 | 0,503 | 0,474 | 0,444 | 0,414 | |
| Large beams | 0,518 | 0,492 | 0,466 | 0,440 | 0,414 | 0,362 | 0,310 | 0,259 |
| Concrete Slabs | 0,414 | 0,355 | 0,315 | 0,283 | 0,255 | 0,229 | | |

Figure 4.3. Production standards for cut and bending of steel reinforcement bar (adapted from Branco (1998)).

### 4.4.3. Operational estimating

Unlike unit rate estimating which starts from the resources required for a work unit and then assigns the total resources to a measured work quantity, operational estimating considers all the resources needed for a construction package from the start. This may have several advantages:

- Estimating is activity oriented, thus closer to the way works are carried out on site;
- Activities are examined to select the most efficient construction methods;
- Resource outputs are more realistic because they relate to a construction schedule.

### 4.4.4. Criticism of detailed estimating methods

The development of operational estimating largely arose out of the criticisms to the traditional unit rate estimating applied to BoQs. Traditional bills have been criticised for their lack of relationship to the construction process and unit rates for being established irrespectively of the production reality. Actually, any bill item may relate to works performed in different locations and time instances and for this reason, resource outputs should be taken differently. On the contrary, operational estimating is activity oriented, thus much closer to the production process. Accordingly, it has been claimed that, in order to be effective, operational estimating would require the use of a different type of bills, since the layout of traditional bills would be unsuitable for this form of estimating; but earlier attempts to introduce operational bills have failed.

In reality, estimators currently use operational estimating for many items of typically structured BoQ, whenever those items refer to construction works for which unit rate estimating may not be appropriate. Furthermore, operational estimating depends on unit production output analysis before the gang of resources and the materials required for a specific construction package may possibly be computed. This is because unit production outputs are the best known way of gathering historical data and making it usable for the future. Therefore, it may be stated that both unit rate and operational estimating currently use common data structures in construction.

The question is thus how to select the adequate estimating method according to the work under consideration. The costs of excavation, for example, are likely to be much more related to the overall plant used in that work than to the resources forecast to perform one cubic meter of it. This is because performing such an operation possibly encompasses periods of inactivity for some plant, which may not be included in the unit rate. Total resource quantities actually employed on site may thus substantially diverge from the amount calculated by multiplying the unit rate by the estimated quantity of work. And this may lead to unpredictable costs. Therefore, an activity approach to the excavation work seems more appropriate, whereby time and resources required to perform the whole estimated quantity are established accordingly.

In general, unit rate estimating is preferred for building projects whereas operational estimating is mostly used for civil engineering projects for the following main reasons:

- The type of resources used in both types of projects. Building projects tend to be more labour intensive than civil engineering projects which use considerably more plant. Plant is susceptible to idle times which accrue costs that are not readily catered for in the unit rate approach. Labour is normally more versatile and less expensive.
- The typical form of the BoQ used. Bills for civil engineering projects tend to be best suited to operational estimating because they are easier to relate to construction activities than those used for building projects. Moreover, the usual complexity of building BoQ makes unit rate estimating the most reasonable method to use for most of their items.
- The usual procedures used in estimating. These also play an important role because both productivity data and cost data are commonly structured under unit rate format.

## 4.5. Types of costs

As stated in section 4.4.1. of Chapter 4, costing is a key aspect of analytical estimating. Construction costs are usually divided into two main classes: direct costs and indirect costs. Direct costs are those related to actual production works on the construction site. They include costs of labour and plant directly involved in performing those works, costs of materials needed for production and provisions for subcontracts. Costs of this nature are, at least in theory, easy to identify and to assess.

Indirect costs, on the contrary, cannot be allocated to individual units of work because they represent costs of a more general nature. However, they count towards all production units and must be allowed for within the overall costs of production. Furthermore, indirect costs are much less precise in terms of their assessment and they are often difficult to allocate to individual projects. Indirect cost items include preliminary costs or site on-costs, the contractor's general overheads (head office charges) and expenditure costs incurred away from the project. Many of these cost items can therefore only be allocated to the projects on some form of rough proportion basis or by means of a calculated percentage. Figure 4.4 below shows the usual cost structure of construction projects.

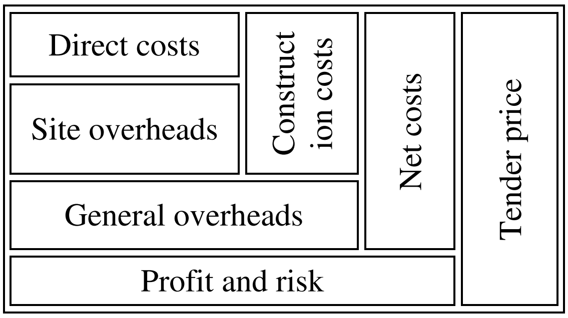


Figure 4.4. Typical cost structure for construction projects
(Adapted from McCaffer, R. 1986).

### 4.5.1. Labour costs

The costs of labour should include all items associated with employment, such as national insurance, sick pay, bonus and productivity schemes, holiday pay, severance payments, professional training, etc. All payments required by national working agreements should also be considered in the costs of labour. Accordingly, labour costs usually considered by contractors for estimation purposes are all-in labour rates.

Due to the large amount of legal labour charges, actual costs to construction companies of employing labour are presently more than twice the cost of the basic rates of pay. This will vary according to the conditions applied by individual contractors, relevant legislation and the availability of labour.

Labour costs are relevant both for direct and indirect cost assessment. Labour pertaining to direct costs includes all trades directly involved in the construction works on site, like craftsmen, gangers, labourers, tool operators and so on. However, there are some advantages to including the labour cost of some plant operators in the hourly rate of such equipment (for example, the tower crane operator). This may be useful for cost comparison with hired equipment which often comes with operator. Site staff costs are seldom included in direct costs but are recovered as either head office overheads or as a lump sum within the site on-costs. All head office labour is included in indirect costs as mentioned above.

Table 4.7 illustrates a typical all-in rate calculation. Figures presented may be different among European countries but the calculation logic is the same. Contractors need to adapt calculations to the geographical area where they intend to work, to national rules governing wages, to employer's liability insurance taxes, etc. Some possible differences are as follows:

- The number of hours worked each week may vary;
- The allowance for bad weather depends on the geographical area of work and on the exposition of the work to be carried out;
- Wages obviously vary considerably among countries and among regions within each country;
- Attraction bonuses may be required to entice good craftsmen;
- Extra payments for special skills may be compulsory in some countries;
- The performance of economy may determine substantial changes in wages and on attraction bonuses.

Table 4.7. Calculation of all-in rates for construction labour.

| Description | Entry Column | Calculation column |
|---|---|---|
| Working time | | |
| Total working hours | 52 x 40 | 2 080 |
| Average duration of a day work | 2080 / (52 x 7) | 5,71 |
| Actual duration of a day work | 2080 / (52 x 5) | 8,00 |
| Public holidays | 14 x 5,71 | - 80 |
| Annual holidays | 30 x 5,71 | - 171 |
| Sickness | 14 x 8,00 | - 112 |
| Absence | 2 x 8,00 | - 16 |
| Bad weather | 6 x 8,00 | - 48 |
| Bank holiday (24th December) | 1 x 5,71 | - 6 |
| **Total productive hours** | | **1 647** |
| **Overheads** | | |
| National Insurance + Employer Liability & Third Party Insurance | 23,75 + 8,60 | 32,35% |
| Annual holidays | 30 x 5,71 x 1,3235 | 13,76% |
| Holiday payment | 22 x 8,00 x 1,3235 | 14,14% |
| Christmas payment | 30 x 5,71 x 1,3235 | 13,76% |
| Public holidays | 14 x 5,71 x 1,3235 | 6,42% |
| Bank holiday | 1 x 5,71 x 1,3235 | 0,46% |
| Sickness | 14 x 8,00 x 1,3235 | 9,00% |
| Bad weather | 6 x 8,00 x 1,3235 | 3,86% |
| Compensations for | 30 x 0,5 x 5,71 | 13,94% |

| Description | Entry Column | Calculation column |
|---|---|---|
| unemployment | + 12 x 3 x 0,5 x 8,00 | |
| Meals | | 20,00% |
| Tools | | 5,00% |
| Health & safety | | 5,00% |
| Training levy | | 1,00% |
| **Total overheads** | | **138,69%** |

Table 4.8 shows an example of the hourly rate calculation for a skilled worker and a labourer following the official wage rate agreed between employers and construction unions for particular year

Table 4.8. Hourly rate calculation example.

| Workers | Month pay (€) | Hourly single rate (€) | Hourly rate with overheads (~140%) (€) |
|---|---|---|---|
| Skilled worker | 470,00 | 470 x 12 / 2 080 = 2,72 | € 6,91 |
| Labourer | 400,00 | 4 00 x 12 / 2 080 = 2,31 | € 5,54 |

### 4.5.2. Material costs

The costs of materials include their net costs delivered to the site or to the contractor's workshops. Added to this are the costs of storage and a wastage factor covering the difference between the quantities of materials purchased and those eventually integrated in construction products paid for by the client. Moreover, measured quantities are usually net - exclusive of any bulking or shrinkage factors. Some allowances have also to be made for buying margins, where, for example, the price allowed for at the time of tender is different from the price actually paid for the materials when delivered to the site. Vandalism, materials deterioration and misuse of materials will also need consideration and possibly be allowed for under this heading.
The allocation of the costs of materials by cost types depends on the expected use of such materials. For example, materials to be incorporated in ordinary construction works are included in direct costs; materials to be used in preliminary works (for example, site limitation works) are included under this heading; materials required for any work not directly related to site production are obviously allocated to some class of indirect costs.

### 4.5.3. Plant costs

Plant can be classified as non-mechanical, mechanical or small tools. The cost of small tools for exclusive use of craftsmen is sometimes added as a percentage of their salary rate. Other small tools are normally included as a site on-cost although they can also be viewed as a general overhead expense.
Large items of plant, such as tower cranes, may be charged for as preliminary costs or, where they are directly related to a specific item of work, as in the case of earth moving, they can be included in full in corresponding direct costs.

The cost of mechanical plant may be evaluated as the sum of ownership costs, maintenance costs and operating costs, e.g.:

$$\mathbf{Tc = OWc + MAc + Opc} \quad (4.1)$$

Ownership costs include purchase cost, depreciation, interest charges and taxation, management costs, insurances and so on. Maintenance costs relate to keeping the machine in good condition for operation. Operation costs include consumable costs (like fuel, oil, etc.) and operator wages. The above expression may be written using unit costs instead, that is:

$$\mathbf{Tc = owc \times T + mac \times E + opc \times t} \quad (4.2)$$

where **T** is the current time, **E** is the time during which the machine is working and **t** is the time during which the operator is using the machine.

Construction companies compute hourly or daily machine rates by adding up all possible costs related to the machine and by making some assumptions about its use. For example, the yearly costs of repair depend on how much the machine is used whereas insurance taxes are rather independent from that. Therefore, an assumption of the expected number of working hours of the machine has to be made prior to establishing the hourly rate.

Table 4.9. below shows an example of calculation of the hourly rate of a machine purchased for € 85 000 and an estimated sunk value of 10% of the purchasing value. The financing interest rate was 8%. Ownership costs were estimated by using the average investment depreciation method; maintenance costs were considered as a percentage of ownership costs; for the calculation of operation costs, the hourly consumption costs were estimated, assuming operation time 30% greater than the effective working time, that is t = 1,3 E. Assuming 80% productive time for the machine, the total number of productive hours per year was calculated allowing for the establishment of hourly ownership and maintenance costs. Operation costs were computed directly from the labour cost information given by table 4.8.

Medium to large contractors tend to hire the plant from either a separate plant hire firm or through one of their own subsidiary plant companies. Smaller companies often hire plant from specialist companies, unless they foresee a large plant utilisation in which case they may consider purchasing it. Actually, locking large amounts of capital in plant may not be a good idea if it can be better used elsewhere.

### 4.5.4. Subcontractor costs

Outsourcing has become a norm in the industry with main construction companies using relatively little directly employed labour. This is because although they may give up some profit, they find many benefits in employing subcontractors to carry out the work on their behalf - fewer staff means lower fixed costs, more flexibility, smaller financial risks, etc. Moreover, the contractor does not need any general outlay of cash in order to finance the subcontracted work. Subcontracting nowadays covers a wide range of construction works. Most of them directly relate to production on site (for example, a subcontract for brickwork) but they may also refer to other works (for example, health and safety on site). Accordingly, subcontract costs may be direct costs or indirect costs (site on costs for the example of health and safety).
The costs of subcontracts include their net costs plus the expenses related to the utilisation of the site facilities by their staff and an allowance for management and supervision.

Table 4.9. Calculation of all-in rates for an earth moving machine.

| Description | Entry Column | Calculation column | Hourly rate (€) |
|---|---|---|---|
| Purchasing value | € 85 000,00 | | |
| Time of depreciation | 10 years | | |
| Sunk value | € 8 500,00 | | |
| Interest rate | 8% | | |
| **Working time** | | | |
| Total working hours | 52 x 40 | 2 080 | |
| Public holidays | 14 x 5,71 | - 80 | |
| Stoppage | 10 x 8,00 | - 80 | |
| Bad weather | 6 x 8,00 | - 48 | |
| Bank holiday | 1 x 5,71 | - 6 | |
| Productive activity | 80% | | |
| **Total productive hours** | | **1 500** | |
| **Ownership costs** | | | |
| Annual depreciation | €76 500/10 | € 7 650,00 | |
| Average annual investment | € 4 207,50 | | |
| Annual interests | (8,00%) | € 336,60 | |
| Management Costs | (2,00%) | € 84,15 | |
| Insurance costs | (1,50%) | € 63,11 | |
| **Total OWc** | | € 8 133,86 | **€ 5,42** |
| **Maintenance costs** | | | |
| Annual maintenance | 8% x 85 000,00 | | |
| **Total MAc** | | € 6 800 | **€ 4,53** |
| **Operation costs** | | | |
| Hourly consumptions | | € 18,00 | |
| Operator | 1,3 x € 6,91 | € 8,98 | |
| **Total OPc** | | | **€ 26,98** |
| **Total costs** | | | **€ 36,93** |

### 4.5.5. Preliminary costs

Construction regulations in most European countries (including Poland and the United Kingdom) allow contractors to price project overheads on a specific bill of preliminaries. Preliminary costs are diverse and vary considerably among projects but it is convenient to use a comprehensive set of costs headings as a checklist of costs incurred in a specific project. Figure 4.5. presents such a checklist provided by the Code of Estimating Practice (COEP) of the Chartered Institute of Building (CIOB) of the UK.

| | |
|---|---|
| Employer's requirements | Accommodation<br>Furniture<br>Telephone<br>Equipment<br>Transport<br>Attendance |
| Management and staff | Site manager<br>General Foreman<br>Engineer<br>Planning Engineer<br>Foreman<br>Ass. Engineer<br>Clerk / Typist<br>Security/Watchman |
| Facilities and Services | Power / lighting / heating<br>Water<br>Telephones<br>Stationary and postage<br>Office equipment<br>Computers |
| Facilities and Services | Humidity and temperature control<br>Security and safety measures<br>Temporary electrics<br>Waste skips |
| Mechanical Plant | Crane and driver<br>Hoist<br>Dumper<br>Forklift<br>Tractor and trailer<br>Mixer<br>Concrete finishing equipment<br>Compressor and tools<br>Pumps<br>Fuel and transport for plant |
| Temporary Works | Access routes<br>Hard standings<br>Traffic control<br>De-watering<br>Hoarding<br>Fencing<br>Notice board<br>Shoring & Centring<br>Temporary structures<br>Protection |
| Non-mechanical Plant | External scaffolding<br>Internal scaffolding<br>Hoist towers<br>Mobile towers<br>Small tools and equipment<br>Surveying instruments |

Figure 4.5. Checklist for current preliminary costs.

| | | | |
|---|---|---|---|
| Site Accommodation | Offices<br>Scores<br>Canteen/welfare<br>Toilets<br>Drying and first aid<br>Foundations and drainage<br>Rates and charges<br>Erection and fitting out<br>Furniture<br>Removal<br>Transport | Contract Conditions | Fluctuations<br>Insurances<br>Bonds<br>Warranties<br>Special conditions<br>Professional fees |
| Attendant Labour | Unloading and distribution<br>Cleaning<br>Setting-out assistants<br>Drivers and pump attendance<br>General attendance<br>Scaffold adaptation | Miscellaneous | Setting out consumables<br>Testing and samples<br>Winter working<br>Quality assurance<br>Site limitations<br>Protective clothing |

Figure 4.5. Checklist for current preliminary costs (continued). [15]

The regulations allow that the costs of site erecting, maintenance and dismantling construction sites of public projects may be summed up on a specific contractual item, namely:

a) Site erection, construction, dismantling, demolition and maintenance;
b) Works required ensuring worker safety (including subcontractor workers) and public safety, to prevent material damages in adjacent constructions, to accomplish safety regulations and to ensure the good shape of public access ways;
c) The re-establishment through temporary works of all accesses to properties and public ways damaged by the project implementation and to prevent water stagnation that those works may possibly imply;
d) The construction of site accesses and internal ways; and,
e) Other works established in law.

### 4.5.6. Overheads

These items represent the costs associated with managing a company or of facilitating the construction project. They include the costs of maintaining a head office, workshop and off-site

storage compound for plant and materials. However, some companies prefer to deal with plant independently, as mentioned above.
Overheads are recovered from a project by means of a percentage addition to the costs directly associated with the construction project, together with the site on-costs. The percentage applied must be adjusted regularly and relates to the turnover expectations of the company.

## 4.6. Cost monitoring and cost control

### 4.6.1. Introduction

Effective management requires control, but like in planning, project participants may have different views on the control approach best suited to their needs. Actually, planning and control are closely related, in a way that actions that had not been planned cannot be controlled; conversely, there is no point in planning what is not intended to be controlled. An important issue in the control process is distinguishing two complementary, yet different, aspects of control: monitoring which involves collecting and evaluating performance data, and control proper relating to the actions to be taken on the basis of data collected.
Control may be about a wide number of aspects of construction projects but time and costs are usually elected as the most important. This chapter is about the control of costs, but in order to effectively control project costs, the other aspects of control must be taken into consideration. Moreover, cost is a money issue, the other being value, both of which have to be looked at simultaneously when it comes to the control of money, which is essential for project success. The remainder of this chapter deals with time and cost control, whereas the next chapter focuses on the control of money in broader terms.

### 4.6.2. The control of time in aspect of costs

Time control is closely related to time planning and may use similar tools, like the time schedule and the programme of works. The starting point for time control is progress monitoring, which must be checked against the project schedule for control purposes. In order to monitor performance, information needs to be collected within a structured reporting system so that appropriate action can be taken if necessary. It is also essential that documents used for planning may be easily adopted for control, because changes in planning may follow from actions derived from control.
As a matter of fact, correcting time deviations may require activity re-scheduling, either by using additional resources or by modifying construction technologies so that some time may be saved.

#### 4.6.2.1. Progress monitoring

The first step in progress monitoring is progress recording in order to provide a sound status report of project evolution. The format of the report is not standard in construction but the following key issues are essential for subsequent action:

- Summary highlighting which activities are behind schedule or out of sequence;
- Report;
- Comments on possible actions to be taken for correction.

Progress may be directly recorded on the construction programme if the scheduling approach used enables it. This is the case of the bar chart diagram often used in construction that may be presented to support a number of report information. Figure 4.6 shows how a bar chart may easily allow for progress recording. In this example, activities B and C are delayed by one week and half a week respectively at the control date on the 15$^{th}$ of February. Maintaining this delay, the project will end up after the initially forecasted due date by half a week because activity C belongs to the critical path.

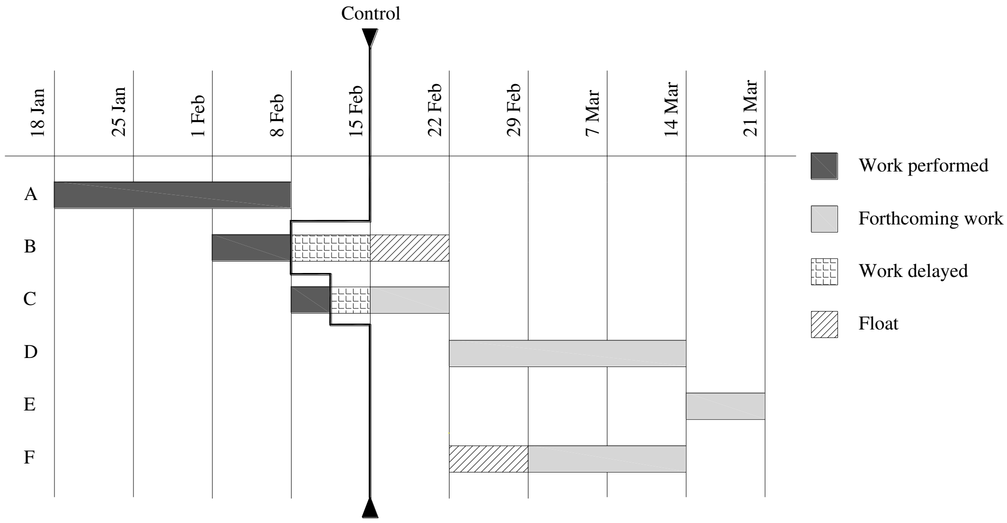


Figure 4.6. Presentation of a bar chart for control purposes.

Other planning tools, like the network diagrams, may not enable such visual effects, because all time information is recorded numerically. Despite the advantages of the latter for accurately treating information, the graphical impact of the former may be viewed as one of their most important advantages. Accordingly, bar charts are often used as a reporting format of the scheduling process although it may have been conducted by a network approach. This makes them one of the most widely used tools for scheduling and control purposes.

However, progress recording on the bar chart is not an easy task. First, it must be noted that the aim of progress recording is setting the project time status. This means either depicting how much time elapsed from the start of each activity on the corresponding bar or gauging how much time is needed to finish each activity by using forecasted resources. Differences may arise if actual productivity rates differ from the ones used for scheduling. Construction managers often use a simplified approach, whereby the percentage completed for each activity is estimated and entered on the diagram. But this implies assuming a linear relationship between time and work volume, which may not be the case for some construction operations. A more accurate relationship would otherwise require substantial additional effort from the staff involved.

Second, progress measuring may raise other difficulties, especially during the design phase. For example, design progress cannot be derived from the comparison between the number of drawings produced and the number of drawings forecasted for the project. Difficult decisions may possibly be yet to come, and this may be very time consuming. Design appraisal from local authorities is another good example, because time allocation to this activity is only possible by using past experience for similar projects which often reveals extreme variations. Therefore, time elapsed is not often an accurate measure of activity status but only serves for monitoring scheduling assumptions.

An alternative method for measuring construction physical progress, known as *earned value,* may also be used. This is established in money terms by valuating the work performed and comparing it to the forecast. Comparisons may be either numerical or graphical. Figure 4.7 shows the graphical evaluation of a project using three curves: the earliest event and latest event valuation curves are plotted by valuating activities scheduled for the earliest and the latest starting times respectively. The earned value curve is established by valuating works actually performed. The project will run on time if the earned value curve stays within the value envelope defined by the former two curves.

Figure 4.7. shows an example where the earned value is below the value envelope in months 3 and 4, above in months 7 and 8, and inside in months 1, 2, 5 and 6. In months 9 and 10 the earned value curve is coincident with the earliest start valuation curve. However, this may not

reveal if the project is ahead or behind schedule in time terms but that the project is generating value faster or slower than expected. Chapter 6 of this manual includes a more detailed discussion on this topic.

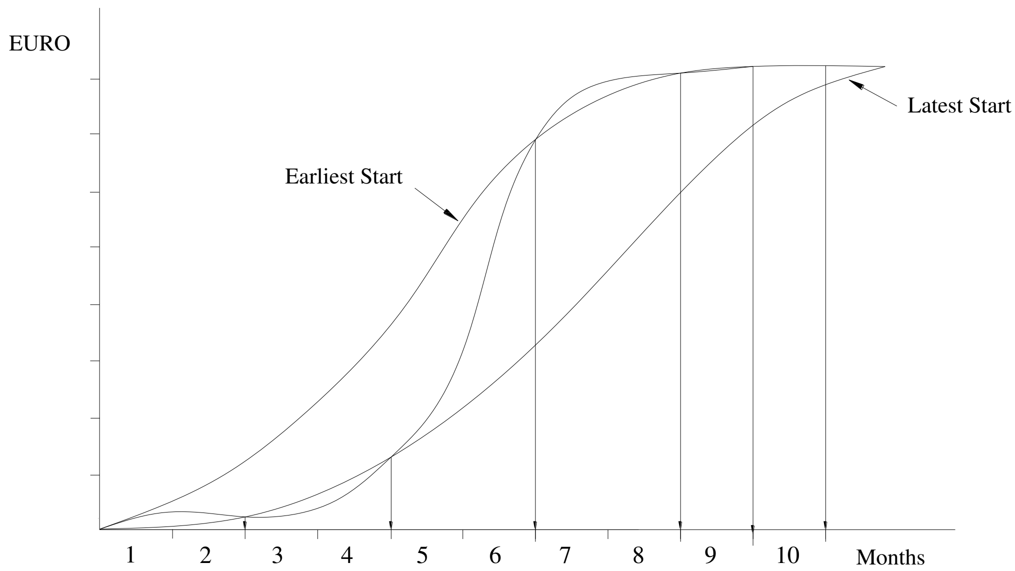


Figure 4.7. Earned value analysis.

Earned value analysis is less significant than above during the design phase because the cost time relationship is harder to establish for design phase operations. Moreover, some decisions taking place during the design phase may be difficult to plan accurately, like those implying approval from authorities.

#### 4.6.2.2. Progress control

Progress control is the process whereby action is taken in order to correct scheduling deviations. In the construction reality, this means delays from the activity due dates. Additionally, a distinction between *delay* and *disruption* is often made. A *delay* occurs when programmed activities do not start or finish on time or both. Disruption is when duplication effort or out of sequence work is required. *Disruptions* may not lead to delays but may result in claims for loss and expense if they were caused by the client. Moreover, activity delays may not necessarily result in project extension of time unless critical activities are affected.
Design delays may possibly occur due to the fault of the design team or due to the fault of the client. Examples of actions (or inactions) of the client that may lead to design delays include variations and changes in the scope of works, late design approval, inaccurate land survey, delays in ground testing etc. Delays from local authority approval are not usually the client's fault but are non-culpable for the design team.
Delays in the construction stage are generally classified as culpable or non-culpable for the contractor in most international construction regulations. Time extensions for project conclusions are usually granted for non-culpable delays in legal construction regulations.

Where a project has been delayed, through the fault of the contractor, he may wish to bring forward the completion date in order to avoid site over costs or penalties for late completion. The client may also ask the contractor to recover the time lost in which case he should be compensated for extra trouble and effort through a separate agreement. Acceleration or speeding up the work can be achieved in two main ways, or through a combination of these:

- Improving the production process;
- Shifting to a faster production process.

A way of improving the production process is through better work organisation. This may be achieved by fostering the supply chain, increasing the concurrency of site operations, allocating more resources to the construction activities and so on. This may bring extra costs to the project (due to the need for additional site management and quality control), introduce inefficiencies (resulting from inadequate gang sizes, congestions among site operatives, plant and package contractors), increase accident risks (following from the hazard exposition increase of site personnel), etc.
Adopting a faster production process frequently implies changing the technological approach to some or all construction activities, therefore implying the increase of direct costs of activities affected and raising new problems of site organisation. The contractor needs to balance all these considerations and decide to what extent it is feasible to speed up the work.
This may be done by using a sound cost-time optimisation technique as described in nest chapter of this manual. Such techniques attempt to balance the direct costs and the indirect costs against time, giving the optimal project duration which minimises the project total costs. Direct costs are obtained by adding up the direct costs of all project activities and typically rise as activity durations are shortened. Indirect costs, on the contrary, tend to increase with the project duration and may include penalties for delays. The breakeven point yields the duration beyond which it is not financially feasible to speed up the project.

### 4.6.3. Cost control

Similarly to planning, the starting point for cost control is monitoring the project costs. Contractor's value is the value of work carried out as certified by the client's representative, based on interim valuations.
The contractor's value is cost for the client, who may also need to spend other moneys for paying his own staff, taxes and other suppliers. The client's value may be measured through the benefit extracted from the project concluded. The following sections are about contractor's cost control. Contractors need to keep in check the number of cost issues, comprising direct costs, site overheads and general overheads.

#### 4.6.3.1. Labour costs

Monitoring labour costs involves recording actual man-hour expenditure on each work item and producing the man-hour distribution report. The information is first collected by the foremen on site and recorded on the daily time check report, where each worker's time is placed against the corresponding work item. The daily time sheet should evidence if special conditions occurred when performing a work item, therefore justifying any atypical work load on that item.
The man-hour distribution sheet may then be produced on a weekly or monthly basis. Data on man-hour expenditure in each work item is first summarised from the daily time sheets, and then valuated using the contractor's costs of labour.
Beyond allowing for valuating work performed on site, relating man-hours to work items is a valuable piece of information for resource control purposes because it helps to identify causes of low productivity. For completed work items, man-hours expended are compared to the budgeted man-hours for that item, but for incomplete work items, the valuation of interim quantities is needed. Information is then summarised on the man-hour report of each work item. Figure 4.8. shows an example of a man-hour report for the work item concrete frame of warehouse project. Actual man-hours expended are taken off the man-hour distribution sheet for the current time period. Forecast man-hours are evaluated for the quantity of work performed during the same time period. Current time data is cumulated on the right section of the figure, giving the present status of the project performance for this work item.

| Responsible Organization: ____________________ | | | Report Dates | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Project Description:__Warehouse___________________ | | | From: _______________ | | | To: _______________ | | | | |

| Identification | | | Current Period Man-hours | | | Total Man-Hours | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Resource | Performance Agency | Work item | Actual | Estimate | (Overrun) Underrun | Actual to Date | Estimate | Forecast to complete | Projected (Overrun) Underrun |
| Crew Supervisor | XPTO | Concrete structure | 236 | 210 | (26) | 915 | 2500 | 2800 | (300) |
| Structural concrete worker | | idem | 963 | 900 | (63) | 4193 | 9000 | 9550 | (550) |
| Crane operator | | idem | 215 | 225 | 10 | 1045 | 2950 | 2850 | 100 |
| Light equipment operator | | idem | 506 | 500 | (6) | 1658 | 4250 | 4120 | 130 |

Figure 4.8. Man-hour report for the concrete frame of a warehouse project.

Differences between actual and forecasted man-hours are easily detected in the man-hour report and may help the manager to introduce necessary corrections. For example, if the actual man-hours reported systematically exceed the forecasted man-hours with no justifiable reason (e.g. reported on the daily time sheet), then productivity may have been overestimated and may have to be corrected for the future. Conversely, productivity data may have been underestimated or a learning effect may be in place if actual man-hours reported tend to be less than expected from planning. In this case, the remainder of the work item may be planned for increased productivity. This is a key aspect of labour control in construction project management and is essential for cost control.
Taking into account the information of figure 4.8., an update forecast may be made for the total man-hours required to complete the work item. The difference between the updated forecast and the budgeted man-hours yields a measure of shortage or excess of man-hours allocated to that item whether the balance is positive or negative. Moreover, the result of multiplying the difference by unit labour costs is a measure of labour cost balance for the work item and is a valuable piece of information for cost control.

#### 4.6.3.2. Materials costs

Materials are controlled at various levels in construction sites. Materials used on a project are demanded by the site staff through a standard requisition procedure. The requisition is normally sent to the company purchasing department to procure the materials. For control purposes, the site should maintain a requisition record by keeping copies of requisitions issued and by summarising materials demanded on a specific sheet.
The first level of control may be exercised by comparing materials needed with the material budget list. If an item does not appear in the list, this is an indication that it was not in the scope of the project. Moreover, if quantities needed do not match quantities budgeted for a given work item, this indicates that some problem occurred in the process, which requires consideration.
For a number of reasons, materials requisitioned may be available at the company warehouses or at another site (excess quantities previously bought by the company, materials rejected in another project because of changes ordered by the client, etc.), in which case a requisition is issued to that location. Otherwise, a purchase order is sent to the suppliers selected to provide the required materials. Some companies may allow sites to directly procure materials in special cases - e.g. specific materials, regular suppliers, large projects for the company head office, etc. For control to be exercised appropriately, it is essential that a record of purchases is maintained by the company.
Materials received on site must have a delivery ticket issued by the supplier department or external supplier, giving details of the materials delivered, including quantities delivered and values. Materials supplied by other sites or departments of the company are valuated internally according to internal valuating procedures. Materials purchased externally are evaluated by

suppliers against corresponding prices. Information is collected in an arriving materials report which must be continuously updated by the receiving entity or individual on site. This may be the person in charge of the site warehouse (for nails, tiles, bricks, etc.), the foreman (ready-mixed concrete and construction lumber, for example), the plant operators (the concrete mix plant operator for sand, cement and gravel, for example), etc.
The arriving materials report is useful for monitoring materials received on site and for inventory purposes. Possible discrepancies may be detected by comparing requisitions issued with the arriving materials report (in terms of materials specifications, quality or quantity) therefore allowing subsequent action to be taken.
Materials used on site should be charged to the work items. For some materials, this may be done as soon as they are received on site, because they are used in a specific work item (for example, a water tank is specific to the water installation work item). For other materials, the charge to a work item may only be done after they are requested by the site warehouse for that work item. The person responsible for the site warehouse should keep track of materials transferred to production, by maintaining an inflow-outflow report. Materials received by foremen must be allocated to specific work items, as well. This may be difficult to do but if no effort is made, the controlling effort may be jeopardised.
At this point, a third level of materials control may be employed by comparing materials forecasted and effectively used in each work item. Differences may reveal estimating errors, abnormal consumptions, poor material management, excessive waste, etc. Obviously, most companies do not control all single material in a given project because that would imply substantial effort and significant costs to achieve.
For the materials that cannot be directly charged to work items, or for the less relevant for control purposes, an inventory is regularly made on site. This may be done by using the balance data of the warehouse inflow-outflow report and the records of other receiving personnel on their arrival materials reports. Materials consumed on site are then reasonably distributed over the volume of work performed in each work item.
The cost of materials effectively used in each work item may be finally evaluated by multiplying the quantities of materials used by the value placed on their corresponding delivery ticket. This may be compared to the costs of materials forecasted to that work item, giving important cost information for materials cost control.
A fourth level of materials control is exercised at the accounting department of the company head-office. Firstly, values placed at the supplier delivery tickets must be compared with prices agreed at the procurement stage; secondly, invoices are compared with the delivery tickets.

### 4.6.3.3. Plant costs

Monitoring plant costs implies recording actual number of hours per work item for each piece of plant required. This may be derived from the equipment time cards filled in by plant operators on a daily basis. Cards indicate the number of working hours of usage and their distribution by work items. Idle time is also recorded and should be distributed by work items as well. Additionally, cards report breaks due to mechanical or electrical faults and time used for maintenance or repairing operations. Complementary information on site work conditions may help justify unusual work performance. Information on consumption and performance may be fruitfully recorded for setting plant costs.
The advantages of relating plant-hours to work items are identical to those mentioned for labour and report sheets similar to the one displayed in figure 4.3. may be used with minor changes. The most important change is in the resource column which refers to a plant code instead of a labour craft. Moreover, the plant report sheet may be used similarly to the labour report sheet.
The difference between the updated forecast and the budgeted plant-hours yields a measure of shortage or excess of plant-hours allocated to that item, whether the balance is positive or

negative. Moreover, the result of multiplying the difference by unit plant costs is a measure of labour cost balance for the work item and is a valuable piece of information for cost control.

#### 4.6.3.4. Subcontractor costs

The increasing outsourcing in construction has raised the interest of main contractors for subcontract control. This comprises several areas of control, namely quality, safety, time and, most interestingly for this chapter, cost.
Subcontract cost control relies on monitoring the work performed on site and comparing it to the work invoiced by the subcontractor. Work quantities and work conditions may prove different to those expected by the subcontractor in which case he may claim for extra costs to the main contractor. Claims may eventually prove to be the main contractor's liability or deemed to be the client's responsibility. In this case, the main contractor may decide to claim against the client.
Cost control of labour only subcontractors additionally encompasses materials control because, under this type of arrangement, materials needed for performing the works are supplied by the main contractor.

#### 4.6.3.5. Site overheads

Controlling site overheads is not different from controlling direct costs for a number of items. This may be checked from the current preliminary items as displayed in figure 4.2. In fact, the cost of most of those items is built up from elementary cost components as those described in the previous sections. For some projects, management and staff are shared with other projects, thus corresponding costs must be allocated to the project costs according to the applicable percentage.

#### 4.6.3.6. General overheads

The overhead costs of the company are compiled at the company head office and should be controlled by the company head office staff. Standard overhead percentage to each project is decided by the company according to the business volume.

### 4.7. Delayed payments – legal and contractual consequences

When starting a control of project costs, one should assume that development of the project at the concept stage, project documentation, financing sources and expected effects were consistent with the binding provisions of law, and in case of EU projects, were based on EU directives.

From among basic legal provisions, one should mention in particular the following documents, which are binding in Poland:

- the act dated 29 January 2004 Public Procurement Law[5]
- the Act on public finances dated 30 June 2005[6]
- the act dated 27 April 2001 Environment Protection Law[7]
- the act dated 23 April 1964 Civil Code[8]
- Guidelines for development of environmental investments, co-financed by the Cohesion Fund and the European Regional Development Fund in the years 2007-2013

With regard to EU relations, in the part regarding construction projects, including both cubature and line projects, one should consider:

[5] Journal of Laws of 2010 No. 113, item 759 as amended
[6] Journal of Laws No. 249, item 2014, as amended
[7] Journal of Laws of 2008 No.25, item 150, as amended
[8] Journal of Laws of 1964 No.16, item 93, as amended

- Resolution of the Council (EC) no. 1083/2006 of 11 July 2006, establishing regulations regarding the European Regional Development Fund, the European Social Fund and the Cohesion Fund[9]
- Guidelines of the European Commission regarding national regional help for the years 2007 – 2013[10]
- Community guidelines regarding state help for protection of the natural environment[11]

Detailed legal conditions are adopted in individual states by internal regulations, and in Poland they were specified in the Guidelines by the Ministry of Regional Development, considering the act dated 6 December 2006 on rules of conducting development policy and national guidelines regarding eligibility of expenses within the scope of structural funds and the Cohesion Fund in the program period 2007 – 2013, and regarding eligibility of costs incurred when executing construction projects in the Operational Programme "Infrastructure and environment" dated 21 June 2011, on which our analyses will focus.

With regard to cost assessment of construction projects in Polish conditions, one should consider mainly the above mentioned Civil Code, as the basic legal act regulating the civil-law relations between natural and legal persons. In particular:

- Title XVI Civil Code – regarding contracts for construction works
- Title XV Civil Code – regarding contracts for specific work

With regard to remuneration, Title XVI of the Civil Code in art. 647 provides that in concluding a contract, the contractor undertakes to, among others, complete construction works, and the ordering party undertakes to pay the agreed remuneration. Title XV of the Civil Code in art. 629 specifies that the parties can adopt the form of remuneration by cost estimation, and in art. 632 these costs are related to lump remuneration. The remuneration is therefore a specific payment for performing a service which can consist of completion of construction works, or planning and completion of construction works, or completion of a construction object.

A separate issue is the assessment, on the basis of the aforementioned guidelines, of rules and possibilities of eligibility of these costs subject to co-financing from European Union funds. In this regard, it should be stated that only an actually incurred expense can be regarded as eligible. That means an expense actually incurred in payment terms. Such expenses can be divided into several basic groups.

These are:

Project management expenses, regarding:

- supervision of construction works
- general costs
- personal expenses, etc.
- costs related to IT support of the project management
- other expenses, such as costs of expert opinions, technical or legal consultancy

Expenses related to property purchases, subject to detailed provisions, and in case of EU co-financing, not exceeding 10% of the investment's value.

When discussing construction works, we specify them as:

[9] Official Journal of the EU L 210 of 31.07.2006, page 25 as amended
[10] Official Journal of the EU C 54 of 4.03.2006, page 13
[11] Official Journal of the EU C 82 of 1.04. 2008

- expenses for preparation of the construction site
- expenses for construction works necessary for the project execution,
- expenses necessary to recreate the road surface (in case of road works)
- expenses for equipment and appliances which will constitute fixed assets being part of investment expenses and a fixed element of the project.

A very important group of costs are expenses related to additional, substitute and supplementary works, having influence on increased value of orders, and even if it is necessary to award contracts by means of non-competitive procedures, they should be discussed separately.

The engineer plays an important role in the event of a construction contract executed on the basis of FIDIC contract terms, , both within the scope of execution and cost control of works (FIDIC 16.2b, delayed payments and consequences). The assessment and control of works and costs incurred by the investor with regard to the position of the engineer are subject to control by the ordering party.

Management of a construction project is connected with the obligation of the Engineer to analyse the material work progress on the current basis in relation to the schedule presented in the contractor's offer and the costs planned in this period.

In the event of any disturbance of balance between the expected indexes, the Engineer in agreement with the investor obliges the contractor to prepare a recovery program, and in a situation of a particular threat to execution of the project, the investor makes immediate decisions.

They can often lead to the introduction of necessary changes in the contract, and sometimes to inclusion of additional, substitute or supplementary works.

In such a case it may be necessary to conduct additional tender procedures, usually as a non -competitive procedure.

Such procedures, when using co-financing from EU funds, must conform with the requirements of EU directives, in particular Directive 2004/18/CE and Directive 2004/17/CE, as well as the Public Procurement Law in force in Poland.

The importance of abiding by the relevant provisions, especially those mentioned above as binding in Poland, is supported by "Guidelines for interpreting prerequisites allowing the conducting of to conduct a public contract awarding procedure in the course of negotiations with announcement, competitive dialogue, negotiations without announcement, a single-source procurement procedure and a request for quote" adopted on 18 November 2010 by the Standing Committee of the Council of Ministers.

One of the popular and internationally adopted methods, gradually implemented in Poland, is the earned value method[12], usually used in large investments, including construction projects. Managers from various countries communicate with one another using several parameters in order to quickly describe the status of a venture. Answers to questions about the cost index and the schedule index provide all the information needed regarding the work progress. A great advantage of this method is the possibility to assess in detail future costs of complex investments already at the level of 15-20 percent participation in the venture, so this is a highly efficient method. The initial progress of task performance allows for an estimate of final results with high precision.

[12] Author D. Łukowiak. Source M. Hałas – Project Management Conf.

In case of a short-term task, the situation is simple, after completion of the task 100% of planned costs constitutes the earned value EV. In case of longer tasks, it is necessary to be able to estimate the earned value in the course of task execution. There are several methods available, for example: a very easy 50-50 method where, after commencement of the task, 50% of the budget is assigned to EV, and the remaining 50% is assigned after conclusion of the task (if there are many tasks, this method is useful due to their statistical distribution). In other methods the task is divided into many parts with an assigned % of the budget.

The cost index provides the answer to the question of how much we get for each Zloty spent.

CI = EV/Ac
EV = earned value
CI = cost index
Ac = actual cost.

The schedule index is a comparison of what was supposed to be done to what has been done. If the index is more than zero, work is conducted faster. If, however, it is less than zero, this means that there is a delay.

SI = EV/Pc
EV = earned value

SI = schedule index
Pc = planned cost.

Thanks to these indicators, we can calculate the final cost of the investment and the date of its completion. These calculations are called the final cost estimate FCE and the estimated execution period EEP. The formulas are very simple FCE = (initial project budget) / CI, EEP = (initial planned execution time) / CI. Specialised software available on the market allows for calculation of parameters for the earned value method. An example of such software is MS Project.

Another method, used in particular in the execution of road construction and in other line projects, consists of analysis of so-called milestones achieved by the contractor.

Analysis covers both consistency of execution of a part of the investment with the material schedule of construction works, and the related value of performed works subject to payment certificates which takes into account the financial schedule. The basic system of detailed cost control often includes, in particular in the case of projects co-financed by the European Union, so-called check lists and tables with settlement elements, filled in by contractors and attached to individual applications for payments, indicating at the same time, in particular in the case of contracts based on cost estimates, the differences between the bills of quantities and the actual quantity survey for the performed works, presented by the Supervising Inspector. The situation is much more difficult in the case of lump sum contracts where the basis is the value of planned works specified in the offer, regardless of its scope, which results from the risk of the contractor.

An example check list is presented in table 4.10. (important parts).

Table 4.10. An Example of the check list

**Name of the beneficiary:** **Name of the project:**
**No. of the agreement for co-financing of the project:** **No. of the application for payment:**
**Payment type:** **Entry date of the application for payment/correction of the application for payment:**

| | | | |
|---|---|---|---|
| **Notes:** | | | |
| ***SUBJECT MATTER VERIFICATION – ELIGIBILITY*** | | | |
| 1. | Were any defects/irregularities discovered as a result of control of the project? Did the conducted controls of orders executed within the scope of the project show any violations resulting in imposing a financial correction? [13] | | |
| 2. | Was the expense incurred:<br>a) directly connected with execution of the material scope determined in the co-financing agreement/project description?,<br>b) actually executed in payment terms (actually incurred), and were the works/services/deliveries actually completed? | | |
| **DEPENDING ON THE CATEGORY OF THE ELIGIBLE EXPENSE:** | | | |
| | **Project development:** | | |
| 3. | Were the declared expenses regarding project development provided for in the co-financing agreement and in the application for co-financing in the section entitled "Project description"? | | |
| | **Project management:** | | |
| 4. | Were the expenses incurred for project management provided for in the co-financing agreement and in the application for co-financing in the section entitled "Project description"? | | |
| 5. | In case of supervision over the project execution:<br>a) if the supervision is performed within the scope of a separate supervision contract – do the presented expenses refer only to remuneration of the supervising engineer? | | |
| | **Purchase of real estate:** | | |
| 6. | Was the purchase of real estate provided for in the co-financing agreement and in the application for co-financing in the section entitled "Project description"? | | |
| 7. | Were the expenses incurred necessary to purchase the real estate and do they refer to a real estate the purchase of which constitutes an eligible expense? | | |
| | **Construction and assembly:** | | |
| 8. | Contractual expenses – is the scope of works the expenses refer to consistent with the contract concluded with the contractor, which was already verified in terms of consistency with the co-financing agreement/project description? If the contract concluded with the contractor has not been previously verified, it should be verified at this stage in terms of its consistency with the scope of the project confirmed in the co-financing agreement. | | |

[13] Pursuant to the Attachment to *Guidelines to the Operational Program Infrastructure and Environment – Administering financial corrections for violations of the public procurement law due to execution of projects co-financed from EU funds.*

| | | | |
|---|---|---|---|
| 9. | In case of additional and substitute works:<br>- are they consistent with the scope of the project indicated in the project description/con-financing agreement?<br>- were they ordered according to binding rules in the Guidelines? Are the expenses within the scope of substitute, additional and supplementary works justified and properly documented (were conducted in particular according to provisions of the Public Procurement Law)? | | |
| 10. | In case of an application for the final payment:<br>was there a final decision regarding the occupancy permit (if required by regulations) or a notification to a competent office about completion of the construction? | | |
| | **<u>Equipment and appliances</u>:** | | |
| 11. | Are the expenses incurred to purchase fixed assets being a part of investment expenses and constituting a permanent part of the project consistent with the contract concluded with the contractor, which has already been verified in terms of its consistency with the co-financing agreement/project description? If the contract concluded with the contractor has not been previously verified, it should be verified at this stage in terms of consistency with the scope of works confirmed in the co-financing agreement. | | |
| 12. | <u>In case of declaring VAT as an eligible expense:</u><br>is declaring VAT in the application for payment as an eligible expense consistent with information provided in the application for co-financing (including the declaration about VAT eligibility) and in the co-financing agreement (project description)? | | |
| **Notes:** | | | |
| **Calculation of the amount of confirmed expenses**<br>**(to be filled in after a formal, subject matter and reporting verification)** | | | |
| 13. | The amount of expenses considered not eligible: | **Amount:** | **Notes:** |
| 14. | The amount of expenses suspended until further clarification: | **Amount:** | **Notes:** |
| 15. | The confirmed total amount of eligible expenses (PLN), | **Amount:** | **Notes:** |
| 16. | The amount of financial correction decreasing the amount of co-financing: | **Amount:** | |
| 17. 28. | The amount of co-financing from the EU funds (calculated according to the proportion)*:<br>$X_{dofWoP} = \frac{dof_{UoDUE} \times wkw_{WoP}}{wkw_{Uod}}$ | % | **Amount:** |

On the basis of verification of check lists for applications for co-financing, regarding individual types of works and tasks, the components of which were presented, and the tables of settlement elements, the investor can determine correctness of financial flows resulting from the co-financing agreement.

Usually the analysis of completed checklists and tables of settlement elements attached to the application for payment constitutes sufficient grounds to approve cost eligibility, regardless of whether these costs come only from the state budget or local government funds, or are a result of co-financing from EU funds.

A prerequisite for the above is meeting requirements resulting from the cost estimate enclosed by the contractor to the offer, and the technical specification of performance and acceptance of construction works, being part of the project documentation.

Another necessary prerequisite is consistency of the costs incurred with provisions resulting from the Public Procurement Law implementing Directive 2004/18 and Directive 2004/17 of the European Union.

A separate issue is the cost incurred due to the necessity, arising in the course of project execution, to introduce orders for additional, supplementary or substitute works.

Such costs cause the most difficulties in correct settlement of an investment, and in the event of violation of the Public Procurement Law, in particular when using co-financing from the European Union, an incorrect settlement may lead to the imposition of additional penalties on the investor in form of corrections by the European Commission.

Guidelines regarding the amount of corrections are included in respective EC directives, and in case of grave violations of the competitiveness rule, they may amount to even 100% of the value of the project co-financing.

Late payments

Late payments are usually reflected in provisions of the contract concluded with the contractor, regarding penalties for delays. At the same time they are regulated in Poland by the Act on payment terms in commercial transactions, in force since January 2004. In many member states of the European Union the directive on preventing delays in payments regarding commercial transactions is binding. It states that in case of a delay in payment, the supplier of the goods or services is automatically entitled to interest payment, without the need to demand it.

This is related to an amendment which was introduced in the Civil Code (Journal of Laws of 2010 no. 40, item 222) regarding the obligatory payment guarantee (up to the amount of the possible claim due to remuneration resulting from the contract and additional works or works necessary to execute the contract and accepted in writing by the investor, for example in an annex).

### 4.8. Literature and further reading for chapter 4


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### 4.9. Set of Exercises for chapter 4

**Exercise 4.1.**
What is the expected precision of estimating methods in each phase of the project:

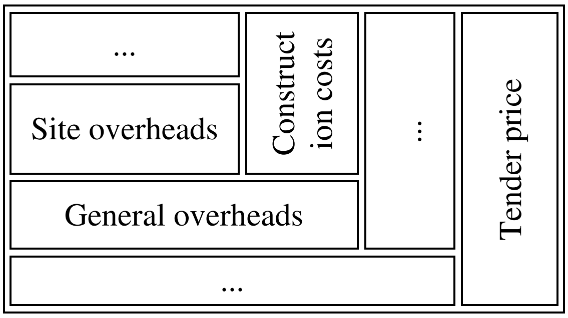
- At the inception stage (...% to ...%);
- In the design phase (...% to ...%);
- In the construction phase (...% to ...%)?

**Exercise 4.2.**
Which of the estimating methods listed below can be used at the inception stage of the project

- Cost per unit;
- Floor area method;
- Elemental cost plans;
- Approximate quantities;
- Unit rate estimating?

**Exercise 4.3.**
Fill the gaps in the diagram of a typical cost structure for construction projects using proposals for terms listed below:

- Profit and risk;
- Direct costs;
- Net costs.




**Exercise 4.4.**
Direct costs of a construction project are the sum of 3 components. Which of these?

- Site overheads;
- Labour costs;
- Preliminary costs;
- Material costs;
- Plant costs.

**Exercise 4.5.**
The potential investor is considering building a hotel with 80 bedrooms. What is the expected budget for the project (calculated using "cost per unit" method) if we know that the estimated cost of a bedroom is between €8 000 and €10 000?

- € 64 000;
- € 80 000;
- € 72 000;
- between € 64 000 and € 80 000.

**Exercise 4.6.**
Calculate the cost of municipal road project if you have the main works and rates identified in the table:

| Type of works | Quantity ($m^2$) | Cost/$m^2$ (€) |
|---|---|---|
| Land acquisition | 50 000 | 10,00 |
| Earth movements | 100 000 | 3,00 |
| Paving | 40 000 | 25,00 |

- € 190 000;
- € 1 800 000;
- € 900 000.

**Exercise 4.7.**
Progress control - assign descriptions:

- A *delay* ... 1 or 2?
- A *disruption* ... 1 or 2?

1. is when duplication effort or out of sequence work is required.
2. occurs when programmed activities do not start or finish on time or both.

**Exercise 4.8.**
Which methods can be used in a process of time control of a project?

- Earned Value Method;
- Net Present Value Method;
- Simply: using the schedule of project for control purposes.

**Exercise 4.9.**
The cost of mechanical plant may be evaluated as the sum of 3 components: ownership costs, maintenance costs and ...:

- operating costs;
- overall costs;
- operator wages.

**Exercise 4.10**
Expenses related to property purchases, subject to detailed provisions, and in case of EU co-financing, cannot exceed:

- € 10 000 000;
- 10% of the investment's value;
- both 10% of the investment's value and € 10 000 000.

# CHAPTER 5
# PROJECT TIME CONTROL

## OBJECTIVES OF THE CHAPTER 5

The chapter presents different types of schedules used in construction projects. The advantages and disadvantages of schedules and the conditions that should be satisfied in order to draw up a proper schedule are also widely described. This chapter also contains information about updating, optimising and applying network charts and calculation of network chart parameters. The last subchapter refers to an assessment of delays, disruptions and consequences.

## LEARNING OUTCOMES FOR THE CHAPTER 5

After reading this chapter you will be more familiar with different types of schedules in the construction industry and the methods of preparing proper schedules. You will also know how to calculate network diagrams and all the related parameters, such as the critical path, the earliest and latest start or finish of activities. You will be familiar with assessment of delays and disruptions in construction projects too.

## 5.1. Introduction

A schedule is a plan coordinating the activities of all organisations, enterprises and companies involved in a construction project. It determines the order, interrelationship, duration and rate of performing construction operations as well as the demand for labour force, equipment, materials and financial resources. A construction process will be difficult to carry out can hardly be performed if the activities of particular construction enterprises are not coordinated. One of technological models in construction is a schedule chart reflecting the construction process over a particular period of time. Schedule charts are used to determine the duration of work and, sometimes, the sequence of operations. A schedule chart is a textual-graphical document in the form of a table. It may be divided into two parts: the calculated parameters and a time scale (see Table 5.1). The former consists of the numerical information about the amount of work, labour requirements, gang sizes and the duration of work to be performed. These data may be provided based on the results of the preliminary work (see Fig 5.1.). The latter presents the duration of work graphically on a time scale.

In developing a schedule chart, the sequence of technological processes should be strictly observed, whilst attempting to plan more operations to be performed simultaneously. At the same time, the requirements for labour safety should also be satisfied.

If a schedule chart is drawn up for construction operations, labour requirements should be calculated in hours, while for construction projects it should be expressed in shifts.

The best way is to choose such labour requirements that would allow work duration in days to be expressed as an integer (whole number). The data on the past output are often used for this purpose. They are usually lower than the actual values for the calculated period.

Table 5.1. Schedule of operations in hours [10]

| Operation | Volume of work | Labour requirements | | A gang | Work duration | Hours | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Labourers | Plant | | | 1 | 2 | 3 | 4 | 5 | 6 |
| 1-th operation | | | | | | | | | | | |
| 2-th operation | | | | | | | | | | | |
| n-th operation | | | | | | | | | | | |

Therefore, determining the percentage of the actual output against the planned one, it is recommended to take lower labour requirement than first calculated. This is obtained from the following formula:

$$a = \frac{D_{ap} - D_{pr}}{D_{ap}} \cdot 100\,\% \qquad (5.1)$$

where $a$ actually achieved output (in per cent), $D_{ap}$ calculated labour requirement per working day, $D_{pr}$ the specified labour requirement per working day.

The calculated parameters of a schedule chart are shown graphically in Table 5.2. Graphical representation of all operations allows us to determine the total time of project construction. If this time is extended compared to that specified in the contract, the chart should be updated. The time may be reduced by increasing the number of concurrently performed operations or the number of workers.

It is also possible to increase the number of shifts or to use more advanced technologies, which help to increase labour productivity. When the schedule of operations is made, the schedule of labour requirements is usually drawn up at the bottom of the diagram. For this purpose, the total number of men working on the site at the same time is calculated and the labour schedule for the overall construction period is drawn up on a particular scale. A 'jumping' number of the workers is usually obtained, which is shown as a continuous line $A_1$ in Fig 5.1.

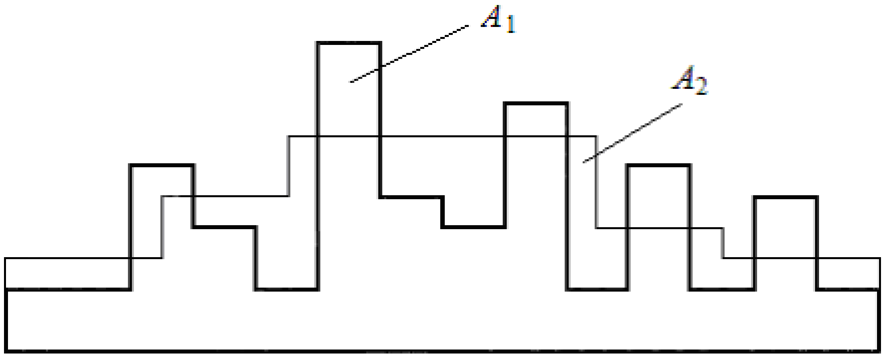



Fig 5.1. Labour requirement schedule.[10]

Table 5.2. Schedule of operations

| Nr | Operation | Work volume | | Labour requirement in shifts | Gang | Work duration in shifts | | Completion, percent | Number of shifts | Month | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unit | Amount | | | Calculated | Selected | | | Days | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | | | | | |
| | | | | | | | | | | | | | | | | |

According to schedule $A_1$, the number of workmen in a gang should be often reduced or increased which is hardly possible in practice. When the gang sizes are balanced, the work organisation and labour productivity are better. Therefore, the first schedule should be updated. For this purpose, the time of operations and the number of workmen should be revised so that the gang size is changed as seldom as possible during the whole construction period.

The amount of work on the project usually increases when the number of workmen in a gang grows. When the work is completed, the labour requirement gradually decreases. Labour requirement schedule (shown as a thin line $A_2$ in Fig 5.1) is updated according to the revised schedule of operations.
An average gang size $N_{\text{vid}}$ for the construction project calculated according to the updated labour schedule is as follows:

$$N_{\text{vid}} = \frac{\sum D_{\text{pr}}}{\text{T}} \tag{5.2}$$

where $N_{\text{vid}}$ is an average number of workmen, $D_{\text{pr}}$ the total labour requirement for working days, $T$ time of construction in days.
Properly drawn up, a schedule chart and a labour schedule based on it should satisfy at least one of these conditions:

$$K_1 = \frac{\sum T_{\text{past}}}{\text{T}} \geq 0{,}5 - 0{,}6 \tag{5.3}$$

$$K_2 = \frac{N_{\text{max}}}{N_{\text{vid}}} = \frac{N_{\text{vid}}}{N_{\text{min}}} \leq 1{,}5 \ldots 1{,}7 \tag{5.4}$$

where $T_{past}$ time of construction when the gang size is constant, $N_{\max}$ the largest number of workmen, $N_{\min}$ the smallest number of workmen, $T$ time of construction, $K_1$ coefficient denoting constant labour requirement, $K_2$ coefficient denoting relative variability of labour requirement.
Construction is a complex branch of industry. Construction operations depend on many external and internal factors. Although attempts are made to take these factors into consideration when planning construction operations, even the best programmes can hardly reflect all possible effects, which can delay construction and destroy plans.

Continuous control of construction operations is needed to complete a construction project on time. The following actions should be taken:

● To determine the completion time of particular construction operations, the efficiency of work and production potential;
● To compare the data obtained with the data provided by the model of construction operations; to analyse the causes of delays, if the latter occur;
● To assess unavoidable problems and predict the execution of operations according to plan.
Periodicity of control depends on the project's significance. It is calculated that falling behind the plan during a certain period may be partly or completely eliminated without changing work hours in construction.

On some projects, the execution of construction operations is checked once a week. The results of inspection are reflected in the schedules of operations.

In Fig 5.2., one of the techniques used for presenting the results of the construction work control in a schedule is demonstrated. According to the diagram, the performance of operations is checked every ten days. After 10 days, i.e. time period $t_1$, it has been found that operation Nr. 1 is two days behind the programme; operation No. 2 is not completed, while operation Nr. 3 is not begun. Checking the execution of particular construction operations, it is also possible to determine the value (significance) of the performed operations, which may be indicated at the bottom of the chart by a line different from that used to denote the planned work.

The presentation of construction work progress in a schedule refers to the actual completion time not allowing, however, for prediction of the completion dates of operations. In practice, schedules are most commonly used in construction because they are simpler and more easily drawn up than other models describing the progress of construction. The annual programme of a construction enterprise may be presented as a schedule. Based on the contracts with the customers, the programme of construction work completion in a particular year may be shown graphically (see Fig 5.3.). In such a schedule, transfers of the gangs engaged in construction from one project to another may also be reflected.

Assume that the construction firm 'X' should complete three projects A, B and C according to the annual programme. At the same time, it is planning to commence and complete three projects E, F and G. According to the annual programme, the construction of four projects D, G, J and K is not to be completed and will be continued the following year. At the beginning of the year three gangs of men 1, 2, 3 were working in the firm 'X'. Fig 5.3. illustrates the projects in which the above gangs are engaged and shows what projects will be started when projects A, B and C are completed. Since the volume of work has increased, a newly formed gang 4 will start working on project I in June.

| Operation | Work days | Work days | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | | | | 5 | | | | | 10 | | | | | 15 | | | | | 20 | | | | 24 |
| Operation No 1 | $n_1$ | | | | | | | | | | | | | | | | | | | | | | | | |
| Operation No 2 | $n_2$ | | | | | | | | | | | | | | | | | | | | | | | | |
| Operation No 3 | $n_3$ | | | | | | | | | | | | | | | | | | | | | | | | |
| ... | ... | | | | | | | | | | | | | | | | | | | | | | | | |
| Operation No *n-1* | $n_{t\text{-}1}$ | | | | | | | | | | | | | | | | | | | | | | | | |
| Operation No *n* | $n_t$ | | | | | | | | | | | | | | | | | | | | | | | | |
| Total value | Plan | $V_{pl}$ | | | | | | | | | | | $V_{pl}$ | | | | | | | | | | | | |
| | Fact | $V_{fact}$ | | | | | | | | | | | $V_{fact}$ | | | | | | | | | | | | |

Fig 5.2. The presentation of construction progress control in the schedules of operations [10]

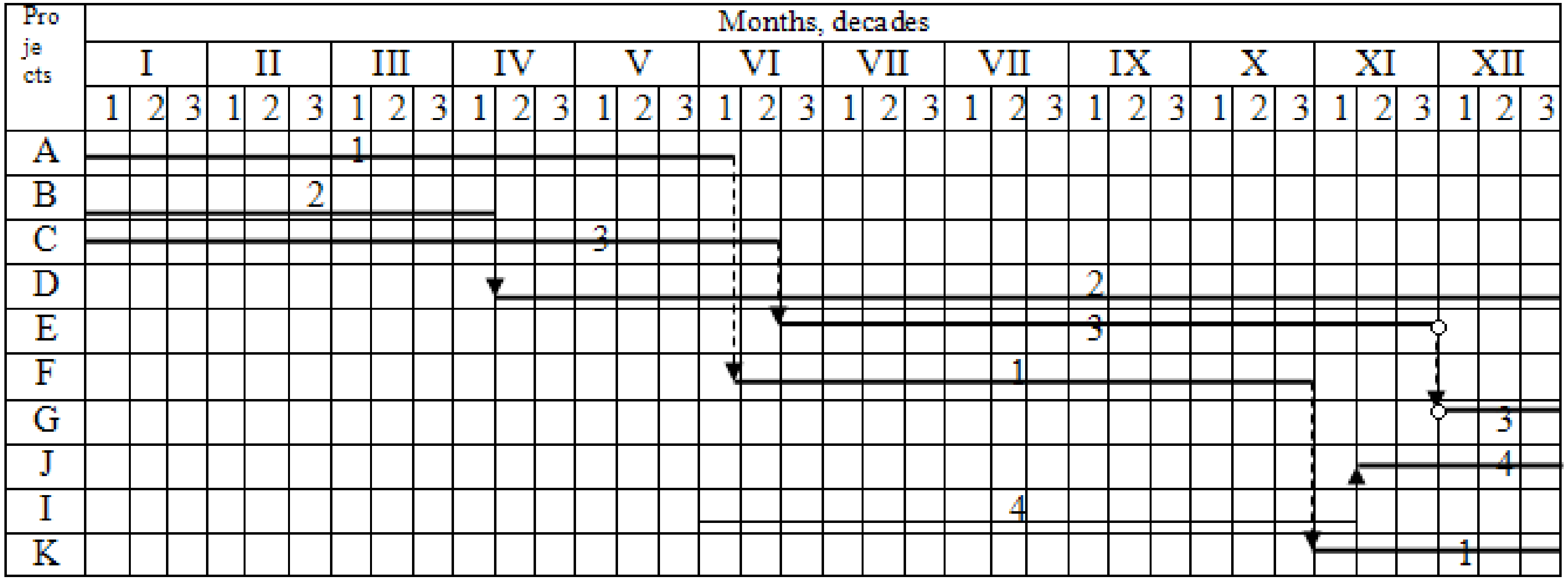



Fig 5.3. Annual programme of a construction company [10]

Managers of the above firm may determine the resources required for construction according to the available annual programme before the work is started and update the schedules if necessary. Schedules are widely used, although they have quite a few disadvantages. The major disadvantages are as follows:

● A schedule is a model of only one alternative not reflecting the dynamics of production: therefore, corrective actions are needed to eliminate the drawbacks and a schedule should be updated; the correction takes time and new problems may arise in this period. Therefore, the revised schedules do not reflect a true picture either;
● It is often difficult to assess the progress of construction at any moment of time, i.e. to determine based on schedules, if the work is ahead or behind the plan;
● Schedules do not allow managers to determine the influence of delayed operations on the subsequent works and overall project duration;
● Schedules do not show true relationships between the concurrent operations from technological and organisational perspectives, though attempts are made to denote them by special notation;
● Based on schedules, it is rather difficult to determine key operations requiring a manager's special attention and affecting the total time of construction;
● The progress of construction can be difficult to predict from the schedules. Therefore, the planning of operations is rather complicated; and,
● Mathematical expression of schedules is very complicated, making it difficult to use mathematical methods and computers in solving construction problems.

The above disadvantages are acceptable when using schedules in the construction of small and medium-size buildings.

### 5.2. Networks: concepts and preparation

Networks were first used in the USA. In 1958 a team of researchers developed a so-called PERT – Program Evaluation and Review Technique aimed to manage and control the 'Polaris' project. The chart resembles a net, therefore, the name network.

Since then, a system of network planning and control has been developed based on PERT. It is used for major construction projects.

In fact, a network is an improved schedule. The sequence of operations is clearly shown in a network, which is not possible with a schedule. In addition, it has none of a schedule's disadvantages and its parameters can be calculated by a computer.

A schedule may be transformed into a network in the following way:

● All operations (activities) should start and finish at an event (represented by a circle);
● The activity is represented by a straight line, with an arrow showing its sequence;
● Activities are interrelated in terms of organisation and technologies used.

Schedule and network diagrams of the same situation are shown in Fig 5.4.

In this way, a network diagram of construction operations is obtained showing the organisation of the process and the technology used. Since the construction technology is relatively stable, the diagram considered is actually invariable and may be used as a dynamic informational (mathematical) model. By generalising the data obtained, it is possible to assess the situation and the decisions made.

*a*

| No | Operation | Duration in days | Months | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Days | | | | | | | | | | | | | |
| 1. | Operation 1 | 1 | | | | | | | | | | | | | | |
| 2. | Operation 2 | 2 | | | | | | | | | | | | | | |
| 3. | Operation 3 | 4 | | | | | | | | | | | | | | |
| 4. | Operation 4 | 4 | | | | | | | | | | | | | | |
| 5. | Operation 5 | 3 | | | | | | | | | | | | | | |
| 6. | Operation 6 | 3 | | | | | | | | | | | | | | |

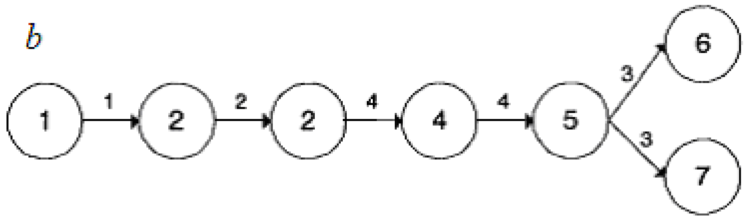



Fig 5.4. Schedule (a) and network (b) charts for the same operations [10]

The chart can be updated, based on the real situation and changes made. The main concepts of a network and the terms used are as follows:

**A network model** is a chart presenting activities (operations) to be performed to achieve a defined goal (goals) and their interrelations.

**A network chart** is a schedule of construction operations with the calculated completion times, i.e. a network model with calculated parameters.

**Activity** is a process requiring a certain amount of time, materials and plant to be performed; it is represented by a continuous vector line (an arrow) (see Fig 5.5., *a*).

**Spare time (float)** is required by construction technology. It is represented by a point vector line (an arrow) (Fig 5.5., *b*).

**Dummy activity** is a conventional element (not requiring any time or materials to be performed), which shows interrelations between activities or their sequence. Any activity cannot start, if the previous activity is not completed. It is represented by a dotted vector line (an arrow) (see Fig 5.5., c).

**Event** is a start and finish of any activity. It is represented by a circle. All activities, floats and dummies in a network model are related to the initial and final event. It may be the junction of two or more activities, floats or dummies and is given a number written down in a circle (Fig 5.6).

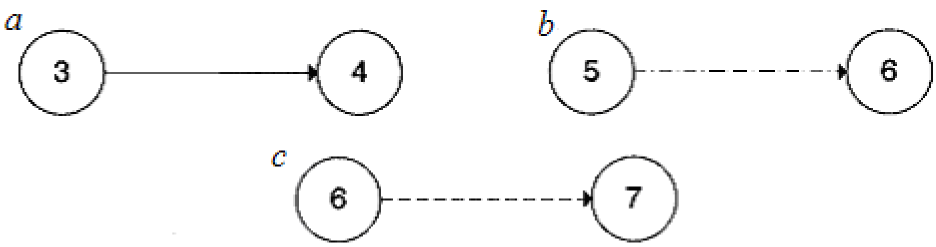



Fig 5.5. Representation of activity (a), float (spare time) (b) and dummy (c) [10]

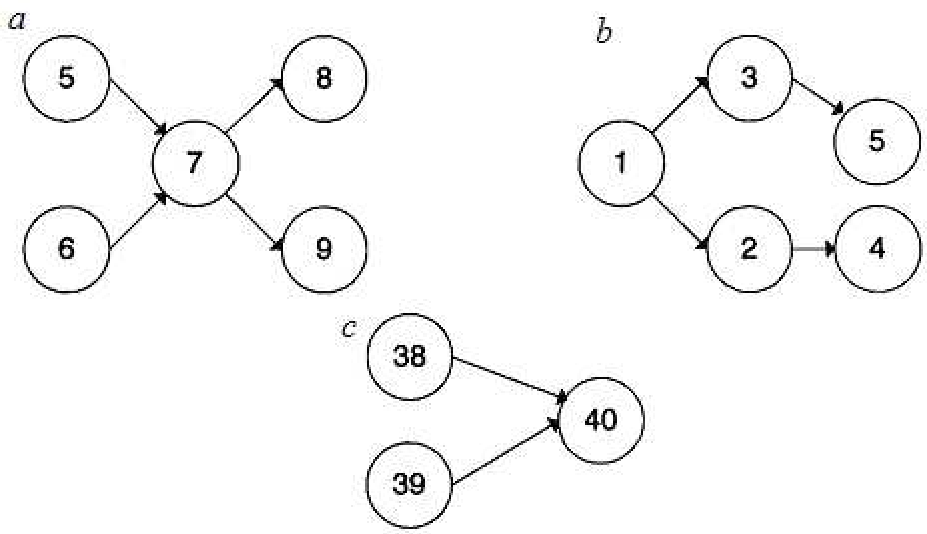



Fig 5.6. Representation of preceding and succeeding activities [10]

**Preceding activity** – its finish is the start of the succeeding activity (Fig 5.6., *a*). The preceding activities are 5-7 and 6-7. If they are not finished, the activities 7-8 and 8-9 cannot start. When the preceding activities are completed, other activities may start. The last event of a preceding activity is the first event of the following activity.
**Succeeding activity** is the activity which can start only if a particular other activity or activities are completed; these are activities 7-8 and 7-9 (Fig 5.6., *a*).
When the network parameters are calculated: floats and dependencies can represent preceding and succeeding activities.
**The earliest event** is the first event when the activity starts; this is event 1 (Fig 5.6., *b*).
**The earliest activity** is the activity having no preceding activities in the network model; these are activities 1-2 and 1-3 (Fig 5.6., *b*).
**The final activity** is the activity having no succeeding activities according to the network; these are activities 38-40 and 39-40 (Fig 5.6., c).
**The final event** is the last event of the final activity; this is event 40 (Fig 5.6., c).
**The duration of the activity** is the time needed to complete the activity. It is specified depending on the conditions of the work; this is indicated by a number above the vector.
**The longest path** is the path from the earliest to the final (latest) event in the diagram. This can be more than one (Fig 5.7.): 1-2-4-6-7 (duration 12); 1-2-3-6-7 (duration 11); 1-3-6-7 (duration 13); 1-3-5-67 (duration 18); 1-2-3-5-6-7 (duration 16).
**Critical path** is the longest path through the network (Fig 5.7.; 1-3-5-6-7, of the length 18). It is clearly shown on the network.
**Critical activities** are activities on the critical path.
**Subcritical path** is any longest path whose duration is shorter that the duration of the critical path by magnitude smaller than the control period. For example, if the control period is equal to 3 time intervals (Fig, 5.7.), then the subcritical path is 1-2-3-5-6-7, with the duration 16. Critical or subcritical path can pass though the sequence vector.
**Critical zone** is the total number of activities whose time is shorter than the control period. The network model may be properly constructed by following the particular rules.
**Numbering of events.** Two events cannot have the same number because it is confusing. According to the methods of calculation in the network, the final event number should be larger than the earliest event number.
**Presentation of parallel activities.** To represent the activities performed simultaneously, additional float event should be introduced (Fig 5.7., *b, c* correct; Fig 5.8., *a* incorrect).

**Starting the succeeding activity before the preceding activity is not completed.** If the activity *b* must be started before the activity *a* is completed, the latter should be split into two independent activities (Fig 5.8., *e*).

**Open contour.** A closed contour of activities should not be formed in the network model (Fig 5.8., *f*). This may happen only if the interdependence of activities is not properly determined.

**Presentation of activities' interrelationships.** The introduction of this conventional element helps **to show the dependence of a particular activity on one or more other activities** (Fig 5.9., *a* and *b*). The activity 5-6 can start only when the activity 1-2 is finished (Fig 5.9., *a*) or the activity 5-7 (Fig 5.9., *b)* can start when the activity 1-2 and 3-4 are completed.

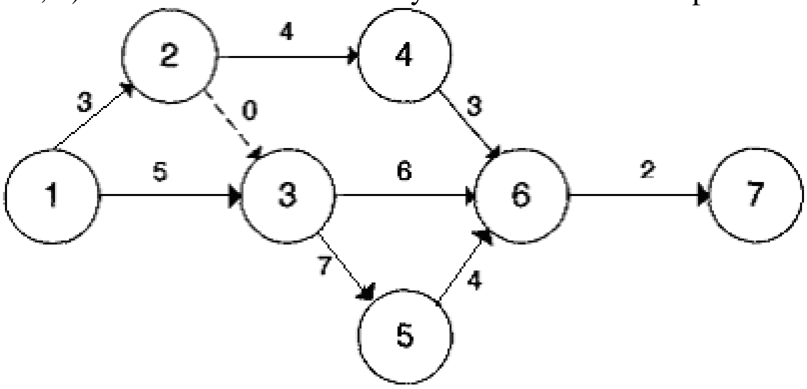



Fig 5.7. Representation of activity duration and paths in a network chart [10]

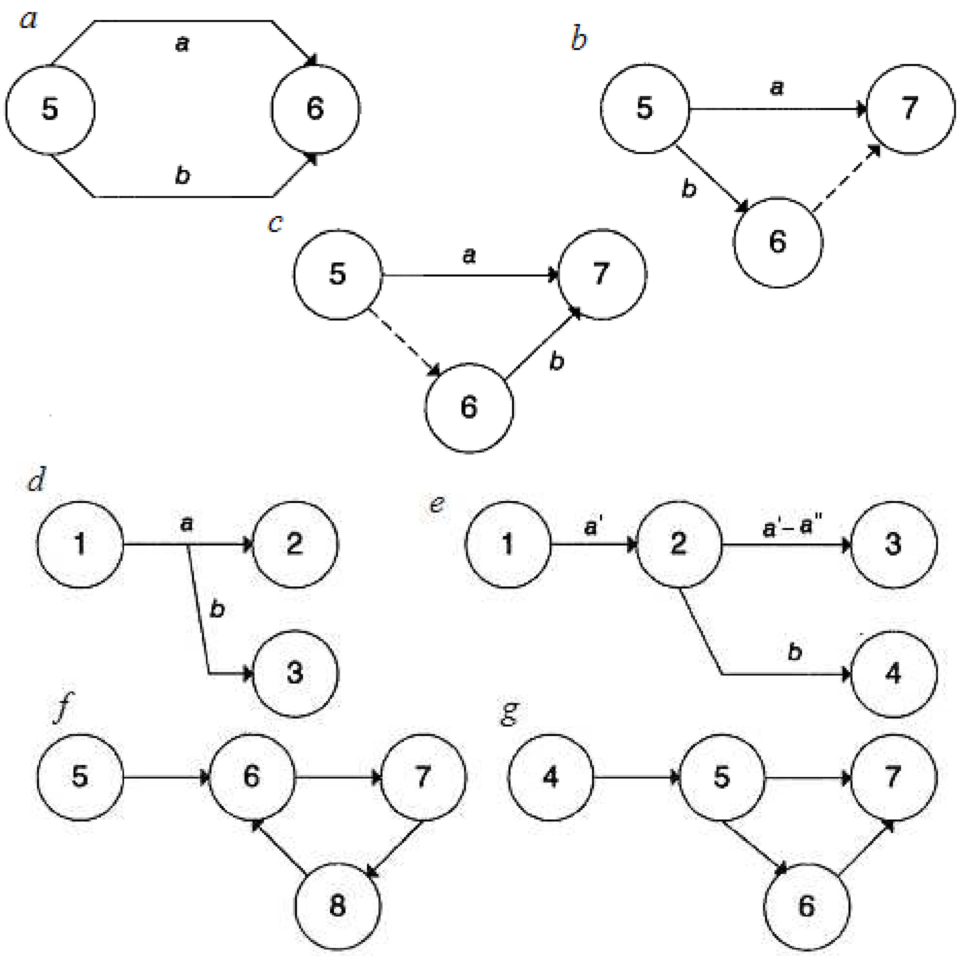



Fig 5.8. Rules of network chart development: *a, d* and *f* incorrect, *b, c, e, g* correct; *b* and *c* concurrent activities, *e* a succeeding activity starts when a preceding activity is not completed; *g* open contour rule; *a*, *a'*, *a"*, *b* activities [10]

**Presentation of overlapping activities in construction**. When presenting overlapping activities in a network model, technological relationships of activities are often not properly shown. This may be avoided by introducing some additional relationships (Fig 5.9., c).

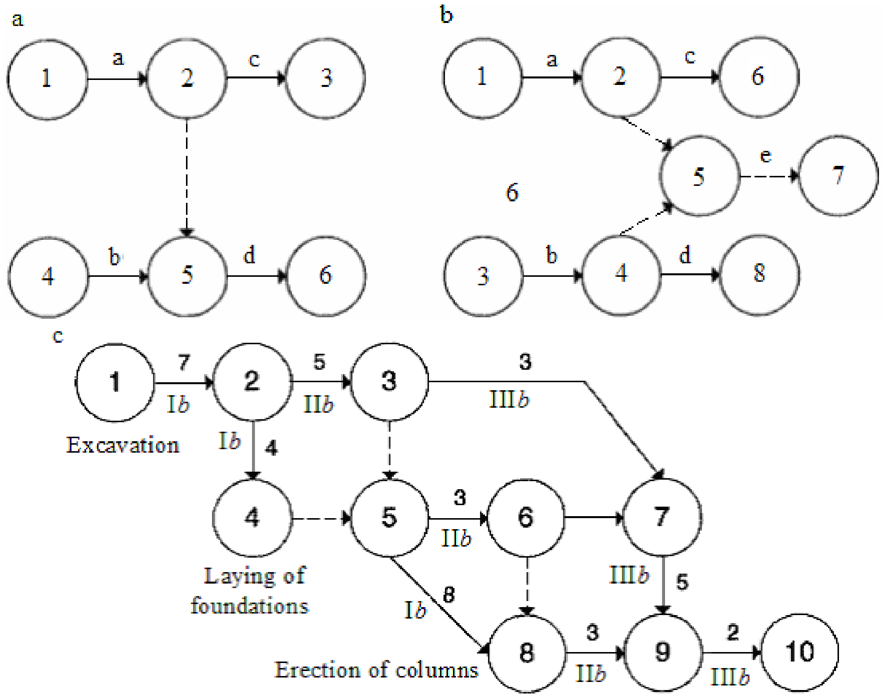



Fig 5.9. Interrelationships of operations and presentation of construction flows in a network chart [10]

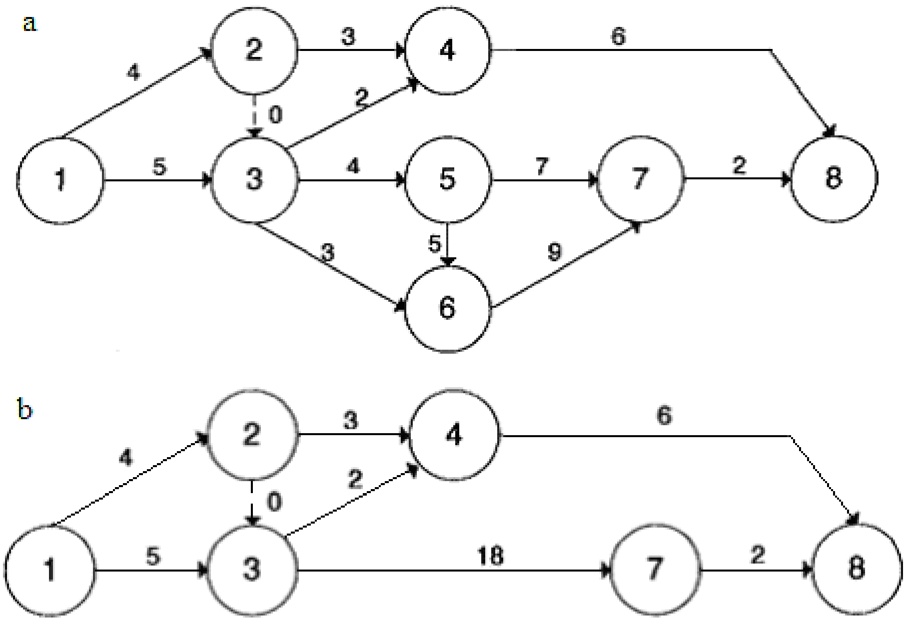



Fig 5.10. Simplification of a network: *a* not simplified, *b* simplified [10]

**Simplification of a network**. Depending on the control level, the constructed network may be more or less detailed. A simplified network presents a group of activities as a single activity, having, however, one earliest and one last event (Fig 5.10, *a*; activities 3-5, 3-6, 5-6, 6-7). Activities with external links cannot be grouped (Fig 5.10, *a*; activities 2-3). The duration of the succeeding activity is the longest path of the grouped activities (Fig 5.10., *b*; it is 18 for the longest path of the activities 3-5-6-7).

## 5.3. Calculation of network chart parameters

As mentioned above, *n* complete paths can be between the earliest and the last event in a network chart. They have a certain amount of spare time compared to the critical path. Therefore, it may be stated that the activities on these paths can also have some spare time. This shows that these activities could and actually have different starting and finishing times. The above spare time and time of activity's start and finish make the parameters of a network chart. They are calculated as follows:

- The earliest time of starting and finishing an activity;
- The length (duration) of the critical path;
- The latest time of starting and finishing an activity;
- Total and partial amount of spare time available in an activity.

**The notation of network parameters:**

i - j an activity considered;
h - i preceding activity;
j - k succeeding activity;
1 - j the earliest activity;
i - z the latest activity;
$t_{i-j}$ duration of an activity;
$T_{i-j}^{apr}$ the earliest starting time of an activity;
$T_{i-j}^{apb}$ the earliest finishing time of an activity;
$t_{kr}$ length (duration) of the critical path;
$T_{i-j}^{vpr}$ the latest starting time of an activity;
$T_{i-j}^{vpb}$ the latest finishing time of an activity;
$R_{i-j}$ the total spare time available in an activity;
$r_{i-j}$ a part of the spare time available in an activity.

The earliest time of the start and the earliest time of the finish of an activity are referred to as the early time parameters of an activity, while the latest time of the start and the latest time of the finish of an activity are called the late time parameters of an activity. The early time parameters of network activity are calculated in turn, starting from the earliest and finishing with the latest activity.

**The earliest start of an activity** is the highest earliest finish of the activity which immediately precede it. It is the longest path (overall project duration) from the network initial event to the initial event of some activity. The total earliest time of the start of activities having the same initial event is the earliest finish time of preceding activities:

$$T_{i-j}^{apr} = max T_{h\text{-}i}^{apb} \tag{5.5}$$

**The earliest finish of any activity** is the earliest possible time of completing an activity.

The earliest finish of any activity is the earliest start of this activity plus the duration of the project:

$$T_{i-j}^{abb} = T_{i-j}^{apr} + t_{i-j} \tag{5.6}$$

The earliest start of the initial activity is zero, while the earliest finish is the duration of this activity:

$$T_{1-j}^{apr} = 0 \tag{5.7}$$

$$T_{1-j}^{apr} = 0 + t_{1-j} = t_{1-j} \tag{5.8}$$

**The length of the critical path** is the length of the longest path which is also calculated as the earliest finish of the final activity:

$$t_{kr} = max T_{i-z}^{apb} \tag{5.9}$$

**The latest start of an activity** is the latest time when this activity can start without lengthening the critical path.
**The latest finish of an activity** is the latest time when this activity can be completed without lengthening the critical path. The latest finish of an activity is determined by the difference between the critical path and the longest path of the final event of a particular activity. The latest finish times of the activities with the same final event are the same.
The late time parameters of an activity are calculated by the formulas in a particular order: first, the final activity of a network is dealt with, and then the first activity is analysed.
The latest finish of the preceding activity is the latest start of the succeeding activity.
The latest start of this activity is the difference between its latest finish and duration:

$$T_{i-j}^{vpb} = \min T_{j-k}^{vpr} \tag{5.10}$$

$$T_{i-j}^{vpr} = T_{i-j}^{vpb} - t_{i-j} \tag{5.11}$$

The latest finish of the final activity is the duration of a critical path:

$$T_{i-z}^{vpb} = t_{kr} = \max T_{i-z}^{apb} \tag{5.12}$$

$$T_{i=z}^{vpr} = t_{kr} = t_{i-z} \tag{5.13}$$

The latest start of the final activity is the difference between the critical path and duration of the activity.
**Total amount of spare time available in an activity** is the ultimate time allowed to lengthen the activity's duration without affecting the critical path. The total spare time is the difference in the parameters of the earliest and the latest activities:

$$R_{i-j} = T_{i-j}^{vpb} - T_{i-j}^{apb} = T_{i-j}^{vpr} - T_{i-j}^{apr} \tag{5.14}$$

**A part of the total spare time available in an activity** is the largest amount of time, which can be used to increase the duration of an activity without affecting the earliest time of the succeeding activities. It is found when a particular event is the finish of at least two activities. If one of them has some spare time, the spare time of another will be zero.
A part of the total spare time is calculated as difference between the earliest time of the start and finish of the preceding activity:

$$r_{i-j} = T_{j-k}^{apr} - T_{i-j}^{apb} \tag{5.15}$$

A part of the total spare time is the smaller amount of the total spare time or can be equal to it:

$$r_{i-j} \le R_{i-j} \tag{5.16}$$

Given the early and late time parameters and the amount of spare time, it is not difficult to find which activities are on the critical path. The activities whose total and partial amount of spare time is zero can be found on the critical path.
The parameters of a network chart can be calculated manually or using a computer. In manual calculation, tables or sector methods are commonly used. The events in a table are numbered according to the rules of coding when the number of the earliest event (relationship, float) should be smaller than the number of the final event. The table for calculating network parameters is given below (see Table 5.3).
Calculations in the table are carried out in the following order:
1. The initial data on each activity obtained from a network model are filled in the first three columns. They include: numbers of the earliest events of activities (1), activity code (2), activity duration (3). In filling in the second column of the table it is important that the activities be listed in the increasing order of the earliest event, while the activities starting with the same event be arranged in the increasing order of the final event of activities. This facilitates the calculations and helps avoid errors.

Table 5.3.
Calculation of a network chart

| No of the earliest event | Activity code $i$-$j$ | Activity duration $t_{i-j}$ | Early parameters | | Late parameters | | Spare time (float) | |
|---|---|---|---|---|---|---|---|---|
| | | | Start $T_{i-j}^{\text{apr}}$ | Finish $T_{i-j}^{\text{apb}}$ | Start $T_{i-j}^{\text{vpr}}$ | Finish $T_{i-j}^{\text{vpb}}$ | $R_{i-j}$ | $r_{i-j}$ |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |

2. Early time parameters are calculated for each activity (columns 4, 5). Calculation is carried out from the earliest to the latest event. Early time parameters of the earliest activity are calculated from formulas 5, 7 and 8, while for other activities formulas 5.5 and 5.6 are used.
It should be noted that the time of the earliest start of activities starting with the same event is the same.
3. Late time parameters are calculated for each activity (columns 6, 7). The calculation order is from the latest to the earliest activity. These parameters are calculated from formulas 5.12 and 5.13 for the latest activities, while for other activities formulas 5.10 and 5.11 are used. First, the latest finish times of activities are determined. For the activities finishing with the same final event the highest finish time is the same.
4. The total and partial spare time is calculated (by formulas 5.14 and 5.15, respectively). It should be remembered that the partial spare time of the final activities is equal to the total spare time and it may be either equal to or smaller than the total spare time (formula 5.16).
5. The critical path passing through the activities having no total or partial spare time is plotted. In the activities through which the critical path passes these are underlined, while on the network chart they are plotted by a thicker or coloured line (Fig 5.11.).

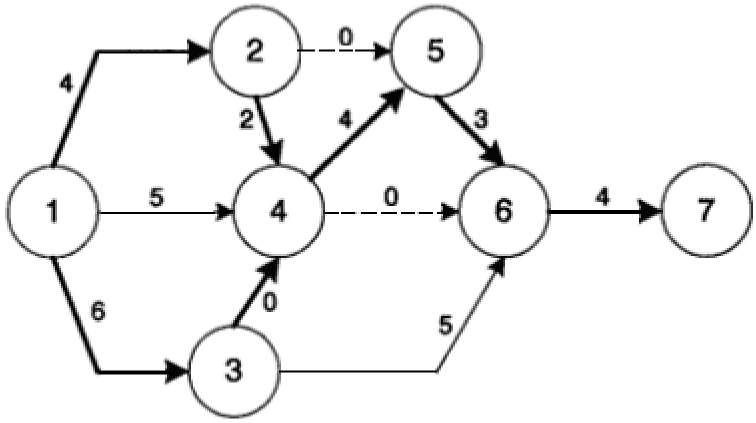



Fig 5.11. An example of a network diagram [10]

Calculation of network chart parameters is presented in Table 5.4.
The calculations performed show that the critical path passes through events 1-2-4-5 and 1-3-4-5-6-7.
Using the sector approach the parameters of a network chart are calculated based on the network model. Network model events are indicated by large circles divided into four sectors. The data on activities and events given in the sectors are needed for calculations (Fig 5.12.).
The calculation of network parameters using a vector approach is similar to the use of tables, however, some formulas are different.

Table 5.4.
Calculation of network chart parameters

| No of the earliest event | Activity code *i-j* | Activity duration $t_{i-j}$ | Early parameters | | Late parameters | | Spare time (float) | |
|---|---|---|---|---|---|---|---|---|
| | | | Start $T_{i-j}^{apr}$ | Finish $T_{i-j}^{apb}$ | Start $T_{i-j}^{vpr}$ | Finish $T_{i-j}^{vpb}$ | $R_{i-j}$ | $r_{i-j}$ |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| - | 1-2 | 4 | 0 | 4 | 0 | 4 | 0 | 0 |
| - | 1-3 | 6 | 0 | 6 | 0 | 6 | 0 | 0 |
| - | 1-4 | 5 | 0 | 5 | 1 | 6 | 1 | 1 |
| 1 | 2-4 | 2 | 4 | 6 | 4 | 6 | 0 | 0 |
| 1 | 2-5 | 0 | 4 | 4 | 10 | 10 | 6 | 6 |
| 1 | 3-4 | 0 | 6 | 6 | 6 | 6 | 0 | 0 |
| 1 | 3-6 | 5 | 6 | 11 | 8 | 13 | 2 | 2 |
| 1,2,3 | 4-5 | 4 | 6 | 10 | 6 | 10 | 0 | 0 |
| 1,2,3 | 4-6 | 0 | 6 | 6 | 13 | 13 | 7 | 7 |
| 2,4 | 5-6 | 3 | 10 | 13 | 10 | 13 | 0 | 0 |
| 3,4,5 | 6-7 | 4 | 13 | 17 | 13 | 17 | 0 | 0 |

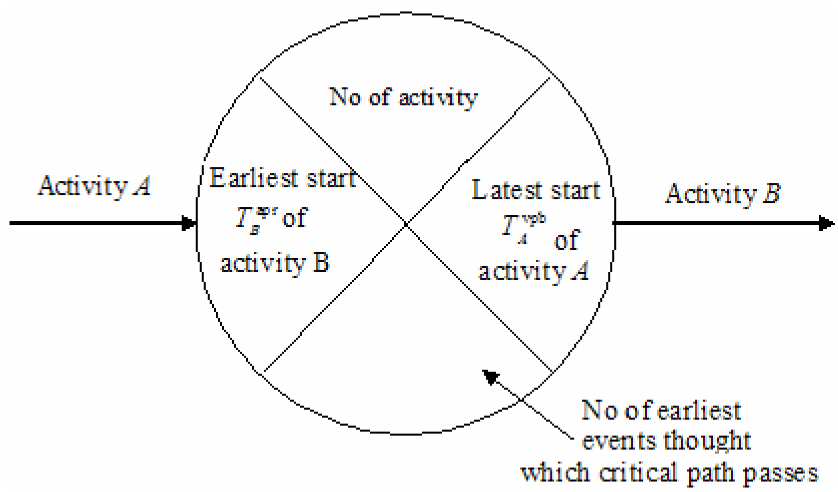



Fig 5.12. Sectors of a circle representing a network chart event [10]

The earliest start of an activity (except for the earliest activity) is calculated from the formula:

$$T_{i-j}^{apr} = \max\left(T_{h-i}^{apr} + h_{h-i}\right) \quad (5.17)$$

i.e. the earliest start of this activity is the earliest start of the preceding activity plus its duration.

The latest finish (except for the final activity) is obtained from the formula:

$$T_{i-j}^{vpb} = \min\left(T_{j-k}^{vpb} - t_{j-k}\right) \quad (5.18)$$

where the above finish time is the difference between the latest finish time of a succeeding activity plus its duration.

The total spare time (float) is calculated by the formula:

$$R_{i-j} = T_{i-j}^{vpb} - \left(T_{i-j}^{apr} + t_{i-j}\right) \quad (5.19)$$

i.e. the total spare time available in an activity is the difference between its latest finish and the earliest start time plus overall duration. Partial spare time (free float) is obtained from the formula:

$$r_{i-j} = T_{i-j}^{apr} - \left(T_{i-j}^{apr} + t_{i-j}\right) \qquad (5.20)$$

i.e. partial spare time of an activity is the difference between the earliest start of the succeeding activity and the earliest finish of the preceding activity plus overall duration.

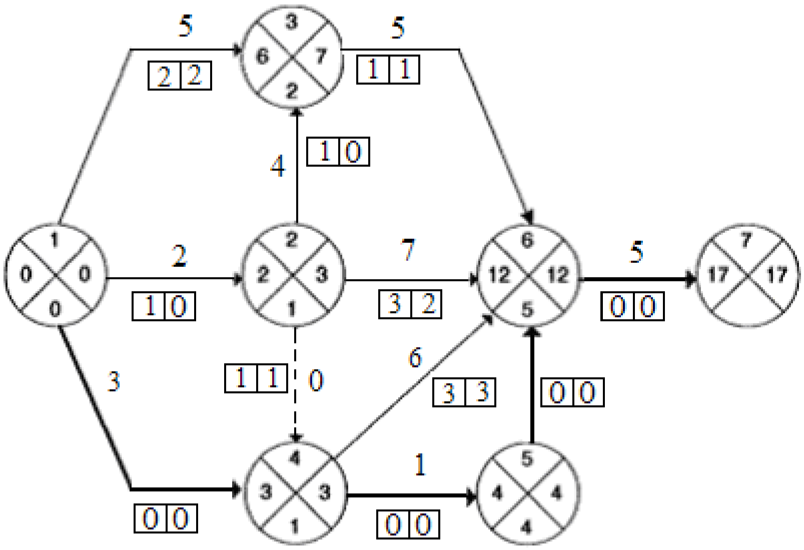



Fig 5.13. Sector method of calculating network parameters [10]

First, the values of the left – side sectors are calculated by formula 5.17. Calculation begins with the earliest event. Then, the right – side sector values are dealt with by using formula 5.18. The calculation begins with the final event whose right – side sector value is equal to the left – side sector value.

When the values in the left – side and right – side sectors are calculated, the critical path is determined. This is the longest path passing through the events whose values of the left – side and right – side sectors are equal.

When the critical path is calculated by formulas 5.19 and 5.20, the total and partial spare times (floats) of activities are determined. The obtained values are indicated below the activity's vector (Fig 5.13.). The value of $R_{i-j}$ is inserted in the left – side rectangle, while the value of $r_{i-j}$ is inserted in the right – side rectangle.

The calculation by a sector method does not require strict numbering of events as well as allowing to avoid errors in the inserting the initial data and to increase the rate of calculation. However, if the values are often corrected, the network has little use because the calculated data required for the analysis could be deleted.

## 5.4. Updating, optimising and applying network charts

It is difficult to develop a network chart to perform all the construction operations of a particular project on the first try. A common practice involves updating and optimisation of the original version.

Network optimisation is associated with the search for an optimal variant of the chart which may be evaluated from various perspectives. Thus, an optimal network for an individual construction project is usually not optimal for the construction enterprise as a whole, because it does not take into account the resources and demands of other projects of this particular enterprise.

It is difficult to optimise network charts because of the wide variety of criteria involved. Therefore, a unified methodology is hard to find. In practice, networks which are updated with

respect to time and resources are used. Now, in Lithuania (as in other countries) the work value is becoming increasingly important.
The network should first be updated in terms of time and then according to resources, if required. Network chart updating in relation to time aims to reduce project duration, i.e. the critical path.

Some activities used to achieve this include:

- Distribution of labour resources;
- Coordination of technological processes;
- Use of additional labour force;
- Variation of output rates; and,
- Changing the project.

It is also difficult to update a network chart according to the available resources because they are plentiful and various. Therefore, it is common practice to correct the network chart according to the available labour force and the supply of plant and materials.
To make a network chart comprehensible and suitable for controlling the construction progress, it should be drawn on a time scale.
Usually, a network chart is drawn on a time scale according to the earliest start of activities. A projection connecting two events on the field axis is the sum of the values relating to project duration and part of resources.
When a network chart is drawn on a time scale, a labour network is usually drawn under it. In the fraction above the labour line, the numerator means project duration, while the denominator denotes the number of labourers (Fig 5.14.).
In construction management which is based on a network chart, an emphasis is placed on the analysis of activities found on the critical path. The construction progress is checked in a similar way to how it is done using a bar chart, i.e. each week or decade.
Senior managers can use more accurate enlarged network charts.

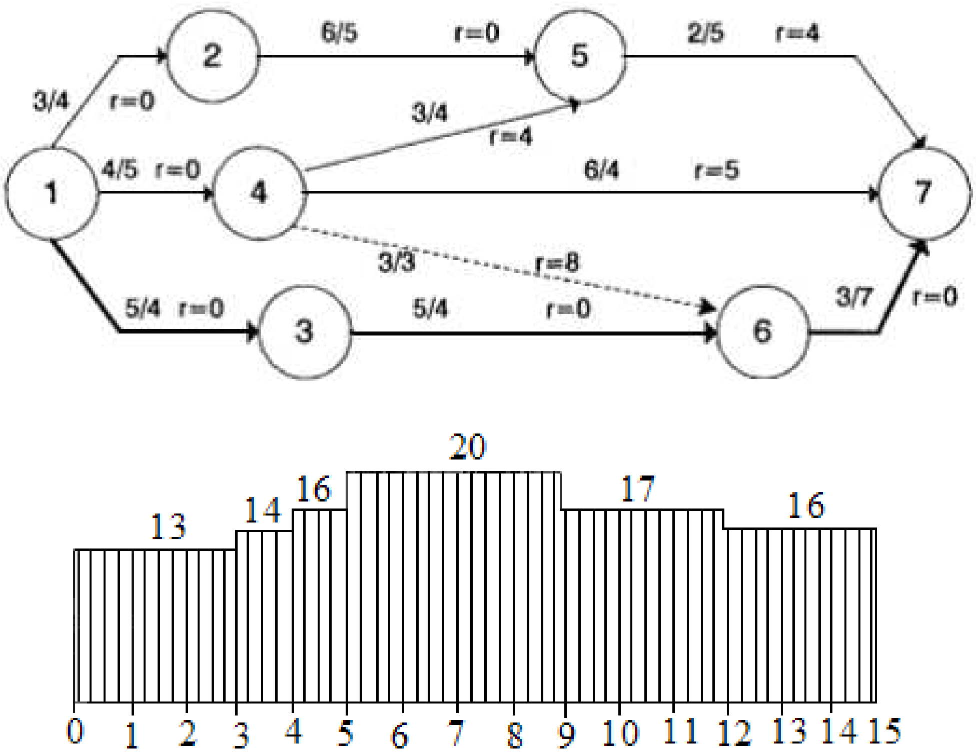



Fig 5.14. The network chart on a time scale and labour requirement network [10]

### 5.5. Assessment of delays / disruptions and consequences

In previous chapters, conditions were discussed regarding basic rules and legal provisions which allow the initiation of a tender procedure, together with requirements for obtaining co-financing from EU funds.

It is therefore not necessary to present these issues again with regard to controlling the execution time of a construction project and its consistency with the investor's needs, resulting from the contract signed with the contractor.

It should be emphasised that both EU directives and legal acts of individual countries do not provide an unambiguous ruling with regard to the imposition of a date and method of completing a construction project by the investor.

Directives 2004/18/CE and 2004/17/CE determine the rules for completing a construction project as constructing a facility using any chosen means.

The time of project execution is usually controlled on the basis of a schedule presented by the contractor in the offer, which is also consistent with investor's requirements from the specification being the basis for the tender procedure.

At this point, it should be noted that, in case of a contract based on FIDIC terms, the contractor presents a detailed project execution plan within 28 days from the date of commencing work, after signing the contract.

Usually, the schedule is presented in form of a GANT diagram, as the most useful in construction projects, in particular in case of line projects, often with milestones ♦ marked according to the investor's requirements, which become the basis for interim controls of the timing of project execution.

This method allows for current control of individual stages and of the whole construction project after its completion.

In case of delays in construction, it allows the contractor to introduce corrective programs, as ordered by the Engineer or representatives of the investor's supervision.

Here, the earned value method mentioned in the previous chapter is often applied.

In developing schedules, PERT and CPM methods based on the critical path analysis seem much less useful in construction projects, not requiring particular studies related to technical forecasts and a wide range of execution options.

In case of simple projects, not technically advanced and not presenting geological, property and weather problems, control of the investment execution term, whether partial or final, does not pose any major problems to the representatives of technical supervision and the investor, although unexpected circumstances may occur here as well.

However, it should be noted that also in the above mentioned circumstances, both the investor and the contractor, in undertaking to complete a construction project, should consider all risks connected with timely execution of the task.

In construction projects of a medium and high level of technical complexity and of a medium and high value, regardless of possible co-financing from EU funds, it is extremely difficult to avoid delays at individual stages of execution.

These delays are usually the object of disputes and various claims between the parties to the contract, and also the engineer who is not a party to the contract, according to the FIDIC contract terms, or a contractual representative of the investor's supervision, chosen pursuant to other provisions of the contract.

Such disputes may be both causes and results of delays when executing a construction project.

Listed below are stages when circumstances arise which may disrupt the planned terms of project execution:

1.The stage of tender procedure:
a) announcements and their content;
b) terms of reference and doubts reported by the bidders;
c) questions by the bidders (contractors);
d) the investor providing answers in an untimely or imprecise manner;
e) dates of the bid opening and the possibility to postpone it
f) protests and appeals by the bidders; and,
g) conclusion of tender procedures and their assessment by the contractors.

2. The stage of project execution and reasons for delays in construction works:
a) delays in signing the contract
b) misunderstandings between the parties participating in the project execution;
- the investor and the contractors as parties
- the designer and the above mentioned parties
- the engineer (supervising inspectors) as the parties controlling the course of project execution;
- relation of the investor and the contractor to subcontractors.

The most frequent objects of disputes are:

From the contractor's point of view:
- date of handing over the construction site;
- mistakes made by the designer;
- unsatisfactory author's supervision by the designer;
- changes introduced by the designer;
- no approval for suggestions of possible changes made by the construction manager;
- untimely acceptance of works by the supervising inspector;
- cost estimate of additional and substitute works by the engineer;
- untimely confirmation of the Interim Payment Certification by the engineer;
- questioning the quality of works by the supervising inspector; and,
- no approval for prolonging the contract execution term.

From the Engineer's or the investor's supervision officers' point of view:
- questioning decisions of the supervision officers by the Ordering party;
- lack of approval by the Ordering Party for introducing annexes to the contract; and,
- cost estimate of prolonging the contract execution term.

From the Investor's point of view:
- decisions by the engineer or representatives of the investor's supervision;
- cost estimates by the engineer or representatives of the investor's supervision;
- changes introduced by the engineer or representatives of the investor's supervision;
- changes introduced by the designer;
- changes introduced by the contractor;

- proposals of additional and substitute works; and,
- proposals to prolong the work completion term.

Methods of settling disputes between the parties and parties to the contract:
- agreement;
- compromise;
- claims without reaching an agreement;
- arbitration;
- court; and,
- termination of the contract.

Results of disputes between the parties to the contract:
- delay in execution of the contract;
- deteriorating work quality;
- increased costs of contract execution;
- no possibility to qualify part of the costs in case of co-financing from EU funds; and,
- risk of financial correction.

Causes of delays in completion of construction works can be assigned to [10]:
- human factors;
- factors related to the contract; and,
- unforeseeable factors.

The first of these groups was discussed above in the assessment of the characteristics of disputes arising in the course of investment execution, to a large extent due to the level of knowledge, qualifications and reliability in preparing the project feasibility study, the project documentation, punctuality and professionalism in controlling and accepting construction works at individual stages of the project execution.

One should pay particular attention to verifying necessary attestations, and, if necessary, perform laboratory tests of materials used in construction.

Using the quality formula, the better description of the object of the order is prepared by the investor, the closer they get to staying within the optimum framework of meeting the schedule presented in the terms of reference based on the feasibility study.

Apart from the investor, an important role is played by the planning and design company which prepares the project documentation and the cost estimates in such a form as to allow proper financial control of progress and costs incurred.

Furthermore, this enables the avoidance of numerous questions regarding the terms of reference, presented by potential contractors to the investor, and simultaneously after completion of individual work stages, for avoidance of questioning of the expenses incurred during control by institutes authorized to do so, for example by the Public Procurement Office, the Ministry of Finance or the Tax Inspectorate.

Any changes made in the construction design, whether they result from mistakes in the documentation, or are requested by the investor, the contractor or representatives of the investor’s supervision, usually have significant impact on dates of investment execution and on possible delays.

In preparing the project documentation for completion of works and construction facilities, according to recommendations by the European Commission, the investor should pay attention in particular to the correct execution of environmental documentation as mistakes made in this regard have a large impact on timely execution of the project, and often force the investor to introduce significant changes in the documentation.

This usually results in the need for changes in the contract signed with the contractor, or to initiation of a separate tender procedure.

In the case of important changes resulting from environmental conditions, it is usually not possible to conduct a non-competitive procedure which significantly prolongs the term of completing the project and obtaining an occupancy permit.

In the case of road projects, the European Commission points to the necessity to implement provisions of the Directive 2008/96/EC pertaining to safety management of road infrastructure, emphasizing the fact that assessment and audit procedures of road traffic should also be implemented in the case of roads parallel to paid highways and expressways.

In the opinion of the European Commission, this is one of the priority elements and is subject to special analysis.

The consequence of disregarding safety rules of road traffic is the need to introduce supplementary changes to the project, a delay in the execution term which leads to financial penalties resulting from the signed contract, and additional amounts resulting from financial corrections required by provisions of the European Commission.

With regard to the above statements, the role of the second type of the above mentioned factors must be noted, that is the factors directly connected with the contract and the signed agreement.

The role of a correctly drafted contract between the parties, with all necessary conditions, and literal assigning of obligations of the parties to the contract, is of utmost importance, both for the part regarding the costs and the term of the project execution.

A very important element of the contract signed by the investor is precise specification of the role of the engineer if the contract is based on FIDIC contract terms, or a representative of the investor or the investor's supervision.

Also, without infringing on the rules resulting from the Directive 2004/18/EC and the Directive 2004/17/EC, one should define in detail the conditions referring to both work and financial relations between the contractor and the subcontractors.

One should emphasise that the role of the engineer, in case of a contract based on FIDIC contract terms, or a representative of the investor's supervision appointed by the investor, is very important.

Therefore, mistakes made by them or by their appointed representatives have great influence on proper execution of the contract, with regard to both the financial terms and the schedule, and in an unfortunate event they may lead to losing co-financing, for example from EU funds.

The main responsibilities of the engineer or representatives of the investor's supervision, influencing correct control over the execution time of a construction project, are:
- correct entries in the construction log by supervising inspectors;
- information about dates of visits of representatives of the author's supervision, and related changes in the project;
- reaction to notifications by the contractor regarding interim acceptances;
- confirmation of acceptance by the supervising inspectors; and,
- use and documentation of use of recovered materials.

The most frequent problems in activities of the engineer or representatives of the investor, that is supervising inspectors, related to a construction log used in construction projects, are:
- lack of information about equipment brought to the construction site and back, and specification of the equipment's location;
- lack of information about materials brought to the construction site and assigning a storage place for them by the engineer; and,
- lack of documents confirming that attestation of materials was verified as consistent with documentation.

The Contractor is not responsible for a design and specification of construction works developed by the investor. The Contractor shall present to the investor monthly reports on work progress, on the dates specified in the contract, until all works are completed.
The reports shall reflect in detail completion of works, deliveries and trials, including the works performed by subcontractors.

Before commencing final trials, the contractor shall deliver to the engineer or representatives of the investor's supervision the as-is documentation together with necessary operation and maintenance manuals. If results of final trials are negative, and repeated trials have the same results, the engineer or representatives of the investor's supervision may request additional trials or reject all works or a part of them, and on the investor's request accept only a correctly completed part of works. In the last case the investor shall fulfil their obligations resulting from the contract, and the value of the contract will be decreased by the value of not performed or incorrectly performed works, also in consideration of their consequences.

As for consequences of delays in completing a construction project, they result mainly from the contents of the contract concluded between the investor and the contractor where the parties accept provisions resulting from failure to fulfil contractual obligations by one of the parties.
This pertains mainly to execution dates, meeting payment terms, quality of works and materials, acceptance dates and conditions, removing defects and failures, warranty repairs, obtaining necessary approvals and permits, purchase of land, property rights, etc.
In all these situations, the parties who suffered losses are entitled to compensation procedures, regardless of obligations resulting from securing proper execution of the signed contract.

### 5.6. Literature and further reading for chapter 5


1. Clough, R.H., Sears G.A. Construction Project Management, (1979)
2. Helmuth, Obata, Kassabaum, Inc. (HOK) Guidebook to Sustainable Design
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5. Kimmons R. L. Project Management Basics: A Step by Step Approach, (1990)
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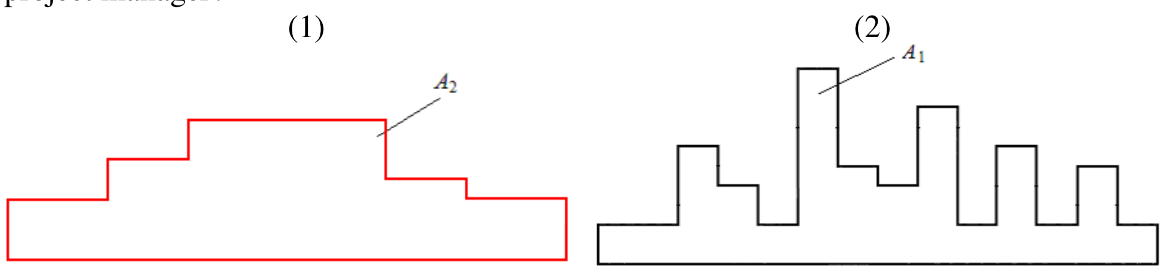
8. Zornada M. Introduction to process plant start-up, (2002)
9. Tenah K.A. (1985) The Construction Management Process
10. L. Ustinovičius, D. Migilinskas, P. Miksta, E. Zavadskas, A. Minasowicz, J. Zawistowski: „Planning and Scheduling in Construction", Leonardo da Vinci nr: PT04/PP/02/18/417, pt.: "Recognition of needs and creation of the professional training in the area of preparation and management of infrastructure construction projects financed by the European Union", Warsaw, Vilnius, (2006)

### 5.7. Set of Exercises for chapter 5

**Exercise 5.1:**
Which of the below presented labour requirement schedules would You choose if You were a project manager?




a) Since the gang sizes are balanced, the work organisation and labour productivity are better. Number (1) is correct.
b) Since the gang sizes are balanced, the work organisation and labour productivity are worse. Number (2) is correct.
c) Both of the schedules are quite the same and it makes no difference which one would be chosen.

**Exercise 5.2:**
Decide which of the sentences listed below are true and which are false:
a) Schedules do not determine the demand for equipment.
b) A schedule is a model of only one alternative not reflecting the dynamics of production.
c) Schedules do not allow managers to determine the influence of the delayed operations on the subsequent works and overall project duration.
d) Schedules do not show true relationships between the concurrent operations from technological and organisational perspectives, though the attempts are made to denote them by special notation.
e) Schedules do not determine the order of construction operations.

**Exercise 5.3:**

Match the sentences in the box to the expressions listed below in order to formulate correct definitions.

a) **A network model…**
b) **Activity…**
c) **Spare time (float)...**
d) **Succeeding activity…**
e) **The final activity…**
f) **Critical path…**

… is the longest path through the network.

… is required by construction technology. It is represented by a point vector line.

…is the activity having no succeeding activities according to the network.

… is the activity which can start only if a particular other activity or activities are completed.

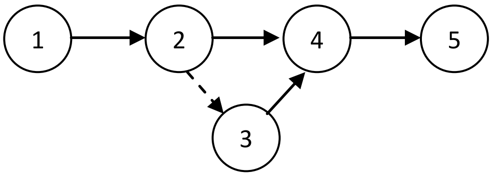
… is a chart presenting activities (operations) to be performed to achieve a defined goal (goals) and their interrelations.

… is a process requiring a certain amount of time, materials and plant to be performed; it is represented by a continuous vector line.

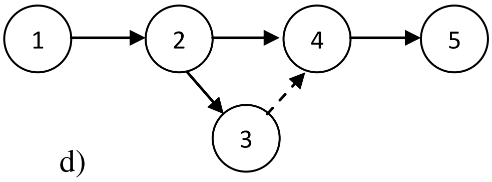
**Exercise 5.4:**

Decide which of the network charts shown below are correct and which are incorrect?

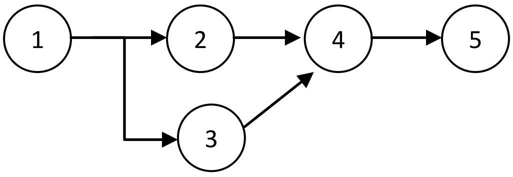
a)



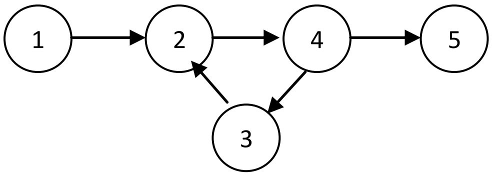
b)



c)

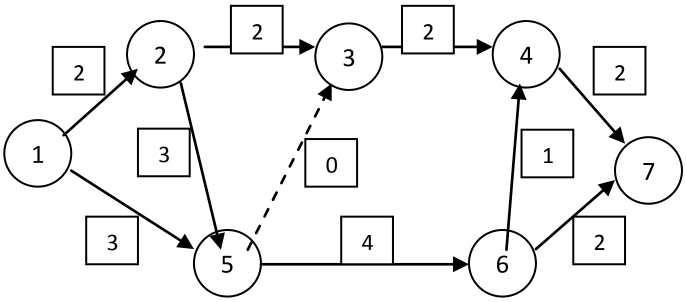


d)



**Exercise 5.5:**

Calculate the parameters of the network diagram presented below. Calculations should be prepared in the table, located below the diagram.

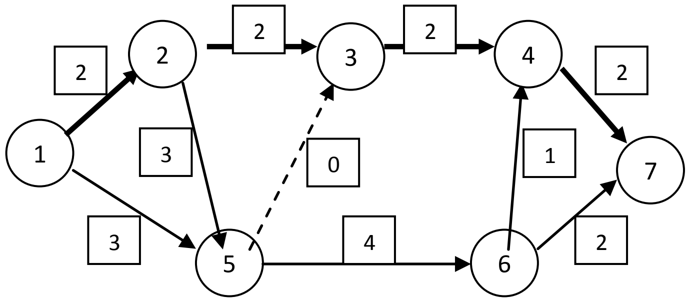


| No of the earliest event | Activity code *i-j* | Activity duration $t_{i-j}$ | Early parameters | | Late parameters | | Spare time (float) | |
|---|---|---|---|---|---|---|---|---|
| | | | Start $T_{i-j}^{apr}$ | Finish $T_{i-j}^{apb}$ | Start $T_{i-j}^{vpr}$ | Finish $T_{i-j}^{vpb}$ | $R_{i-j}$ | $r_{i-j}$ |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | | | | | | | | |

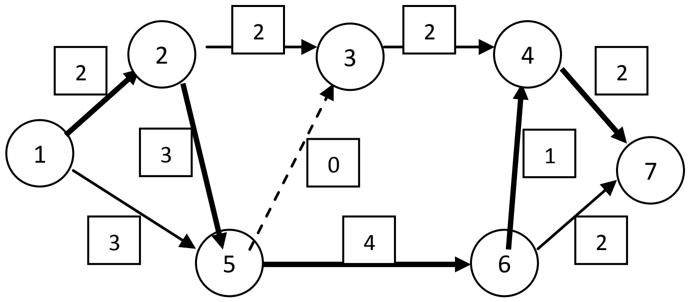
**Exercise 5.6:**

Which network diagram shows the proper critical path? Choose the right answer.

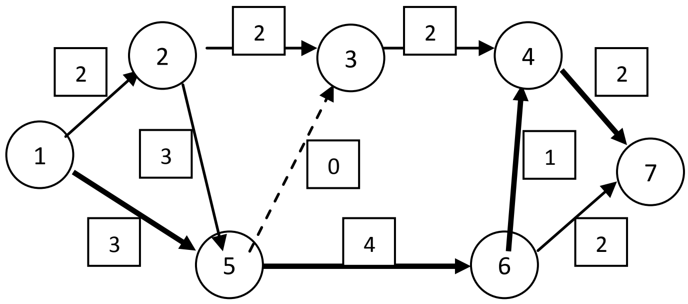
a)




b)

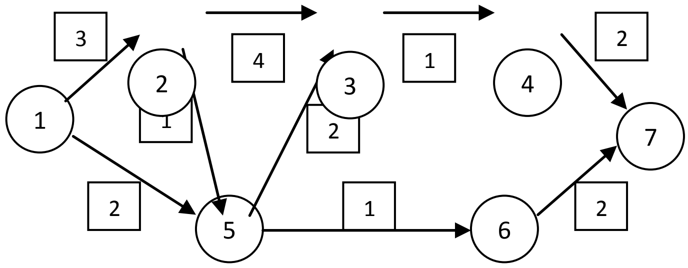



c)




**Exercise 5.7:**

Show the critical path on the network diagram below.




**Exercise 5.8:**

Which are the most frequent objects of disputes in project execution, from the contractor's point of view are? Write at least 7 of them.

**Exercise 5.9:**

What are the results of disputes between the parties to the contract? Choose the right answers.

a) delay in execution of the contract

b) increased costs of contract execution

c) risk of financial correction

d) deteriorating work quality

e) no possibility to qualify part of the costs in case of co-financing from EU funds.

**Exercise 5.10:**

What are the most frequent problems in activities of the engineer or representatives of the investor that is supervising inspectors, related to a construction log used in construction projects? Write three of them (descriptive question).

# CHAPTER 6
# CASE STUDIES

## OBJECTIVES OF THE CHAPTER 6

The primary objective of this chapter is to present a set of case studies related to construction schedules and cost estimation.

## LEARNING OUTCOMES FOR THE CHAPTER 6

The primary learning outcome for this chapter is to gather practical information about the nature of construction scheduling and cost estimation, including problems which arise in the management of construction projects.

## 6.1. CASE STUDY 1 (Poland): Schedule of operations

**This problem** is to demonstrate a schedule of operations for residential house building works.

**List of works:** piling, forming ground beams, drainage and forming ground slab, forming frame, forming concrete floor slabs, forming stairs, external brickwork, partitions, windows, forming roof structure, roof finishing, plumbing and eng. service, electrical installation, plaster works, joinery finishing, floor finishing, painting and decorations, external landscaping, another external works and clean up.
All construction works can be divided in five groups: sub-structure works, frame works, enclosure and roofing works, services and finishing, external works.
SUB-STRUCTURE: piling, forming ground beams, drainage and form ground slab.
FRAME: forming frame, forming concrete floor slabs and forming stairs.
ENCLOSURE AND ROOFING: external brickwork, partitions, windows, forming roof structure and roof finishing.
SERVICES AND FINISHINGS: plumbing and eng. service, electrical installation, plaster works, joinery finishing, floor finishing, painting and decorations and clean up.
EXTERNAL WORKS: external works, external landscaping.
**Works sequence**. All works of the works programme start with sub-structures works - piling works, forming ground beams, drainage and forming ground slab. After piling, ground beams forming, drainage and forming ground slab works begin forming of frame works. Frame forming works do with floor slabs and stairs forming works. A little bit later external brickworks and partitions begin. Erection of windows and roofing works begin, when the biggest part of external brick works has been done. Plumbing, engineering service and electrical installation works usually divide into a few stages. First steps of plumbing, engineering service and electrical installation works (pipes, wires installation) begin before plastering works. Other stages begin after plastering and decorating works. Joinery finishings, floor finishings are usually done before or at the same time as painting and decorating works. External works usually don't have a straight link with internal works.

Construction project works durations and labour requirements/needs are presented in table 6.1.

Table 6.1.

Works durations and need of labour

| No | DESCRIPTION OF WORKS | WORKS DURATION IN WEEKS | NEED FOR LABOUR |
|---|---|---|---|
| | SUB-STRUCTURE | | |
| 1 | Piling | 3 | 3 |
| 2 | Form ground beams | 2 | 5 |
| 3 | Drainage and form ground slab | 3 | 5 |
| | FRAME | | |
| 4 | Form frame | 6 | 8 |
| 5 | Form concrete floor slabs | 6 | 8 |
| 6 | Form stairs | 6 | 3 |
| | ENCLOSURE AND ROOFING | | |
| 7 | External brickwork | 5 | 12 |
| 8 | Partitions | 8 | 10 |
| 9 | Windows | 6 | 6 |
| 10 | Form roof structure | 4 | 5 |
| 11 | Roof finishing | 2 | 6 |
| | SERVICES AND FINISHINGS | | |
| 12 | Plumbing and Eng. service | 8 | 6 |
| 13 | Electrical installation | 6 | 6 |
| 14 | Plaster works | 8 | 8 |
| 15 | Joinery finishing | 6 | 4 |
| 16 | Floor finishing | 6 | 6 |
| 17 | Painting and decorations | 8 | 10 |
| 18 | Clean up | 2 | 4 |
| | EXTERNAL WORKS | | |
| 19 | External works | 10 | 6 |
| 20 | External landscaping | 5 | 6 |

Schedule of operations is shown in Fig. 6.1.

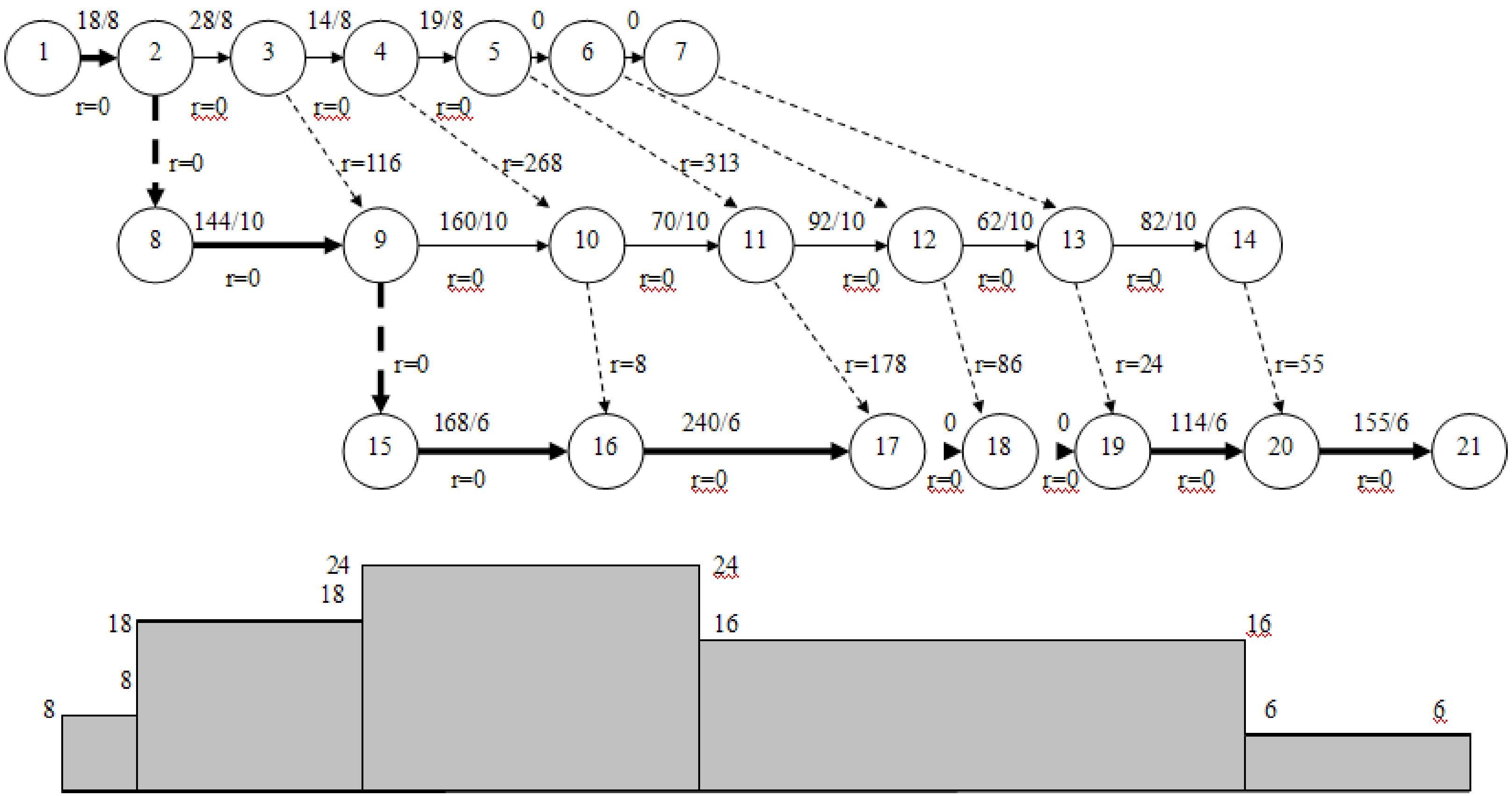



Fig. 6.1. Network and need for labour

## 6.2. CASE STUDY 2 (Poland): Network calculation

**Case study** is to demonstrate network calculation for the building works.

**Calculation**. For network calculations, data from table 6.1. have been used. Network parameters are evaluated in Table 6.2. Network and labour requirements are shown in Fig. 6.1.

Table 6.2. Network parameters calculation

| Activity code | Description of works | Activity duration | Early parameters | | Late parameters | | Spare time (float) | |
|---|---|---|---|---|---|---|---|---|
| | | | Start | Finish | Start | Finish | Total float | Free float |
| i-j | | $t_{i-j}$ | $T^{apr}_{i-j}$ | $T^{apb}_{i-j}$ | $T^{pr}_{i-j}$ | $T^{pb}_{i-j}$ | $R_{i-j}$ | $r_{i-j}$ |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1-2 | Sub-structure I | 18 | 0 | 18 | 0 | 18 | 0 | 0 |
| 2-3 | Sub-structure II | 28 | 18 | 46 | 134 | 162 | 116 | 0 |
| 2-8 | | 0 | 18 | 18 | 18 | 18 | 0 | 0 |
| 3-4 | Sub-structure III | 14 | 46 | 60 | 316 | 330 | 270 | 0 |
| 3-9 | | 0 | 46 | 46 | 162 | 162 | 116 | 116 |
| 4-5 | Sub-structure V | 19 | 60 | 79 | 397 | 416 | 337 | 0 |
| 4-10 | | 0 | 60 | 60 | 330 | 330 | 270 | 262 |
| 5-6 | | 0 | 79 | 79 | 508 | 508 | 429 | 0 |
| 5-11 | | 0 | 79 | 79 | 416 | 416 | 337 | 313 |
| 6-7 | | 0 | 79 | 79 | 570 | 570 | 491 | 0 |
| 6-12 | | 0 | 79 | 79 | 508 | 508 | 429 | 405 |
| 7-13 | | 0 | 79 | 79 | 570 | 570 | 491 | 467 |
| 8-9 | Frame I | 144 | 18 | 162 | 18 | 162 | 0 | 0 |
| 9-10 | Frame II | 160 | 162 | 322 | 170 | 330 | 8 | 0 |
| 9-15 | | 0 | 162 | 162 | 162 | 162 | 0 | 0 |
| 10-11 | Frame III | 70 | 322 | 392 | 346 | 416 | 24 | 0 |
| 10-16 | | 0 | 322 | 322 | 330 | 330 | 8 | 8 |
| 11-12 | Frame V | 92 | 392 | 484 | 416 | 508 | 24 | 0 |
| 11-17 | | 0 | 392 | 392 | 570 | 570 | 178 | 178 |
| 12-13 | Frame IV | 62 | 484 | 546 | 508 | 570 | 24 | 0 |
| 12-18 | | 0 | 484 | 484 | 570 | 570 | 86 | 86 |
| 13-14 | Frame VI | 83 | 546 | 629 | 601 | 684 | 55 | 0 |
| 13-19 | | 0 | 546 | 546 | 570 | 570 | 24 | 24 |
| 14-20 | | 0 | 629 | 629 | 684 | 684 | 55 | 55 |
| 15-16 | Roofing I | 168 | 162 | 330 | 162 | 330 | 0 | 0 |
| 16-17 | Roofing II | 240 | 330 | 570 | 330 | 570 | 0 | 0 |
| 17-18 | | 0 | 570 | 570 | 570 | 570 | 0 | 0 |
| 18-19 | | 0 | 570 | 570 | 570 | 570 | 0 | 0 |
| 19-20 | Roofing IV | 114 | 570 | 684 | 570 | 684 | 0 | 0 |
| 20-21 | Roofing VI | 155 | 684 | 839 | 684 | 839 | 0 | 0 |

## 6.3. CASE STUDY 3 (Turkey): Disputes

Some owners look at the design and construction communities to provide even more services than just combining design and construction. Expanded and creative approaches have been developed to meet the needs of owners who do not have or even desire to develop the competencies and staff to develop, operate, maintain, and even finance their construction projects. Turnkey construction is a form of design build in which the owner enters into an agreement with one firm to assume all of the legal and financial responsibility to design and build the facility, with the owner committing to purchase the facility at a stated price once it is satisfactorily completed and operating. The 'keys' of the facility pass to the owner after the design builder has finished construction and has operated and maintained the facility just long enough to demonstrate that each building system, as well as the entire project, is built and operates according to the owner's criteria. In the turnkey approach, the turnkey contractor finances the design, construction, and operation of the project rather than receiving periodic payments. The capital investment is short term, because once the facility is accepted by the owner, typically the turnkey contractor is paid in one lump sum payment.

Although most of the risks associated with the project remain with the turnkey contractor until closing, delay in turning over the keys is one possible claim between the owner and the turnkey contractor. Another potential claim involving the owner deals with the degree of completeness required of the contractor under the terms of the turnkey contract. Scope disputes on a turnkey project can cause as much interference and disruption on a turnkey project as any dispute on a design-bid-build project. On the Izmir-Aydin road, Aydin motorway project in Turkey, the owner widened the motorway section to three lanes each way, and the maximum grade was dropped from 6% to 4,5%. The effect of this change was to greatly increase the excavation and embankment quantities and to increase the lengths of the anticipated tunnels. Other scope changes included additional interchanges, bridges, and roads from the new motorway linking it to existing major arteries. But the owner was not inclined to view these as a change in scope. The owner held the view that it had purchased a design for the entire road regardless of whether it was shown on the preliminary plans or indicated in the specifications.

Other disputes may involve only the turnkey contractor and its trade contractors. Such delays and claims are related to the inherent risks of the construction process rather than stemming from the turnkey method of project delivery (Barry et al, 2000).

### 6.4. CASE STUDY 4 (Italy): Delays in payment of Public Administration

In Italy the problem of delayed payments in the public works sector is becoming more and more a concern and affects all contracting authorities.

The basis of a survey conducted by 'ANCE (National Association of Builders) in the second half of 2011, shows that the average time of payment in public works has reached 8 months (1 month and a half more than in the first half of 2011).

The average delay, in fact, is 159 days, 45 days longer than in May 2011 (when the average delay was 114 days), with peaks of delay exceeding two years.

The expenses restraint measures, with detailed reference to the Internal Stability Pact, and the inefficiency of government (delays in issuing the certificate or money order, complex bureaucracy) are the two main causes of delay in which the institutions should intervene to ensure improved timeliness in payments from the public administration and ensure the conditions necessary to the normal course of business.

The Internal Stability Pact was introduced in 1999 and constitutes the main tool of control in the net debt of local authorities (regions, provinces, municipalities) nationwide.

It is an indispensable tool that ensures that the criteria set by the European Stability and Growth Pact are achieved, but, at the same time, it severely limits the ability of local investment by the local authorities and represents a source of risk to the survival of construction companies that undergo the effects of delayed payments for works, even when resources are available from local authorities.

In recent years, the strong hardening of conditions of Internal Stability Pact has aggravated these negative effects, resulting in a situation of extreme suffering for construction companies, already hit hard by the credit crunch brought about by the banks due to the economic financial crisis.

The absence of effective tools has so far resulted in a strong increase in demand for loans from banks, in a context of rising costs of banking operations, and an extension of payment terms to suppliers.

Because of the delay in payment for works which have been properly carried out, construction companies are struggling to provide the resources necessary to give continuity to business activity and maintain employment.

Given the steady worsening of the phenomenon of delayed payments, companies have found themselves forced to seek to address their lack of liquidity caused by the failure of payments from the Public Administrations.

The survey shows that companies have focused on the delay in payment times to suppliers and sub-contractors, thus triggering a series of delays that may jeopardise the entire production sector.

The widespread nature of payment delays is increasingly forcing companies to suspend construction work in the event of late payment.

It is therefore necessary to amend some rules of the Stability Pact to facilitate the payment of capital expenditures and, on the other hand, to work on the penalty system to encourage institutions to improve efficiency in the payment of sums due for works done.

So there is the need for the new European directive on late payments to be implemented soon in Italy. This will help to adapt national legislation, which , in respect to penalties for delayed payments from public administrations in public works, seems to be among the least severe of Europe (our main partners apply penalties 3 to 4 times higher in case of delay from the public administrations).

The use of various tools has to be strengthened, such as the certification of claims by the government for sales purposes without recourse, that can allow companies, even with an additional cost, to obtain the liquidity necessary to continue their business.

In the public works sector, it is necessary to rapidly implement the new European Directive on late payments of 16 February 2011 to improve the efficiency of Public Administrations and at the same time ensure a better level of compensation for businesses affected by delays.

The text of the new Directive provides for a standard term of payment of 30 days – that can be derogated within a maximum of 60 days - by public administrations and greatly increases the compensation for construction companies in the event of late payment from the public administrations, in particular by introducing a basic interest rate (ECB) increased by 8% as early as 1 day lateness.

With regards to private contracts, the text of the new Directive ensures freedom of contract, simply requiring that payment times over 60 days are adequately justified, and provides for sanctions in case of delay compared to the payment terms specified in the contract.

### 6.5. CASE STUDY 5 (Poland): Urban street project scheduling.

The purpose of this case study is to present the method and the possibility of urban street reconstruction with a total length of 450 meters. General characteristics and scopes of construction works include reconstruction of the street, construction of sidewalks, construction of drainage, supply of temporary site facilities, electricity, felling and protection of green. The section of street is designed to be widened to 7 meters. Moreover the contractor is supposed to perform a rainwater drainage and a 2-meter wide sidewalk along the west side of the street, which will be separated from the street by a green belt. Some part of growing trees and shrubs, colliding with the investment, is intended to be removed, while the other trees and shrubs interfering with the investment are designated for protection. The detailed activities, which are necessary to be performed during the project include: organisation of substitute motion with the construction of facilities, street widening, rainwater drainage system implementation, sidewalk implementation, felling and protection of green areas, construction of the street, organisation of construction site, planting of greenery with splashing soil onto ditches, removal of construction facilities. It is assumed that the organisation of substitute motion with the construction of facilities and the organisation of construction site start at the same time. Moreover rainwater drainage system implementation can only start when street widening and construction of the street are completed. Another condition related to the diagram is that the planting of greenery with splashing soil onto ditches cannot be initiated before felling and protection of green areas and the organisation of construction site are finished. The dependencies and durations of the activities were discussed by the project manager and the contractor.

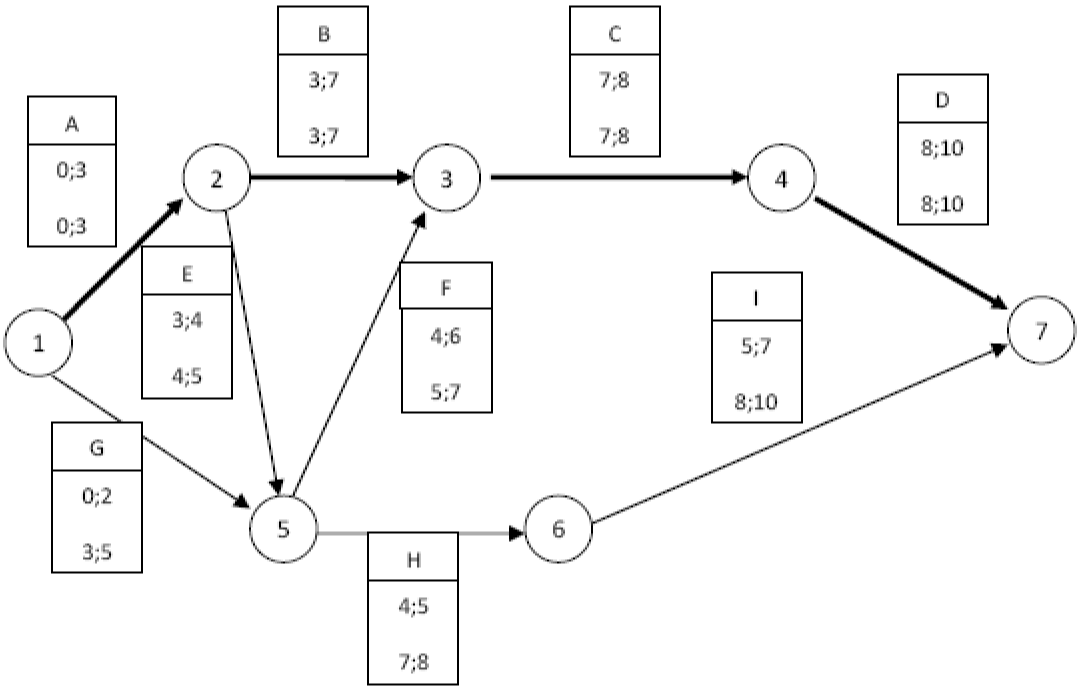
The final draft is presented in the table below.

| Activity | Description of activities | Activity directly preceding | Duration (weeks) |
|---|---|---|---|
| A | Organisation of substitute motion with the construction of facilities | - | 3 |
| B | Street widening | A | 4 |
| C | Rainwater drainage system implementation | B,F | 1 |
| D | Sidewalk implementation | C | 2 |
| E | Felling and protection of green areas | A | 1 |
| F | Construction of the street | E,G | 2 |
| G | Organisation of construction site | - | 2 |
| H | Planting of greenery with splashing soil onto ditches | E,G | 1 |
| I | Removal of construction facilities | H | 2 |

The most important issue for the contractor is to finish the project on time. For this reason it is necessary to determinate which activities have priority in terms of their start and end. The only way to find it out was to prepare a proper calculation of diagram network.

| Activity code *i-j* | Activity duration $t_{i-j}$ | Early parameters | | Late parameters | | Spare time (float) | |
|---|---|---|---|---|---|---|---|
| | | Start $T_{i-j}^{apr}$ | Finish $T_{i-j}^{apb}$ | Start $T_{i-j}^{vpr}$ | Finish $T_{i-j}^{vpb}$ | $R_{i-j}$ | $r_{i-j}$ |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| A | 3 | 0 | 3 | 0 | 3 | 0 | 0 |
| B | 4 | 3 | 7 | 3 | 7 | 0 | 0 |
| C | 1 | 7 | 8 | 7 | 8 | 0 | 0 |
| D | 2 | 8 | 10 | 8 | 10 | 0 | 0 |
| E | 1 | 3 | 4 | 4 | 5 | 1 | 0 |
| F | 2 | 4 | 6 | 5 | 7 | 1 | 1 |
| G | 2 | 0 | 2 | 3 | 5 | 3 | 2 |
| H | 1 | 4 | 5 | 7 | 8 | 3 | 0 |
| I | 2 | 5 | 7 | 8 | 10 | 3 | 3 |

The next step in this case was to use an algorithm for scheduling a set of given activities, named the Critical Path Method.




The activities through which the critical path passes on the network chart are plotted by a thicker black line. As it can be seen on the network diagram the whole initial stage of construction works last 10 weeks. The critical path passes through activities A,B,C and D. For the contractor is means that any delay during organisation of substitute motion with the construction of facilities, street widening, rainwater drainage system implementation or sidewalk implementation, will affect the completion time of the whole project.

### 6.6. CASE STUDY 6: The American University in Cairo School of Science and Engineering, Spring 2010

A contractor entered into a contract in the FIDIC form for the construction of a new bridge.

In the course of the work the new bridge was to cross over a line of an old sewer which lies under a road embankment. At the date of tender the old sewer was known to be in existence but its construction line and precise level was not known. It was thought to be at least 100 years old. All this information, together with the approximate location of the line of the sewer, was shown on a drawing given to the contractor at tender stage. The contractor encountered the old sewer whilst driving the excavation. As a result, the excavation flooded with sewer and silt from the old sewer which was fractured when the earth surrounding it was disturbed. The engineer and the contractor met and reached a joint decision that the old sewer should be shut temporarily at a nearby manhole and the engineer issued instructions accordingly. Subsequently the old sewer was repaired by the contractor by inserting a new section of pipe of the same diameter.

You are requested to read the above statement carefully and give your point of view about the following:

A. Who should bear the cost of the extra work carried out for shutting and the replacement of the pipe section?

B. Who should bear the costs of remedy for the flooded excavation?

C. Is the contractor entitled to any time extension? If yes, what does the contractor have to do to get that time extension?

State the conditions and the FIDIC clauses on which you base your case.

# CHAPTER 7

# GLOSSARY[14] [15]

| Term | Definition |
|---|---|
| **Absenteeism** | A failure of labour resource to arrive at the designated work place. |
| **Activity** | The making up of lost time at the employer's expense (see also Recovery). |
| **Aftercare engineer** | The aftercare engineer provides a support service to the client/user during the initial 6–12 months of occupancy and is, therefore, most likely a member of the commissioning team. |
| **Approximate quantities** | The estimated quantity of work, usually prepared from a scheme design and before detailed design is carried out, for the purpose of cost estimating. |
| **As-build** | Work carried out. |
| **Bills of Quantities** | A document, usually prepared according to defined rules, which sets out the measured quantity of work and describes the quality standard of materials and workmanship for pricing |
| **Budget** | Quantification of resources needed to achieve a task by a set time, within which the task owners are required to work. Note: a budget consists of a financial and/or quantitative statement, prepared and approved prior to a defined period, for the purpose of attaining a given objective for that period. |
| **Buffer** | see Contingency. |
| **Business case** | Information necessary to enable approval, authorisation and policy-making bodies to assess a project proposal and reach a reasoned decision. |
| **Cash flow** | The balance of money received against money spent according to a defined formula, sometimes referred to as accounting rules; the rate at which money is spent in the past (actual) and in the future (forecast and planned). |

[14] Chartered Institute of Building (2010) Code of Practice for Project Management for Construction and Development (4th edition), Wiley-Blackwell

[15] Chartered Institute of Building (2011) Guide to Good Practice in the Management of Time in Complex Projects(1st edition), Wiley-Blackwell

| **Term** | **Definition** |
|---|---|
| **CDM Regulations** | The health and safety rules and regulations applicable in the UK. |
| **Change order** | An alternative name for variation order, it indicates a change to the project brief. |
| **Change control** | A process that ensures potential changes to the deliverables of a project or the sequence of work in a project, are recorded, evaluated, authorised and managed. |
| **Change management** | The art and science of controlling the effect of a departure from the contract quality, quantity, methodology, cost and timing of the work |
| **Client** | Entity, individual or organisation commissioning and funding the project, directly or indirectly. |
| **Client advisor** | An independent construction professional engaged by the client to give advice in the early stages of a project, as advocated by the Latham Report. |
| **Commissioning team** | *Client commissioning*: predominantly the client's personnel assisted by the contractor and consultants. *Engineering services commissioning*: specialist contractors and equipment manufacturers monitored by the main contractor and consultants concerned. |
| **Completion date** | The end-date for the works, the subject of the planning and scheduling process. |
| **Consultants** | Advisors to the client and members of the project team. Also includes design team. |
| **Contiguous duration** | The gross period of time required to carry out an activity in an uninterrupted process. |
| **Contingency** | A provision of resource and/or time which may or may not be required. |
| **Contingency plan** | Mitigation plan alternative course(s) of action devised to cope with project risks. |
| **Contractor** | Generally applied to: (a) the main contractor responsible for the total construction and completion process; or (b) two or more contractors responsible under separate contractual provisions for major or high technology parts of a very complex facility. (see **Subcontractor**). |

| Term | Definition |
|---|---|
| **Designed and Build** | A form of project procurement in which the contractor also carries the design responsibilities. |
| **Design audit** | Carried out by members of an *independent* design team providing confirmation or otherwise that the project design meets, in the best possible way, the client's brief and objectives. |
| **Design freeze** | Completion and client's final approval of the design and associated processes, i.e. no further changes are contemplated or accepted within the budget approved in the project brief. |
| **Design team** | Architects, engineers and technology specialists responsible for the conceptual design aspects and their development into drawings, specifications and instructions required for construction of the facility and associated processes. |
| **Down time** | The period (usually brief) when work is suspended. |
| **Driving relationship** | A relationship by which either the logical start or logical finish of an activity is dependent upon the start or finish of an activity. |
| **Duration** | A period between the start and finish of an activity. |
| **End user** | Organisation or individual who occupies and operates the facility and may or may not be the client. |
| **Engineer, procure and construct** | Sometimes called 'turnkey'; a form of contract in which the contractor adopts the obligation of fitness for purpose in designing and providing the finished product ready for use. |
| **Environmental conditions** | Usually weather conditions, but can be other conditions in which activities have to be carried out, e.g. mines and some large-scale, heavy-engineering projects (dams, nuclear power stations and the like). |
| **Facilities management** | Planning, organisation and managing physical assets and their related support services in a cost-effective way to give the optimum return on investment in both financial and quality terms. |
| **Facility** | All types of constructions, e.g. buildings, shopping malls, terminals, hospitals, hotels, sporting/leisure centres, industrial/processing/chemical plants and installations and other infrastructure projects. |

| Term | Definition |
|---|---|
| **Feasibility stage** | Initial project development and planning carried out by assessing the client's objectives and providing advice and expertise in order to help the client define more precisely what is needed and how it can be achieved. |
| **Handbook** | See **Project handbook**. |
| **Implied variation** | An act or omission which is deemed to be a variation. |
| **Key date** | A term usually used for the date upon which a work stage is to be completed. |
| **Labour** | A human resource. |
| **Life-cycle costing** | Establishes the present value of the total cost of an asset over its operating life, using discounted cash flow techniques, for the purpose of comparison with alternatives available. This enables investment options to be more effectively evaluated for decision-making. |
| **Lockout** | Exclusion of the workforce from the works by the employer. |
| **Logistics** | Management of the flow of resources from procurement to completion of the works. |
| **Master programme** | This is the name given under some forms of contract to the baseline schedule, against which progress is expected to be monitored. It bears no relationship to the concept of the dynamic working schedule, used as a time model for the purposes of time management. |
| **Mitigation** | Action taken to alleviate predictable loss, expense or delay. |
| **Occupation** | Sometimes called *migration* or *decanting*. It is the actual process of physical movement (transfer) and placement of personnel (employees) into their new working environment of the facility. |
| **Out-turn cost** | The ultimate cost of a project: the tender cost plus the cost of variations and compensation for loss and/or expense, including consultant's fees, planning fees and licenses etc. |
| **Overload** | The status of a project in which, in order to meet a duration, resources are required in excess of that planned. |
| **Overtime** | Time required to be worked in excess of the regular or normal hours of work. |

| Term | Definition |
| --- | --- |
| **Pacing** | Slowing down of work for the reduction of resources to keep pace with delayed work. |
| **Planning** | The determination and communication of an intended course of action incorporating detailed method(s) showing time, place and resources required. |
| **Planning gain** | A condition attached to a planning approval which brings benefits to the community at a developer's expense. |
| **Planning supervisor** | A consultant or contractor appointed by a client under the CDM Regulations to carry out this role. |
| **Prime cost sum** | A contingent sum of money included in the contract sum for work to be carried out by a specialist subcontractor of for materials yet to be specified. |
| **Principal contractor** | The contractor appointed by a client under the CDM Regulations to carry out this role. |
| **Programme** | The time-control document required by some form of contract, usually in printed form (see also Schedule). |
| **Programme management** | A programme of works comprises a number of projects that are related because they contribute to a common outcome. Programme management provides coordinated governance to the realisation of benefits that result from projects; it is concerned with initiating projects, managing the interdependencies between projects, managing risk, and resolving conflicting priorities and resources across the projects. |
| **Procurement** | The process (but not limited only to the tender procedures) of obtaining goods and services from preparation and processing of a requisition through to receipt and approval of the payment. |
| **Project** | Unique process, consisting of a set of co-ordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including constraints of time, cost and resources. |
| **Project brief** | Statement that describes the purpose, cost, time and performance requirements/constraints for a project. |

| Term | Definition |
|---|---|
| **Project execution plan** | A plan for carrying out a project, to meet specific objectives, that is prepared by or for the project manager. In some instances this is also known as the project management plan. |
| **Project handbook** | Guide to the project team members in the performance of their duties, identifying their responsibilities and detailing the various activities and procedures (often called the project bible). Also called project execution plan, project manual and project quality plan. |
| **Project insurance** | Project insurance is the descriptive title for a suite of insurances that are specifically designed to meet the needs of individual projects as opposed to relying on the individual insurance arrangements of the project team. |
| **Project manager** | Individual or body with authority, accountability and responsibility for managing a project to achieve specific objectives. |
| **Project schedule** | Time plan for a project or process. Note: on a construction project this is usually referred to as a 'project programme'. The construction industry tends to refer to programmes rather than schedules. Indeed the term schedule tends to mean a schedule of items in tabular form, e.g. door schedule, ironmongery schedule, etc. |
| **Project scope** | All the work to be carried out to reach the project's objectives: there could well be several contracts involved in project delivery from project viability, feasibility, design and implementation/construction. |
| **Project sponsor** | The project sponsor represents the client (which is usually the government) acting as a single focal point of contact with the project manager for the day-to-day management of the interests of the client organisation. |
| **Project team** | Client, project manager, design team, consultants, contractors and subcontractors. |
| **Provisional sum** | A contingent sum of money included in the contract sum for work of which the detail cannot be fully described at the time of tender. |
| **Recovery** | Making up of lost time at the contractor's expense (see also Acceleration). |

| Term | Definition |
| --- | --- |
| **Remaining time** | The duration planned to elapse before an activity is completed. |
| **Resource** | Anything necessary for the achievement of work but typically materials, labour, plant, space, cost. |
| **Risk** | Combination of the probability or frequency of occurrence of a defined threat or opportunity and the magnitude of the consequences of the occurrence. |
| **Risk analysis** | Systematic use of available information to determine how often specified events may occur and the magnitude of their likely consequences. |
| **Risk factor** | Associated with the anticipation and reduction of the effects of risk and problems by a proactive approach to project development and planning. |
| **Risk management** | Systematic application of policies, procedures, methods and practices to the tasks of identifying, analysing, evaluating, treating and monitoring risk. |
| **Risk register** | Formal record of identified risks. |
| **Schedule** | The time-model for the work. |
| **Statutory approvals** | Permissions which are required by law. |
| **Strategy stage** | During this stage a sound basis is created for the client on which decisions can be made allowing the project to proceed to completion. It provides a framework for the effective execution of the project. |
| **Subcontractor** | An individual or company to whom the contractor sublets the whole or any part of the works. This covers such elements as design, specialist trades and labour-only supply. |
| **Temporary works** | Work which must be carried out in order to construct the permanent works, but which is not intended to remain. |
| **Tenant** | Facility user who is generally not the client or the developer. |
| **Tender** | An offer to carry out work for compensation under a contract (also known as a bid). |

| Term | Definition |
|---|---|
| **Testing and commissioning** | The process of validating and adjusting the permanent works, or any part of it, and rendering it fit for use. |
| **Trade** | A particular specialised type of work. |
| **Unexpected contingencies** | A time allowance which is unused (see also Contingency). |
| **User** | The ultimate occupier of the facility. |
| **Utilities** | The public-company suppliers of water, gas, electricity, communications and other public available service. |
| **Variation** | An instructed change as defined under the contract. |
| **Work pattern** | The name given of work in the detail which renders it unique amongst other work descriptions of like type. |
| **Zone of operation** | A division of the work for the purpose of management and control. |

# Notes

# Notes