KINGKRETE® We Create Future ACADEMY

CPD SEMINAR CPD-WP-WS-01

Waterstops and Joint Sealing in Water-Retaining Structures

Selecting, detailing, installing and testing joint seals for tanks, reservoirs and basements

0.75 LEU | AIA LU|HSW | 45 MIN | PRACTITIONER

RIBA core curriculum · Design, construction and technology



BEFORE WE START

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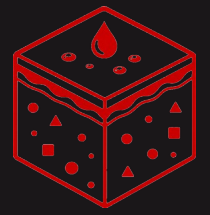
ABOUT THIS COURSE

Why this matters

Most leaks in water-retaining concrete start at a joint. Getting the joint seal right is cheaper than any repair after the structure is filled.

This seminar explains how joints in tanks, reservoirs and basements are loaded by water pressure and movement, compares the main waterstop and joint-sealing technologies, sets out the site detailing that makes them work, and covers tightness testing, inspection and remedial injection.

FOR Structural and civil engineers, water-sector designers, specifiers and contractors



CREDIT

0.75 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

Identify

the joints in water-retaining and below-ground structures and the water pressure and movement each must resist

HSW

02

Compare

PVC and elastomeric waterstops, hydrophilic swelling seals, injection hoses and external joint tapes

03

Detail

waterstop placement, splicing, fixing and concrete compaction at construction and movement joints

HSW

04

Specify

testing, inspection and remedial injection for joints in tanks, reservoirs and basements

HSW

AGENDA

How the next 45 minutes run

01	Joints, pressure and movement	LO1	8 min
02	Waterstop profiles and materials	LO2	8 min
03	Swelling seals, hoses and tapes	LO2	8 min
04	Detailing and installation	LO3	8 min
05	Testing, inspection and repair	LO4	8 min
Q	Knowledge check and summary	LO1–LO4	5 min

01

MODULE 01 · 8 MIN · LO1

Joints, pressure and movement

Where water-retaining structures leak, and what each joint has to resist

JOINT TYPES

Four kinds of joint in water-retaining concrete

Each joint is named by what it must do. That decides how far it moves and which seal it needs.

01

Construction joint

Where one pour stops and the next starts. Designed to stay closed, but still a plane of weakness to water.

02

Contraction joint

Planned break that lets the concrete shrink and cool without random cracking. Opens a little, then stays put.

03

Expansion joint

Full-width gap with a compressible filler. Lets panels expand, contract and shift relative to each other.

04

Sliding or partial joint

Wall-to-base or roof-to-wall joint that allows restrained movement in one direction while carrying load.

HEAD OF WATER

Every metre of water adds pressure on the joint

9.8 kPa

Hydrostatic pressure for each metre of water depth

~1 bar

Pressure at the base of a 10 m deep reservoir or basement

hD/h

Ratio of water head to wall thickness used in EN 1992-3 crack limits

Pressure grows linearly with depth, so the lowest joints in a tank or basement carry the highest load and are the hardest to repair.



What each joint must resist

Joint	Typical movement	Sealing approach
Construction	Negligible; hairline opening from shrinkage	Centre or external waterstop, hydrophilic strip or injection hose
Contraction	Small opening, typically a fraction of a millimetre	Waterstop across the joint plus a sealant groove on the water face
Expansion	Opening, closing and shear, often several millimetres	Centre-bulb waterstop, filler board and immersion-grade sealant
Wall-to-base sliding	Rotation and slip at the wall foot	Flexible waterstop or bearing detail plus external seal

Movement figures are indicative. Derive design values from temperature range, shrinkage and restraint for each structure.

DESIGN PRINCIPLE

Every joint is a potential leak path

Concrete itself is rarely the weak link in a well-designed tank. The joints are. Fewer, well-placed joints with a continuous, properly installed seal will outperform many joints sealed in a hurry.

Planning the joint layout

01

Assess restraint

Estimate early-age thermal and shrinkage strains and how much the base restrains walls.

02

Choose a strategy

Decide between closely spaced movement joints or full restraint with crack-control steel.

03

Set pour sizes

Locate construction joints to suit pour volumes, access and the reinforcement layout.

04

Check continuity

Trace each seal round the structure so every joint forms one closed, connected system.

05

Record on drawings

Show joint type, waterstop profile and junction pieces on plans and sections.

EN 1992-3 and ACI 350 both describe joint and reinforcement strategies for controlling cracking in liquid-retaining structures.

In a 9 m deep reservoir, which joint usually sees the highest water pressure and is hardest to repair?

A The roof slab construction joints

B The wall-to-base kicker joint

C Vertical joints near the top of the wall

D The joint around the access hatch

In a 9 m deep reservoir, which joint usually sees the highest water pressure and is hardest to repair?

A The roof slab construction joints

B The wall-to-base kicker joint

C Vertical joints near the top of the wall

D The joint around the access hatch

WHY Pressure rises with depth, so the wall-to-base joint carries the full head and is buried and hard to reach once the tank is in service.

02

MODULE 02 · 8 MIN · LO2

Waterstop profiles and materials

Centre and external waterstops in PVC, thermoplastic elastomer and rubber

Internal and external waterstops

01	**Internal (centre) waterstop**	Cast into the middle of the section, half in each pour. Resists pressure from either side.
02	**External (rear-guard) type**	Fixed to the face, ribs cast into concrete. Works best on the pressure side of the element.
03	**Under-slab use**	External types sit on blinding below base slabs and avoid congested reinforcement.
04	**Combined systems**	Centre and external waterstops can be joined with factory transition pieces where needed.

Centre-bulb, dumbbell and ribbed profiles

Centre-bulb

- Hollow bulb sits in the joint gap
- Bulb deforms to take opening and shear
- First choice for expansion joints
- Bulb must stay clear of the concrete

Dumbbell

- Solid or hollow end bulbs anchor in concrete
- Long water path around the end bulbs
- Used at construction and some movement joints
- Can be combined with a centre bulb

Ribbed flat

- Multiple ribs along each flange
- Each rib lengthens the leak path
- Suited to construction and contraction joints
- Limited movement capacity

Choose width and thickness from the head of water and the expected movement, not from habit.

PVC, thermoplastic elastomer and rubber compared

Property	Plasticised PVC	Thermoplastic elastomer	Vulcanised rubber
Site splicing	Heat-welded butt joints	Heat-welded butt joints	Vulcanised or factory-made joints
Elastic recovery	Moderate; can set under load	Good	Very good
Low-temperature use	Stiffens noticeably in cold	Stays flexible	Stays flexible
Long-term change	Plasticiser loss can embrittle	No plasticiser to lose	Grade-dependent; check oil resistance
Typical role	Construction and many movement joints	Movement and chemically exposed joints	Large movements and high heads

Elastomer tensile, elongation and tear properties are usually tested to ASTM D412 and ASTM D624.

SIZING RULES OF THUMB

Width and embedment drive performance

150 mm

Typical minimum width for construction joint waterstops

225 mm

Typical minimum width for movement joint waterstops

2 × agg

Typical clear gap to rebar: about twice max aggregate size

Wider waterstops lengthen the leak path and tolerate placing errors. Treat these as typical starting points and confirm against the governing code and head.

What a waterstop specification should state

01

Material and standard

Polymer type and the specification it must meet, for example CRD-C 572 for PVC waterstops.

02

Profile and size

Profile shape, width and thickness for each joint type, shown on the drawings.

03

Physical properties

Tensile strength, elongation and tear resistance, with the test methods named.

04

Junction pieces

Factory-made tees, crosses and corners so that only straight butt welds happen on site.

05

Liquid compatibility

Resistance to the stored liquid, and potable-water approval where the tank holds drinking water.

Which waterstop profile is the usual first choice for an expansion joint that must open, close and shear?

A Ribbed flat profile with no bulb

B External rear-guard strip on the dry face

C Bentonite hydrophilic strip

D Centre-bulb profile with the bulb in the gap

QUICK CHECK · LO2 · ANSWER

Which waterstop profile is the usual first choice for an expansion joint that must open, close and shear?

A Ribbed flat profile with no bulb

B External rear-guard strip on the dry face

C Bentonite hydrophilic strip

D Centre-bulb profile with the bulb in the gap

WHY The hollow centre bulb sits across the joint gap and deforms with opening and shear, so the embedded flanges are not torn.

03

MODULE 03 · 8 MIN · LO2

Swelling seals, hoses and tapes

Hydrophilic strips, re-injectable hoses and external joint tapes

Bentonite and modified rubber swelling strips

Bentonite-based

- Clay swells strongly in fresh water
- Swelling reduced in saline water
- Can wash out if wet before casting
- Low cost, simple to fix

Modified rubber

- Hydrophilic polymer in a rubber matrix
- More tolerant of saline groundwater
- Often coated to delay early swelling
- Keeps shape through limited cycles

Both are construction joint products. Neither bridges a moving joint.

Rules for hydrophilic strips

01	**Give enough cover**	Keep the strip well inside the section, typically 75 mm or more from the nearest face.
02	**Keep it dry before casting**	Rain or ponded water causes early swelling, so the strip loses capacity before it is cast in.
03	**Bed it fully**	Fix continuously to a sound, clean surface with adhesive or nails; no gaps or loose ends.
04	**Beware wet and dry cycles**	Repeated cycling can degrade some products; use only types designed and tested for it.
05	**Butt joints tightly**	Lengths must touch end to end or be lapped side by side as the supplier details.

How a re-injectable hose system works

01

Fix the hose

Clip the hose tight to the joint face at close centres before the next pour.

02

Lead out the ends

Bring inlet and vent ends to accessible boxes, keeping each run within supplier length.

03

Cast and cure

Pour the next lift. The hose stays empty while the concrete hardens and shrinks.

04

Inject the resin

Pump resin or grout until it emerges at the vent, filling voids and fine cracks.

05

Flush to reuse

With re-injectable types, flush the channel so the joint can be injected again later.

Inject after most early shrinkage has occurred, usually once the structure is close to its service condition.

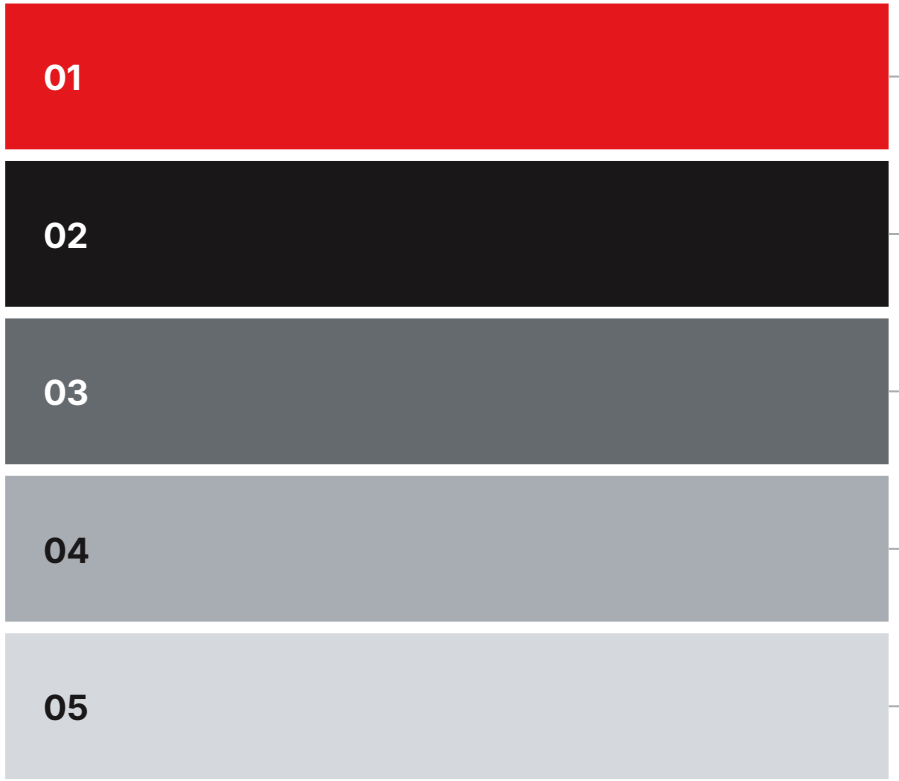
Choosing the injection material

Material	Behaviour	Best used for
Microfine cement grout	Rigid once set; compatible with concrete	Dry or damp joints with wider voids and no expected movement
Polyurethane resin	Low viscosity; flexible or rigid grades; reacts with water	Wet or leaking joints and fine cracks needing some flexibility
Acrylic gel	Very low viscosity; forms a flexible, water-swelling gel	Fine voids and joints in permanently damp conditions

Confirm the hose and resin are compatible and that re-injection is possible with the chosen combination.

DEFENCE IN DEPTH

Layered sealing at a basement wall joint



Backfill and drainage
Free-draining layer and protection board reduce the water pressure at the wall.

External joint tape
Bonded elastomeric tape bridges the joint on the pressure face of the wall.

Centre waterstop
Embedded primary seal giving a long leak path through the section.

Injection hose
Secondary line that can be activated if a leak appears in service.

Internal face
Inspected surface where any residual damp can be seen and traced.

Not every structure needs every layer. Match the number of lines of defence to the use and the consequence of a leak.

A swelling strip at a basement construction joint was rained on for two days before the next pour. What is the main risk?

A The strip will bond too strongly to the concrete

B The strip may have swollen early and lost sealing capacity

C The strip will become rigid and crack the wall

D The strip will need injecting with resin

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WHY Hydrophilic strips react with water. Swelling before casting uses up their capacity and can loosen them, so they may not seal later.

04

MODULE 04 · 8 MIN · LO3

Detailing and installation

Placement, splicing, fixing, compaction and sealants on site

Installing a centre waterstop at a wall joint

01

Set out the line

Mark the centreline so half the waterstop width lands in each pour.

02

Use split stop-ends

Hold the projecting half between split formwork so it stays straight and flat.

03

Fix to reinforcement

Clip or tie the flange edges to the steel at regular centres to stop it folding.

04

Inspect before casting

Check position, welds, cleanliness and the clear gap to reinforcement.

05

Clean before next pour

Remove laitance and debris from the exposed half before the second pour.

Never puncture the waterstop inside its sealing width; fix only through edge eyelets or the outer margin.

Splices that keep the seal continuous

01

Butt-weld thermoplastics

Fuse PVC and TPE ends with a heated blade and alignment jig so ribs and bulbs line up.

02

Vulcanise rubber

Rubber waterstops need vulcanised splices or factory-made joints, not site adhesives.

03

Factory junctions

Tees, crosses and corners should be factory-made so site work is straight butt welds only.

04

Never lap or tape

Overlapped, glued or taped ends leave a direct water path and are not acceptable.

05

Inspect every weld

Look for full fusion, no voids or misalignment, and bend-test sample welds.

Vertical and horizontal waterstops behave differently

Vertical waterstop

- Concrete flows past both faces as it rises
- Main risk is the waterstop being pushed over
- Support edges to stop folding
- Vibrate close but never against it

Horizontal waterstop

- Air and bleed water collect under the flange
- Voids form a direct leak path
- Lift flange edges slightly to vent air
- Fill from one side until concrete rises under

Poor compaction around the waterstop causes more leaks than waterstop failure itself.

Faults to look for during installation

01	**Folded or displaced flange**	Inadequate fixing lets the concrete fold the waterstop, halving its effective width.
02	**Bulb cast into concrete**	A centre bulb filled with concrete can no longer move; the joint will tear in service.
03	**Congested reinforcement**	Too little space for concrete to flow leaves honeycombing beside the waterstop.
04	**Damaged or dirty surface**	Tears, holes, oil or dried mortar on the flange break the bond with fresh concrete.

Sealing the water face of movement joints

01

Polysulfide

Two-part grades have a long record in permanent immersion and good chemical resistance.

02

Polyurethane

Immersion-rated grades suit many tanks; check resistance to the stored liquid.

03

Joint geometry

Use a bond breaker or backer so the sealant bonds to two sides only; follow width-to-depth ratios.

04

Surface preparation

Clean, dry, sound arrises with the specified primer; most failures are adhesion failures.

05

Potable water approval

In drinking water tanks, use sealants approved under the relevant national scheme.

Two runs of PVC waterstop meet at a wall-to-wall corner. What is the correct way to connect them?

A Overlap the ends by 150 mm and bond with adhesive

B Butt the ends together and seal with joint tape

C Use a factory-made corner piece and butt-weld both legs

D Leave a small gap and fill it with sealant

QUICK CHECK · LO3 · ANSWER

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WHY Factory junctions keep complex shapes off site, leaving straight butt-fusion welds. Laps, tape and gaps all leave a leak path.

05

MODULE 05 · 8 MIN · LO4

Testing, inspection and repair

Tightness testing, hold-point inspection and remedial injection

Hold points for joint sealing

01

Material submittals

Check profiles, properties and approvals against the specification before ordering.

02

Trial welds

Each welder makes sample splices that are inspected and bend-tested before work starts.

03

Pre-pour inspection

Position, fixing, welds, cover, cleanliness and swelling-strip condition, signed off.

04

Post-strike check

Look for honeycombing, exposed or displaced waterstop and damage at joints.

05

Records

Photographs and as-built joint layout support later testing and any repairs.

Hydrostatic tightness test of a tank

01

Prepare the structure

Complete curing, close outlets, keep walls clear of backfill where visual checks apply.

02

Fill in stages

Fill to maximum operating level at a controlled rate, checking joints as it rises.

03

Stabilise

Hold the water to let the concrete absorb moisture before measuring begins.

04

Measure the drop

Record level at set intervals; correct for evaporation and rainfall.

05

Assess and record

Compare the loss with the specified criterion and inspect the exterior.

ACI 350.1 defines test procedures and acceptance criteria for environmental engineering containment structures.

What counts as a pass

% / day

Allowable loss stated as a percentage of contained volume per day

Dry hand

Typical visual criterion: damp spots must not wet a dry hand

0

Flowing leaks or running water on the exterior face

The allowable loss is typically a small fraction of a percent of volume per day and depends on the tightness class specified. State the class in the contract.

Matching the repair to the defect

Defect found	Typical remedy	Notes
Damp joint, hose installed	Inject through the hose with PU, acrylic or cement	Least disruptive; vent until resin appears at the far end
Active leak, no hose	Drill and inject packers with water-reactive PU resin	Drill to intersect the joint plane behind the waterstop
Honeycomb beside waterstop	Cut back, then inject or replace with repair mortar	Find the full extent before choosing the method
Failed water-face sealant	Remove, prepare and reseal with immersion grade	Drain tank; check why adhesion failed first

Retest after repair. A repaired joint is accepted only when the structure passes the specified tightness test.

CASE BRIEF

Leaking kicker joint in a treated water reservoir

THE BRIEF

Structure

Rectangular reservoir, 7 m water depth, 400 mm walls

Joint seal

PVC centre waterstop plus re-injectable hose at the kicker

Test result

Loss above the specified criterion; damp band along one wall

Constraint

Drinking water use, so all materials need potable approval

01 **Locate the leak**

Map damp areas on the exterior and check pour records and photos for that wall.

02 **Inject the hose**

Use an approved resin, injecting each run until it appears at the vent box.

03 **Treat any bypass**

Drill and inject packers where damp persists beside honeycombed concrete.

04 **Retest the tank**

Repeat the full tightness test to the original class before acceptance.

Why is a tank held full for a stabilisation period before water-level readings begin in a tightness test?

A To let the concrete absorb water so absorption is not read as leakage

B To allow the waterstops to swell and seal

C To let the joint sealant cure under pressure

D To allow the water temperature to reach 20 °C

Why is a tank held full for a stabilisation period before water-level readings begin in a tightness test?

A **To let the concrete absorb water so absorption is not read as leakage**

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C To let the joint sealant cure under pressure

D To allow the water temperature to reach 20 °C

WHY Dry concrete absorbs water when first filled. Measuring too early would count that absorption as leakage and overstate the loss.

SUMMARY

Four things to take away

LO1 Every joint is a leak path; pressure grows with depth, so lower joints and kicker joints need the most care

LO2 Choose waterstop profile and material by movement, head and liquid; swelling strips suit construction joints

LO3 Keep waterstops centred, fixed and fused with factory junctions, and compact concrete fully around them

LO4 Specify hold-point inspections, an ACI 350.1-type tightness test and a planned route for remedial injection

EARN YOUR CREDIT

Complete the online assessment

10

questions drawn at random from the four objectives

80%

to pass; two attempts, reshuffled each time

0.75

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Standards and references

ACI 350

Code requirements for environmental engineering concrete structures

ACI 350.1

Specification for tightness testing of environmental engineering concrete containment structures

ACI 504R

Guide to sealing joints in concrete structures

EN 1992-3

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

CRD-C 572

Corps of Engineers specifications for polyvinylchloride waterstop

ASTM D412

Test methods for vulcanized rubber and thermoplastic elastomers — Tension

ASTM D624

Test method for tear strength of conventional vulcanized rubber and thermoplastic elastomers

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THANK YOU FOR ATTENDING

Questions?

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

