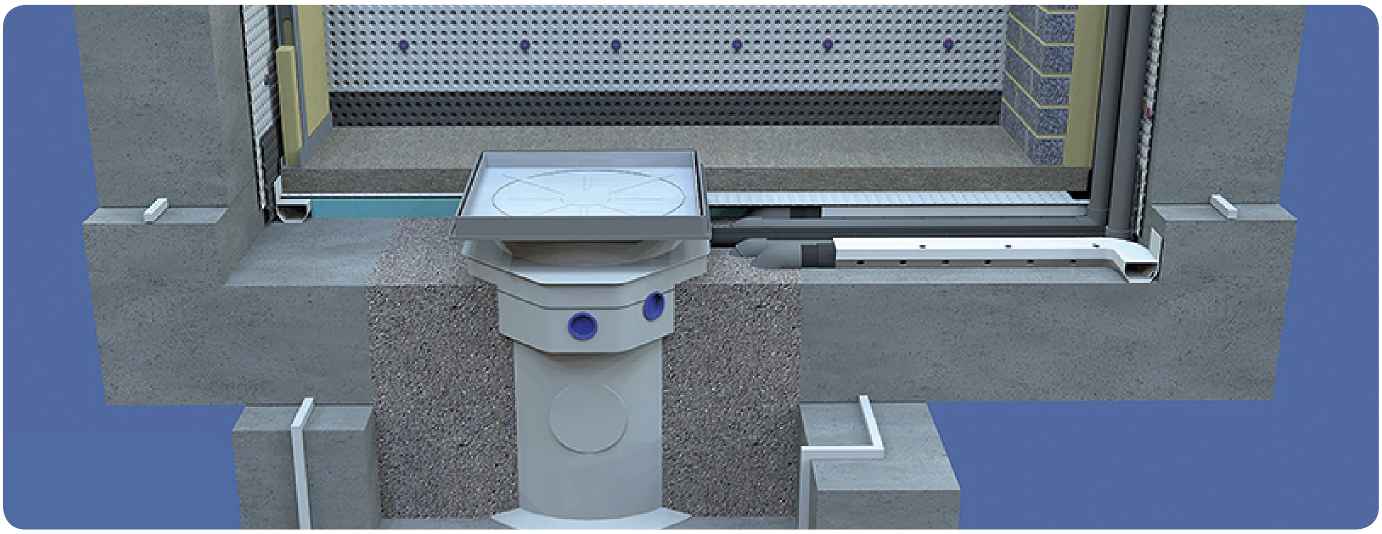
TECHNICAL ARTICLE

Insulation as a Spacer in Type C Systems

Practical and Technical Considerations



ARTICLE - INSULATION IN TYPE C SYSTEMS

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1. Introduction

There continues to be debate over the use of XPS insulation as the spacer within Type C cavity drain waterproofing systems (CDM) where drainage channels are placed above the raft/slab of the basement.

This paper attempts to introduce readers to the concept behind waterproofing drainage channels, explaining both the downfalls of non-maintainable systems without dedicated drainage channels, and the science behind the maintainable drainage channel method, with the aim of dispelling any confusion that may exist.

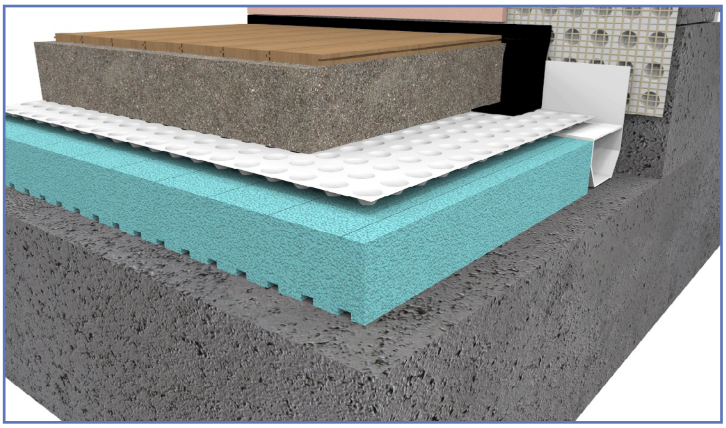

Figure 1: Closed-cell insulation correctly used as the spacer within a Type C cavity drain membrane waterproofing system

1.1 The History Of Drainage Channels

Perimeter drainage channels were first introduced in the UK in 1997, and it quickly became apparent that the ability to capture water at the point where it enters the structure with high volume drainage channels was much safer and offered many design advantages.

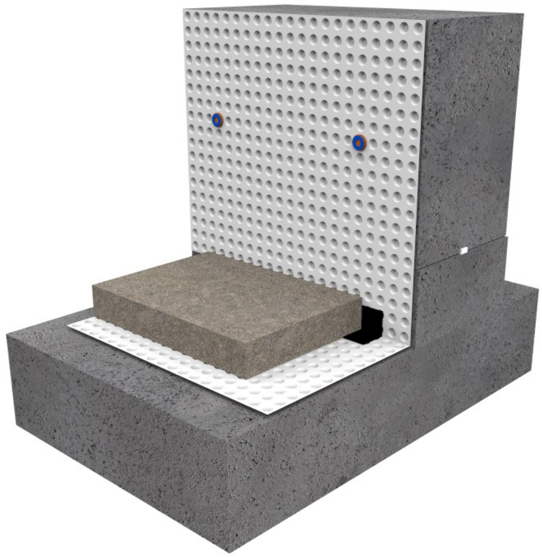

Figure 2: A Type C system pre-drainage channels, with the floor membrane the only drainage medium

This was in comparison to having the water entering the structure at the same weaknesses and moving it across the floor to the collection sump, which in many cases was not laid to a fall and, at best, included only very rudimentary attempts to assist the movement of water to the sump.

In cases where drainage channels are not used, and on a concrete slab with standard undulations of +/- 10mm, water will often struggle to reach the collection point due to the fact that the only drainage medium is the 8mm or 20mm floor membrane, which is effectively rendered useless by the undulations in the slab.

Since the use of 50mm deep drainage channel became established from approximately 2001, the incidence of failures of Cavity Drain Membrane Systems have greatly reduced, as the channels ensure that even with an undulating floor, water still has a minimum drainage depth of at least 50mm that allows it to move quickly and efficiently to the removal point.

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2. The Dangers Of Non-Maintainable Systems

2.1. Non-Maintainable Type C Systems

In the waterproofing industry there remains a common argument that Type C systems without dedicated drainage channels can be maintainable. The argument is based around the idea that, although such cavity drain systems rely purely on the shallow void between the floor membrane and the slab/raft in order to move water to the removal point, it is still maintainable because the final pipe connection into the sump is still accessible.

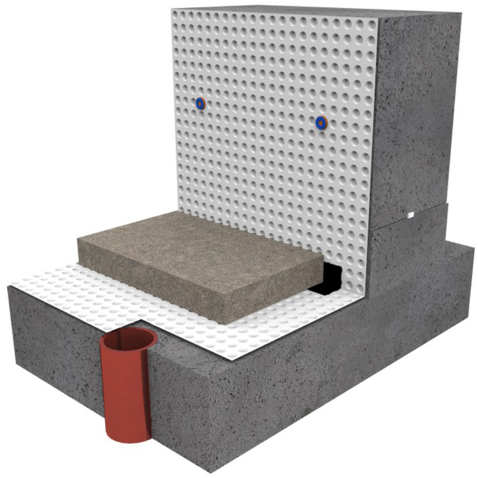

Figure 3: A non-maintainable Type C system with no drainage channels

Whilst we would agree that the final pipe connection is accessible in such scenarios, it certainly does not grant sufficient access to the drainage medium itself, i.e., the entire drainage surface area between the floor membrane and the slab. Using this pipe connection alone would therefore make it impossible for a floor to be inspected, cleaned or jetted if the need arose.

Where the Type C waterproofing system does not include drainage channels, as described above, it cannot be fully maintainable, and will fall short of the key recommendation outlined within section 10.3.1 of the British Standard for waterproofing – BS 8102:2009 – that Type C systems should be maintainable.

2.2. The Dangers Of Draining Across The Floor

Where non-maintainable systems rely on the void between the floor membrane and the slab/raft acting as the drainage medium, the water must naturally take a longer and slower path from the point of ingress across the floor to the removal point. This slow and often stationary water between the membrane and the concrete therefore creates a major issue, causing a chemical reaction that pulls unused sodium hydroxide and calcium hydroxide from the concrete below, which reacts with carbon dioxide in order to form calcium carbonate - otherwise known as limescale.
In many cases this limescale build-up can be sufficient to totally block the void beneath the floor membrane, consequently leading to a system failure as the entire drainage medium disappears.

Figure 4: When limescale completely blocks a Type C system, leading to complete system failure

Because in such situations the drainage conduit IS the membrane void, the only way to remedy such a blockage is to completely pull up the membrane and start again.

It is because of such failures that building insurance companies require Type C systems to include maintainable channels and why BS 8102:2009 recommends that Type C systems are always maintainable.

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Overall, a correctly designed Type C system that includes drainage channels is safer because:

- The water within the channels is not directly in contact with the concrete slab/raft;
- The channel is much deeper. At 50mm plus the depth of the floor membrane, a significantly greater build-up of limescale would be required to stop the water. Furthermore, the greater visibility of the channel space also increases the chance of an issue being identified at a service;
- The channel system can be inspected and cleaned without significant disruption and, in most cases, without the need to remove the whole system.

2.3. Falls & Slopes

Draining across the slab/raft would be much safer if there was a fall or slope to ensure that there was no chance of water remaining standing between the floor membrane and the concrete.

However, there are numerous drawbacks to this technique, despite the fact that it at least gives the water a chance to move to the collection point. Firstly, as explained in section 1.2, if a failure were to occur then, due to the fact that the system is not maintainable, the only remedy is to rip it all up and start again, meaning that it also fails the British Standard requirements.

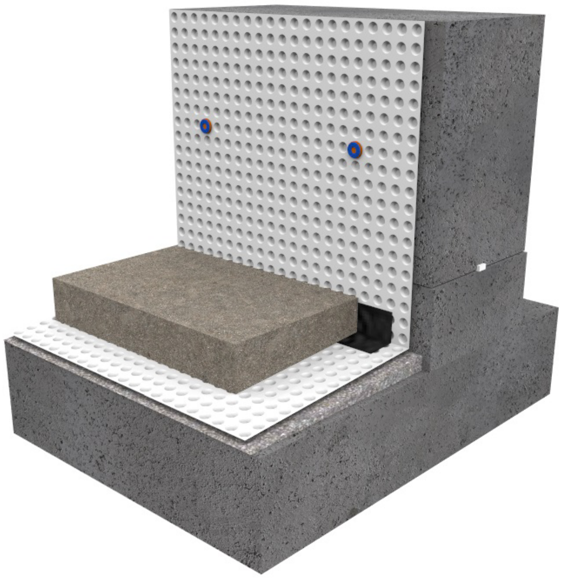

Figure 5: Type C systems can be designed with a fall/slope to manage the water, but this can be difficult and costly

Furthermore, the process of thickening a slab in order to create a fall or slope is a difficult and costly practice, that can often add significant material and labour costs to a project, in the form of:

- The cost of the extra concrete and screed that is required, especially in a large structure. For example, if the slope of the slab rises by 100mm, then the screed also needs to be thickened by 100mm to take out the slope;
- The cost of digging the extra depth out of the ground. An extra 100mm of depth required in order to form the slope will also need to be dug out of the ground, and the earth will need to be removed and disposed of;
- The difficulty of forming a consistent slope using modern, liquid concrete that is often pumped at a low viscosity. Such attempts often become troughs that, instead of directing water, capture it in large puddles of standing water and actually contribute to the failure of the system.

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3. The Benefits of Type C Systems With Maintainable Drainage

3.1. Maintainability

Collecting, moving and discharging ingressing water within a perimeter drainage system, which includes strategically placed inspection ports, means that the cavity drain system becomes fully maintainable, as it can be inspected, cleaned and jetted at regular intervals. This maintainability is a key recommendation within section 10.3.1 of the British Standard for waterproofing - BS 8102:2009 - when it comes to Type C waterproofing systems.

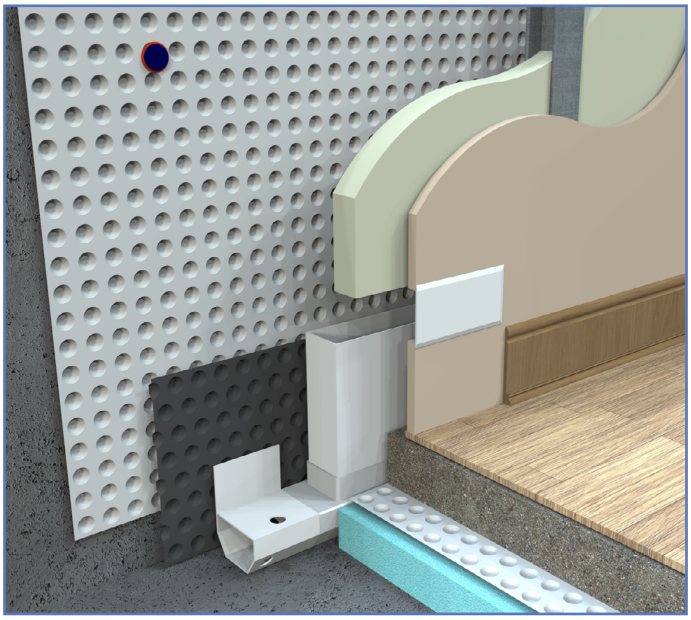

Figure 6: A Newton inspection port in a maintainable Type C system

The inspection ports supplied by Newton Waterproofing Systems and installed by Newton Specialist Contractors also have a typically larger cross-section than most alternatives currently specified in the waterproofing industry; some being up to 10 times smaller at their narrowest point. When it comes to inspection ports, a larger cross-section not only makes the identification and rectification of problems achievable, but also significantly improves the ability to maintain the CDM system.

3.2. Drainage Capability

The volume of water that the system can handle is measurable by carefully backfilling water from the sump to the full 50mm height of the channels, then monitoring the depth of water within the channels via the inspection ports.

In all cases where this test is performed, when the pumps are switched on, the volume of water reaching the sump is greater than that which the pumps are able to remove, initially giving the impression that the pumps are not working.

Using this method it has also been calculated that a system with 50 linear metres of 50mm channel is able to move 6 litres of water per second. The drainage channels are therefore able to deliver a greater volume of water to the sump than the pumps are capable of discharging, confirming that, even in cases where the structure is extremely porous, the limiting factor of a cavity drainage system is the pumping capability, not the drainage volume of the channels.

Finally, it is also extremely important to note that:

1. It is only through the use of channels that the drainage capacity of a Type C system be calculated and verified
2. The ability of the drainage system to remove large volumes of water has greatly reduced the incidence of failures common to systems where the drainage medium was previously just a 8mm or 20mm floor membrane.

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3.3. Should Channels Be Recessed Or Placed On The Slab/Raft?

Newton's Type C CDM System is actually able to support both methods, as the floor membrane remains at the same level relative to the drainage channel with either technique. However, where possible we would recommend placing the drainage channels on the slab/raft, and using XPS insulation as a spacer between the slab and floor membrane, due to a number of reasons:

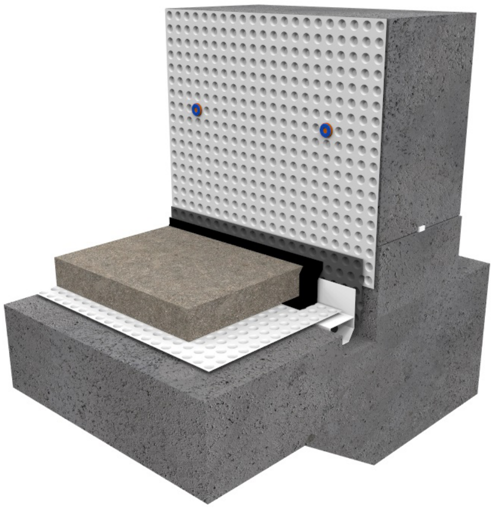

Figure 7: The drainage channel recessed into the slab

3.3.1. Simplicity Of Design

The engineer will very rarely design slabs and rafts that include a recess for drainage channels. In order to allow for a recess the engineer will need to:

1. Lower the steel by 50mm to ensure there is a correct amount of concrete cover, and;
2. Thicken the raft or slab to ensure that the required concrete thickness is maintained.

3.3.2. The Cost To The Client And The Environment

Thickening the raft/slab in order to allow for a recess will result in more earth being removed and disposed of, therefore increasing the cost to the client.

There will also be a significant increase in the amount of concrete required in order to thicken the slab by enough to accommodate the relatively small 50mm x 100m channels. This adds even more cost to the project and releases more of the greenhouse gases associated with concrete production into the environment.

In contrast, placing the channels on the slab and using insulation as a spacer requires no extra earth removal or concrete, and means that less insulation is required to meet the desired U-Value for the floor build.

3.3.3. The Ease Of Buildability

Using insulation boards as a spacer better meets the design requirements of BS 8102:2009 with regards to buildability, as they are extremely simple to install.

In contrast, recesses in concrete are much more difficult to accurately form, due to a number of reasons:

1. Firstly because the timber formers either float, or are not perfectly aligned and positioned. This can result in both practical and political difficulties for the contractor on site, as arguments ensue about whose responsibility it is to deal with a recess that is out of alignment, too shallow, or contains chunks of cured concrete as a result of the formers not being tightly abutted.
2. Secondly, the Groundworker will be required to produce a slab/raft that allows for a recess and therefore has the reinforcement steel 50mm lower than normal. In our experience, an unconventional and trickier build such as this has a much greater risk of inaccuracy.

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3. Thirdly, with raft construction there is no wall to position and fix the timber former to. The alternatives of tying the formers to the reinforcement steel or placing them into the fresh concrete and weighing them down are both extremely unreliable when you are looking to create a clean and accurate drainage channel recess.

4. Finally, if the timber formers have not correctly displaced the concrete then the last option is to mechanically remove it. This method is a time-consuming and labour intensive process however, and can often lead to less-than-satisfactory results due to the high costs involved.

In our experience, producing a well designed, well-placed, water-resisting concrete structure is hard enough without adding further complications. Instead of having to potentially deal with any of the issues outlined above, using the insulated spacer method allows all trades on site to proceed as normal.

3.3.4. Why Not Use The Screed As The Spacer?

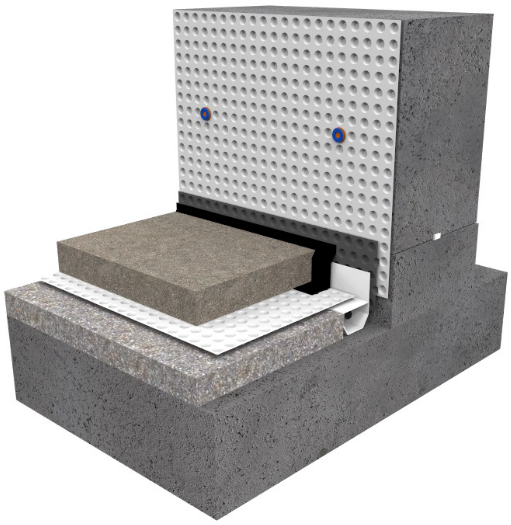

Figure 8: Using the screed as the spacer in a Type C system

Much like Section 2.3.2, using screed as a spacer would be both financially and environmentally costly, as cement production has a particularly high carbon footprint.

Furthermore, with only a nominal thermal resistance value of 0.41, the screed will barely contribute towards the thermal efficiency of the floor build, meaning that more insulation will be required above the floor membrane to in order to achieve the desired U-value. Unlike concrete, screed is also very porous and slowly breaks down during extended saturation, causing the thermal qualities to reduce even further.

Overall, when insulation boards can be used in exactly the same way, it is difficult to support the use of a material that by comparison is costly, difficult to place, environmentally unfriendly and thermally inefficient. By comparison, a thermally efficient insulated spacer is lightweight, quick to install, recyclable and, with a thermal resistance value of 0.035, is over 10 times more thermally efficient than screed.

3.4. What About Floatation?

If loaded by a screed above the floor membrane then there is no physical possibility that floatation of the insulation boards will lift the floor.

At 2 x the density of water, just 65mm of screed presses down with a force equivalent to 130mm of pressure. When we consider that even a fully charged 50mm drainage channel and 20mm floor membrane can exert a maximum of 70mm of water pressure upwards, the weight of the screed easily negates this, and no chemical bonding of the insulation to the slab is required.

Even if the pressure within a drained system were able to reach 80mm of water, at this point the 20mm floor membrane would fail at the joints, allowing the pressure to release and preventing any further pressure from building. Were it to reach this point it is also worth pointing out that the system has now effectively failed, and any further water will now lie on top of the floor membrane, adding further downward pressure.

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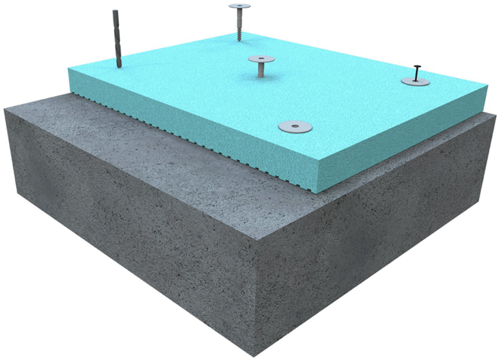

Figure 9: Closed-cell insulation boards can be easily fixed down in order to prevent floatation

3.4.1. What If There Is No Screed?

To use the example of a chipboard floor above the membrane, chipboard has a density which is only 0.72 the density of water. Therefore, if the chipboard is 18mm deep, it would only require 13mm of water within the drainage channels in order to float the floor.

In such scenarios however, there is a simple solution, which is to fix each insulation board to the floor with 5 plastic fixings to hold the insulation down. The downward pressure exerted by these fixings is substantially greater than the floatation force.

3.5. What If Water Passes Through The Slab/Raft?

It is very rare that water will pass through well-placed and correctly reinforced concrete floor slabs or rafts that have been designed to the EN 1992 standard for water-resisting structures, which is the recommendation of BS 8102:2009 for earth-retained or below-ground structures.

This is due to the fact that high quality concrete such as this is already inherently waterproof. Furthermore, the placement and compaction of concrete for a slab or raft is significantly easier than it is for a concrete wall, and as a result, defects such as honeycombing that are more common in walls, are extremely rare in slabs/rafts by comparison.

Whilst the situation may be different in a remedial scenario where a property is older and the concrete is not as high quality, it is still extremely rare for water to pass through the main body of concrete. This is due to the fact that water follows the path of least resistance, meaning that it is far more likely to enter the structure through a weakness at the wall/floor junction or a joint within the slab/raft, which is where the drainage channels are positioned in order to deal with it.

On the rare occasions that water finds a defect by which it passes through the main body of the slab/raft, any water that makes it into the structure will seep between the underside of the insulation and the imperfections of the slab to be released into the drainage channels. Newton Fibran XPS 500-C insulation boards also include a grooved lower surface in order to assist in the movement of this water to the drainage channels.

Even if the water is coming in more quickly, it will still follow the path of least resistance and rise between the abutting boards of insulation until the pressure is released by the floor membrane above, allowing the water to be harmlessly directed towards a drainage channel and removed.

The greatest risk of pressurised water entering through the slab or raft is at the construction joints. Even when these joints are waterproofed with waterbars and/or waterstops, they should be further protected with Newton Floordrain channels placed above the joint and connected to the rest of the drainage system.

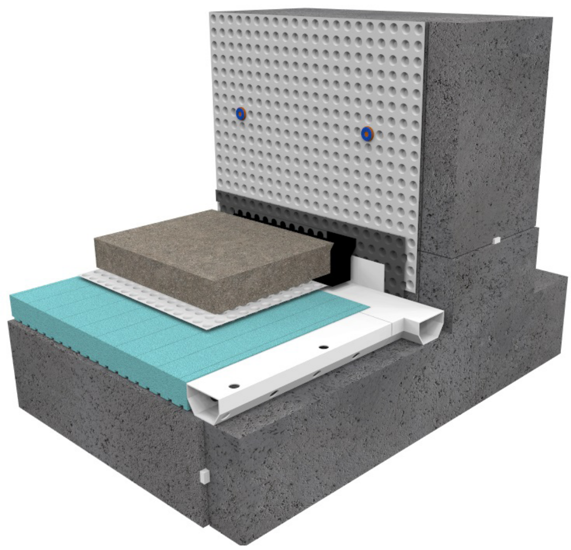

Figure 10: A comprehensive Type C system utilising closed-cell insulation and drainage channels to capture ingressing water

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3.6. Closed Cell Insulation

3.6.1. Will The Insulation Degrade?

Newton only recommends carefully selected, high density, closed-cell, extruded polystyrene insulation boards that will not degrade, even when permanently immersed in water below and around a structure. The Declaration of Performance for Newton Fibran XPS 500-C confirms the technical capabilities of this insulation.

Newton also possess letters from Kingspan, Fibran, Dow and Cellecta confirming the correct use of their XPS insulation boards within our waterproofing specifications.

3.6.2. Will The Insulation Deform?

Newton Fibran XPS 500-C has a compression rating of:

- 500 kPa (50 tonnes per square metre) to EN 826, which allows for 10% deformation
- 165 kPa (16.5 tonnes per square metre) to EN 1606, which allows for a maximum compressive creep of 2% over a 50-year period.

Newton considers that deformation of up to 10%, as allowed by EN 826, is too much for a structure to endure. As such, we use the higher performance figure of 2% compressive creep, outlined by EN 1606, as the maximum allowed.

Because the cuspated profile of the cavity drain membranes means that the lower surface area of the membrane is approximately 10% less (depending on the specific membrane used) than the upper layer, the load from above the membrane is also not distributed evenly through onto the insulation. As a result, Newton's membrane data sheets explicitly state that the maximum safe load to be placed over the 508R floor membrane in order to comply with EN 1606 is 16.5 kPa (1.65 tonnes per square metre). If the load is to be higher than this, either an alternative insulation such as Foamglas should be used, or another method devised to safely transfer the load to the slab or raft.

Newton has also used a third-party testing company to independently test the compression of the Newton Fibran XPS 500-C when used beneath floor membranes. The independent testing showed that even with 25 kPa loaded through the Newton 508R onto the Fibran XPS 500-C, the compression of the insulation is only 0.91mm over 50 years, which is still less than the 2% permitted by EN 1606, and so the insulation is fully compliant. The test data and supporting DoP are available from Newton Waterproofing by request.

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3.7. Insuring Type C Waterproofing

The benefits of maintainable drainage channels are supported by many of the major insurance providers in the construction industry.

Because it is not possible to properly maintain and recover Type C systems without serviceable drainage systems, and because of the number of failures of these systems, Type C waterproofing without drainage channels are not accepted by two of the three main building insurance companies, and Newton also understand that a third insurer is currently reviewing their policy on the matter as well.

4. Conclusion

Although other companies and suppliers may contest the use of insulation and drainage channels within Type C systems, based upon the comprehensive evidence presented within this paper, the expert opinion of Newton Waterproofing Systems is that if a contractor, specifier, developer or homeowner is looking for a Type C waterproofing system that is, at the very least, maintainable, compliant with the British Standard, and can be underwritten by an insurer, then drainage channels are an absolute necessity.

Beyond this, the further benefits provided by installing a drainage channel system that utilises XPS insulation as a spacer are numerous and wide-ranging, from design simplicity and financial and environmental savings, to the ease of buildability and energy efficiency improvements. The overall effect being that such a system will deliver benefits to every member of the construction team, from the architect to the installer to the end client.

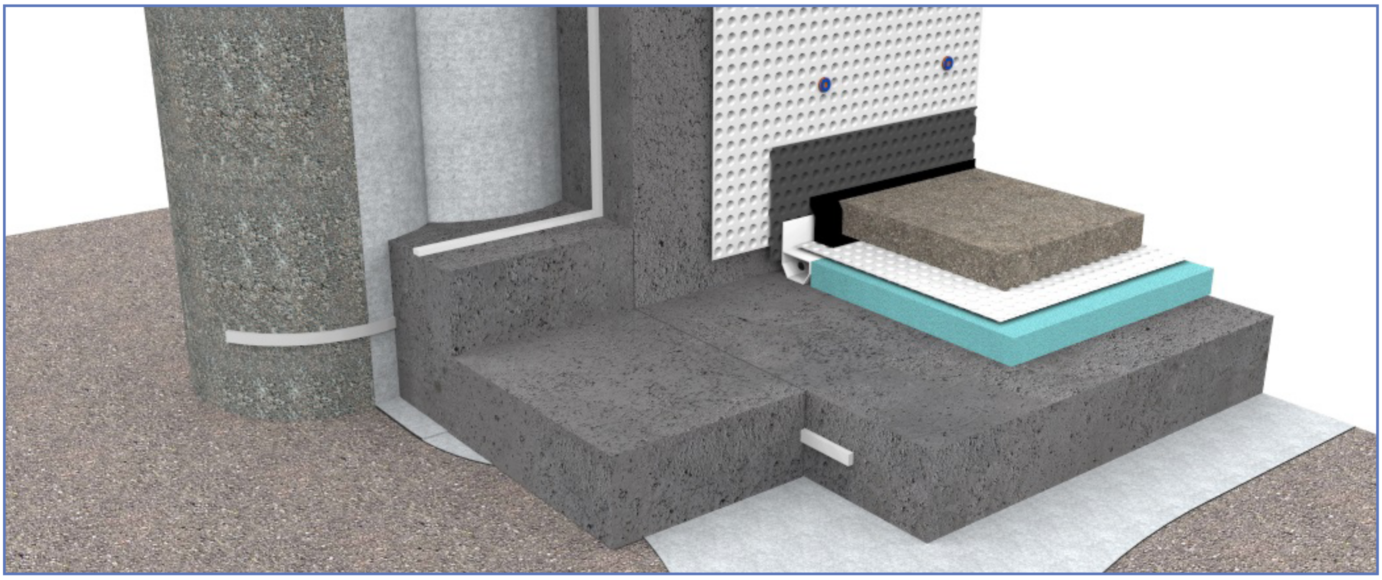

Figure 11: For comprehensive protection in line with BS 8102:2009, combining Type A protection externally, Type B protection as an integral part of the structure, and Type C protection internally with closed-cell insulation and correctly installed drainage channels will give the greatest chance of success

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