



COLORED CONCRETE WORKS™

**An initiative for more color
in architecture**

LANXESS
Energizing Chemistry



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Reference projects
Left side:
Residential building, Paju, Korea
Alexa Shopping Center,
Berlin, Germany

Right side:
New Årsta Bridge,
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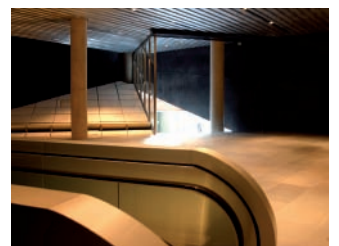
An initiative for more color in architecture

More publicity for colored concrete

Colored Concrete Works™ is an initiative by LANXESS to showcase the versatile, aesthetic and technical characteristics of concrete colored with Bayferrox® pigments. Colored Concrete Works™ has been conceived as a set of case studies, which document the use of colored concrete in international construction projects, for example.

Focus of attention: the reference projects

Although the outstanding practical characteristics of concrete are recognized everywhere, this universal construction material still frequently suffers from a negative image. Therefore, a focus of the initiative is case studies outlining in particular reference projects where building owners and architects tell about their experiences working with colored concrete.



Colored concrete provides a clear distinction and stronger presence.



COLORED CONCRETE WORKS™

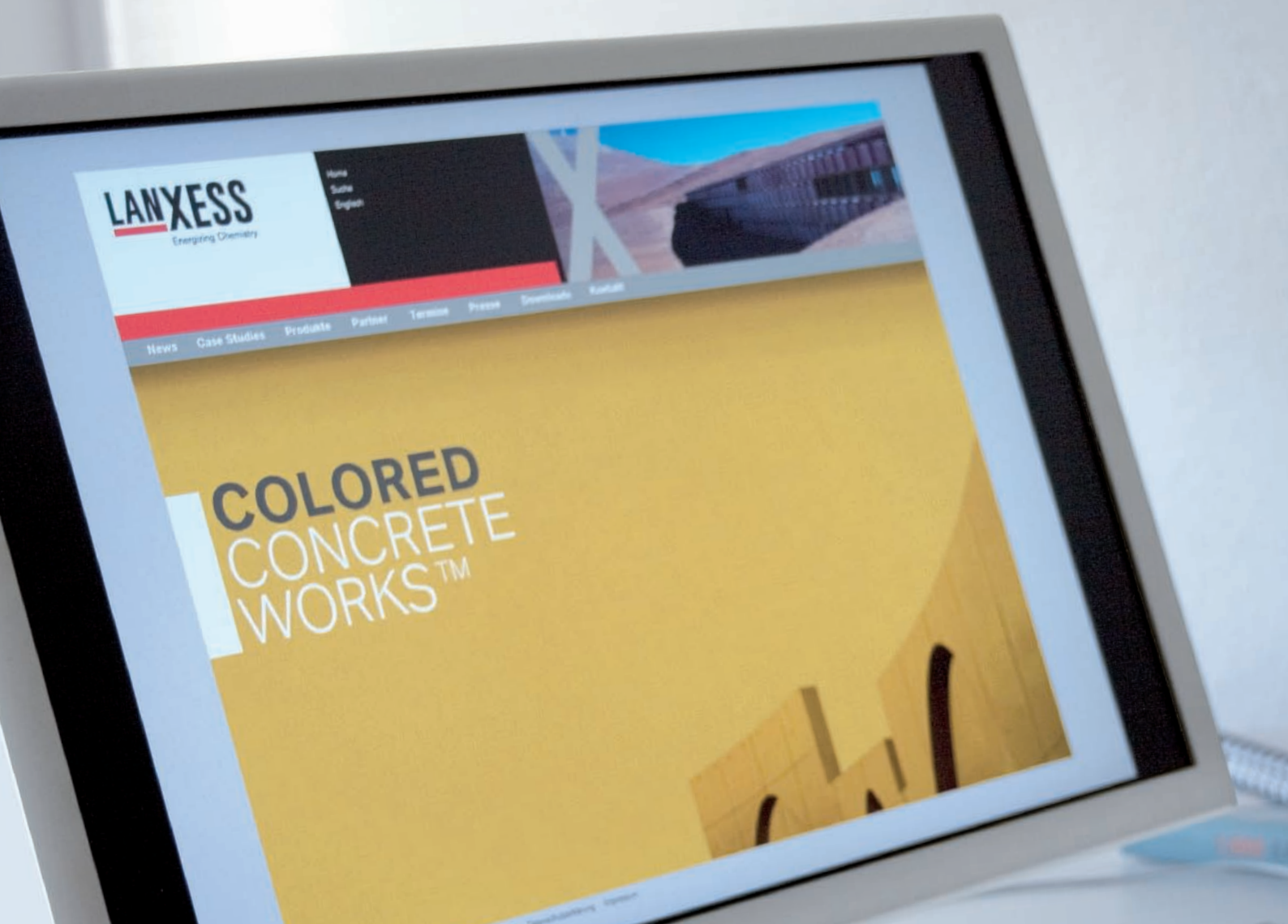
The color of the Bodega Antión, designed by the world-renowned architect Jesús Marino PASCUAL in the Spanish wine-growing region of La Rioja, supports the overall architectural concept.

Creating added value and structural improvement

Colored concrete offers added value for anyone who works with it because it adds permanent beauty to a standard construction material. This not only makes structures more desirable, it also distinguishes them from others. More and more architects, building owners and manufacturers are discovering this potential—a trend that Colored Concrete Works™ supports on a permanent basis.

Creating sustainability

In order for color to become interesting and relevant as a marketing instrument for architects, building owners and manufacturers, the Colored Concrete Works™ initiative operates in several fields simultaneously. Not only case studies and building specifications, but also symposiums and workshops contribute to the lasting enhancement of interest in colored concrete.



**Colored Concrete Works™ –
the communication**

A high profile in the most important communication channels

To ensure that the Colored Concrete Works™ initiative from LANXESS achieves the widest possible publicity, an interested specialist audience is not the only group able to gain detailed information on the broad topic spectrum offered by Colored Concrete Works™. Anyone who would like to know more about the architectural possibilities of colored concrete can use various communication channels to gain more information. For instance, on the key medium, the Internet, at www.colored-concrete-works.com, numerous sources of information are available: from current trade show dates and press articles on colored concrete through precise product information to downloads of Colored Concrete Works™ case studies and Bayferrox® product data sheets. Colored Concrete Works™ case studies, for example, which are also sent as mailings to architects, primarily enable building owners and architects to voice their opinions and report on their experiences working with colored concrete. Further information includes fair posters, advertisements and informational brochures – which all address the topic of colored architectural concrete.




Example: the Colored Concrete Works™ case studies. They document the use of colored concrete in international building projects, showing successful examples of how the unique technical attributes of this universal construction material can be optimally combined with aesthetic requirements.

Products and delivery forms



Selecting the color

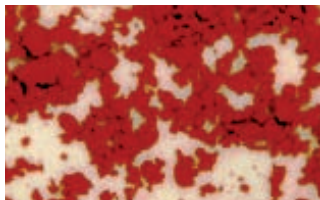
To initiate the planning of colored exposed concrete, a clear vision of the desired color is necessary. The Bayferrox® and Chrome Oxide Green pigments suitably cover the color range that is particularly sought after.

Bayferrox® red		Yellow-red to blue-red
Bayferrox® yellow		Greenish to reddish shade of yellow
Bayferrox® brown		Light brown to dark brown/red-brown
Bayferrox® black		Dark gray to anthracite
Chrome Oxide Green		

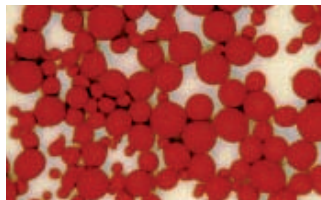
With the titanium dioxide and cobalt blue pigments available on the market, white and blue shades are also possible.

Delivery forms for pigments

The color pigments are available in powder form, but also as pigment preparations. In addition to powder as the original delivery form for these pigments, various forms of pigment preparations exist, such as granulates, compacted powders or slurries which can be manually added to the concrete. Due to their lack of dust and excellent flow characteristics, the pigment preparations specified mainly offer application advantages. This is particularly of interest if the pigment processor uses bigger amounts of pigment or utilizes an automatic metering system.



Powder



**Granulates
Compacted pigments**



Slurry

Product range

A broad range of pigments and delivery forms are available. Along with pigments in powder form and granulated or compacted pigments, the products can also be supplied through our network of partner companies, for example, in liquid form, in water-soluble bags, in small packets, etc.

- Bayferrox®
- COLORTHERM®
- Chrome Oxide Green
- Purofer®
- Oxined®
- Slurry:
 - Hydrocol
 - Hydroferrox
 - Fluined®
- Specials:
 - formirapid®
 - HobbyColor®





**The Pink Gallery, Paju, Korea.
4 % Bayferrox® 130 C.**

**Page 8: New Årsta Bridge in
Stockholm, Sweden.
For the red-brown coloring of
the concrete, 350 t of iron oxide
pigment powder were used –
a special mixture based on
Bayferrox® 640.**

Dosage



Manual pigment dosage

The quantities required from individual ready-mix concrete or pre-cast concrete manufacturers are normally relatively low, especially if pigments are used on a project-related basis. In other words, the manual mixing of pigments is generally regarded as sufficient. As an alternative to the portion-wise addition of powder pigments or preparations, in many cases the addition of pigments in water-soluble bags is advantageous. This procedure offers the advantage of enabling the clean usage of the pigments.



Slurry dosage

The inorganic pigments normally used for the building materials can be transported in liquid suspension form. These pigment suspensions—also called slurries in the following description – are both free-flowing and dust-free. With the appropriate pumps, they can also be fed from long distances into the mixture. Moreover, dosage proves to be relatively easy using dosage cylinders or hydrometers. In the process, the pigment user has the choice between a suspension, produced on site in a dedicated slurry tank, or purchasing a finished slurry from a pigment supplier.



Dry/wet dosage

Unlike the slurry dosage, in which a larger quantity of pigment suspension is manufactured at any one time, in the dry/wet dosage process only the exact quantity of pigment is transferred to a suspension that is required for coloring the next concrete batch. During this procedure, the quantity of water necessary for the first batch is added in a small agitating tub, which also functions as a scale. Then the corresponding quantity of pigment is transferred into the agitating tub by means of a screw conveyor, which is controlled by the scale mentioned above. After a short period of agitation, the finished suspension can be pumped into the concrete mixer.



Dry dosage

In addition to the dosage methods specified above, the pigment (regardless of whether it is a powder pigment or a preparation such as granulates or compacted pigment) can also be metered in dry form. For this process, a broad range of gravimetric or pneumatic dosage systems are available. There are no universally valid guidelines for deciding which combination of pigment delivery form and dosage system is the best alternative in a specific case scenario. To reach an evaluation, both the specific local requirements and the various economic interests of the respective operation must be considered. Only careful prior consideration of the individual conditions can guarantee that the method decided upon proves correct in the long run.



ESO Hotel, Cerro Paranal, Chile.
Pigment: 2 % Bayferrox® 600 N,
applied to cement. Concrete:
compression strength class C20/25
(B25) and C27/37 (B35).

The pigment

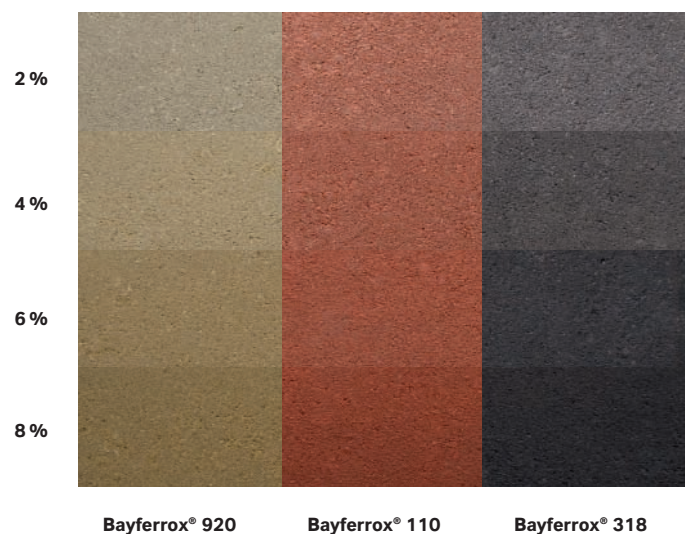
The selection of the pigment is of crucial importance to the quality of the final product. Long-term evaluations of colored concrete that has been exposed to different climate conditions in various locations have shown that inorganic oxide pigments exhibit particularly good color fastness characteristics.

Color	Name	Pigment name
Black	Iron oxide black	Bayferrox® black
Red	Iron oxide red	Bayferrox® red
Yellow	Iron oxide yellow	Bayferrox® yellow
Brown	Iron oxide brown	Bayferrox® brown
Green	Chrome oxide green	Chrome Oxide Green
White	Titanium dioxide	e.g. TRONOX®

Processing information

Pigmentation grade

Knowledge of the optimal pigmentation level helps save money so that no more pigment is used than is absolutely necessary. Increasing the amount of pigment per batch of concrete intensifies the color up to a certain point. However, upon further addition of pigment, one arrives at a range in which adding further quantities of pigment produces no substantial color intensity, and thus becomes economically inefficient. Generally speaking, adding pigment beyond 5 % (based on cement) is normally not necessary.

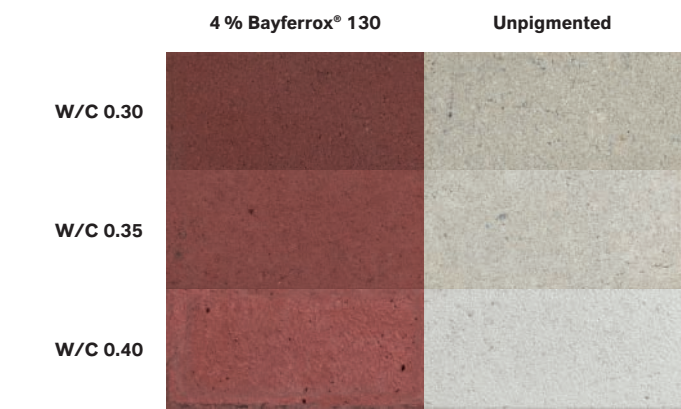




Bodega Antión, La Rioja, Spain.
The 12,000 m³ of concrete necessary for the project was colored with formirapid®. This corresponds to a total consumption of 120 t of formirapid® yellow. Packaging the product in water-soluble 10 kg paper bags enabled direct addition to the concrete mixer. 10 kg (= 1 bag) was required to color 1 m³ of concrete.

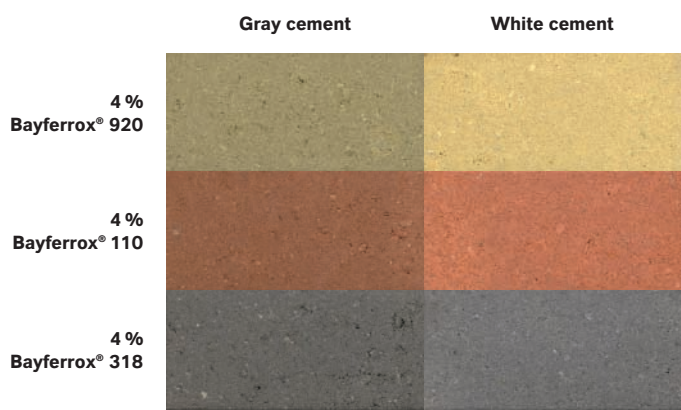
Water/cement ratio and concrete color shade

If one compares the color shades of different types of concrete with varying amounts of water, color shades will be different, even if the same amount of pigmentation has been added. As a basic rule: the higher the water/cement ratio, the lighter the concrete will be.



Actual color of the cement

Gray absorbs all colors wherever they occur. For this reason, concrete manufactured using ordinary Portland cement cannot be colored as brightly as concrete containing white cement. However, the increase in color purity obtained from using white cement depends on which pigment is used. If black is used, there is practically no difference between concrete consisting of white or gray cement. For a dark brown and red, the difference is small—for yellow, on the other hand, it is very pronounced. The brighter and purer the desired shade of color should be, the more white cement is necessary for attaining the target color.



Dispersion of pigments

The dispersion of pigments is an important criterion in the production of pigmented concrete. Colored goods require an even, satisfactory dispersion or distribution of the pigments. As described in the table, some important basic rules apply when mixing the raw materials.

Recommended sequence for filling the mixer:	Breakdown of mixing time:
Premix aggregates + pigment + cement + water	Sand + pigment: about 10–20 s
Mixing time 1.5–2 min	Sand + pigment + cement: about 15–20 s
	Sand + pigment + cement + water: about 1–1.5 min
Each mixer has a minimum mixing time. If this full time is not completed, no homogeneous distribution of the pigment can be obtained even through changes to the individual mixing times or the addition of components into the mixer. Required mixing times largely depend upon the performance capability of the concrete mixer. The specifications for mixing times listed above are therefore only to be taken as rough indications.	

Exceptions are possible when using suspensions. Here it may be possible to add the slurry into a mixture which is already wet.

Weather resistance

Weather resistance

The Roman aqueduct, which supplied Cologne, Germany with water from the Eifel Mountains 2,000 years ago, was built with trass cement. If one had colored this antique “concrete” with natural iron oxides, which at that time were already widely known, then the water pipeline, parts of which can still be visited, would still be colored today. Deviations from the original color would be minor. These color changes, which can be seen on uncolored and colored concrete alike, can be both temporary (e.g. efflorescence) and permanent (e.g. exposed aggregate) in character.



**Concrete bricks (unweathered comparison sample in the foreground).
Start of weathering exposure: 1970, photo: 1995.**

Efflorescence on concrete

Efflorescence is the scourge of all concrete manufacturers, especially when color is being used and aesthetic demands are placed on the concrete. It should be noted that neither Bayferrox® nor Chrome Oxide Green pigments have an influence on the occurrence of efflorescence. By nature, the white lime secretions are more easily recognizable on colored concrete than on natural gray or even white concrete. Efflorescence results from the formation of lime traces during the hardening of the cement. Already present in the mixing water (primary efflorescence) or in external water sources, e.g. rain or dew (secondary efflorescence), the lime deposits travel to the concrete surface. There, a reaction to carbon dioxide in the air turns the minerals into insoluble calcium carbonate.



Unweathered



Effloresced



**Weathered for 1 year (*)
(*) depending on the climate conditions**

Efflorescence disappears after a certain time by itself.

Concrete technology

The requirements placed on the pigments used to color building materials are stipulated in standards. In Europe, the use of pigments for coloring building materials is specified by EN 12 878 "Pigments for the coloring of building materials based on cement and/or lime". In the United States, please refer to ASTM C 979 "Pigments for integrally colored concrete".

EN 12 878

Conformance is validated by in-house production control and the resulting certification by a notified body (CE test mark). The notified body issues certificates that replace the previous certificates of compliance. The CE mark, which is also affixed to the packaging, documents this conformance. In EN 12 878, further tests are stipulated for reinforced concrete (Cat. B), in particular regarding their frequency. In order to meet the standard requirements, particularly regarding the documentation, these products are managed separately as so-called special formulations at LANXESS. In the test certificate, all required data on the respective batch are listed and the targeted application is defined.

ASTM C 979

In this standard, the requirements for pigments of colored concrete are specified. LANXESS pigments adhere to the standard requirements.





Reference projects

From top left:

- Church, Seoul, Korea
- Residential building, Paju, Korea
- University building, Paju, Korea
- Bodega Antión, La Rioja, Spain

From lower left:

- Sewage treatment plant, Paju, Korea
- Administration building, Paju, Korea
- Residential building, Seoul, Korea
- Administration building, Korea

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