 

# Glossary of some terms used in cement, concrete and in the analysis of cementitious materials

**NOTES:**

1. **This Glossary of terms used in cement, concrete cement analysis is available for free download. We hope you find it useful - please do distribute it freely to any colleagues who may also benefit from it.**

2. **This Glossary will be added to over time - in the early stages there will be omissions, which should gradually be rectified. Please click on the button below if you want to suggest any new words.**

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4. **Just save this pdf file to your desktop, or other convenient place, and open it when you need to look something up.**

5. **Do check back to www.understanding-cement.com/glossary.html for updated versions!**

6. **How to use: the terms in the column on the left are arranged in alphabetical order. Either scroll down to find what you are looking for, or use the 'Search' option in Acrobat Reader for your search term.**

7. **Many terms have a link to other Glossary entries, or to our 'Understanding Cement' web site or other sites for further information.**

8. **If you cannot find what you are looking for, please click on the red button below to tell us! This will take you to a page on our web site where you can suggest a new word. (Needs an internet connection.) If we can, we'll include it in the next update.**

**Click button to suggest a new word !**

**AFm**

AFm ($Al_2O_3$-$Fe_2O_3$-mono) represents another group of calcium aluminate hydrates with the general formula:

$[Ca_2(Al, Fe)(OH_6)].X.nH_2O$

where X represents a singly charged anion or 'half' a doubly charged anion. X may be one of many anions; the most important in Portland cement hydration are hydroxyl, sulfate and carbonate.

'Monosulfate' – present in most mature Portland cement concretes – has the formula:

$C_3A.CaSO_4.12H_2O$

**AFt**

AFt ($Al_2O_3$-$Fe_2O_3$-tri) represents a group of calcium sulfoaluminate hydrates. AFt has the general formula:

$[Ca_3(Al,Fe)(OH)_6.12H_2O]_2.X_3.xH_2O$

where X represents a doubly charged anion or, sometimes, two singly charged anions. Ettringite is the most common and important member of the AFt group (X in this case denoting sulfate.) The formula for ettringite (ignoring any iron substitution for aluminium) can also be written as:

$[Ca_3Al(OH)_6.12H_2O]_2.(SO_4)_3.2H_2O$ or
$C_3A.3CaSO_4.32H_2O$

**Aggregate**

Sand and gravel mixed with cement and water to make concrete.

**Air setting**

Loss of flowability or formation of lumps of cement during storage. Can be due to cement hydration from water in gypsum added during grinding, or to syngenite formation.

**Alite**

Impure tricalcium silicate. The main hydraulic mineral in Portland cement, typically comprising 50%-70% of the cement.

For more information, see:
www.understanding-cement.com/clinker.html

**Alkali-carbonate reaction (dedolomitization)**

Some aggregates containing dolomite react with the alkaline cement pore fluid. The process is not fully understood but involves the replacement of dolomite by calcite and magnesium hydroxide crystals:

$CaMg(CO_3)_2 + 2OH^- \rightarrow CaCO_3 + Mg(OH)_2 + CO_3^{2+}$

The presence of clay in the aggregate appears to be of importance.

**Alkali-silica reaction**

A reaction between the cement pore fluid in concrete with certain types of silica, which may occur in concrete aggregate. Susceptible types of silica include strained or microcrystalline quartz, glass, cristobalite, tridymite, opal, flint, and chert. A gel is formed which exerts an expansive force within the concrete and which may lead to widespread cracking and failure of the concrete.

For more information, see:
www.understanding-cement.com/alkali-silica.html

**Alkali sulfate**

Alkali sulfate in the context of Portland cement clinkers means primarily sodium sulfate (mineral name thenardite) or potassium sulfate (mineral name arcanite) or calcium langbeinite. Exactly which minerals form depends on the amounts and proportions of potassium and sodium in the clinker, and also the ratio of available alkali to sulfate.

For more information, see:
www.understanding-cement.com/variability.html

**Alumina Ratio (AR or A/F)**

An important parameter in cement clinker composition.

Given by:

$Al_2O_3$ / $Fe_2O_3$

Where $Al_2O_3$ and $Fe_2O_3$ are the relevant oxide contents of the clinker.

For more information, see:
www.understanding-cement.com/parameters.html

**Aluminate**

Impure tricalcium aluminate. Very reactive on contact with water but only weakly hydraulic. Typically comprises 5%-10% of Ordinary Portland Cement. Plays an important role in the setting of cement.

For more information, see:
www.understanding-cement.com/clinker.html

**AR (or A/F)**

See Alumina Ratio

**Autoclaved aerated concrete (AAC)**

Lightweight concrete, usually in the form of blocks. AAC has a low density due to the inclusion of large numbers of air cells, typically 1mm – 5mm across.

Produced in an autoclave at high pressure and temperature. Materials used in AAC production are typically cement and lime as the binder, with sand or pulverized fuel ash (PFA) as the source of silica. The air cells are formed by the addition of aluminium powder, which generates hydrogen bubbles in the alkaline environment of the mix.

AAC does not contain the normal cement hydration products present in concrete cured at normal temperatures. The main constituent of AAC is 1.1nm tobermorite.

 

**Belite**

Impure dicalcium silicate. A hydraulic mineral in Portland cement, typically comprising 5%-30% of the cement. Also an important hydraulic mineral in natural hydraulic lime.

For more information, see: www.understanding-cement.com/clinker.html

**Bogue calculation**

Calculation to give the approximate proportions of the four main clinker minerals in Portland cement, requiring the clinker bulk analysis and the free lime content, **the free lime being subtracted from the total CaO before calculating the mineral proportions**.

Approximately given by:

$C_3S = 4.0710CaO - 7.602SiO2 - 6.7187Al_2O_3 - 1.429Fe_2O_3$

$C_2S = -3.0710CaO + 8.6024SiO2 + 5.0683Al_2O_3 + 1.0785Fe_2O_3$

$C_3A = 2.6504Al_2O_3 - 1.6920Fe_2O_3$

$C_4AF = 3.0432Fe_2O_3$

Can be applied to cements by subtracting $0.7SO_3$ from the CaO, as well as the correction for free lime. This assumes all the sulfate is present as calcium sulfate; this is unlikely to be strictly the case as some sulfate will be present as clinker alkali sulfate.

For more information, see: www.understanding-cement.com/bogue.html

**$C_2S$**

$C_2S$ represents dicalcium silicate in cement chemistry notation. Belite in cement clinker is $C_2S$ with impurities.

For more information, see: www.understanding-cement.com/clinker.html

 

**$C_3A$**

$C_3A$ represents tricalcium aluminate in cement chemistry notation. Aluminate phase in cement clinker is $C_3A$ with impurities.

For more information, see:
www.understanding-cement.com/clinker.html

**$C_3S$**

$C_3S$ represents tricalcium silicate in cement chemistry notation. Alite in cement clinker is $C_3S$ with impurities.

For more information, see:
www.understanding-cement.com/clinker.html

**$C_4AF$**

$C_4AF$ represents tetracalcium aluminoferrite in cement chemistry notation. Ferrite phase in cement clinker may approximate to this composition but the proportions of C, A and F may also vary considerably. Ferrite also contains impurities.

For more information, see:
www.understanding-cement.com/clinker.html

**Calcium Aluminate Cement (=CAC, High Alumina Cement, HAC)**

Typically made from limestone and bauxite, or other material with a high alumina content, heated to about 1500 °C, at which temperature it is completely molten. When cooled, the cooled liquid contains principally calcium aluminate (CA) with $C_{12}A_7$. Other calcium aluminates may be present. CACs typically show rapid strength growth and good resistance to sulfates and chemical attack generally. Often used in grouts, floor screeds and other cementitious applications blended with Portland cement and gypsum.

See also 'conversion.'

**Calcium hydroxide (Portlandite)**

See cement hydration products

**Calcium silicate bricks**

Dense bricks, blocks or pavers, usually produced by autoclaving sand and lime mixes. 1.1nm tobermorite is the principal constituent.

**Cement**

Hydraulic powder which reacts with water to form a solid mass. The most common type of cement in use is Portland Cement, of which there are a number of different types. See cement types.

**Cementitious**

Adjective – a material that is cementitious has the ability to bond other materials together.

**Cement Chemistry Notation**

An arcane but convenient notation where single letters represent oxides:

C=CaO, S=$SiO_2$, F=$Fe_2O_3$, A=$Al_2O_3$, N=$Na_2O$, K=$K_2O$
T=$TiO_2$, H=$H_2O$, M=MgO, P=$P_2O_5$, also:

$\bar{S}$ = $SO_3$ – spoken as 'Ess-bar'

$\bar{C}$ = $CO_2$ - spoken as 'See-bar'

The last two are becoming used rather less-commonly; it is easy to write a line above a letter when writing with a pen but more difficult with a word processor.

For example, $C_3S$ represents tricalcium silicate and $C_3A$ represents tricalcium aluminate.

For more information, see:
www.understanding-cement.com/notation.html

**Cement clinker**

Portland cement clinker is the unground (unmilled) nodular product from the kiln. Clinker is typically composed of nodules ranging in size from 30mm to dust.

For more information, see:
www.understanding-cement.com/clinker.html

**Cement hydration**

Process of reaction of cement with water. The most important cement hydration product is calcium silicate hydrate, often abbreviated to 'C-S-H'.

For more information, see:
www.understanding-cement.com/hydration.html

 

**Cement hydration products**

**In-situ hydration product:** hydration product which has formed within the volume formerly occupied by a cement grain - usually this is only visible by SEM for the larger grains. In-situ hydration product is usually relatively pure C-S-H. Also known as 'inner product.' See also 'Undesignated product.'

**Undesignated product**: hydration product forming the matrix containing all other hydration products in the concrete apart from in-situ hydration product. Strictly, the space originally occupied by water on mixing but in practice also includes the volumes formerly occupied by small cement grains, the outlines of which later are obscured. Also known as 'outer-product' and 'undifferentiated product.' See also 'In-situ hydration product'.

**Calcium hydroxide (Portlandite):** $Ca(OH)_2$ or CH, Probably forms mainly in regions in concrete initially occupied by water on mixing.

**Ettringite:** forms mainly in the early stages of cement hydration. After a few days, monosulfate, rather than ettringite, is normally the main sulfate-containing phase in hydrated cement. Formula is $C_3A.3CaSO_4.32H_2O$. Ettringite is commonly found in concrete subjected to sulfate attack. See also AFt phase.

**Monosulfate:** the main sulfate-containing phase in mature concrete. Formula is $C_3A.CaSO_4.12H_2O$. See also AFm phase.

For more information, see:
www.understanding-cement.com/hydration.html

**Cement mill**

In principle, a large rotating cylinder containing steel balls which smash the clinker particles to produce a fine powder. In practice the product of much engineering evolution to achieve maximum efficiency. Cement mills typically contain several chambers with different sized grinding media (steel balls) to grind the cement particles increasingly finely. Screens (meshes) within the mill control particle size. Oversized particles may be returned for further grinding.

For more information, see:
www.understanding-cement.com/milling.html

**Cement types**

There are many different types of cement. The most common is Portland Cement. Other types include:

calcium aluminate cement, or CAC; also known as high alumina cement, or HAC
calcium sulfoaluminate cement (CSA)
hydraulic lime
extended cements – mixtures of Portland Cement with other reactive material which take part in the hydration process, such as fly ash or ground slag; also known as blended cements or composite cements.

**CH**

CH represents calcium hydroxide in cement chemistry notation.

**Clinker**

See cement clinker.

 

**Clinker milling or clinker grinding**

Process of reducing the clinker particle size. Clinker is ground finely, usually interground with gypsum, to produce cement. Particle size of the ground clinker in cement is typically 100μm down to sub-micron. There are various ways of controlling the cement particle size, most commonly by cement surface area (eg: $350m^2\ kg^{-1}$) but particle size distribution or sieve residue are also sometimes used.

For more information, see:
www.understanding-cement.com/milling.html

**Clinker mineral proportions**

Proportions of the four main minerals in Portland cement clinker (alite - $C_3S$; belite – $C_2S$; aluminate - $C_3A$ and ferrite - $C_4AF$ are commonly calculated using the Bogue calculation. This calculation uses assumed pure mineral compositions and requires the bulk analysis of the clinker for CaO, $SiO_2$, $Al_2O_3$ and $Fe_2O_3$, and the unreacted lime in the cement ('free lime').

For more information, see:
www.understanding-cement.com/bogue.html

**Concrete**

A synthetic rock containing sand and gravel aggregate, bonded in a cementitious matrix.

**Conversion**

Applied to concrete made from calcium aluminate cements, this is the process of conversion of one form of calcium aluminate hydrate to another. The principal component of CAC - calcium aluminate or CA - hydrates to form calcium aluminate hydrate ($CAH_{10}$). This is very strong, but also unstable at normal temperatures. It slowly, over a period of months or years depending on the concrete mix and ambient conditions, converts to $C_3AH_6$ plus aluminium hydroxide and water. Conversion results in some loss of strength of the concrete because the porosity of the cement paste increases. How significant this strength loss is, depends on the particular circumstances of the case.

See also calcium aluminate cement

| | |
|---|---|
| **C-S-H** | C-S-H represents calcium silicate hydrate in cement chemistry notation. The '-' indicate no exact stoichiometric proportions are intended. |
| **Delayed Ettringite Formation (DEF)** | A particular form of sulfate attack which may occur in concrete cured at high temperatures. Does not require additional sulfate – the sulfate originally in the cement is sufficient to produce DEF. See also DEF and TSA.<br><br>For more information, see:<br>www.understanding-cement.com/sulfate.html |
| **EDX** | Energy-dispersive X-ray microanalysis (sometimes also known as EDS: Energy-dispersive X-ray Spectroscopy and EDAX.)<br><br>For more information, see:<br>www.whd.co.uk |
| **Ettringite** | See cement hydration products |
| **False setting (false-setting, plaster set)** | False setting can occur as concrete or mortar is being mixed. It happens if there is an excess of soluble sulfate available in the cement pore fluid (mix water). This results in the formation of crystals of gypsum (calcium sulfate dihydrate) and these crystals cause the mix to stiffen. The gypsum crystals may re-dissolve, so it may be possible to mix through a false set and restore workability.<br><br>For more information, see:<br>www.understanding-cement.com/variability.html |
| **Ferrite** | Impure tetracalcium aluminoferrite. Typically comprises 5%-10% of Ordinary Portland Cement. Black or dark grey in colour, ferrite gives cement the characteristic grey colour.<br><br>For more information, see:<br>www.understanding-cement.com/clinker.html |

**Fine filler effect**

The physical effect of the incorporation of fine powder (of cement fineness or finer) in concrete mixes can have a beneficial effect on the concrete. These small particles act as additional nucleation sites on which cement hydrates can form, resulting on more rapid cement hydration and a more uniform, denser, microstructure giving higher strengths.

The fine filler effect is a physical effect and separate from any chemical reactions in which the fine particles may participate.

Ground limestone is a typical example of a material that can act as a fine filler.

**Flash setting**

Flash setting occurs if insufficient sulfate is available in the pore fluid (mix water) to control the hydration of the aluminate ($C_3A$) phase in the cement. The aluminate phase is the most reactive phase in cement and reacts quickly with water to produce calcium aluminate hydrates. These crystals bond particles together in the mix and reduce workability. In the extreme case, they can form an interlocking mass which produces a solid mix. Unlike false setting, flash setting cannot be mixed through, as the calcium aluminate hydrates do not re-dissolve.

For more information, see:
www.understanding-cement.com/variability.html

**Free lime**

Unreacted lime (calcium oxide, CaO) in Portland cement clinker; usually less than about 2%.

**Grindability**

A descriptive term, usually applied to clinker but also to raw materials and coal, indicating the ease with which the material can be ground to the required fineness.

Grindability can be quantified by procedures based on grinding a quantity of material for a fixed time and assessing the degree of comminution of the material. The Hardgrove Test is a widely-used test.

Factors which may adversely affect clinker grindability include: low nodule porosity; increasing proportion of flux phases, especially ferrite and the presence of numerous, large, belite clusters. Improving the homogeneity of the raw feed is likely to improve clinker grindability.

**Hydraulic**

The ability to react with water to form a solid.

A 'latently hydraulic' material is one that reacts with water to form a solid if a small amount of activator is added. Typical activators are cement or lime, or other alkaline material such as sodium hydroxide.

Ground granulated blastfurnace slag (=GGBFS, GBFS) is a latently hydraulic material. When mixed with Portland cement, GBFS is activated by the alkaline environment provided by the cement.

**Hydrogarnet**

Hydrated mineral of variable composition: often referred to as $C_3AH_6$ but this is only one end member of a solid solution series bounded by $C_3AH_6$, $C_3FH_6$, $C_3AS_3$, $C_3FS_3$. Occurs in concrete in sites formerly occupied by ferrite phase. Also a significant phase in autoclaved concrete products especially when made using pulverised fuel ash (PFA).

**In-situ hydration product**

See cement hydration products

**Kiln**

See rotary kiln.

 

**Lime Saturation Factor (LSF)**

An important parameter in cement clinker composition. Given by:

$CaO / (2.8SiO_2 + 1.2 Al_2O_3 + 0.65Fe_2O_3)$

Where CaO, $SiO_2$, $Al_2O_3$ and $Fe_2O_3$ are the relevant oxide contents of the clinker.

For more information, see:
www.understanding-cement.com/parameters.html

**LSF**

See Lime Saturation Factor

**Metakaolin**

Metakaolin is produced by heating kaolinite (china clay). This results in a highly reactive pozzolan.

Inclusion of metakaolin in a concrete mix can result in a beneficial effect on concrete properties, including strength and durability.

**Microsilica**

By-product of silicon production. As used in concrete, it has a small particle size (typically about 0.1µm across) and a high surface area. It is a very reactive pozzolan, usually applied in concrete as a slurry.

Inclusion of microsilica in a concrete mix can result in a beneficial effect on concrete properties, including strength and durability.

**Monosulfate phase**

See cement hydration products

**Optical microscopy of cement and clinker**

Examining cement or cement clinker using optical microscopy is a powerful technique in troubleshooting cement production problems. Is also used on many plants (=cement works) as a kiln control technique.

For more information, see:
www.whd.co.uk

 

**Periclase**

Magnesium oxide, MgO. Periclase crystals form in Portland cement clinker if the clinker MgO content is greater than about 2%. Below 2% the MgO can be accommodated within the crystal structures of the clinker minerals. Excessive amounts of periclase can lead to expansion of hardened concrete, as the periclase hydrates to form magnesium hydroxide. For this reason, the MgO content of cement is limited by national standards.

**PFA (Pulverised Fuel Ash)**

PFA is the fused non-combustible mineral component in pulverized coal, separated from the flue gas. In the flame, the mineral assemblages fuse to form a molten blob, which is spherical in shape due to the surface tension of the liquid. The molten material usually solidifies before impacting any hard surface, so PFA is largely composed of small glassy spheres, typically 100µm to sub-micron in diameter.

Partial replacement of cement by PFA can result in a beneficial effect on concrete properties, including strength and durability.

**Portland cement**

There are various types of Portland cement. The most common is the typical 'grey cement.' Usually made by heating limestone and clay at about 1450 °C and grinding the resulting clinker with a little gypsum to control the setting process.

For more information, see:
www.understanding-cement.com/basic.html

**Pozzolanic**

Pozzolanic materials are predominantly siliceous and do not react with water alone, but react with lime and water to produce calcium silicate hydrate. When mixed with Portland cement, they can contribute significantly to calcium silicate hydrate formation and therefore to strength development.

Pozzolanic materials mixed with lime also form calcium silicate hydrate and such mixtures are an effective hydraulic cement. Hydraulic lime was produced in this way by the Romans and is still produced today.

Pozzolanic materials include: pulverized fuel ash (PFA); metakaolin; ground fired clay and silica fume (microsilica).

**Pre-calciner**

Dry process type of kiln with an additional burner at the base of the preheater tower. Most new kilns are of the pre-calciner type as it is the most energy-efficient of the different types of cement kiln.

For more information, see:
www.understanding-cement.com/kiln.html

**Raw meal**

Raw (unburned) material as it is fed to the kiln, comprising ground raw materials mixed in the correct proportions.

For more information, see:
www.understanding-cement.com/raw-materials.html

**Reactions in the cement kiln**

Typically those of: calcination (loss of carbon dioxide from limestone); formation of intermediate products (part of the process of combining the raw materials but intermediate products are not present in the final clinker); and clinkering (formation of nodules from raw meal as liquid forms, combination of belite and free lime to form alite).

For more information, see:
www.understanding-cement.com/reactions.html

**Rotary kiln**

Almost all Portland cement clinker is produced in a rotary kiln. In essence, the rotary kiln is a long cylinder with a flame at one end. The kiln is inclined at a small angle, with the flame (burner) end being slightly lower. Kiln feed is introduced at the cool end and, due to the rotating motion of the kiln, gradually passes down the kiln towards the burner. Cement clinker is formed in the burning zone, near the flame, and finally the clinker passes out of the kiln and cools.

For more information, see:
www.understanding-cement.com/kiln.html

**SEM**

Scanning Electron Microscope; also Scanning Electron Microscopy.

For more information, see:
www.whd.co.uk

**Silica fume**

See microsilica.

**Silica Ratio (SR)**

An important parameter in cement clinker composition. Given by:

$SiO_2 / (Al_2O_3 + Fe_2O_3)$

Where $SiO_2$, $Al_2O_3$ and $Fe_2O_3$ are the relevant oxide contents of the clinker.

For more information, see:
www.understanding-cement.com/parameters.html

 

**Slag**

Slag used as a partial cement replacement material in concrete is blastfurnace slag, a by-product of iron production. In the iron-smelting process, limestone is added to the iron ore to react with impurities – mainly these are rich in alumina and silica. The slag is a liquid at about 1500 °C and is typically tapped off and rapidly cooled with water to form a solid with a high glass content (typically 90%-95%). When ground to cement fineness, the slag is latently hydraulic. Also referred to as Ground Granulated Blast Furnace Slag – GGBFS.

Partial replacement of cement by slag can result in a beneficial effect on concrete properties, including strength and durability.

**Slump**

An empirical test of concrete workability. Concrete is placed in a conical container, which is then lifted off the concrete. The degree to which the cone of wet concrete subsides under its own weight is termed 'slump.'

Set or hardened concrete will have a zero slump. The higher the slump, the 'runnier' or sloppier' the concrete.

**SR**

See Silica Ratio

**Stratlingite**

An AFm phase with an aluminosilicate anion, composition $C_2ASH_8$.

**Strength**

Concrete strength depends on a number of factors, including:

porosity (which in turn depends on compaction, water-cement ratio, air entrainment and any other factors relating to voids)

aggregate grading (particle size distribution of the aggregate)

age

aggregate-paste bond

aggregate strength

admixture-related factors

cement content

curing temperature

cement type (including replacement materials, eg: PFA, slag)

other cement-related factors (especially at early ages, these include cement fineness, alite content, soluble alkali content, alite reactivity)

**Sulfate (sulphate) attack**

Concrete made from Portland cement is susceptible to attack by solutions that contain sulfate. There are different forms of sulfate attack. A typical form might be where, for example, sulfate-containing groundwater reacts with concrete foundations. Concrete suffering from sulfate attack typically contains much ettringite and, possibly, gypsum, although the symptoms of sulfate attack vary widely.

For more information, see: www.understanding-cement.com/sulfate.html

**Sulfate-resisting Portland Cement (SRPC)**

Portland cement made with a low aluminate ($C_3A$) content. Hydration products of the aluminate phase make concrete more susceptible to sulfate attack.

**Suspension preheater**

Dry process type of kiln in which raw feed is fed from the top of a tower – the preheater tower – downwards through a series of cyclones and then into the kiln at the bottom of the tower. Heat is transferred from the hot kiln gases which pass upwards through the cyclones, to the raw meal as it passes downwards.

For more information, see:
www.understanding-cement.com/kiln.html

**Syngenite**

Portland cement hydration product composed of alkalis and sulfates. Typically found in air-set cement, such as in old bags of cement, where syngenite has formed at the points of contact of the cement grains. This results in a loss of flowability of the powder, or the formation of 'lumps' of cement in more severe cases.

Syngenite has the formula:

$K_2Ca(SO_4)_2.H_2O$

Syngenite may also form during normal cement hydration in a concrete or mortar mix. See also air setting.

**Thaumasite (TSA)**

Thaumasite formation is a particular type of sulfate attack ('TSA' - thaumasite form of sulfate attack) in which thaumasite -($Ca_3Si(OH)_6(SO_4)(CO_3).12H_2O$) - forms through a combination of sulfate attack and carbonation. TSA can attack the surface regions of concrete foundations but more commonly is found in masonry and render. Usually thought to require cold conditions to form.

For more information, see:
www.understanding-cement.com/sulfate.html

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**Tobermorite**

Tobermorite (strictly, 1.1nm tobermorite) is the main constituent of autoclaved aerated concrete and of calcium silicate bricks. It is a calcium silicate hydrate. When produced from a mixture of lime and silica sand, it has the idealized composition $C_5S_6H_5$.

When produced from mixes including cement and, especially, pulverized fuel ash or slag, tobermorite also contains aluminium. These tobermorites tend to be 'anomalous tobermorites.'

**Undesignated product**

See cement hydration products

**Water cement ratio**

Water/cement ratio (w/c) is defined as the weight of water in a mix divided by the weight of cement. Eg: a mix containing 400 Kg cement and 180 kg water per cubic metre of concrete has a water/cement ratio of 180/400 = 0.45.

For more information, see:
www.understanding-cement.com/hydration.html

**Wet process kiln**

The original type of rotary cement kiln, in which the raw meal is fed as slurry into the kiln. This is the simplest type of rotary kiln, but it is not energy-efficient. The water has to be driven off and the process of heat transfer from the hot kiln gases to the raw meal is inefficient. Because the process is so thermally inefficient, wet process kilns have to be longer than dry process kilns.

For more information, see:
www.understanding-cement.com/kiln.html

**White Portland cement**

Portland cement which does not contain ferrite phase. Normal cement is grey due to the presence of ferrite. White cement is made using raw materials of very low iron content so that ferrite does not form. Used in specialized architectural applications.

**Workability**

A general descriptive term describing the rheology of fresh concrete – how easily it can be mixed, placed, compacted etc.. In layman's terms, the 'runnier' or 'sloppier' the concrete, the better the workability.

Adding water to improve concrete workability generally results in a more porous concrete of lower strength and more susceptible to damage by, for example, frost or chemical attack.

**X-ray diffraction (XRD)**

A powerful analytical technique used for a wide variety of materials. Used to analyse both hydrated and unhydrated cementitious materials. Usually used to analyse powders. Gives a structural analysis based on crystal lattice spacings. Only works with crystalline material, hence cannot detect, for example, calcium silicate hydrate in normal concrete, except as a broad 'amorphous hump.'

Can be used to identify defects in concrete such as sulfate attack by determining the presence of salts such as ettringite or thaumasite.

Can be used with cement or clinker to identify mineral phases; can be used quantitatively by a skilled operator.

Routinely used to analyse clinker free lime contents during cement manufacture.

**X-ray Fluorescence (XRF)**

Analytical technique for determining the bulk elemental analysis of a material.

An incident beam of X-rays excites characteristic elemental X-rays within the specimen; these are then used to quantify the proportions of each element.

This is a compositional technique, not structural, therefore the crystallinity of the sample does not matter (unlike X-ray diffraction).

Widely used to analyse cement raw materials, clinker and cement.