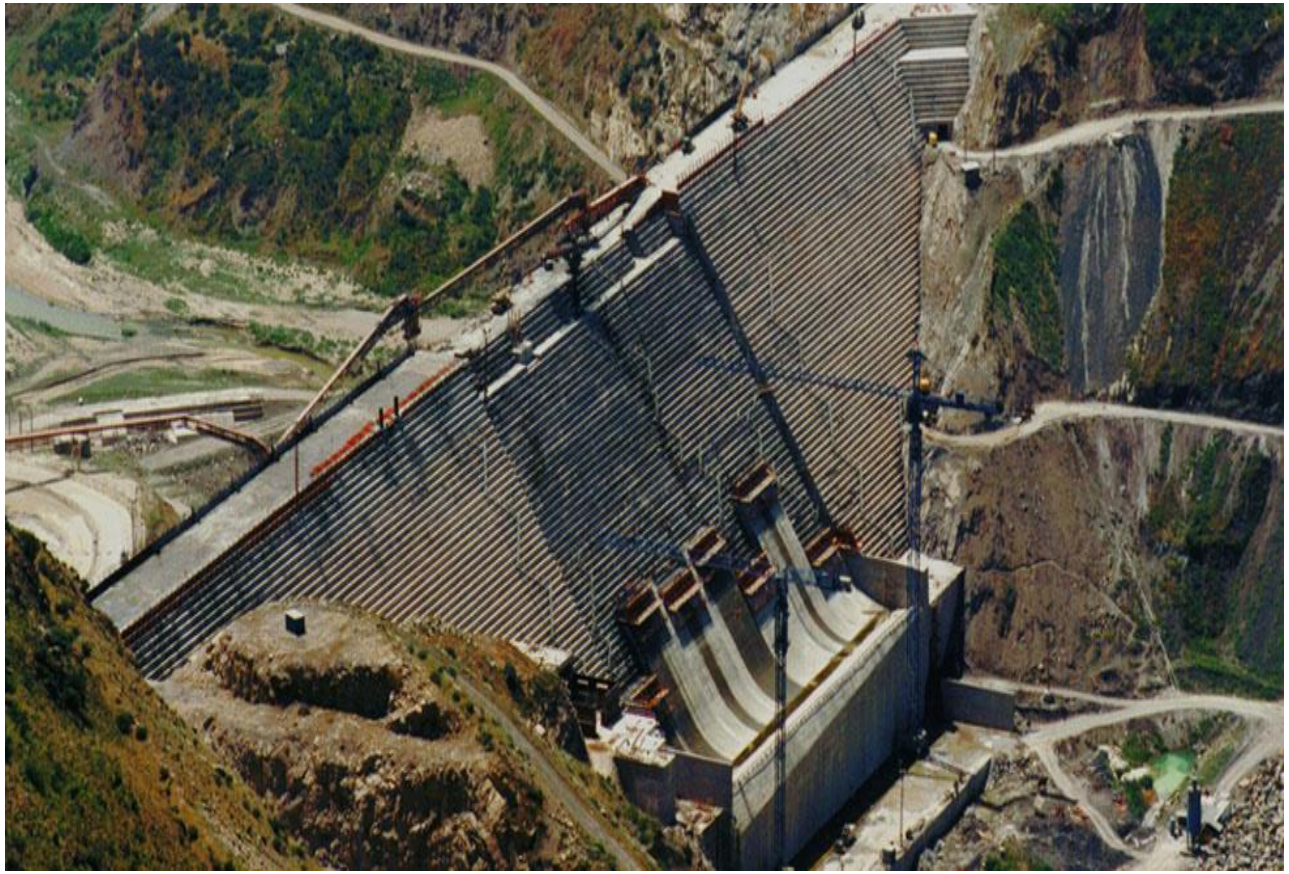
Common vocabulary in Hydraulics construction site



Construction phase

Commisionning phase

Figure 1: Beni-Haroun RCC dam

Common vocabulary in Hydraulics construction site

Water transfert El eulma- Mahouane

Water transfert In Salah -Tamanraset

Figure-2: Water supply projects

Common vocabulary in Hydraulics construction site

- **What is a construction site?**
- Whatch the video: https://www.youtube.com/watch?v=mbwuj58UEPg

- A construction site is an area or piece of land where construction work is taking place after contractor handed over the contract.
- Generally construction sites are referred to as ‘building sites’. This usually implies that buildings or houses are being constructed, whereas ‘construction site’ covers a large scope of work. This could refer to anything from a house extension to road or bridge or dams construction or a huge engineering project, such as the creation of a new power station.

Common vocabulary in Hydraulics construction site

- Construction sites are exciting; however, when working onsite, it's important to be aware of any potential risks to yourself or to others and where possible.

- Integrity of people then integrity of equipment.

- You should be familiar about safety rules and to protect yourself and the environment (HSE: Health Safety & Environment).

Common vocabulary in Hydraulics construction site

- **key roles working onsite**
- Depends on construction project type and phases ; tasks are varying and accordingly the intervenant however it include.

Site Manager: incharge of planning and coordinating resources, ensure smooth communication between working teams and contractors, monitor progress and produce many kind of reports for clients.

Engineers: plan, design and manage construction operations by leading field specialist and operators and skilled workers. They also assemble the necessary equipment and materials required to achieve the construction in accordance with quality and safety standards.

Common vocabulary in Hydraulics construction site

- **key roles working onsite**
- **Surveyors:** (In Fr: Topographes) provide measurements and professional advice on a range of construction-related matters, from the beginning to the end of the project.
- **Operators:** employees who are preparing ground, driving heavy machinery, moving materials, erecting scaffolding and carrying out work whilst a project is in progress.
- **Skilled people:** can be carpenters, plumbers, painters and welders but not limited to these categories it depends on the nature of the project and the progress phase.
- We have also support from cost controller, accountant and legal expert in addition to human resource.

key parties involved in construction projects

- Any construction has an **Owner** (**client**), in French we call it **Maitre d'ouvrage**.
- The builder of the construction is called **Contractor,** in French **Maitre d'œuvre** .
- The construction is built by the contractor to the benifit of the client, these works of build is managed by a **Contract**.
- In case of big and/or high tech projects contractor can **Sub-contract** some works, in French we call it **Sous-traitant**.
- The organizations providing technical study and drawing are known as **Designers** (Bureau d'étude).

key parties involved in construction projects

Definitions:

Owner (Client): Every construction project starts with an owner who has a **need for new or expanded facilities that will satisfy a specific demand**. Client duties are: what is to be constructed, where, when and by whom. He can be from **public** or **private** sector. He can be a natural or legal person (**Fr**. personne **physique** ou **morale**). It is not compulsory that client has full competency or time to fulfill his role.

e.g: Natural person can be an entrepreneur. Legal person (DUCH: Direction d'Urbanism et de la Construction et de l'Habitat).

The owner is **accountable** for the following:

- Developing the needs and requirements of the end users.
- Determining the quantity, by defining the scope of work.
- Creating the overall budget for the project and the calendar of reception .
- Providing the funding for the project and making periodic payments to the designers and the contractor.
- Select contractors, designers and conclud the contract.
- Reception of the construction.

key parties involved in construction projects

Contractor: The Main Contractor oversees and manages the construction for the Client, following the design prescription. The work is delivered under a contractual agreement with clear terms and conditions. They must have the skills, knowledge, experience and, where relevant, the organisational capability to carry out the work safely and without risk to health.

The Main Contractor can select specialist sub-contractors based on their capability/experience, availability and price. Contractor ensure that construction works will not be delayed by lack of product/material, equipment and human resources availability and that achieved construction cost remains within the estimate, so they can remain profitable and meet client needs.

Contractor duties:

- Plan, manage and monitor all work carried out by himself and their workers or his sub-contractor.
- Ensure that all workers have the skills, knowledge, training and experience to carry out the work required, , same apply for sub-contractor.
- Ensure appropriate supervision, information and instructions to workers under his control, same apply for sub-contractor.
- Do not start work on site unless reasonable steps have been taken and permits are in place and welfare facilities are provided for workers.

key parties involved in construction projects

Designers: A designer is an organisation or individual whose business involves preparing or modifying designs for construction projects, or arranging for, or instructing, others to do this. Designs include drawings, design details, specifications, bills of quantity and design calculations. (UK, CDM regulations,2015). Designers can be architects, engineering consultancy, or anyone who specifies and alters designs as part of their work.

Designers are accountable for:

- When preparing or modifying designs; check of any pre-construction information provided by the client.
- Take steps to reduce or control any risks that cannot be eliminated.
- Provide design information to client and principal contractor.
- Communicate, cooperate and coordinate with client contractor, sub-contractor.
- Eg: Tractebel (international engineering firm from Belgium) was the engineering consultancy for Beni-Haroun and Koudiat Acerdoun dams selected by l'ANBT.
- **Contract:** it is an agreement between two parties (client & contractor) such that is enforceable (execution) by the law and it must be agreed. It is a negotiation between both parties for cost control first and other terms and conditions. The two parties involved are one or more property owners and one or more contractors.Contracts have many aspects that should be read carefully, they are complex legal instruments that help govern the relationships between concerned parties.

Contract legal aspects and types

Legal aspects (volet juridique):

- **Project Scope and Performance Standards:** must be defined in details by describing the work to be performed, **quality standard,** and the expected reception. Failure to commit will lead to dispute according to contract clauses.
- **Payment and Compensation:** Contract stipulate the payment mode and schedule and the currency of payment.
- **Timeframes and Delays:** specify the project timeline and may include penalties for delays as per the agreed Terms and Conditions (T&C).
- **Risk Allocation and Insurance:** contracts allocate risks between parties. Insurance requirements, such as liability and worker's compensation to protect the parties involved in case of accidents, damage, or disputes.
- **Dispute Resolution:** In case of disagreements the contract define the resolution process (negotiation, mediation, arbitration or litigation) and the legal court for dispute and the language used for that.
- **Regulatory Compliance:** The contract should outline who is responsible for obtaining permits and meeting country legal requirements.
- **Termination and Suspension:** Circumstances under which the contract can be terminated or suspended should be clearly mentioned (breaches of contract (rupture de contrat), insolvency (insolvabilité), or force majeure events.

Contract legal aspects and types

Important:

A well-drafted contract can prevent disputes, give chance to claim any change, and ensure that the construction project performs smoothly and successfully. However, the legal aspects of construction contracts are subject to change, so it is essential to engage legal counsel with expertise in construction law to review, to create and enforce these agreements effectively. So, projects can be executed with a greater degree of confidence, safeguarding the interests of all parties involved. This will make the deal a win-win for both parties.

Main contracts types:

Contracts types depends on the project complexity and circumstance. Here are main but it is not limited to only these.

- lump-sum contract
- cost-plus construction contract
- unit price contract
- design and build contract
- incentive construction contract
- integrated project delivery contract
- time and materials contract

Contract legal aspects and types

contracts types definition:

- **Lump-sum contract**: Contractor deliver the project at a pre-agreed price.
- **Cost-plus construction contract**: Contractor is paid for all the construction expense (e.g: mobilization and custom fees).
- **Unit price contract:** The client pays the contractor on unit basis at agreed upon rates.
- **Design and build contract:** Both design and construction cost are addressed simultaneously.
- **Incentive construction contract:** Agreed-upon payment if the project is delivered by a certain milestone.
- **Integrated project delivery contract:** A multi-party agreement between design firm, constructor, and client.
- **Build Operate then Transfer (BOT) contract:** The contractor designs, builds, and manages the construction until the end of the concession period. Then he will transfer it to the property of the owner after getting profits on invested capital, and accepted the risks.

Contract legal aspects and types

Contract type	Advantages	Disadvantages
Lump-sum	Presents a digestible, easy-to-plan-for figure to the owner.	Aren't a good fit for complicated projects.
Cost-plus construction	There's seemingly no risk of losing, it focus on quality	You must keep tracking of all of your expenses and some times you are limited to " not to exceed" amounts for cost.
Unit price	Suitable for projects that can be easily divided into units.	In complexe projects can lead to profit loss if the initial estimates are off-target.
Design and build	Speed up the process and avoid disputes between the designer and builder	No competitive bidding phase, the final costs may be higher.
Incentive construction	Beneficial for controlling costs and timelines. Communication is good.	If the terms and conditions are not clear, it can lead to disputes. Contractor and owner should agree on what incentive looks like.
Integrated project delivery	It spread the risk and reward fairly across parties.	still relatively new, some design firms and subcontractors may not want to participate
Build Operate Transfer BOT	the risk associated with such large-investment projects is shared between the parties.	Suitable for large and complexe projects , It can be tedious and time-consuming.

Common jargon in construction

Terminology and definitions in construction:

Preliminary study (étude préliminaire): A preliminary study includes a technical survey of your site to make sure that premises (fr. locaux/construction)or land property is suitable for the development of the project. We are carrying out all necessary inspections and investigations such as:

- Topographique and geotechnical survey
- Environmental impact assessment
- Obtaining and analyzing of data in archives
- Communication with municipality and state authorities

Feasibility study (étude de faisabilité): it is an assessment of the practicality of a project or system and a detailed analysis that considers all of the critical aspects of a proposed project in order to determine the likelihood of its succeeding. It must assesses whether a proposed project is legally and technically feasible, as well as economically justified and profitable(in most cases). This means that the project will generate enough profit to justify the investment.

Common jargon in construction

Terminology and definitions in construction:

Preliminary design (Avant projet sommaire APS): In contrast to detailed design this document define the main parameters of the project. These include the job site location, total area, as well as the capacity or the volume that specify the project. it gives summarily the key element of the project. It is useful in pre-investment stage(phase primaire).

Detailed design (Avant projet détaillé APD): Detailed design is the phase that provides a level of documentation that clearly defines the design, specification and scheduling of all works and materials necessary to complete the project. it is the most commonly used to obtain a contractor for the construction of the works. It include the following:

- Proposed materials, techniques and standards for execution.
- Specifications of systems, calculation and dimension.
- longitudinal profiles and cross profiles.
- Earth work and site management plans.
- work scheduling …….

Project life cycle (Fig-3)

Source: https://tractebel-engie.com/en

Contract execution

Contract handover: to avoid any misinterpretation of contract term and conditions legal department in company should make an explanation to the team executing this contract and share lesson learned from past similar contracts.

Work order: after signing the contract by both parties and making a good handover, it is mandatory that client begun work by initiating a work order (order de service)describing the requested works and the estimated related cost. This work order will be annexed to the invoice in order to get paid and avoid any misunderstanding.

What if the contract miss some details?

Contract execution

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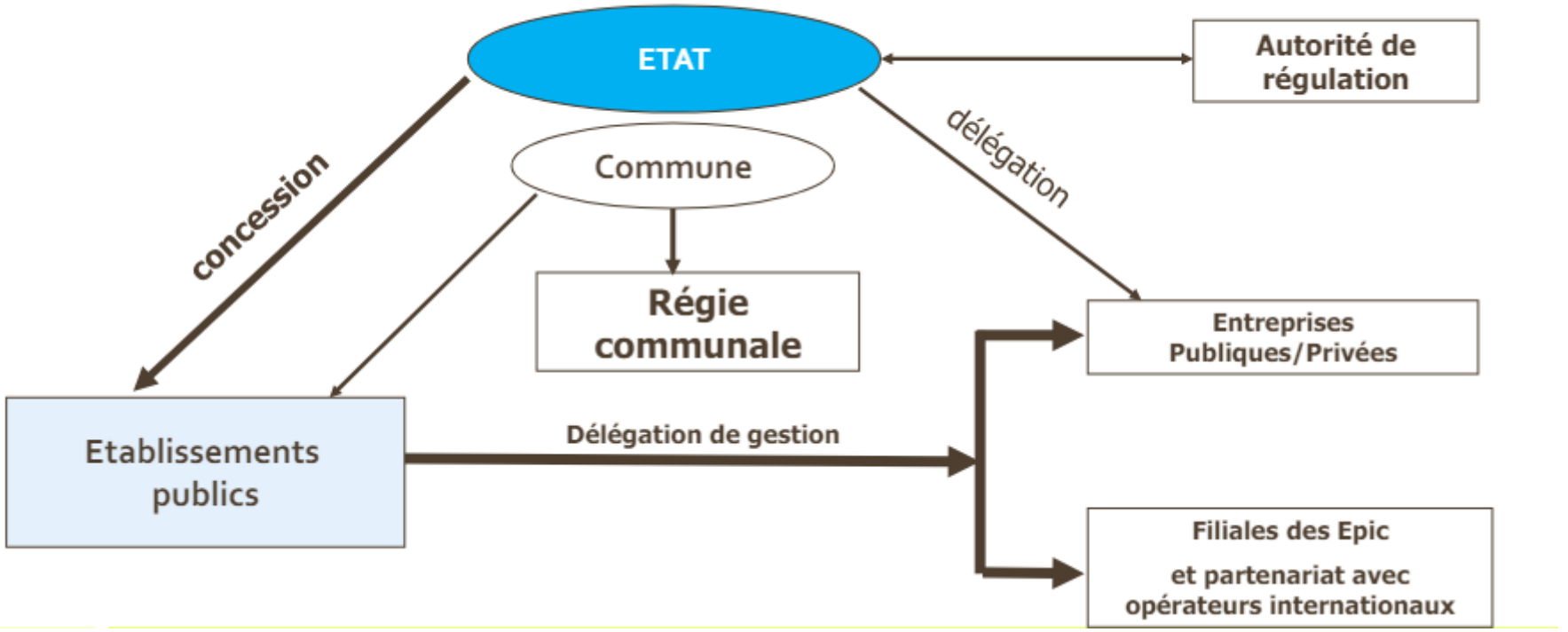
What if the contract miss some details?

Hydraulic sector Management in Algeria



Ref: Djelouah K, 2018

Hydraulics infra-structure in Algeria by 2018

8800 forages
5,7 Mo de m³ /jour

80 barrages
8,6 Mrds m³

11 stations dessalement
2,1 Mo de m³ / jour

21 transfert et adduction
en aval barrages et à l'extrème sud

100 stations
de traitement
5 Mo de m³ /jour

23 stations
déminéralisation
254.000 m³ / jour

+14.000 d'ouvrages
de stockage et régulation
8,8 Mo de m³

127.000 km de réseaux

Ref: Djelouah K, 2018

Hydraulics works mechanisation

Mechanisation: is the process of changing from working largely or exclusively by hand or with animals to the use of machine. This machine is defined as is a physical system that uses power to apply forces and control movement to perform an actions in order to accelerate production and improve efficiency of the whole operations. It reduce considerably the project lead time.

Histroy of mechanisation in hydraulics:

From the water wheel and Archimedes' screw in the ancient civilization passing by watermill during the middle age to arrive at the powered pumps and petrol engine that make several types of machines and equipment improving hydraulics works productivity and quality.

Earth moving equipment has a huge impact on water supply, sewage networks and hydraulics constructions.

In our days the component of hydraulics systems are in rapid change and a lot of automation has introduced to manage effectively hydraulics constructions and operations.

Hydraulics systems and components

- Urban hydraulics systems are mainly water supply, sewage networks and its associated structures such pumping stations, waste water treatment plant, desalination plant, storage system…….

Works Executions and Planning

A good work execution means a well site organization and well thought out process, which ensures a healthy and safe construction site during its build. An organized hydraulics construction site establishing a well and **efficient coordination system** among different parties, and performing a **good site layout planning**.

These works must meet the standards in regulation and apply the maximum possible mechanical tool and equipment to make the project economically profitable and provides solutions that improve efficiency.

Note: **mechanisation only is not enough** but operations planning of the mechanical tools is a crucial step to achieve the goal of a hydraulics works efficiency.

Job planning and schedule

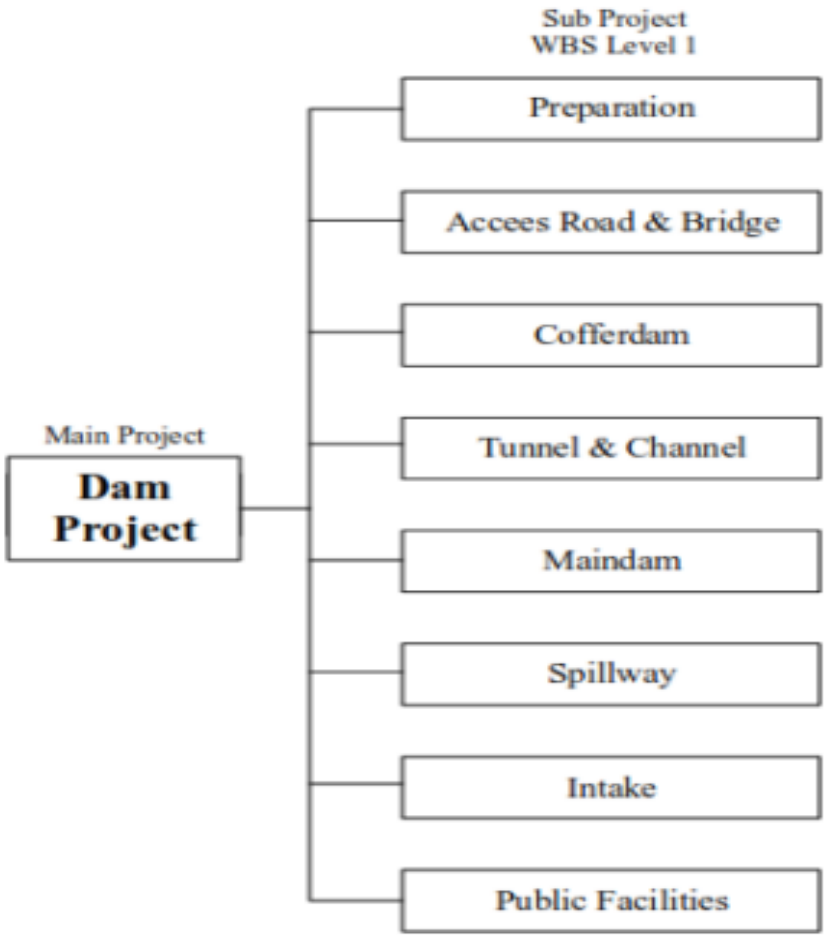


Figure 4: Work break down of a Dam Project

Job planning and schedule

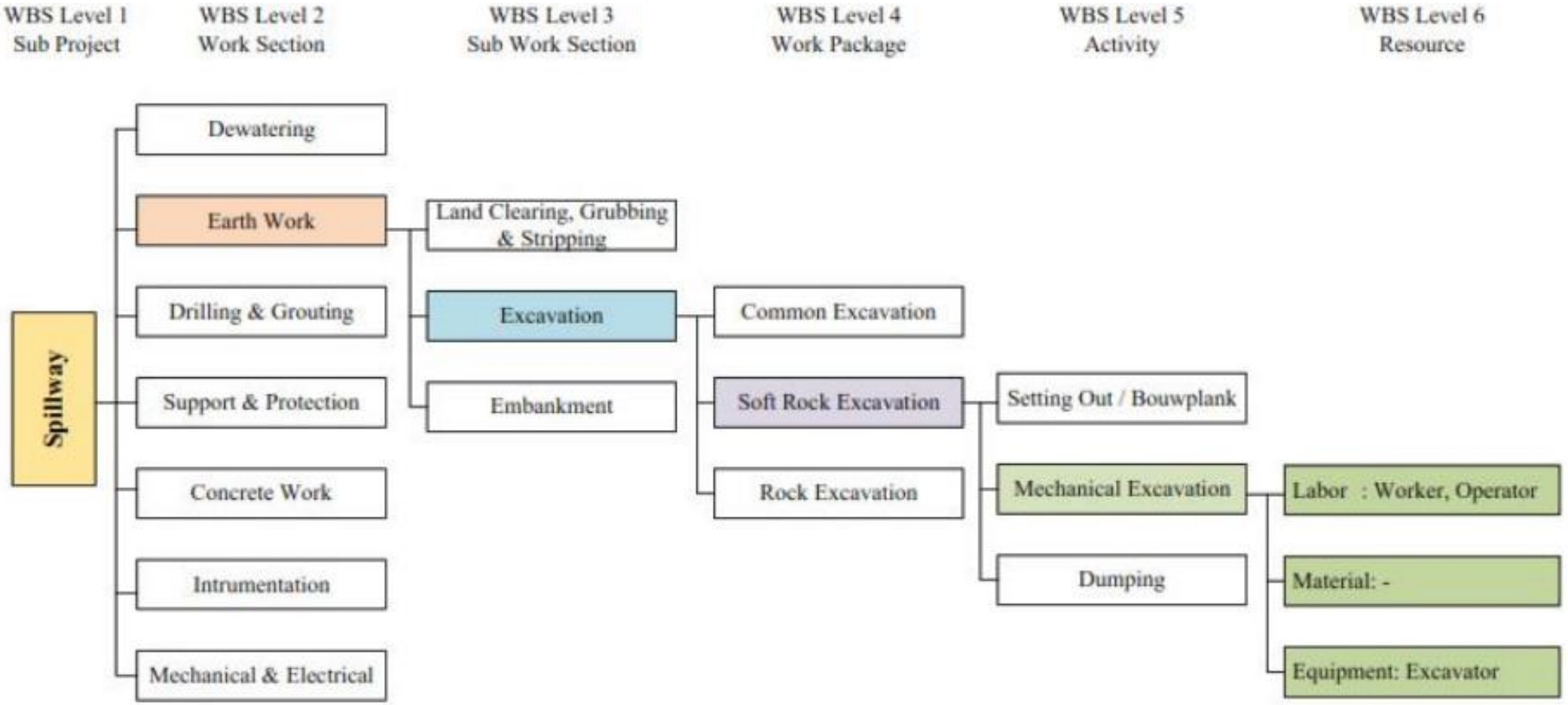


Figure 5: Work break down for spill way construction

Job planning and schedule

- At the lowest level of the WBS we have the work package which is a clearly defined activity or group of activities whose duration can be estimated.

- A project schedule includes
  - the sequence of activities,
  - the duration planned for each activity, and
  - relationships or dependencies between the beginnings and ends of different activities.

- The project schedule is created
  - AFTER the scope planning has created the WBS
  - BEFORE project resource planning

Job planning and schedule

Project scheduling is one of the most important processes which combines time, tasks, resources and cost in a project.

Schedules are created by listing the activities, determining activity durations, and assigning activity relationships.

The tools figure out the schedule are:

- Gantt Chart
- Diagram network (AOA + AON)

Job planning and schedule

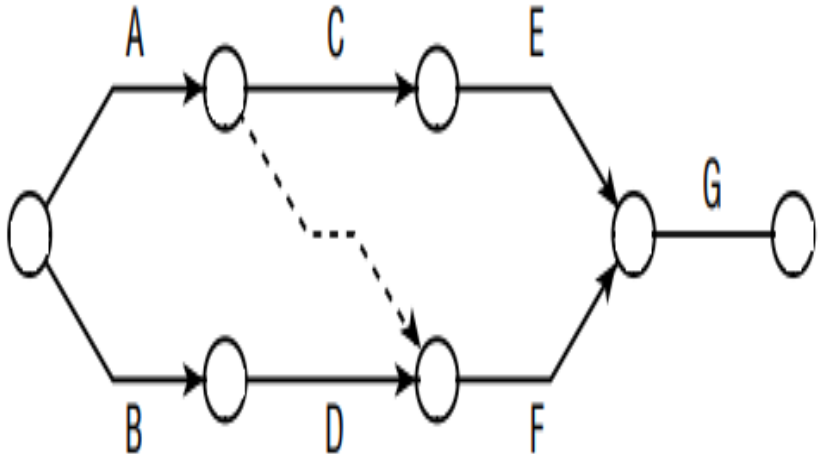


Figure 6: **Activity on arrow diagram**

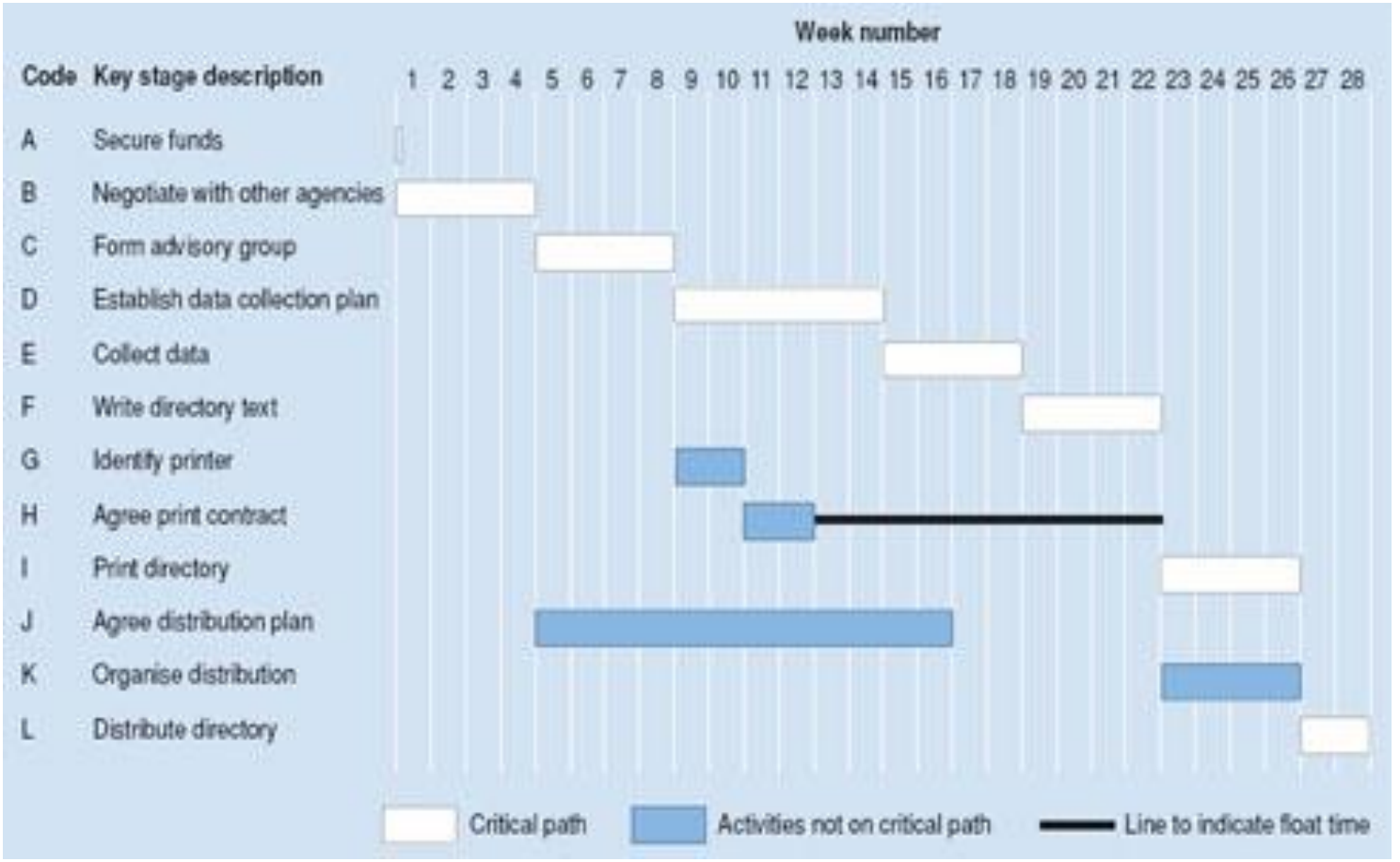


Figure 7: **Barr chart schedule**

Job planning and schedule

- Network Diagram: **A**ctivity **O**n **N**ode (Precedence Diagramming Method)

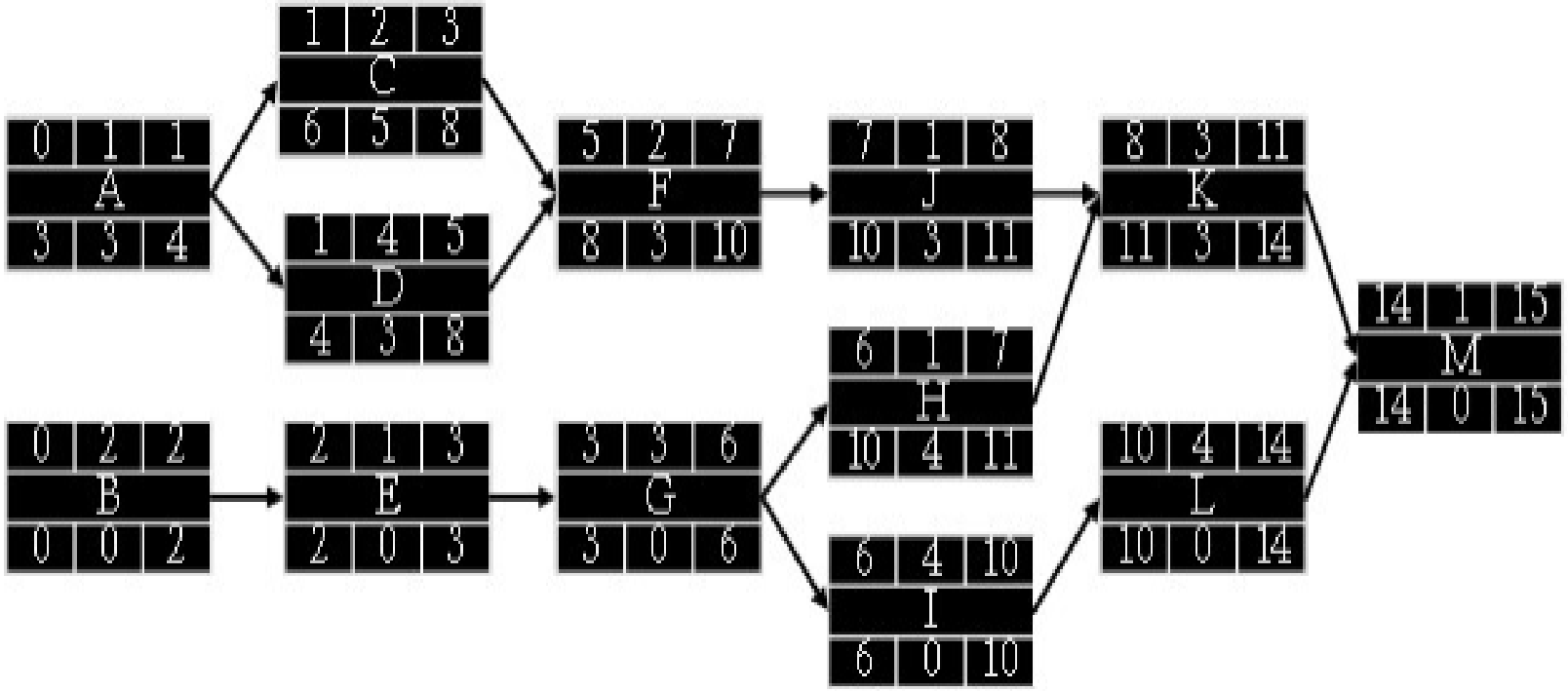


Figure 8: Activity Network Diagram with Durations

Hydraulics works sequences

The winner of the tender needs some necessay documents such as the **POS** (Plan d'Occupation des Sols) and the **PDAU** (Plan Directeur d'Aménagement et d'Urbanisme) to run any activity .

After getting the official start of the works by receiving the work order, a 1 st visit to job site with relevant actors (Intervenants) is compulsory. At this stage an execution plan/file is delivered to the contractor, this installation visit is documented in the meeting minutes (Procés verbal **PV**).

- We will see here the construction of a potable water supply network and the steps that comprises:
- 1) Job planning and schedule,
- 2) site preparation,
- 3) Earth moving and excavation,
- 4) trench dewatering (if needed),
- 5) pipe jointing (raccordement) systems,
- 6) pipe laying and backfilling (pose et remblais),
- 7) testing.

Job site installation (Water supply network)

In water supply network a special coordination is required since multiple steps are conducted simultaneously; at laying the pipe and testing it, the back fill started at the other ends. The lay down can not be started only if the route is completly clear which is difficult in urban area.

An agreement with the regulatory authority should be obtained about the working area so that other daily activities are not significantly affected during construction . It is **mandatory** to develop a **traffic control** plan:

1) **Traffic assessment:** the volume, speed, and types of vehicles, as well as pedestrian activity. Consider nearby intersections, road configurations, and any existing traffic control devices.

Figure -9: job site warnings signs

Job site installation (Water supply network)

2) **Work Zone Identification:** Identify the pipe-laying activities areas. Determine if temporary lane closures or full road closures are necessary or not and assess the potential impact on traffic patterns.

3) **Roadway Markings and Signage:** Proper signage is highly important to ensure safety and security of job site, crossings for pedestrians, warnings signs (speed limitation, restricted access, detours,..) must be clearly visible day and night.

4) **Temporary Traffic Control Devices:** Deploy temporary traffic control devices, including cones, barricades, delineators, and channelising devices, to guide traffic safely through the work zone. This must be for a temporary period.

5) **Flagging Operations:** some times signage is not enough and manual flagging operations are necessary to control traffic, you should have trained flaggers to guide vehicles safely through the work zone.

6) **Emergency Response Planning:** Develop protocols for emergency to navigate through the work job sie efficiently by coordinating with local emergency services to ensure they are aware of the project and can help and know how to help.

These are the main steps to have practical traffic control plan in urban zones that must regularly assessed on effectiveness. In rural area it will be more easier to install a job site since you have more space.

Job site installation

Pipes received onsite must be certified prior to leave the factory and checked again at job site t check any damage during the loading and unloading, It must be stored and stacked as showen in Fig-10.

Figure-10

Pipes and fittings waiting to be installed should be kept clean in a fenced storage as a protection against potential theft and vandalism Fig-11.

Figure-11

Earth moving and excavation (Terassement)

For water supply network excavation is the most expensive part of pipe laying, the selection of trench dimension and its positioning is made by the topographic surveyor, he is a key player to refers all excavations, its coordinates and its altitudes. Now day it is conducted using an electronic distance metering (EDM).

Excavation can be made by hand in case of confined space but it is mainly mechanized. There are a lot of types of excavators that can be classified based on size and the type of its bucket (godet).

Figure-12: Excavotor for wide trench

Figure-13: Excavotor for narrow trench

Earth moving and excavation (Soil challenges)

It is not easy to excavate any type of soil, see the below figure to understand how much the problem is complicated (figure-14) and see also (figure-15) the recommended trench side slope angle (Θ) in function of (H, L[kg/m2], Ø).

H: maximum allowable depth of the trench.

L[kg/m2]: acceptable load on the soil.

Ø: Pipe diameter

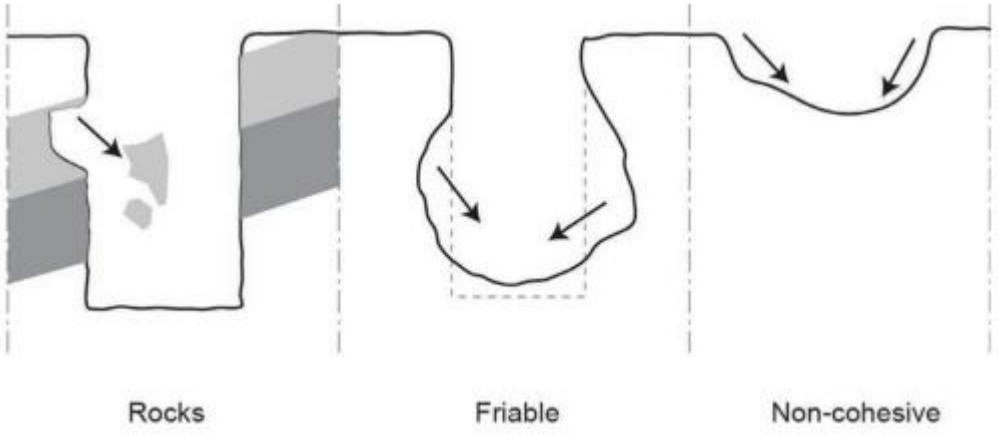


Figure-14:Soil types

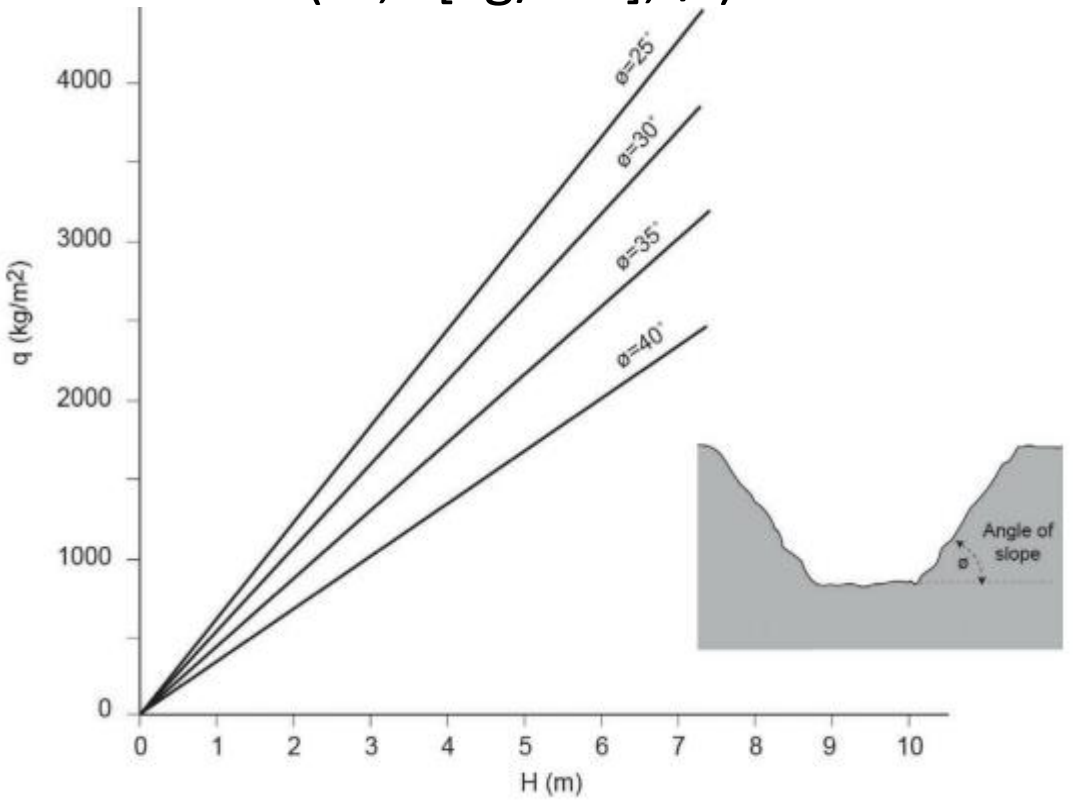


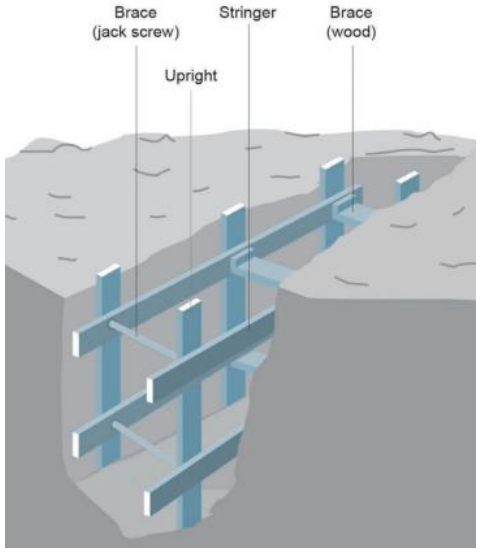
Figure-15: Trench slope angle

Earth moving and excavation (Soil challenges)

For quick and small project that not require high standards we can use the below norms from the american water wroks association as reference at different type of soil figure 16, slope marker is (Hz/ver).

To ensure trench slope from collapse differents

Techniques of protection can be applied see below:



wooden panel

Palplanche (fr)

Steel panel

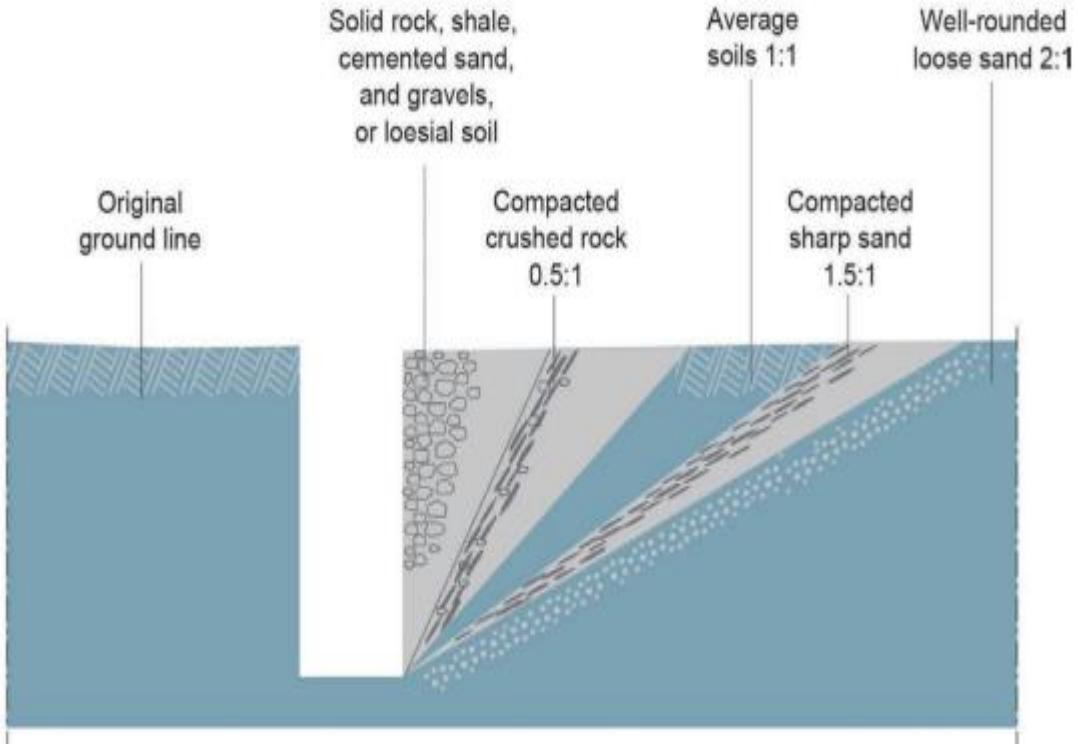


Figure-16:Trench slopes according to soil type.

Earth moving and excavation (Terassement)

For big projecst of water transfer, especially for large diameter and long distance cost are very high (In Salah- Tamanraset water Transfer for 740 Km, 100000 m3/Day) , mecanisation and planning are the key elements to make it cost effective. One of the best machine that reduce the pharaonic cost (US$2.5 billion) is the use of Trencher Machine mainly for soft to medium formation.

This Trencher is used for big diameter pipelines and

deep trenching works (sewage, water, drainage networks).

Benifits:

- Superior performances compared/ traditional excavators
- Fuel consumption reduction
- Safe & easier trencher operation (No skilled operator)
- Smart tracker; GPS data recorder

Figure 17:Chainsaw Trencher for big diameter and deep trench 1.8 m (Courtsey Tesmec)

Earth moving and excavation (Terassement)

For smaller trenches (Less than 300 mm wide and 1 m deep) vacuum excavation can be used. After cutting the surface and removing the top layer in a conventional manner, a special pneumatic digging tool is used. so, the soil is then removed through a flexible hose. This technique is used in urban areas where traffic is high see the below figure-18 and watch the following video at this link https://www.youtube.com/watch?v=NYU_46yaSXo.

Figure 18: Vacuum Excavator

Earth moving and excavation (Terassement)

Vacuum excavator is the safest, fastest, and most economical method of excavation. Its benefits include:

- **Reducing noise and keep the work area clean,**
- **Reduce considerably man power and equipment required,**
- **Minimising traffic disruption in big cities,**
- **Reduce cost of service.**

The preferred excavation method depends on:

available space on the site, soil conditions,

and width and depth of the trench.

Of course the contract will indicate this

Conditions.

In confined space and unknown

Pipe route it is mandotory to do

it manually , see figure-19.

Figure-19: Manually excavated trench

Earth moving and excavation (Terassement)

Contracts are well defining the excavation types according to soil type and network size and type, digging depth is a standard for each type of network (water, sewer,…..). The Algerian authority made the DTR_2006 as a main guide to define most of networks works, you can dowload it from here: https://kupdf.net/download/dtr-vrd-2006_58cd53d5dc0d608a57c3463a_pdf.

If the network/pipe route present some hills and up/down topography a grading is necessary using graders and/ or backloader (Most common equipment in Algeria) as polyvalent machine.

Figure-20: Motor Grader (Niveuleuse)

Figure-21: Back-loader

Earth moving and excavation (Trench dewatering)

In some situation water can influx from ground into trench and precipitation can also fill up the trench while bad weather conditions. So, the solution is dewatering techniques.

For surface water, it will be handled by centrifugal or vacuum/diaphragm pumps.

For saturated water, we must opt for wellpoint dewatering technique (see figure-22).

Wellpoint dewatering: is a groundwater control method that removes water from saturated soils. It is a small-diameter, closely-spaced shallow well, which offers a highly economic and versatile method of groundwater control where drawdown requirements onsite are less than 5-6 m in depth.

To understand how the technique it works please watch the Video in this link:

https://www.youtube.com/watch?app=desktop&v=lUjTjADapcc

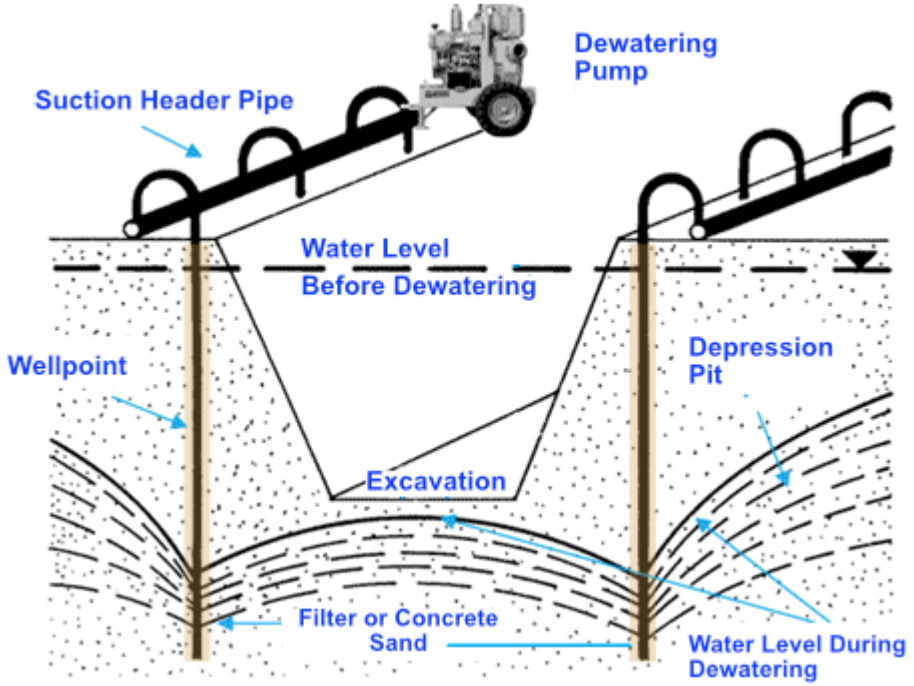


Figure-22: Wellpoint dewatering technique

Source: www.prattandsons.com/product

Network construction: Pipes laying (Terrassement)

To select the right pipe for water transfer/supply we should consider the following:

- Application Type and future expansion,
- Codes/References and standards required by the client,
- Material Compatibility to the environment (soil+water+salt), corrosion is big challenge for Iron pipes,
- Size/diameter, pressure and temperature,
- Durability and future maintenance.

When laying the pipe inside the trench and according to the pipe material, the trench bed can be made of **sand**, **gravel** or **dry concrete**, which assumes that the surface of the trench bottom is even and properly compacted. A huge care should be taken to avoid point loads being transmitted to the PVC pipes in particular because of soil seasonal behavior due to **moisture**

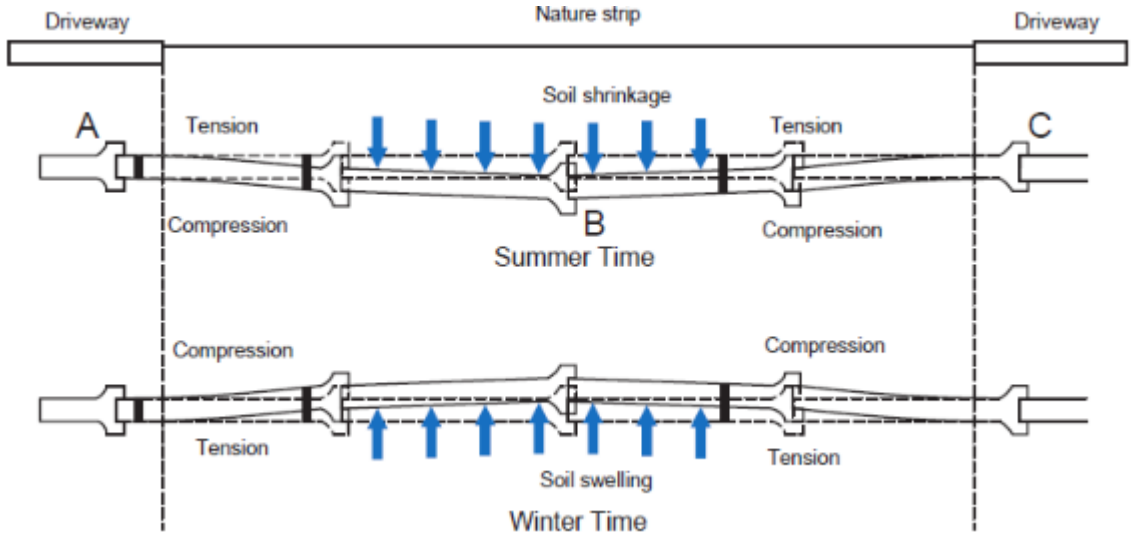


Figure 23: Pipe –soil movement due to moisture change (Rajeev et al 2012) in PhD Thesis BOUATIA 2021

Network construction: Pipes laying (Terrassement)

To ensing a good pipe laying we should consider the following :

- The bed of the trench should be free from any large grain size rocks and masonry remains, see typical trecn back fill Fig-24 a.
- The distance between the trench wall and the pipe external diameter is function of pipe diameter Fig-24-b.
- Pipe of potable water network is always the most elevated network see Fig-24-c.
- Warning grid is a must after laying the pipe, it is about 20-30 cm from surface.
- While back fill, the soil is normally placed in the trench in layers of 15-20 cm, and each layer is well compacted by machines that prevent pipe from damage see Fig-25.

a) **b)** **c)**

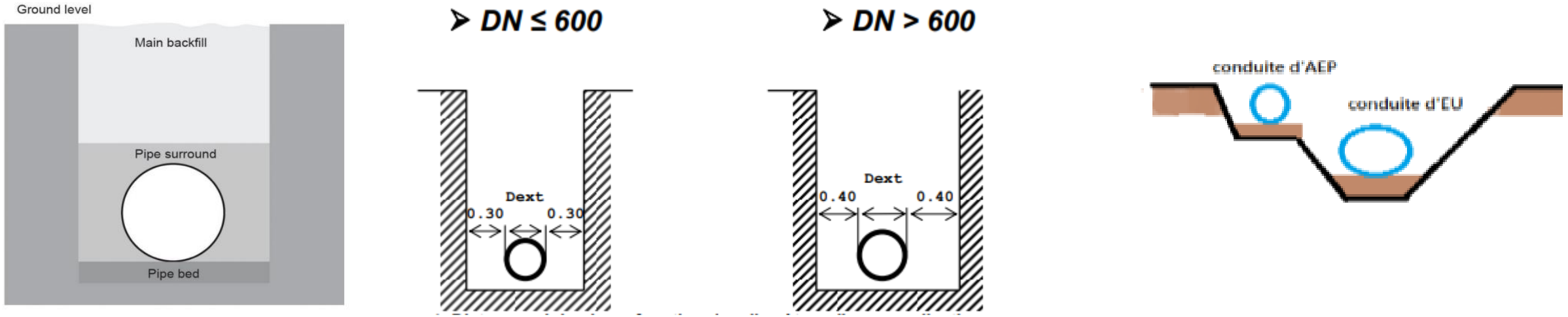


Figure 24: Back fill and pipe positionning inside thrench

Network construction: Pipes laying (Pose de canalisations)

Note that the laying of pipes on the prepared bed in a position ready **for jointing** require appropriate equipment and skills. There are a lot of technique suitable to each pipe type and diameter:

- **Threaded Joints:** For small pipes with threaded ends are joined by screwing them together.
- **Solvent Welding:** It involves applying a solvent adhesive to the plastic pipe ends, which chemically bonds and fuses them together, creating a strong connection.
- **Heat Fusion:** Heat fusion is used for joining polyethylene (PE) pipes. It involves heating the pipe ends to a specific temperature and then joining them together, it create a solid and permanent connection after cooling, See **Fig-25**.
- **Mechanical Couplings:** are used to join pipes of various materials & large diameter. They consist of two separate halves that are tightened around the pipe ends, creating a mechanical connection.

Pipe lying methods:

Open Trench: This traditional method that is backfilled and compacted after the pipes are installed.

Sliplining: In this method, a new pipe is inserted into an existing pipe, which serves as a host pipe. Old cast iron (Fonte) and corroded pipes are suitable for such method.

Figure-25: P.E Heat Fusion technique

Network construction: Pipes laying (Pose de canalisations)

Pipe lying methods:

Auger Boring: involves using a rotating cutting head to create a horizontal bore While simultaneously pushing the pipe through the ground, see Fig-26. used to cross rail way and road. Watch the following video to understand how it works: https://www.youtube.com/watch?v=lbIU6CTVgvs

Figure-26: Auger Boring method to cross railway

Plowing: used for installing pipes in shallow depths, such as for irrigation systems by cutting a narrow slit in the ground and simultaneously lay the pipe.

Note: for medium and large diameter they are using

The pipe layer machine Fig-28

Figure 28: Pipe layer machine

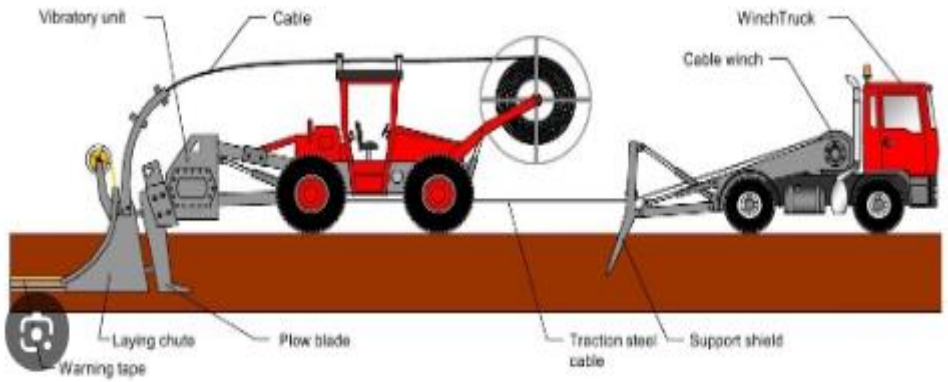


Figure -27: Plowing of HDPE pipe

Network construction: Pipes laying (Pose de canalisations)

Remark: It is mandatory to regularly check and adjust the alignment of the pipes during the installation. Use the best surveying tools to verify that the pipes are correctly positioned and aligned according to the design specifications and drawings.

Compacting: The soil is normally placed in the trench in layers of 15-20 cm (if no specifications from client), and each layer is well compacted by machines that do not damage the pipe and do not allow it float. The much complicated compacting norms are for the pipe under road and in urban area. We can not perform compacting in presence of water.

The contractor define the compacting protocol and compacting equipment in function of:

- The thickness of the back fill layer to be compacted,
- Theoretical compacting load by hour by width,
- Number of pass,
- Speed of compacting device.

a) vibration **b) roller**

Figure 29: Compating equipment, plate (a) and roller (b) compactor

Network construction: Pipes laying (Pose de canalisations)

Remark: compacted back fill must be check and some laboratory tests are necessary. Here we should make difference between compaction (Compactage) and compactness (compacité):

Compaction (Compactage): refer to the rate (%) of compacting which equal: Dry volume masse/ referential volum mass.

Compactness (Compacité): is the complement to 100% of void index, C= 100-e. example a soil with 6% void index has a compactness of 94% .

The scope of work of he projec define this in details and there are standards regulate this.

To check compliance we have proctor test

The Proctor test: measures soil compaction to determine the point at which soils can most efficiently be compacted using construction equipment, based on their optimal moisture content and maximum dry weight. In another term a given soil type will become most dense and achieve its maximum dry density, for example 95 proctor means the on-site soil density must be equal to 95% of the maximum achievable compaction.

Network construction: Pipes laying above the ground

Laying above the ground

In some cases pipes are not buried in the ground especially while crossing rivers and wadis (oueds) and face high mountain slope. These pipes are mainly metallic (HDPE pipe **PE100** can be used in drinking/potable water applications where pipework is laid above ground) . So, to lay it above the ground many aspects are to be considered:

- Support system for the pipe must take in account the forces applied from the pipe on the support and soil.
- Thermal expansion and contraction calculation should be accurate as much as possible.

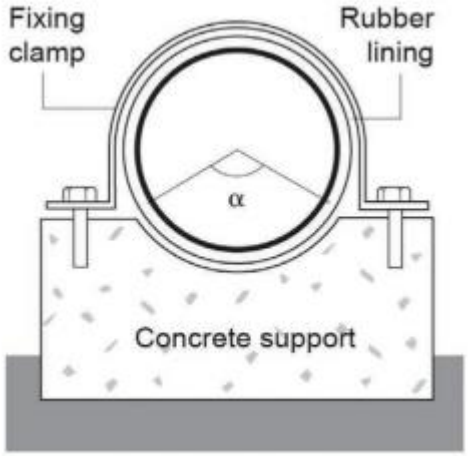


Figure-30: Pipes laid above ground and at crossing (Bridge attached) and at high slope .

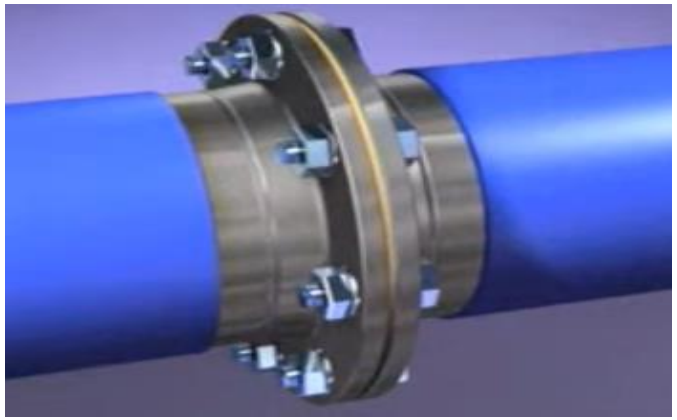
Pipes laying (Pose de canalisations)

Jointing system (assemblage) :

To avoide leakage pipes are joineted with the appropriate tool, here are some:

Flanged tool joint (bride de raccordement) Fig-31 a),

Glande joint (Joint de presse etoupe) Fig- 31 b),



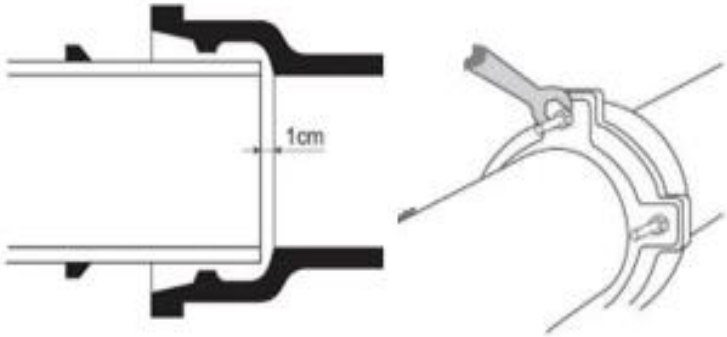


Figure 31: Most known jointing system

To well understand jointing systems, procedure and norms see the foolowing guide in french at the below link**:**

https://rabat.eregulations.org/media/GUIDE%20TECHNIQUE%20EAU%20VERSION%20MODIFIEE%20finMAI%202009.pdf

Network construction /testing

As soon as the pipes laid we should proceed for testing as per the norm suggested by client which generally comply to ISO PN 10, PN 16, PN 25, PN 40 . Which means:

PN 10 leakage test and flange dimension at 10 bar pressure generally for branched network in small rural town.

PN 16 leakage test and flange dimension at 16 bar pressure looped network in big cities

PN 25 & PN 40 leakage test and flange dimension at 25 bar & 40 bar pressure for high diameter and high flow pipes (Adduction).

The testing procedure comprises also the strength of the anchorage and support structures for pipes.

There must be enough backfilling (remblais) to avoid movement of the pipes during the test, but the joints should be left exposed until the end of the test see figure 32.

The pressure test is usually **50 % higher** than the maximum working pressure expected for the network.

Pressure can be conducted by water and the pipe is vented or compressed air.

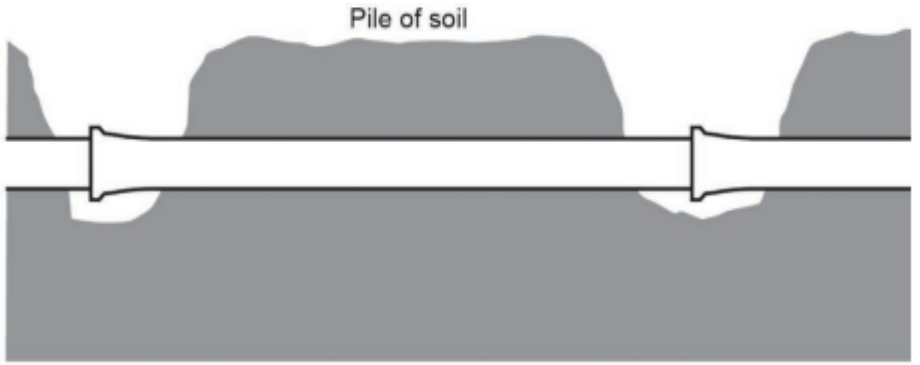


Figure 32: Preparation for network pipe testing

Concrete (Béton hydraulique)

Concrete is used in many areas of civil works and hydrotechnique. A good knowledge of this material, its properties, its origin and the process how to make it is very useful for an engineer who will deal with hydraulic infrastructure, buildings. It is the building material for the 20th ad the 21st century owing to its easy and mass production and availability f its composition.

In French terminology, we said

''Béton Hydraulique '' where the binder is hydraulic and the term '' Béton'' **used alone** refer to

Concrete: is a composite material that consists of a mixture of **hydraulic cement** that acts as a binder, **aggregates** for reinforcement, and **water**, with or without **admixtures**, fibers, or other cementitious materials (fly ash, limestone, silica fume, natural pozzolana....).

Hydraulic Cement: It is a powder result from grinding natural mineral raw materials obtained from quarries (carrières) that pass over a firing process. It hardens by chemical reaction with water (hydration) and is capable of doing so under water. The hydration reactions result in the formation of a solid mass. The most know and used hydraulic cement is **Portland** cement.

Concrete (Béton hydraulique)

Aggregates: Concrete aggregates are composed of geological materials such as gravel, sand and crushed rock from quarries . The size of the particles determines whether it is a coarse aggregate (e.g. gravel) or a fine aggregate (e.g. sand). Its main roles are:

- To make concrete mixes more compact,
- To decrease the consumption of cement and water,
- Contributing to the mechanical strength of the concrete.

Aggregates should be **non-porous**, **clean from dust**, **hard**, **chemically inert**. A good coarse aggregate should fall into a size range as follow:

Gravel 5/15 mm (Fr.Gravillonette),

Gravel 15/25 (for reinforced concrete),

Gravel 25/40 (Aggregate pour béton de propreté),

Concrete (Béton hydraulique)

Cement production process:

The raw material that are used to manufacture Cement are mainly clay and limestone got from the quarry (Carrière) after crushing and grinding the raw material, the process will continue by burning it at 1500° C to produce Clinker a basic material necessary to make cement. So, the raw mix is heated and then rapidly cooled to produce the marble-sized pellets of clinker. Cement is produced by grinding clinker (added with different active ingredients to achieve the desired properties of cement) into a fine powder, see the below figures.

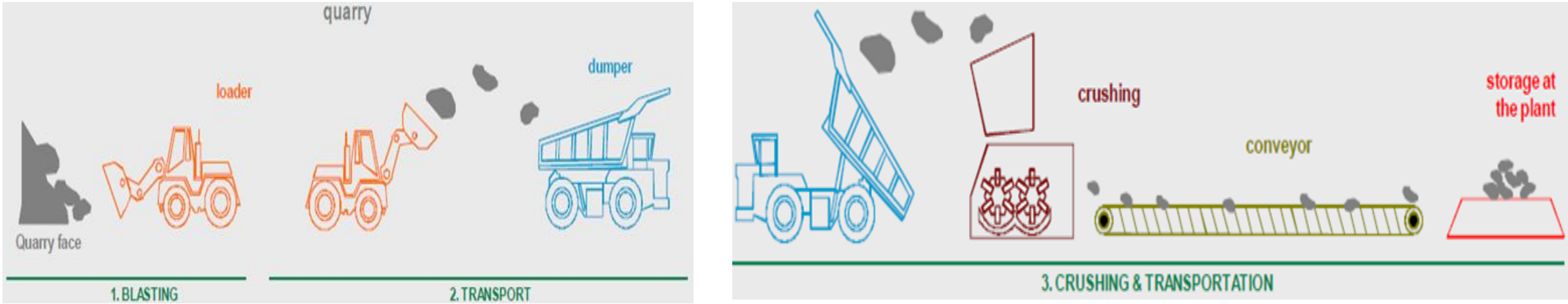


Figure 33: Raw material from quarry to plant (blasting and crushing).

Concrete (Béton hydraulique)

Cement production process: The other raw materials that are used in cement manufacturing, called additives, **are high purity limestone, sand and iron ore**. These additives mixed with raw material (70% limestone+ 30% Clay) produce a raw mix named kiln feed or Oven feed. It will be sent for (at 1500° C) then cooling to produce klinker as mentiooned before (Clinkerisation), see Fig 34 .

Around 4-5% gypsum is added to clinker to control the setting time of the final cement. The cooled clinker and gypsum mixture is ground into a grey powder called Ordinary Portland Cement (OPC) Fig 35.

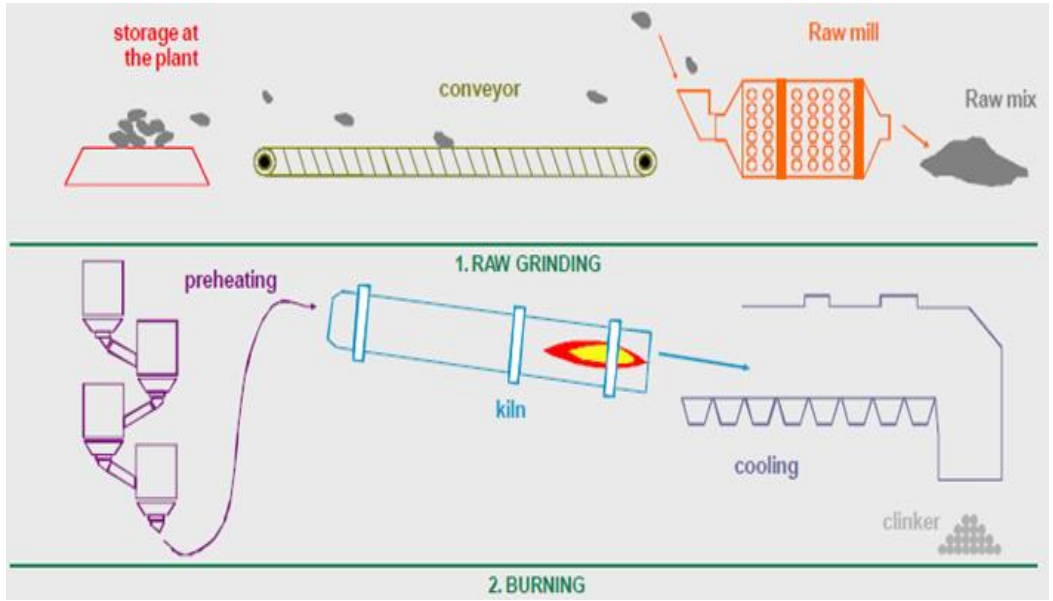


Figure 34: Clinkerisation

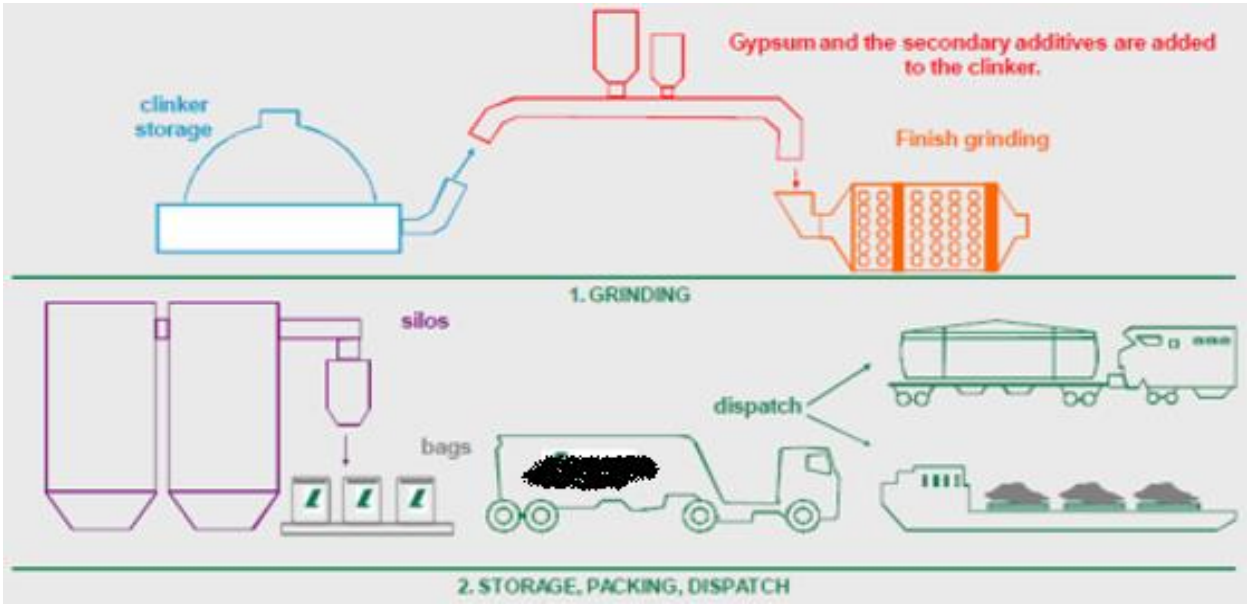


Figure 35: Ordinary Portland Cement manufactring

Concrete (Béton hydraulique)

Cement classes:

Classes Notation	Types and Definition	Application
CEM I	Portland cement clinker as main constituent **> 95%: example Strength class 32.5R** (high initial strength)	all-purpose cement or concrete. Basic requieremements
CEM II	Portland Composite Cement: various mixtures of Portland cement with, for example, shale, fly ash (cendre volatile), blast furnace slag, pozzolana… **Clinker 65% -95%**. **Example Strength class 42.5N**	Floorings repair. Masonry mortars/ special mortars. Reinforced concrete.
CEM III	blast furnace cement (Cement du haut fourneau) mixed with Portland cement is in 3 classes: A,B and C; where CEM III/A contains (35%-65%) Clinker CEM III/B contains (20%-35%) Clinker CEM III/C contains (5%-20%) of Clinker. **Example Strength class 32.5N**	Marine structures High-performance concrete Sulfate-rich soils Water retaining structures Mass concrete
CEM IV	Pozzolanic cement contains < 50% of Pozzolan and/or fly ash	Concretes exposed to chemical aggressive agents
CEM V	Composite cement: it contains mixtures of Portland cement, blast furnace slag and pozzolans.	Extreme sulfate resistance is necessary Underwater tunnels

Concrete (Béton hydraulique)

Cement classes and abreviations:

Cements are denoted by **CEM** followed by the number of the main type in Roman numerals. When it is followed by a slash followed by the letters **A,B** or **C** it indicate the percentage decreasing in clinker content. The designation may be followed by a horizontal stroke and a capital letter indicating the constituent used in addition to the Portland cement clinker.

The strength classification into classes (32.5 – 42.5 – 52.5) **MPa ,**is based on a concrete compressive strength test after 28 days. Within each strength class, determines the distinction between the **N** 'Normal' that denotes normal strength and **R** 'Rapid' when high early strength is required for construction.

Concrete making and dosing methods

To make a good concrete we must give a lot of care to **w/c** value (water to cement ratio) and it should be determined at the planning stage in accordance to required and the particular function.

The higher the **w/c** value, the lower the strength. The ratio of water to cement can also have an effect on the curing (= hydration), it must have a w/c value of at least 0.4 (which represents 40% water). If more water is added the cement can no longer bind the water, and the liquid emerges ("bleeds"). If the proportion of cement is too high there is a danger of too rapid drying and shrinking. We note there are some substances used to improve concrete quality as per the case. They are known as admixtures and additives (Adjuvant et additifs).

Concrete (Béton hydraulique)

Concrete dosing methods : Once the components of the mix have been defined, we should bear in mind that the proportion will vary according to the resistance, finish or adherence of concrete wanted to obtain. This can be done by different dosing methods which can be:

Dosification of a concrete by volume: It is the oldest method, and the most used for in situ mixtures due to its easy application and its immediacy. It consists of determining the necessary quantities of each component through a table of proportions relationships made to make a cubic meter of concrete. It is carried out in small works.

Methods of dosage based on the content of cement

- Fuller method: It is indicated for pieces that are not too reinforced, with rounded aggregates and a maximum size of 70mm, and a maximum resistance for concrete of 300 kg / m3.
- Bolomey's formula: It speaks of the improvement of Fuller's law, discussed in the previous point. But this aims to obtain an "economic" concrete in cement, and is indicated for high-density concrete.

Dosing methods based on compressive strength

These methods suitable for small conventional construction sites, the starting point is the compressive strength to be obtained with the concrete mix. It is based on the results obtained with the Abrams cone.

Concrete (Béton hydraulique)

Concrete admixtures (Adjuvant.Fr)

- Concrete admixtures are liquid used to improve the behavior of concrete under a variety of conditions. They influence the concrete by chemical or physical processes. They can change **workability** or air content. see below Table. The admixtures have only a minor effect on the mass and volume.
- To **accelerate** its setting time, and decrease **heat evolution** and increase water tightness.
- To enhance the **pumpability** of the concrete mixture and **increase the bond** of concrete to steel reinforcement.
- To reduce **segregation** and bleeding of the concrete and decrease the rate of **slump loss** (taux de pert par affaissement),

Admixtures	Function
Concrete plasticiser and super plasticiser	Gives the concrete a more plastic consistency despite the low water content so that it flows better. This makes it easier to distribute the fresh concrete in the formwork.
Air-entraining agent	Leads to the formation of air bubbles by means of chemical foaming. A higher proportion of air improves concrete's thermal insulation properties.
Sealant	Makes the solid concrete waterproof.
Retardant	Delays the curing of the fresh concrete, important in large building parts that are to be produced without construction joints.
Accelerator	Accelerates the curing and hardening process, is particularly important in sprayed concrete to ensure that it quickly reaches a basic stability and does not drip (for example, when used in building work overhead).
Pressing aids	Improves the flowability. Used primarily in prestressed concrete.
Stabiliser	Prevents "bleeding" (emergence of water) and ensures better cohesion of the mix.

Table 2: Standard concrete admixtures **Source: Concrete construction K.H 2015**

Concrete (Béton hydraulique)

Concrete/cement additives:

Additives are added **to cement** during manufacturing to get new properties for cement. A distinction is made between two different groups:

Type I: Almost inactive additives (stone dust, pigment)

Type II: Pozzolanic or latent hydraulic additives (fly ash, silica dust).

So the difference between additives and admixtures, is that admixtures are added **to the concrete** mixture before or during mixing.

Concrete consistency:

It concern fresh concrete by its relative mobility or ability to flow that influence the workability. So, no separation of the constituent elements should take place. Consistency should be determined before the begining of construction and should be monitored during production. Consistency can be measured by slump test known as Abrams cone.

Concrete (Béton hydraulique)

Concrete tests: Test on concrete can be conducted on fresh concrete or on solide concrete. we cite here the most used and best standard.

Fresh Concrete: the best test to measure consistency and workability of fresh concrete is Slump test (Slump cone/ Abrams cone) known by its simplicity of apparatus used and simple procedure, see Fig 36.

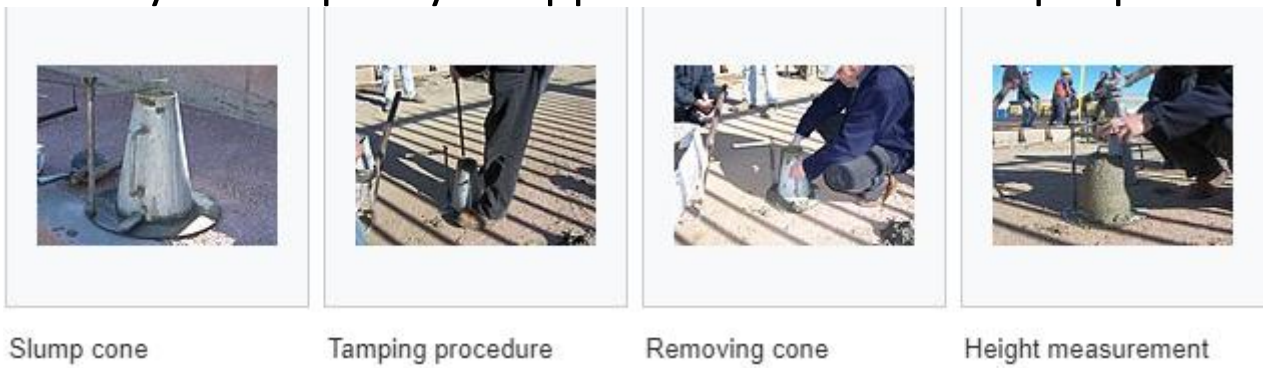


Figure-36: Slump cone test/ Abrams cone (Cone d'Affaissement)

It is conducted in several standards, here below is the classes of concrete according to **EN 12350-2 norm**.

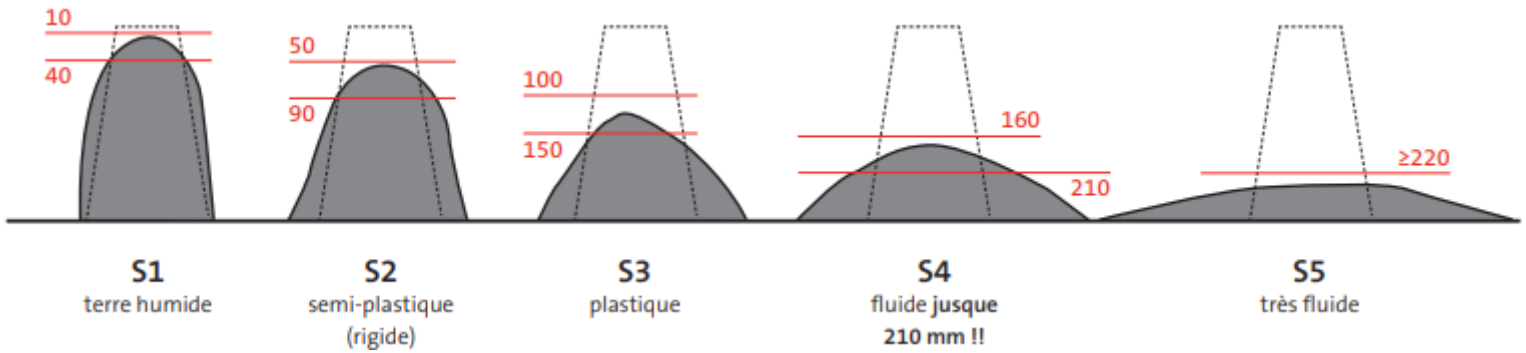


Figure 37: concrete classes limits by Abrams cone (Slump test) **Source: Holcim Brochure**

Concrete (Béton hydraulique)

Solid Concrete tests :

We have The **compressive strength** which is given in terms of the characteristic of concrete **tested** at 28 days, it is the most common performance attribute used when designining structures. Compressive strength is calculated from the failure load applied on cylindrical concrete sample megapascals (MPa).

Fig-38: concrete compressive strength

Concrete tensile strength: (Contraint de traction)

Tensile strength of concrete is very important properties which greatly affect the extent and size of cracking in structures. Moreover, the concrete is very weak in tension dueto its brittle nature (Fragile: fr). Tensile strength test **ASTM C39** is to determine the load at which the Concrete members may crack

Furthermore, splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.

The procedure of testing is based on the **ASTM C496.**

Split cylinder testing machine (Essay d'ecrassement)

Note: There existe other tests that fit for other norms.

Fig-39: Split cylinder testing machine

key parties involved in construction projects

References:

- Bouatia, 2021 , Numerical Analysis of Pipeline Behavior on High Unstable Unsaturated Slope. Case of AEP pipe of Ain Tinn-Mila. A Phd thesis.
- Concrete Technology Manual • Chapter 3 Review of Concrete Mix Designs , JUNE 2013
- Djelouah K, 2018. Accès à l'eau et à l'assainissement en Algérie. Presentation given at UNCTAD Multi-year Expert Meeting on Trade, Services and Development. Water and Sanitation, Energy and Food-related Logistics Services. Geneva 7-8 May 2018.
- https://www.pier-uk.co.uk/about-vacuum-excavation/ (Accessed on April 10th ,2024)
- UK, Construction Design and Management regulations,2015 on https://www.hse.gov.uk/construction/cdm/2015/designers.htm#:~:text=A%20designer (Accessed on Feb 10th ,2024)
- https://www.aucklanddesignmanual.co.nz/
- https://testbook.com/civil-engineering/laying-of-water-supply-pipes (Accessed on April 26th, 2024)
- https://www.vvmcem.be/en/product/cement-types/ (Accessed on April 26th, 2024)