Chemical Protection or Flexibility?

Coatings Manufacturer Claims to Offer Both

Appropriate secondary containment has long been a legal requirement in many countries, particularly around tanks, storage vessels and other plant equipment containing hazardous liquids. Regulations (such as the Control of Pollution Regulations 2001 in England) are enacted to establish preventative measures. By not complying with these regulations, companies run the risk of being heavily fined, sometimes to the extent of incurring criminal proceedings. As an example, a malt producer was fined £20K for an oil fuel leak polluting the River Larkin in Suffolk, United Kingdom. The company spent a further £100K on the clean-up and maintenance costs.

Concrete bunds are commonly used as secondary containment systems to protect the environment from spills of corrosive and toxic chemicals. Concrete is cost-effective and provides good structural strength, however, due to its porosity, can be easily permeated and has poor chemical resistance, making it susceptible to deterioration through chemical attack. In addition, concrete is highly prone to cracking due to substrate movement and freeze-thaw cycles. If the deterioration is not addressed early, the structural integrity of the concrete will suffer and can result in contamination of the surrounding areas and ground water.

Fig 1 and 2 – Examples of deteriorated secondary containment

Secondary Containment Protection

Secondary containment is commonly protected with barrier coatings, which should be impervious to the liquid and resistant to chemical attack. In addition, the protective layer would benefit from a certain degree of flexibility. This flexibility combats the problem inherent in concrete - cracking.

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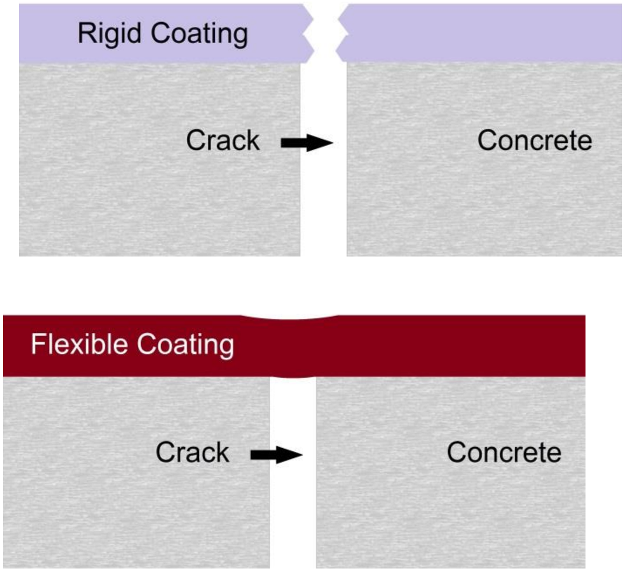

Fig 3 and 4 – Rigid vs flexible coatings

Why Does Concrete Crack?

- Plastic shrinkage is produced when fresh concrete in its plastic state is subjected to rapid moisture loss.
- Excessive loading where heavy loads cause the ground underneath the concrete to move and because the flexural strength of concrete is lower than its compressive strength, the concrete bends to its breaking point.
- Thermal expansion/contraction - significant tensile stresses in concrete are created by temperature fluctuations.
- Movement and settlement - during freeze/thaw cycles, frozen ground can lift and then settle when the ground thaws.
- Corrosion of reinforcement - corrosion from steel rebar can induce stresses, greater than the tensile strength of the concrete.

Secondary containment protection solutions typically possess only one or two of the three properties required for continuous performance: resistance to penetration, resistance to chemical attack and resistance to movement.

Conventional chemical resistant coatings have high crosslink density. They are rigid and inflexible due to difficult to break bonds, yet offer a good chemical resistance barrier due to their relative impermeability. Flexible coatings on the other hand, with the exception of rubber, have low crosslink density and offer good flexibility, but they are permeable, thus acting as a poor chemical resistant barrier.

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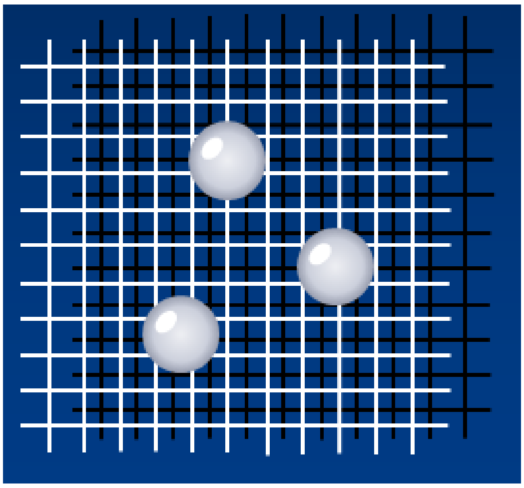

Fig 5 - High crosslink density

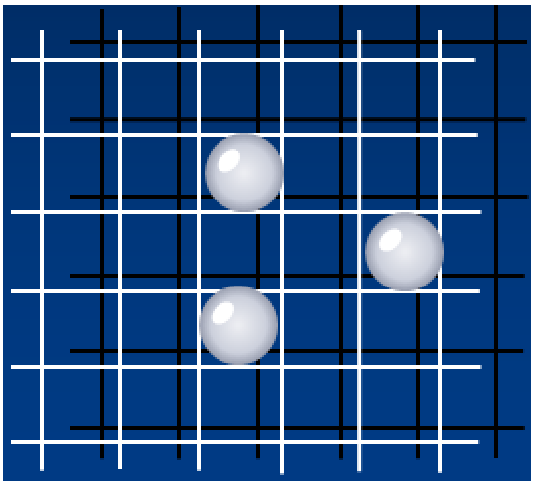

Fig 6 - Low crosslink density

Requirement for a New System

Due to exceedingly strict regulations a requirement for a new solution was identified. Such solution would exhibit the following properties:

- Good flexibility/ crack bridging properties
- Excellent overall chemical resistance
- Good adhesion to concrete and steel
- Solvent-free
- Good usable life
- Low surface bloom and good cure over a range of ambient temperatures
- Application by brush

New Coating Development

Back in 2009, Belzona, a manufacturer of specialist coatings and repair composites, started to investigate a new coating concept. Taking the desired design parameters into consideration, Belzona's R&D Department developed a hybrid polymer technology incorporating a new resin, which provides desired flexibility, and additional raw materials designed for chemical resistance.

Development took over four years due to long-term chemical testing. Ruckseeta Patel, R&D Chemist who led the development of the new coating, commented: "Prior to releasing a new material to the market, we ensure that it is thoroughly tested. This coating was tested against a very broad range of chemicals at various concentrations and we are very happy with the results. Some independent testing will also continue for another 18 months." Based on the initial feedback the system is expected to become a welcomed solution to replace coating systems that currently exhibit cracking.

The new coating system is titled Belzona 4361 and combines the desired chemical properties with the sufficient flexibility to remain intact if a crack appears in the underlying substrate, due to the incorporation of flexible segments in the polymer chain.

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Fig 7 and 8 - Belzona 4361 applied to a concrete bund area

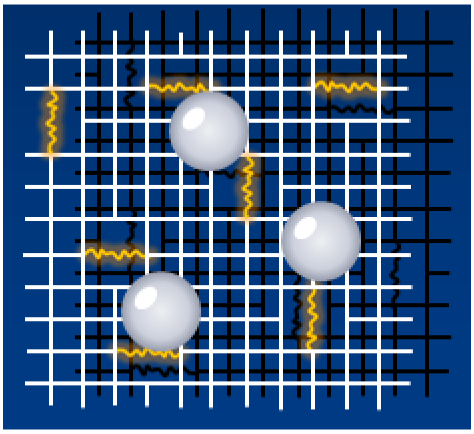

Fig 9 - Flexible segments in the polymer chain of Belzona 4361

<u>Put it to the Test!</u>

In order to ascertain its suitability for protecting bunds from chemical attack, the new coating was subjected to a series of tests over four years.

Flexibility Tests

Elongation was measured in accordance with ASTM D412 and recorded at 20% when cured at 20°C/68°F. To ensure the coating maintains its flexibility at low temperatures, a test in accordance with ASTM D552 was performed, resulting in a pass at temperatures down to 0°C/32°F.

A bend test was also performed, where the steel test panel was bent at a 90˚ angle. Visual inspection showed no signs of cracking.

Fig 10 and 11 – Bend Test

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Chemical Resistance

Chemical resistance was tested against one of the market leaders' coatings, taking into account most common chemicals which are contained by bunds.
Test panels were immersed in specified chemicals for the duration of one year see Table 1 for detailed results.

	Sample A (Belzona 4361)	Sample B (Coating system by another manufacturer)
93% Sulphuric Acid	Ok after 52 weeks	Failed after 1 day
90% Sulphuric Acid	Ok after 52 weeks	Failed after 2 days
20% Sulphuric Acid	Ok after 52 weeks	Failed after 9 months
37% Hydrochloric Acid	Ok after 52 weeks	Failed after 5 days
10% Hydrochloric Acid	Ok after 52 weeks	Failed after 9 months
43% Phosphoric Acid	Failed after 1 month	Failed after 5 days
25% Phosphoric Acid	Failed after 9 months	Failed after 5 days
10% Acetic Acid	Failed after 1 week	Failed after 5 days
2% Acetic Acid	Ok after 52 weeks	Failed after 5 months
25% Ammonia	Failed after 1 month	Failed after 1 week
Ethyl Acetate	Ok after 52 weeks	Failed after 5 days
Ethanolamine	Failed after 1 week	Failed after 5 days
MEK	Failed after 1 day	Failed after 1 day
Ethanol	Ok after 52 weeks	Failed after 2 months
Methanol	Failed after 4 months	Failed after 5 days

Table 1

Sample B (Coating system by another manufacturer) showed signs of failure quite rapidly after only a few days of exposure. Sample A (Belzona 4361) on the other hand was able to withstand the test media for longer periods.

Crack-bridging and Chemical Resistance Testing - WHG Approval, Universitat Stuttgart

The WHG Approval is part of a German water law for protecting surface water and groundwater. Only secondary chemical containment coatings with WHG Approval can be used in areas where strict regulations are in place in order to protect potable water against chemical pollutants.

The testing takes two years to complete and Belzona 4361 passed a key milestone - the first six months of testing. WHG presents a rigorous independent testing and the results will be equally relevant in Europe and globally.

The full WHG approval consists of a combination of crack-bridging, chemical resistance and aging tests. First, a number of concrete test blocks specially designed to test crack-bridging ability are coated with Belzona 4361 in accordance with the recommended application procedure. After cure, crack-bridging tests are first performed by creating a crack within the concrete and ensuring the coating remains intact. This is followed by chemical resistance testing where the chemical is positioned onto the test coating so that the crack in the concrete is directly underneath. Signs of chemical attack are visually observed, in particular

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to see if the chemical reagent attacks the test coating severely enough to penetrate through the crack due to the reduction in film thickness over the crack.

To replicate real life exposure or aging, the remaining coated test blocks are respectively stored in damp sand and placed outdoors. After six months and two years respectively of aging exposure, crack-bridging and chemical resistance tests are repeated. Belzona 4361 has recently passed the crack-bridging and chemical resistance tests after six months of aging exposure and will be repeated again in 18 months' time.

Various tests carried out and fully completed are summarised below.

Testing Standard	Test Name	Result
ASTM D2240	Hardness Test	Shore D 60
ASTM D4060	Taber Abrasion	62.9mm^3 loss per 1000 cycles, 1kg load CS17 wheels (dry)
ISO 11357-2	Heat Resistance – Glass Transition Temperature	26°C/79°F cure at 20°C/68°F cure
ASTM D1002	Tensile Shear Adhesion	1790psi (12.3Mpa) at 20°C/68°F cure
ASTM D4541 and ISO 4624	Pull off Adhesion	Damp concrete – 780psi (5.4Mpa), Dry concrete – 810psi (5.6Mpa), Blasted mild steel - 3540psi (24.4Mpa)
ASTM D256	Impact Resistance – Izod Pendulum	Nothed: 11.4KJ/m^2 (120J/m) at 20°C/68°F cure Unnotched: 12.8KJ/m^2 (160J/m) at 20°C/68°F cure
ASTM D2794	Impact Resistance - Falling Weight	> 78.7 in.lbs (>9.1kg.m)
ASTM D695	Compressive Yield Strength	10150psi (70 Mpa) at 20°C/68°F cure
ASTM D412	Elongation	20% at 20°C/68°F cure
ASTM D790	Flexural Yield Strength	940psi (6.5 Mpa) at 20°C/68°F cure
ASTM D552	Low Temperature Flexibility	Pass, maintains flexibility down to 32°F (0°C)
ASTM D412 (Die C)	Tensile Strength	3490psi (24.1Mpa) at 20°C/68°F cure
In-house test	Shelf life	3 years when stored between 0°C/32°F and 25°C/77°F

To see the application of Belzona 4361, view this video and for more information please visit the product page.

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-END-

Notes to Editor;

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- Established in 1952, Belzona has pioneered innovative polymer technology that has revolutionised industrial repair and maintenance procedures.
- Belzona is a leading company in the design and manufacture of polymer repair composites and industrial protective coatings for the repair, protection and improvement of machinery, equipment, buildings and structures.
- At Harrogate, the full Belzona product range is manufactured to stringent quality and environmental control guidelines complying with the requirements of ISO 9001:2008 and ISO 14001:2004.
- Belzona has over 140 Distributors in more than 120 countries ensuring not only the availability of Belzona materials, but also specification support, project management, application and supervision services. Distributorships and their teams are supported by Belzona Corporate offices in Europe, North America and Asia.

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