KINGKRETE® We Create Future ACADEMY

CPD SEMINAR CPD-WP-BS-01

Waterproofing Below Ground: Grades, Protection Types and Combined Systems

Designing basements that stay dry: grades, ground risks, materials, details and verification

1.0 LEU | AIA LU|HSW | 60 MIN | PRACTITIONER

RIBA core curriculum · Design, construction and technology



BEFORE WE START

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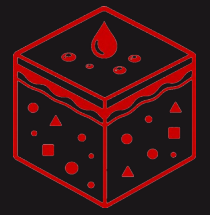
Questions about specific products or services are answered after the course, outside the time that earns credit.

Why this matters

Below-ground spaces are costly to repair once occupied, and most leaks trace back to a wrong groundwater assumption or a poorly made detail.

This course explains how BS 8102 grades and ground conditions set the design, compares barrier, structurally integral and drained protection, reviews sheet membranes and bituminous, cementitious and crystalline coatings, and covers the joints, sequencing, protection, testing and repairs that keep a basement dry.

FOR Architects, structural and geotechnical engineers, specifiers and contractors



CREDIT

1.0 LEU · AIA LU|HSW

RIBA TOPIC

Design, construction and technology

LEVEL

Practitioner

FORMAT

Live, in-office or self-paced

ASSESSMENT

10 questions, 80% to pass

LEARNING OBJECTIVES

By the end of this course you will be able to

01

Explain

the grades of protection for below-ground spaces and how groundwater, ground chemistry and intended use set the design

02

Compare

barrier, structurally integral and drained protection, and decide when to combine them

03

Select

barrier materials, including bonded sheet membranes, bituminous coatings and cementitious and crystalline coatings, for positive-side and negative-side application

04

Specify

the details, sequencing, protection and inspection that decide whether a below-ground structure stays dry

HSW

HSW

HSW

AGENDA

How the next 60 minutes run

01	Water, ground and grades	LO1	11 min
02	Types A, B and C	LO2	11 min
03	Choosing barrier materials	LO3	11 min
04	Combined systems and details	LO2, LO3, LO4	11 min
05	Protect, inspect and remediate	LO4	11 min
Q	Knowledge check and summary	LO1–LO4	5 min

01

MODULE 01 · 11 MIN · LO1

Water, ground and grades

How groundwater, ground chemistry and intended use set the design

What a basement has to hold back

01

Hydrostatic pressure

Groundwater pushes on walls and slab at about 10 kPa per metre of head, forcing water through any defect.

02

Seasonal and tidal water

Perched water, storm runoff and tidal swings can lift levels well above a single borehole reading.

03

Ground gases

Radon and methane migrate through soil and enter by the same cracks and joints that let water in.

04

Aggressive chemistry

Sulfates and chlorides in soil and groundwater attack concrete and corrode its reinforcement.

05

Vapour and condensation

Even a structure with no liquid leaks passes moisture vapour that must be managed for sensitive uses.

Pressure grows with every metre of depth

10 kPa

Approximate water pressure per metre of head (about 1.45 psi)

80 kPa

Pressure at the base of an 8 m basement with water to ground level

8 t/m²

Approximate uplift on the slab from that same 80 kPa head

Pressure acts on every square metre of wall and slab, all the time. A barrier that holds at 2 m of head may not hold at 8 m, and uplift must also be resisted structurally.

Three grades of protection set the target

Grade	Performance expected	Typical uses
Grade 1	Some seepage and damp areas tolerable; local drainage may be needed	Car parking, plant rooms without electrical equipment
Grade 2	No water penetration; damp areas from external moisture tolerable	Plant rooms and workshops needing a drier space, storage
Grade 3	No water penetration; ventilation, dehumidification or cooling needed	Homes, offices, retail, leisure and controlled-environment stores

The grade describes the internal environment the client needs, not a waterproofing product. Agree it in writing at brief stage.

What the ground investigation must tell you

01	**Groundwater level over time**	Readings from monitored standpipes across seasons, not one reading on the day of drilling.
02	**Soil permeability**	Clays hold water against walls; sands and gravels deliver large flows to any defect or drain.
03	**Ground chemistry**	Sulfate, chloride and pH results that set the concrete exposure class and membrane choice.
04	**Ground gas**	Radon potential, and methane or carbon dioxide from made ground, landfill or organic soils.
05	**Contamination and flooding**	Hydrocarbons that attack some membranes, and surface water routes that can flood backfill.

Hot, coastal ground raises the stakes

01

Shallow saline water

Coastal plains often hold groundwater within a few metres of the surface, close to sea level.

02

Sulfates and chlorides

Saline soils and salt flats carry both, so concrete and reinforcement face combined attack.

03

Salt build-up

Capillary rise and evaporation concentrate salts near ground level and at the base of walls.

04

Heat on site

High temperatures shorten working times for coatings and soften bituminous products.

05

Tides and dewatering

Levels can swing with tides near the shore and rise quickly when temporary dewatering stops.

DESIGN ASSUMPTION

Assume water to full height

Unless long-term monitoring proves otherwise, design for groundwater at the full retained height. Water tables rise, drains block and backfill fills like a bath; a basement designed for today's reading is designed to leak.



Five decisions that shape the design



Agree the use

Confirm what each space will be used for now, and its likely future uses.

Set the grade

Assign grade 1, 2 or 3 to each zone and record it in the brief.

Assess the ground

Water level, permeability, chemistry and gas from the investigation.

Choose protection

Select Type A, B, C or a combination to suit the grade and risk.

Detail and verify

Design joints and penetrations, then define tests and hold points.

BS 8102 expects a waterproofing design specialist to be part of the design team from the outset.

One borehole reading put water 4 m below ground. The basement is 7 m deep. What head should the design assume at formation?

A 3 m, measured from the recorded water level

B 7 m, the full retained height

C 4 m, measured from ground to the water level

D None, because water lies below the ground surface

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WHY With only one reading and no long-term monitoring, assume water can rise to the full retained height, giving roughly 70 kPa at formation.

02

MODULE 02 · 11 MIN · LO2

Types A, B and C

Barrier, structurally integral and drained protection compared

THREE TYPES

Three ways to keep water out

01

Type A – barrier

A membrane or coating applied to the structure that stops water passing through it.

02

Type B – integral

The concrete itself, designed, mixed, jointed and cured to resist water penetration.

03

Type C – drained

Water that gets through is collected in a cavity and drained or pumped away.

SIDE BY SIDE

Comparing Types A, B and C

Aspect	Type A barrier	Type B integral	Type C drained
Principle	Stops water at a membrane or coating layer	Watertight concrete with controlled cracking and sealed joints	Accepts some ingress, then collects and removes it
Main dependency	Continuity of the barrier and its details	Mix design, crack control and joint detailing	Drainage, pumps, power and maintenance
Access to repair	Often hidden once backfilled or cast against	Injection from inside at cracks and joints	Good: channels and sumps reachable inside
Key risk	Damage during backfill, or a poor lap or detail	Cracks wider than designed, poorly formed joints	Pump failure, blocked channels, lime build-up
Ongoing care	Little once buried	Little beyond monitoring for leaks	Scheduled servicing for the building's life

No type is automatically best. Each fails in a different way, which is why combining them adds real resilience.

Tightness classes in EN 1992-3

01	**Class 0**	Some leakage acceptable, or leakage of liquids irrelevant to the use.
02	**Class 1**	Leakage limited; some damp patches allowed. Through-cracks typically limited to 0.05–0.2 mm.
03	**Class 2**	Leakage minimal; appearance not impaired by staining. Through-cracks avoided or sealed.
04	**Class 3**	No leakage permitted; generally needs special measures such as liners or prestress.

What makes concrete watertight

01

Low-permeability mix

Low water–cement ratio and adequate binder, often with a permeability-reducing admixture.

02

Crack control

Reinforcement and pour sequence designed to limit early thermal and shrinkage cracking.

03

Sealed joints

Waterbars, swelling strips or injection hoses at every construction and movement joint.

04

Compaction and curing

Full compaction and sustained curing; honeycombing and cold joints become leak paths.

05

Cover and durability

Cover and concrete class matched to the sulfate and chloride exposure of the ground.

Drained systems live or die by their pumps

2+

Pumps per sump: duty and standby, each sized for the design inflow

24/7

High-level alarm and backup power, so failure is noticed and survived

Annual

Typical minimum servicing interval for pumps, channels and sumps

---

A drained system never stops working, so it must never stop being maintained. Provide access points to flush channels, treat free lime and plan for pump replacement.

Single type versus combined protection

Single type

- Simpler to design, build and coordinate
- Lower first cost and fewer trades on site
- One defect can lead straight to a leak
- Reasonable where grade and water risk are low

Combined types

- Two independent lines of defence
- A defect in one is caught by the other
- Advised for grade 3 or high water tables
- Needs compatible materials and clear responsibility

Combined systems only help if each layer is designed to work on its own, not as a partial back-up.

DESIGN PRINCIPLE

Higher consequences need a second line

Where a leak would be costly or hard to fix, such as homes or archives below a high water table, combine protection types so that no single defect, crack or pump failure lets water into the space.

A Type C cavity drain lining is proposed for a grade 3 basement that depends on pumping. Which provision is essential?

A A single large pump sized for twice the inflow

B A bonded membrane on the inside face of the cavity

C Sealing access points so the finishes stay clean

D Duty and standby pumps, an alarm and maintenance access

QUICK CHECK · LO2 · ANSWER

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D — Duty and standby pumps, an alarm and maintenance access

WHY A drained system depends on continuous pumping. Duty and standby pumps, an alarm with backup power and access for servicing make failure unlikely and noticeable.

03

MODULE 03 · 11 MIN · LO3

Choosing barrier materials

Sheet membranes and coatings for positive- and negative-side use

Positive side versus negative side

Positive side (wet face)

- Applied where water arrives, on the outer face
- Water pressure presses the barrier onto the structure
- Protects concrete and reinforcement from the ground
- Needs working space or pre-applied installation
- Hard to reach once backfilled or cast against

Negative side (dry face)

- Applied on the inner face, away from the water
- Water pressure tries to push the barrier off
- Concrete stays wet and exposed to the ground
- Useful in refurbishment or with no outside access
- Needs a strongly bonded or penetrating material

The main barrier material families

01

Bonded sheet membranes

Factory-made sheets of modified bitumen or polymer, bonded to the structure or to fresh concrete.

02

Bituminous coatings

Polymer-modified bitumen emulsions or solutions applied in coats; for the positive side.

03

Cementitious coatings

Rigid or polymer-modified flexible slurries bonded to concrete; some resist negative pressure.

04

Crystalline coatings

Cement-based slurries whose active chemicals grow crystals within the concrete's pores.

05

Liquid membranes

Cold-applied polyurethane, polyurea or similar, forming a seamless bonded film.

Pre-applied versus post-applied membranes

Pre-applied (blindside)

- Fixed before concreting, on blinding or piled walls
- Concrete cast against it bonds to the membrane face
- Suits secant piles, sheet piles and tight boundaries
- Cannot be inspected once the concrete is placed
- Must be protected from rebar fixing and traffic

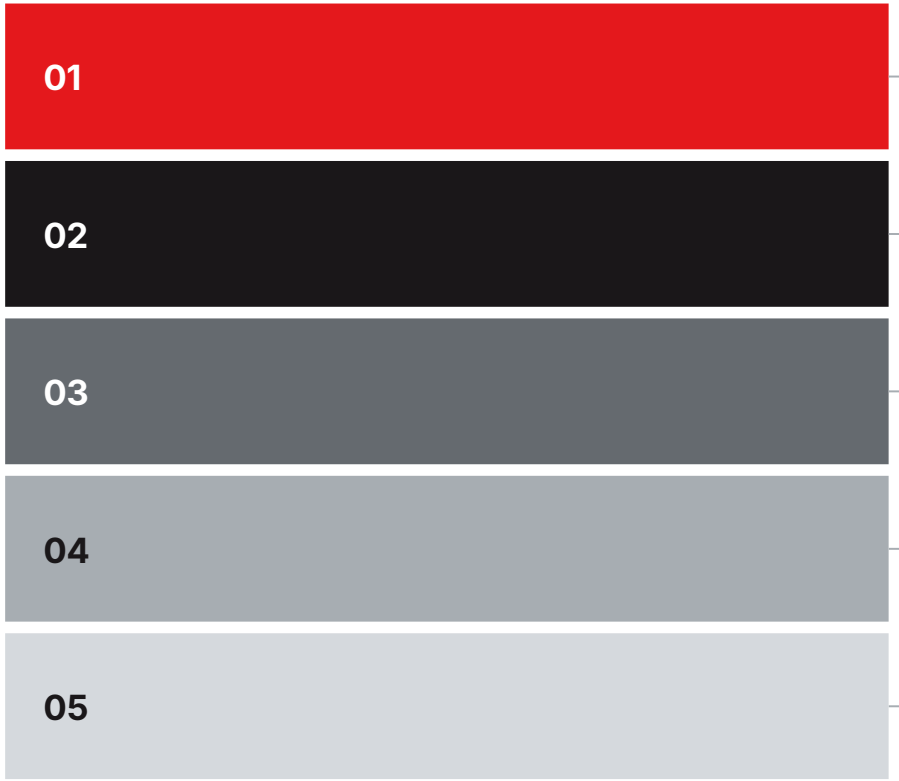
Post-applied

- Applied to the outer face of the cured structure
- Needs excavation and working space beside walls
- Can be inspected and tested before backfilling
- Substrate must be clean, sound and suitably dry
- Needs protection board before backfilling

Water travels under an unbonded membrane

A loose-laid sheet lets water entering at one defect run between membrane and concrete until it finds a crack or joint, often metres away. A fully bonded membrane keeps the leak at the defect, so it is far easier to find and fix.

Typical post-applied wall build-up



Granular backfill
Placed and compacted in layers, free of sharp stones and debris against the wall.

Drainage or protection board
Shields the membrane from backfill and relieves water pressure at the face.

Bonded membrane
Sheet or liquid-applied, lapped and detailed continuously into the slab junction.

Primer
Matched to the membrane; binds dust and improves adhesion to the concrete.

Reinforced concrete wall
Sound, clean face with tie holes filled, fins removed and corners prepared.

Terminate the membrane typically 150 mm above finished ground and protect its top edge from sunlight and water entry.

Matching coatings to the face and the water

01	**Bituminous coatings**	Positive side only; flexible, but soften in heat and dislike solvents and hydrocarbons.
02	**Rigid cementitious**	Strong bond to sound concrete; can resist negative pressure but will not bridge new cracks.
03	**Flexible cementitious**	Polymer-modified to bridge fine cracks; confirm any negative-side rating before use there.
04	**Crystalline coatings**	Positive or negative side; seal pores and fine cracks in damp concrete; not crack-bridging.

How crystalline coatings seal concrete



Apply to damp concrete

Slurry brushed or sprayed onto a saturated, open-pored, prepared surface.

Chemicals diffuse

Active chemicals migrate into the capillary pores, carried by moisture.

Crystals form

They react with lime and unhydrated cement to form insoluble crystals in the pores.

Fine cracks self-seal

If water later enters a hairline crack, renewed growth can seal it again.

Cure and protect

Keep damp while curing; protect from rapid drying, frost and early traffic.

Self-sealing is typically limited to hairline cracks of about 0.4 mm. Wider or moving cracks need injection or joint details.

A refurbished basement has no external access and damp walls under low head. Which barrier best suits the internal face?

A A crystalline coating on the prepared, damp concrete

B A self-adhesive bituminous sheet on the inside face

C A bitumen emulsion coating brushed on the inside face

D A post-applied sheet on the outside, from the inside

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WHY On the negative side, water pressure pushes surface barriers off. Crystalline coatings work within damp concrete pores, so they suit internal application.

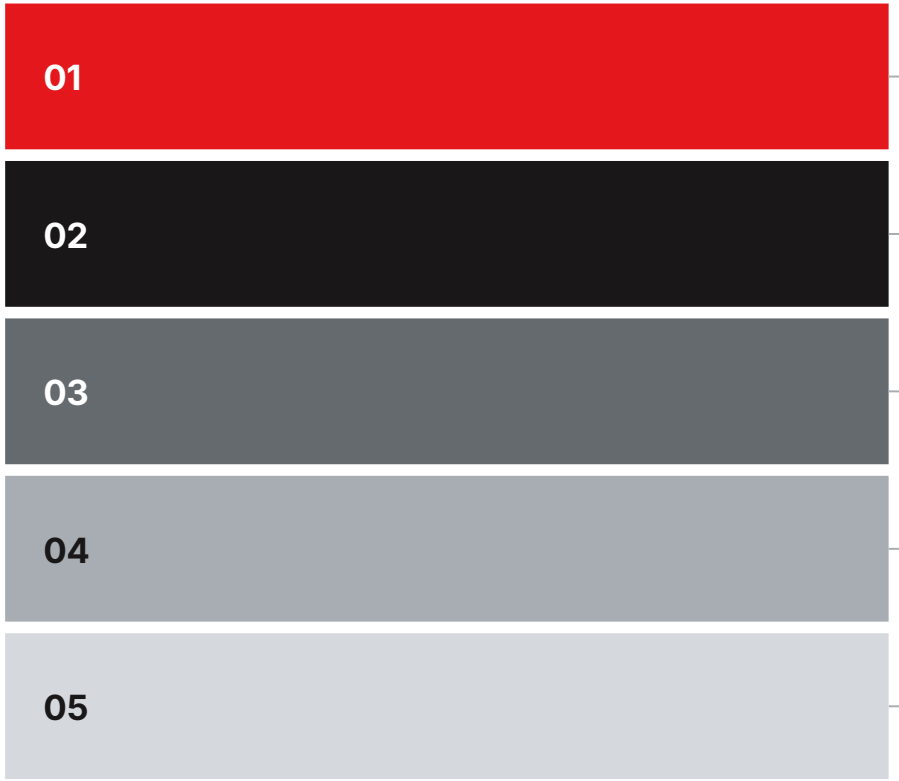
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MODULE 04 · 11 MIN · LO2, LO3, LO4

Combined systems and details

Putting protection types together and detailing the weak points

Pre-applied membrane under a raft slab



Reinforced concrete raft
Cast directly onto the membrane so the concrete bonds to its surface layer.

Bonding surface layer
Granular or adhesive face that keys mechanically into the fresh concrete.

Membrane carrier sheet
Polymer sheet forming the waterproof barrier, with laps taped or sealed as specified.

Blinding concrete
Smooth, level surface, typically 50–75 mm thick, free of sharp edges and ponding.

Prepared formation
Compacted sub-base, with a gas venting or drainage layer where the design needs it.

Return the membrane up the pile wall or formwork and protect laps until the concrete is placed.

WORKED EXAMPLE

Choosing protection for a coastal basement

THE BRIEF

Use

Two levels: car park, plus residents' gym, storage and plant rooms

Depth

8 m to formation, secant piled walls on the site boundary

Groundwater

Saline, about 2 m below ground, tidal influence, high sulfates

Grades

Grade 3 for gym and storage, grade 2 for plant, grade 1 for parking

01 **Design head**

Assume water to full height: about 80 kPa at formation, plus uplift on the raft.

02 **Type B structure**

Concrete to EN 1992-3 class 1, sulfate-resisting mix, waterbars at every joint.

03 **Type A barrier**

Pre-applied bonded membrane under the raft and on the piles, as there is no outside access.

04 **Type C for grade 3**

Cavity drain lining with duty and standby pumps behind the gym and storage.

05 **Verify and hand over**

Hold points on membrane and joints, leak checks, and a pump maintenance plan.

Kickers and construction joints

01

Kickers

Cast with the slab where possible; well compacted and free of laitance, or use a kickerless system.

02

Waterbars

External or centrally cast PVC or rubber bars, continuous and welded at junctions.

03

Swelling strips

Hydrophilic strips that expand when wet; need confinement and protection from early rain.

04

Injection hoses

Cast into the joint so resin can be injected later if a leak appears.

05

Joint preparation

Remove laitance, expose aggregate and clear debris before the next pour.

Sealing pile heads through the slab

01	**Cut back and clean**	Trim to sound concrete, remove contaminated material and wash the pile head.
02	**Treat the pile head**	Apply a crystalline or cementitious slurry across the head and down its sides.
03	**Seal the bars**	Fit swelling sealant or collars round projecting bars where they enter the slab.
04	**Lap the membrane**	Dress the slab membrane to the pile with a compatible detail, not tape alone.

Penetrations and service entries

01

Plan and group

Fix positions and cluster entries before the pour; avoid coring through walls later.

02

Puddle flanges

Cast-in flanges on pipes lengthen the water path and anchor the sealants.

03

Swelling collars

Hydrophilic collars fitted round pipes before concreting seal the interface.

04

Sleeves for movement

Sleeves let services move without tearing the barrier; seal the annulus.

05

Membrane collars

Preformed collars or reinforcement make the barrier continuous round the pipe.

Where systems meet: the riskiest lines

Transition	Risk	Good practice
Slab to wall	Pre-applied under slab meets post-applied wall	Use a tested transition detail with a generous bonded overlap
Wall to ground level	Water and sunlight at the termination	Run typically 150 mm above ground and seal the top edge
Old to new structure	Different movement and materials	Movement joint with flexible barrier and injection back-up
Membrane to waterbar	Leak path along the interface	Use compatible materials confirmed in writing by the supplier
Barrier to drained lining	Water routed to the wrong place	Direct any leakage to channels, never behind finishes

Draw every transition at large scale and name who builds and who inspects it.

Which joint detail gives a planned route to seal a construction joint leak after the basement is finished?

A A kicker cast separately the day after the slab

B A wider joint left open for later inspection

C An injection hose cast into the joint

D A bitumen coating applied on the internal face

QUICK CHECK · LO4 · ANSWER

Which joint detail gives a planned route to seal a construction joint leak after the basement is finished?

A A kicker cast separately the day after the slab

B A wider joint left open for later inspection

C An injection hose cast into the joint

D A bitumen coating applied on the internal face

WHY A cast-in injection hose lets resin be pumped into the joint later without drilling, giving a planned route to seal any leak that appears.

05

MODULE 05 · 11 MIN · LO4

Protect, inspect and remediate

Sequencing, protection, testing and repair that keep the basement dry

A sequence that protects the barrier

01

Prepare substrate

Blinding, piles or wall faces made sound and clean, then accepted at a hold point.

02

Install and inspect

Membrane or coating laid; laps and details checked before anything covers them.

03

Protect at once

Protection board or screed placed the same day, before steel or backfill.

04

Concrete and joints

Pour with waterbars and hoses in place; cure fully and record any defects.

05

Backfill in layers

Selected fill placed and compacted in shallow layers against protection.

06

Test and hand over

Check for leaks before finishes hide the structure; record hose locations.

Protecting the barrier from the site

01

Protection boards

Board or drainage composite fixed as soon as the membrane is accepted, not days later.

02

Selected backfill

Granular fill free of rubble and sharp stones, compacted in shallow layers.

03

Trades and traffic

Keep steel fixers, plant and scaffold off exposed membrane; repair damage at once.

04

Weather and heat

Shade coatings from strong sun; respect temperature and dew-point limits.

05

Dewatering control

Keep dewatering running until the structure can resist pressure and uplift.

Hydrostatic testing of membranes

D5385

ASTM test method for hydrostatic pressure resistance of membranes

80 kPa

Design head for an 8 m basement that the tested result must exceed

Ask for results under conditions that match the project, including laps and joints, and compare the head resisted with the design head. Tests confirm the material; inspection confirms the work.

Inspection and site testing

01	**Hold points**	Sign-off of substrate, membrane, joints and protection before each is covered.
02	**Lap and seam checks**	Visual checks with probing or other test methods agreed for the membrane type.
03	**Thickness checks**	Wet-film gauges and coverage records for liquid membranes and coatings.
04	**Flood or water tests**	Where practical, flood horizontal areas before covering to reveal leaks.
05	**Records**	Photos and marked-up drawings of joints, hoses and repairs for the O&M file.

Remediation by injection

01

Find the source

Map damp patches against joints, cracks and penetrations before choosing a repair.

02

Polyurethane resins

Hydrophobic foams stop active flows; flexible resins then seal the crack.

03

Acrylic gels

Low-viscosity gels injected through the wall can form a curtain behind a failed barrier.

04

Epoxy resins

Restore strength in dry, non-moving cracks; not suited to active leaks.

05

Pre-installed hoses

Let joints be injected without drilling, provided they were cast in.

Handing over a basement that stays dry

01	**Waterproofing records**	As-built drawings of barriers, joints, hoses and service entries for the owner.
02	**Maintenance plan**	Pump servicing, alarm tests and channel flushing for any drained system.
03	**First wet season**	Inspect after the first high groundwater period and act on any damp early.
04	**Protect the envelope**	No drilling or fixing into walls and slab without approval and a sealing method.

KEY MESSAGE

Details, not materials, decide the outcome

Most below-ground leaks start at a joint, a penetration, a damaged membrane or a lap made in a hurry. Specify the details, the sequence and the hold points as carefully as the materials.



A post-applied wall membrane passed inspection on Monday and backfilling starts on Thursday. What should happen in between?

A Leave it exposed so that it can be inspected again

B Fix protection board promptly and keep trades off it

C Apply another coat of primer over the membrane

D Switch off dewatering to load-test the membrane

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WHY Membranes are most often damaged after acceptance. Protection should go on promptly, and other trades and plant should be kept off it until backfill.

SUMMARY

Four things to take away

LO1 Agree the grade for each space and design for water to full height unless long-term data shows otherwise

LO2 Types A, B and C fail in different ways; combine them where a leak would be costly, as in grade 3

LO3 Match the barrier to the face: bonded membranes outside, crystalline coatings where access is limited

LO4 Specify joints, penetrations, protection, sequence and hold points; most leaks start at the details

EARN YOUR CREDIT

Complete the online assessment

10

questions drawn at random from the four objectives

80%

to pass; two attempts, reshuffled each time

1.0

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Standards and references

BS 8102:2022

Protection of below ground structures against water ingress – Code of practice

BS 8485

Code of practice for the design of protective measures for methane and carbon dioxide ground gases

EN 1992-3

Eurocode 2 Part 3: Liquid retaining and containment structures (now merged into EN 1992-1-1:2023)

EN 206

Concrete – Specification, performance, production and conformity

ASTM D5385

Standard test method for hydrostatic pressure resistance of waterproofing membranes

ACI 212.3R

Report on chemical admixtures for concrete

EN 13967

Flexible sheets for waterproofing – Plastic and rubber damp proof sheets including basement tanking sheet

BRE Special Digest 1

Concrete in aggressive ground

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THANK YOU FOR ATTENDING

Questions?

Kashif Aijaz
KingKrete Academy · www.kingkrete.com

This concludes The American Institute of Architects Continuing Education Systems course.

