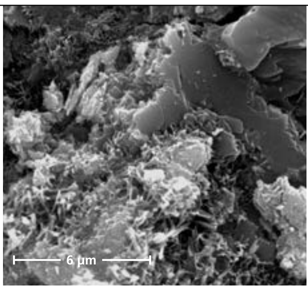
Dyckerhoff

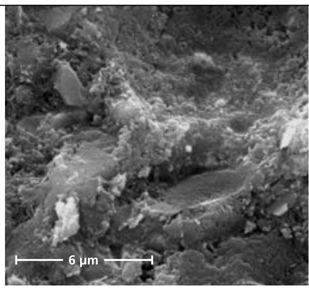
Dyckerhoff VARIODUR®

Premium cements for high-performance concretes

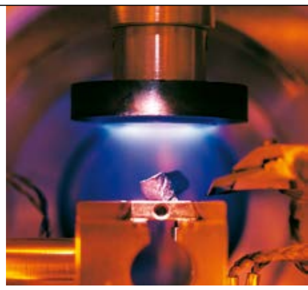
Dyckerhoff VARIODUR®
Premium cements with MIKRODUR® Technology



Standard concrete



High-performance concrete with MIKRODUR Technology



Scanning electron microscope

Evaluation of scanning electron microscope

Dyckerhoff VARIODUR premium cements enable concretes with exceptional properties without complex approval procedures, since as standard cements they are exclusively made from standardized cement constituents.

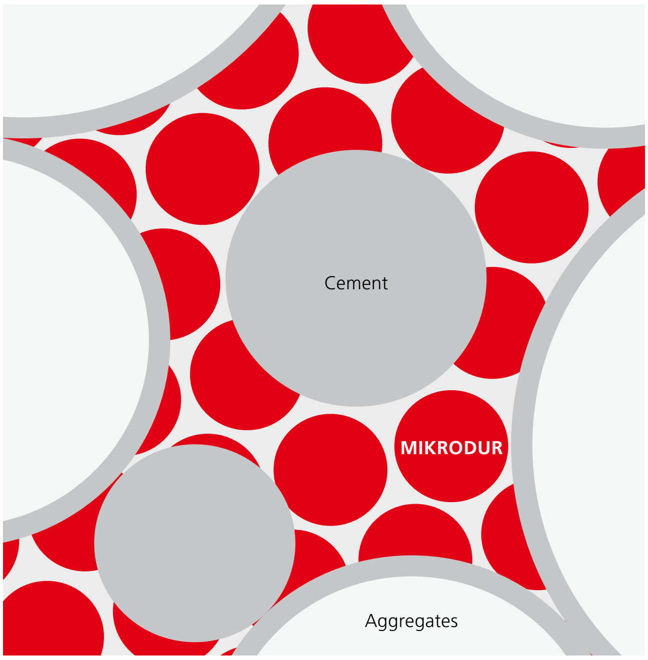
Dyckerhoff premium cements are high-performance binders for manufacturing concretes that must meet especially strict requirements. Constant uniform product quality is already ensured by the choice of raw materials in the cement plant by a special separation and mixing process, and by stringent quality control.

Dyckerhoff premium cements are granulometrically optimized by the unique MIKRODUR Technology. The interstitial filling of the cement matrix ensures an extremely dense structure in the concrete. Specifically graded proportions of finely ground granulated blast furnace slags ensure high consistency.

Exposure classes

Class	Description of the environment	Informative examples where exposure classes may occur
XA1	Slightly aggressive chemical environment according to EN 206-1: 2001-07, Table 2	Containers of wastewater treatment plants; slurry containers
XA2	Moderately aggressive chemical environment according to EN 206-1: 2001-07, Table 2 and marine structures	Concrete elements that come into contact with seawater; concrete constructions in soils aggressive to concrete
XA3	Highly aggressive chemical environment according to EN 206-1: 2001-07, Table 2	Industrial wastewater treatment plants with chemically aggressive wastewaters; silage silos and feed alleys; cooling towers with flue-gas discharge

Dyckerhoff VARIODUR CEM II/B-S 52.5 R, CEM III/A 52.5 R and CEM III/A 52.5 N-SR (na) are standard cements for the manufacture of high-strength and ultra-high-strength concretes with high resistance to aggressive media.



Natural draft cooling tower

Manufacture of concrete pipes

Industrial wastewater treatment plant

High-strength mass concrete

Concretes made with Dyckerhoff VARIODUR are recommended for all structural components exposed to aggressive environments. VARIODUR 50 has been tested for high sulfate resistance and is classified as SR cement (German General Building Authority Approval: DIBt No. Z-3.11-1938).

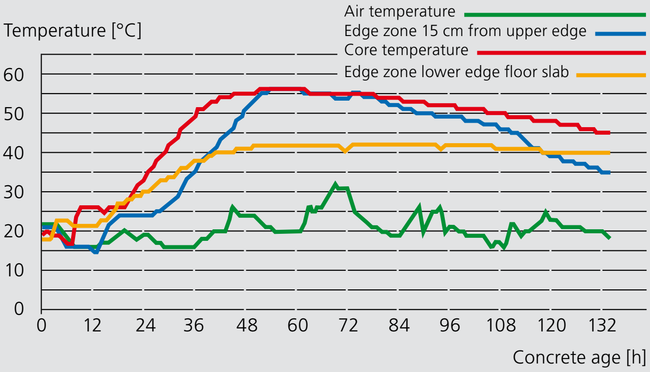
Dyckerhoff VARIODUR for construction of natural draft cooling towers

Cement formulations adjusted to process engineering combine durability with rapid development of early strength for high climbing performance of the formwork. High-performance concretes are moreover characterized by a uniform appearance in bright, attractive exposed concrete quality.

Dyckerhoff VARIODUR for use in wastewater components

The dense structure with good early and final strengths ensures great resistance when exposed to environments of changing aggressiveness. This is of equal significance for in-situ concrete components and concrete pipes manufactured in precast plants.

Development of hydration heat floor slab component A Kranhaus Süd structure, Cologne



Dyckerhoff VARIODUR for high-strength mass concrete

Optimized consistent heat of hydration on a low level and, at the same time, great strength potential for meeting special requirements. Sulfate-resistant and high resistance to freeze-thaw with de-icing salt. In the massive 21 x 32 x 1.60 m thick foundation of the Kranhaus Süd structure in Cologne, Germany, C60/75 high-strength mass concrete with a consistency of F5 was used. At a maximum core temperature of 55 °C, the difference to the edge zone was less than 15 K.

Cement data

Dyckerhoff VARIODUR		VARIODUR 30 CEM II/B-S 52.5 R	VARIODUR 40 CEM III/A 52.5 R	VARIODUR 50 CEM III/A 52.5 N-SR (na)
Water demand	[%]	30	31	32
Initial setting time	[min]	175	180	220
Relative brightness	[Y]	50	53	55
Compressive strength 2d	[MPa]	38	34	28
Compressive strength 7d	[MPa]	63	60	56
Compressive strength 28d	[MPa]	72	73	74

Renovation and extension of bridges
with special concretes based on Dyckerhoff VARIODUR


Example: renovation of…


…Hollandse Brug


Example: Bridge extension…


…in the SAAone projekt

Renovation of deck slabs (Almere)

Hollandse Brug is the name of the highway bridge along the A6 motorway that connects the Dutch capital of Amsterdam with the city of Almere, which was established on the Flevoland Polder as recently as in 1975. In 2010, the reinforced-concrete bridge of 350-m length was provided with a new deck slab of special concrete from Dyckerhoff Basal made with the Dyckerhoff premium cement VARIODUR 50 CEM III/A 52.5 N-SR (na). The Dyckerhoff Basal plant based in Almere delivered around 2,000 m³ of ready-mixed concrete for renovating the more than 10,000 m² of road surface.

The renovation was planned with a concrete slab 17 cm thick to be placed on the existing bridge construction and provided with 8-mm epoxy resin coating for additional surface protection. The requirements placed on the concrete after 48 hours, with a granular blast furnace slag content of at least 50 % in the cement, specified high adhesive tensile strength and rapid compressive strength of > 35 MPa, as well as < 2.5 % residual moisture for applying the epoxy resin coating. In addition, high resistance was required to freeze-thaw with de-icing salt (exposure class XF4), as well as low-shrinkage hardening and absence of cracks.

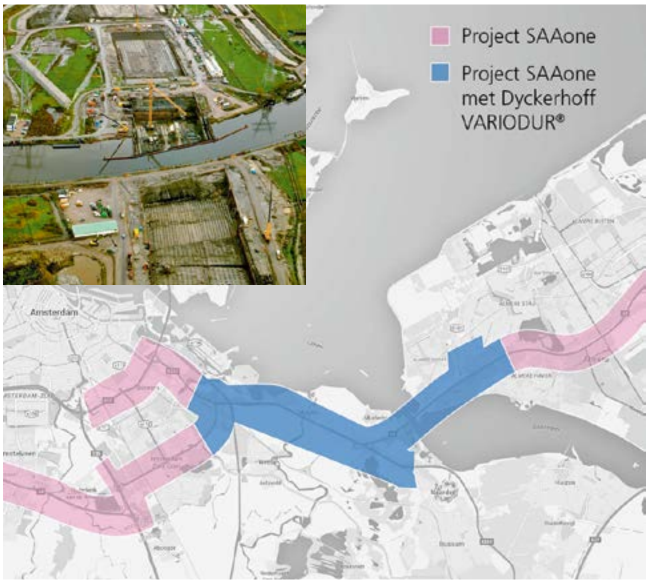
Concrete-technological data renovation Almere

Strength class		C60/75
Exposure class		XC4, XD3, XF4
Flow spread		F4: 490 – 550 mm
CEM III/A 52.5N-SR (na)		340 kg/m³
Fly ash		50 kg/m³
w/c ratio		0.45
Compressive strength	2d	40 MPa
Compressive strength	7d	65 MPa
Compressive strength	28d	80 MPa
Wheathering CDF test		348 g/m²

Extension project SAAone (Amsterdam-Almere)

The structure, built in in 2016, is an extension of the already existing bridge across Gooimeer and IJmeer between Amsterdam and Almere in the Netherlands that had become too narrow.

The bridge across the Amsterdam-Rhine Canal was designed to be self-supporting. The high-strength ready-mixed concrete of strength class C70/85 chosen for this project was also produced with Dyckerhoff VARIODUR 50 CEM III/A 52.5 N-SR (na) due to low heat of hydration and high resistance of the high-performance concrete to freeze-thaw with de-icing salt.



Example: renovation of …

… Ewijk Bridge

Application of high-strength concrete …

… with a special finisher

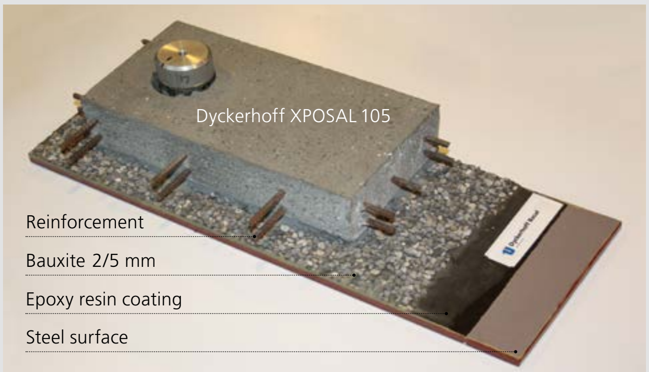
Renovation with XPOSAL 105 based on Dyckerhoff VARIODUR 30

The old Waal Bridge (Ewijk Bridge) was built in 1976. It is one of the steel bridges in the Netherlands that, prior to renovation, was no longer able to support current traffic levels.

A method that has previously been applied many times in the Netherlands consists of strengthening the supporting slab by a deck cover of reinforced high-strength concrete (C90/105). This reduces the stress by up to 80 % in the supporting slab compared to an asphalt cover layer, thereby significantly increasing the service life of the bridge.

The composition of the high-strength concrete was developed by Dyckerhoff Basal in the Netherlands together with the Wilhelm Dyckerhoff Institut in Wiesbaden, Germany. The result: Dyckerhoff XPOSAL 105 stands for a robust high-strength concrete of compressive strength class C90/105 based on Dyckerhoff VARIODUR 30 CEM II/B-S 52.5 R. All the concrete was delivered by the Dyckerhoff Basal plant in Arnhem. In 20 working days in the period from June to December 2016, a total of approx. 2,400 m³ of Dyckerhoff XPOSAL 105 was delivered; on two occasions, concreting also took place at night.

The Dutch contractor consortium consisting of Strukton and Ballast Nedam had developed a special finisher that placed strict requirements on the uniformity of the concrete. The paving equipment used is capable of generating high compaction energy to ensure a very strong bond between concrete and steel over a width of 12 m. At a speed of 20 cm per minute, 100 m of bridge decks were placed in one day. On the steel surface, a bonding course of bauxite and epoxy resin was applied for optimal adhesion. Use was made of both conventional steel reinforcement as well as 75 kg/m³ of steel fibers, added by a new batching unit at the plant. The mixing trucks had been provided with special 'rain caps' to guard against rainwater to ensure optimal consistency of Dyckerhoff XPOSAL 105.



Concrete-technological data renovation Ewijk

Strength / exposure class	C90/105; XF4
Flow spread	F3 / F4: 450 – 500 mm
Processing time	≥ 2 hours
Air entrainment	≤ 2.0 %
Density	≤ 2,500 kg/m³ (± 5 %)
Flexural strength	10 MPa (± 25 %)
Young's modulus	50,000 MPa (± 10 %)
Autogenous shrinkage	≤ 3.0 ‰
Resistance to freeze-thaw with de-icing salt	≤ 100 g/m²
Chloride migration	≤ 2.0 * 10^{-12} m²/sec
Coarse aggregate 2/5 mm	ASR resistant
Steel fibers (L = 12.5 mm, D = 0.4 mm)	≥ 75 kg/m³ (evenly distributed)

UHPC
Ultra High Performance Concrete


Columns (7 cm)


Staircases (3 cm)


Fish-farming basin (6 cm)…


…made of glued elements

Ultra High Performance Concretes are based on optimization of the packing density of the hardened cement paste. This is achieved, as generally known, by filling the cavities with special admixtures such as silica fume, which, moreover, due to the pozzolanic reaction of the structure of the cement paste, additionally increases its density.

However, high-performance concretes can more easily be obtained with modern cement technology, as the examples on pages 4 and 5 show. The DAfStb guideline on UHPC contains high-strength classes, which will later also be included in the new versions of the concrete standards: C130/145, C150/165 and 175/190.

While C175/190 will likely be available only with extremely high dosing of micro steel fibers, C150/165 is capable of achieving this class with moderate dosing of micro steel fibers and C130/145 entirely without any, using Dyckerhoff VARIODUR 40, together with suitable superplasticizers.

When performing strength tests, great care must be taken to use only absolutely faultless steel forms and that the surfaces of the cylinder specimen are ground plane-parallel prior to testing.

Special structural building components – e.g., columns with a diameter of 7 cm, a staircase exhibit example with steps of 3 cm thickness and a two-level basin for fish-farming filled with seawater with a wall thickness of 6 cm – are examples of possible applications of UHPC. (Application examples made with ULTRALITH by Benno Drössler GmbH & Co. Bauunternehmung KG, Siegen, Germany, based on Dyckerhoff NANODUR® Compound 5941)

However, in the area of structural engineering, only standard cements can currently be used. For verification of performance, a simple UHPC formulation with VARIODUR 40 CEM III/A 52.5 R was tested, without silica fume and without the often performed special granulometric grading of aggregate sizes.

Pit sand 0/2 mm and high-grade basalt chippings 2/5 mm were used here, as well as a special superplasticizer based on polycarboxylate ether (PCE) for adjustment to an easy-to-process consistency for low water/cement ratios.

UHPC formulation

VARIODUR 40 CEM III/A 52.5 R		700 kg/m³
Pit sand 0/2 mm		480 kg/m³
High-grade basalt chippings 2/5 mm		1,300 kg/m³
Superplasticizer on PCE base for low w/c ratios		16.8 kg/m³
Water (incl. water from PCE)		136 kg/m³
w/c ratio		< 0.20
Flow spread		430 mm
Compressive strength (10/10/10 cm cube)	7d	147 MPa
Compressive strength (15/30 cm cylinder)	7d	137 MPa
Young's modulus	7d	54,000 MPa
Compressive strength (10/10/10 cm cube)	28d	162 MPa
Compressive strength (15/30 cm cylinder)	28d	158 MPa
Young's modulus	28d	55,600 MPa

Research projects

C^3 carbon concrete composite (BMBF[1])

The new C³ high-performance concretes, in comparison with the concretes currently available on the market, will be more durable, have an optimized bond for carbon reinforcement and demonstrate significantly enhanced energy and CO_2 balance results. Building structures of C³ high-performance concretes are characterized by high mechanical performance with low environmental impact and are expected to have a longer service life.

The objective of C³ sub-project B2 was to develop new binder concepts with a higher proportion of composite constituents. The result is VARIODUR C (Carbon), which satisfied the requirements of the project, with compressive strength of > 100 MPa and flexural strength of > 10 MPa in the concrete.

Formulation example VARIODUR C

Suitable for standardization as CEM VI (S-LL) 52.5 N following implementation of the new EN 197-1		
VARIODUR C		620 kg/m³
Crushed granite 2/5 mm		840 kg/m³
Sand 0/2 mm		530 kg/m³
Sand BCS 413		250 kg/m³
Superplasticizer based on PCE		16 kg/m³
Water		145 kg/m³
w/c ratio		0.23
Prism strength*	28d	120 MPa
3-point flexural strength*	28d	12 MPa
*prism 4 cm x 4 cm x 16 cm; 28-day storage of the test specimen under water at 20 °C		

[1] German Federal Ministry for Education and Research

The development of the binder concept for VARIODUR C (Carbon) was supported and granted by:

Bundesministerium für Bildung und Forschung

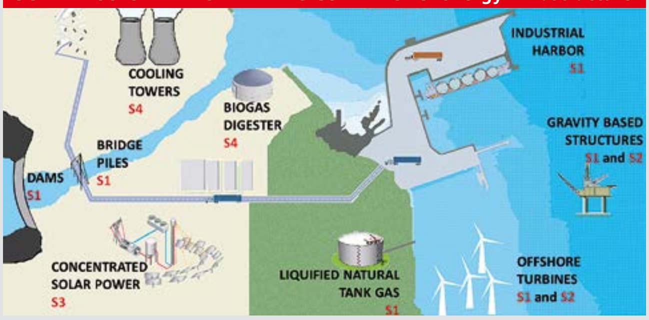
zwanzig20 PARTNERSCHAFT FÜR INNOVATION

LORCENIS (European Union)

Long-lasting reinforced concrete for energy infrastructure under severe operating conditions

Infrastructure projects always involve major investments and the structures must, moreover, often be erected under unfavorable ambient conditions: e.g., with offshore wind turbine plants in the North Sea and the Baltic See at low temperatures and under icy conditions. Likewise, solar power plants in hot desert regions place great demands on construction materials when exposed to extreme temperature changes. Cooling towers and biogas power plants are, in addition, exposed to aggressive media.
Dyckerhoff collaborated on the LORCENIS project to develop new concepts with VARIODUR for production of especially long-lasting and robust concretes.

SCENARIOS. SEVERE OPERATING CONDITIONS: energy infrastructure



Scenario 1 (**S1**): Cold ΔTª, ice impact, abrasion, corrosion, freeze thaw, deep sea
Scenario 2 (**S2**): Mechanical fatigue
Scenario 3 (**S3**): Hot ΔTª
Scenario 4 (**S4**): Acid corrosion

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 685445.

Dyckerhoff VARIODUR

in mortars

Renovation of the masonry at the Einsiedelstein bridge on the A1 motorway

Grout based on VARIODUR 50 at the Höllenbach viaduct

VARIODUR is highly suitable as binder for the manufacture of high-quality cement mortars.

For the conversion and renovation of the listed bridges Einsiedelstein and Höllenbach in connection with 6-lane widening of the A1 motorway between Wermelskirchen and Wuppertal Langerfeld in the Rhine-Ruhr region of Germany, VARIODUR 50 CEM III/A 52.5 N-SR (na) was used in bedding and jointing mortars for natural-stone facing, as well as in backfilling mortar.

For further information
and individual consultation
you can contact us at:

Cement sales region Northwest,
Netherlands and Belgium, Denmark
Dyckerhoff GmbH
Lienener Straße 89
49525 Lengerich
Germany
Phone +49 5481 31-327 /-436
Fax +49 5481 31-590
verkauf-nordwest@dyckerhoff.com

Cement sales region Southeast,
Switzerland
Dyckerhoff GmbH
Biebricher Straße 68
65203 Wiesbaden
Germany
Phone +49 611 676-1237 /-1241
Fax +49 611 676-61237 /-61241
verkauf-suedost@dyckerhoff.com

Sales region Luxembourg, France
Cimalux S.A.
B.P. 146
L-4002 Esch-sur-Alzette
Luxembourg
Phone +352 55 25 25 297
Fax +352 42 08 44
info@cimalux.lu
www.cimalux.lu

Export
Dyckerhoff GmbH
Biebricher Straße 68
65203 Wiesbaden
Germany
Phone +49 611 676-1282
Fax +49 611 676-1320
export@dyckerhoff.com
www.dyckerhoff.com

Design: wellKOM. Kommunikationsdesign GmbH   Stand: 04/2021

Dyckerhoff GmbH, Product Marketing
P.O. Box 2247, 65012 Wiesbaden, Germany
Phone +49 611 676-1187
marketing@dyckerhoff.com www.dyckerhoff.com