Waterproof Concrete With Site Supervision Ltd

Because concrete isn't waterproof without experienced, close supervision.

Why is waterproof concrete waterproof, chemical proof and crack proof?

Quick Conclusion:

Waterproof concrete is too dense for water to be pushed through quickly and chemicals block the fine routes through completely and prevent capillary action. Some chemicals dissolve in water and cannot get through dense concrete to attack steel bars. But other chemicals, such as sulphates, attack the concrete crystals on the surface so PFA or GGBS needs adding to waterproof concrete for sulphate resistance. Drying cracking cannot occur because waterproof concrete has insufficient excess water to dry off and create tension within.

By Phillip Sacre, Waterproof Concrete With Site Supervision Ltd AND the UK's leading Basement Construction Expert.

References:
Within the concrete industry: quarrying, cement manufacture, readymix and so on, there is a post-graduate diploma one can study for and a series of four text books contain all the necessary knowledge to obtain it. These are “Advanced Concrete Technology” edited by John Newmam and Ben Seng Choo. I have read large parts of these books and this information paper is written as a direct result of the understanding I have gained, particularly from the chapters “Durability concept: pore structure and transport processes” by Lars-Olaf Nilsson in the Volume 'Concrete Properties'; “Admixtures for concrete, mortar and grout” by John Dransfield in the Volume ‘Constituent Materials’; and “Concrete construction for liquid retaining structures” by Tony Threlfall in the volume 'Processes'.
Another important source is the e-book “Understanding Cement” by Nick Winter.
Other sources have been used as well to increase understanding but not quoted unless acknowledged.

Concrete is.

Concrete is aggregate of various sizes, sand, cement and water. It might also have cement substitute and chemicals such as water reducing agent.

These can be in any number of proportions some of which would be very porous and some very dense.

Waterproof concrete is a dense mix of aggregate, sand and cement. It is made denser than C35 with extra sand, a lot of extra cement to act as a filler and limited water which would otherwise push the solid ingredients apart to make space for itself.

A cubic metre of C35 might have 950kgs of stones, 900kgs of sharp sand, 200kgs of cement, 55% water, so 110litres(kgs), and a little WRA.

This totals 2260kgs and there will be some air allowed to complete the cubic metre.

A cubic metre of waterproof concrete might have the same 950kgs of stones but extra sand, say 1000kgs, 350kgs of cement and only 45% water – which is actually more – 157.5 litres(kgs).

This totals 2457.5kgs and any air should be removed during compaction.

<u>The concrete mixes we will compare.</u>

So create 3 pictures in your mind's eye: waterproof concrete, C35 and C35 with extra water added on site against the rules.

<u>What goes on in these concretes?</u>

1. Waterproof concrete.

In the waterproof concrete there is enough sand to completely fill the spaces between the stones. There is enough cement to completely fill the spaces between the sand and, although there is more water, there is less water to coat each grain of cement.

So, to begin with, all the cement grains are wet all over and just touching each other rather like mixed marbels in a jar. The spaces in between are filled with water.

In due course (this will be after the concrete is placed and compacted) the surface of the cement dissolves in the water close to it, forming gel. The gel takes up slightly more room than was taken by the water and cement now forming it, so gel is forced into some of the larger space still containing water.

Hours later the gel turns to crystals. Crystals have less water than gel so water is released. By now the remaining water is able to dissolve the new surface of the cement revealed after the first surface gelled and turned to crystals. Again gel is forced out into the water-filled spaces and become crystals.

Any water still in the spaces is able to react with any remaining cement but it has trouble getting through all the densely intertwined crystals, so the rate of reaction is far slower.

But what we already have is a single skeleton of crystals surrounding what remains of every cement grain and every space between grains of cement has become severely restricted. If you took away the cement remaining it would be like an Aero chocolate bar. Continuous chocolate full of bubbles.

The crystals have locked on to the aggregate and sand as well.

2. C35.

In comparison, our C35 mix has insufficient sand to fill all the space beteen the stones, insufficient cement to fill the space between the sand and extra water filling the extra spaces.

So, when the cement begins to dissolve more dissolves at once because their is more water available for each grain and more space for gel to form and crystalise.

The skeleton formed out of crystals is not as neat or complete so, although after any period more cement in C35 has crystalised – become concrete, it is not as strong a structure and the spaces between grains are quite open.

3. C35 but with water added on site.

We can also picture the worst mix, C35 that the workmen wetted up with more water. The water-filled spaces are bigger so that when gel from one grain oozes out it might not mix with gel from its neighbour. In this way, poor concrete with either little cement or too much water, is very weak and porous.

Porosity.

Let us now consider porosity. How easily water might be pushed through under pressure. For instance water outside a basement wall.

The wetted up C35 is full of water anyway. So water will flow through easily.

The C35 is denser but there is still inter-connected water, so, under pressure, water would be pushed through. However, above ground, C35 properly placed and compacted does shrug off rainwater quite well.

I have explained that, in waterproof concrete, water struggles to even travel the microns through crystals to get to more cement but there are still very narrow routes between crystals with water in them.

The result is that water under pressure can be forced through (waterproof concrete without chemicals*) in tiny amounts: so tiny that if it was a sewage plant you would not see the water on the outside because it would dry off.
*BS 8007:1987. 'Code of practice for design of concrete structures for retaining aqueous liquids'

Therefore, if the same concrete was used for a basement, the basement would seem damp.

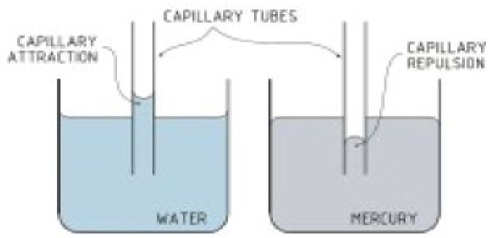
Capillary action.

More important in the basement situation is that the very fine pores between the cement crystals act as capillary tubes.

So while waterproof concrete without chemicals is good enough to stop much water being pushed through, the issue of water being pulled in is much worse and the concrete will remain damp inside.

The answer has been around a long time. Capillary action can be reversed by any suitable additive that makes the inside of concrete 'unwetable'.

This simple sketch shows the difference between mercury and water with the same tube pushed in.



Something is needed to line the pores in the concrete to repell, instead of attract, water. Sika and Pudlo have been using processed animal fat for 100 years. Caltite uses bitumen. BASF uses something much more modern (and secret), Xypex does not seem to bother. Many smaller brands (e.g. Ronafix and Feb) use SBR.

Super plasticiser.

All the major brands also incorporate a modern super plasticiser that gives the workability of 60% water with only 45% water. So their concrete is easily compacted so that all the cement grains touch.

The capillary-reversing chemicals also block the pores that little bit more to make concrete watertight under pressure.

Chemical resistance.

Chemicals deliterious to reinforced concrete are either those that attack the concrete or those that attack the steel.

Anything that can attack steel needs to be dissolved in water to do so (mostly road salt and oxygen). By keeping out the water on the surface good C35 and waterproof concrete protect the steel. C35 for 60 years, waterproof concrete indefinitely.

The other chemicals that attack the concrete do so at the surface. These are mainly sulphate in aggresive ground and sea water and carbon dioxide. The solution here, no matter what the concrete, is to add PFA or GGBS to the cement so that when cement is eroded the chemical will quickly expose a surface of alternative material it cannot attack, and the structure is protected.

PFA or GGBS in waterproof concrete.

But note that PFA and GGBS are waste products from other hot industries. They are glassy surfaced silicates that in the presence of slaked lime (present in cement reacting with water) they join in the crystalisation processes. But it has been found that only the glassy surfaces react. Their hollow, klinker cores remain complete so if their is much of either in concrete, in places they will connect together creating a route through for water.

Shrinkage Cracking.

Whilst there are other causes of cracking during the initial curing period, hardened concrete mostly cracks only because excess water dries off creating a vacuum void that, in places, creates a tension so strong within that concrete cracks.

The C35 with extra water will crack.
The C35 might never crack.
The waterproof concrete, with the least water in the first place, will never crack.