THE WHITE GUIDE

PREFACE

The White Guide is a reference book where information about white cement, concrete and mortar can be obtained. The guide provides information on application, handling and definitions within the 3 subjects.
The book is addressed to people looking for an easy way to access basic knowledge about white cement and its applications. The book is divided up into the main sections cement, mortar and concrete, with corresponding subsections.

Aalborg Portland White A/S, 1st edition, 2006

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CEMENT

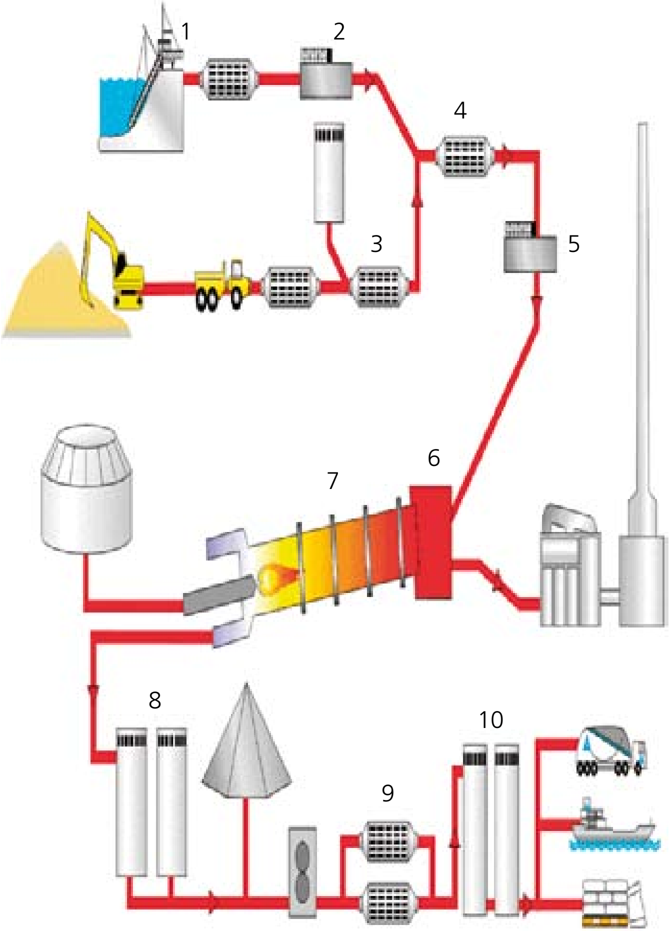
WHAT IS WHITE CEMENT Cement is a powdery material which hardens when mixed with water. It serves as binder for natural and artificially processed aggregates, such as sand and gravel, for production of mortar, plaster and concrete. White cement has essentially the same properties as grey cement, except for colour. The whiteness of the cement depends on the raw materials and the manufacturing process. It is the metal oxides primarily iron and manganese that influence the whiteness and undertone of cement.

AALBORG PORTLAND WHITE Aalborg Portland White A/S is the world's largest manufacturer and exporter of white cement with production facilities in Denmark, Egypt, Malaysia, China and USA. The production facilities in Denmark, have an annual capacity of 860.000 tons white cement, most of which is exported to some 70 countries. Aalborg Portland White A/S is a part of Aalborg Portland Group.

Flexibility, service and reliable supply are some of the key words that characterise Aalborg Portland White A/S. We believe that these properties have contributed to the ever-increasing number of customers. Thanks to our loyal customers, Aalborg Portland White A/S have for the last two decades maintained the position as the largest exporter of white cement in the world.

RAW MATERIALS

THE MAIN RAW MATERIALS FOR THE MANUFACTURE OF CEMENT ARE LIMESTONE, SAND AND GYPSUM.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CEMENT PRODUCTION

1. Limestone is extracted from the quarry
2. Water is added to the crushed limestone to form a slurry
3. Sand and Kaolin/Alu-silicates are crushed.
4. The limestone is then blended with the other raw materials (clay/shale/sand) and crushed
5. Water is added to the crushed raw materials to form a slurry and then stored in basins
6. The slurry is pumped to the upper end of the kiln
7. In the kiln all water evaporates and clinker is formed at a temperature close to 1500˚C
8. The clinkers are cooled rapidly and then stored
9. The clinkers are ground in the cement mills where a small amount of gypsum is added to improve the properties of the end product
10. At the end of this stage, the clinker has become cement which is then stored in silos and roaded into road tankers or packed into bags for dispatch.

AALBORG WHITE® Very pure limestone, which is abundant in the Aalborg area, is combined with advanced technology and a dedicated and skilled workforce, possessing experience gathered over several decades. These are the reasons why AALBORG WHITE® cement from Aalborg Portland White A/S deserves its world-wide reputation as white cement of an unsurpassed quality.

As the only white cement in the world AALBORG WHITE® cement combines the properties of high reflection, high strengths, low alkali content and high sulphate resistance in one product. Furthermore, AALBORG WHITE® cement is known for its consistent product quality.


AALBORG
WHITE®
White Portland Cement
AALBORG
WHITE®
White Portland Cement
1500 kg

Properties

AALBORG WHITE® Made in Denmark	
Type	CEM I 52.5 R
Strength class	52.5 R
C_3A	5%
Alkali content	0.2 - 0.3%
Expansion (mm)	0 - 2
L.O.I	0 - 1.0%
SO_3	1.8 - 2.3%
Chloride	0 - 0.02%
Y-reflection	85.0 - 89.5%

Jan 2006

Density and setting	
Specific density (kg/m^3)	3120 - 3180
Bulk density (kg/m^3)	1100
Initial set (min)	85 - 130

Jan 2006

Cement strength			
1 day MPa	2 day MPa	7 day MPa	28 day MPa
18 - 24	34 - 42	55 - 67	70 - 79

Jan 2006

Certification

AALBORG WHITE® operates a quality management system which complies with the requirements of EN ISO 9001:2000, registered by Dancert, DK.
AALBORG WHITE® cement is product certified according to the European Norm EN 197-1:2001/EN197-2:2001, by the certification body Dancert Certification No. 1073-CPD-06209.

AALBORG WHITE® cement complies with the requirements of the American ASTM C 150-02 for type I, II, III and V cement as well as for low alkali cement. Type V cement must contain less than 5% tricalciumaluminate (C_3A).

AALBORG WHITE®´s environmental management system is certified according to EN/ISO 14001:2004.

Safety sheet

Caution should be taken when working with cement, since contact with cement mixed with water or body fluids (e.g. sweat or eye fluid), or with concrete or mortar should be avoided as it may cause irritation, dermatitis or burns. If such contact occurs, the affected area should be washed without delay with plenty of clean water. In case of eye contact rinse immediately with clean water and seek medical advice.

Chrome neutral

AALBORG WHITE® is chromate neutral because only chromatefree raw materials are used for its production. Thereby, the limit of 2mg/kg soluble chromate in cement is met without limitations of time.


AALBORG WHITE
VOLVO

Logistics

Aalborg Portland White's department of logistics provides customer solutions and delivery on time.

AALBORG WHITE® cement is available in:

20 kg paper bags

25 kg paper bags

40 kg paper bags

42.8 kg paper bags

50 kg paper bags

Big bags of approx. 1500 kg with or without spout.

Bulk cement is delivered directly to the customer's storage silo by truck or ship. The trucks can deliver app. 25 tons per load whereas a ship can deliver between 1000 – 30.000 ton per load.

Storage conditions and durability

AALBORG WHITE® cement can be stored for at least six months, if kept indoor under suitable and dry conditions. Care should be taken to avoid moist in connection with the cement bags.

Do not store directly on the ground, on a floor or in direct contact with an outer wall. We recommend that cement bags are stacked on a counter floor 10-20 cm above the regular floor, or on pallets. The cavity below the counter floor should be ventilated to keep the bags dry.

Cement that has been stored for a long time, should be examined by e.g. trial castings prior to use. If the cement contains stony lumps it should not be used, as the strength cannot be guaranteed.


AALBORG
WHITE

CONCRETE

WHAT IS CONCRETE Concrete is a composite building material produced from combining aggregate, water and cement binder. After mixing, the cement reacts with the water, binding the aggregates together and eventually hardens into a stone-like material.

The mixture of water and cement, the so-called cement paste, acts as glue in the composite material. The strength of the glue increases for higher contents of cement relative to water. Therefore, the strength of a concrete is often characterised by the ratio of water to cement (w/c-ratio) in the cement paste.

AALBORG WHITE® is used as binder in white, light grey or coloured concrete

APPLICATIONS Concrete is a very versatile material and can be used in various appliccations:

- *In-situ*, or cast-in-place concrete. The formwork is mounted at the construction site, and the ready-mix concrete is delivered at the site. The elements are steel reinforced and are meant for high load bearing capacity.
- *Pre-cast elements*. Steel reinforced construction elements with high loadbearing capacity manufactured in factories and transported to the construction site for assembling. The production of the elements takes place under optimum conditions, and the uniformity and quality of these are assessed more efficiently.
- *Bricks, blocks and tiles*. Building materials manufactured in factories under optimum conditions with major application areas within paving and housing.
- *Terrazzo*. Concrete polished until the aggregates are visible. A colour contrast between aggregates and paste is generated. These are used for floors, tables, etc.
- *Garden constructions*. Concrete elements manufactured in factories meant for garden ornamental purposes; e.g. benches, fountains, etc.

CONCRETE TECHNOLOGY

Types of concrete

The concrete type selected must be suited for the casting and the transport conditions. If the formwork has very complex geometry and the concrete is to be heavily reinforced, SCC is the optimal solution, while for casting in unaccessible areas against uneven surfaces, shotcrete may be the best solution. Below is a short description of the different types of concrete:

Conventional concrete; concrete with a slump of 100-150 mm for traditional applications of concrete, including housing.

Concrete for concrete products; very dry and stiff concrete with very low workability (slump test: 0 mm). The concrete is forced into a mould by mechanical loading or intense vibration. This procedure allows for demoulding immediately after casting and therefore a more efficient use of moulds and high production rates.

High slump concrete – HSC; concrete with a slump of 200-250 mm, which can be cast used limited vibration. There flow of HSC is obtained by the addition of super plasticizers.

Self compacting concrete – SCC; similar to HSC but the content of super plasticizer is higher, and normally of a more advanced type. SCC is a vibration-free concrete with the ability to fill complex or heavily reinforced forms. A brochure on the subject can be downloaded or ordered online at www.aalborgwhite.com

Fiber reinforced concrete - FRC; Normally HSC or SCC with high contents of short fibres (e.g. steel, glass, polypropylene). These significantly increase the tensile strength of the concrete. FRC is used for constructions with high loadbearing capacity or for elements with slim cross-section.

Shotcrete; Concrete with workability high enough to be pumped, but still conserving cohesiveness in order to be able to build up into thick layers when sprayed at high pressure against a surface. Shotcrete is applied by means of compressed air at the spraying nozzle. Two processes exist: dry, where aggregates and powder is pumped and water is added at the nozzle prior to shooting, and wet, where a ready-mix concrete is pumped and shot from the nozzle. The wet method is becoming the preferred as the quality of the concrete is more consistent.

Colour

AALBORG WHITE® produces clean, bright colours, especially for light pastels. Many different colours can be created by adding pigments to concrete made with white portland cement.

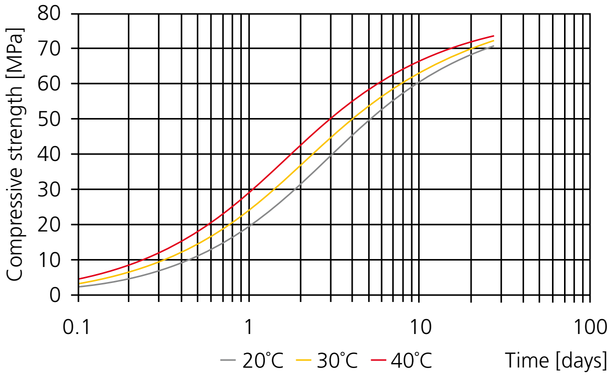
Two or more pigments can be combined to achieve a wide range of colours. White cement or a mixture of white and grey cement can be specified to provide a consistent colour of choice. An even greater variety of decorative looks can be achieved by using coloured aggregates and varying the surface finish treatment or texture.

Cement hydration

When water is added to a cement binder, chemical reactions will begin (i.e. hydration of cement). The strength of the concrete or mortar is proportional to the degree of reaction of the cement grains. The concrete is said to have "set" once the reaction products have formed a self-bearing matrix able to carry a predefined load. The rate at which hydration occurs increases with temperature and decreasing ratio of water to cement.

The presence of water is required for the reactions to take place. In order to ensure a closed, tight surface of concrete products, these should never become exposed to severe drying conditions within the first days of hydration. A high relative humidity at the surface of the products should be ensured, by either sealing or storing in water or in special conditioning chambers.

Considerable amount of heat is developed during hydration. If massive concrete structures are cast in cold weather conditions, an insulation strategy should be prepared to avoid large differences in temperature between the core of the concrete and the surface. A temperature difference higher than 15-20°C may lead to severe cracking (i.e. thermal cracking). Other possibilities are to cool/warm the concrete prior to casting or to reduce the temperature at the core of the elements by means of cooling pipes.



Strength development at different curing temperatures

Workability

Workability of concrete is a term used to express the ability of the fresh concrete to be handled and cast fulfilling the requirements predefined for a particular application. Normally, workability is related to the ability of the concrete to flow by its own weight and is quantified by a slump-test.

Depending on the application area, the ideal consistency of the concrete can vary significantly. A very stiff and dry concrete may be selected for casting bricks or blocks in the moulds with high vibration to compact the concrete. This procedure allows for demoulding immediately after casting and therefore gives a more efficient use of the moulds and higher production rates. For other applications a very flowable concrete, like a self compacting concrete, that can fill-in the moulds without the need of vibration may be preferable. It is of importance that the workability of the fresh concrete fulfils the requirements in order to carry out the casting operations successfully. As hydration occurs from the time of mixing with water, the workability will decrease with time. The maximum time from mixing to casting is dependent on the concrete recipe and the additives used.

Damage mechanisms

Alkali-silica reaction; Alkalis in concrete can react with reactive SiO_2 in some aggregates of poor quality. An expansive gel is formed which eventually may lead to cracking and spalling of the concrete surface. The concrete loses strength. AALBORG WHITE® has very low contents of alkalis and therefore prevents alkali silica reactions from taking place.

Thermocracking; If the concrete is subjected to large differences in temperature between the core and the surface, cracks may develop. Concrete expands upon heating while it contracts upon cooling. If the concrete is too young, i.e. has not yet developed the necessary tensile strength to withstand the deformation while such processes occur, cracks may form. To avoid this, a proper planning of casting and curing activities should be carried out, accounting for the weather conditions.

Shrinkage cracking; Concrete shrinks upon hydration. If too large sections of the concrete are cast without separating joints, the concrete will crack in a direction perpendicular to the length of the concrete structure. In time this can lead to corrosion of the reinforcement which is exposed through the cracks.

Chloride initiated corrosion; reinforced concrete structures in marine environment or subjected to de-icing salts are exposed to chloride. Chloride is slowly transported into the concrete and may eventually initiate corrosion. This is because chloride lowers the pH at the steelconcrete interface. Long lifetime is ensured by selecting a dense, high-quality concrete.

Sulfate or acid attack; concrete in contact with a sulphate rich environment can be damaged if a non-sulphate-resisting cement is selected. Sulphates react expansively with the cement paste leading to cracking, disintegration and/or spalling of the surface. If the concrete is in contact with strong acidic liquids, e.g. sewers, the concrete will progressively be etched away. A very dense concrete slows down this process remarkably.

Freeze-thaw; freeze/thaw action may lead to disintegration or spalling of the concrete surface. The damage is caused by the 9 % expansion when water forms ice. Collapse occurs if insufficient air void volume is available for taking up the stresses formed upon this expansion in porous concrete. Low w/c-ratio or air contents of app. 5-7% in concretes provides resistance against freeze/thaw action

Carbonation; Cement paste contains more than 25 % calcium hydroxide, giving a high pH in the paste that offers protection to the reinforcement against corrosion. Carbon dioxide is transported into the concrete throughout its service life, reacting with the calcium hydroxide to form calcium carbonate. During time the pH is lowered as the calcium hydroxide is progressively removed. The reinforcement may eventually corrode after many years. Long lifetime is ensured by selecting a dense, high-quality concrete.

CONCRETE PRODUCTION

Materials

Water

Use clean water e.g. tap water.

Aggregates

In white concrete, aggregates have a pronounced effect on the appearance of the finished concrete. The aggregates should therefore be selected, stored and used in an appropriate way so as to meet the aesthetic demands to the finished concrete surface.

The mix of the aggregates should be kept as constant as possible in order to avoid differences in shade of the finished concrete surface.

Additives

All additives should be white or light coloured to avoid discolouration of the white concrete.

The most typical additives in white concrete are:

Pigments: Pure brilliant colours are obtained when using AALBORG WHITE© combined with pigments. Pigments are inorganic compounds are alkali and weather-resistant and do not fade in sunlight. Pigments are produced in all colours, in accordance with the colour notation system NCS (Natural Colour System)

Silica fume: very fine reactive SiO_2 powder that can be obtained in different shades of colour from dark grey to white. Silica fume reacts with calcium hydroxide forming load bearing minerals similar to those formed by cement hydration. The concrete becomes denser, strength develops faster and the final strength is increased. The durability of the concrete structure is improved.

Metakaolin; finely ground calcined kaolin which generally is white. The effects on concrete properties are similar to those observed when adding of silica fume.

Admixtures

All admixtures should be colourless to avoid discoloration of the white or light concrete.

Dosage should follow the guidelines from the producer. To ensure the effectiveness of the dosage and the requested white colour it is recommended always to carry out trial mixes.

The most typical admixtures in white concrete are:

Sterates; zink or calcium sterate can be added to the concrete to enhance hydrophobicity of the concrete surface. The absorption of water is significantly reduced by using such admixture, and efflorescence has also been proved to be reduced by the addition of sterates.

Silanes and siloxanes; hydrophobic agents that can either be interrupted or applied externally. They have an effect similar to sterates, only with improved resistance to UV radiation.

Accelerators; The reaction of the cement with water can be accelerated by the addition of minerals such as calcium formiate or lithium carbonate. By doing so, strength develops faster and the period where the concrete is vulnerable to drying and freeze/thaw action is reduced. Acceleration of the concrete has also been seen to reduce efflorescence.

Retarders: Sodium gluconate, citric acid and tartaric acid are examples of additives which retard the reaction of cement with water. The purpose of using retarders could be to reduce heat development due to weather or other onsite conditions.

Air entraining agents; Air void provides improved freeze/thaw resistance and also improves the workability of the concrete. Air entraining agents are also used to reduce the risk of efflorescence.

Plasticizers; chemical additives which improve the workability of the concrete. The water content in the concrete can be reduced by 5 to 10 % by such admixture without loss of workability. This may be of interest because the lower w/c ratios results in a dense concrete. Plasticizers are normally used because increased workability is preferred due to a certain selection of transport and casting.

Superplasticizers; chemical additives with similar properties at that of plasticizers. However, these admixtures are much more effective and water contentcan be reduced as much as 20-30% without loss of workability. Superplasticizers are required for the production of SCC.

Viscosity Modifying Agents; these are applied for increasing the viscosity of highly fluid concretes, as e.g. SCC, to avoid segregation.

Processing

It is very important that the concrete composition is uniform, especially with regard to water/cement ratio, paste content and air content, since these variables influence both cast ability and the surface porosity as well as strength.

Increased surface porosity results in visible colour differences that become more pronounced when the surface is wet. High porosity also increases the accumulation of dirt and promotes the growth of algae, lichen, etc. Variations in wetting and dirtying of the surface owing to the design of the building will accentuate these differences.

Mixing of the concrete

Ensuring a consistent ratio between the different constituents in relation to each other is very important, and weighing of these should therefore be carried out consistently and accurately. This also applies to the order in which the constituents are added, and the mixing sequence should be the same each time.

The sequence of mixing is generally the following: first aggregates, then powder, and finally the water with different chemical additives.

Coloured concrete (incorporating pigment) should be mixed longer than usual to avoid streaking.

Consistent strength development of the concrete requires a minimum of 1½ minutes. At the construction site, a mixing time of 2 minutes or more is recommended.

The mixer and other equipment that comes into contact with the concrete during production should be clean, particularly with regard to oil and grease.

Testing

Fresh concrete properties.

The most important properties to test from a practical point of view are workability, air content and stability of the fresh concrete. The stability cannot directly be measured and is to be procured by the specifications to the ready-mix concrete supplier, through proper mix design. Testing procedures for fresh concrete can be found in e.g. EN-12350.

Workability is normally measured by means of a 300 mm high truncated cone with upper inner diameter of 100 mm and lower inner diameter of 200 mm. The cone is mounted on a levelled floor and filled up with concrete. The concrete is stamped 25 times with a 16 mm round steel bar for each 100 mm of concrete. The cone is then lifted and the slump of the concrete cone is measured, and used as an indicator of workability.

For very soft concretes, as SCC, the slump is too high to be measured by this method. Instead, the cone is turned upside down and filled with concrete. No stamping is applied due to the large flow of the concrete. The cone is then lifted and the spread of the concrete is measured as an indicator of workability.

The most popular method to measure air content in the fresh concrete is by means of the pressure method. It is based on the relation between the volume of air and the applied pressure given by Boyle's law. When commercial air meters for concrete are used, no calculations need to be carried out as graduations in percentage of air are provided.

Mechanical properties

The most common mechanical property determined on concrete is the compressive strength. Mechanical properties are normally tested both on samples with specific dimensions cast once the concrete is delivered from the ready-mix plant, and on cores drilled out from the concrete structure. The latter can also reveal if errors have occurred during the casting operations, as e.g. too soft vibration.

Depending on the project, more mechanical properties may become of interest, such as modulus of elasticity, creep and shrinkage.

Testing procedures for hardened concrete can be found in e.g. EN-12390.

Durability properties

The most common durability related properties measured on concrete are freeze/thaw resistance, alkali-silica reactivity and chemical attack (most commonly ingress of chloride and sulphates). Many and very different testing methods exist for measuring these properties. The selected test method should conform the local applicable normative.

During the life time of a concrete structure, following properties are monitored; crack development (normally by visual inspection) and corrosion of reinforcement (normally by use of electrodes capable of measuring the difference in electric potential between different regions of the reinforcement).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Transport to site

This is only an issue when concrete is delivered from ready-mix concrete plants. The maximum transportation time from the plant to the construction site should never be so long that the workability upon delivery is lower than specified. Transport takes place in concrete trucks with continuous slow mixing to avoid segregation.

Transport on site

When fresh concrete is transported on the construction site, segregation may occur. This is more likely for soft concretes, or concrete subjected to large free falls. Concrete should therefore be treated gently, avoiding excessive vibrations prior to casting. Furthermore, the concrete should be shielded from rain in order to maintain the desired workability and quality.

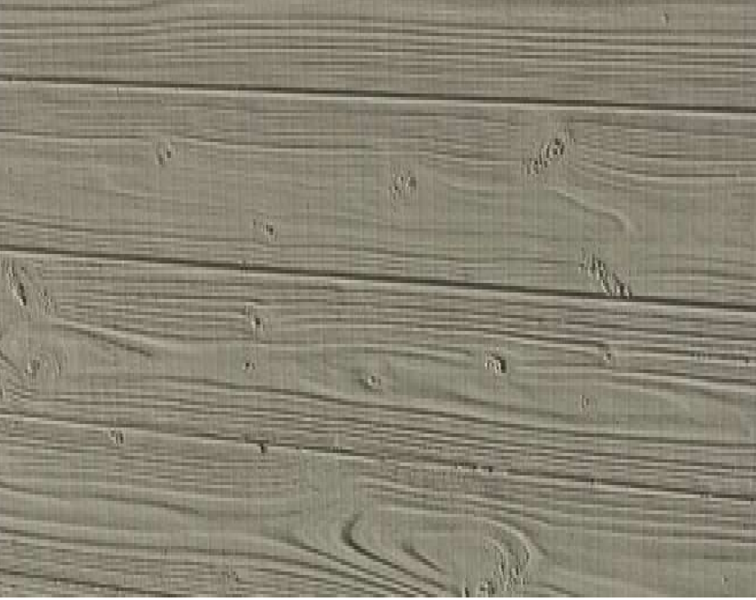
Pumping, long drops and other handling methods involving large pressure fluctuations affect the air content and flowability of the concrete, as well as creating a risk of segregation and producing air pockets inside the concrete. These methods should be used as gently as possible or avoided.

Formwork

Formworks for concrete can be manufactured of wood, steel or plastic. The formwork determines whether the finished surface in general is smooth, profiled or patterned, and for as cast surfaces yields the final surface texture. It is therefore essential to consider the choice of formwork material and release agent thoroughly. In particular the following issues should be taken into consideration:

Plastic formwork is fairly reasonable in price. It is resistant to wear and comfortable to work with. Oiling is not usually necessary, but the formwork surface must be moistened with water before casting. Formwork of fibreglassreinforced polyester is just as wear-resistant as steel formwork. Plastic formwork is also dense and presents a risk of air blisters in the concrete surface.

Steel formwork is ideal for the production of large, smooth surfaces. Although expensive, it is very durable and the risk of formwork defects is less than with wooden formwork. On the other hand, the risk of permanent deformation is greater and steel formwork should be checked by measuring frequently. Because of the density of steel formwork, it has a tendency to increase the number of air blisters in the concrete surface. Uniform smooth surface can be difficult to achieve.



Wooden formwork can be used to impact a rough or smooth surface to the finished concrete. Wooden formwork must be impregnated with lacquered to avoid colour changes. The boards used in wooden formwork must be glued together or sealed in another way to prevent dark lines or edges on concrete elements. The structure of raw wood can be enhanced by acid washing or sandblasting the wooden surface.

Reinforcement incl. spacers

Concrete has great compressive strength, but little tensile strength. To overcome this limitation, concrete is most often constructed with the addition of steel reinforcement bars (rebars), steel mesh, cables, or steel fibres to produce reinforced concrete. Concrete can also be pre- or post stressed, allowing for beams or slabs with a longer span than is practical with conventional reinforced concrete. A wrong handling of the reinforcement may damage the formwork or the construction.

The reinforcement bars and meshes are to be sufficiently interconnected to avoid misplacing during casting. The concrete cover, i.e. mini-mum distance from reinforcement to concrete surface, required by applicable norms, is ensured by spacers of either mortar or plastic specimens.

Concrete pouring height

To avoid segregation of the concrete due to high free falls, it is recommended to avoid pouring heights larger than 1 meter, but allowing for variations in consistency, size of aggregates and formwork geometry.

Vibration

Vibration is the most common way to compacting concrete. Most commonly poker vibrators (in-situ walls), plate/beam vibrator (concrete floors), and vibration tables (pre-cast elements) are used.

Poker vibrators should be used uniformly throughout the entire concrete mass, and only when the concrete is evenly distributed in the mould.

For pre-cast elements cast in vibrated moulds, the vibration must be uniform for the entire mould.

Finishing

Trowelling should be carried out at the appropriate time. Over-working the surface should be avoided, as it creates so-called "burn marks" on the surface – areas of varying porosity.

Alternatives to trowelling include brushing or impressing patterns in the fresh concrete surface. Concrete consistency, brush type and time from casting to final surface treatment all influence the final expression. The appropriate procedure for achieving the desired expression should be determined in advance by means of trial castings.

Curing

To obtain a good quality of the hardened concrete surface, the concrete should not be allowed to dry out during the first days after casting. A varying water to cement ratio influences both visible colour and surface porosity. A uniform loss of moisture during hardening is therefore essential in order to obtain uniform colour and porosity of concrete surfaces.

The first 24-48 maturity hours are the most important – after that the differences in colour and porosity from varying moisture loss become less pronounced.

There are several ways of controlling water loss from the surface:

- Curing compound sprayed on the surface
  (an emulsion that forms a thin impermeable coating)
- Plastic sheets, impervious paper or other coverings
  – be aware of the risk of condensation producing patterns on the surface.
- Keeping the formwork on

Clear curing compounds may be used without much risk of changing the appearance of the concrete surface if applied in normal dosages.

Spraying with water or damp coverings may increase the risk of lime efflorescence.

Curing temperature also influences the colour: lowering the temperature darkens the surface colour.

Demoulding

The time needed between casting and demoulding depends on temperature, humidity and wind conditions, and necessary strength of the concrete.

Casting under special conditions

Freeze/thaw action can result in severe damage of the concrete, especially during the first days of hydration, if no protective actions are taken. The concrete can be protected by pre-heating the concrete prior to casting. Normally it is sufficient to pre-heat the mixing water to about 70-80ºC or add a small dose of steam. Another method is to cover with insulating materials. Rapid-hardening cements can be used to increase the heat developed during hydration, and thereby, the temperature of the concrete.

Surface treatment of the concrete

Acid etching with thinned hydrochloric acid, acetic acid or phosphoric acid removes the outer layer of cement paste. Before treatment, the concrete must be thoroughly wetted with water. Normally, acid is applied with a broom or scrubbing brush working from bottom to top. The treatment time must be as short as possible followed immediately by thorough flushing with clean water.

Sandblasting is a widely used surface treatment of hardened concrete, e.g. in-situ concrete. The method removes the outer layer of cement paste so that the aggregate becomes visible. The surface is left rough but quite uniform. Sandblasting is normally preferred with quartz sand. The treatment is often carried out in two stages. Coarse grinded sand is used first, the day after casting, followed sometime later by fine-sand blasting to create an even and uniform finished surface.

Chiselling and polishing; The surface of in-situ concrete is occasionally treated by chiselling. About 2 cm is removed in this way and therefore the concrete has to be quite strong to withstand the treatment, i.e. after it has been allowed to harden for 8 to 14 days. Chiselling requires professional craftsmen.
Polishing or grinding the surface (usually in terrazzo) creates a strong and easy-to-clean surface.

Exposed aggregates by retarding agents delay the hardening of the concrete surface. After formwork stripping the surface layer can be removed by flushing or brushing. The retarder is applied to the formwork in an even layer and is allowed to dry before casting. The strength and thickness of the applied retarder determines exposure depth (although normally less than one third of the maximum aggregate size).

AESTHETIC DURABILITY White concrete is more sensitive to aesthetic durability than ordinary grey. One reason is that dirt particles and growths are more visible against a light background than on the darker surface of concrete produced from grey cement. To ensure a satisfactory result, it is more important to address the aesthetic dimension properly for white concrete than it is for grey, especially in areas with a predominantly moderate climate.

Design guidelines

There are three levels in the design of a structure:

- General shape and placement of the structure
- Detailing
- Surface texture

General shape; The overall shape and orientation of any structure influences how different parts are affected by the weather patterns in the particular location where it is situated, under the influence of nearby structures, vegetation, topographical features and the direction of the prevailing wind. This means that the concrete surfaces are subjected to unevenly distributed amounts of water, sun, airborne particles, etc., for the entire duration of the structure’s service life.

Detailing; There are two major objectives when designing details for a concrete structure. Obtaining the desired architectural expression, style and function and removing water or distributing it in a desirable way on the surfaces.
Viewing distance should be considered when choosing details, since very small details are a waste of resources if the observer will be too far away to distinguish them. Similarly, large details are impossible to see in their entirety if the observer will be very close to the structure.
Easy access to all surfaces should be possible to permit later cleaning of and repairs to the structure.

Surface texture The wide variety of different textures makes it possible to create almost any expression desired.

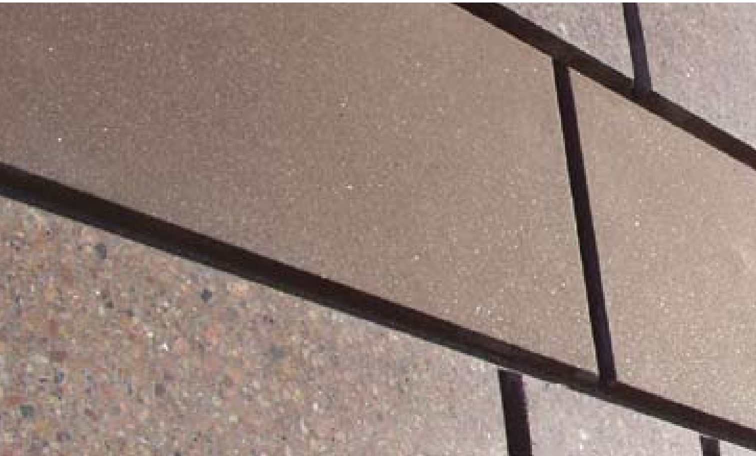
There are, however, three main concerns with regard to aesthetic durability when selecting a surface texture:

- Conceal or emphasize dirt deposits
- Extent of promoting the removal of dirt deposits.
- Functions of the surface.

A very smooth texture combined with a very dense concrete surface will very much promote the removal of dirt by rain or washing, but will also leave any dirt that is nevertheless deposited visible on the surface.

A very rough, uneven and porous surface will accumulate a lot of deposits and promote algae growth etc., but will also make it much harder to see dirt deposits.

The choice of surface texture should be based on the expected load, which is influenced by general shape and detailing, the colour and porosity of the concrete composition, and the desired maintenance intervals to ensure the desired aesthetic appearance.



Maintenance guidelines

Maintenance of structures aims to preserve a certain aesthetic expression. Most maintenance of structures is carried out for three different reasons:

- Cleaning
- Repairs
- Preventive maintenance

Cleaning A more or less evenly distributed layer of dirt normally covers aged concrete surfaces. Removing the dirt by cleaning part of the surface will create contrasts with the remaining surfaces. It should therefore be considered if cleaning is actually desirable in the given situation.

Most cleaning methods damage the surface to some extent by removing part of the skin layer of paste and/or changing the texture. Cleaning can be done using high-pressure water, chemicals, sandblasting, steam or flame. When cleaning with chemicals, it is advisable to use an absorbent paste together with the chemical agent, or to use the chemical in the form of a foamed paste. This prevents the dissolved dirt from being absorbed by the pores in the concrete surface, transporting the dirt further into the concrete surface instead of removing it.

Repairs The objectives of repairs are usually to either prevent further structural damage or improve the visual impression. Achieving both objectives requires the repair to be both physically and visually comparable to the original surface with regard to texture, colour and porosity. Therefore it is necessary to use a concrete or mortar composition as close to the original mix as possible, as well as form materials that match the existing texture as closely as possible. It is more important that the surface characteristics of the repaired patches match those of the surrounding surfaces as closely as possible, than to achieve an immediate colour match between the patch and the original surface in order to ensure good long-term visual compatibility. Surface porosity and roughness in particular should be similar to ensure a comparable uptake of moisture and dirt between the repair patch and the surrounding surfaces.

Ready-mixed repair mortars or other materials can be used for minor defects that will not be viewed from within 5 metres.

Preventive maintenance

The reason for preventive maintenance is to delay visual degradation and physical deterioration.

Hydrophobic agents can be used by way of impregnation to reduce the permeability of the surface. This will to some extent prevent water from being absorbed by the surface, and therefore reduce the amount of dirt being deposited. Most of these agents require repeated treatments at differing intervals.

A special area of preventive maintenance is anti-graffiti coatings. Anti-graffiti coatings can be either a clear coating or a visible finish, and vary from lacquer-like layers, through sacrificial coatings (typically wax), to drying-retardant coatings, which slow down the drying time of paint.

Before coatings are applied, it is advisable to carry out a trial application in an inconspicuous area to ensure that the coating does not change the appearance of the concrete in an unacceptable way, especially with regard to gloss and hue.

Efflorescence

Lime blooming – or efflorescence – or other surface discolorations may appear up to a year after completion. Lime efflorescence is formed when dissolved calcium hydroxide dissipates to the surface, where it combines with atmospheric carbon dioxide and precipitates as the low solubility product calcium carbonate. Lime efflorescence may be lessened by reducing the amount of alkali in the concrete materials, and by ensuring a dense, impermeable surface.

Lime efflorescence may be removed. Light precipitations may be removed by cleaning the surface with a stiff brush, more resilient precipitations by washing once or more with a weak acidic solution. Before the acid is applied, the surface should be wetted to avoid the acid being drawn into the pores of the concrete.

CONCRETE MIX DESIGN The selection of a concrete recipe for a certain operation must comply with the applicable local normative. In Europe, EN-206 and national attachments apply. The overall procedure is however similar in most countries; to determine the exposure environment, to seek the minimum requirements for a concrete in that environment, and plan a quality control testing routine.

Mix design based on AALBORG WHITE® [kg/m³]

Materials	Self compacting concrete*	Conventionel slump concrete	Terrazzo
AALBORG WHITE®	350-400	340-380	440-550
Filler/Sand (0-0.5 mm)			0-110
Sand 0 - 4	600-700	650-750	
Course aggregate 4 - 16	1100-1200	1000-1200	1550-1650
Water	140-160	136-152	163-204
Air entrainment agent	0.3-0.5% of cement	0-0.2% of cement	
Super plasticizer	2.5-3.5% of cement	0.5-1.0% of cement	0.5-1.0% of cement
Water/Cement	0.4	0.4	0.37
Air content	~6.5%	~5%	~0-3%
Strength class	50	50	50-60

*Special brochure on self compacting concrete can be order on-line at www.AalborgWhite.com

— Dosages depend on additive type

MORTAR

WHAT IS MORTAR Mortar is a mixture of cement, sand and water and has a wide range of applications. Additives are often used to give the mortar different properties and characteristics.

AALBORG WHITE® cement is often used as binder in various types of mortar and together with lime in a lime-cement mortar.

APPLICATIONS Mortar has a wide range of applications. When aesthetic appeal is a priority, AALBORG WHITE© becomes an obvious choice in the formulations. AALBORG WHITE© with its high reflective index, in addition to high strength and consistent chemical composition, makes it a preferred cement for mortar products such as renders, plaster, tile grouts, self-levelling underlays and patching & repair mortars.

MORTAR TECHNOLOGY

Adhesive strength

High adhesion to the substrate is essential, especially where the surface is smooth, relatively non-absorbent or difficult to coat. Most important to adhesion is the plaster fluidity (flow). The more fluid the plaster the more plaster will penetrate into the substrate and create bond. Adhesion can be increased for plasters with the same flow by adding fairly high amounts of redispersible polymer (normally 1-2% of dry-mix mortar) or by adding fine fillers.

Flexural strength

High flexural strength of plaster is important in order to avoid cracks. Flexural strength and compressive strength are more or less correlated, regardless of plaster formulation. Only the content of redispersible polymer has a significant effect. Compressive strength decreases for increasing air content and/or increasing sand-to-powder ratio.

Cracking resistance

High volume content of sand and good water retention properties are beneficial to avoid cracking following autogenous or selfdesiccation shrinkage.

Water retention

The ability of the render to avoid drying out before hardening is essential. Water evaporation from the surface of fresh render will lead to a weak surface and crack formation. Drying out of fresh render due to water uptake by the substrate will lead to poor adhesion. Good water retention is obtained by adding cellulose.

Water repellence

The ability of the render to repel surface water is of great importance. Firstly this effect will ensure that the substrate beneath is kept dry. Secondly water repellence is believed to have a positive effect on minimising the tendency of efflorescence. Water repellence is obtained by adding sterate (~0.5-2 wt. % to powder) or some special redispesible polymers (~1-2 wt. % to dry-mix mortar) with hydrophobic properties, another way is after-treatment of the surfase with a hydrophobic agent.

MORTAR PRODUCTION

Materials

Water

Use clean water e.g. tap water.

Aggregates

Aggregates have a great impact on the appearance i.e. colour and texture of the finished mortar. The aggregates should therefore be selected with care so as to meet the aesthetic demands to the finished mortar.

Additives

Additives give many of the required technical properties of mortars.

Pigments; Pure clear colours are obtained when AALBORG WHITE® is used as the raw material in colour mortars combined with pigment. The pigments are inorganic compounds that are alkali and weather-resistant and do not fade in sunlight. Pigment is produced in all colours, e.g. in accordance with the colour notation system NCS (Natural Colour System)

Sterates; zink sterate or calcium sterate can be added to the mortar to enhance hyprophobicity of the mortars surface. The absorption of water is significantly reduced by using such additives, which also reduces efflorescence.

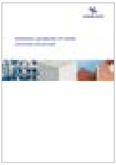
Accelerators; The reaction of the cement with water can be accelerated by the addition of materials such as chloride, calcium formiate or lithium carbonate. By doing so, strength is developed faster and reduces the time period where the mortar is vulnerable to drying and freeze/thaw action.

Retarders; Sodium gluconate, citric acid and tartaric acid are examples of additives which retard the reaction of the cement with water. The purpose of using these could result from a wish to increase the open time of the mortar..

Thickening and water retaining agents; Cellulose is a water soluble additive used as a thickener that builds up a certain viscosity. Cellulose can retain the water during the setting reaction keeping the mortar from drying out too fast and thereby giving a longer open time to apply the mortar.

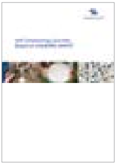
DOWNLOADS

For additional information and inspiration of our product AALBORG WHITE® and its applications, please visit our website at www.AalborgWhite.com under publications and download or order brochures of interest.



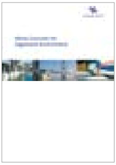
Aesthetic Durability of White Concrete Structures

Guidelines on how to obtain aesthetically durable white concrete structures. The report is based on a combination of literature, field observations and experimental investigations.



Self Compacting Concrete

Successful use of Self Compacting Concrete - or SCC - requires knowledge of this new concrete material - its strengths and weaknesses, possibilities and limitations.



White Concrete for Aggressive Environment

This report documents the durability and strength of white concrete based on AALBORG WHITE® cement. The documentation is based on a large experimental examination.

White Concrete for Aggressive Environment

- COWI Evaluation Report

AALBORG WHITE® Concrete Hardening

- COWI Technical Paper

Concrete Surfaces

– beautiful solutions with AALBORG WHITE®

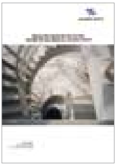
Historical development shows that since the end of the 19th century, the use of concrete has progressed because it is mainly an inexpensive and flexible material.

Research and Development Centre

Innovation and technical excellence are key words to AALBORG WHITE®. AALBORG WHITE® Research and Development Centre have build up excellent expertise within the manufacture, testing and use of white cement.

White Concrete Technology

White concrete is synonymous with light, clear colours and beautifully consistent surfaces. Constructions automatically look more elegant and slim when they are created using white concrete.



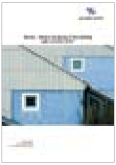
Beauty that Stands the Test of Time

An ancient technique with a modern appeal. It has been known for centuries. It still applies: Terrazzo is a terrific product and AALBORG WHITE® is a terrific cement for making terrazzo.

Light up the City

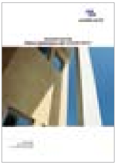
with Products Based on AALBORG WHITE®

- Take a Walk on the White Side. Concrete is practical in towns and cities, but we need colours around us. Play with the colours.



Mortars

Mortars are used in a wide range of applications, and when aesthetic appeal is a priority, AALBORG WHITE® is often included in the formulation.



Structural Concrete

Brilliant Sophistication with AALBORG WHITE®

- Sophisticated, brightly coloured concrete structures with concrete panels or in situ cast structures.

The Individual Touch

Seeing the possibilities – and exploiting them – is what it's all about! AALBORG WHITE® is white cement simply made for thinking creatively in concrete, mortar and paint.

Big Bags - the way to do it

Guide to handling Big Bags

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