

Technology and Concepts for Watertight Concrete Construction



The Components of Watertight Concrete

A watertight concrete structure can be designed to “keep water in” – or – to “keep water out” – or – both.

In future even greater controls on water quality and increasing regulations for the protection of ground water, will require the construction of many more watertight concrete structures. These requirements will affect all industries.

In the water industry, for instance this can be for both fresh water supply and waste water treatment facilities.

All of this is in addition to the rapidly increasing need for residential and commercial buildings to optimize land usage, with habitable deep basements. Many new developments are also in areas with rising groundwater levels such as inner cities, where water is no longer abstracted by local industry.



▲ Keeping Water In

- ▲ Reservoirs and Water Tanks
- ▲ Waste Water Treatment Plants
- ▲ Dams
- ▲ Secondary Containment Bunds
- ▲ Swimming Pools
- ▲ Sewers and Pipelines

▲ Keeping Water Out

- ▲ Basements
- ▲ Parking Garages
- ▲ Underground Stations and Subways
- ▲ Utility Vaults
- ▲ Marine Structures
- ▲ Tunnels

The Concrete Technology

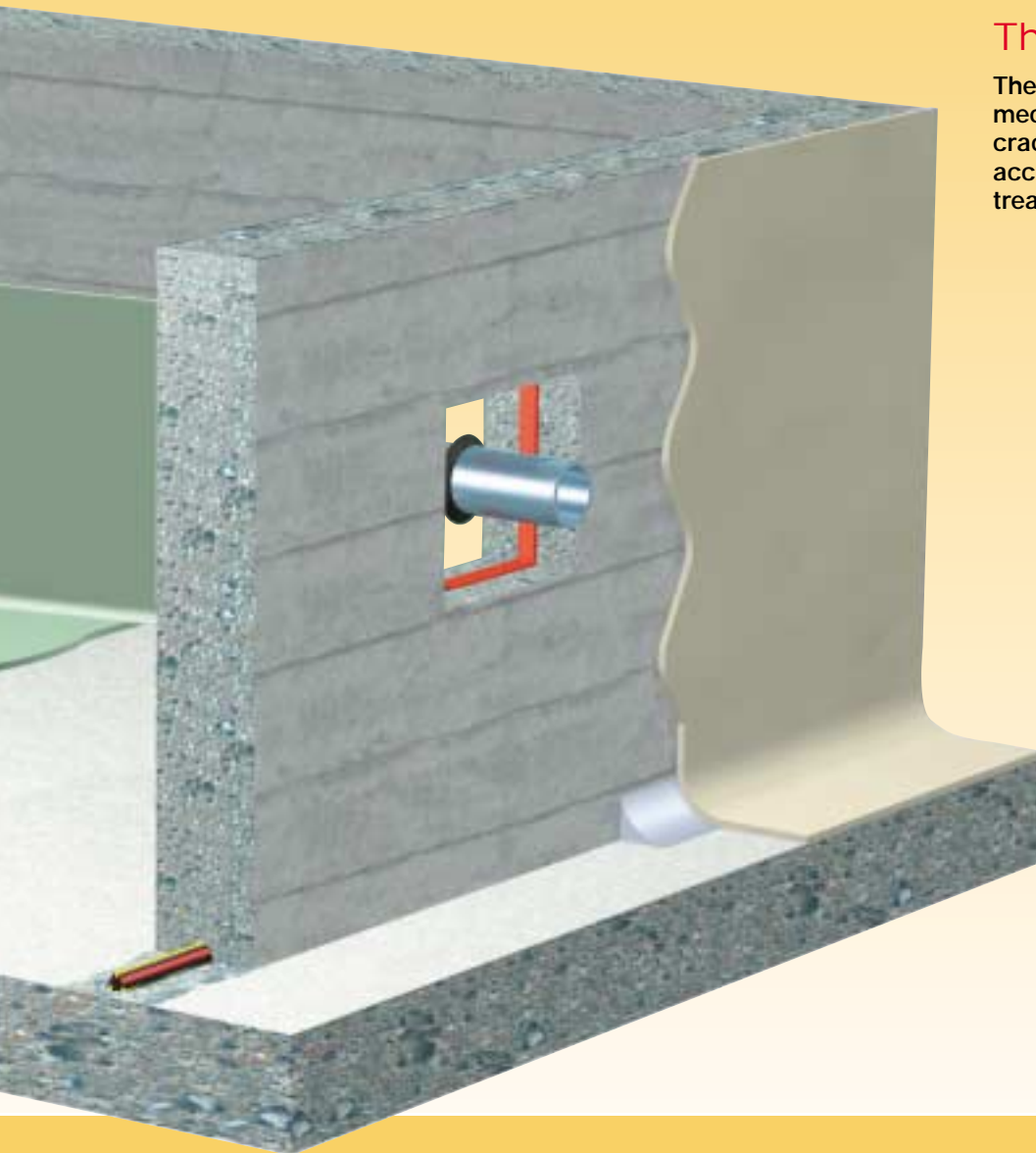
Dense impermeable concrete is essential. Watertight Concrete is produced by minimizing capillary volume and permeability.



The Jointing

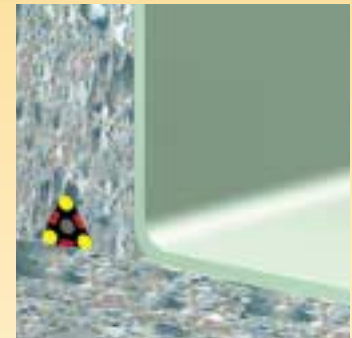
Construction and r sealed.





The Additional Protection

There are often additional demands such as mechanical resistance, chemical resistance, crack bridging, etc. which must be accommodated by compatible additional treatments.



g Technology

movement joints must be securely



The Penetrations

Pipe entries, utility services, etc. always have to penetrate the watertight structure and these points must also be securely sealed.



The Requirements for Watertight Conc

In The Design Office: Specification by Usage (To BS 8102)



Grade

1

Typical Structure & Requirements

Basic utility.
Underground Parking Garages.
Plant rooms (excluding electrical equipment).

BS 8102:
Grade 1: Slight seepage and damp patches are tolerable.

Sika® Solutions

- Watertight concrete system:
Water reducing admixture
- Sikament®
- Capillary blocking system:
- Sika®-1
- Joint sealing system:
- SikaSwell® Systems or
 - Traditional Waterbars



Grade

2

Residential and Commercial Basements
Workshops, plant rooms and retail storage where a drier environment is required.

BS 8102:
Grade 2: No water penetration but moisture vapour tolerable.

- Watertight concrete system:
High range water reducing admixtures
- Sikament®
- Capillary blocking system:
- Sika®-1
- Joint sealing system:
- SikaSwell® Systems
 - Sikadur®-Combiflex®
 - Sika® Injectoflex-System



Grade

3

Ventilated residential and working areas including offices, restaurants and leisure facilities.

BS 8102:
Grade 3: A dry environment is required and water penetration is intolerable.

- Watertight concrete system:
High range water reducing admixture
- Sikament®
- Capillary blocking system:
- Sika®-1
- Joint sealing system:
- Sikadur®-Combiflex®
 - SikaSwell® Systems-
 - Sika® Injectoflex-System



Grade

4

Use for archives, store houses of sensitive material, computer rooms.

BS 8102:
Grade 4: A totally dry environment. Vapour impermeable.

- Watertight concrete system:
High range water reducing admixture
- Sikament®
- Capillary blocking system:
- Sika®-1
- Joint sealing system:
- Sikadur®-Combiflex®
 - SikaSwell® Systems®
 - Sika® Injectoflex-System
- Coating system:
- EpoCem® and Sikagard® as internal vapour-proof and/or protective coatings.



Additional performance requirements

- ▲ Hygienic and easy to clean
- ▲ Approved for contact with drinking water
- ▲ Crack bridging
- ▲ Chemically resistant
- ▲ De-icing salt resistant
- ▲ Waste water resistant

Sika® Solutions

- Sika® Watertight concrete and joint sealing systems as Grade 3 and 4 above. Plus:
- EpoCem® systems, Sikagard® coatings or SikaTop® cementitious renderings as the additional protective layers depending on the specific requirements.

On The Construction Site: Good Concreting Practice

▲ The Formwork

Formwork joints shall be sufficiently tight to prevent leakage of liquid. Formwork shall impart a smooth finish to the resulting concrete surface:-

- ▲ To fulfil this requirement use Mould Release Agents like Separol®.
- ▲ Loosening, striking and removal of formwork should be done without shock or vibration.
- ▲ Minimum recommended striking times must be adhered to.
- ▲ Extended waiting periods can be beneficial to curing.

▲ The Steel Reinforcement

▲ In watertight construction the design and fixing of steel reinforcement is particularly important to absolutely minimise potential problems such as:-

- ▲ Crack behavior due to insufficient steel reinforcement.
- ▲ Insufficient concrete cover, which can lead to increased plastic shrinkage during construction and an accelerated rate of corrosion damage in service.
- ▲ Obstruction of jointing systems by congested reinforcement or by changing the designed position and/or correct installation of the joint.
- ▲ Congestion – leading to inadequate concrete compaction producing honeycombing or voids.

▲ The Curing

Curing of concrete reduces the porosity and pore size in the concrete surface layer of 20 to 50mm, and produces the necessary non continuous pore system. Curing is also important in reducing the risk of surface crazing and plastic shrinkage cracking. For watertight concrete complete and correct curing is essential, e.g. by covering immediately with damp hessian and plastic sheeting and by keeping formwork in place for extended periods. Also note:-

- ▲ Liquid applied curing membranes are not normally the most effective for watertight construction.
- ▲ Curing must always be carried out for the absolute minimum time as generally recommended by BS 8110 and protected from evaporation for at least 3 days in all cases, more when exposed to aggressive conditions.
- ▲ Temperature fluctuations must be minimized.

Ambient Conditions	Minimum Curing Time (Full 24 Hour Days)		
	at 5-10°C	at 20°C	at 30°C
<u>Good</u> RH>80% Protected from Sun & Wind	-maintain protection for minimum 3 days		
<u>Average</u> Intermediate RH>50-80% Partially Protected from Sun & Wind	5	4	3
<u>Poor</u> RH<50% Not Protected from Sun & Wind	7	3	3

Watertight Concrete Curing Times
(Adapted from BS 8110: Portland and Sulphate Resisting Cement.)

▲ Typical Mix Design

Minimum Cementitious Content :- 350 kg/m³
 Maximum Water / Cement Ratio:- 0.45
 Admixtures : Sika®-1 7 Litres/m³
 Sikament®-10 @ 0.8 -1.2% by weight of Concrete

The Technology of Watertight Concrete

Crack-free concrete can be said to be "watertight" if the volume of water penetrating it is lower than the minimum vapourisable volume of water on the opposite side.

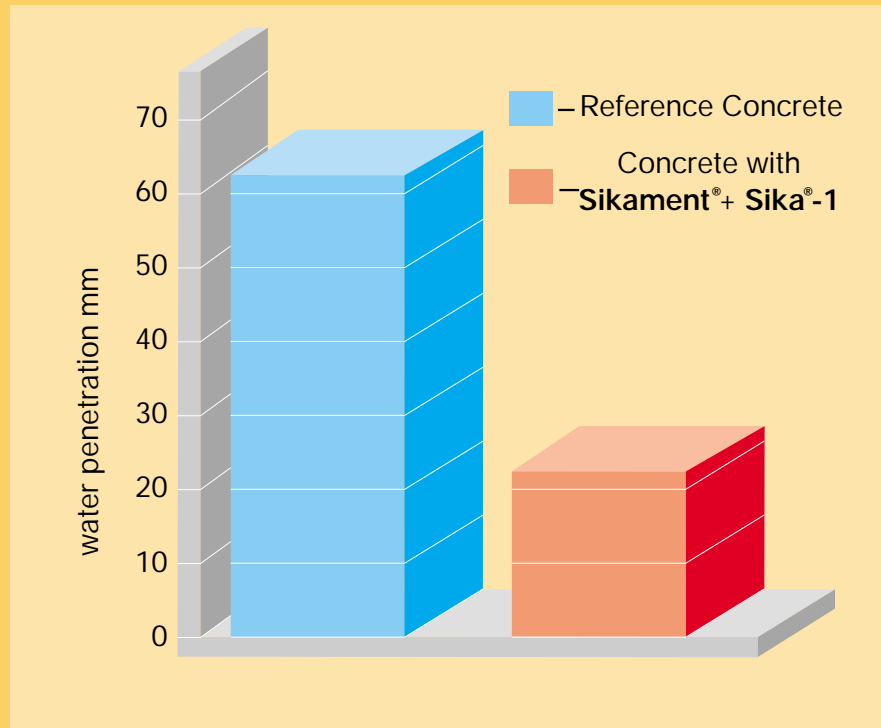
Test of Water Permeability through Concrete

Water Absorption under Pressure
(i.e According to DIN-Stand.1048
(mod.)/ENV 206)

- ▲ Water absorption in $\text{g}/\text{m}^2 \times \text{h}$
- ▲ Measurement: Max. water penetration in mm after 24 hours with a water pressure of 5 bar.

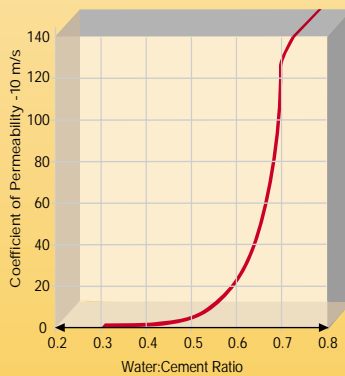


Note: The ISAT - Initial Surface Absorption Test is not applicable with the Sika® system for watertight concrete, as watertightness increases under pressure following limited initial surface absorption.

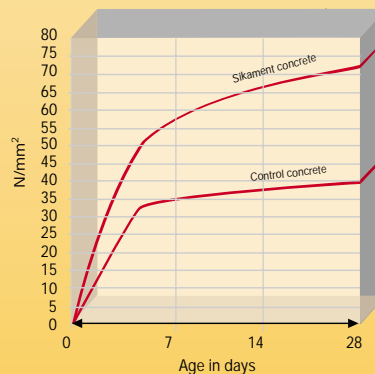


Reduction of Concrete Permeability with Sikament®

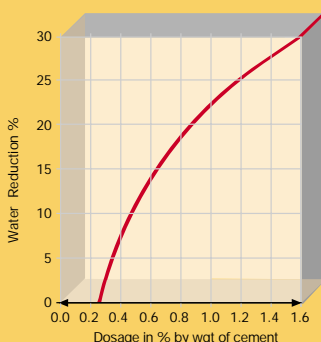
Effect of Water Cement Ratio on Permeability



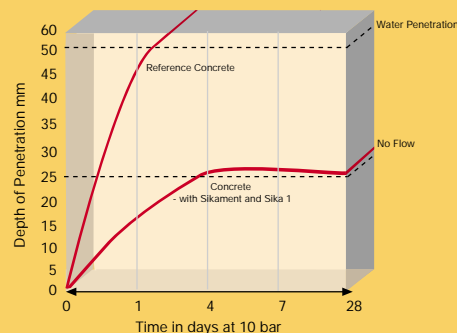
Effect of Sikament® on Strength Gain



Effect of Sikament® Dosage on Water Reduction



Effect of Sikament® and Sika®-1 on Watertightness



Reduction of Concrete Permeability with Sika®-1

Integral Blocking of Capillary Pores by using a Poreblocking Waterproofer - Sika®-1

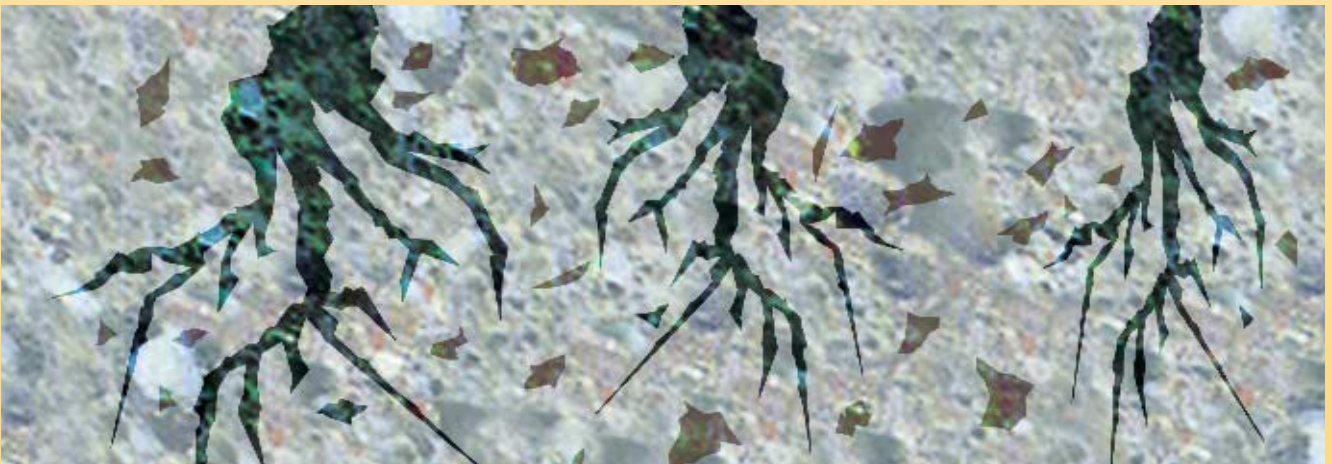
Sika® incorporates Sika®-1 containing complex colloidal silicates with extremely high reactivity. These fine particles improve crystallization of the cement hydration products, resulting in further blocking of the pores and therefore formation of a dense cement matrix. These pore blocking materials also line the inside of capillary pores forming a barrier, which strongly reduces the ability of water to penetrate.

If water does penetrate under pressure, swelling action of the silicate hydrates formed in the matrix takes place. This then effectively blocks the pores – even at 10 bar or 100 metre head of water pressure.

Sika® Watertight Concrete therefore uses the dual technologies of Sika®-1 and Sikament® synchronised to produce the optimum performance.

Without Sika® Watertight System

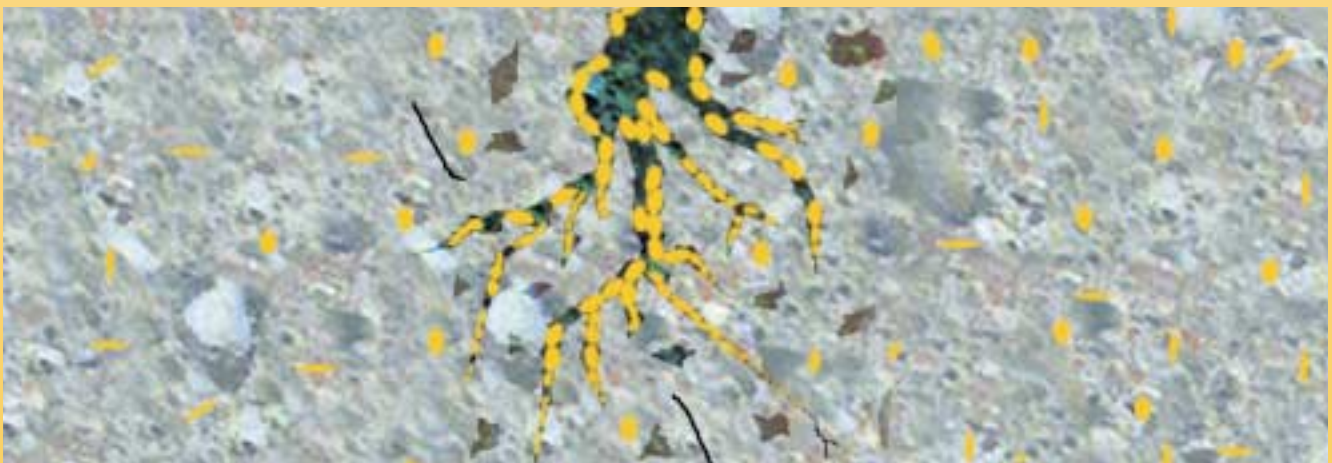
Concrete Sample (Control)



- ▲ Standard control concrete provides more capillaries which can lead to failure of the concrete sample as this increased capillary structure provides a migratory path for water particularly when under pressure.

With Sika® Watertight System

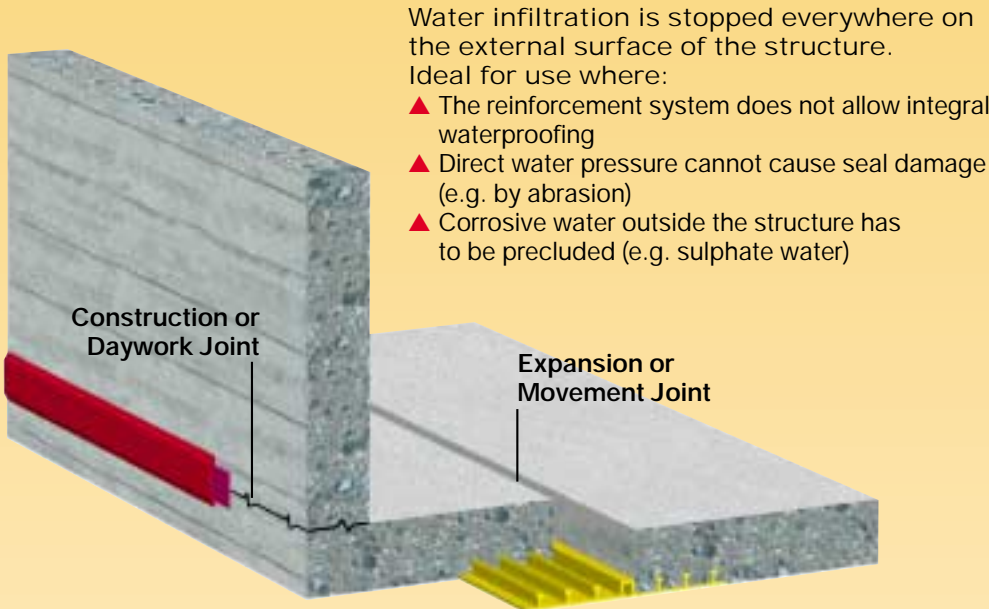
Concrete Sample (Sika® Watertight)



- ▲ Sika® Watertight concrete contains fewer capillaries reducing the potential migratory route for water. Should water attempt to pass through, the colloidal silicate Sika®-1 swells and blocks the path. The pore blocker is distributed throughout the concrete matrix. This dual effect ensures a watertight concrete is achieved.

The Different Principles and Systems for Achieving Watertight Joints

Principle 1 External Surface Applied



Two Systems are Available



Suitable Grades for Construction and Expansion Joints.

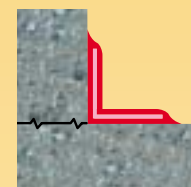
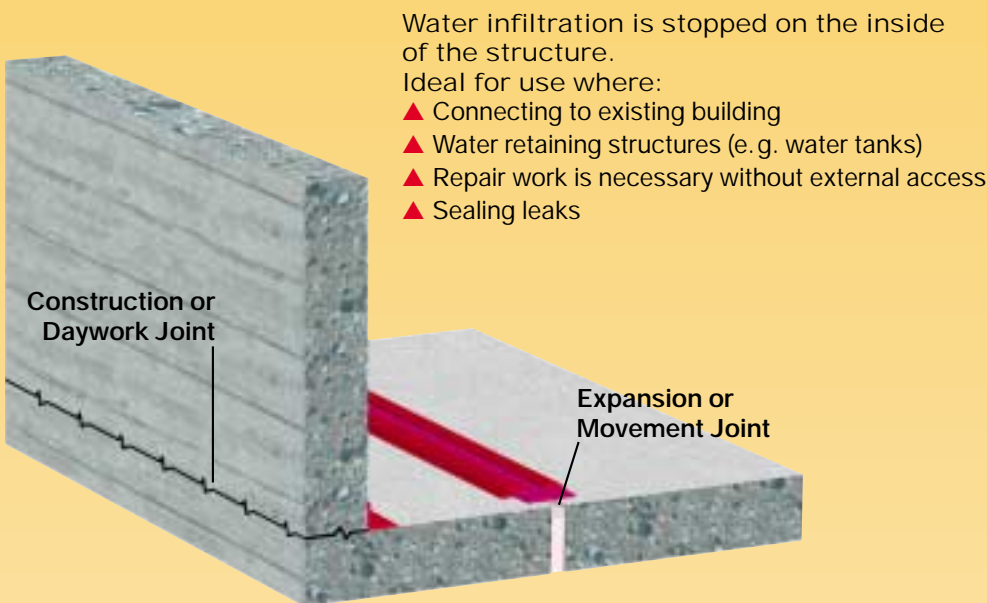
1. Traditional PVC Waterstop®



Suitable for both Construction and Expansion Joints.

2. Sikadur®-Combiflex® System

Principle 2 Internal Surface Applied



Suitable for both Construction and Expansion Joints.

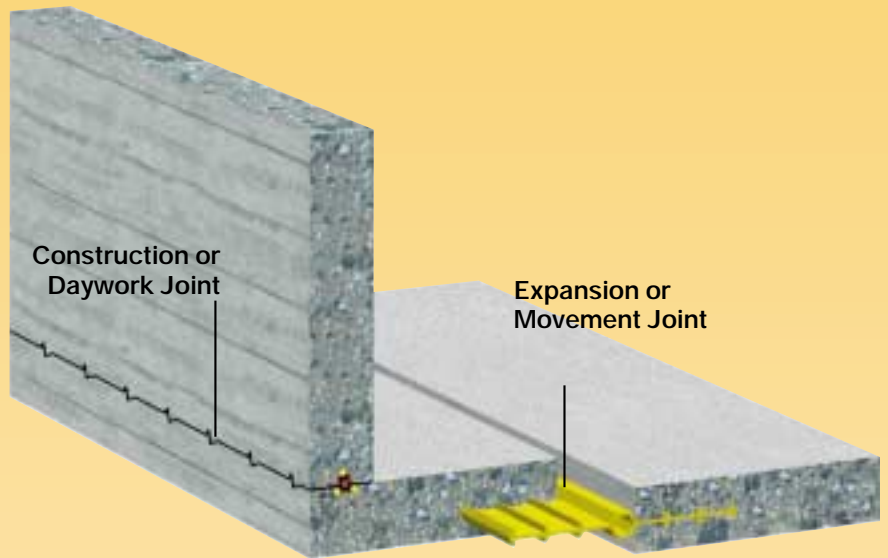
Sikadur®-Combiflex® System

Principle 3 Integral Cast in Situ

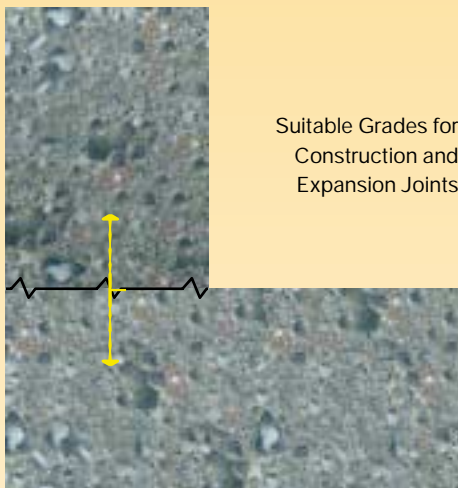
Water is stopped inside of the structure.

Ideal for use where:

- ▲ External waterproofing is undesirable for aesthetic reasons
- ▲ Subsequent application of the seal is not possible for time or technical reasons
- ▲ The seal has to be protected from abrasion

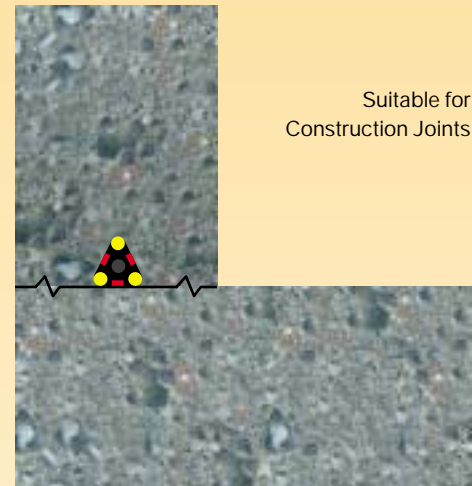


Four Systems are Available



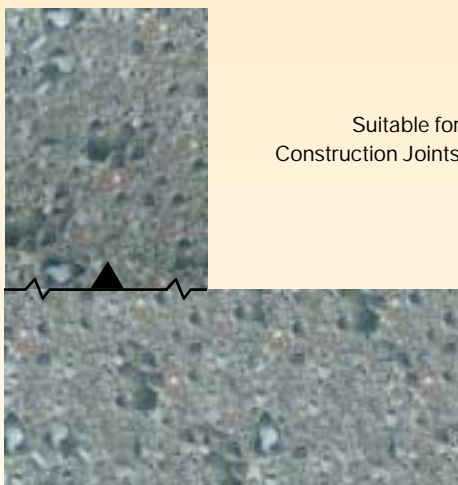
Suitable Grades for
Construction and
Expansion Joints

System 1: Traditional PVC Waterstop
- **Integral Waterbar**



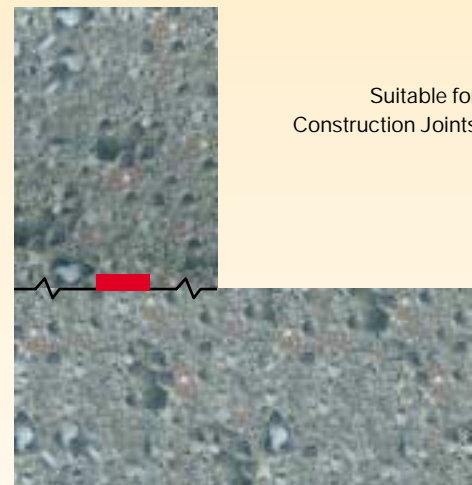
Suitable for
Construction Joints

System 2: Integral Re-Injectable and
Hydrophilic Hose
- **Sika® Injectoflex System**



Suitable for
Construction Joints

System 3: Gun Applied Hydrophilic Sealant
- **SikaSwell®-S**



Suitable for
Construction Joints

System 4: Preformed Hydrophilic Strips
- **SikaSwell®-P**

The Technology of Watertight Jointing

Sealing of Expansion and Construction Joints with Traditional Waterstops

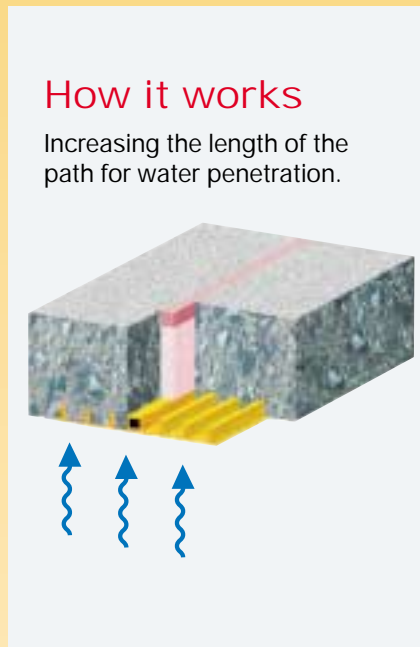
Flexible PVC waterstop sections for the sealing of construction and movement joints.

Advantages

- ▲ Ribbed flanges for anchoring and sealing.
- ▲ Increased distance for water penetration.
- ▲ No risk due to insufficient surface preparation.
- ▲ Application independent of the weather.

Limitations

- ▲ Precise location and fixing is necessary.
- ▲ Complicated formwork and concreting work is required.
- ▲ Leaks are difficult to locate and to repair.
- ▲ Connections between new and existing structures are not possible.



Integral applied
Traditional Waterstop fixed integrally in the concrete.

For construction joints



For movement joints



External surface applied
Applied with the external face on the blinding concrete or form work.

For construction joints



For movement joints



Sealing of Expansion- and Construction Joints as well as Cracks with Sikadur®-Combiflex® System

High performance joint sealing system consisting of Sika® Hypalon sealing strip and Sikadur® epoxy adhesive.

Advantages

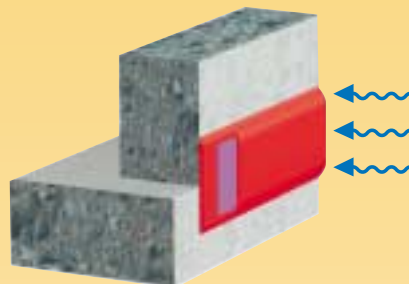
- ▲ Adaptable to the construction program.
- ▲ Easy to adjust to complicated construction details.
- ▲ Simultaneous additional crack sealing possible.
- ▲ Damage or leaks can be repaired externally or internally.
- ▲ Easy to control the application because it is visible.
- ▲ Easy to repair damage.

Limitations

- ▲ Application more difficult under extreme conditions (cold, rain).
- ▲ Additional mechanical protection may be required from backfilling.

Function

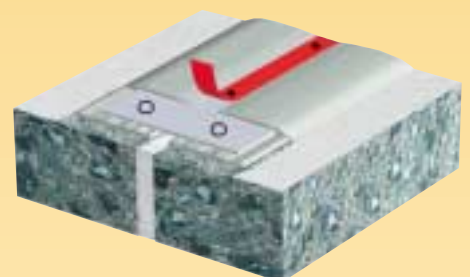
Increasing the path of water penetration and fully bonded to the concrete preventing water ingress.



Available Systems

A range of different widths and thicknesses are available.

- ▲ Combiflex® strip thickness of 1 mm
For low mechanical demand.
- ▲ Combiflex® strip thickness of 2 mm
For higher mechanical demand.
- ▲ Combiflex® strip widths
Standard 15 and 20cm, wider on request.
- ▲ Sikadur®-Combiflex® adhesive
High performance epoxy adhesive.



Sealing of Construction Joints with Sika® Injectoflex System

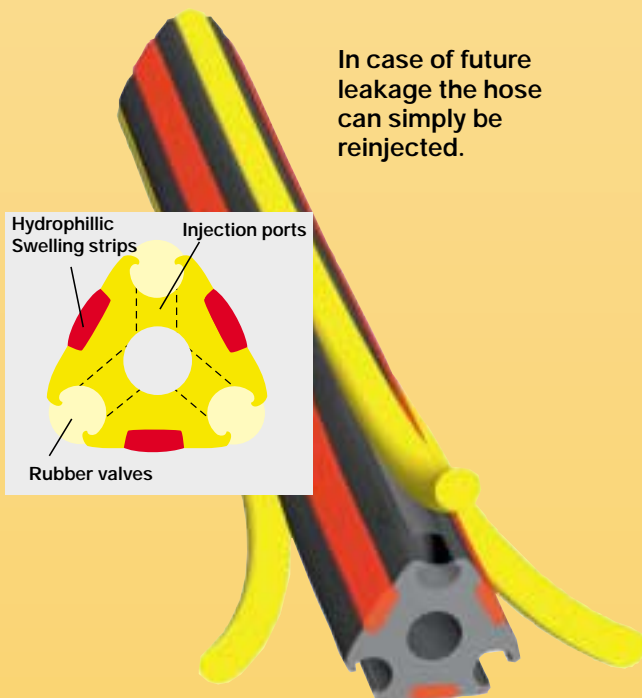
Sika® Injectoflex Hoses have three hydrophillic surfaces, which swell to seal the joint. In addition the system can be injected and re-injected in case of future movement/settlement etc.

Advantages

- ▲ Accurate waterstopping by 2 methods.
- ▲ Easy to install.
- ▲ Adaptable to any form of structure and program.
- ▲ No additional fixing of formwork or steel reinforcement is required.
- ▲ The major advantage of Sika® Injectoflex is that this system can be injected or re-injected at any time in the future to seal the joint - due to movement, damage, excessive loading etc.

Limitations

- ▲ Not suitable for movement joints

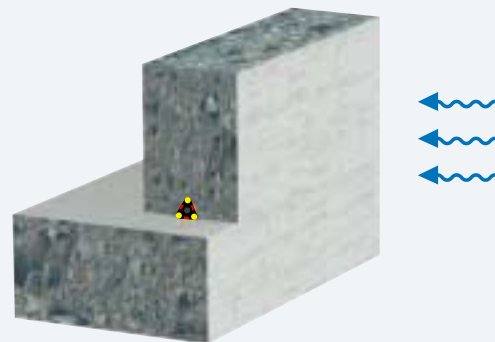
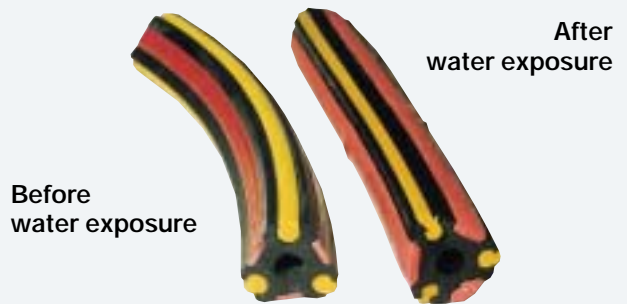


Function

The sealing process occurs in two ways.

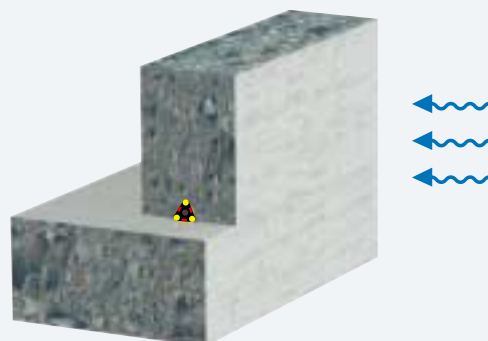
Method 1

Swelling caused by water exposure. Sika® Injectoflex has hydrophillic (water absorbing) swelling profiles on each of its 3 sides. Penetrating water "activates" the three exterior surfaces of the Sika® Injectoflex Hose, which swell to seal the joint.



Method 2

If necessary, in the second method, the system can be injected with Sika InjectoCem® (micro cement) or with Sika® Injection® (resin), which again fills and seals the joint.



The Technology of Watertight Jointing Systems (continued)

Sealing of Construction Joints with SikaSwell® Sealants and Profiles

SikaSwell®-P Profiles

Sealing Profiles which swell in contact with water to seal construction joints .

Advantages

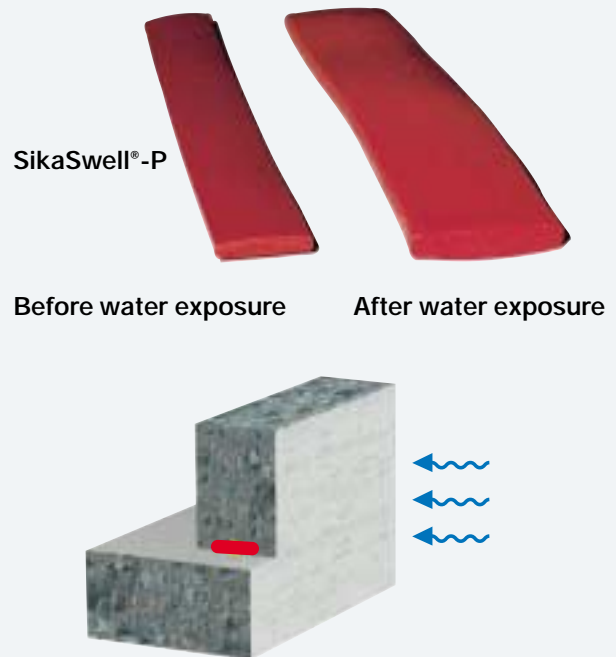
- ▲ Swells in contact with water
- ▲ Permanently water resistant, no leaching
- ▲ Elastic
- ▲ Easy, simple application
- ▲ With protective coating to avoid premature swelling

Limitations

- ▲ Not suitable for expansion joints
- ▲ Cannot be injected
- ▲ Not suitable for rapidly rising ground water as immediate sealing is not possible due to the time required for the profile to swell.
- ▲ Although SikaSwell®-P has been tested to 3.5 bar, it is not normally recommended for joints in structures with requirements greater than Grade 1 to BS 8102.

Function

After contact with water the exterior surfaces of the profiles swell. The resultant pressure increases the path of water penetration.



SikaSwell®-S Sealants

SikaSwell® S is a gun applied water swelling sealant for construction joints and penetrations.

SikaSwell®-S can also be used for fixing of Sika® Injectoflex® or SikaSwell® profiles.

Advantages

- ▲ Easy, simple application
- ▲ No additional fixing is required
- ▲ No jointing is required
- ▲ Can be easily adapted to very irregular surfaces

Limitations

- ▲ Not suitable for expansion joints
- ▲ Dependent on weather conditions (moisture sensitive in application)
- ▲ Although SikaSwell®-S has been tested up to 3.5 bar, it is not normally recommended for joints in structures with requirements greater than Grade 1 to BS 8102
- ▲ Not suitable for rapidly rising water as immediate sealing is not possible due to the time required for SikaSwell®-S to expand.

Function

SikaSwell®-S is a gun applied swelling profile which expands when it is exposed to water. The resultant pressure increases the path for water penetration, and effectively seals the joint.



Design of Penetrations and Ties to Ensure Watertightness



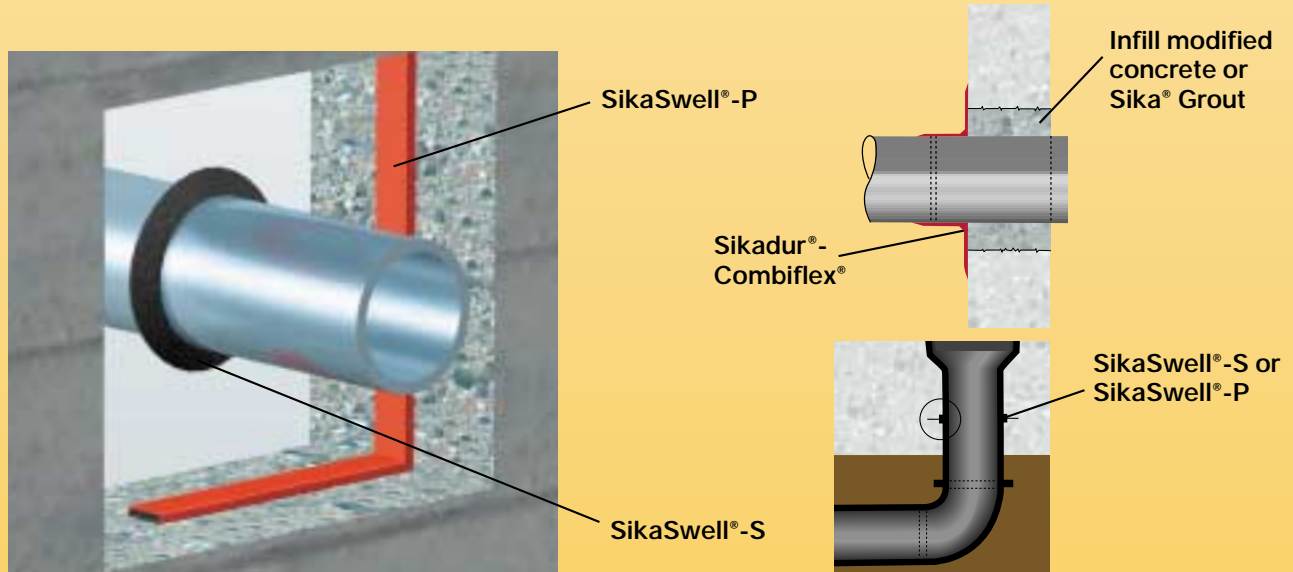
The Penetrations

With any watertight construction, continuity of the sealing system is essential for success. When pipe entries, utility services and conduits are placed in or through a structure, the watertightness of the structure is at risk unless securely sealed.

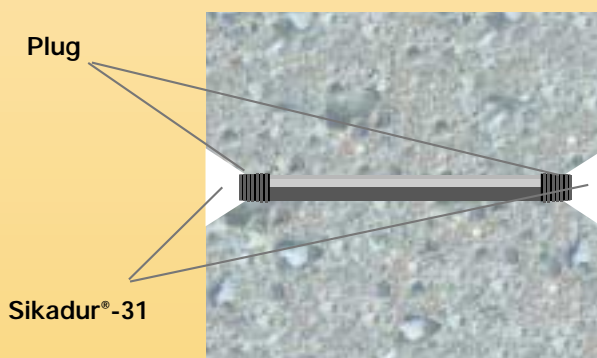
Pipe Entries

Sika® has developed simple and innovative systems for these applications using hydrophillic SikaSwell® Sealants and Profiles.

A further solution for pipe entries, utility services etc. that can be applied after the concrete work is the well proven Sikadur®-Combiflex® System.



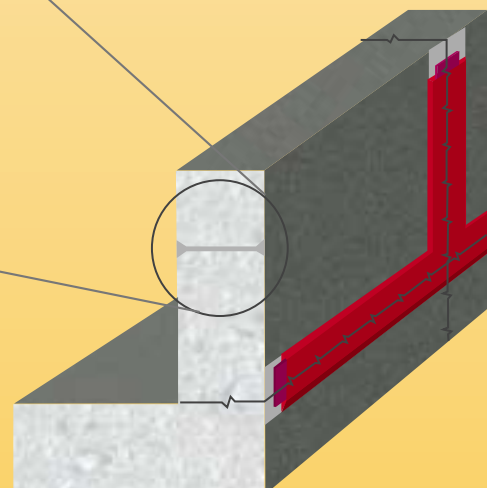
Formwork - Ties



In watertight construction the formwork ties have to be securely sealed.

Sikadur®-31 Epoxy mortar is the ideal solution.

Note: When complex or multiple ties exist the complete Sikadur®-Combiflex® System can be recommended if more practical on site.



A Selection of Case Studies



United Kingdom

Project

25 metre circumference Spheraactor, Anglian Water Innovation, Cambridge.

Requirement

Spherical Precast Concrete Tank for the innovative 'Kaldness' Sewage Treatment Process. High quality watertight and durable precast concrete sections to be completely sealed internally and protected externally from aggressive gases.

Sika® Solution

Sikament® in the precast concrete with **Sikadur-Combiflex®** surface applied internal jointing system. **Sikagard® 550W®** high performance, crack bridging protective coating.

Watertight spherical sewage treatment tank of precast high durability concrete.



United Kingdom

Project

Brook House, Park Lane, London.

Requirement

Development of luxury apartments with deep basement for utility services and quality car parking in an area with a high water table.

Sika® Solution

Sika® Watertight Concrete with **Sika®-1** and **Sikament®** for basement walls and floor slab construction. Construction joints and penetrations sealed with **Sikadur®-31** adhesive and **SikaSwell®** profiles.

Watertight underground parking and utility services for luxury apartments
BS 8102
Grades 1 and 2





United Kingdom

Watertight deep habitable office basement to BS 8102 Grade 3

Project

New Office Building,
25 Victoria Street, London.

Requirement

Multi storey office and retail building with a fully habitable deep basement on an unusually shaped site subject to continually high water pressure from the ground water.

Sika Solution

150 m run of 7 m high basement wall to be cast in **Sika® Watertight Concrete** with **Sika®-1** and **Sikament®** in a 1.5 m thick concrete raft and floor slab. Above ground exposed concrete protected against carbonation and chloride ingress with **Sikagard®-680S**.



United Kingdom

Vapourtight totally dry underground hospital basement to BS 8102 Grade 4

Project

Philip Harris House,
Guys Hospital, London.

Requirements

8 storey extension to Guys Hospital with one storey completely below ground level and 1.5m below the rising water table. Completely watertight facilities were essential for the sensitive work of the hospital - some designated to BS 8102 Grade 4 requiring vapour-tight construction for a totally dry environment.

Sika Solution

Sika® Watertight concrete with **Sika®-1**, **Sikament®** and **Sikaflex® sealants** used throughout. **Sikadur®** and **Sikagard®** coatings were applied onto the new concrete to create the important totally dry areas.



Technology and Concepts for Watertight Concrete Construction

Additional Specialist and Designer Concretes from Sika®:-



Corrosion Resistant Concrete

Achieved by using Sika's unique migratory corrosion inhibitor
-Sika® FerroGard®

Chemically Resistant and High Strength Concrete

Utilising Sika's power pack with silica fume - Sikacrete®



Underwater Concrete

Designed to resist washout and provide high strength concrete - Sika® UCS

Self Compacting Concrete

Vibration free concrete for Precast and Readymix applications - using Sika® Viscocrete® technology



Pumpable Concrete

Made easy with the liquid concrete stabiliser - Sikapump® and Sikamix®

Accelerated Shotcrete

Accelerators and rebound reducers for shotcrete including the new alkali free accelerator - Sigunite® 49AF



Foam Concrete

Foaming concrete systems, ideal for void filling or trench reinstatement - Sikaporo®

High Early Strength Concrete

Utilising Sika's Rapid Technology



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Herts, AL7 1BQ
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Environmental



Protection

Sika Ireland Limited

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Dublin 11, Ireland
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Telephone: (01) 8620709
e-mail: info@sika.ie



Production

The information and, in particular, the recommendations relating to the application and end-use of Sika products, are given in good faith based on Sika's current knowledge and experience of the products when properly stored, handled and applied under normal conditions. In practice, the differences in materials, substrates and actual site conditions are such that no warranty in respect of merchantability or of fitness for a particular purpose, nor any liability arising out of any legal relationship whatsoever, can be inferred either from this information, or from any written recommendations, or from any other advice offered. The proprietary rights of third parties must be observed. All orders are accepted subject to our current terms of sale and delivery. Users should always refer to the most recent issue of the Technical Data Sheet for the product concerned, copies of which will be supplied on request.

For more information on Sika visit www.barbourproductsearch.info