MANUAL ON CONSTRUCTION RISKS, DAMAGE TO THE WORKS AND ADVANCED LOSS OF PROFITS (ALOP)

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1. CHARACTERISTICS OF CONSTRUCTION PROJECTS

Given the special features of Construction Projects, in order to identify and assess the potential risk factors it is necessary to know the nature and functions of the different agents involved in the whole construction process, as well as the standard administrative procedure followed for the programming and awarding of this kind of works.

1.1. PARTIES INVOLVED IN A CONSTRUCTION PROJECT

The different agents involved in a Civil Works Project are: the Promoter, the Project Designer, the Contractor, the Construction Management and the Public Administration.

The Promoter is, in general, a natural person or legal entity (either public or private) interested in the performance of a construction work that provides the necessary financial resources for the execution and obtains a benefit from the works.

The Project Designer is, in a wide sense, a natural person or legal entity with technical capability and skills who elaborates, on behalf of the Promoter, the document called "Project", comprising the precise instructions for the performance of the works, as well as the execution budget. In a strict legal sense, it is a natural person with an Architecture or Engineering background with membership of the respective professional association. With his signature, he becomes personally responsible for the adequacy of the Project. The Project Designer's liability is usually covered by general or specific Civil Liability policies, in function of the importance of the works and the foreseeable damage.

The Contractor is a natural person or legal entity that does not require specific professional skills, entrusted by the Promoter in exchange for a fee and under the conditions agreed prior to the execution of works -the entire project or only the designated portion-, to provide and order the necessary means to that end. The legal relationship between the Contractor and the Promoter is the so-called "Construction Contract", according to which the Contractor may in turn assign portions of the work to a third party (Subcontractor), although subcontracting does not generally create a legal link with the Promoter, but only with the Contractor.

If the Promoter assigns the whole construction work to a single contractor, this is known as "Main Contractor". However, if the Promoter assigns different project units (foundation, structure, etc.) to different contractors, these are denominated "Independent Contractors", who have legal relationship with the Promoter, but not among each other.

The Construction Management has a double meaning. On the one hand, it refers to the act of supervision and technical management of the works; on the other hand, it refers to one or several natural persons with a technical degree and adequate professional skills to conduct such supervision.

The Health & Safety Manager/Coordinator is, during the elaboration of the Construction Project, the competent technician entrusted by the Promoter in order to coordinate the implementation of the general principles of prevention on making decisions (either constructive, technical or regarding organization) with the aim of planning the different works or work stages that will be developed simultaneously or successively under safety conditions. During the execution works, it is integrated into the Construction Management.

H&S coordinators are essential during the project and construction stages whenever there is involvement of several project designers (structures, utilities, etc.) and several construction companies (contractors, subcontractors, etc.) respectively. In the case of a single project designer or a single constructor there is no need for coordination, so that the responsibility for safety may fall on the Project Designer or the Construction Management at each stage (project and execution).

Both the H&S coordinator during the project stage and the H&S coordinator during the construction stage are key figures in order to guarantee adequate safety conditions during the execution works, establishing a Health & Safety Study during the project stage and enforcing the implemented safety measures during the execution stage. Notwithstanding the appointment of said coordinators, the Promoter is not exempted from responsibility for safety matters, as he gives authority to the H&S Coordinator over contractors and subcontractors involved in order to achieve the required safety levels.

On the other hand, contractors and subcontractors must conduct specific safety plans through which safety measures will be effectively implemented, respecting the minimum criteria established in the H&S Study. They shall be responsible for the correct implementation of the preventive measures determined in the Safety Plan to be approved by the person in charge of safety at the worksite (appointed Coordinator or Construction Management), in relation to the obligations which correspond directly to them or, when applicable, to freelance workers hired by them.

Contractors and subcontractors shall be held jointly liable for the consequences due to failure to comply with the preventive measures as foreseen in the Plan. Therefore, the liabilities of the H&S Coordinators, Construction Management and the Promoter shall not exempt contractors and subcontractors from theirs.

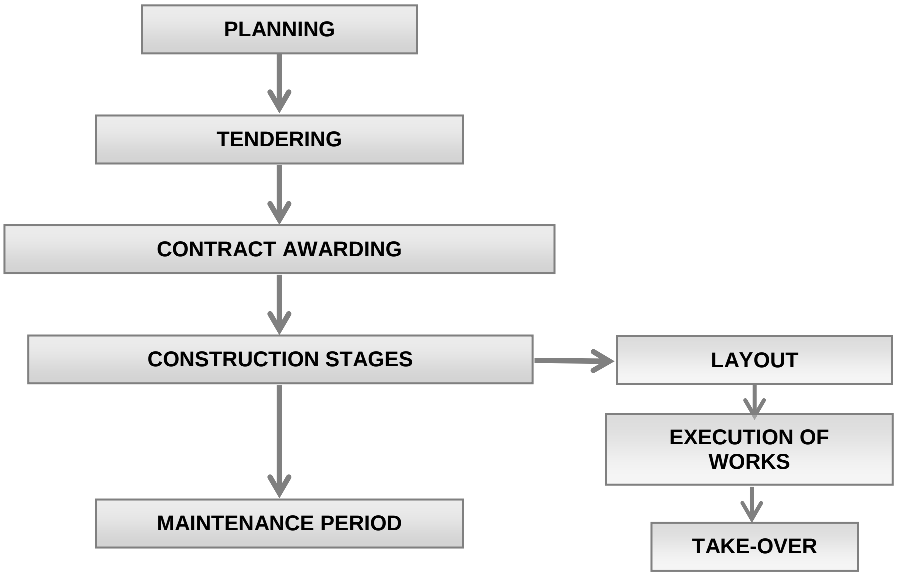
The Public Administration is referred to any administrative level directly or indirectly present in the development of a Civil Works Project according to the respective level of competence: state, autonomic or local.

Within the process development there may appear third parties that turn out to be essential for the correct progress of the works. It is the case of the "interested parties", in the administrative sense of the term. In a construction project file, these are all those natural or legal persons whose properties or rights may be affected by a resolution or who simply hold a direct interest in the subject matter. As an example, this category includes all those people whose properties must be expropriated because of the construction works and also duly registered organizations representing diffuse interests.

Personnel at work

1.2. CONSTRUCTION PROJECT STAGES

The execution of any civil works or construction project (or the improvement of already existing ones) begins long before the machinery starts to operate at the worksite. Prior to this, it is developed a laborious process which starts when a necessity to be met is considered to exist, either to improve the public services or to satisfy private needs (e.g., the need for a road is put forward for the improvement of communications between two towns, etc.). Then, it shall be necessary to study the different possible alternatives, the economic cost and the social and environmental impacts of the construction work. Eventually, the most adequate alternative shall be adopted. This process can take months and even years, so that the promoter can be either private or the Public Administration.



Construction Project stages

1.2.1. PLANNING

The needs to be covered and the objectives to be achieved are defined in this stage.

The first step to take is to do a **feasibility study** to solve all the physical, economical, environmental and perhaps political questions put forward.

The study starts with the collection of all the necessary data for the design of a solution to such need, which can be topographical (measurement of the real surface area of a piece of land), hydrological (pluviometry of a basin, etc.), statistical (road traffic, etc.) or others.

In this stage, the consultant engineer must work together with other professionals (financiers, etc.) and national or local authorities with decision making power, in order to study the social and economic implications, as well as the environmental impacts of the project.

Once this study is approved by the promoter, the elaboration of the *Project Draft* is entrusted to an Engineering Consulting Company that will carry out a first study on the project to be developed. It is in this phase when the competent bodies make a decision on, for example, the route of the road, etc. In the further phases, the Project will be defined in full detail.

During this phase there is a great advance in constructive details, cost determination, construction progress chart and project execution budget. In this phase, onsite investigations are essential in order to detect specific difficulties in relation with the site geology, and the environmental impacts shall be detailed, including physical, biotic and social environments. In general, it is in this phase when the final solution is chosen, and it will be detailed in the definitive design phase or **Construction Project**.

1.2.2. TENDERING

Once the Project has been sufficiently detailed and specified, the works tendering is publicly announced. Tendering is compulsory in the case that the promoter is the Public Administration. However, in the case of a private promoter, the public tendering procedure can be disregarded and bids can be requested directly from several competing contractors.

In general, tendering documents comprise the following: *Sets of administrative clauses, particular clauses* (contracting, prices, project execution time frames, method of payment and conditions to be fulfilled by the constructor) and *Sets of technical specifications* (technical features of the Project, scope, documents included, previous studies, tests, basic documentation to be used, scales, number of copies, degree of completion of layouts, progress charts, project units including prices and, all in all, the technical requirements which must be met by the project in order to be accepted by the Public Administration).

The companies interested in the accomplishment of the project place their bids in compliance with the aforedescribed sets. In these bids, the tendering companies commit themselves to start and execute the works according to the specifications, time period and budget set out. Alternative solutions can also be added to the initial proposal specified in the Sets (or Lists) of conditions.

1.2.3. CONTRACT AWARDING

The promoter evaluates the different bids in function of the budget, experience, technical and financial guarantees, environmental studies, quality certificates, etc. and the bidder submitting the best bid will be awarded the Construction Contract.

The supervision of works shall be carried out by the same project designer or a different one, as determined by the promoter.

1.2.4. CONSTRUCTION

After the contract is awarded, the first job is to prepare the land for building upon (ground clearing, setting out…).

Ground clearing

The plots are then marked out with the layout of the foundations. This is known as setting out, which is an essential step before proceeding to the next phase.

Setting out of works

The project construction may take from months to several years. So, during the construction period, the Promoter pays the agreed amounts to the Contractor at regularly scheduled times according to the work progress certified by the supervising engineer.

Therefore, the payments of insurance premiums for large construction projects are sometimes agreed in a similar way: payments in advance for the coming year. For simpler control, as a general rule, the regular payments are determined on the total insurance premium.

1.2.5. TAKE-OVER AND MAINTENANCE PERIOD

Construction Works are regarded as "completed" after the Construction Management certifies that they have been completed in accordance with the contract and after signature of the so-called *Provisional Acceptance Certificate*. The Contractor's contractual liability ends at that very moment, although it can be extended during the "Maintenance Period", lasting between six and twelve months. Within this period, the contractor is obliged to carry out, at his own expense, any correction or repair considered necessary, besides rectifying all defects, faults or flaws in the construction works. After signature of the *Final Acceptance Certificate*, the contractor is exempted from all contractual liability.

In Spain, with regard to buildings for residential use, the contractor is subject to legal liabilities for a 10-year period in case of structural defects, as determined by Law 39/1999 of the Spanish Building Act (LOE - *Ley de Ordenación de la Edificación*).

1.3. THE CIVIL WORKS CONTRACT

The contract for Works of Civil Engineering Construction, or Civil Works Contract, is the legal instrument which allows splitting the financial responsibility between the promoter of the construction project and the contractor. Therefore, it comprises, among others, those clauses obliging the contractor to insure the works against loss or damage. Consequently, it is essential for a good risk analysis to review this document.

1.4. CONTENTS OF THE PROJECT DOCUMENT

Construction Projects shall include, at least, the following:

1. **Project Report,** with a description of the purpose of the project and comprising the following: previous information, situation prior to commencement of works, needs to be satisfied, justification of the solution adopted and detail of all the factors to be taken into account.

2. **General and detailed Layout Plans**, necessary for the perfect definition of the Project, as well as those delimiting the land area occupied and the restitution of easements and other real rights, if applicable, and services affected by the project execution.

3. A **Set of Particular Technical Prescriptions**, where the works will be described and their execution will be regulated, stating the way it will be carried out, measurement of executed project units and control on quality and on the contractor's technical obligations as well.

4. **Project Budget,** either made up by several partial values or not, including unit prices and a breakdown of prices, in its case, status of measurements and precise details for their evaluation.

5. Project Development Program or **Work Plan** on an indicative basis, including an estimate of time and cost.

6. All kind of references on which the setting out of the works will be based.

7. As much documentation as provided by legal regulations.

8. The **Health & Safety Study** or in its case the Basic Study on Health & Safety, under the terms provided in the Health & Safety regulations for construction sites.

In certain cases, one or some of the previous documents can be simplified, rewritten or even eliminated -in such way as statutorily determined-, provided that the resulting documentation suffices to define, evaluate and execute the works that it comprises.

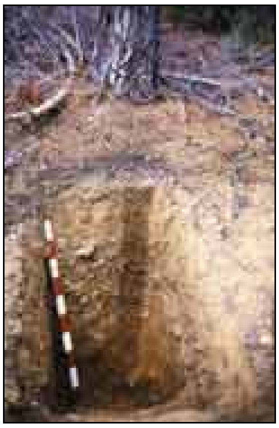
Unless it is incompatible with the nature of the project (e.g., in the case of an urbanization project), the project must include a **Geotechnical Study** of the land where it is to be developed.

1.4.1. GEOTECHNICAL STUDY

The Geotechnical Study is the result of the works related to the inspection and characterization of the subsoil affected by an Engineering or Architecture project, derived from the need of knowing the behaviour of the ground under the influence of the construction. Besides comprising the formal descriptive aspects of the ground, this study usually includes certain recommendations for the construction Project in those aspects where it “interacts” with the ground.

This study must include a definition of: nature of materials to be excavated, excavation method, slopes to be adopted, bearing capacity of the ground to support the fillers, the method of filling, possible foundation settlements and time needed to achieve the required capacity, safety coefficients adopted, the measures to increase them -if unacceptable-, and the measures to reduce and/or accelerate the foundation settlements.

Prior to conducting the Geotechnical Study, it is essential to know every data which might condition its characteristics, stresses and influences. In particular and by no means intended to be exhaustive, the following can be mentioned: ground profile, existence of spills, pipeline and underground services, existence of possible faults, expansive soils, aggressive soils, existence and location of fillers, wells, galleries, underground tanks, etc.



Test pit

This study usually comprises the following stages:

1. Definition of the geotechnical campaign to be performed.
2. Ground prospecting and sample taking.
3. Laboratory tests.
4. Preparation of documentation.
5. Report edition (including sections of conclusions and recommendations).

If the construction project has a considerable extension, the insurance provider must verify that an adequate number of samples have been taken in the geotechnical study in proportion to the land area involved. Besides, additional samples must be foreseen as the works go on in order to detect alterations in the ground conditions, appearance of strata different from those foreseen, alterations of the water table level, etc. (e.g., for the construction of a several km tunnel, additional samples must be foreseen).

Boring machine

In the case that the construction project has singular elements of high relevance (e.g. bridges), it must be verified that the geotechnical study envisages specifically and exhaustively the spots where the sensitive elements of the own structure (supports, foundations, buttresses, etc.) or auxiliary elements (e.g. falsework) are going to be placed, in order to prevent as much as possible the occurrence of landslides or differential settlements during the execution phase.

The geotechnical study must be conducted by qualified technical personnel according to the regulations in force.

1.4.2. HEALTH & SAFETY PROJECT

Occupational Risk Prevention is nowadays considered to be a matter of high importance.

Following, the Spanish regulations regarding this issue are analyzed:

The basic character of Law 1/1995 on Occupational Risk Prevention does not only imply an absolute obligatory compliance as a Minimum Provision, but also of provisions of lower rank (Royal Decrees, Ministerial Orders, etc.). This law is mainly aimed towards permanent workplaces, making compulsory a study on potential hazards and the adoption of suitable preventive and corrective measures.

Due to their nature, construction sites are provisional workplaces, making compulsory the adoption of these measures, and if the labour inspection proves non-observance of regulations on occupational risk prevention, this would entail a serious and imminent risk to the safety and health of workers which may call for an immediate work stoppage.

It must be taken into account that, excepting exceptional cases commented in press releases, jurisprudence tends to admit the so-called **objective liability**. The worker has absolute protection against accidents and the contractor has a liability arising from the mere fact of developing an activity involving the possibility of accidents occurring, independently from the obligation to adopt all the necessary precautions. Then, the absence of prevention becomes an aggravating factor of liability, instead of being the determining factor.

In the case of construction works, the regulation is included in Royal Decree RD 1627/1997 of Minimum Provisions on this matter. The decree distinguishes between Basic Study and Health & Safety Study, and the predictions included are thereafter developed by the contractor in the Health & Safety Plan.

During the project preparation stage, the promoter has the obligation of preparing a **Health & Safety Study** in those construction projects in which any of the following cases exists:

- That the Project Execution Budget is equal to or exceeds €450,759.08 ($540,910.8).
- That the estimated duration is in excess of 30 working days, with the employment at any given stage of more than 20 workers simultaneously.
- That the volume of estimated labour, understanding by such the sum of the days of work of all workers on the construction site, is in excess of 500 person-days.
- Tunnel, gallery, underground pipeline and dam construction works.

It shall include, at least, the following documents:

- ☑ Project Report.
- ☑ Set of Particular Conditions.
- ☑ Layout Plans.
- ☑ Measurements of every Occupational Health & Safety units or elements which have been defined or projected.
- ☑ Budget.

The **Project Report** shall describe the procedures, technical equipments and auxiliary means to be used or foreseen to be used; identification of avoidable occupational risks, then indicating the necessary technical measures to achieve that aim; list of occupational risks which cannot be eliminated according to the aforementioned, specifying the preventive measures and technical protections to control and mitigate such risks and evaluating its effectiveness, specially when alternative measures are proposed.

Likewise, it will include a description of the sanitary and common services the worksite must be provided with, in function of the number of workers to make use of them.

In the elaboration of the Project Report, the site environment conditions must be taken into account, as well as the typology and characteristics of the materials and elements to be used, determination of the construction process and order of work execution, as well as any kind of activity carried out at the site, with compulsory location and identification of the areas where works included in one or several of the following categories are to be carried out, as well as their corresponding specific measures:

- Work which puts workers at risk of burial, engulfment or falling from a height, where the risk is particularly aggravated by the nature of the work or processes used or by the environment at the place of work or site.
- Work in which the exposure to chemical or biological agents involves a particularly serious risk or for which the specific surveillance of workers' health is legally enforceable.
- Work near high voltage power lines.
- Work involving risk of drowning.

- Excavation of tunnels, wells and other work involving underground earthworks.
- Work carried out under water with a system of air supply.
- Work carried out in caissons with a compressed-air atmosphere.
- Work involving the use of explosives.
- Work requiring the assembly or dismantling of heavy prefabricated components.

The **Set of Particular Conditions** must envisage the legal regulations applicable to the own technical specifications of the subject project, as well as the prescriptions to be fulfilled in relation to the features, use and maintenance of machinery and equipment, implements and tools, systems and preventive equipment.

The **Layout Plans** refer to the necessary graphics, plots and diagrams for a better definition and understanding of the preventive measures defined in the Project Report, expressing the necessary technical specifications.

The study must be and integral part of the Execution Project or, in its case, of the Construction Project. Besides, it must be coherent with its contents and comprise the adequate preventive measures against the risks entailed by the project. The budget for the Health & Safety Study must be one more item included in the project budget, and it will not include the costs demanded by a correct professional accomplishment of works, complying with the regulations in force and the generally accepted technical criteria put forward by specialized organizations.

The **Basic Study** must be accomplished provided that the aforedescribed conditions are not fulfilled, and it must include the regulations on Health & Safety applying to the project. To that aim, it must envisage the identification of avoidable occupational risks, indicating the necessary technical measures to be adopted; list of occupational risks which cannot be eliminated in accordance with the aforementioned, specifying the preventive measures and technical protections in order to control and mitigate said risks and evaluating its effectiveness, specially when alternative measures are proposed. When applicable, it must take into account the types of activity carried out on the construction site, and it shall include specific measures related to works included in one or several of the previous sections.
Both the Study and the Basic Study on Health & Safety shall also envisage forecasts and useful information for carrying out, at a later date, possible subsequent works in correct health and safety conditions.

Each contractor shall elaborate a specific **Occupational Health & Safety Plan** for each work, in which the forecasts contained in the Study or Basic Study shall be analysed, studied, developed and complemented, on the basis of its own system for executing the work.

When applicable, this plan shall include proposed alternative prevention measures, which the contractor shall suggest with the corresponding technical justification and which may not involve a reduction in the protection levels provided for in the Study or Basic Study.

The Health & Safety Plan shall have to be approved, prior to commencement of works, by the Health & Safety Coordinator during the construction stage. In the case of Public Administration works, the plan, together with the corresponding report by the Health & Safety coordinator during the construction phase, will be submitted to approval by the project awarding public authority. When appointing a coordinator is not necessary, his functions will be assumed by the Construction Management.

Safety at work

1.4.3. ENVIRONMENTAL IMPACT STUDY

Projects to be subject to Environmental Impact Assessment (EIA) must include an Environmental Impact Study which shall contain at least the following information:

- ☑ General description of the Project and foreseeable requirements in relation to the use of the ground and other natural resources. Estimate of the types and amounts of waste spills and emissions of materials or energy.

- ☑ Exposition of the different alternatives studied and justification of the overriding reasons for the solution adopted, taking into account the environmental impacts.

- ☑ An estimate of the foreseeable direct or indirect impact of the project on the human population, flora and fauna, ground, air, water, climatic factors, landscape and properties, including the Historical and Artistic Patrimony and the Archaeological Patrimony as well.

- ☑ The measures envisaged for reducing, eliminating or compensating for significant environmental impacts.

- ☑ Environmental surveillance program.

- ☑ Summary of the study and conclusions in easily understandable terms. Report, if applicable, on the informational or technical difficulties found during the development of the study.

The description of the Project and its actions must include:

- ☑ Project location.

- ☑ Detailed account of the actions inherent to the subject project which may have an impact on the environment, through a detailed exam of both the construction and the operation phases.

- ☑ Description of materials to be employed, ground to be occupied, and other natural resources the elimination of which or negative effects caused are regarded as necessary for the project execution.

- ☑ Description of types, quantities and composition of waste, spills, emissions or any other element derived from the action, either temporary during the construction phase or permanent after it is completed and under operation, particularly, noise, vibrations, smells, light emissions, particle emissions, etc.

- ☑ Review of the technically viable alternatives, and a justification of the proposed solution.

- ☑ Description of the foreseeable requirements in time, in relation to the use of the ground and other natural resources for each alternative examined.

The environmental inventory and description of the key ecological and environmental interactions must include the following:

- ☑ Survey on the site condition and its environmental conditions prior to accomplishment of the works, as well as the existing types of ground occupancy and exploitation of other natural resources, taking into consideration the pre-existing activities.

- ☑ Identification, census, inventory, quantification and, if applicable, cartography of all the environmental aspects which may be affected by the Project.

- ☑ Description of the key ecological interactions and their justification.

- ☑ Demarcation and cartography description of the territory or basin affected by the project for each of the environmental aspects defined.

☑ Comparative study on the current and future environmental situation, with and without the action derived from the project subject to assessment, for each alternative examined.

The aforementioned descriptions and surveys shall be as concise as possible for the understanding of the possible effects of the Project on the environment.

Construction site environment

1.4.4. PROVISIONS ON QUALITY CONTROL AT THE CONSTRUCTION SITE

Quality Control at the construction site is defined in the Set of Technical Conditions, which is an integral part in every project.

It is divided into:

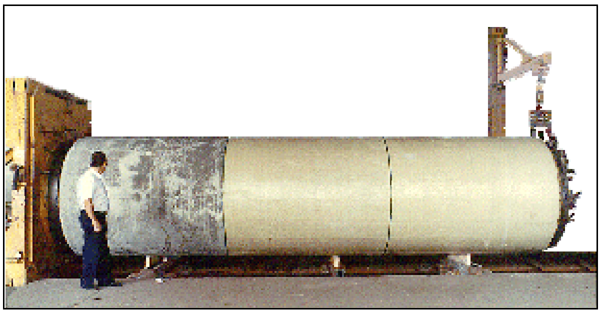
- Control of material receipt.
- Control of project units execution.

In the case of Spain:

- It is a normal provision that the control is effectively accomplished by laboratories or independent institutions of either official or private character, provided that they are duly accredited through certification issued by competent organizations.

- The set must define, for each of the materials or construction items, the inspection unit (volume of works or number of units which are the basis for the sampling), the number of samples to be taken, tests to be accomplished and actions in case of rejection (taking more samples, etc.). These aspects are frequently established with reference to determined legal provisions, regulations, etc.

- The regulations usually accept three control levels: intense, normal and reduced. Starting from normal control specifications, reductions or intensifications are established according to factors such as: certification of suppliers, level of surveillance by the Construction Management, rejection or acceptance of material lots, etc.



Concrete Quality Control operations

- It is convenient that the Set of Particular Technical Prescriptions expressly include the provisions on sampling, tests to be accomplished and accepted tolerances, and not only the reference to the applicable provision. It must be stated that, according to the Spanish standard for reinforced concrete structures (EHE), the control level must also appear in the layout plans.

1.5. PECULIARITIES AND CURRENT SITUATION OF CONSTRUCTION PROJECTS

In order to define in a few lines the features of a Construction Project, we must firstly focus on the general features, leaving the specialized descriptions for each specific type of construction.

Among the peculiarities defining construction works, the following can be highlighted:

- The works carried out make up a **changing environment**, developed in open locations highly exposed to environmental agents (wind, rain, etc.), conditioning orographic factors such as uneven pieces of land and accesses, with the intervention of several agents (the interaction of which may be favourable or unfavourable), with execution of complex tasks and use of heavy or singular equipment and which, in a general and compulsory way, require exhaustive planning and rigorous management control and degree of fulfilment of milestones and objectives.

- Many of these works are of **"public interest"** when they do not rest in the public domain. Due to this, these are projects where the intervention and control by the different public administrations are shown to their full extent.

- The project execution demands a large amount of machinery and **heavy equipment** which, due to its characteristics, is very costly and has low manoeuvrability, requiring specialized and careful handling. Most accidents associated with this type of equipment are collisions either with other construction elements or other equipment, overturns, runovers and mechanical breakdowns.

Backhoe

In spite of the low speed, due to the large mass of this type of equipment, damage is much bigger in collisions with the construction elements or with other equipment, and it can additionally lead to collapses or landslides with the resultant collapse of walls or embankments. In case of someone being run over, the same characteristic causes serious injuries due to the excess of weight.

The use or transportation of heavy equipment through open roads with road traffic, together with its low manoeuvrability, may cause collisions with other private vehicles with serious results.

Unskillfulness or carelessness by the maintenance staff may result in misplacement of spare parts or high-cost direct damage because of the high price of components or of the own machine.

Handling of equipment on little cohesive soils may result in blocks or even overturn smashing people, or property destruction, besides the need of specialized equipment for removal and the delays entailed.

The condition of each machinery and equipment entering the worksite must be checked by competent personnel, keeping the results in a record file for the Public Works -at the authority's disposal-, where characteristics, use and maintenance must be recorded.

TBM (Tunnel Boring Machine)

- A large part of these construction projects occupy a large **surface extension** (e.g., a road). This surface extension may have aggravating effects on the risk of accident:

Dam construction

- The nature of the ground may vary enormously from one zone to another in different aspects: ground type, soil cohesion, depth of the water table, etc. Due to this reason, the insurance agent must verify that the contents of the geotechnical study are adequate, in both number of samples and analyses and laboratory tests carried out. The lacks of the geotechnical study may lead to undesired situations such as: lack of adequacy of the ground extracted to be used in the construction, inadequacy of the ground to bear the load of the construction, existence of rocky strata requiring controlled blasting, flooding of excavations, etc.

  These circumstances always imply an indirect (and sometimes direct) economic loss for the contractor. As technical operations to solve this problem (supplies of external materials, soil consolidation works, blastings, etc.) are not included in the original project, they must be paid for separately and unfailingly cause delays in the project execution. On the other hand, there is a risk of direct damage due to landslides, floods or loss of stability affecting formworks or machinery, with structure collision or tilting failures.

- It hampers the access of workers to the site from designated areas for vehicle parking.

- There is a possibility of entry by non staff people especially when, due to its extension, it represents an obstacle for people to access collective transport means. In such cases, there is a higher probability of accidents (e.g. trench fall, etc.) and the division of the site into zones and -wherever possible- the construction of public ways should be taken into account.

- The surface extension makes surveillance more difficult in general, and particularly that regarding materials collection which tend to be placed in the surroundings of the worksite and facilitate theft or vandalic acts. In such case, additional measures for material protection must be foreseen.

- Exposure to risk of a completed project is different from exposure to risk of another one under construction. For example, an open trench is more exposed to rain and flood than the completed pipeline.

Building construction

- **The ever-growing competition in the construction industry**. At the tendering stage, contractors will not only compete on price, but also on project execution time frames. Quality of workmanship and materials, construction techniques used and date of commencement of works may determine the success or economic failure for the contractor. This leads to reducing the safety margin as much as possible, hence increasing risks. All of these factors also affect the risks assumed by the insurance providers, as they must face factors of economic nature.

- Unskilled workforce.

- **Innovation** or prototype use is another factor to be highlighted in this type of projects, due to the following:

  - In many occasions, the projects to be developed get more audacious each time, based upon purely theoretical calculations.

  - In occasions, the novelty of materials to be used, with little or no experience of them.

  - Progress in construction methods and techniques.

  It is relevant to take into account that every important engineering project has singular characteristics, so that it turns out to be a prototype (tunnels, dams, highways, etc.).

- The increase in all type of works and the higher value of the different constructions result in higher technical an economic risk produced by such value increase.

- As already developed in previous sections, from the moment when the need for a construction work is presented until it is completed, there is a succession of stages where a mistake in one of them may affect the subsequent stages. For example, a calculation error in a bridge beam may result in collapse during the construction phase through the cantilever method if certain loads have not been considered.

- Moreover, there may be a large number of agents intervening in all these stages: contractors, subcontractors, project designers that may be different from the Construction Management, etc. Poor coordination among them or inadequate performance of one of them, increase the risk of occurrence of an accident.

  An example of this is the Pavilion of Discovery fire at Expo '92 in Seville, due to welding works carried out by a subcontracted company.

Pavilion of Discovery fire. Expo '92 (Seville)

- A construction work is usually made up by different construction elements with different hazards each. For example, considering a stretch of a highway, part of it can be constructed in the open air, part in a tunnel and part on a viaduct, and the hazards of tunnels, viaducts and open air are very different from each other and hence must be analyzed independently.

  Consequently, the possible risks related to construction may mean losses higher than the constructor's economic potential.

Pipe breakage after trench flooding

One option is to start a **reserve fund** in order to assume these risks, but sometimes it happens to be very expensive and uncertain. Besides, the more intense competition within the sector does not allow construction companies to include in their bids extra charges which are enough to absorb all the unforeseen risks.

An interesting option for construction companies in order to avoid starting a reserve fund (and therefore eliminate the consequences derived from a calculation error of such fund), is to **transfer risks** through contracting an insurance company which, by means of underwriting a Contractor's All Risks (CAR) insurance policy, provides cover against the multiple risks that may arise during the construction process.

This insurance thus contributes significantly to construction costs, and at the same time it provides financial protection to all the interested parties.

In addition to the aforementioned, banks require loan guarantees which must be evidenced through an appropriate insurance cover. There is a growing demand for contracting this insurance by financial entities granting loans for construction, as this way the sums lent and the continuity of the works are guaranteed.

2. CONSTRUCTION RISKS

2.1. GENERAL CLASSIFICATION OF CONSTRUCTION RISKS

It would be impossible to enumerate all the risks which may arise during the development of construction projects, as the likelihood and unforeseeability of accidents are sufficient factors to have them covered. Therefore, we shall focus on those usually subject to insurance coverage. These are divided into three different categories:

Indemnifiable losses

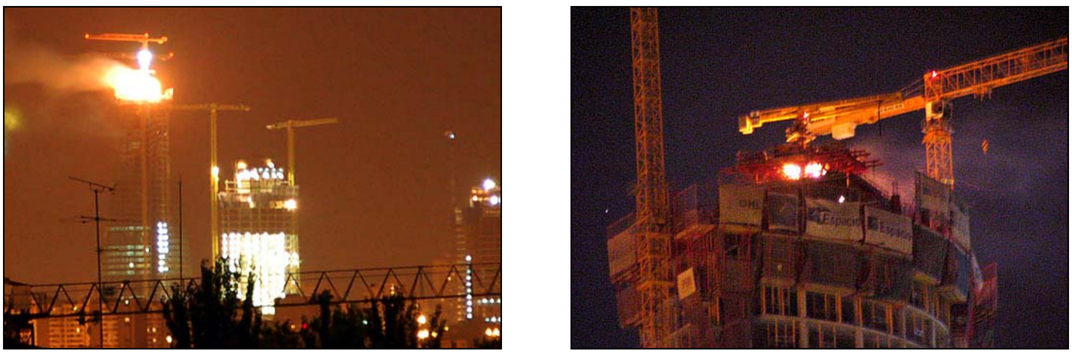
- Conventional (ordinary) risks
- Catastrophic (extraordinary) risks
- Risks inherent to the works

2.1.1. CONVENTIONAL RISKS

The most frequent ones are:

- Fire. There are many different reasons for a fire starting. Following is a list of typical circumstances that imply the existence of a high fire load: messy storage of wood, use of flammable liquids for engine combustion, use of plastics and combustible materials, welding works, heaters in warehouses, cigarette butts not properly extinguished (e.g. the Windsor Tower fire in Madrid in March 2005), electric material, etc.

  Example of this was a fire during the construction of Espacio Tower, one of the four towers making up the CTBA (Cuatro Torres Business Area), in Madrid.



Fire during the construction of Espacio Tower (Madrid)

It is a relatively frequent accident (on top of the accident-rate ranking for several years), with claims involving large amounts of money.

- Lightning. Atmospheric electricity may cause damage, especially to transformers and buildings higher than others nearby. It is important to take into account the lack of lightning conductors during the construction stage. Moreover, the risk is sometimes aggravated by the presence of cranes, masts or flagpoles.

- Explosion. Boilers, provisional transformers for electricity supply, compressors or other devices may be installed at the worksite, with a risk of explosion. Possible explosions originated outside the site are also covered.

- Theft. It used to be covered in the beginning, but nowadays almost all the insurance providers exclude this risk from the policy wording (Refer to section on excluded risks, optional covers).

- Bird falling.

2.1.2. CATASTROPHIC RISKS (*FORCE MAJEURE* OR EXTRAORDINARY RISKS)

The most remarkable are those derived from **Acts of God** (which are foreseeable, although their effects are unavoidable), as well as other risks which are absolutely **unforeseeable**.

Among the catastrophic risks, the ones caused by **Acts of God** comprise the following:

- Winds, storms, hurricanes and cyclones: They may cause serious damage, and hence this fact must be taken into account in the project at the time of making the calculations in compliance with the regulations regarding this matter; although the completed projects are protected, this hazard exists during the construction stage.

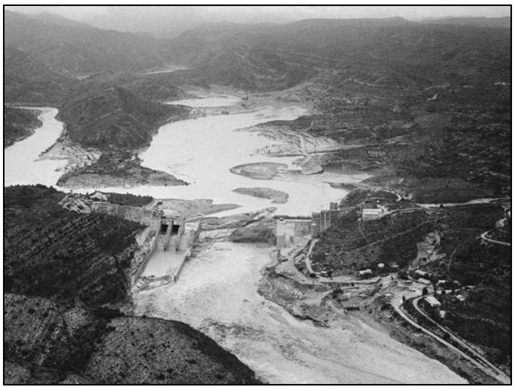
  In the case of Spain, rarely do these events bring about total losses. However, the number of partial accidents due to said circumstances is remarkable, the most frequent being those related to crane overturns, aluminium roofs being dislodged, collapse of fresh walls, etc.

- Floods and water-induced damage: Atmospheric variations imply that hydrological phenomena are likely to happen. Along with the fact that the mere existence of water at the worksite is already a permanent risk for the construction, it can be concluded that damage by water is one of the most frequent ones in insurance claims.

The main reasons for water-induced damage are the following:

- Insufficient consideration in the project of the hydrological and meteorological conditions, therefore, lack of preventive measures such as diversion galleries, sheet pile walls, drainages, unavailability of diversion channels or enough dewatering pumps in ditches, etc.

  For example, as the return period in the calculations of the Tous Dam was insufficient, an uncontrolled flood caused the dam to overflow.



Tous Dam after the flood (1982)

Tous Dam (2002)

- Execution of works during periods with special hazards due to risk of rain.

- Lack of an alarm system or insufficient speed in communicating overflows.

- Location of the worksite, warehouses or other facilities at places with possible threat of overflowing or flooding such as, for example, river courses which were dry at the moment.

Rain damage to channel construction

- Earthquakes: The risk of seismicity in the area is a fact that must be taken into consideration in the Project Draft by applying the seismic regulations in force. Nevertheless, as it happened in the case of wind, there is only protection against damage for completed works, but not during the construction stage. For example, in the case of Spain, despite not being one of the areas with the highest seismic activity, there are zones like Granada, Murcia and North of Huesca, with a relative danger of earthquakes. In any case, even though a great earthquake is not likely to happen, there is still the chance of small seismic movements capable of causing, for example, the collapse of a building under construction.

- Ground subsidence, landslides and rockfalls: In these cases, the problems many times arise from the lack of a good geotechnical study or simply bad luck, given that -although the geological and geotechnical studies are more and more accurate- the deeper layers of ground may surprise with pockets of different material (e.g. clay strata, weathered rocks, etc.), causing accidents to happen.

  In addition to the aforementioned, prevention measures are expensive, so that they are usually attempted to be avoided, despite the fact that the risk is increased. For example, in trench construction, many times they are not carried out under the appropriate safety measures (timbering, shallow sheetpiling, etc.), so that landslides usually happen with the subsequent damage to the works, machinery or adjoining buildings.

  These subsidences are usually caused by the pressure exerted by the ground walls depending on its different types, moistures, etc. Risk may increase due to meteorological conditions, the effects of nearby traffic, adjoining constructions or material deposits, and overloads transmitted by cranes or other lifting equipment. In other occasions, the struts do not have base supports able to withstand the pressures transmitted, causing the ground to give way.

  All these aspects are aggravated in excavations, due to the existence of water infiltrations. In these cases, hydrostatic pressure increases with increasing depth, causing higher weakness in the ground.

  As an example, it can be mentioned the recent ground subsidence during Line 5 Metro extension works in Barcelona, which also resulted in the collapse of buildings and evacuation of over one thousand people from El Carmel district, as well as the demolition of several buildings.

  The tunnel was being constructed by using the New Austrian Tunnelling Method (NATM). The excavation of the sides of the tunnel could bring about an uneven change in the pressures supported by the tunnel, causing the ground to subside, situation which was aggravated by the existence of a fault near the zone where the accident took place.

Ground subsidence at El Carmel

Buildings affected by ground subsidence caused by metro extension works at El Carmel

Besides the material damage, the ground subsidence caused the collapse of the adjoining housing buildings.

On the other hand, with regard to **unforeseeable accidents**, delimiting the fortuitous case is a much more complex question which is usually left to the judgement of the court, so that it is a matter of case law. On an indicative basis, the following characteristics can be mentioned:

- The event must happen absolutely by chance. Although it is possible, it is not an avoidable consequence of the activity developed.
- There must be total absence of fraudulent behaviour.
- A sufficient activity must have been made in order to prevent the damage.

The fortuitous case excludes the insured’s liability, in the absence of express legal provision, so that it usually brings as a consequence an obligation for the insurance provider to compensate for the damage to the insured and, if any, to third parties.

2.1.3. RISKS OF THE CONSTRUCTION PROJECT ITSELF

These include the risks due to the activities carried out during the construction stage. Among the infinity of risks which may be present, the most frequent are:

- Defects in workmanship, unskillfulness, negligence and malicious acts (fraud). One of the characteristics already mentioned is the lack, in many occasions, of specialized workforce. This circumstance, together with the variety of workplaces is the reason for the unskillfulness of workers to cause a large number or accidents. Next are listed some of the most frequent ones:
  - Incorrect formwork underpinning, with partial collapsing.
  - Defective arrangement of formwork.
  - Abrupt concrete pouring, with collapse of plants under construction.
  - Defective crane anchoring which may cause people to fall.
  - Inadequate storages which, on producing unexpected overloads, result in partial collapse of the structure (e.g. the collapse of a pipeline trench because the materials are placed very close to it).

Accumulation of material near the trench

  - Lack of skill or carelessness in handling equipment, cause of innumerable damages to the own construction work as well as to third parties.
  - Negligence in the implementation of preventive measures: forgetting to connect the water evacuation pumps, lack of foresight in load lifting, and the like.

- Errors in calculation or design and employment of defective or inadequate materials. Such factors usually result in large accidents. For example, a badly proportioned pier may cause part of a flooring to totally (or almost totally) collapse.

  For example, the accident during the construction of a viaduct at Almuñécar (Granada) after the collapsing of sliding formwork caused serious property damage and death of six people.

  Although the cause is yet to be confirmed, among the various hypotheses considered are:

  - Fatigue of materials, due to defective manufacturing or the effect of corrosion.
  - Poor quality of the material (Turkish steel laminated with different verification methods).
  - Technical failure due to poor construction.


Metal scaffold collapse at Autovía del Mediterráneo worksite in Almuñécar (Granada)

2.2. SPECIFIC RISKS ASSOCIATED WITH CERTAIN CIVIL WORKS

The risks to be analyzed are different in function of the type of work. **Specific Risks** affect a particular type of work, and **Generic Risks** affect all types of works (orography, hydrology, etc.).

Once the aforementioned has been said, and aimed at providing a practical view, in the following we shall focus on the construction features and risk factors associated with some of the most frequent Civil Engineering works.

2.2.1. MAJOR RISKS ASSOCIATED WITH BRIDGE CONSTRUCTION

Prior to analyzing the major risks associated with bridge construction, following is a description of the main bridge construction methods:

a) <u>Falsework Method</u>

In-situ concrete bridge construction requires an appropriate shape of the different concrete elements (slabs, girders, piers, etc). To that aim, fluid concrete is poured into moulds known as formwork (or shuttering), waiting for the necessary chemical reactions until the concrete sets and acquires the necessary resistance required. These formworks rest on the scaffolding system (falsework), the function of which is to transmit the weight of the non-bearing concrete to the ground.

All of these auxiliary elements are removed after the concrete has set and acquired its own bearing capacity.

Most of these auxiliary elements are made of steel although, in occasions, timber elements are also used.

There are different types of falsework depending on the requirements, the obstacle to span and the type of structure to be built:

- **Fixed falsework**, founded directly on the ground.

Falsework assembly. Crossroads in Czermiakowska, Warsaw, Poland

- **Mobile falsework**. These structures are usually made up by beams and studs resting on tubes or wheels, so that they can be pushed and placed in the next span. Their use is very widespread when a series of equal elements -both in section and length- must be poured, becoming very economical in this case and for not very high bridges as well.

Mobile falsework

- **Sliding falsework**. Used for bridge pier construction.

Sliding falsework

- **Cantilever falsework**. Auxiliary structures made up by a scaffolding system resting on transversal beams secured on the bridge supports, so that they can slide from one segment to another. These structures are useful in the construction of long bridges on rough ground, as they cannot rest on the ground.

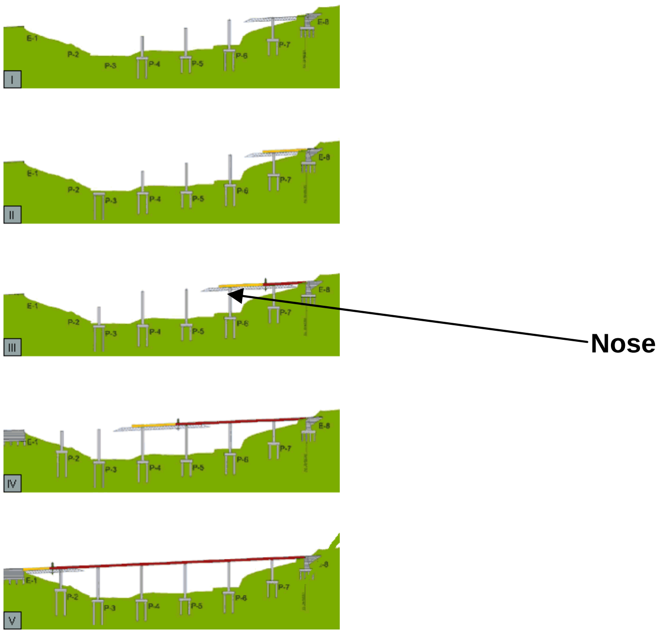
Cantilever falsework in bridge over River Lek. Vianen, The Netherlands

In most occasions, the falsework structure has a large size and is complicated to assemble, sometimes representing more than one third of the total construction project budget. Due to this, the structure design and calculation must be precise, so that it is usually carried out by specialized companies.

b) Incremental launching method

This construction technique consists of building the bridge superstructure into variable length (10 - 30 m) segments -or sections-, from one to the other end to be spanned.

The process follows the following scheme:



Bridge construction with the incremental launching method

Prior to the construction of the superstructure, the bridge piers that will support segments as the process progresses are constructed.

The different segments to slide are cast in situ, in a fixed formwork situated behind the abutment where the construction starts. The reinforcement is placed into the formwork and the concrete is cast. It must be waited until it sets and hardens, and then it is pre-stressed. After these operations, it is stripped and then slided towards the bridge by means of hydraulic jacks supported on neoprene, chrome steel plate, etc. Immediately alter, the following section is cast and slided again. The tip of the bridge is reinforced with an auxiliary element made of steel, called “nose”, which rests on the next pier during the sliding, thus decreasing the cantilever moments resulting from the bridge’s own weight.

Sliding structure at Tarango bridge (Mexico)

c) <u>Cantilever Method</u>

This construction method consists of building the superstructure starting from the piers or abutments, and adding partial segments (3 - 5 m long) supported on the preceding segment. To this aim, sliding cantilever formwork is used.

If it is decided to start the superstructure from a pier, the cantilever construction elements must be stayed by means of vertical tensioning devices on the initial pier or provisionally resting until the body of the bridge is stable enough.

If the construction starts at a bridge abutment, the span must be anchored with anchoring rods (according to the ground typology) to protect the bridge foundation and to compensate the bending forces which might arise.

This manoeuvre is performed in a more or less symmetrical way from each pylon in order to keep it balanced and not subject to moments capable of causing it to overturn.

Bridge construction from abutments.
Provisional diagonal supporting bracings (yellow)

Cantilever bridge construction from piers

RISKS

Among the possible risks associated with these construction methods, the most remarkable ones are:

- Whatever the type of bridge considered, the **underwater foundation** is one of the most delicate parts, because of the difficulty in finding a ground capable of withstanding the pressures, and therefore special foundations such as piles or pneumatic caissons are frequently used. The piers must withstand the permanent load and overloads without settlements, and they must also be insensitive to the action of natural agents like wind, large floodings, etc.

- Bridges are constructions aimed at withstanding dynamic loads. Due to this reason, certain phenomena which are not so relevant in other types of structures (e.g., resonance) gain importance. Moving loads considered on an individual basis produce a vibration in the structure; when several moving loads act simultaneously, the vibrations produced can either cancel each other out, or -on the contrary- act in the same direction, generating a supervibration causing the structure to collapse. This phenomenon was already known in the antiquity, when the armies would break ranks before crossing a bridge.

- When there is a great distance to be spanned, the number of piers must at first be high. The problem usually lies in the fact that long bridges are built in order to pass over branches of water or rivers. The difficulties inherent to the construction of the supports (underwater works, cofferdam construction for water evacuation, etc.) imply limiting their number as much as possible by increasing the span width, which forces the use of solutions such as suspension bridges stayed with high pylons and therefore very slender, with a tendency to vibrate by the effect of the wind.

- Large span lengths cause the deck to undergo the "waving ribbon" effect. Vertical overloads, and particularly the seismic loads and the pressure-suction cycles of the wind generate a vibration which may cause the deck to collapse, so that it must be stiffened by means of box girders.

- In the case of viaducts, they usually pass over very deep gorges. This is usually achieved by means of arch configurations when the length is not excessive, and through the incremental launching or cantilever technique for higher lengths. Viaduct construction requires the installation of very complex auxiliary high supporting elements which undergo the buckling phenomenon in all their extension, with possible overturning due to the high moments generated, causing the collapse of the structure under construction.

- In bridge construction, prefabricated elements are sometimes employed and lifted by means of cranes. If the working height is high and weather conditions are adverse, the operations to be carried out with a climbing crane are very dangerous. The own assembly and dismantling of the crane is a very delicate task which may result in accidents like the collapse of part of the crane.

Besides the risks which could be classified as general for all types of bridge construction, every construction technique presents particularities which must be taken into account in the risk analysis:

- **In bridge construction with the Falsework Method**. The main risk is derived from a bad calculation or assembly of these structures, which are sometimes very complex. Poor design or assembly during concrete casting may result in bending or collapsing due to insufficient foundation, etc. Special attention must be paid to the connection of lattices making up the structure.

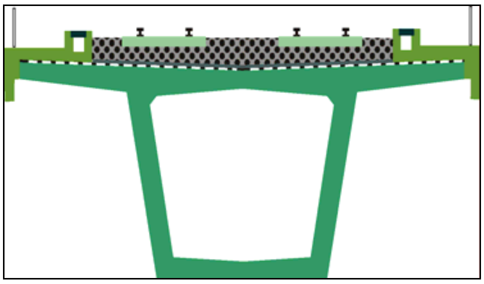
- **In bridge construction with the Incremental Launching Method**. One of the major risks is due to the excessive bending supported and the possible collapse of the constructed segment given the great length and weight of the cantilever segments, which sometimes can reach 60 m without intermediate support if it is so required by the obstacle to span.

  In some occasions, the superstructure to be built between one end and the other is not straight but inclined, so that it must be taken into account the installation of a braking system to prevent the segment from sliding uncontrollably through the supports.

  As some bridge elements can be cast in situ, it is convenient to protect the manufacturing area from bad weather (e.g., with protection canvas) so that the construction is not affected.

- **In bridge construction with the Cantilever Method.** Likewise with the previous method, the cantilever elements are subject to bending forces, and the loads supported are in many occasions superior to the loads supported once the bridge is completed. Therefore, on designing the bridge structure it is also convenient to take into account the different construction stages. In order to avoid -as much as possible- this load difference, temporary bracings are frequently used.

  For the construction of steel box-girder bridges, it is important to prevent dent problems which have sometimes caused accidents.



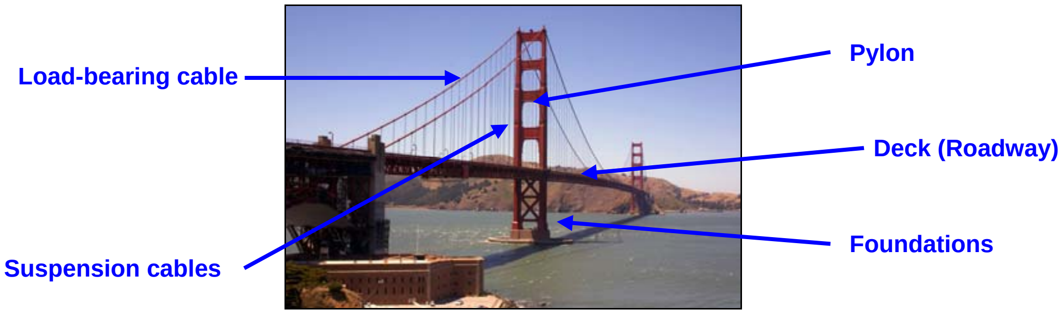
Cross-section of deck supporting box-girder

- **Suspension bridges**. The construction of this type of bridge is complex and involves risks, so that they are analyzed particularly.

  Suspension bridges are structures which support thanks to their shape. The structure is basically composed of the main cables (load-bearing cables) from which the deck is suspended by means of vertical hangers affixed to the ends of the span to be bridged, and they have the necessary sag to bear the loads acting upon it through a pure-tension mechanism.

  These bridges are composed of:

  - Pylons or towers. These structures serve as support for the load-bearing cables.
  - Foundation. The function of which is to transmit to the ground the loads from the pylons.
  - Deck. These are usually box girders, as they are more rigid and allow reducing the vibration effects caused by the wind.
  - Load-bearing (main) cables. They support the deck loads.
  - Suspension (secondary) cables. They allow the connection between the deck and the load-bearing cable. They can be vertical or slightly inclined (in order to mitigate vibration problems).



Golden Gate Bridge

The construction is difficult and implies many hazards, so that any negligence or lack of assembly may cause accidents to happen.

Suspension bridges are flexible, this feature being their major advantage but their major inconvenience as well, as it is the reason why they are very sensitive to the effects of wind and dynamic loads due to the traffic passing over.

Sometimes, this type of bridge requires very high pylons (of up to 300 m), which makes them sensitive to wind-induced vibrations. In order to avoid this effect as much as possible, bracings must be foreseen in order to increase its stiffness.

These bridges transmit much load to the ground, which in many occasions implies the need of building deep foundations, sometimes causing problems in the foundation draining and making it necessary to resort to special foundations (pneumatic caissons, etc).

In the construction of this type of bridge, the cables must be anchored either to one end of the bridge, to the ground (provided it has adequate features) or to concrete blocks. Defective anchoring of these elements may result in an accident and implies a risk to be considered.

Suspension bridge. Detail of anchorage blocks

They are very sensitive to Forces of Nature.

Suspension bridge

2.2.2. MAJOR RISKS ASSOCIATED WITH DAM CONSTRUCTION

A dam is a Civil Engineering construction which serves to contain the water of a natural course with two different aims, either alternative or simultaneous, according to the cases:

- To increase the level so that it can be diverted through a spillway in order to regulate the volume of water.

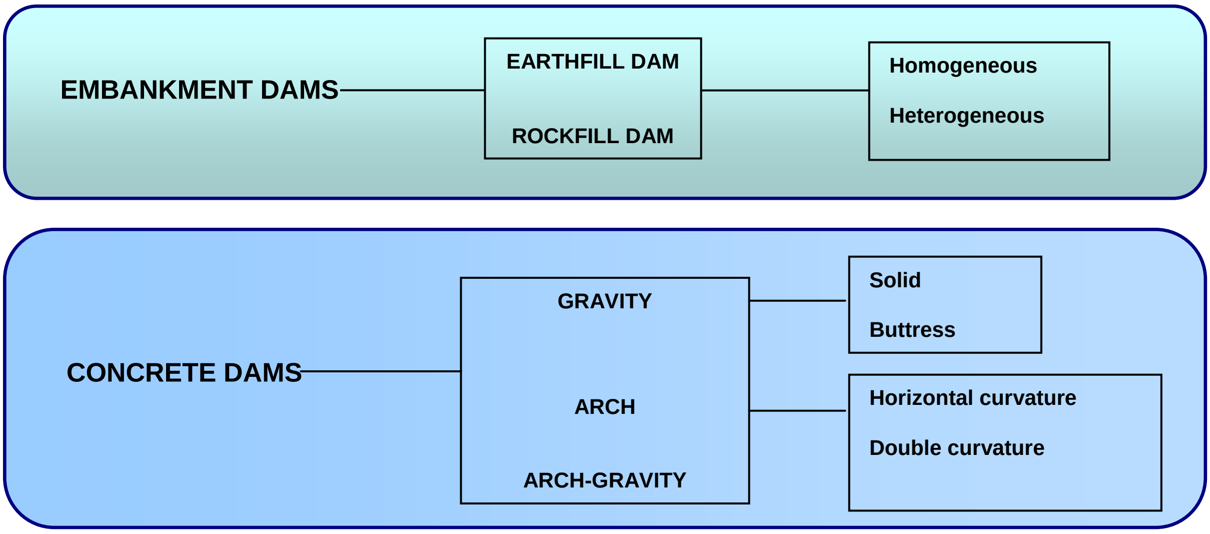
- To create a reservoir in order to retain the excess of water, allowing the supply of the liquid in moments of shortage.

Dams must fulfil a double function: they must be impervious and stable to resist the water pushing behind it.

Conde Guadalhorce Dam

Dam types

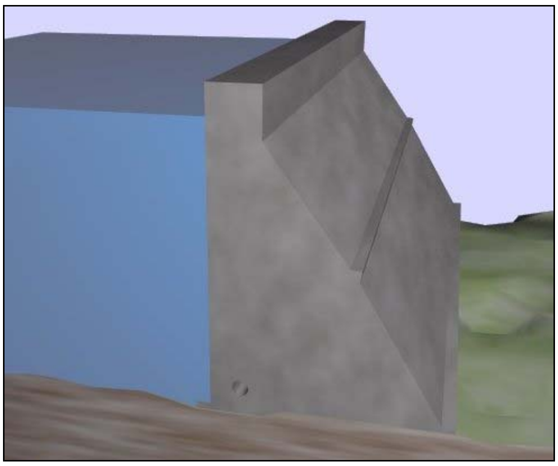
Dams can be grouped into two major categories on the basis of their composition: **concrete dams** and **embankment dams**. The selection of one or the other type depends on the topography and conditions of the ground.



a) Concrete dams are fundamentally constructed with concrete, with or without steel frameworks.

There are three different subcategories:

- Gravity dams: The water is held back because of the own weight of the dam, without the intervention of the arch shape.



Gravity dam scheme

- Arch dams: Arch dams transmit the thrust (vertical and horizontal loads) towards its foundation and abutments, due to the “arch” effect. They may have horizontal or double -horizontal and vertical- curvature, which is the most normal.

Double curvature dam

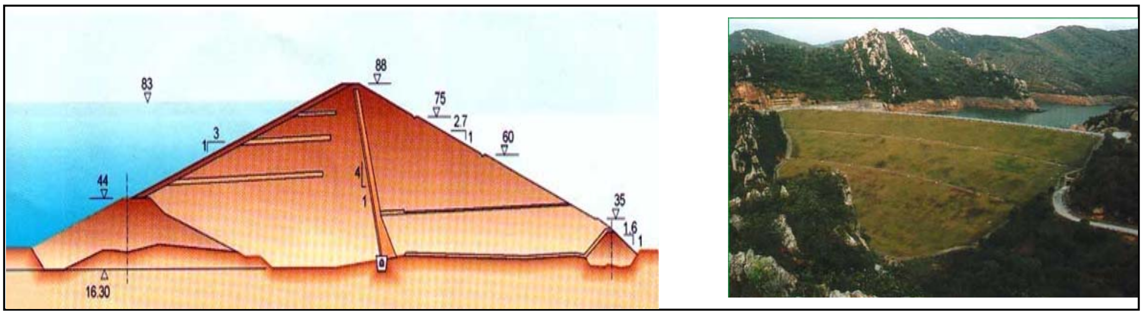
- Arch-Gravity dams: A combination of the two previous dam types. The single action of the curvature is insufficient to withstand the thrust and the dam must be provided with a certain weight to compensate this defect.

b) Embankment dams are constituted by materials provided by nature which do not suffer any chemical process of transformation, being treated and laid through compaction procedures of soil mechanics, acting by gravity. They are composed of stone, gravel, earth, silt and clay, in accordance with the following classification:

- Rockfill dams. When more than 50% of the material is composed of rock.
- Earthfill dams. Also known as “rolled earth dams”. For materials with lower grain size.

According to the distribution of materials:

- Homogeneous: When all the material that the embankment dam is made of has the same characteristics. It may deal with more or less impervious materials (clay or silt). It requires very smooth slopes for the haunches to be stable under the different actions which may show up.

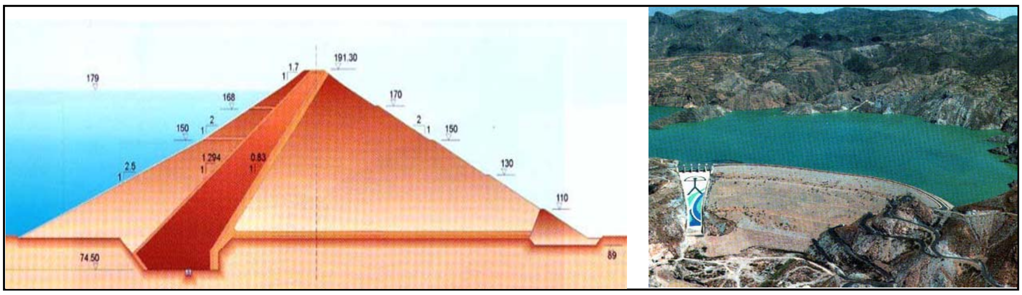


Homogeneous dam

- Zoned: This is the most common type of dam, with employment of different materials, with an impervious core (usually clay) and more permeable materials as we get further from the dam core. So, one part of the dam fulfils the impermeability criterion and the rest has enough resistance to provide the construction with overall stability. They allow for higher slope inclination, so that the dam occupies a lower surface area.

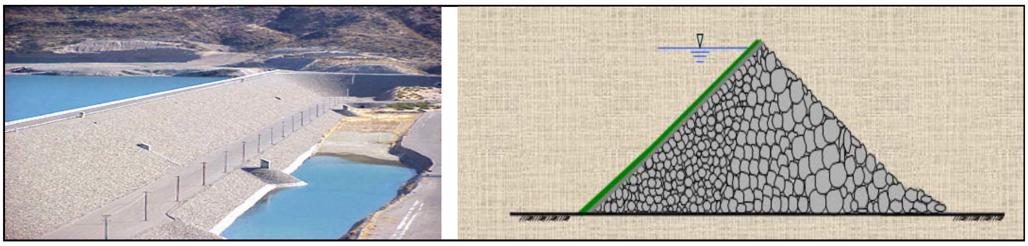
  Zoned dams may have two different construction typologies:

  - An impervious core (made from clay or silt), either in the interior of the dam, in the centre (vertical or almost vertical) or near the upstream facing (inclined).



Heterogeneous embankment dam with central core

  - An impervious facing covering the upstream slope area. This can be achieved through concrete or asphalt fabric screens.



Heterogeneous embankment dam with impervious screen

Construction method

Dam construction follows the following process:

1. River diversion

For the construction of the dam side in the course of the river, it is necessary to divert the river to create a dry work area at the damsite. This dry area can be created in two different ways:

- By totally diverting the river through an artificial course. It consists of the construction of an artificial course, for which it is needed to construct a temporary dam, called cofferdam (or diversion dam), in order to make a pool for the water to enter through the new course. It is a conduit (open channel or pipe) which transports the diverted water to a spot downstream. Moreover, the cofferdam shall contain the waters which cannot be held by the conduit.

Diversion tunnel at Ralco dam (Chile)

Stone cofferdam at Three Gorges Dam (China)

- By leaving only a portion of the waterway dry and channelling the passage of current through the rest, thus successively carrying out the work.

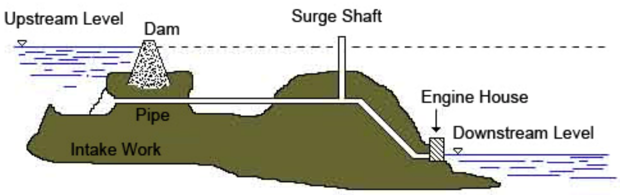
2. Auxiliary works

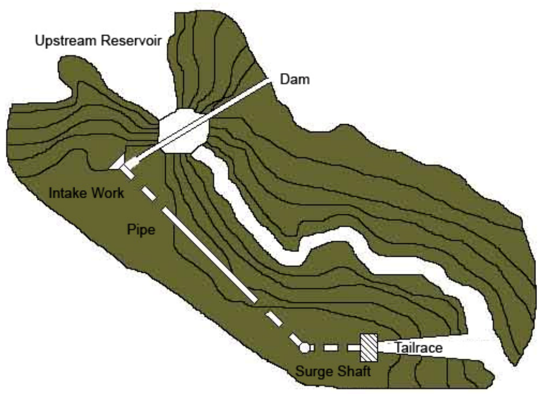
It is necessary for dam construction to transport large amounts of construction material, in many cases across very irregular or mountainous land. Therefore, it becomes necessary to construct provisional access roads and bridges, as well as tunnels (in occasions) or even to carry out slope filling works, etc.

Moreover, depending on the function to be fulfilled by the dam, different water pathways must also be built -most of them underground- including the respective water inlet and outlet structures.

These works include:

- Water intake towers and supply tunnels for water supply projects.
- Upstream and downstream galleries.
- Penstocks.
- Surge shafts.
- Galleries for hydroelectric plant turbine room and transformers.



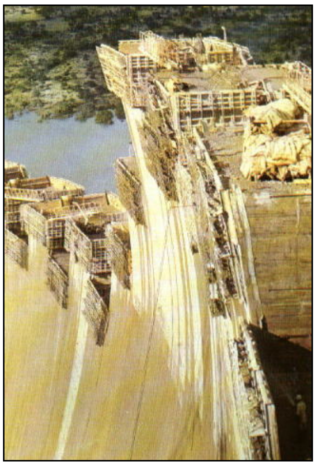


3. Construction of the dam itself

The construction method varies depending on the type of dam:

- <u>Concrete dams</u>. These are built basically through two different methods:

a) **Conventional method**. Individual sections are constructed as blocks and concreted forming "towers", the size of which depends on considerations in relation to the construction project and the setting heat to be expected. In this case, the decisive factors are: the temperature during the on-site concrete casting, the cement percentage, the concrete cooling system and the weather conditions at the damsite, as the setting and cooling temperatures may be affected.



Construction with blocks

There must be interruptions during the construction, so that *construction joints* are produced, which are practically horizontal shaped. Besides, the so called *functional joints* are constructed in order to prevent cracks from occurring in the concrete expansion and contraction processes -with possible seepage and resistance reduction-, causing the division of the dam into blocks with certain independence from each other. After the project completion, when the dam's own weight acts, and prior to filling the reservoir, cement suspension is injected in the block cracks in order to achieve the monolithic structure.

b) **RCC (Roller Compacted Concrete) Method**. RCC is also known as "Rollcrete". In this construction technique, the concrete is transported to the dam surface by trucks or conveyor belts. Then, it is distributed with bulldozers and compacted with vibratory rollers. The thickness of the concrete layer ranges between 30 and 50 cm. In order to ensure watertightness on both sides (dam facings), these are built of concrete according to the conventional method. Additionally, cement mortar is laid between the horizontal layers of Roller Compacted Concrete.

Concrete is saved by using this method, together with a lower setting heat, thus avoiding the functional joints. Therefore, it is more economical than the previous technique.

Ralco dam construction (Chile)

- Embankment dams:

a) Impervious inner core. Embankment dams are built by placing selected layers (30 to 50 cm thick) of fill material with different grain size, pre-treated if necessary. This material is compacted, important operation to prevent settlements and obtain the maximum resistance. During compaction, as the optimum degree of density depends on the water content of the material, work must stop during rainfall. In isolate cases, hard rainfall may make necessary the removal of material already placed and compacted before placing the next layer.

b) Rockfill dams with impervious face

- Concrete-faced rockfill dams (CFRD): The impervious element in this type of dam is a concrete slab on the upstream slope in contact with the reservoir water. The concrete face is made up by triangle-shaped or quadrilateral-shaped slabs joined by means of impervious joints (corrugated copper plates or some bituminous substance), and allowing the independent movement of each slab.

  At the dam toe, on the upstream side, the slab is connected to a concrete retaining wall which forms the transition between the rock subsoil and the impervious concrete slab.

The fundamental defect of the concrete face is the great difference in deformability compared to the material of the dam, which makes it very sensitive to possible dam settlements, which may leave the wall unsupported, and therefore they are reinforced in two directions.

- Asphalt facing: The impervious element is a bituminous layer placed on the upstream slope of the dam.

  The advantage lies in the fact that, besides being impervious, the material is also flexible, so that it adapts very well to dam settlements. Additionally, the construction and repair are easy and fast, and in the event of cracks occurring, they may close on their own thanks to the plasticity feature of the material.

Execution of asphalt layer at Ralco dam

  The construction method is similar to concrete facing rockfill dams, with the difference that the asphalt layer is laid once the dam body has reached its definitive height. The face is generally built in several layers (30-50 cm thick), and it must be supported on a flat surface made of porous or asphaltic concrete. The tamping is done with rollers moved from the crest.

RISKS

- The project and construction of a dam present special problems demanding high knowledge of several sciences and techniques: Geology, foundations, Hydraulics, properties and treatment of materials, etc. Perhaps, that is the reason why it requires, more than any other construction project, the collaboration of several specialists and team work. As a conclusion, the plan and the project have special importance in dam construction, for the corresponding works and for the river diversion system.

- River diversion. The maximum flood to be diverted is the major problem in designing and determining the dimensions of the diversion elements. It must be determined based on the following dilemma:

  - If we fall short, floods higher than the diversion capacity will be spilt over the diversion works and will flow through the old natural course, flooding the works that are being built.

  - If, in order to avoid this, a very wide diversion is done, it may be excessively costly.

  The drainage capacity of diversion tunnels is generally designed to have a 30 to 50-year return period flood event, in order to prevent flooding during the construction.

  Therefore, the two major risks associated with dam construction during the construction stage are: 1) The possible flooding of the works due to rain-induced floods (they are very sensitive to natural hazards), as such flows are not contained by the diversion elements; and 2) The risks derived from the necessary explosions to demolish the temporary cofferdams.

Two moments of a cofferdam demolition (with explosives) at Three Gorges Dam (China)

- Auxiliary works. Due to the fact that access roads are provisional, no coating layer is applied on them, meaning that they are exposed to rain and possible floods.

  In general, temporary works (roads, bridges, fillings, etc.) are very affected by landslides induced, for example, by hard rainfall; as well as natural hazards (earthquakes, etc.).

- Materials storage warehouses and construction machinery are highly exposed to landslides, if they are located in the proximities of slopes susceptible to landsliding.

- Embankment dams. These dams do not withstand being overtaken by floods, both during construction and once under operation, as the little cohesion of the materials they are composed of could be reduced, which might cause the collapse of part of the wall, as well as filtration areas. That is why it is important to carry out a good study on historical rainfall on the river during the project stage.

The dam toe is one of the most important elements in the construction of concrete facing dams. Its correct formation is essential to assure the watertightness of the dam.

Internal erosion may develop in the joint zones between the impervious material of the dam core and the integrated concrete structures (bottom drain, etc.). In order to prevent this phenomenon, they must be planned and constructed with special care.

- Double curvature dams. They are very slender and may adopt very daring and complex shapes, which allows them to be very high and with small thickness. This complexity requires great skillfulness and experience from the constructors, who must resort to uncommon construction systems and the use of expensive construction equipment as well. Due to this, any mistake made either during the planning or the project stage may lead to future accidents.

  Generally, because of the large loads transmitted to the ground due to the “arch” effect, it must be resorted to extensive foundation works.

  Concrete may be altered by the presence of meteorological or environmental agents, by increasing its resistance in direct proportion to its thickness. Increase in thickness may lead to being less demanding with the quality of the materials in order to save costs.

  A double curvature dam must be monolithic, so that the damsite is required to be resistant and little deformable, resorting if necessary to ground improvement techniques (injections, etc.).

- Although damage by fire is not one of the major risks for these construction projects, material warehouses, workshops and construction equipment must be equipped with their corresponding fire extinguishing equipment.

  As for the basin (bowl-shaped piece of land which serves for containing water) and the damsite (piece of land where the dam itself is located), they are required to be impervious, so that it is necessary to prevent seepage insofar as possible. Due to this, it is vital to conduct a proper ground study in order to get to know its characteristics and mechanical behaviour. For example, limestone soil which may have caverns would be bad soil, whereas marl or granite grounds (provided they are not jointed) show a good behaviour.

2.2.3. MAJOR RISKS ASSOCIATED WITH BUILDING CONSTRUCTION

Construction stages

Building construction comprises the following stages:

1. Main work

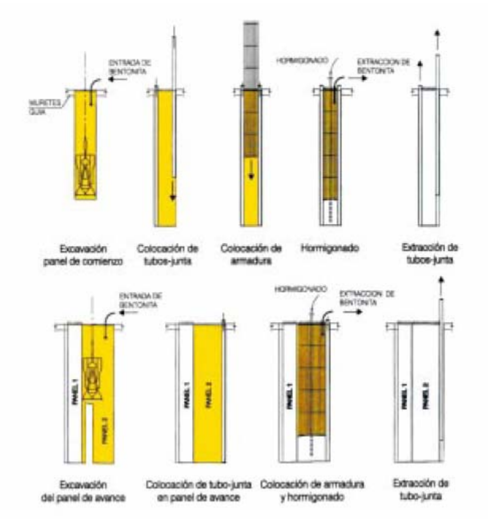
It includes every construction element designed and built in order to guarantee the stability of the building:

- **Foundation.** It is the part of a structure in direct contact with the ground which transmits the load of the structure to the underlying ground.

  Buildings (and mainly in the case of high-rise buildings), transmit important loads to the ground. In order to prevent non-uniform building settlements, these loads must be absorbed by the ground through the foundation, which must be supported on highly resistant ground (rock or similar).

  Therefore, there are different types of foundations in function of the loads to be transmitted and according to the characteristics of the ground and its behaviour (ground bearing capacity):

TYPES OF FOUNDATIONS	
SUPERFICIAL	Footings Slabs
SEMI-DEEP	Floating caisson
DEEP	Piles Diaphragm walls



Diaphragm wall construction

- **Structure.** The group of resistant elements providing stability to the building, i.e.: piers, girders, floorings, load bearing walls, roof structure, etc.

2. Secondary works

Works with regard to general finishes:

- Closings. Curtain walls are frequent in this type of buildings. They are usually composed of an aluminium structure (selected due to its light weight) upon which the glasses are placed.
- Claddings
- Walls
- Pavements
- Tile laying
- Ceilings, etc…

Petronas Towers (Kuala Lumpur)

3. Utilities

The major utilities of a building are:

- Plumbing
- Sewerage
- Hot water
- Air conditioning
- Heating
- Gas
- Electricity
- Communication (telephone line, ADSL, …).

RISKS

- Theft. It acquires importance, given that elements like bathroom fittings and copper tubes are very much in demand. Theft results in ever-growing economic losses.

- Lightning. Special attention must be paid to the existence of electric transformers, cranes, masts, etc., and also to the fact that the building under construction may be higher than the adjoining constructions, given that there are no lightning conductors available during the construction stage.

- Fire. This is one of the major risks in building construction, both during the construction stage and after the start-up. And it becomes more important in the case of high-rise buildings. Costs derived from fire claims are usually high, and in the case of high-rise buildings this fact is aggravated by the difficulty in achieving floors above a certain height. Due to all of this, they must be kept in mind.

Windsor Tower (Madrid) after the fire

The most important flammable and combustible materials in building construction are the following:

- Auxiliary equipment (scaffolding, formwork, etc.)
- Construction machinery (backhoes, etc.…).
- Construction materials (timber, plastic, steel, etc.).
- Packaging (paper, cardboard, etc.)
- Temporary warehouses.
- Lubricants (greases, combustibles, detergent, etc.)
- Vegetation
- Appliances and furniture already installed.

Among the many reasons which may cause a fire to start, the most remarkable ones are:

- Defective safety system (absence of person in charge, substitute, etc.)
- Negligence: Throwing cigarette butts, improper use of heating inside the building, etc,
- Unauthorized hot works.
- Waste accumulation (paper, etc.)
- Defective electrical connections.
- Storage of materials inside the building (packaging, timber, flammable elements, etc.) all over the floors.
- Reduction in safety facilities due to lack of time and cost reduction.
- “Chimney effect” (also known as “stack effect”) of the central core (central concrete wall present in many high-rise buildings, which allows the absorption of the horizontal stresses of the wind, also serving as location for general installations), brackets and, in general, hollows.
- Lack of training of the staff.
- Weather conditions (wind, etc.).
- Fire-fighters’ ignorance of the place.

As a consequence, it is essential -above all in high-rise buildings- the implementation of preventive protections against fire from the beginning.

The preventive measures during the construction stage comprise the following:

- Existence of Heads of Safety at the workplace.
- Instructions to personnel on basic fire extinguishing measures through a training course.
- Information to fire brigades and periodical visits.
- Emergency plans.
- Order and cleanliness.
- Periodic disposal of waste and accumulated materials (limiting the amount of these and implementing safety measures such as minimum distances between materials, fire walls, etc.).
- Maintenance.
- Sufficient amount of portable fire extinguishers.
- Provision of water for the fire extinguishing system (pipes, dry column, temporary tanks, etc.)
- Daily disposal of flammable materials from the interior of plants under construction.
- Precaution measures must be taken if welding or similar works are carried out: Hot Works permit approved, as well as the presence of a person trained in fire extinguishing during the operation, and subsequent supervision.
- Fencing the premises to prevent fire propagation.

- Design errors/Defective materials. These are fundamentally due to a bad project planning, incorrect use of calculation software, errors in the choice of materials or in the construction. If new construction systems are employed and the constructor is not familiarized with them (lack of constructive details, etc.), this may lead to imprecise execution.

- Defects in foundation. It is important to conduct a good geotechnical study, where the characteristics and behaviour of the ground (load bearing capacities, possibility of settlements, etc.) are studied.

  There are grounds where the building settlement may imply higher risks, among others:

  - Foundations in soft or fill soils. The major risk is the occurrence of uncontrolled differential settlements.

  - Foundation in expansive terrains with clayish soils. They can be mixed with sands or silts and present the property of undergoing large volume variations on being reduced or increased the degree of humidity. The problem derives from the fact that the deformations are neither homogeneous nor proportional to the degree of humidity and they can exert great pressure on the building, generally in the form of upward movements, being able to lift it or produce settlements in the case of reduction in humidity. They are especially dangerous in warm climates, where they undergo seasonal expansions and retractions.

  - Foundation in karstic terrains. Karstification is the geologic process of differential chemical and mechanical erosion by water on soluble bodies of rock, such as limestone, dolomite, gypsum, or salt, at or near the Earth’s surface. Karstification is exhibited best on thick, fractured, and pure limestones in a humid environment in which the subsurface and surface are being modified simultaneously.

    The resulting karst morphology is usually characterized by dolines (sinkholes), hums (towers), caves, and a complex subsurface drainage system. All of these may lead to total or partial collapse of the building either during the construction stage or once the building is in operation.

In addition to the ground, errors may occur during the foundation works, which may cause damage. Among other errors, the following can be highlighted:

Diaphragm walls:

- Incidents may take place in diaphragm walls construction due to a failure in the correct insertion of the framework-cages into the deep hole down to the planned depth, as they get stuck in the walls or pipes.

- Concrete cuttings in piles or diaphragm walls causing differential settlements independent from the structure.

Clamshell bucket employed in diaphragm wall construction

Piles:

- Inadequate pile selection where the pile does not adapt to the ground may lead to failures which are detected either during the execution or once the foundation is hidden.

- Insufficient pile length, as during the ground boring test false rejections may take place in hard strata but with insufficient thickness, and the surface may not present enough bearing capacity to support loads or settlements may arise.

Insertion of pile frame

- Incidents may occur in the construction of piles due to failures during the tube hoisting works at the end of the pile construction. A portion of the just-inserted framework is often pulled out. The consequence is a reduction in the load bearing capacity of the pile -which, in some occasions, must even be replaced-.

- If the groundwater level is high and the pile is driven without a pipe, concrete washing may take place before it hardens sufficiently.

- The planned load bearing capacity may not be achieved when deviations in the vertical axis occur, due to obstacles or poor drilling execution, beyond the admitted measurement tolerances, which usually happens for lengthy piles.

As a preventive measure, it is recommended to check the resistance of piles or walls through methods like ultrasound, etc.

- For the basement excavation, the building is stabilised by means of retaining walls with provisional systems for thrust absorption. On eliminating said provisional systems, the horizontal stresses they cause are sometimes forgotten, an important aspect in the case of parallel expansion joints, etc.

The repair of these failures is usually expensive, greatly exceeding the initial foundation costs, as additional measures must be taken (pile replacement, injections, etc).

Settlements:

The appearance of settlements cannot be avoided during the construction works. However, these settlements do not mean a problem, as they are usually under control so that, in case that the permissible limits are exceeded, it is possible to resort to constructive measures to have the problem solved (expansion joints, etc). The problem lies in the settlements produced by poor construction (hard rains causing landslides, wrong assessment of the load bearing capacity, defective design, etc.) which may endanger the building stability.

In most cases, the repair of these settlements is very costly, so that many times it necessarily leads to building demolition.

Ground settlements

➤ Errors during structure construction

- **Concrete structures:**
  - Incorrect frame arrangement and anchorage, mainly in flooring-beam joints.
  - Defects in formwork.
  - Inadequate concrete cast-in-place, due to excessive prepared concretes, framework densification, high water/cement ratio, etc.
  - Shrinkage cracks in walls due to lack of joints, etc.

Concrete structure formwork

- **Steel structures:**
    - Buckling.
    - Denting.
    - Stability during erection works.
    - Appropriate welding execution and range tolerances which may cause structural collapses.

➤ Earthquakes. The behaviour of a building during an earthquake depends on factors such as:

- **Symmetry**. A symmetrical building (with regard to rigidity of materials, distributions, etc.) behaves better than an asymmetrical one.

- The **type of structure**. Rigid structures (walls, etc.) face earthquake-induced stresses by means of their high resistance to deformation and transmission of the seismic load by means of their rigidity. However, the disadvantage is that rigid structures do not show mobility or ductility, causing cracks to appear. On the other hand, steel structures face the stresses by withstanding great deformations, so that joints must do likewise.

  In general, the behaviour of the steel structures is better than the concrete ones, as they do not collapse quickly in the presence of excessive stresses. Besides, their conditions can be improved through framework reinforcement. Excessive stresses usually results in concrete failure, with the risk of a possible total collapse.

- The **type of foundation**. Deep foundations (piles, etc.) show a better behaviour than the shallow ones (footings, slabs, etc). In spite of the fact that slabs in soft soils may show a good behaviour in an earthquake, the risk of settlements is higher than in the case of foundations like piles.

- The **type of ground**. Sound rock responds better to the effects of an earthquake than water-saturated sandy soil or artificial fills.

- **Poor construction** and **poor quality of materials** become evident in the event of an earthquake.

- <u>Winds.</u> Wind is a factor that must be taken into account in building construction, and it becomes especially relevant in high-rise building construction.

  Factors such as location, shape (the more irregular the building, the more irregular the distribution of the wind forces), openings in the lower part of the building or the existence of adjoining buildings, have an influence on the action of the wind on the building, by increasing the wind speed or by causing turbulences leading to an increase in the wind pressure on the building and possible damage to structural elements and their connections.

  The wind may lift light objects, and this phenomenon gains greater importance during the construction phase.

  Regulations on building design to withstand the wind-induced loads are different according to the region. These regulations consider the wind strengths as static loads. However, in high structures there is also an involvement of the dynamic effects produced by the direction and force oscillations of the wind (gusts, vibrations, whirlwind effects, etc.). These effects produce important stresses.

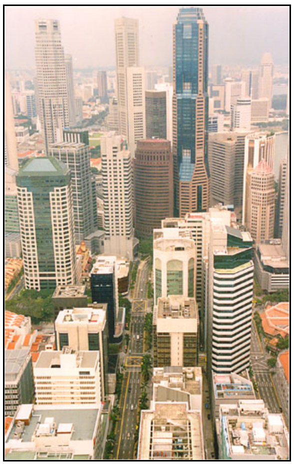
  Another possible effect to be taken into account in high-rise buildings is the resonance phenomenon (when the frequency of the wind coincides with the natural frequency of the building). In this situation, the building responds with vibrations which may cause from uncomfortable situations for the user -who may be obliged to evacuate the building- to the collapse of the structure.

- <u>Other risks:</u>

  - Terrorism
  - Impact from the air
  - Demolition. This action requires specialized personnel. As it is a complex process, it requires high technology, a thorough study on which system to use and a good planning, as well as a survey on the adjoining buildings because of the possible adverse effects caused on them by the demolition.

Demolition of a building floor

- Loss of Profits. In many cases, the owner of the buildings wishes to market them for office use, so that they are leasehold beforehand. Delay in the completion of works may result in financial damage due to loss of profits which the owner will sometimes not be able to face.



2.2.4. MAJOR RISKS ASSOCIATED WITH UNDERGROUND PIPELINE CONSTRUCTION

Construction stages

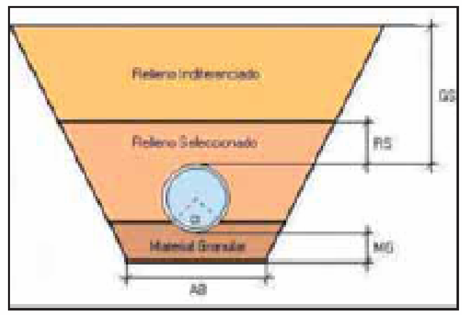
The construction of this Civil Engineering Work comprises the following stages:

1. Installation and stockpiling of materials.

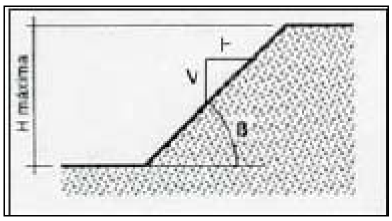
2. Setting out.

3. Ground moving. The route of the pipeline works attempts to adapt to the topography of the natural terrain, so that the natural profile of the terrain must be modified. In some cases, the elevation of the terrain must be reduced (when the elevation of the pipeline is below the original terrain), which is known as *clearing.* In other cases, it must be increased (when the elevation of the pipeline is above the original terrain), which is known as *earth filling.* Ground moving must be carried out in all cases.

4. Trench excavation. It is any longitudinal excavation, the essential function of which is to contain service and supply pipelines. They must be calculated and excavated in such way that a correct and reliable pipeline installation is guaranteed.



The **slopes** are created at the margins of the excavation. These slopes are defined through their inclination; this value is generally denominated as “H:V”, indicating a vertical increase of V metres per H horizontal metres added. Expressed as a percentage, X% indicates that the addition of 100 horizontal metres leads to a vertical raise of X metres. The maximum inclination of the slope will be calculated according to the type of terrain crossed (internal friction angle). So, rocky terrains allow more vertical slopes of 1:2 or 1:3 (indicating an elevation of 2 or 3 metres per horizontal metre added). Nevertheless, the slope inclinations must be flatter (1:1 or 2:1) in compact or easily subject to erosion terrains.



H:V. Slope inclination

Any excavation with a slope higher than its natural slope ß (data which can be obtained from the Geotechnical Study that accompanies the Project Report) is regarded as dangerous.

5. Trench bottom. It shall be excavated to the grade line (upon which the pipeline is supported) provided that the ground is uniform (with no stones, etc. left exposed), stable and with sufficient bearing capacity. Otherwise, it shall be excavated below the grade line supporting the pipeline in order to carry out a subsequent filling (loose earth, gravel, crushed stone) compacting and surface leveling.

6. Pipeline installation. This phase comprises the following steps:

- Transport, handling and storage.
- Pipe laying.
- Pipe joining.
- Anchorages and supports.
- Drains. Water stagnation or water veins flowing through the trench bottom may take place during the installation, which would possibly lead to landsliding in the trench bottom or pipeline flotation. In order to avoid these risk situations, when the elevation of the groundwater level is above the trench bottom, it must be foreseen to eliminate water through drains to allow water evacuation until the pipe has been installed and the trench has been filled up to a sufficient height.

Pipe transport

Joints

7. Trench filling and compaction. The trench must be filled once the pipe is installed. Then, the ground must be compacted in order to avoid ground settlements.

8. Ground reinstatement.

RISKS

Risks during the construction stage

- Risk of rockfall, slope failure and ground settling due, among other causes, to:
  - Atmospheric phenomena.
  - Wrong determination of the necessary slope.
  - Ground weathering: The ground disintegrates and may lose their cohesion under the action of atmospheric elements, such as humidity, dryness, ice or thaw, leading to collapses.
  - Lack of slope protection. For example, those derived from operation failures in one of the elements making up the timbering, the dimension of which is calculated for certain maximum foreseeable loads. The materials to be stockpiled, the products resulting from the excavation which must not be immediately removed, machinery, trucks used, etc., may present a problem of overload that may lead to misoperation of the timbering.
  - The existence of road traffic may transmit vibrations, leading to slope failures.
  - Open face length and time. Open trenches are highly exposed to natural hazards. The longer the length, the higher the risk because a longer extension of open trench is exposed to the inclemency of the weather during a longer period of time.
  - Lack of bearing capacity and stability of the trench bottom due to not taking the necessary precautions.
  - The compaction of fill material is done by layers (low thickness layers). Inadequate compaction may lead to ground subsidence derived from a poor support.
  - Risk of fines leaching (fines migration). In soils with a high groundwater level, under saturated conditions, the filler fines or the trench bottom fines may migrate to the neighbouring soil of the trench bottom or walls and vice versa. Any migration of particles

from one zone to another may lead to ground settlement and loss of either the necessary support or the lateral support of the tube, or both.

- Risk of hillside erosion due to a lack of the necessary protective measures (nets, walls, etc.).

- Risk of damage to the pipeline caused by strikes (dents, cracks, breakage, etc.,-special care must be taken at the edges of the pipeline-) and deformations due to poor attachment or elevation during the pipe installation (transport, handling, storage at the worksite and laying) and trench filler compaction.

- Risk of entry of an element (water, mud, earth, animals, etc.) in the pipes installed inside the trench on occasions when said pipeline stretch must be left exposed for a certain period of time.

- Risk derived from welding of joints, in case it is required.

- Risk of crack, breakage, seepage or misfunction in the pipelines in case of improper execution of joints and placement of the pipeline on supports.

- Risk of pipe movement. The inadequate support or anchorage, the lengthy stretches between consecutive supports, etc., may cause pipeline movement and flotation in situations such as floods, etc.

Risks after the start-up of the pipeline produced during the maintenance period

- Landslide due to fines migration resulting from poor water evacuation, a wrong calculation in the Project or mistakes during the construction.

- Damage to and/or misfunctioning of pipes, derived from poor design in project or mistakes in the construction stage (poor execution of joints, poor execution of pipe anchorage, etc.).

- Consequential Losses due to defects in design during the project stage.

- Consequential Losses due to defects in design during the construction stage.

Natural hazards

- Extraordinary rainfalls or floods (high groundwater levels, infiltrations, superficial runoffs, underground waters, leaking from other existing pipelines, etc.)

- Hurricanes, earthquakes or landslides which may affect the laying and placing of the pipeline.

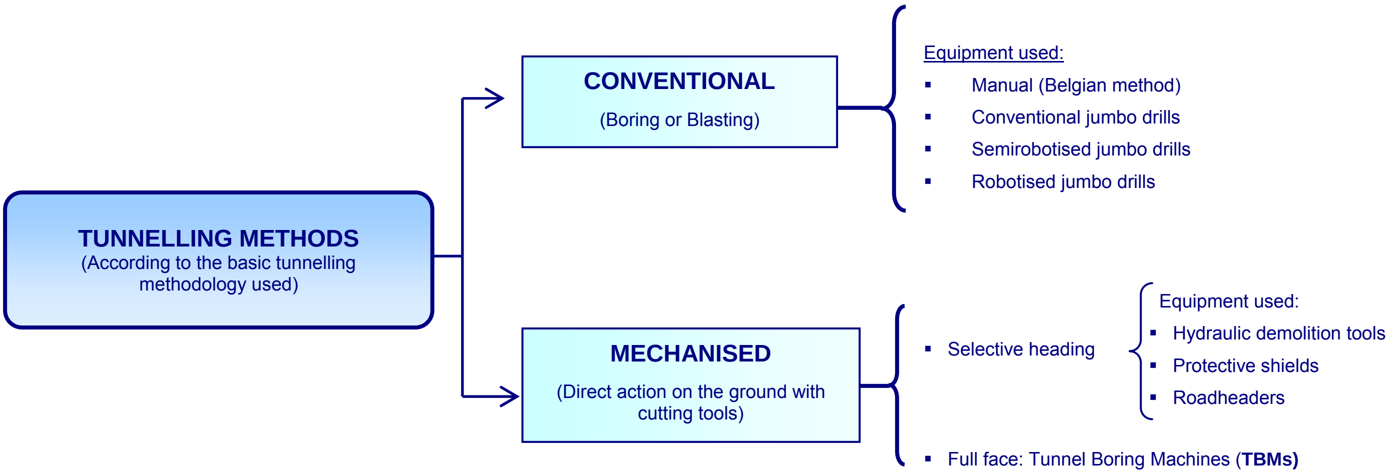
Other hazards

- Malicious acts.
- Theft.
- Fire due to operations such as welding, etc.
- Collisions, vehicle crashes, etc.
- Fall of construction materials (pipes during handling and laying; machinery, etc.), stones, loose materials, etc.
- Injury to third parties either during the construction stage (falls, overturns, runovers by machinery, landslides, floods, collapse of neighbouring buildings, breakage of pipelines in service, the effects of the blasting may cause damage to pre-existing works, electric contacts, intoxication or explosion on intercepting gas pipelines, etc.)

2.2.5. MAJOR RISKS ASSOCIATED WITH TUNNEL CONSTRUCTION WITH TBM'S

Tunnel construction works basically consist of building a structure, the tunnel, inside the natural formations of the ground. As a consequence of the ground to be drilled (hard rock, soft rock and soils), the limited dimensions and accessibility to the work front and the possible adverse effects (breakages, filtrations, etc) that may be caused in the environment (adjoining buildings, etc.), there arise certain problems involving, in function of the characteristics and behaviour of the ground (instability, rock abrasiveness, etc.), the application of the excavation procedure which best adapts to said ground.

Consequently, the success in building a tunnel will be due to work procedures which allow obtaining appropriate capacities while maintaining the overall stability of the affected environment.



The mechanised excavation achieves those objectives, obtaining high degrees of mechanization and automation of the process through the successive development of new machines with new technologies and the assistance of complementary construction techniques.

Among the different mechanised tunnelling procedures, the TBM system offers greater possibilities for development and expansion compared to other conventional excavation methods.

This excavation system consists of using Tunnel Boring Machines (TBMs), integral insofar as they are capable to excavate the tunnel full face by themselves (in general, the excavation section is circular) while collaborating in the placement of a temporary or definitive support in order to ensure the stability of the excavation and removing the debris as well. The TBM advances leaving behind the tunnel completed.

There is not a "universal" TBM which can be used for all types of grounds, so that the TBMs must adapt to the characteristics of the ground and, according to its geotechnical behaviour, these machines may show differences that are reflected in their design and operations.

The basic techniques to be applied in function of the type of ground to be drilled may be divided into two great groups: Hard Rock TBMs (moles) and Soft Rock TBMs (shields). During the last years, models which may be regarded as "mixed" TBMs have been developed, combining elements of both aforementioned methods.

RISKS

The use of Tunnel Boring Machines improves safety. However, this does not mean being totally exempt from risks: even with TBMs, tunnel construction is a dynamic work where unforeseen events can always take place.

Moreover, it must be kept in mind that these machines are highly costly and they are prototypes designed so as to respond to the needs of a ground with determined characteristics. Inappropriate selection, poor design of the TBM or non-specialized operators result in failure, because no changes can be made on the machine once the construction has started. In the event of entrapment, the works to free the victim are slow, difficult and dangerous, and result in stoppage for months. In some cases, this situation may lead to a cost so high that the system may not be advantageous any longer. Therefore, the versatility of the machines must be kept in mind at the moment of being chosen.

In order to select the appropriate TBM, it is essential to have a precise and timely knowledge of the characteristics of the ground to be drilled so that it can be perfectly defined, so that we can implement all the measures to prevent the appearance of unforeseen types of ground and avoid dangers affecting the personnel and technical means.

Underground excavation crown. Jointed ground

It must not be forgotten that the works are developed in an underground environment, and there is movement of ground as the excavation progresses. That is the reason why risks may be present both during the construction stage and after completion of the project. So, different factors like these must be taken into account in the ground study:

- Possibility of ground settlements which may cause the tunnel to collapse, so that enough overburden is intended to be above the tunnel.
- Possible presence of water which may involve problems in the excavation, such as landslides.
- Loss of ground which sometimes results in the appearance of chimneys.
- TBM blockage in the ground.
- The hardness and abrasiveness of rocks result in an important reduction in the TBMs capacity and a considerable increase in the maintenance expenses (e.g., replacement of cutting disks which get worn out more easily due to the abrasiveness of the ground. As a consequence, this technique may stop being profitable or even become unviable.
- Presence of gases.
- Probability of a fire to happen. The level of risk is increased in very long tunnels, and it can be mitigated if the necessary emergency runways are built simultaneously.
- Impossibility to carry out ground treatments from the interior of the tunnel.

TBMs are complex machines, the handling and proper operation of which require specialized personnel able to get the most out of the TBM and with more than enough reaction capacity in order to find solutions to every problem and unforeseen events which may arise.

The maintenance of a TBM is very expensive, but it is compensated for by the increase in capacity resulting from its use, in contrast with other excavation methods. In occasions, due to reasons beyond the excavation itself, financial risks (mainly Loss of Profits) may arise due to a delay in the construction derived from problems such as: increase in time spent in receiving spare parts, delays in logistics and supplies, maintenance, etc. For example, the TBM needs continuous supply of electric power, and a delay in the logistics of the process results in long stoppage times due to reasons beyond the excavation itself, which may also involve financial risk.

The work routine may also be an inconvenient, as the personnel may forget the risks present at the working environment.

3. CONSTRUCTION INSURANCE

Consequently to all the aforementioned, during the development of this type of works there may occur a large number of events resulting in economic loss to persons or entities involved in the design and execution of the work, or damage to third parties, circumstances which determine the necessity of insurance and, in consequence, the obligation derived from the contract for the insurance providers to face claims which, in some occasions, may represent large amounts of money. Besides, it is observed to be a very specialized type of insurance.

3.1. CONSTRUCTION INSURANCES

Construction insurances are the principal risk transfer instrument. These are, among others:

CIVIL WORKS	BUILDINGS
Contractor's All Risks (CAR) Insurance	Contractor's All Risks (CAR) Insurance
Erection All Risks (EAR) Insurance	Erection All Risks (EAR) Insurance
Material Damage Insurance	Material Damage Insurance
Completed Civil Work Insurance	Civil Liability Insurance
Operations All Risks Insurance	Decennial insurance covering structure damage
Civil Liability Insurance	3-year insurance backed guarantee
Machinery Breakdown Insurance	1-year insurance backed guarantee

3.1.1. ERECTION ALL RISKS (EAR) INSURANCE

This insurance covers against damage to insured properties during the erection works regarding machinery, apparatus and metal structures at the construction site, provided that the occurrence of such damage is accidental and unforeseen.

This insurance policy covers the erection of any equipment or process and/or a whole manufacturing plant.

It is very similar to the CAR Insurance. However, the major difference lays in the fact that in EAR Insurance there is a testing period (off load / on load tests) of equipment before provisional delivery to the proprietor, beginning with the completion of the erection works and ending with the commencement of maintenance works.

Only shall this testing period be covered provided it is specifically agreed in the Particular Conditions of the policy.

Eolic park

3.1.2. MACHINERY INSURANCE

This insurance policy provides cover against losses and material damage to the insured machinery, under operation or otherwise, consequently to internal or external damage, provided that they are caused by accidental and unforeseen events.

Double shield TBM

3.1.3. CIVIL LIABILITY INSURANCE

The activity developed by the construction company implies risks involved with the work itself and with its environment, which can bring about damage to third parties (either persons or properties). Hence, the object of the insurance is, in a wide sense, to protect the insured against liabilities due to an accidental event, that is to say, the compensation for economic injury to a patrimony as a consequence of an accident, resulting from the obligation to indemnify damage to third parties.

3.1.4. COMPLETED CIVIL WORKS INSURANCE

This type of insurance cover provides protection against damage to Civil Works after completion of the works, due to: acts of individual vandalism, natural disasters (earthquakes, floods, etc.) and impacts of terrestrial, aquatic or air vehicles.

Exceptions: Malicious acts, war, nuclear radiation, inherent vice, normal wear and tear, expansion/contraction movements due to thermal reasons, poor maintenance, consequential losses or damage and, unless agreed to the contrary, strike, riot, etc.

3.1.5. DECENNIAL INSURANCE

This insurance modality is aimed at protecting owners, promoters and purchasers of buildings or part of these from the date of works acceptance and for a 10-year period, against property damage due to determined construction vices or flaws directly affecting the building stability.

After promulgation of Spanish Law 38/1999 of November 5, on Building Ordinances (LOE), the 10-year guarantee is compulsory for any building for housing provided that the Work Permit application for new works or over pre-existing ones were after May 6, 2000.

The promoter is the insurance taker and is obliged by law to contract a Decennial Insurance.

As a result of Law 53/2002 of December 30, on Fiscal, Administrative and Social Order measures, the LOE was modified in such way that Self-Constructions and renovation works are exempted from the obligation to contract insurance.

Structural damage. Damaged pillar

Building cracks

From the different types of Engineering insurance, the main features of the Contractor's All Risks (CAR) Insurance are developed in the present manual.

3.2. CONTRACTOR'S ALL RISKS (CAR) INSURANCE

Contractor's All Risks Insurance (CAR) is an insurance modality that covers all types of Engineering Civil Works, with the fundamental aim of protecting against accidental loss or damage to the works, including the contractor's construction plant and equipment, as well as third parties' claims due to personal damage, provided that these directly result from such construction works.

It belongs to the category of "All Risk" insurance, so that it covers every concept not expressly excluded.

House buildings, office buildings, warehouses, hospitals, schools, theatres, churches, cinemas, hotels, factories, silos, bridges, dams, gates, channels, tunnels, roads, piers, watering and draining works, etc. are types of constructions that can be insured.

3.2.1. MAIN FEATURES

- **Insured parties**

  It provides cover to any party with an interest in the construction project to be carried out: promoter, constructor or subcontractors, if any, frequently including all the suppliers of materials and equipment, and rarely, the engineer, consultant or architect. The insurance taker could happen to be the main contractor or the promoter, all the intervening parties being the insured. It is even possible to find policies including a "main payee" clause in favour of an entity which finances the construction and demands insurance for the works.

  It is in the event of a loss when it becomes evident the advantage of insuring all the parties under a single policy, as it is not necessary to make investigations to find the guilty party. Consequently, there is no delay in repair works, with normal progress in the works at non-affected areas.

  Insurance companies usually do not include the engineer among the insured parties mainly because, if they did, all the losses resulting from defective design would be indemnified with no possible appeal, excepting special cases of proven negligence, which is extremely difficult to prove. Moreover, civil liability of engineers and architects can be covered through a specific professionals' policy.

Insured items

This insurance provides comprehensive coverage against possible **accidental or foreseen** loss or material damage to the insured works.

This cover is extended to:

1. **Works**. Understanding as such, the permanent and temporary works either completed or under construction. These concepts include the necessary materials, supplies, and spare parts for the construction of the insured project.

   The concept “Civil Works under construction” includes from ground preparation works (ground moving, etc.), auxiliary constructions (access roads, cofferdams, etc.) to air conditioning installation or finishes in general.

   All the materials stored at the worksite and intended for the construction works are also included here.

   Besides, other properties and liabilities can be optionally insured:

2. **Auxiliary Equipment**. This concept includes the elements which are not part of the works, but are necessary for the project construction, among others: scaffolding, formwork, auxiliary bridges, carpentry and timber framing, tools, provisional constructions, power facilities and supplies, dewatering/drainage pipelines, fuels and the rest of similar own properties.

Scaffolding at building construction

3. **Construction machinery**. This concept comprises the group of all types of machinery taking part in the construction works: cranes –fixed or mobile-, excavators, piling machinery, ground treatment machinery, loaders, concrete mixers, drillers, etc.

   This insurance provides cover against **external damage** to construction machinery as long as they are at the worksite, as well as internal damage (mechanical or electrical) resulting from external damage.

   It makes no difference in the possibility of cover whether the machinery is property of the contractor or otherwise (leased or rented).

   The aforementioned construction machinery and equipment are even covered during loading and unloading works, transitory storage at the construction site and during erection and dismantling as well.

   Risks associated with machinery and equipment are: overturn, collision, landslide, rockfalls, flood and fire.

4. **Employees' and workers' personal belongings**. Due to the problems that may arise in the event of damage, this cover must only be offered in exceptional cases, and with a Limit of Indemnity per worker.

5. **Debris removal expenses**

6. **Civil Liability**. It deals with third parties' compensation claims resulting from an accidental damage to their persons or properties due to accidents occurring at the insured worksite directly connected with the construction works.

   Claims due to accidents to the insured's employees or workers are excluded.

Place of Validity

It is only valid at the worksite. For claims under Material Damage insurance, the accident must have taken place at the worksite. As for Civil Liability insurance, the cause of the accident must have been originated at the worksite.

The storage of materials is covered under the CAR Insurance provided that it takes place within the site, but not otherwise.

Term of Insurance (Period of Insurance)

It is a **temporary** insurance, starting either on the commencement of the construction works or after unloading of the insured properties at the construction site, and ending on the promoter's acceptance or start-up of the works.

Should the works be completed or totally or partially started up before the deadline set out in the policy, the insurance shall be automatically cancelled with no premium refund. This fact may represent a problem if the Provisional Acceptance Certificate has not been signed (the signature can be much delayed due to the change in ownership: the plot of land is owned by the promoter, whereas the construction work is property of the constructor) or the subject portion of work has not been effectively started up.

On the contrary, should the delay in works result in completion after the date stated in the Particular Conditions of the policy, an extension should be agreed with the insurance company in order to keep in force the insurance, with the payment of an additional premium established depending on the particular circumstances in each case. The company would reserve the right to accept or reject this extension. In occasions, in order to avoid extensions, the period of time agreed can be longer than the expected time span so as to cover possible delays -which is usually more economical-.

The policy can be underwritten once the construction works have commenced, adjusting the insurance premium according to the non-covered construction period.

Should the construction work be interrupted, the insured shall notify this circumstance to the company as soon as possible. In this case, both parties might agree a total or partial suspension of the covers under this policy.

The insured may request for reinstatement of coverage at any time; in this case, the contract shall be extended to the suspension period.

- Without insurance premium payment, if the suspension of covers was total and the stoppage did not result in aggravation of risk.

- With payment of the corresponding insurance premium if the suspension of covers was partial or the stoppage resulted in aggravation of risk.

The cover period for the contractor's plant and equipment shall commence on arrival of such elements at the insured construction site, and shall expire after removal or when the work is completed.

Although optional, it is frequent to extend the duration of the insurance during the so-called **Maintenance Period** following the completion of the construction works, in general for a period of 12 months, although the covers are limited within this period (as it shall be seen in the corresponding section).

The term of insurance in a CAR Policy cannot be cancelled, with the following exceptions:

- In the event of an important material change in the insured risk, under determined circumstances.

  During the course of the contract, the insurer shall notify the insurance company, as soon as possible, of any circumstances aggravating the risk of such nature that, had they been known by the company on the perfection of the contract, this would have been cancelled or signed under more onerous conditions. For example, the variation in the diameter of the diversion tunnel in dam construction -so that the construction is exposed to floods corresponding to a 10-year return period instead of 25 years- would result in material change in risk or alteration of the exposure initially insured. Suspension of works for longer than one month also represents a material change in risk.

  The insured shall notify the insurer, as soon as possible, of any change in the risk, so that the latter can decide on the new conditions for the insurance contract. Otherwise, should the insurer discover such changes after the occurrence of the accident, the contractor shall have to assume the fact of not being compensated.

  Likewise, if during the course of the contract, the insured notifies the insurer of all the circumstances mitigating the risks of such nature that, had they been known by the company prior to the signature of the contract, this would have been signed under more favourable conditions, after expiry of the period covered by the insurance premium the insurer shall have to refund the corresponding amount of future premium.

- Project abandonment. That is to say, termination of the Construction Contract by the promoter or any essential contractor, due to whatsoever reason (financial, technical, etc). Should the projected works be resumed, it shall be possible to reinstate the insurance cover.

Covered Risks

As this is an "All Risk" insurance, all the risks are covered except for those expressly excluded, provided that the direct damage or material loss be a direct consequence of an accidental and unforeseen cause arising all of a sudden. Therefore, the policy shall only cover those properties designated in the Particular Conditions.

The different types of loss or damage usually covered under the insurance contract can be classified according to the **nature of the damage**:

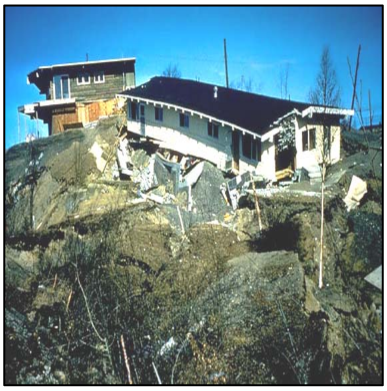
- Damage to owned properties. Among all the risks that may be present at a construction site, a large portion of the exposure to risk is constituted by the material damage to elements used in the works, either during transportation or storage, or after they are incorporated in the works, resulting in any type of economic loss to the contractor with no loss or damage to third parties.

  This type of damage includes direct damage and the subsequent consequential losses as well.

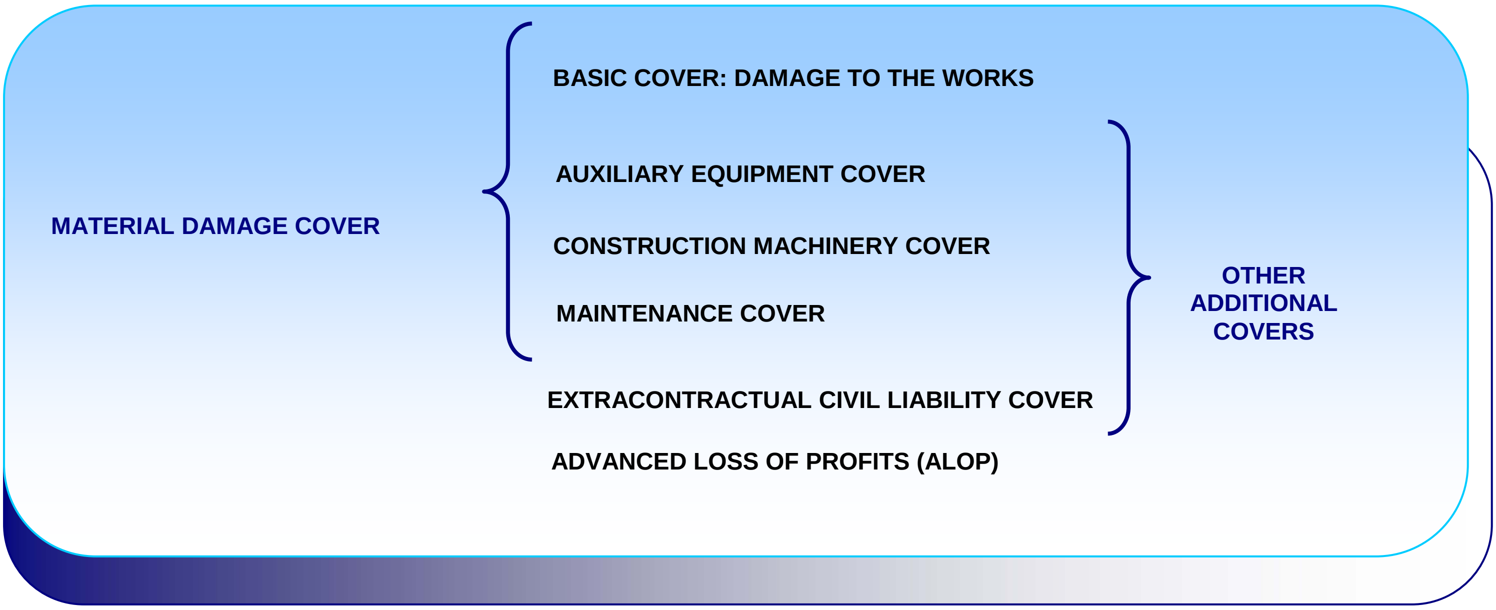
- Damage to Third Parties. In occasions, liabilities arising out of construction activities may be serious, and the attribution of liability for damage to third parties may produce discussions and even lawsuits. These damages to third parties can be considered in respect of:

  - **Injury to persons**. Either contractor's employees or external personnel.

  - **Damage to properties**. Total or partial destruction of properties belonging to third parties, either natural persons or legal entities.



According to the type of damage to be covered, the insurance covers which can be guaranteed are the following:



1. Material damage cover

This modality covers, with the exception of those expressly excluded, the economic consequences resulting from material damage (as a consequence of an accidental unforeseen event that occurs suddenly) to any type of construction works during the execution stage.

1.1. Basic cover. Damage to the works. It provides cover for the Civil Works and installations (with inclusion of the cost of materials, workmanship or any other with an influence on the final cost) incorporated into the insured construction project, as stated in the Particular Conditions.

1.2. Extensions. They are only valid provided they are expressly included in the Particular Conditions. Among these, we can distinguish the following:

1.2.1. Material Damage to the construction

- Socio-political risks (riots, tumults, etc., including terrorism or otherwise)
- Theft and burglary
- Defective design

1.2.2. Material Damage to other properties

- Auxiliary equipment
- Construction machinery
- Pre-existing properties

1.2.3. Consequential Losses

- Extraordinary expenses in concept of overtime, nightwork or public holidays work
- Debris removal expenses
- Professional fees
- Strike and riot
- Terrorism
- Fire extinguishing costs

2. **Maintenance Period**. Optionally.

3. **Extracontractual Civil Liability**. Optionally.

4. **Advanced Loss of Profits (ALOP)**. Optionally.

Excluded risks

Given that it is an "All Risk" Insurance, it provides coverage for all risks of loss except those expressly excluded in the policy. Among these, there is a distinction between **General Exclusions**, of general knowledge, and the **Specific Exclusions**, particular exceptions which must adapt to a determined project. For example, in trench works, the insurer may suggest coverage restrictions in order to reduce the risks to an acceptable limit, or rather exclude foreseeable risks (trench blockage caused by landslides due to normal rainfall, etc.).

In general terms:

These risks affect the Material Damage and Civil Liability covers. For example:

a) Fraud by the insured, damage intentionally caused by the insured.
b) War, invasion, revolution, hostilities, rebellion, insurrection, military coup, terrorism, etc.
c) Nuclear reaction or radiation, or radioactive pollution. Nuclear Hazards insurance is specific of atomic energy insurers like national pools, managed by insurers and specialized engineers. However, the construction of nuclear power plants does not represent any kind of atomic hazard during the construction stage until the radioactive fuel is supplied, so that they can be insured under this cover.
d) Expropriation, confiscation, requisition or destruction of or damage to property by order of any lawfully constituted authority.
e) Theft or disappearance.
f) Damage at the expense of other than the insured.
g) Sanctions due to breach of contract, penalties.

In specific terms:

These risks are solely referred to material damage, such as:

a) Loss or damage due to actions committed by persons responsible for the management of the work, contrary to usual regulations and provisions, recognized by Architecture and/or Engineering and which, due to their nature, constitute criminal negligence or serious felony as recognized by the competent authorities. “Good practice” means to work according to safety regulations and acknowledged professional rules, following a planned method and based upon scientific knowledge and current technical experiences in Engineering. This is applied from the identification of the need for the project until the start-up.

   In these cases, it is usually the tribunal who rules whether the action or omission by the technician constitutes criminal negligence or serious felony. Damage caused by the person responsible for the works is rarely considered as criminal negligence or serious felony, as required by this exception, but rather simple negligence or minor fault. An example of this would be a trench collapse due to excavation works with no trench timbers or support -decision made by the construction manager-.

Diaphragm wall construction

b) Deterioration resulting from defects or inherent vice, lack of use, wear and tear, normal atmospheric conditions, corrosion and oxidation. Under this section, there is no coverage for a series of events with no accidental and foreseeable character, necessary conditions for a damage to be covered. Nevertheless, this exclusion is not extended to other parts of the construction work damaged as a consequence of an accident arisen in such circumstances (consequential damage).

For example, the insurance company would not be liable for the replacement of a pillar after corrosion due to the passing of time. Nevertheless, should this deterioration result in collapse of part of the flooring and beams supported by the pillar, this (consequential) damage would be covered by the insurance.

c) Rectification costs of defective material, design or workmanship. For example, let us suppose that, during a building's construction phase, cracks are detected in the flooring and these resulted from defective concrete -and this material must thus be replaced. The rectification costs of cement would not be covered by the insurance, but the cost of the rest of materials making up the flooring (girders, vaults, etc.) would.

In the above example, it is clear that the damage is not accidental or unforeseen, but due to a wrong decision -in this case, lack of material control- by the engineer, who sometimes sets aside the safety of calculations and assumes risks for the sole purpose of reducing costs.

Therefore, should the insurer assume the risk of defective design in any case, these actions (non-verification of calculations, no control of materials, etc.) would be encouraged. That is the reason why the exclusion of defects in design is a **preventive measure**, given that damage associated with defective design can become serious.

Before making a decision on the extension covers, additional information must be searched for and analyzed.

d) In respect of the cover for damage to machinery, loss or damage due to internal mechanical and/or electrical breakdown in machines and their accessories resulting from their own operation, are excluded. A high level of maintenance and adequate knowledge by the operators contribute to avoid accidents in machinery and mobile equipment. Equipment in poor operating condition may indirectly cause damage to the construction works.

Complementary covers

Although initially excluded, these are additional covers that can be included by contracting the corresponding coverage. Therefore, they are optional covers with inclusion of these guarantees provided they are agreed in the Particular Conditions and through the corresponding increase in premium.

1) Material Damage to the Works. Loss or damage due to:

a) Socio-political risks (riots, tumults, etc., including terrorism or otherwise).

Depending on the location and circumstances, there can be totally different situations of danger and interest for this cover.

b) Theft and burglary. Depending on the location of the construction site, this damage is almost sure to happen (for example, copper wires, etc. are very coveted). Theft and disappearance of materials at the sites represent ever-growing amounts of money, so that the insurance companies tend to eliminate this risk from the general cover of the policy and include it as a complementary cover to be studied in each case.

c) Defective design. The insurance can provide cover under two different levels:

a) Limited to the consequences, excluding the part of the works where the defect was produced, which is the most common formula in Spanish policies. This point is developed next.

For clarification regarding this section, it must be distinguished between Rectification Cost and Replacement Cost.

"Rectification Cost" is the necessary cost incurred to make something defective become as accurate as it should be; it could be similar to the repair cost, and it must be implicitly understood that the term "Rectification Cost" is used when there has been no damage, but simply a defect.

"Replacement or Reconstruction Cost" is the necessary cost incurred in order to replace or reconstruct a damaged property.

Defective material. The insurance company shall not be liable for payment of neither rectification costs resulting from usage of defective material nor replacement costs of such material should the part of the works with it constructed collapse.

In this last case, the insurance would cover the cost of the rest of materials integrating the part of the works constructed with the defective material, as well as any damage to the other parts of the works damaged as a result of the said circumstances.

For example, if the cement used in the construction of one floor turns out to be defective, the failure is observed and it must be rectified, but the insurance company is not liable for the subsequent demolition and reconstruction expenses. However, if one floor collapses because the cement is in poor condition and it also results in damage to the lower floors, the insurance does not cover the replacement cost of the cement, although it covers the costs of beams, steel, etc., integrating the floor, as well as any damage caused to lower floors.

Defective design. The insurance company shall not be liable for payment of Rectification and Replacement Costs of parts of the works with defects in design. In the case of Spain, however, the cover extends to loss or damage to other parts of the works caused by collapse of the part of the works with defects in design or plans.

In other countries, the consequential damage is not included since it is considered that any damage due to defective design must be covered under the project designer's professional Civil Liability Policy.

Defective workmanship. The insurance company shall not be liable for payment of Rectification Costs of parts of the works with defects due to unskillful workmanship. The policy provides cover for the Replacement Costs of the imperfect construction works, as well as any damage to other parts of the works resulting from collapse of parts of the imperfect construction.

In summary:

- Rectification or Repair Costs of defective parts of the work <u>are always excluded</u> from the insurance cover.

  Loss or damage to other parts of the works due to defects in material, design or workmanship, are always excluded.

- Replacement or Reconstruction costs:

  - Are <u>excluded</u> in the case of defective material. Nevertheless, the costs of other materials integrating the construction are included.

  - Are <u>excluded</u> in the case of defective design.

  - Are <u>included</u> in the case of defective workmanship.

b) Complete

It provides cover for the damaged part and the consequential damage as well. Generally, in these cases the insurer accepts the cover for defective design, but introducing limits of indemnity or high deductibles in order to reduce risks, and the project designer is not usually included as insured party so that he can be claimed liable in the event of damage due to defective design.

2) <u>Material Damage to other properties</u>. Besides the construction work itself, the insurance can provide cover for the insured's properties:

a) **Construction machinery**, in spite of the fact that the cover is limited to damage external to machinery and equipment, excluding internal breakdown -which can be covered under the independent Machinery policies-. (Refer to the corresponding "Exceptions" section).

b) **Auxiliary equipment**. As a general rule, contractor's plant and equipment are insured through an annual policy. Due to the fact that specialized contractors usually purchase or subcontract, for specific purposes, equipment that remains at the worksite for indefinite time, it is allowed to include these elements in the CAR Policy.

c) **Pre-existing properties**. This concept refers to existing constructions (buildings, facilities, etc.) in the surroundings of the works, owned or run by the insured/s and not being part of the insured project to be constructed. The cover is limited to loss or damage due to the execution of the contracted works.

3) <u>Consequential losses</u>. Besides the costs derived from direct material damage, an accident can lead to other costs arising as a consequence of the damage, as well as financial losses in the event that the accident results in delay in the completion of works. In function of it, the following concepts can be insured:

a) Extra charges in concept of overtime, nightwork or public holiday work, express freight (of high importance in erection policies) to eliminate delays produced by a indemnifiable accident.

b) Professional fees: Repair of serious damage, for example in accidents where the stability is affected, may demand professional advice from engineers to verify the design and make calculations for an efficient restoration.

c) Air freights for fast replacement of elements.

d) Demolition and debris removal expenses incurred following an indemnifiable accident.

Debris after demolition

e) Loss or damage due to strike and riot, although this cover must only be provided exceptionally. Provided that strike and riots do not reach the category of popular uprising, these risks can be insured in some occasions as a policy extension including detailed definition of the limits of this exception to the general exclusions.

f) Terrorism

g) Fire extinguishing costs:

As an extension to the General Conditions, it can be expressly stated that the policy also provides coverage, with the maximum limit of the sum insured, for the additional expenses derived from the necessary measures adopted by the Public Authority or the insured in order to extinguish a fire or prevent its propagation -even the payment of the fire brigade bill- provided that such expenses result from an material damage covered under the basic cover against damage to erection works.

Moreover, the insurer shall be liable for payment of the expenses resulting from the employment of the necessary means to mitigate the consequences of an accident, provided that such expenses are not inopportune or disproportioned to the property saved.

The company shall be liable for the payment of the expenses incurred and duly justified.

4) Advanced Loss of Profits (ALOP)

An accident may lead to delay in the start-up of a construction work, which might cause economic damage like loss of profits, rental expenses, etc. For example, the delay in the start-up of a toll road due to an accident results in loss of profits for the operating company.

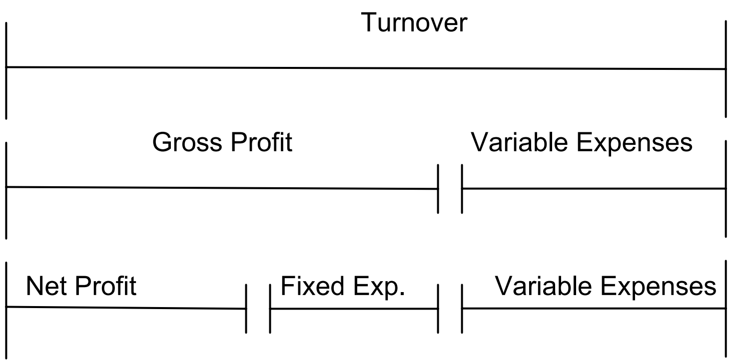
The aim of this insurance is to provide cover for Loss of Profits suffered by the owner, due to a delay in the completion of construction and/or erection works, excepting the normal delays of the works.

There is a necessary requirement for the underwriting of this type of policy: it must be accompanied by a base insurance policy on Contractor's All Risks and/or Erection All Risks.

The inclusion of these covers is recent enough. Although nowadays they are not very frequent, they are expected to achieve high importance in the future.

Highway toll station

The cover is limited to the actual loss of Gross Profit resulting from a delay in the completion of the construction project, provided that such delay is caused by a loss under the CAR and/or EAR cover.



Clauses to be included in the insurance contract

The corresponding clause includes the following:

- *Coverage*

  In case of delay in the start-up of the business insured, provided that such delay results from a damage specified in the CAR/EAR policy wording, the Company shall be liable for the payment of the actual Loss of Gross Profit due to reduction in turnover and/or increase in cost of working as defined below, with the limits of money and time stated in the Particular Conditions of the policy.

  The amount payable as Indemnity in this context shall be:

  - In respect of reduction in Turnover: the sum obtained by applying the Rate of Gross Profit to the amount by which the Turnover during the Indemnity Period shall, in consequence of the damage, fall short of the Standard Turnover.

  - In respect of increase in Cost of Working: The additional expenditure necessarily and reasonably incurred for the sole purpose of avoiding or diminishing the reduction in Turnover which but for that expenditure would have taken place during the Indemnity Period in consequence of the damage, but not exceeding the sum produced by applying the Rate of Gross Profit to the amount of the reduction thereby avoided.

    Should the annual sum insured in this cover be lower than the sum obtained by applying the Rate of Gross Profit to the annual Turnover, the amount payable as indemnity shall be reduced in the same proportion.

- *Exceptions (excluded risks)*

  In addition to the exceptions appearing in the General and Particular Conditions of the policy, the Company shall not indemnify the Insured in respect of:

  - Reduction in Turnover and/or increase in Cost of Working caused by any delay or resulting from:

    - Loss or damage under the cover for Damage to the Works through policy endorsements, unless expressly agreed to in writing and included within the Particular Conditions.

- Loss or damage to the adjoining property, to construction plant and equipment.
- Loss or damage to production means, inputs, shortage, destruction, deterioration or damage to any kind of material necessary for the operation of the insured business.
- Any kind of restriction imposed by the public authorities.
- Unavailability of funds.
- Modifications, enlargements, improvements, rectifications of defects or failures or repair of any kind of deficiency carried out after the occurrence of the damage.
- Loss or damage to goods handed over to or received by the insured, as well as those not covered after expiry of the CAR and/or EAR policy.
- Failures or deficiencies in power supply.
- Any risk not covered under the CAR and/or EAR policy.
- Unloading works.

* Any loss due to sanctions or damage resulting from breach of contract, delay or failure to follow orders, or any penalization of whatsoever nature.
* Loss of business due to reasons like suspension, expiry or cancellation of leasehold agreements, licences, etc., taking place after the effective commencement date of the operations insured.
* Loss or damage to prototypes, unless expressly agreed and included within the Particular Conditions.
* Indirect or consequential damages arising from an accident, like deterioration of goods, loss of market or clients, increase in maintenance costs, delays in services supplied, impossibility to carry out commercial operations, deliberate idleness during work or other similar contingencies.
* Excessive delays in repair or replacement of damaged properties in relation to the timeframe needed under normal conditions of execution.

Through these Special Conditions, it is expressly agreed that the progress chart of the construction and/or erection works shall be included in the policy.

Through modification of the General Conditions of the policy, the insurance company shall not indemnify the insured in respect of damage caused by a deviation in the progress chart of construction and/or erection works in excess of determined timeframes, unless approval of such deviation by the insurer prior to the occurrence of the accident.

- *Term of Insurance (or Insurance Period)*

  It is identical to the Term of Insurance for the CAR and EAR covers, with the exclusion of the Maintenance Period, and it shall be updated in the event of delay in works.

- *Insured parties*

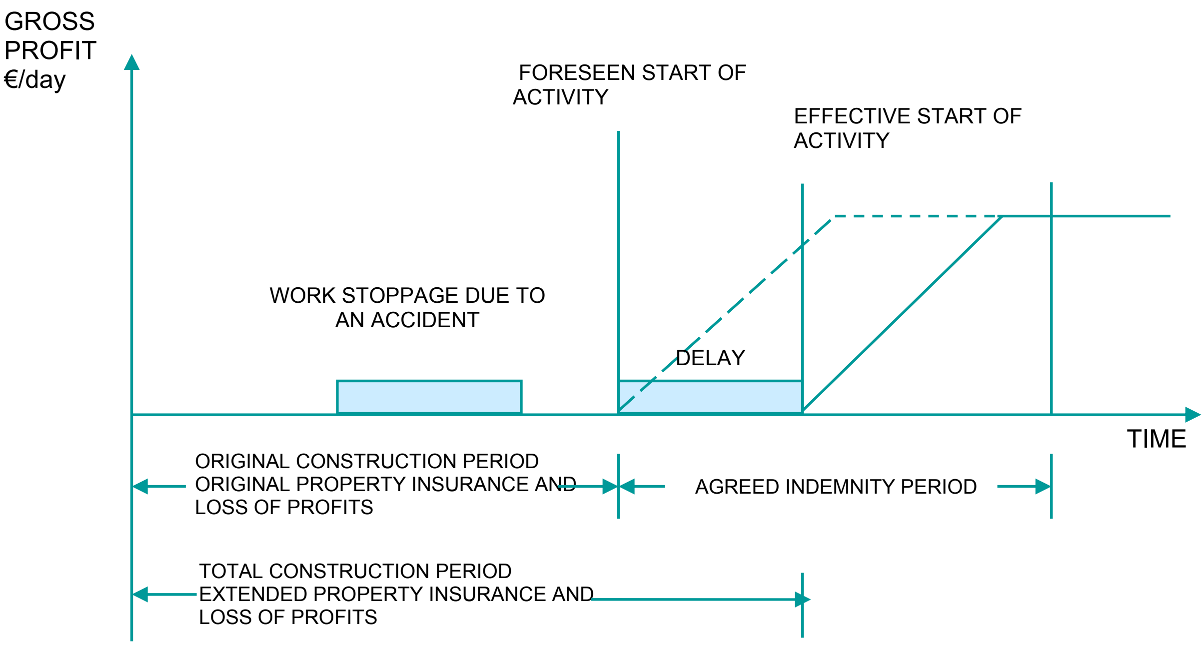
  The policy covers the proprietor of the construction (or erection) project according to the specifications included in the CAR and/or EAR policies.

- *Sum Insured*

  It is usually the expected Annual Profit or the Standing Charges, to be defined in each case.

- *Indemnity Period*

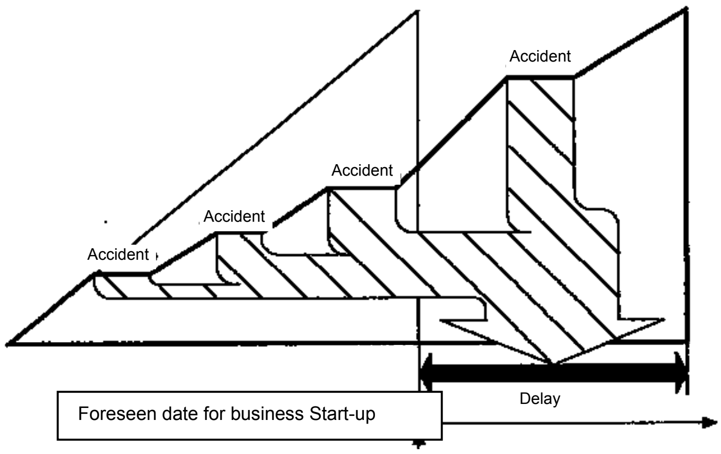
  The Indemnity Period is agreed with the client in the policy wording. This period of time takes into account the delay in works -basis for the compensation-, with commencement on the expected date of completion had the damage not occurred and expiry on the effective date of completion of the project. This time difference between the effective date and the expected date cannot be longer than the Indemnity Period agreed to in the policy.



- *Deductible*

  The policy includes a Time Deductible (expressed in days) which is total, i.e., it is not applied for the occurrence of each accident.

Only one claim shall be admitted under this insurance cover, as there is a single date of project completion -which does not depend on the number of accidents causing material damage-, and this single delay results in claim by the insured under this cover.



5) **Extracontractual Civil Liability (Damage to Third Parties)**. This is an additional cover against involuntary damage to third parties, either injury to persons or damage to properties, limiting the Civil Liability coverage to accidents directly connected with the construction project and originated at the construction site or surroundings.

   Apart from this Extracontractual Civil Liability due to damage to third parties -excluding people involved in the works from such consideration-, the following types of liability can be considered:

   - **Cross Liability**. In the Insurance field, it is understood as the liability attributable to a contractor or subcontractor due to material damage caused to other contractors or subcontractors in charge of the execution of other parts of the work.

     It is of special interest for policies covering erection works.

- **<u>Employer's Civil Liability</u>**. Through this coverage, the insurance guarantees include the payment of claims which, in compliance with the Spanish "Social Security Law" (*"Ley General de la Seguridad Social"*), could be required from the insured in concept of civil liability for damage to the employed personnel due to occupational accidents.

  It is excluded from the CAR Insurance, and it can only be provided in exceptional cases. Bad experience and little appropriateness in a construction policy resulted in general reluctance to underwrite this coverage.

6) **<u>Cover for damage during the Maintenance Period</u>**. As already mentioned in previous sections, the construction contract frequently foresees a 12-month Maintenance Period after take over of the construction works.

The policy can provide cover against loss or damage during this Maintenance Period, provided that it is expressly stated in the Particular Conditions of the policy, although the liabilities shall be limited to:

a) Any loss or damage resulting from a cause arising prior to the commencement of the Maintenance Period provided it is not subject to exclusion in the General or Particular Conditions of the policy.

b) Any loss or damage caused by the contractor during the execution of works carried out for the purpose of complying with his obligations under the Maintenance or Preservation provisions of the Construction Contract provided those not be subject to exclusion in the General or Particular Conditions of the policy.

The coverage indicated in the two previous paragraphs is known as **Extended Maintenance Visits cover**; if only the one indicated in the last paragraph is covered, it is known as **Limited Maintenance Visits cover**.

It is important to highlight that, according to what is stipulated in the previous paragraphs, during the Maintenance Period the hazards of fire, lightning, explosion, *force majeure*, etc. are not covered unless, due to any circumstance, they can be regarded as included in the coverage defined in the above paragraphs.

Extracontractual Civil Liability cover can also be provided during the execution of works, this liability being limited to cover the payment of claims for damage to third parties caused by the contractor while performing maintenance or preservation works stipulated in the Construction Contract. Contractors repairing defects at the worksite need protection against claims by third parties. Although their annual CL policy covers this circumstance, it is becoming a common practice to extend the Maintenance Period of the CL coverage in the CAR Policy, but only for the contractor's legal liability, and not for the promoter's.

Sums insured

In function of the different concepts, the Sums Insured shall be as follows:

1. **Civil Works**. The sum insured shall be the value of the construction as of the date of completion. Due to the fact that the insurance contract is prior to the commencement of works, the sum insured is an estimated value. Therefore, should any differences (modifications or extensions of the project) be observed during the construction stage, the insurer must be informed for inclusion of these differences in the contract, followed by the corresponding premium readjustment in order to avoid **underinsurance** in the event of an accident.

   The sum insured is the basis for the premium calculation.

   After completion of the works, the Sums Insured must be reviewed to verify whether they corresponded to the effective values of risk. If needed, the premium shall have to be adjusted.

   The same criterion is followed for the Maintenance Period.

2. **Construction Machinery**. The sum insured shall correspond to the **Replacement Cost-new** (at the commencement of the insurance), including customs duties, freight and assembly expenses. The insurer shall be held liable for compensation of repair costs at the current price of spare parts and real cost of workmanship. Depreciation in concept of service years must not to be taken into account for the calculation of the sums insured. The values of determined equipment must be verified with a well-known equipment supplier so as to be certain that the sums insured correspond to real values.

   Sometimes, this process may result laborious. For small projects requiring only one or two small cranes, some light equipment and a tooling warehouse, obtaining information does not represent a difficult task. Nevertheless, for major projects it is necessary to have available a list of machinery and equipment, indicating the model, manufacturer, year of manufacture, identification number, serial number and replacement cost-new.

3. **Auxiliary Equipment**. The sum insured shall correspond with the actual value of the auxiliary elements used in the construction which are not included in the section “Construction Machinery”. This value is accepted because most of the possible losses are minor and can be repaired with local materials and workmanship at reasonable costs.

   When adjusting claims for damage to machinery and equipment, the loss adjuster must be careful so that the equipment is not improved at the expense of the insurer.

Restrictions of cover

These are endorsements included in the policy wording, which can be necessary in order to:

- Limit the possible loss or damage resulting from a single accident.
- Prevent or mitigate the high likelihood of damage, by adopting adequate loss prevention measures.

The purpose of these endorsements is to succeed in making the insured parties comply with and maintain certain technical requirements. The clauses must adapt to each construction project on an individual basis, as the requirements vary from one project to another. For example, open trenches are very exposed to natural hazards. The more the length, the higher the risk, given that a larger extension of open trench is exposed for longer to bad weather conditions.

Whenever the constructor decides to construct the trench in its overall length, the insurance provider cannot oblige him to take more precautionary measures or carry out the following completion works. Nevertheless, by including an endorsement in this regard (the “Endorsement concerning sections”), the possible loss may be adjusted by limiting the maximum open stretch of the construction, in function of the length, dimensions, type of ground, as well as the possible damage due to Acts of God (Progress Chart).

Deductible

In this type of insurance cover, the deductible (for Damage to the Works and Third Party liability covers) is the portion of any claim that is not covered by the insurance provider, by which the policy holder self-insures his own risks. Should the amount claimed be less than the stipulated deductible, the total amount shall be borne by the insured; should it be higher, the insurer shall only be liable for the excess over such deductible amount. Should two or more deductibles be applicable, only the highest one shall be taken into account.

The deductible amount varies depending on the size of the construction project and the inherent hazards of the construction site.

Insurance policies providing cover for Civil Works and Plant & Equipment include standard deductibles.

As a general rule, different deductibles are usually agreed for:

- The Construction Works (All Risk), excepting natural hazards.
- Natural hazards (from 5 to 10 times higher).
- Plant and equipment, in order to at least eliminate minor losses and maintenance damage as well.
- Civil Liability.

Increase in these deductibles, whenever requested by the insured, will result in premium reduction.

There are two overriding reasons that justify the existence of deductibles:

- They are intended to awake the interest of the insureds in the adoption of preventive measures against loss or damage, as they bear an important portion of the claim.

- Due to the occurrence of numerous minor accidents causing loss or damage, the application of deductibles is intended to avoid the excessive growth of administrative expenses for the insured and the insurer resulting from the claims for each of these events.

Should natural hazards represent a problem for the construction project, the insurance provider must try to make the insureds bear the payment of higher amounts for natural hazards, encouraging them to adopt adequate prevention measures.

Insurance Premiums

Like in any insurance scheme, the Insurance Premium must be set in the policy. The premium is equal to the premium rate (expressed in ‰) multiplied by the sum insured.

There are no tariffs of rates with fixed premium rates of general application for CAR Insurance. This is due to the fact that each construction must be analyzed according to its specific features and technical considerations, which are different in each case.

Indemnity

After the occurrence of an accident, it is essential for the insurance company to make a prompt investigation on the causes and damage. To that aim, the accident must be notified by the insured as soon as possible, in order to prevent clues from fading away, to continue with the works and to avoid great delay (as a matter of fact, excessive delay in resumption of works may be penalized).

In order to avoid conflicts between the insured and the insurance company, it can be agreed to include claim processing procedures in the policy wording prior to commencement of the works. These are usually instructions in writing to the Construction Management, specifying who must be notified of any damage which may result in claim; which information must be available for the adjuster; and which details the contractor must indicate in the claim invoice presented to the insurer for adjustment and payment.

Therefore, after damage the insurance provider is liable for payment of compensation (indemnity) to the insured party by reimbursing the necessary expenses incurred in order to repair damage to the insured properties, excluding the expenses to eliminate defects that would have resulted independently of the occurrence of the accident.

In the event of an accident, the applicable deductibles shall be subtracted from the total amount of indemnity.

The Sum Insured represents the Maximum Limit of Indemnity to be paid for by the insurer in each accident.

Insurance cannot be an instrument for unjust enrichment. So, the damage claim shall take into account the value of the insured property at the moment immediately before the occurrence of the accident. Therefore, it is essential to correctly determine the insured value of the construction work in order to avoid the application of the **average clause:**

"If the property covered by the Insurance shall at the time of any loss be of greater value than the sum insured hereby, the Insured shall only be entitled to recover hereunder such proportion of the said loss as the sum insured by this policy bears to the total value of the said property".

The correct determination of the amount to be insured helps avoid possible discussions derived from the application of said average clause.

There is a tacit tolerance margin of 10% or higher.

By mutual agreement, both parties shall have the right to exclude either in the policy or after the celebration of the contract, the application of the average clause.

Overinsurance: If the sum insured is remarkably higher than the value of the insured interest, either party shall have the right to demand a reduction in sum insured and Premium, so that the insurance company shall be obliged to refund the excess of premium paid for by the insured. Should the damage occur, the insurance company shall be liable for the compensation due to real damage, provided it is not due to *mala fide* or fraud by the insured.

Some optional covers are contracted with a Maximum Limit of Indemnity per accident and/or duration of works. For example, damage due to socio-political facts, especially terrorism, is limited to a percentage of the value of the works or to a specific amount, damage to pre-existing properties, etc.

3.2.2. OPEN POLICIES

Construction companies of a certain size can make use of the advantages of contracting an open policy ("General Contract") which does not cover a specific risk but all the works carried out by the contractor -with previous notification of their technical features- and offers interesting advantages for both insured and insurer. The condition is that the construction works must have more or less homogeneous features and a sufficient number is built (for example, cost under a certain amount, non-use of certain foundation techniques, etc.).

This system involves advantages like administrative simplicity, simplification of claim procedures, -in occasions- financial aid, as the insurance premium is usually paid in uniform periods of time, with annual adjustment, lower cost and reduction in premium at the end of the period according to the volume agreed.

It is essential to thoroughly study the Particular Conditions.

3.2.3. THE INSURANCE CONTRACT

In general, it is a document or policy agreed with an Insurance Company, including a set of norms that will regulate the insurance contractual relationship between both parties (insured and insurer), with specification of their respective rights and duties.

Through the policy, the insurance company shall be liable for payment of indemnity under the covers expressly stated in the Particular Conditions, within the limits established and in compliance with the General Conditions common to all the covers and the General Conditions specific to those guaranteed covers in each case:

- General Conditions: It is the group of basic principles established by the insurer in order to regulate all the insurance contracts issued in the same insurance branch or type of guarantee (regulations related to extension and object of the insurance, excluded risks in general, claim payment information, bill payments, etc.).

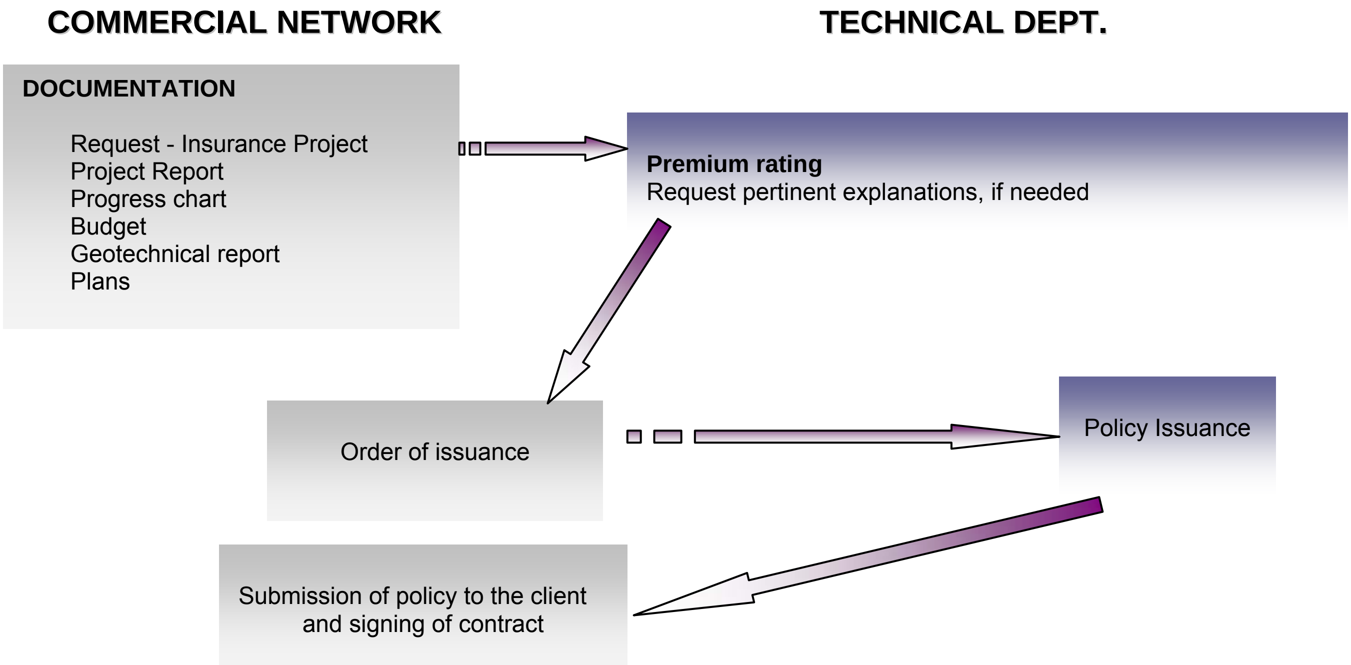
- Particular Conditions: They comprise aspects regarding an individual risk to be insured, name and address of the contracting parties and designation of the insured and payee, if any, insured concept, nature of the risk to be covered, designation and location of insured properties, sum insured or scope of cover, amount of insurance premium, surcharges and taxes, premium due date, as well as the place and terms of payment and the contract duration, indicating the dates when the insurance cover is due to commence and expire.

- Special Conditions: These include specific nuances about the contents of some regulations set out in the General or Particular Conditions (establishment of deductibles paid for by the insured, elimination of some exceptions and inclusion of others, etc.).

4. CAR POLICY UNDERWRITING PROCESS

4.1. POLICY UNDERWRITING. PREMIUM CALCULATION PROCESS

Schematically, the underwriting process of CAR (Contractor's All Risk) Insurance would be represented as follows:



As seen in the diagram above, after request for insurance the underwriter provides a tariff premium for the insured properties.

The final scope of the rating is to determine the premium rate per thousand (‰) to be applied to the covered value so as to obtain the pure premium or risk premium, according to each type of risk and premium (expressed in euros or dollars) of the construction insurance policy. This process is known as **premium rating for the insured construction project**.

There is a great variety of construction projects (buildings, bridges, dams, etc.), so that it is not possible to establish a fixed rate for CAR Insurance, which will depend upon the type of project under the insurance cover.

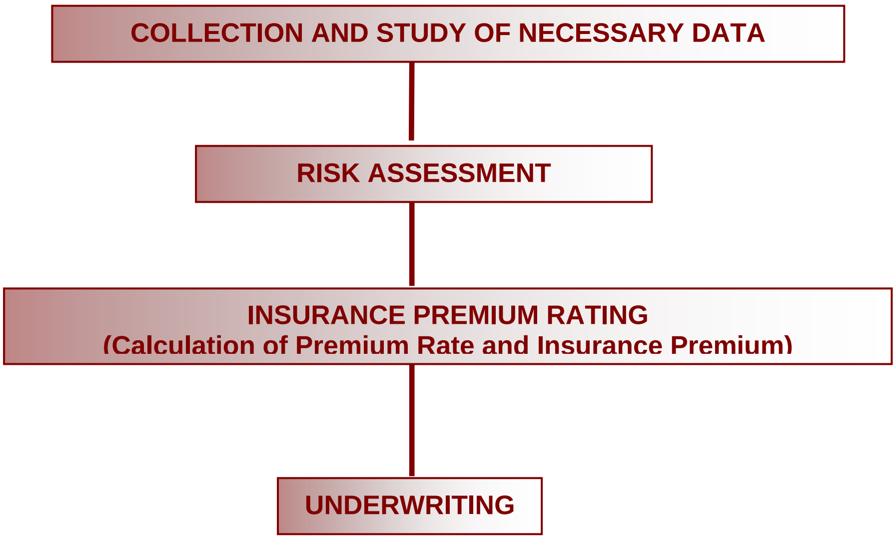
Moreover, as already indicated in previous sections, besides the protection against damage to the works, there are other optional covers (Extracontractual Civil Liability, Maintenance Period, Construction Machinery and Auxiliary Equipment) to be included in the CAR Insurance policy.

Therefore, depending on the type of construction project (technical and insurance-related features) and depending on the covers included, different rates (expressed in ‰) shall be determined:

- Cover for Damage to the Works → R_{DW} Rate (‰)
- Cover for Maintenance Period → R_{MP} Rate (‰)
- Cover for Civil Liability → R_{CL} Rate (‰)
- Cover for Construction Machinery→ R_{MACH} Rate (‰)
- Cover for Auxiliary Equipment → R_{AUX} Rate (‰)

The net premium is calculated with these rates and the corresponding sum insured according to the type of cover.

The premium calculation process -and hence the underwriting process- follows a series of phases or stages described below:



4.1.1. NECESSARY DATA FOR THE UNDERWRITER

For an accurate premium rating for the covered risk, the insurance company must have free access to the worksite, to construction contracts, plans and project specifications reports, plannings and any document regarded as necessary.

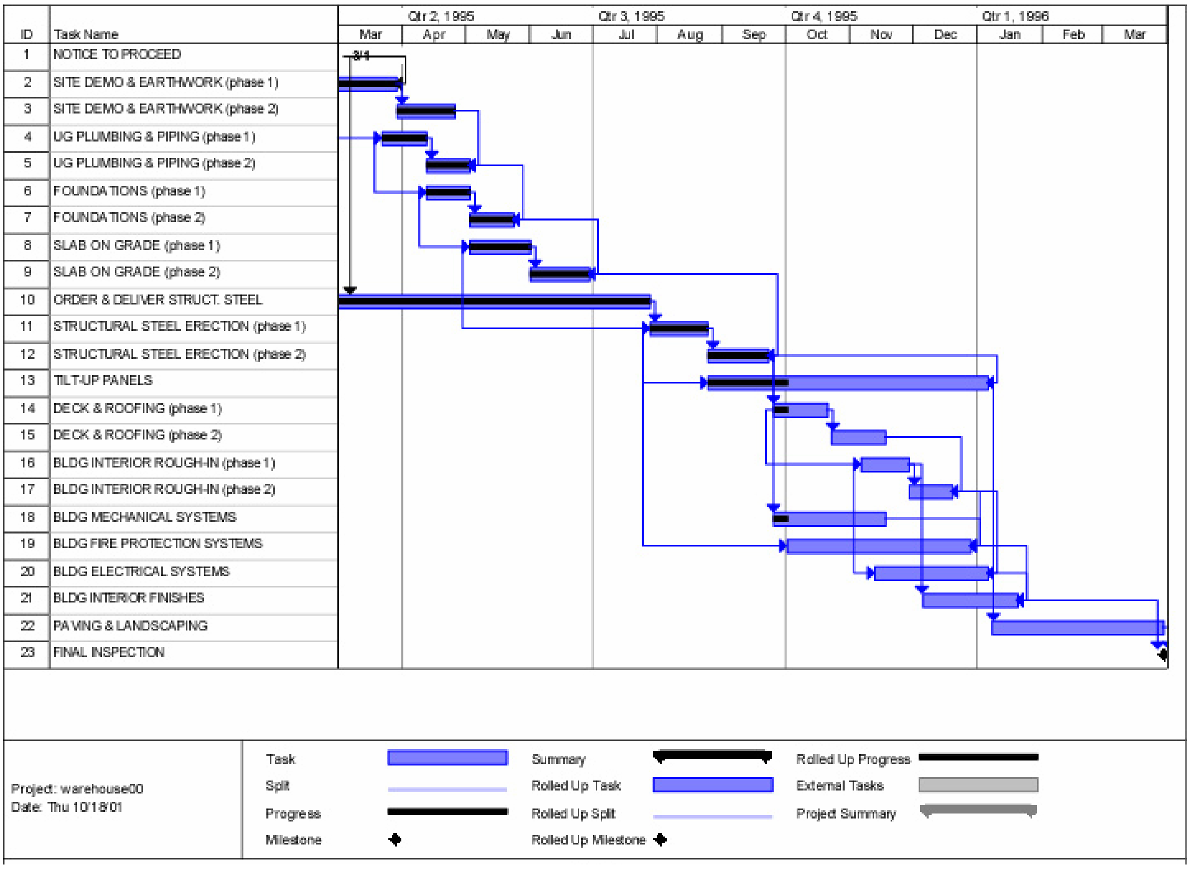
The more complete the data available, the more accuracy for judging the risk, and consequently the fairer the premium for the insurance taker.

Therefore, once the CAR Insurance has been requested, the premium calculation process starts with the insured's provision of all the documents and data regarded as necessary by the insurance company:

Cover for Damage to the Works, Extracontractual Civil Liability and Maintenance Period:

- Geographic and climatic conditions in the area where the project is to be developed.
- Detailed description of the construction to be insured, data obtained from the project (geotechnical study, specifications report, plans, etc.) in order to get a certain idea of the features of the works, construction methods, etc.
- Study and location of the existing infrastructures.

- Construction progress chart. The periods of maximum exposure shall be analyzed in this document. For example, in the construction of a building there is a great difference depending on whether the foundation works are carried out in winter or in summer (in winter, the probability of heavy rain is higher and therefore there is a higher risk of trench flooding or collapse, with the subsequent repair and possible delay in works).



Gantt chart

- Agents involved in the construction project and their liabilities in such project, in order to appoint the insured parties in the contract.

- Value of the construction project, this being understood as the value of the properties exposed to risk, which provides an idea of the approximate value of the damage in the event of an accident. It is useful for the underwriter that the values of exposed risks be included in the progress chart, so that it is possible to know the value exposed to risk at any moment.

- Type of work (as every work will have some specific risks additionally to the common ones).

- Normal Period of Construction (NPC). Expressed in months, it is the estimated execution time according to the type of work.

- Declared Period. Expressed in months, it is the project execution period foreseen in the initial Construction Contract according to the progress chart.

Cover for Construction Machinery:

- Technical specifications of the equipment employed in the construction works.

Cover for Auxiliary Equipment:

- Technical specifications of the Auxiliary Equipment employed in the construction works.

The underwriter shall analyze all the information provided and shall extract all the necessary data for the underwriting.

These aspects will allow:

- To assess the risks and, subsequently, to determine whether a project presents risks that can be assumed under the circumstances or, on the contrary, whether it must be insured under special conditions in order to make up for an extraordinary exposure. For example, if the project site is located at a zone with a high probability of hurricane winds it can be insured, but the underwriter will set high premium rates, limits of indemnity and deductibles so that the risk can be assumed.

- To determine the corresponding premium rate and, according to this value, to calculate the net premium for the CAR Insurance.

4.1.2. RISK ASSESSMENT AND RATING FOR DAMAGE TO THE WORKS

The underwriting involves carrying out an assessment which allows dealing with the risk factors of the insured project and, according to such assessment, to make the subsequent premium rating which allows for the insurance premium calculation.

It is important to highlight that these types of projects are frequently made up by **one or several construction elements**. In the latter case, the risks do not necessarily have to be the same for every construction element. For example, the construction of a stretch of road can comprise different construction elements: road in the open air, a tunnel and several bridges. The essential risk factors to be analyzed for road stretches are not the same as for tunnels or bridges. So, in the stretch of open road, one factor resulting in many accidents can be the “land slope”, whereas on analyzing the risks in bridge construction, an aggravating factor causing damage would be the “bridge type”, a factor which does not even exist or, if it did, it would not have to have the same importance in open roads.

Therefore, in these cases, different risk assessment and calculation of independent premium rates shall be carried out for each construction element. The overall rate for the total construction project shall be determined through weighted sum of these individual rates. This overall premium rate is then used to determine the corresponding insurance premium, as it shall be seen later.

Next is explained the calculation process of the premium rate depending on the cover provided:

1. Risk Assessment

The risks to be assessed are the following:

1.1. Technical risk factors

One factor that must be taken into account is the **technical risk** inherent to the construction project during the successive construction stages, that is to say, its propensity to collapses, settlements, fires, etc. The exposure does not only depend on design, but also on the construction method chosen.

According to whether they must always be considered (with independence of the type of construction work), or whether, on the contrary, their effects depend on the type of construction project to be insured, these risk factors are classified as **generic and specific:**

- Generic risk factors

They must be taken into consideration no matter what the type of construction project is to be insured, and, depending on the case, they may result in change of the initial premium rate.

An example of generic factor would be the "ground quality" as, with independence of the insured project, it might have an influence on the premium rate. If the ground is very firm, there will be no problems with ground settlements, etc., so that the premium rate may be changed or not depending on the type of project. However, if the soil is expansive, there will be an increase in probability and impact of damage to a portion or to the entire construction project. This circumstance shall be reflected through a certain increase in the premium rate (which will vary according to the type of construction project).

The factors usually considered are: quality and type of ground, hydrography, etc.

- Specific factors

Each construction work is defined by a series of particular technical aspects. For example, the specific aspects for buildings can be: “number of basements”, “type of foundation”, “maximum span width”, etc., whereas dams are defined according to the “type of dam”, “dimensions”, “excavation depth”, etc.

A multitude of these technical aspects, specific to each type of project, have more or less influence on the occurrence and consequences of damage during the execution of the construction project (for example, in a road construction, there are factors such as the land slope, road dimensions, excavation depth, maximum height of retaining walls, etc.). The specific technical factors comprise the whole of the said technical aspects, particular to each type of project, which have special importance in the probability of occurrence and impact (economic loss, personal damage, etc.) of an accident. So, only the factors with the highest influence are selected, based upon the experience of accidents in similar construction projects and upon statistical data.

For example, when it comes to providing pipeline insurance, the specific factors to be analyzed would be “number of open sections” or “length of open sections”. Given the existence of many long open sections, in the event of flooding great part of the construction might be lost, resulting in onerous economic consequences. Thus, it would always be important to analyze these factors in this type of construction projects, reflecting their influence by increasing the premium rate. On the contrary, if the project to be insured is a bridge, these factors will not have an influence, whereas others like “maximum span length” “bridge type”, etc., can be more aggravating factors in the event of an accident, or increase the probability of occurrence.

Therefore, aspects like these below shall be analyzed in function of the type of project:

- Features and materials employed.
- Construction methods.
- Safety factors in the construction program.
- Adoption of sufficient safety measures for the execution of works.

1.2. Insurance factors

The covers included in the policy wording and certain insurance aspects may also have an influence (increase or reduction) on the premium rate. Whichever the case may be, the influence factors are, among others:

- Increase due to extensions (additional covers)

Optionally, the policy wording can also include certain aspects like: professional's fees, debris removal operations in the event of damage, etc. As aforedescribed in the corresponding section, these extensions imply an increase in the premium rate as the insurance provider assumes more risks than in the basic coverage.

- Underwriter's evaluation

The experience and evaluation of the policy holder has an influence on the premium rate. For example, when it comes to insuring a dam, if the company and personnel involved have enough experience in similar construction projects, there may be a positive impact on the premium rate (it might even be reduced). On the contrary, if the company or teams to take part in the project have never been involved in similar construction works, or there are evidences of execution problems, accidents due to negligence, a team of inexperienced professionals, etc., these factors will result in an increase in premium.

Therefore, this implies an increase/decrease in the premium rate.

- Change in deductibles

Depending on the type of construction element, the policy wording can include deductibles in function of the risk and the sum insured.

These deductibles can be set both for factors connected with the construction project itself and for complementary covers. So, there are deductibles in function of the risk (for tunnels, viaducts, etc.), in natural hazards, maintenance, tests, complementary covers –SRCC (Strike, Riot and Civil Commotion), Terrorism, Pre-existing properties, Theft, etc.-, as well as others regarded as necessary in each case.

2. **Premium calculation for Material Damage cover**

2.1. **Premium Rate for Damage to the Works cover (R_{DW})**

Either for the whole construction project or for each construction element, according to the data analyzed (type of construction project, execution period, etc.), it is set a premium rate called "**initial rate"**, expressed in ‰, which is the basis for subsequent calculations.

This initial premium rate is set at the least possible value, which can be changed depending on the specific features of the insured project: it is increased if the construction features are aggravating risk factors, and it is reduced if the special features of the construction project mitigate the consequences or probabilities of risk situations, but the final result must never be less than the initial rate.

Such circumstances involving an **increase/reduction** in the initial premium rate (previously determined) must be quantified in order to take into account -either expressed as a percentage on the previously determined rate or as specific rates (expressed in ‰)- the main risk factors which may arise: technical risk factors (generic and specific) and insurance factors, as they have an influence on the premium rate and insurance premium to be determined.

- Final Premium Rate for each construction element (Ri)

According to the initial rate and increase or reduction considered, the final rate for each construction element (R_i) is as follows:

R_i = Initial Rate (‰) ± increase/reduction (‰) due to technical and insurance factors

Where R_i is the final premium rate for each construction element "i".

- Final Premium Rate for Damage to the Works (all the construction items) (R_{DW})

The final rate for damage to the entire construction project is then calculated as a **weighted average** of the premium rates of the different construction items:

CONSTRUCTION PROJECT

1st Construction Item R_1= Rate (‰) ; Sum Insured = SI_1 (€)
2nd Construction Item R_2= Rate (‰) ; Sum Insured = SI_2 (€)
.
.
nth Construction Item R_n = Rate (‰) ; Sum Insured = SI_n (€)

$$\mathbf{R_{DW}} \text{ (Final Rate)} = \frac{\sum_{i=1}^{n} R_i \times SI_i}{\sum_{j=1}^{n} SI_j}$$

Where:

R_i= Calculated rate for each construction element.

SI_i= Sum Insured for each construction element.

R_{DW}= Final premium rate for damage to the entire construction project.

If the construction is made up by a single construction element, the premium rate calculated for such construction element (R_i) equals to the premium rate for the entire project, i.e., R_{DW} = Ri.

2.2. **Premium Rate for Maintenance Period cover (R_{MP})**

The inclusion of a Maintenance Period cover, either for limited or wide maintenance, implies an increase in the premium rate for Damage to the Works expressed as a y% of the final premium rate for Damage to the Works (R_{DW}).

$$\boxed{\mathbf{R_{MP}} = y\% \times R_{DW}}$$

2.3. **Premium Rate for Extracontractual Civil Liability cover (R_{CL})**

Under this cover, the premium rate is calculated with independence from the premium rate for Damage to the Works cover.

Likewise with the premium rate for Damage to the Works, the basis is an initial premium rate (‰), the value of which is determined in function of the Limit of Indemnity which must be imposed for this type of covers. The initial premium rate may be increased or reduced depending on certain factors which may intervene.

These factors may be **incremental** (usually expressed as a specific rate in ‰), and can be due to:

- Location of the worksite in a traffic area (intense, scarce, etc.)
- Partial insurance of the construction.
- Existence of nearby buildings. Including adjoining buildings.
- Inclusion of Cross Liability, etc.

The premium rate can also be modified by a **variation in the deductible**. There will be standard deductibles according to the type of risk. Some risk-determining aspects may have deductibles specific to the risk. Every change in the deductible can result in increase or reduction in the basic rate.

- *Final Premium Rate for Civil Liability cover (R_{CL}):*

$$\mathbf{R_{CL}} = R_i\ (‰) \pm \text{increase / discounts}\ (‰)$$

2.4. **Final Global Premium Rate for Material Damage cover (R_{MD})**

Considering the three aforementioned rates:

- Premium Rate for Damage to the Works cover (R_{DW})
- Premium Rate for Maintenance Period cover (R_{MP})
- Premium Rate for Civil Liability cover (R_{CL})

Should these three covers exist, **the final premium rate for Material Damage cover (R_{MD})** shall be the sum of the three premium rates above. Therefore:

$$\mathbf{R_{MD}} = R_{DW} + R_{MP} + R_{CL}$$

3. **<u>Premium calculation for Construction Machinery cover</u> (R_{MACH})**

Nevertheless, premium rates for Construction Machinery cover are usually calculated on an annual basis. In essence, these are average rates which take into account the fact that not all the machines are used during the whole construction period.

The premium rate for Construction Machinery cover is determined independently from the premium rate for Damage to the Works. This rate, expressed in ‰ for annual periods (R_i) is a function of the type of machine.

The premium rates are quantified on an annual basis for each type of equipment. If the equipment is placed at the worksite for a period of time higher than 1 year, the premium rate R_i is usually increased *a prorrata temporis.* Therefore, the final premium rate R is equal to R_i (‰) times the increase factor.

For periods of time less than one year, the premium rate is decreased by using a reduction factor in function of the months at the worksite. Therefore, R is equal to R_i (‰) times the discount factor.

- Deductible

This **deductible** can be changed for each machine with standard predetermined deductible. This change will have an influence on the premium rate, value expressed as a % of T (T = Initial Rate times the possible variations because of the permanence time of the equipment at the worksite, higher or less than one year).

- Final Premium Rate for Construction Machinery cover (R_{MACH}):

$$\boxed{\mathbf{R_{MACH}} = R_i \pm \text{Change in Deductible (‰)}}$$

4. **<u>Premium calculation for Auxiliary Equipment cover</u> (R_{AUX})**

Premium rates for Auxiliary Equipment can be calculated either for the whole term of insurance of the policy or on an annual basis.

Auxiliary Equipment is usually analyzed on a global basis, and it is assigned an annual rate which is quantified in a fixed value expressed in X‰ per year.

This is an annual rate, so that the premium rate for Auxiliary Equipment must take into account the permanence time of the equipment at the worksite, which coincides with the project execution period - expressed in years and not in months-, so that the premium rate for Auxiliary Equipment cover would be:

$$\boxed{\mathbf{R_i} = \text{X‰ x Project Execution Period (years)}}$$

- Deductible

Variations in the predetermined standard deductible have an influence on the premium rate in function of the increase in the deductible and expressed in (t)% over the premium rate R_i calculated in the previous section.

- Final Premium Rate for Auxiliary Equipment cover (R_{AUX}):

$$\boxed{\mathbf{R_{AUX}} = R_i \pm \text{Change in Deductible (‰)}}$$

5. <u>Determination of the Net Premium for the total works</u> (NP_W)

5.1. Global Net Premium for Material Damage cover (NP_{MD})

The Insurance Premium for Material Damage cover is calculated as follows:

$$\mathbf{NP_{MD}} = \text{Sum Insured} \times \frac{R_{MD}}{1{,}000}$$

Where R_{MD} is the global final rate for Material Damage cover (Refer to Section 2.4)

5.2. Net Premium for Construction Machinery cover (NP_{MACH})

In order to determine the **Total Annual Premium,** we must calculate the premium corresponding to each insured machine (P_i), according to the following formula:

$$\mathbf{(P_i)} = \text{Sum Insured} \times \frac{R_{MACHi}}{1{,}000}$$

Where R_{EQi} is the final premium rate for each machine (Refer to Section 3)

Therefore, the **Total Premium** under this concept shall be:

$$\mathbf{NP_{EQ}} = \sum_{i=1} P_i$$

5.3. Net Premium for Auxiliary Equipment cover (NP_{AUX})

In this case, the Insurance Premium shall be calculated as follows:

$$\mathbf{NP_{AUX}} = \text{Sum Insured} \times \frac{R_{AUX}}{1{,}000}$$

Where R_{AUX} is the final premium rate for Auxiliary Equipment (Refer to Section 4)

5.4. **Net Premium for the Overall Works (NP_W)**

This premium (NP_W) is the sum of the three insurance premiums previously determined, that is to say:

$$NP_W = NP_{MD} + NP_{MACH} + NP_{AUX}$$

4.1.3. RISK SURVEYS AND LOSS PREVENTION

Experience proves that the real risk situation is obtained from **periodic inspections** to the worksite during the execution period. These surveys must be scheduled so that they coincide with crucial phases of the works. Besides, it is important to inspect the worksite prior to the underwriting of the insurance contract.

The inspection works consist of:

- Comparing the written information with the real facts and filling the gaps regarding risk assessment.

- Assessing the general order and organization at the worksite, as well as requesting the necessary improvement measures in order to eliminate anomalous risks.

- Checking the loss prevention measures, as well as providing the Work Manager with recommendations on the adoption of additional measures.

Dowells assembly in tunnel construction

The first visit to the worksite provides the risk surveyor with the best overall idea of the works and a base for assessing the risk. Subsequent periodic visits are aimed at risk prevention and risk management in general, by verifying whether everything meets the project, how risks are affected by possible modifications, safety measures, etc. The importance of order and organization at the worksite must be kept in mind, as these are the factors which best contribute to such prevention.