Materiali per l’Architettura e l’Innovazione Tecnologica (6 CFU)

Tecnologie dei Materiali per l’Ambiente (6 CFU)

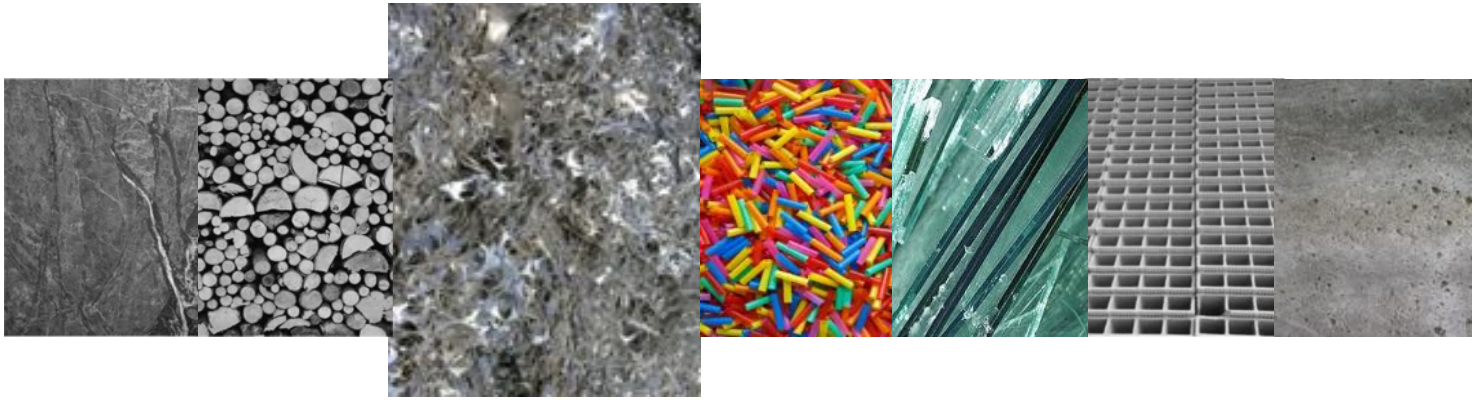
Prof. Alberto De Capua

MpA Lecture — Materials for Architecture

- STEEL
- POLYMERS
- GLASS
- CONCRETE

Seminario a cura di Lidia Errante e Valentina Palco

- **STEEL**
- POLYMERS
- GLASS
- CONCRETE



STEEL - definition and classification

The steels are **IRON** and **CARBON** leagues with a carbon content of less than 2%.

Usually there are also percentages of other elements such as silicon, manganese, phosphorus, sulphur, necessary to give particular characteristics to the finished product or added to improve the steel process.

As the percentage of carbon increases, the resistant characteristics of the product vary, precisely:

- ✓ decreases **ductility**,
- ✓ increases **endurance**;

There are many types of steel, whose compositions and names are defined by special technical standards: in Europe the euronorms (EN) issued by the European Committee for Standardisation (CEN) and in the American continent the ASTM (American Society Testing Materials), in collaboration with the AISI (American Iron and Steel Institute) and internationally the ISO (International Standard Institute).

The steels can be classified in different angles:

- ✓ **group I (UNI EN 10027-2):** basic and quality steels, also called general purpose construction steels.
- ✓ **group II:** special steels, differ from other steels for their chemical composition and for the heat treatment that gives these steels particular mechanical characteristics.

STEEL – classification based on carbon content

are classified in:

- ✓ **TYPE I STEEL** (extra mild, mild or iron), indicated by the symbols Fe37 and Fe45, easily weldable and with a high yield strength, used for plates, tubes, bolts, nails, construction irons;
- ✓ **TYPE II STEEL** (semi-hard and hard), indicated by the symbols from Fe52 to Fe65 and poorly weldable, used for machine components, metal cables, rods for reinforced concrete;

➡ if the carbon content is very **low**, there are soft metals and plastics,
due to the importance of ductility, **carpentry steels** must have a low carbon content: generally less than 0.24%.

➡ If the carbon content is **high**, there are hard and brittle metals.

STEEL – classification based on chemical component

In addition to carbon, there may be additional alloying elements added mostly of the ferroalloys types. Depending on their chemical composition, steels can be divided into :

- ✓ **Low alloyed basic steels:** these are steels in which the content of alloying elements are indicated by **UNI EN 10020** ("Definition and classification of steel types"), no quality requirement is needed for special precautions during the production process.

- ✓ **Alloyed or special steels:** these steels exceeding at least one limit within that indicated by UNI EN 10020. In addition to iron and carbon, they contain silicon, manganese, nickel and chromium, which confer special mechanical/chemical characteristics. The special steels are also called **Ex-ten**, and **Triten**, allow to obtain structures with limited weight because they have a high yield strength, with the addition of copper and chrome assume a fair resistance to oxidation (**CorTen**, Itacor and patinables).

STEEL – physical characteristics

- **SPECIFIC and VOLUME WEIGHT.** The specific weight of steel 7860 kg/m3 (density value) X 9.8 m/s2 (constant of terrestrial gravitational acceleration).

- **COEFFICIENT OF THERMAL DILATION.** The coefficient of thermal expansion, is a fractional variation in the length of a bar per degree of variation in temperature, in steel is equal to 12x10-6 °C-1. The thermal expansion of the bodies, quantified by this coefficient, indicates the variation of its dimensions as the temperature increases, in steel is an important fact because it affects the structural design.

- **COEFFICIENT OF THERMAL CONDUCTIVITY or CONDUCTIVITY.** Steel has a high thermal conductivity, therefore, it produces heat loss by heating and condensation on the cold surfaces of the steel.

STEEL – mechanical characteristics

In steels the mechanical resistance to breakage is not high, but special steels have, instead, higher values of the tensile strength and have better performance thanks to the addition, in the alloy, of manganese, silicon, etc..

- **TENSILE, FLEXURAL, SHEAR AND TORSIONAL STRENGTH.** The steel has high tensile strength and resistance to longitudinal or transverse stresses.

- **RESISTENCE TO FIRE**. Steel does not burn and does not conduct fire because it is a non-combustible material, however its mechanical properties vary considerably depending on the temperature.

The fire resistance of a structural element is defined as its ability to maintain: stability "R", seal "E", thermal insulation "I" (REI). The interval of time in which a structural element subjected to the action of fire is not damaged is defined as "duration of fire resistance". The measures applicable to fire protection can be of the following types: insulating; shielding; heat-transferring. Through:

- **specific adherent** or box-like coatings, such as spray-applied plasters;
- **intumescent paints**, materials that swell at high temperatures creating a cellular structure with overlapping layers and solders of very high insulating power;
- **hybrid structural solutions**, profiles inserted in concrete castings.

STEEL – mechanical characteristics

- **CORROSION RESISTANCE**. Corrosion is the measurable reaction of a metallic material with its environment that modifies the material in a negative way.
    - **Chemical corrosion,** i.e. direct between iron and oxygen with formation of iron oxide that becomes significant at elevated temperatures;
    - **Electrochemical or physical corrosion**, i.e. the reaction that occurs at room temperature in the presence of oxygen and water.

Corrosion is influenced by the chemical composition of the atmosphere, by the chemical composition of steel and alloy elements, by the weather situation and by "climatic attacks", by coatings. In constructions, steel elements are protected with coatings/paints applied after the surface has been properly prepared.

STEEL – technical and technological characteristics

The main technical and technological characteristics of steel concern important properties for material processing and material use, among them:

- **WELDABILITY**. The steels used in construction are all weldable, this characteristic is conditioned by the % of carbon, in fact, above 0.3% of carbon decrease weldability and elongation percentage.
- **PLASTICITY**. In steel deformation, a distinction is made between hot and cold deformation. The latter must be understood as deformation below the recrystallization temperature and, depending on the degree of deformation, causes an alteration of the properties. This work hardening is subject to an ageing process over time and leads to further brittleness, which mainly damages the weldability of the product. Through a second process, such as annealing or quenching and tempering, it is possible to eliminate these disadvantages.
- **HARDNESS**. It can be determined in a non-destructive way, communicates the homogeneity of the material, its tensile strength and possibly its resistance to wear.

STEEL – Uses and Products

Steels are used:

- in carpentry, spatial structures and reticular construction systems;
- in sheet metal works, horizontal closures;
- in reinforced concrete and prestressed concrete;
- as covering materials and furnishings;

Three types of steel are produced, indicated as: **Fe 360; Fe 430; Fe 510** where the number indicates the value of the breaking strength expressed in N/mm2.

With these hot-rolled steels, they are obtained:

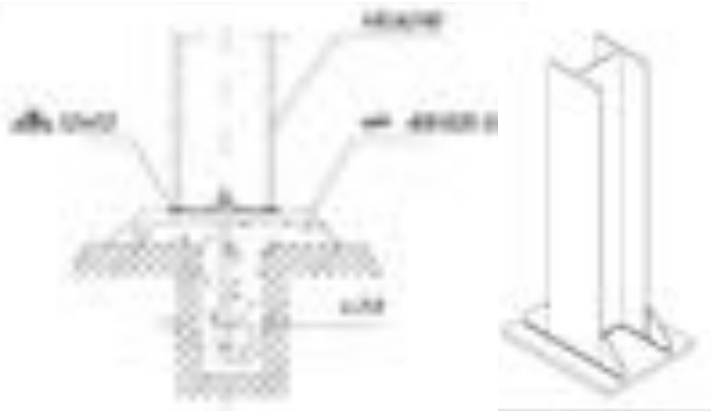
- profiles, bars, wide plates, sheets;
- hollow sections.

The standard specifies minimum values for the two types of product defined above:

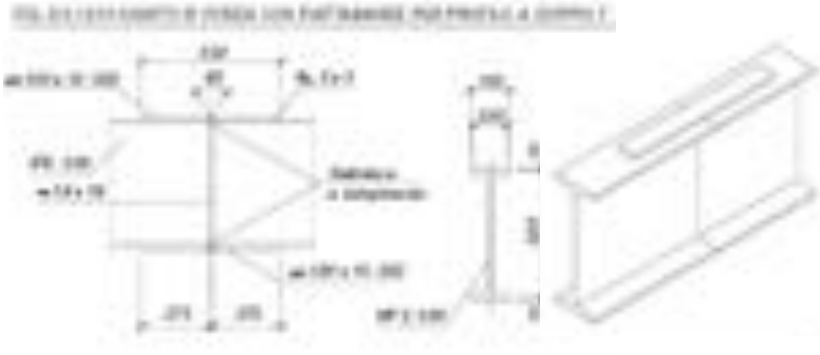
- of the unit breaking tension ft (N/mm2);
- of the yield unit voltage fy (N/mm2);
- KV resistance at temperatures of +20°, 0°, -20° (J = Nm);
- of the percentage elongation at break et .

STEEL – Profiles

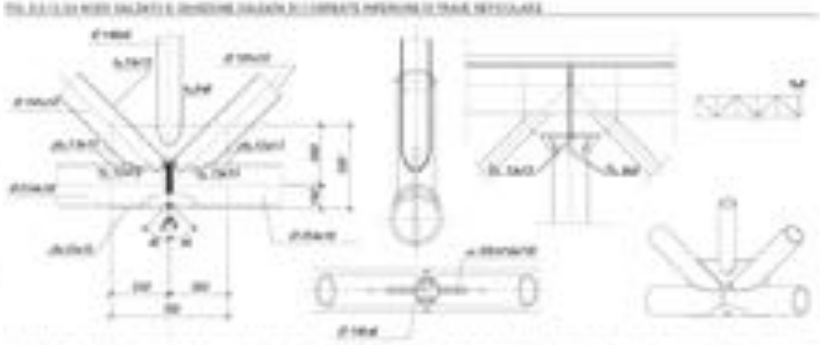
PROFILATI A DOPPIO T	ad ali strette e rastremate		IPN
	ad ali medie e parallele		IPE
	ad ali larghe	serie leggera	HEA
		serie normale	HEB
		serie pesante	HEM



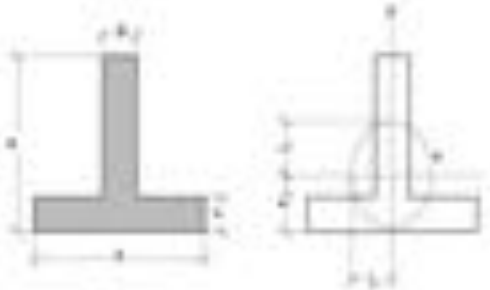
PROFILATI	a doppio T ad ali strette e rastremate (IPN)	
	a T	ad ala stretta
		ad ala larga
	a L	a lati uguali
		a lati disuguali
	a C	serie normale
		serie pesante
		serie speciale
	a Z	a spigoli vivi



PROFILI A SEZIONE CAVA	a sezione circolare	saldati
		senza saldatura
	a sezione quadrata senza saldatura	
	a sezione rettangolare senza saldatura	



STEEL – Profiles



STEEL – Bars and Sheets

Concrete steels are produced by **extrusion** in round and smooth bars or adhesion improved ones; they have variable diameters from 4mm to 34mm.

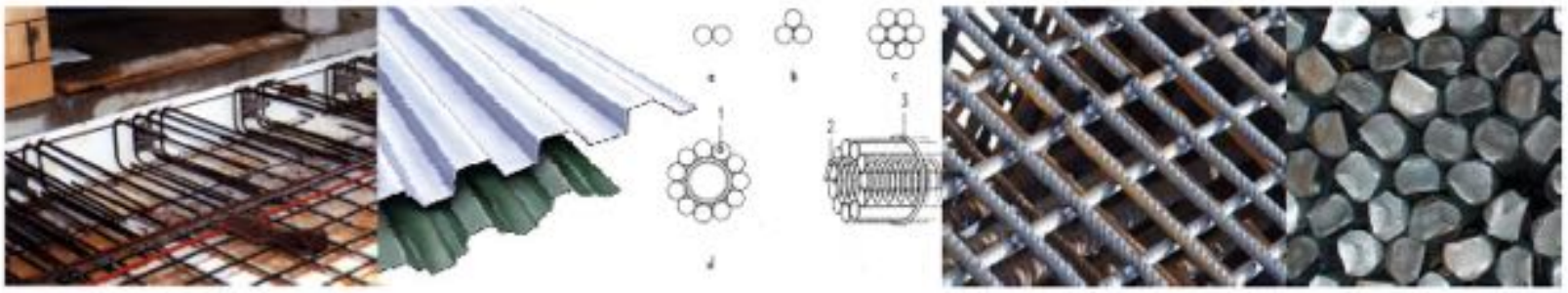
Prestressed steels are special cold rolled steels made of wires of about 2÷3mm diameter, with a diameter of high resistance to breakage, then wound with a helix (strands).

Steel products in sheet form include "corrugated" and "corrugated" sheets.

Connections

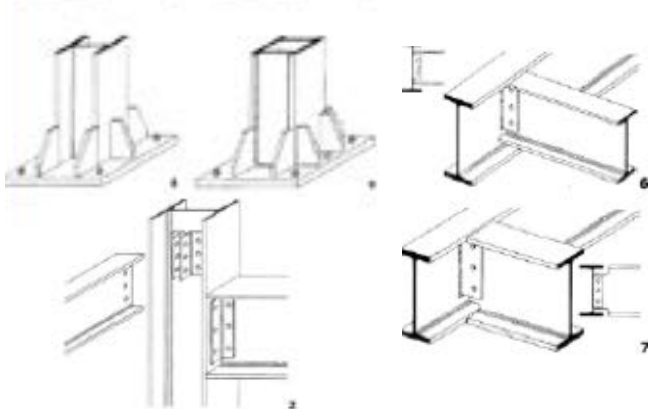
Connections can be made for:

- **NAILING**: this is done by drilling in the two elements to be joined and passing the nail through them, the end of which is returned, ensuring the connection;
- **BOLTING**: is performed using screws and bolts;
- **WELDING**: stable and continuous union along the contact surface, obtained by the action of heat;
- **BONDING**: acrylic, vinyl, epoxy and phenolic adhesives are used.

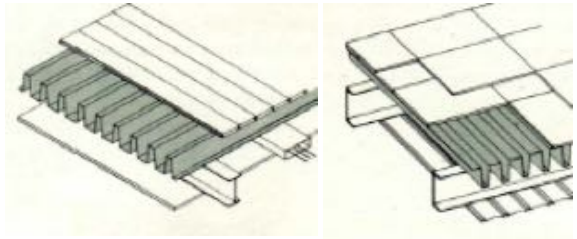


STEEL – Technical elements

BEARING STRUCTURE. Thanks to its mechanical characteristics, steel is used to create structures that are light in relation to their load-bearing capacity. The beam-pillar node is the structural type traditionally used in steel construction: it is the most problematic point, where the presence of forces in different directions makes it necessary to design it very careful.

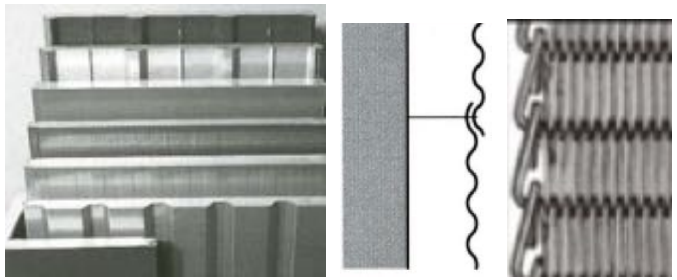


HORIZONTAL CLOSES. Simple or trapezoidal sheet metal ceiling with concrete casting.



VERTICAL CLOSURES. Sandwich elements in which two metal sheets are coupled and interposed by a layer of insulating material;

- metal facades;
- metallic fabrics.



COVERS.

- STEEL
- **POLYMERS**
- GLASS
- CONCRETE

POLYMERS - definition and classification

Plastics and elastomers (rubbers) are macromolecular substances (polymers). The raw materials, obtained by processes of synthesis of organic chemistry, are characterized by the plastic behavior at high temperatures that allows the forming;
Elastomers, which have an elastic behaviour at room temperature, are obtained from liquid polymers, natural or synthetic, whose linear structures are bound together through the chemical process of hardening, called vulcanization.

Plastics used in construction are classified into:

1. THERMOSETTING RESINS **2. THERMOPLASTIC RESINS**

1. Thermosets are defined as those resins that, after an initial prolonged action of heat, become irreversibly infusible.

2. Thermoplastics are defined as those resins which soften with heat and which, with cooling, regain their initial state without changing the chemical structure.

POLYMERS - definition and classification

THERMOSETTING RESINS. The group of these resins has the characteristic of forming three-dimensional bonds between the starting monomers, the irreversible reaction that hardens these resins occurs with temperature rise, often with the addition of hardening catalysts.
Among the thermosetting resins are identified:

Epoxy Resins

They have: Good mechanical properties, good chemical resistance, low shrinkage and excellent adhesion. They are widely used as adhesives on concrete - metal - wood, for the addition of mortars and concrete, they are used as sealants, for chemical-resistant renders, as impregnating agents, as coatings for flooring.

Polyurethane Resins

They have: Good mechanical properties, good chemical resistance, low shrinkage, good adhesion.
When loaded with additives, they take on the property of expanding (polyurethane foam), resulting in a high level of insulation. They are used as sealants, coatings and coatings, for chemical-resistant renders, such as impregnating agents, adhesives and floor coverings.

Polyester Resins

These resins are characterized by: fast curing, low curing temperature, good ease of mixing, resistance to chemicals, good mechanical properties and low viscosity.
Combined with glass or nylon fibres, they give rise to composite materials that are widely used in the production of windows, panels and pipes.

POLYMERS - definition and classification

THERMOPLASTIC RESINS. Thermoplastic resins are linear or branched polymers that can be melted by providing them with an appropriate amount of heat; during the plasticization phase they do not undergo any chemical variation. They can be forged (and re-forged) in any form using injection moulding and extrusion as techniques. Thermoplastic resins can be identified:

Polyethylene

It is obtained by polymerization of ethylene, it can be: low, medium, high density. The differences between the three formulations are related to tensile strength, modulus of bending strength, and softening point. It is used for ducting and electrical equipment.

Polystyrene

The main uses are related to thermal and acoustic insulation systems and the construction of lightweight concrete floors. It is marketed in blocks, panels, tiles, pellets, expanded foams.

Polyvinyl chloride PVC, rigid and plasticised

It is the most widely used resin in the construction industry. Rigid PVC has good resistance to chemical attacks, high resistance to traction and bending, good resistance to abrasion. It is used for the production of pipes and frames for frames, flat and corrugated sheets for roofs or for the construction of partitions. Plasticised PVC does not have rigidity characteristics. It is mainly used for vinyl flooring.

POLYMERS - Physical characteristics

In general, plastics reduce the transmission of energy, whether it be electricity, heat or sound.

- **COEFFICIENT OF THERMAL COIBENCY.** It is generally high.
- **COEFFICIENT OF THERMAL CONDUCTIVITY or CONDUCTIVITY.** Usually it is low.

POLIMERS - Mechanical characteristics

The mechanical and technical characteristics of plastics vary in relation to the difference between thermosets and thermoplastics.

In **thermosets** the mechanical resistance and the technical characteristics of stiffness and brittleness are all the greater when the cross-linking is thicker.

In **thermoplastics**, the mechanical and technical characteristics of stiffness vary with temperature and are susceptible to sliding under the action of applied stresses.

POLYMERS - Technical elements

SEALING

The waterproofing materials are used to prevent the infiltration of water, for capillary rising or gravity in that part of the building organism most at risk (foundations, floors on the ground, vertical closures of the basements, balconies, roofs).

In addition to the main requirement of waterproofing, these materials must have **(UNI 8202):**

- ✓ **Good mechanical properties to withstand structural movements;**
- ✓ **Adequate resistance to static and dynamic punching;**
- ✓ **Dimensional stability;**
- ✓ **Plasticity;**
- ✓ **Resistance to atmospheric agents and ageing, must be unrottable**.

When exposed to UVA rays, acid rain and temperature changes, they require adequate surface protection.

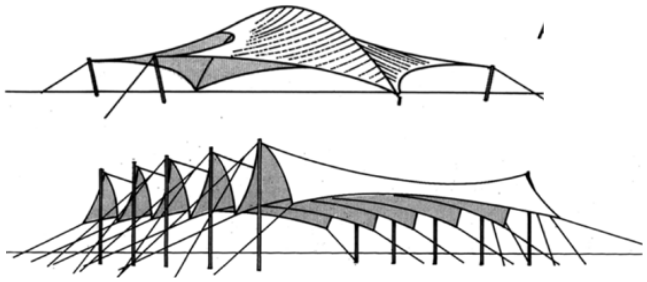
The waterproofing materials are **natural or synthetic.**

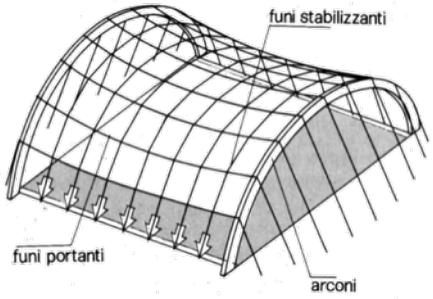
- ✓ The first category includes bituminous materials, which are also used in the production of bituminous membranes and as sealants;
- ✓ The second category includes synthetic membranes.

The waterproofing products, which can be applied cold or hot, are marketed in liquid or pasty form.
in single or multi-layer membranes.
A possible reinforcement, which improves the mechanical characteristics, can be integrated in the laying phase or prepared already in the prefabricated product.

LOAD-BEARING STRUCTURES

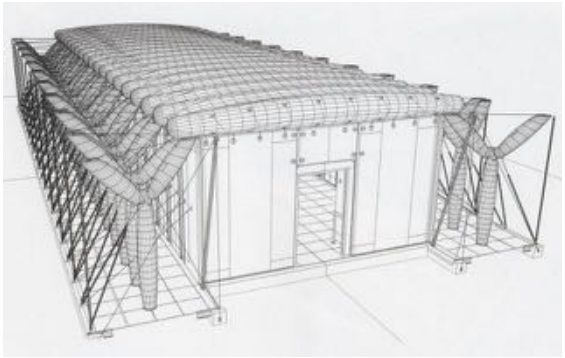
Structures with rope nets. They consist of a net in which the ropes (galvanized steel wires) pre-tension each other, giving the warp a double curvature. The cover is made of transparent polyester.





Tent structures. Tent means a sheet of material so thin that it does not have any resistance to bending, compression, or shearing, but is only capable of reacting to traction. This system is limited to small temporary structures.

Pneumatic structures. They are characterized by being supported by gas, the shape and stability are determined by the state of pressure, higher than the outside, produced by the gas introduced into them. Pneumatic systems can be: single-walled, double-walled.



Airtecture Exhibition Hall , A. Thallemer, 1996, (struttura

GLASS - definition and components

Glass is the product of the cooling of a homogeneous mixture of minerals that, after being melted, pass to the rigid state without crystallizing, but assuming a disorderly molecular structure and rather unstable (amorphous state).

The main constituents of glass are:

- **Silica** is the main component of the base mixture (vitrifying substance); it is present in the mixture for about 75%;
- **Sodium or potassium sulphates** (alkaline oxides) contribute to lowering the melting point of the vitrifier (1100°C); 10-15% of them are present;
- **Calcium or magnesium carbonates** (alkaline earth oxides), 10-15% of which are present,**fati di sodio o potassio** (ossidi alcalini) contribuiscono ad abbassare il punto di fusione del vetrificante (1100°C); sono presenti per il 10-15%;

The replacement of sodium oxide (feldspar) with lead and potassium oxides makes it possible to obtain **crystal,** which is a particularly transparent and brilliant glass plate.The substitution in the mixture of sodium sulphates (sodium-calcium glass) with potassium sulphate makes the mixture more workable and the glass even more brilliant (Bohemian glass). The term **crystal** is often used to refer to sodium-calcium glass, which is characterised by high strength, low fragility and is obtained by annealing the sheets.

GLASS - classification

The glass products are distinguished, on the basis of the manufacturing processes undergone, in:

- **basic glass products**, which do not have any processing other than manufacturing;
- **processed glass products**, which are obtained by further processing to improve performance

BASIC GLASS PRODUCTS

The basic glass products are distinguished, according to the production technology, in:

- *pulled glass;*
- *cast and laminated glass;*
- *float glass;*
- *profiled glass;*
- *pressed glass in moulds;*
- *tempered glass.*

GLASS - basic glass products

The pulled glasses (UNI EN 572(1996)) are made by passing the mixture through a slit, made on a sheet of refractory material; the mixture is pulled and then annealed, this allows to eliminate the internal tensions that can be caused by the cooling differentiated immediately from the sheet.

Cast and laminated glass (UNI EN 572) is made by direct pouring of the melted mixture between the laminating rollers. The different surface of the rollers, smooth or in relief, allows to obtain **smooth or printed glass sheets**, on one side or on both sides.
The deposition of a thin film of metallic oxide allows the surface **colouring** of the sheet. With the same technique, but without annealing, **reinforced glass sheets** are produced from the lamination of molten glass mass into which a wire mesh has been introduced.

Float glass (UNI EN 572), also known as **crystals**, is obtained by casting the glass mass in an inert atmosphere on a bath of molten tin (to float). The glass is deposited on the pond according to a natural thickness of 6 mm and is then subjected to a subsequent annealing and cooling. It is possible to produce sheets with thicknesses between 2 and 19 mm, intervening in the casting phase with appropriate measures. This production process allows to reduce cracks to a minimum, thanks to the lower stress suffered by the slabs.

GLASS - basic glass products

Profiled glass (UNI EN 572) is a translucent element, characterized by the characteristic "U" profile. Obtained by drawing, they have lengths up to 4 m. The profiled glass can be of simple type or reinforced with thin steel wires, arranged in length. They are used as translucent and transparent CV elements.

normale armato retinato

The glass pressed in moulds, also called diffusers because of the lack of transparency, is made by pouring it into special moulds and then compressing, by means of punches, the glassy mixture, which is thus forced to take the shape of the mould. With this procedure it is possible to obtain diffusers in the form of hollow blocks or an air chamber (UNI 9303), with a raised edge.

Tempered glass: tempering (UNI EN 12150, UNI 7697) is a thermal process whose purpose is to induce particular stresses on the glass plate to give it better resistance characteristics, especially in bending. The sheet that has undergone tempering, in addition to better resistance to bending and thermal shock, has the characteristic, once it is caused to break, to be reduced to minute fragments rather than sharp splinters.

GLASS - PROCESSED GLASS PRODUCTS

These are obtained by subsequent processing of basic glass products in order to improve the characteristics of the glass; among these, they stand out:

- reflective glass or low-emission glass;
- double glazing;
- laminated glass;
- chromogenic glasses.

Thanks to the surface treatment, **reflective glasses** are able to reflect at least part of the incident solar radiation by filtering solar energy, thus preventing it from penetrating the environment in the form of light or heat.

Similarly, **low-emissivity glass** is used to contain heat loss through its reflective action towards the interior of the environment. The heat radiated by the heating bodies (radiators, radiant panels) is intercepted and reflected inside the heated environment.

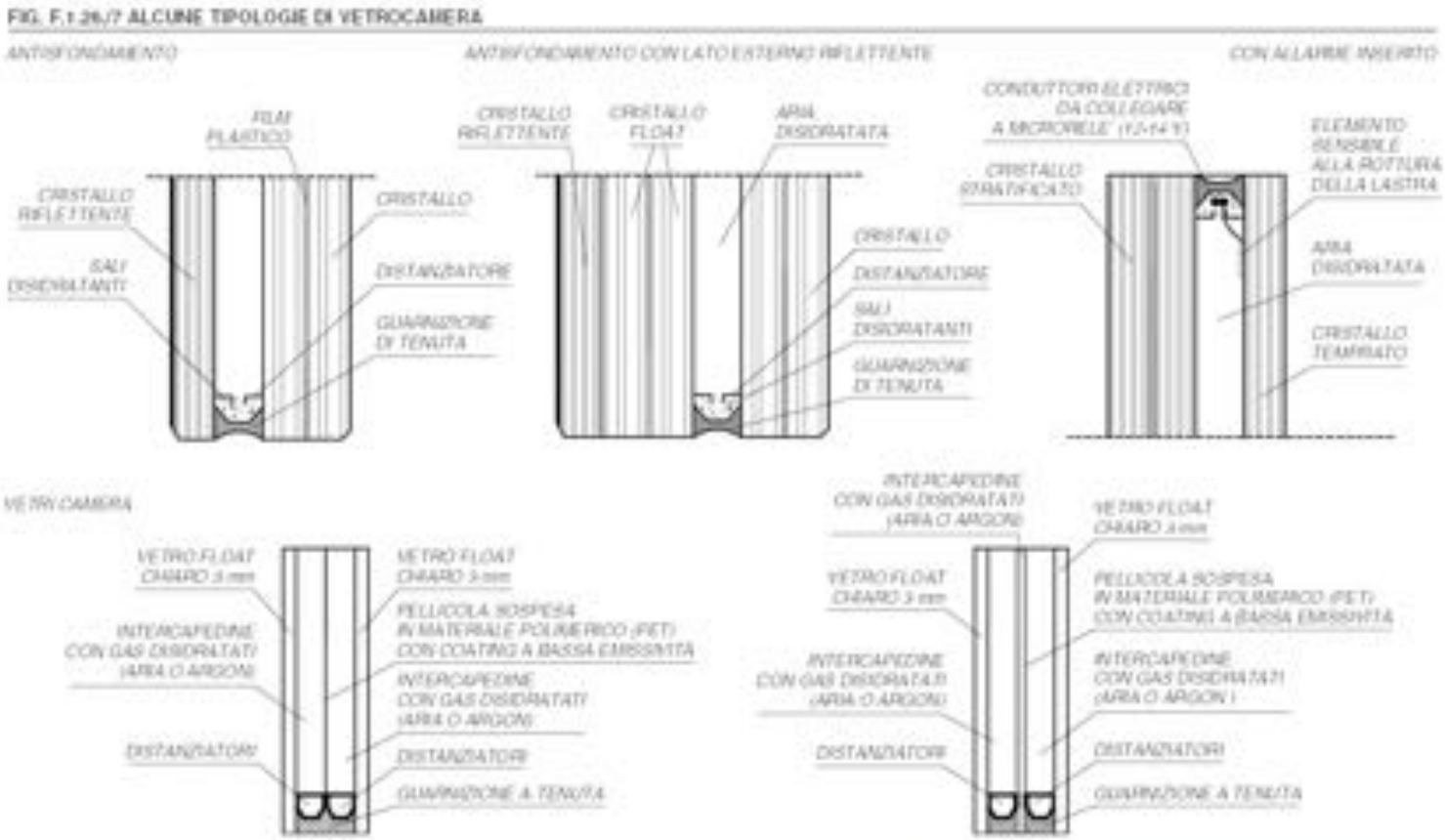
The surface of the sheet is made reflective by the deposit of metals and metal oxides by pyrolysis (hot) or pulverization (at room temperature), and by the application of synthetic films applied to the sheets even after their installation.

GLASS - PROCESSED GLASS PRODUCTS

Insulating glass (UNI 10593) is a panel characterized by insulating properties, both thermal and acoustic.

The panels are obtained by hermetically sealing two or more sheets of glass along the perimeter, so as to leave a gap between them containing dry air or noble gases (argon).

The sheets are spaced by means of a plastic or metal profile (spacer) containing dehydrating powders, while a suitable plastic perimeter seal prevents exchange with the external environment (seal).

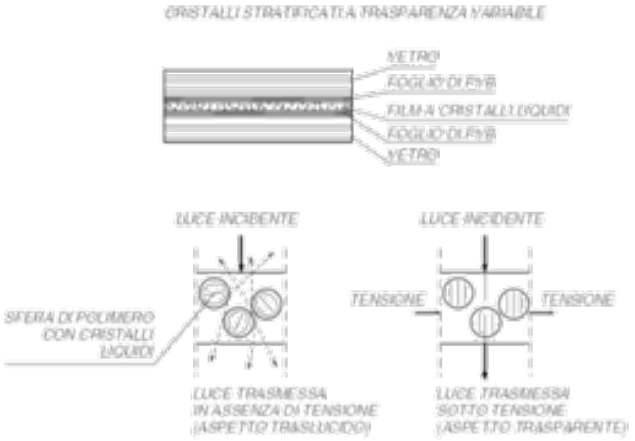


VETRO - PRODOTTI VETRARI TRASFORMATI

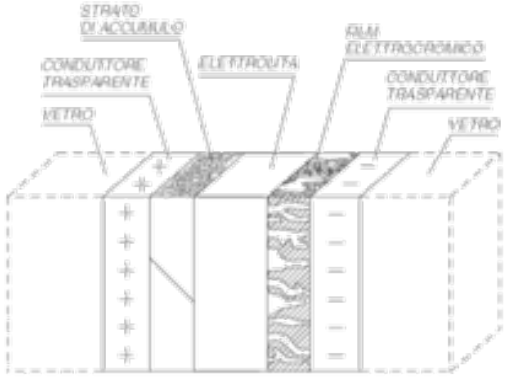
Laminated glass (UNI EN ISO 12543, UNI EN 356, UNI EN 1063) is a panel consisting of the coupling of several sheets of glass, which are joined together over the entire surface through the interposition of a transparent plastic film (0.3-0.5 mm) of polyvinyl butyral (PVB) or polycarbonate.
The presence of the plastic film gives the panel good resistance to impact and breakage; moreover, in the event that the impact causes it to break, the fragments will remain attached to the plastic without dispersing.

Chromogenic glass, panels able to vary their opacity at the command of the user. These are made by coupling two crystals by means of two sheets of PVB with a special liquid crystal film in between, which in the absence of electrical voltage is opaque, while the presence of an electrical field allows the sheet to pass to the transparent state.
The intensity of the electric field can be regulated by means of various external stimuli:

- ✓ such as the variation of light intensity (photochromic),
- ✓ the application of an electric field (electrochromic and liquid crystal),
- ✓ temperature variation (thermochromic).

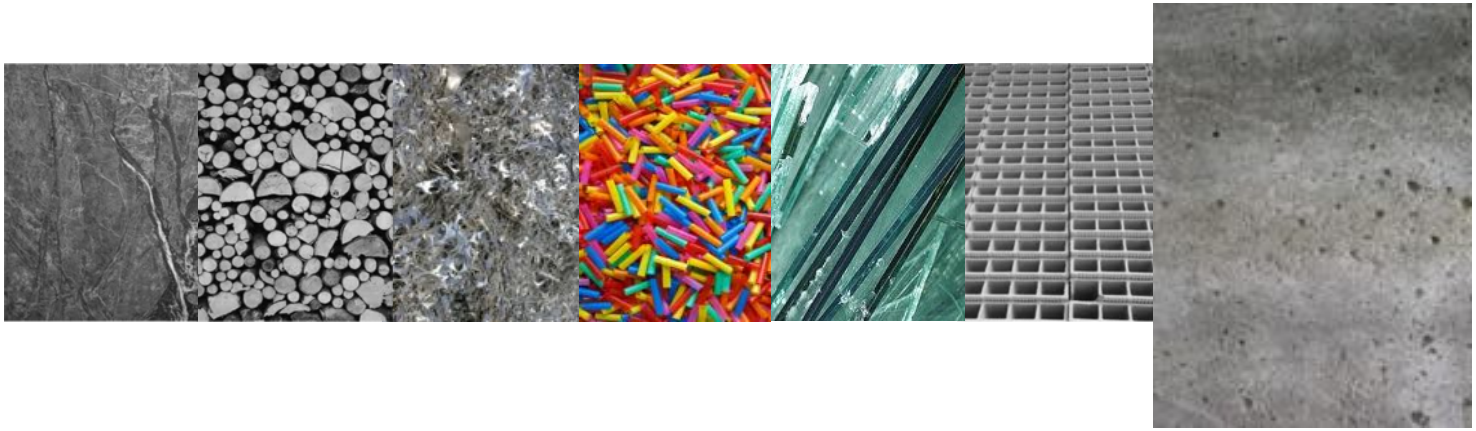


SCHEMA DI FUNZIONAMENTO DI DISPOSITIVO A CRISTALLI LIQUIDI



COMPOSIZIONE DI UN DISPOSITIVO ELETTROCROMICO

- STEEL
- POLIMERS
- GLASS
- **CONCRETE**



CONCRETE - definition

Concrete is a mixture of three fundamental components:

1. cement, which is the binder,
2. water, which hydrates the cement, giving the mixture characteristics of workability and plasticity,
3. aggregates or aggregates which, for ordinary concrete, are of natural origin (sand, gravel or crushed stone) and constitute the skeleton of the mixture.

The aggregates, with a suitably assorted grain size, must be well wrapped in the cement paste and well distributed.

The use of additives (accelerating agents, retardants, plasticizers, airing agents, waterproofing agents) improves the workability of the mix and the performance of the hardened product, whose resistance depends on the water/cement ratio, on the quality and on the mechanical and geometric characteristics of the aggregates, on the method of mixing, laying and compacting.

Lightened concrete (UNI 7548) uses expanded clay, pumice, plaster, wood chips or waste, vegetable fibres, magnesium and aluminium as aggregates.

Cellular gasified concrete is a very light material, 450 kg/mc, easily workable; it is obtained with a mixture of sand and calcium carbonate mixed in water with aluminium powder; the powder develops gas expanding the volume of the initial mixture. For the assembly of the gasified cellular concrete blocks, adhesive mortar with joints of about 1 mm thickness is used.

Binding Agent

Binders are all those materials which, after mixing with water, take on a lithoid consistency over time, subject to two moments of transformation, the first called setting and the second called hardening. Traditionally, the binders used are 4 and have an affinity of behavior, they are:

1. *Lime*
2. *Cementitious Agglomerates*
3. *Gypsum*
4. *Cements*

1. Limes

Limes are the oldest binders. They are classified into two categories according to how they grip:

- Aerial kicks: they make contact with the air reacting with carbon dioxide, is a binder derived from the firing between 800 and 900 ° C of limestone rocks in which the calcium carbonate is present in quantities of not less than 90%.

- Hydraulic lime: they set by reacting with water and whose cooking temperature exceeds 1000°.

2. Cementitious agglomerates

They have better physical characteristics than hydraulic limes but have lower compressive strength, below the legal minimums required of cements.

3. Gypsum

These are hydraulic binders used for interiors, they come from the firing of selenitose rocks. The mineral that is cooked loses part of the water and then resorbs it, increasing in volume and consistency so as to form a hard and compact mass**.**

4. Cements

These are hydraulic binders capable of achieving very high mechanical strengths after setting after hardening. Chemically, the mixtures to obtain the cements are composed of: silica, alumina and iron oxides, calcium oxide and gypsum. They can be classified according to their composition or according to their resistance, referred to the maximum resistance to compression obtained until crushing after 28 days.

From the point of view of the components, they are classified as follows:

- Natural cements or Portland: are obtained by cooking marl with a small addition of gypsum to regulate the process of hydration and subsequent grinding. The marls are finely ground, then stabled and cooked. The product that comes out of the oven is dark grained and is called clinker, this is then pulverized.

- Artificial cements: these are all those hydraulic binders obtained from mixtures of substances of different origins:

pozzolanic cement: obtained by mixing clinker of portland cement with pozzolana, able to define resistance to the actions of brackish water.

blast furnace cement: obtained by mixing clinker of portland cement with basic granulated slag (by-products of the iron and steel industry), capable of guaranteeing a high hydraulic value.

special cements: these are those cements whose composition is the result of mixtures of particular compounds or high firing temperatures or the use of specific additives.

1. *white cements*
2. *coloured cements*
3. *aluminous cements, determine high mechanical strength in a short time*
4. *ferric cement*
5. *extrarapid hardening cement*

CONCRETE - components

The componente of the concrete are: Cement, Water, Aggregates, Additives Cement.
Cement is the active component of concrete. Acontact with the mixture in each cement granule starts a «hydration» process with the formation of a colloidal gelatinous layer (gel). This gel, by hardening and setting, freezes all the inert elements of the compound in a compact mass combination. Today we have a wide range of cements: portland cement, rapid-hardening cement, colored cement.

Water: water is essential in the dough because it determines the hydration reaction of the cement. The water/cement ratio normally stands at 0,50,which is 50 liters of water to 100 kg of cement.

The water in the mixture must be clear, not contain salts in harmful percentages and not be aggressive.
The key parameter of the concrete's resistance is the water/cement ratio, i.e. a mixture with a lower water content is more resistant when the cement content is the same.

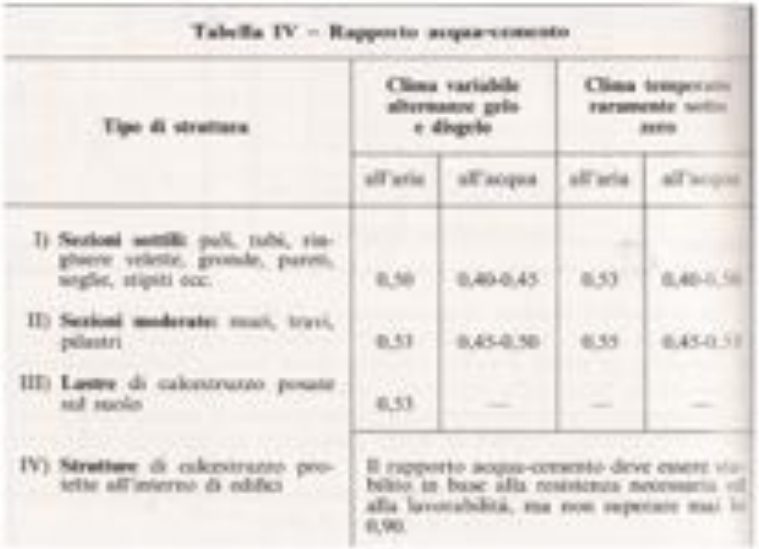


Tabella IV – Rapporto acqua-cemento

Tipo di struttura	Clima variabile alternanze gelo e disgelo		Clima temperato raramente sotto zero	
	all'aria	all'acqua	all'aria	all'acqua
I) Sezioni sottili: pali, tubi, ringhiere velette, grondè, pareti, soglie, stipiti ecc.	0,50	0,40-0,45	0,53	0,40-0,50
II) Sezioni moderate: muri, travi, pilastri	0,53	0,45-0,50	0,55	0,45-0,55
III) Lastre di calcestruzzo posate sul suolo	0,53	—	—	—
IV) Strutture di calcestruzzo protette all'interno di edifici	Il rapporto acqua-cemento deve essere stabilito in base alla resistenza necessaria ed alla lavorabilità, ma non superare mai lo 0,90.			

The dosage of the cement

The dosage of the cement is in relation to the other components of the mix and also in function of the maximum diameter of the inert material used.
By increasing the quantity of cement in the mix, a stronger concrete is obtained. The dosage of the cement is therefore determined according to the use for which the mix is intended.

Tabella III

Impiego del calcestruzzo	Quantità di cemento per metro cubo di impasto	Tipo di cemento
Opere non armate		
Fondazioni all'asciutto, murature di grandi spessori e riempimenti	kg 150	R. 325
Fondazioni in genere, murature e sottofondi	kg 200	R. 325
Opere debolmente armate		
Architravi, fondazioni in acqua e sottofondi	kg 250	R. 325
Opere armate		
Strutture in C. A. normali	kg 300	R. 325 R. 425
Strutture in C. A. notevolmente sollecitate, solai, solettine, ecc.	kg 350	R. 325 R. 425
Strutture in C. A. molto sollecitate o di spessore sottile (inferiore a 10 cm) da lasciare in vista	kg 400-500	R. 425

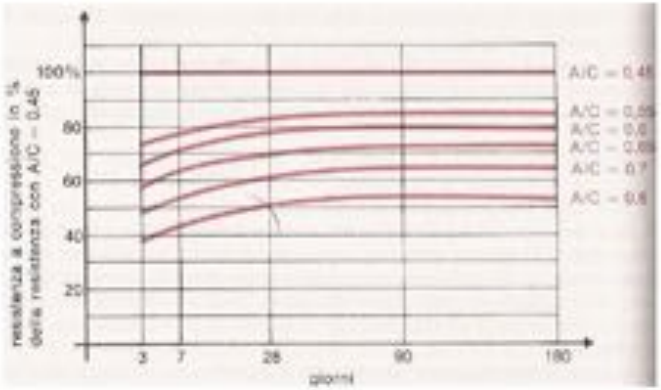
ECCESSO DI ACQUA NELL'IMPASTO

The excessive amount of water is a constant problem in the preparation of concrete. This is harmful and causes:

- Decrease in concrete strength
- Increased withdrawal phenomenon
- Risk of aggregate separation

Decrease in concrete strength

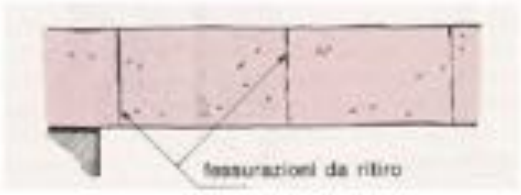
It appears more pronounced in the first few days and then stabilizes at constant values. The graph compares the concrete strengths with various water-cement ratios, compared to the one with a/c = 0.45.



Variazione di resistenza del calcestruzzo al variare del rapporto acqua-cemento

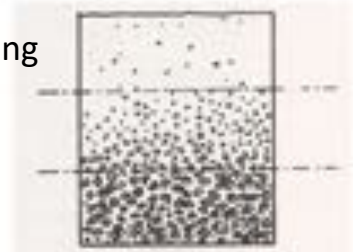
Increased withdrawal phenomenon

Determines cracks in the mass with serious consequences for the impermeability of the structures.



Separation of aggregates

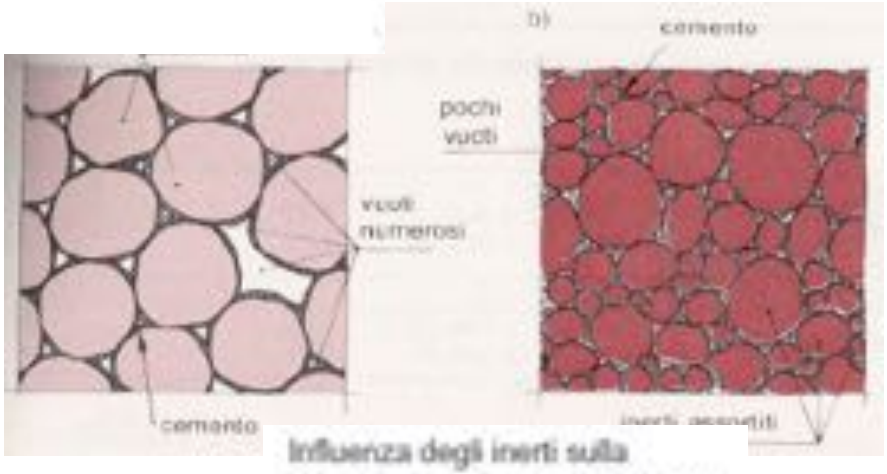
In this case, the aggregates tend to stratify according to their specific weight, completely altering the granulometric characteristics of the concrete.



Composizione del calcestruzzo

Inerti: Sabbia, pietrisco o ghiaia costituiscono gli inerti o aggregati, questi non hanno alcun ruolo durante la presa, ma sono determinanti nel definirne le caratteristiche. La sabbia e la ghiaia devono essere costituite da elementi di granulometria assortita in maniera da costituire una miscela con il minor volume di vuoti.

Aggregates must consist of non-freezing elements, free of brittle, powdery, earthy or other parts that are harmful to the hardening of the mixture and to the preservation of the reinforcement.
Finally, the elements must be of different sizes in order to reduce voids to a minimum, this is crucial to give compactness to the dough and therefore a good mechanical resistance to concrete.



Influenza degli inerti sulla compattezza di un calcestruzzo.

Additivi: Questi componenti hanno la funzione di esaltare determinate prestazioni e possono essere enunciati in base all'azione che esercitano sul materiale:

- acceleratori di presa/indurimento, solubili in acqua (cloruri carbonati);
- ritardatori di presa, (lignosolfati, fosfati, cellulosa);
- plastificanti, prodotti insolubili (bentonite, silice fossile);
- fluidificanti, solubili in acqua (resine, lignosolfati);
- generatori di gas per calcestruzzi alleggeriti (polvere di alluminio);
- coloranti per caratteristiche estetiche (ossidi o sali minerali).

calcestruzzo armato

L'unione del calcestruzzo con l'acciaio costituisce un materiale da costruzione dalle notevoli caratteristiche di resistenza sia a compressione che a trazione.
Tale unione è possibile poichè questi materiali hanno un coefficiente di dilatazione termica molto simile.
L'esecuzione di un opera in calcestruzzo armato prevede:
- preparazione del calcestruzzo;
- preparazione delle casseforme;
- preparazione e posa in opera dell'armatura metallica;
- trasporto e getto del calcestruzzo.

calcestruzzo armato precompresso

Si definisce "pre-sollecitata" una struttura posta artificialmente in stato di "coazione", creando in essa uno stato di tensione interno. Le tensioni così generate modificano le caratteristiche meccaniche apparenti del materiale.
Nel calcestruzzo armato precompresso la pre-sollecitazione conferisce la resistenza agli sforzi di trazione, previa l'applicazione di una precompressione, prodotta da armature metalliche poste in tensione.
I sistemi di precompressione del c.a. possono suddividersi in:
• sistema ad armatura pre-tesa;
• sistema ad armatura post-tesa.

Confezionamento del calcestruzzo

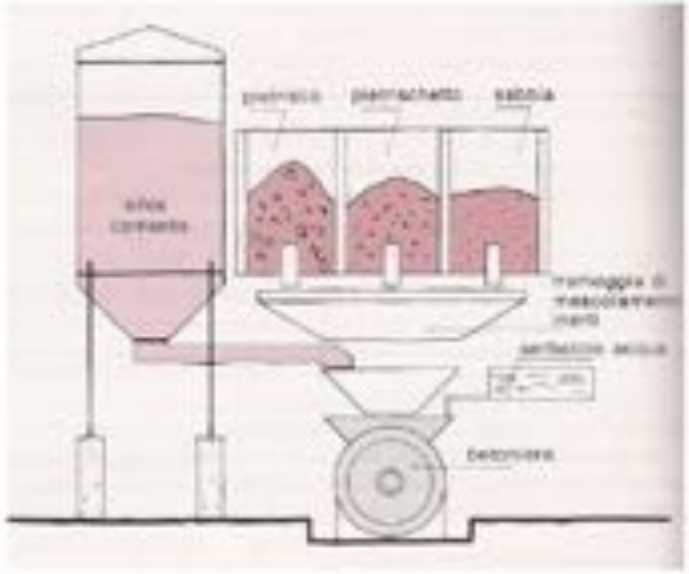
Il confezionamento del calcestruzzo è l'operazione dalla quale dipende l'omogeneità del calcestruzzo stesso. In una centrale di betonaggio si distinguono più settori operativi:

- stoccaggio;
- dosaggio degli inerti e del cemento;
- dosaggio dell'acqua;
- miscelazione dei componenti.

Per confezionare un buon calcestruzzo è necessario tener conto: delle caratteristiche dei componenti, delle condizioni di posa in opera, dei rapporti quantitativi tra i componenti stessi.

Trasporto del calcestruzzo

Il trasporto dell'impasto per brevi distanze può avvenire mediante carriole, nastri trasportatori, tubi a pressione. Per distanze maggiori si usano le autobetoniere, in cui si caricano i componenti asciutti e durante il tragitto avviene l'impasto con l'acqua contenuta in un apposito serbatoio.



Centrale di betonaggio

Trasporto tramite autobetoniera

Preparazione delle casseforme

Le casseforme atte a contenere il getto devono possedere determinati requisiti:

- essere impermeabili al calcestruzzo;
- resistere alle sollecitazioni trasmesse durante il getto e il costipamento;
- essere realizzate con materiali che non reagiscono a contatto con l'impasto e permettono il disarmo dei getti senza pericolo di aderenze;
- nel caso di getti a faccia vista, le pareti devono essere opportunamente rifinite allo scopo di ottenere l'effetto superficiale desiderato.

Posa in opera del calcestruzzo

Il calcestruzzo preparato in cantiere o trasportato mediante autobetoniera viene gettato in opera, cioè depositato nei cassseri predisposti per accoglierlo.

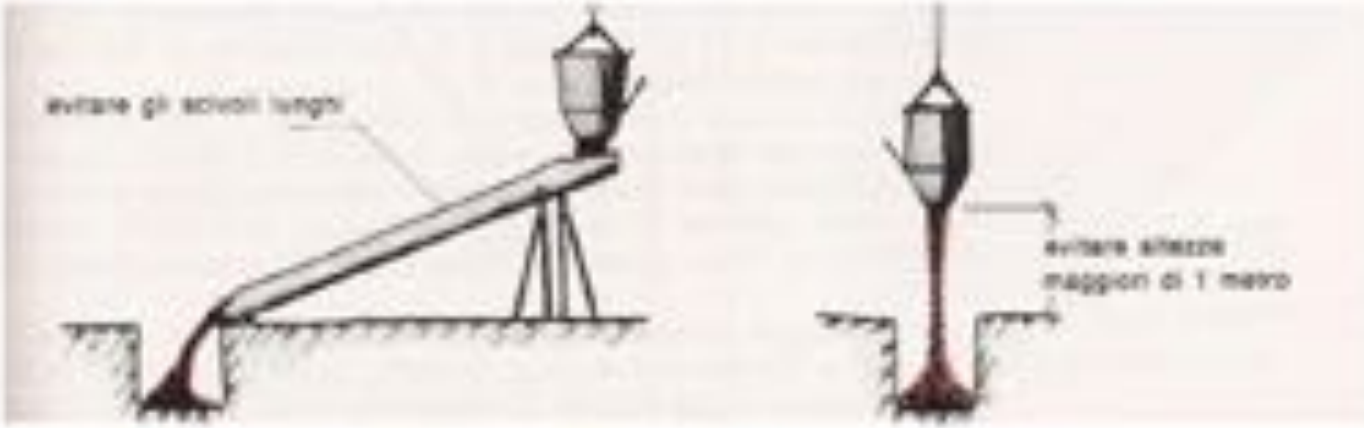
L'operazione richiede attenzione perchè in questa fase il calcestruzzo, può segregarsi, separando le parti grosse dalle fini.

Ciò deve essere evitato realizzando un getto uniforme e soprattutto riducendo al minimo l'altezza da cui il calcestruzzo viene gettato e la velocità di caduta.



Getto dell'impasto tramite pompa per cls


Costipamento dell'impasto nella cassaforma tramite vibratura



Getto dell’impasto

Stagionatura del calcestruzzo

La stagionatura é la fase successiva alla posa in opera, nella quale avviene la maturazione dell'impasto attraverso:

- il progressivo indurimento;
- l'acquisizione delle resistenze meccaniche.

Si distinguono due fasi:

1. la presa, in cui il calcestruzzo passa dallo stato plastico a quello solido;
2. l'indurimento, in cui il materiale acquista tutte le sue capacità di resistenza e si ritiene ultimata in 28 giorni.

Tabella II – Tempi di presa

	Tipo del cemento	Inizio presa	Termine presa
A	normale e ad alta resistenza	dopo 45 minuti	entro 12 ore
B	alluminoso	dopo 30 minuti	entro 10 ore
C	per sbarramenti	dopo 45 minuti	entro 12 ore

Disarmo delle casseforme

Il disarmo è l'operazione di asporto delle casseforme entro le quali è stato eseguito il getto di calcestruzzo. Deve avvenire gradualmente per evitare azioni dinamiche e non deve avvenire prima che la resistenza del conglomerato abbia raggiunto il valore necessario, in relazione all'impiego specifico.

Caratteristiche fisiche

Il calcestruzzo è un materiale eterogeneo, le sue caratteristiche dipendono pertanto dalla composizione della miscela e dalla qualità dei componenti.

- PESO SPECIFICO e di VOLUME: Varia in relazione al grado di compattezza ed alla qualità del cemento impiegato. Le norme UNI 10012/67 stabiliscono: Kg 2400 per 1 m^3 di Cls ordinario; Kg 2220 per 1 m^3 di Cls magro; Kg 2500 per 1 m^3 di Cls armato.

Caratteristiche tecniche e tecnologiche

Le caratteristiche che si richiedono ad un buon calcestruzzo sono:
- lavorabilità;
- durabilità;
- resistenza alle sollecitazioni meccaniche;
- resistenza alle sollecitazioni fisiche.

L'acquisizione di queste caratteristiche avviene in modo progressivo; si assume come valore ufficiale della resistenza, quella raggiunta dal calcestruzzo dopo 28 giorni.

- LAVORABILITÀ. E' l'attitudine a lasciarsi conformare, è un requisito fondamentale per la qualità del prodotto finale, dipende da coesione e consistenza dell'impasto. E' tanto maggiore quanto più è elevato il rapporto acqua/cemento.

- DURABILITÀ. E' l'attitudine a conservare nel tempo le caratteristiche fisico-chimiche. Dipende da fattori intrinseci (dosaggio del cemento; inerti; rapporto acqua-cemento; vibratura del getto) ed estrinseci (temperatura in fase di getto; corrosione; carbonatazione) agenti da soli o congiuntamente.

Elementi tecnici

FONDAZIONI

Trasferiscono i carichi delle strutture verticali al terreno, possono essere:

- dirette, operano direttamente su strati superficiali del terreno;
- indirette, raggiungono gli strati profondi del terreno di posa quando quelli superficiali non forniscono sufficienti garanzie (portanza, stabilità).

PILASTRI

I pilastri possono essere classificati in relazione alle modalità di realizzazione, si avranno così: pilastri gettati in opera, pilastri prefabbricati.

TRAVI

Sono elementi strutturali orizzontali, di tipo lineare, a sezione variamente poligonale, per lo più rettangolare. Una classificazione può essere basata sulle modalità di realizzazione, si hanno quindi: travi completamente gettate in opera entro casseri in legno o metallo, travi semi-prefabbricate, travi prefabbricate che necessitano di collegamenti in opera.

SOLAI

Sono elementi strutturali orizzontali destinati a chiudere e suddividere gli spazi verticalmente.

Caratteristiche meccaniche

- **RESISTENZA A COMPRESSIONE**. Consente di accertare il carico di rottura a compressione necessario per classificare i vari tipi di calcestruzzo. Varia da 80/100 Kg/cmq fino a valori compresi tra 600/700 Kg/cmq.
- **RESISTENZA A TRAZIONE**. E' molto bassa (15/20 Kg/cmq), non viene considerata nei calcoli strutturali, infatti, tutte le resistenze a trazione vengono assolte dall'armatura in ferro.
- **RESISTENZA A FLESSIONE**. Nel calcestruzzo non armato varia tra 1/5 ed 1/10 della resistenza a compressione (15Kg/cmq - 100Kg/cmq).
- **RESISTENZA AL TAGLIO**. Può raggiungere valori pari a 35/50 Kg/cmq, il doppio della resistenza a trazione.

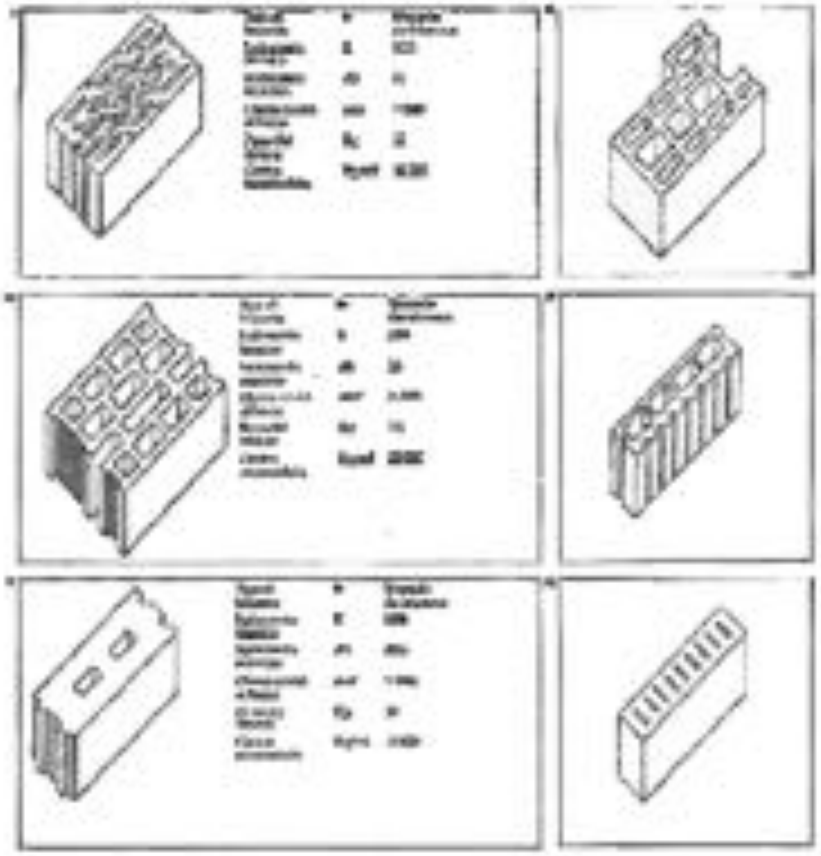
Elementi tecnici

BLOCCHI IN CALCESTRUZZO

Sono prodotti in calcestruzzo pieno, alleggerito o forato, talvolta sagomati per consentire la connessione anche a secco. Sono disponibili in: calcestruzzo normale, calcestruzzo cellulare.

La tecnica di produzione prevede:
- conformazione dell'impasto utilizzando leganti speciali o additivi;
- vibro-compressione e centrifugazione;
- finitura con pigmenti colorati e trattamenti per pareti faccia a vista.

Possono essere impiegati per realizzare:
- pavimentazioni auto-bloccanti;
- muri di sostegno.



Degradation and defects

CRACKS, DETACHMENTS AND DEFORMATIONS

Alveolization - cause: environmental conditions
Degradation that manifests itself with the formation of cavities of variable shape and size. The alveoli are often interconnected and have uneven distribution. In the particular case in which the phenomenon develops essentially in depth with a course of diverticules, the term 'alveolization with caring' can be used.

Air bubbles - cause: laying error
Alteration of the surface of the concrete characterized by the presence of holes of irregular size and distribution generated by the formation of air bubbles at the time of casting.

Surface cracks - cause: laying error Thin texture of cracks on the concrete surface.

Joint degradation - cause: installation error Decoupling, detachment, colour change of the joints

Detachment - cause: design error
Solution of continuity between the surface layers of the material, both between them and with respect to the substrate: it generally preludes the fall of the layers themselves. The term is used in particular for plasters and mosaics. In the case of natural stone materials, the detached parts often take on specific forms depending on the structural and textile characteristics, and therefore the items crust, flaking, exfoliation are preferred.

Exfoliation - cause: natural aging
Degradation that is manifested by the detachment, often followed by a fall, of one or more sub-parallel surface layers.

Display of reinforcement rods - causes: design error, installation error, accidental cause
Detachment of concrete parts with consequent stripping and corrosion of the reinforcement rods.

Fracturing or cracking - causes: design error, installation error, accidental cause
Degradation that manifests itself with the formation of solutions of continuity in the material and that can imply the reciprocal displacement of the parts.

Gravel nests - cause: laying error
Degradation of the surface due to segregation of the concrete components during the casting phase, characterized by irregular cavities, disintegrated surface and larger diameter aggregates in evidence.

Pitting - cause: environmental conditions
Point degradation that manifests itself through the formation of numerous, close, blind holes. The holes tend to be cylindrical in shape with a maximum diameter of a few millimetres.

Swelling - causes: design error, environmental conditions
Surface and localized lifting of the material, which takes on variable shape and consistency.

MACCHIE DEPOSITI E PATINE

Colour change - cause: environmental conditions
Alteration that manifests itself through the variation of one or more parameters that define the color: hue, clarity, saturation. It can manifest itself with different morphologies depending on the conditions and can refer to wide or localized areas.

Surface deposit - causes: natural ageing, environmental conditions
Accumulation of foreign materials of various kinds, such as, for example, dust, soil, guano, etc. It has a variable thickness and, generally, a lack of consistency and adherence to the underlying material.

Scaling - cause: environmental conditions
Layer-shaped deposit, compact and generally adherent to the substrate, composed of inorganic substances or structures of a biological nature.

Rust stain - causes: design error, installation error, accidental event, natural aging
Reddish-brown stains from corrosion of reinforcement rods.

Biological patina - cause: environmental conditions
Thin, soft and homogeneous layer, adherent to the surface and of evident biological nature, of variable colour, mostly green. The biological coating consists mainly of microorganisms to which dust, soil, etc. may adhere.

Presence of vegetation - cause: environmental conditions
Locution used when there are lichens, mosses and plants.

MALTE Definizioni

L'impasto di un legante con acqua o di un legante con acqua e un inerte, prende il nome di malta. Con il generico termine di **legante** o agglomerante si comprendono:

- Il Gesso
- Le Calci
- I Cementi

Le malte vengono denominate in base al legante utilizzato il quale trasferisce alle malte le proprie caratteristiche di presa, si distinguono quindi:

- **malte che fanno presa in presenza d'aria** (malte aeree);
- **malte che fanno presa in presenza d'acqua** (malte idrauliche).

Nell'industria delle costruzioni la malta viene adoperata nella esecuzione di murature, nella preparazione degli intonaci, nella posa di pavimenti o rivestimenti.

Composizione delle malte

Oltre al legante le malte sono costituite da acqua e da inerti.

Acqua: L'acqua deve rispondere ad alcuni requisiti:
- deve essere pura e pulita;
- non deve contenere Limo, Humus o Argilla.

Inerti: Gli inerti (sabbia) da usare nel confezionamento delle malte devono presentarsi privi di impurità organiche ed inorganiche. Le sabbie si distinguono in base a:
- componente litoide predominante nella loro composizione;
- granulometria, variabile da 0.05 a 2 mm;
- provenienza (fiume, cava, lago, mare).

Classificazione delle malte

MALTE AEREE

Sono malte aeree quelle che avviano il processo di presa del legante che le compone esclusivamente in presenza d'aria. Esse sono:

- la malta di calce spenta, malta il cui legante è costituito dalla calce spenta o calce aerea;
- la malta di gesso, caratterizzata da una rapida presa che può essere rallentata dall'uso nell'impasto di calce aerea.

MALTE IDRAULICHE

Si definiscono malte idrauliche, le malte che avviano il processo di presa del legante che le compone, anche in presenza d'acqua. Esse sono:

- le malte di calce aerea e pozzolana, queste acquistano particolari doti di idraulicità con l'aggiunta nell'impasto di pozzolana.
- le malte di calce idraulica, il cui legante è la calce idraulica, derivata da calcari con un contenuto d'argilla che oscilla tra il 6 e il 22 %;
- le malte di cemento, il cui legante è il cemento, legante idraulico che si ottiene da una roccia calcarea che contiene argilla in quantità > 27%.

MALTE BASTARDE

Si definiscono malte bastarde quelle composte da una miscela di più leganti, tale da conferire alla malta finale caratteristiche che l'utilizzo di un solo tipo di legante potrebbe non garantire. Si hanno:

- malte di calce aerea e cemento, queste offrono una sufficiente impermeabilità ed una presa meno lenta della malta di sola calce, mantenendo comunque una buona lavorabilità. Risultano adatte per la realizzazione di intonaci esterni.
- malte di calce idraulica e cemento, queste presentano maggiore resistenza pertanto vengono impiegate per la realizzazione di murature particolarmente sollecitate, intonaci speciali e per i sottofondi delle pavimentazioni.

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