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CPD SEMINAR CPD-FL-VD-01

Vehicle Decks and Car Parks: Protecting Structures and Users

How decks deteriorate, and how to specify, detail and maintain systems that protect them

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

RIBA core curriculum · Design, construction and technology · Health, safety and wellbeing



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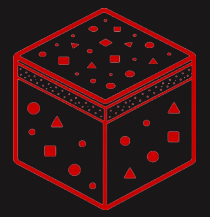
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Why this matters

Car park decks face salt, water, traffic and weather like a bridge. Unprotected, they corrode, spall and leak, putting users and the structure at risk.

This seminar explains how vehicle decks deteriorate, compares rigid, flexible and hybrid deck systems, shows how to select them for top decks, intermediate decks, ramps and ground slabs, and sets out preparation, joints, drainage, inspection and maintenance.

FOR Architects, structural engineers, car park owners, specifiers and contractors



CREDIT

1.0 LEU · AIA LU|HSW

RIBA TOPIC

Design, construction and technology; Health, safety and wellbeing

LEVEL

Practitioner

FORMAT

Live, in-office or self-paced

ASSESSMENT

10 questions, 80% to pass

PREREQUISITE

CPD-FL-RF-01

LEARNING OBJECTIVES

By the end of this course you will be able to

01

Explain

how vehicle decks deteriorate through chlorides, water, cracking, thermal movement and traffic

HSW

02

Compare

deck waterproofing and wearing systems: rigid epoxy, flexible crack-bridging polyurethane and hybrid build-ups

03

Select

systems for exposed top decks, intermediate decks, ramps and ground-bearing slabs, including slip resistance and line marking

HSW

04

Specify

substrate preparation, joints, drainage, inspection and maintenance for car park decks

HSW

AGENDA

How the next 60 minutes run

01	Why car park decks deteriorate	LO1	11 min
02	Deck types and protection options	LO1, LO2	11 min
03	Selecting systems by deck zone	LO2, LO3	11 min
04	Preparation, joints and drainage	LO4	11 min
05	Maintenance and refurbishment	LO4, LO3	11 min
Q	Knowledge check and summary	LO1–LO4	5 min

01

MODULE 01 · 11 MIN · LO1

Why car park decks deteriorate

Chlorides, water, cracking, thermal movement and traffic at work on the deck

WHY CAR PARKS MATTER

A car park deck is a bridge that rarely dries out

Car park decks carry traffic, salt and water like a bridge, yet they are often designed and maintained like a building floor. Left unprotected, they can deteriorate faster than almost any other part of a building.



MECHANISMS

Five agents of deterioration

Most deck damage comes from these agents acting together, not one at a time.

01

Chlorides

Salts reach the reinforcement and break down its protective layer, starting corrosion.

02

Water

Carries chlorides into the concrete, sustains corrosion and leaks to the levels below.

03

Cracking

Gives water and salt a direct path to the steel, bypassing the cover concrete.

04

Thermal movement

Daily heating and cooling open and close cracks and joints, working them wider.

05

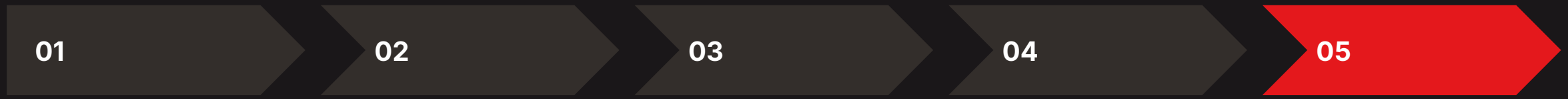
Traffic

Abrasion, scuffing and impact wear away surface protection and expose the concrete.

Where the chlorides come from

01	**De-icing salts**	In cold regions, salty slush carried in on vehicles drips onto every deck, not just the roof.
02	**Airborne salts**	In coastal hot regions, sea spray and salty dust settle on decks and wash into pores and cracks.
03	**Concentration at low points**	Evaporation in ponds and around drains concentrates salts where water lingers.
04	**Cast-in chlorides**	Some older structures contain chlorides from accelerating admixtures, aggregates or water.

From chloride ingress to spalling



Ingress

Chlorides enter by absorption and diffusion, and travel quickly through cracks.

Threshold reached

Chloride at bar depth exceeds the threshold and breaks down the passive layer.

Corrosion starts

Water and oxygen sustain corrosion; pitting can rapidly reduce bar section.

Expansion

Rust occupies several times the volume of the steel and splits the cover.

Spalling

Delaminated concrete breaks away, exposing bars and endangering people below.

Corrosion is commonly associated with chloride of about 0.2 to 0.4% by mass of cement at the bar.

Where and why decks crack

01	**Hogging over supports**	Tension in the top surface over columns and beams opens cracks right above the top steel.
02	**Restraint and shrinkage**	Shrinkage restrained by cores, walls and stiff columns causes cracks through the slab.
03	**Precast unit joints**	Joints between units move with load and temperature and are classic leak paths.
04	**Live or static**	Cracks that open and close daily need flexible, crack-bridging treatment.

THERMAL MOVEMENT

Exposed top decks work hardest

60 °C+

Dark top-deck surfaces in hot regions typically exceed this in summer

20 mm

Movement of a 50 m deck over a 40 K range (α about 10×10^{-6} /K)

Large daily temperature swings open and close cracks and joints, and UV degrades exposed resins. Top decks need flexible, UV-stable protection.

What traffic does to the surface

01

Abrasion

Grit carried on tyres grinds the surface, worst in entry lanes and at barriers and pay points.

02

Tyre scuffing

Power-steered turns and ramps create high shear that strips aggregate and topcoats.

03

Hot tyre pick-up

Hot tyres can soften and lift unsuitable coatings, especially in hot climates.

04

Fluids

Fuel, oil and brake fluid can soften some resins and leave stains that trap dirt.

05

Impact and point loads

Jacks, kerb strikes and snow-clearing equipment chip coatings and edges.

A flat-slab car park shows spalling concentrated around the column heads on the top deck. What is the most likely mechanism?

A Ultraviolet light breaking down the cement paste at the surface

B Chlorides entering hogging cracks and corroding the top reinforcement

C Tyre abrasion wearing away the cover in the parking bays

D Thermal shock from hot tyres cracking the top surface

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D. Thermal shock from hot tyres cracking the top surface

WHY Hogging tension over columns cracks the top surface directly above the top steel, letting chloride-laden water reach the bars and start corrosion that splits the cover.

02

MODULE 02 · 11 MIN · LO1, LO2

Deck types and protection options

Structural forms, guidance, and how rigid, flexible and hybrid systems compare

How the structural form shapes the risk

Deck type	Typical features	Key vulnerability
Flat slab	In-situ slab on columns, no beams; hogging over column heads	Top cracking and corrosion at column heads; punching shear
Post-tensioned	Thinner slabs with fewer cracks; tendons in ducts or sheathing	Chloride attack on tendons and anchorages; tendons hit by drilling
Precast	Double tees or hollowcore units, with or without a topping	Many joints that leak; corrosion at connections and bearings
Ground-bearing slab	Slab on ground at the lowest or basement level	Rising moisture, salt run-off from ramps, ponding

Identify the structural form before choosing protection; each type fails in its own way.

Guidance worth knowing

01	**ACI 362.1R**	Guide for the design and construction of durable concrete parking structures.
02	**IStructE design recommendations**	Design recommendations for multi-storey and underground car parks.
03	**EN 1504-2**	Surface protection systems for concrete: impregnations, coatings and their performance tests.
04	**ICE inspection recommendations**	Recommendations for the inspection, maintenance and management of car park structures.

Keep water and chlorides out of the concrete

Durable decks combine good concrete, adequate cover, falls that drain and a surface protection that keeps water and chlorides out. A membrane cannot rescue a deck that ponds, and drainage cannot rescue a deck left unprotected.

Surface protection options for decks

01

Hydrophobic impregnation

Silane or siloxane lines the pores and cuts water and chloride uptake; no crack bridging or wear layer.

02

Impregnation

Partly fills pores and densifies the surface; limited wear resistance and no crack bridging.

03

Rigid coating

Epoxy with broadcast aggregate; good wear and sealing on sound concrete with few cracks.

04

Flexible coating

Elastomeric polyurethane membrane bridges moving cracks; needs a wearing course for traffic.

Rigid, flexible and hybrid systems

Rigid epoxy

- Hard, abrasion-resistant broadcast finish
- Strong bond to sound, prepared concrete
- Cannot bridge cracks that continue to move
- Aromatic grades chalk and yellow in UV
- Suits intermediate decks with few cracks

Flexible polyurethane

- Elastomeric membrane bridges live cracks
- Wearing course with aggregate takes traffic
- Aliphatic topcoat gives UV stability
- Suits top decks and cracked decks

Hybrid build-up

- Flexible membrane under a harder wear layer
- Or flexible strips only where cracks occur
- Balances crack bridging and abrasion
- Every layer must be tested as one system

Performance depends on formulation and thickness; compare tested system data, not chemistry names.

Deck system families at a glance

System	Best suited to	Crack bridging	Watch points
Rigid epoxy	Intermediate decks, sound concrete, few cracks	Static cracks only, after repair	UV chalking; reflective cracks over live cracks
Flexible PU + wearing course	Exposed top decks, cracked decks, decks over occupied space	Dynamic, at the tested temperature	Moisture and dew point when applying; thickness control
Hybrid build-up	Mixed decks; high wear with moderate movement	Moderate, set by the membrane layer	Layer compatibility; test as a whole system
PMMA	Refurbishment with short closures; cold weather	Flexible grades available	Odour; strict mixing and ventilation
Asphalt over membrane	Top decks needing a robust wearing surface	Provided by the membrane beneath	Added dead load; heat during laying

A generalised guide. Confirm crack-bridging class, wear data and temperature limits for the actual system.

Crack bridging: static is not dynamic

01	**Static crack bridging**	Membrane stretches once over a crack that opens and then stays open.
02	**Dynamic crack bridging**	Membrane survives repeated opening and closing, as over hogging cracks and joints.
03	**ASTM C1305**	Cycles a crack beneath a membrane at low temperature to test crack-bridging ability.
04	**EN 1062-7**	Static (method A) and dynamic (method B) crack-bridging classes for coatings.
05	**Temperature matters**	Membranes stiffen in the cold; check the test temperature suits site extremes.

An exposed top deck over shops has live hogging cracks above the columns. Which system type best meets the need?

A Thin rigid epoxy with broadcast aggregate

B Silane hydrophobic impregnation on its own

C A penetrating pore-blocking impregnation

D Flexible PU membrane, wearing course and UV topcoat

QUICK CHECK · LO2 · ANSWER

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WHY Live cracks need dynamic crack bridging, the shops below need a watertight deck, and exposure needs UV stability: a flexible membrane system meets all three.

03

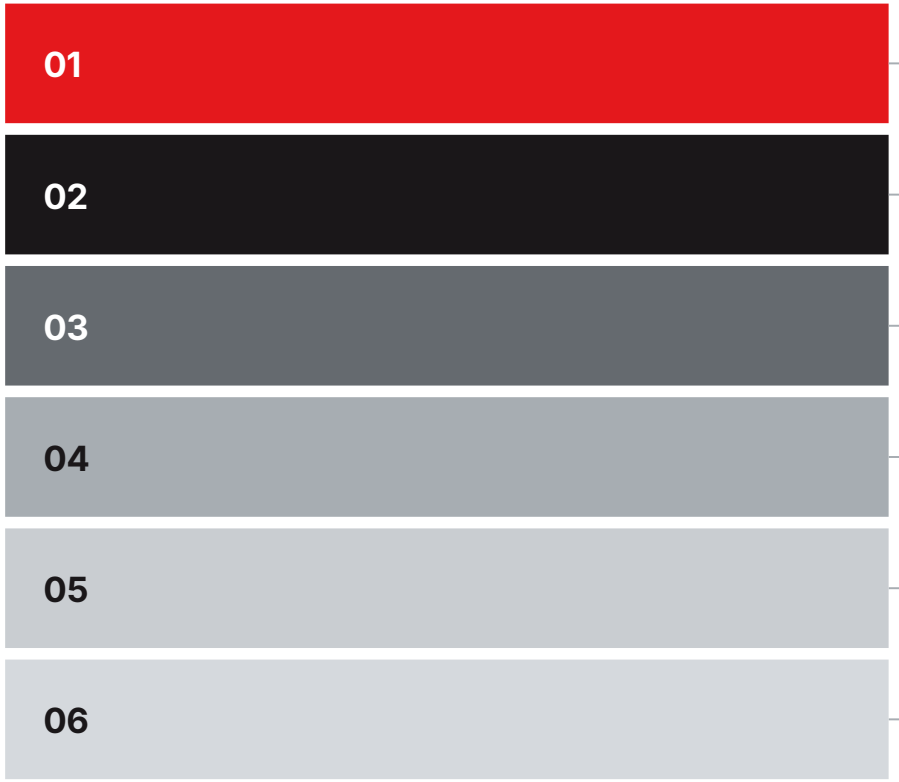
MODULE 03 · 11 MIN · LO2, LO3

Selecting systems by deck zone

Top decks, intermediate decks, ramps and ground slabs, plus grip and markings

TYPICAL BUILD-UP

Top-deck flexible system build-up



UV-stable topcoat
Aliphatic polyurethane seals the aggregate and sets colour; resists UV

Wearing course
Polyurethane or epoxy layer with broadcast aggregate for grip and wear

Flexible membrane
Elastomeric polyurethane, typically 1.5 to 2 mm, bridges dynamic cracks

Detail strips
Reinforced membrane over cracks, joints and upstands, laid first

Primer
Seals the concrete, limits outgassing and provides the bond

Prepared concrete
Repaired, shot-blasted, dry, with falls to drains

Build-ups and thicknesses vary; follow the tested system exactly as stated by its supplier.

Matching the system to the deck zone

Zone	Main demands	Typical choice
Exposed top deck	UV, heat, rain, thermal cracking and movement	Flexible PU membrane, wearing course, UV-stable topcoat
Intermediate deck	Salt drips from vehicles, abrasion, few live cracks	Rigid epoxy broadcast system; flexible strips over cracks
Ramps and turns	High shear, braking, scuffing, run-off	Heavier wearing course with coarser, harder aggregate
Ground-bearing slab	Rising moisture, salt run-off, ponding	Moisture-tolerant primer with a rigid system, or impregnation
Deck over occupied use	Leaks reach shops, offices or plant below	Flexible membrane system whatever the level

Typical choices only. Deck condition, crack movement and programme may change the answer.

Ramps and turning areas need more grip

01

Gradients raise demand

Braking and accelerating on a slope needs more friction than a level parking bay.

02

Coarser aggregate

Larger, harder aggregate broadcast to excess, with a lighter seal to keep it sharp.

03

Turning circles

Helical ramps and aisle ends suffer scuffing; increase the wearing course build.

04

Ramp transitions

Changes of grade and joints catch tyres; keep nosings and edges flush.

05

Cold regions

Ice forms first on ramps; consider heating, extra drainage and plough-proof edges.

SLIP RESISTANCE

Specify grip for pedestrians as well as cars

PTV 36+

Wet pendulum value widely seen as low slip potential for pedestrians

Set wet targets for walkways and bays, use more aggressive aggregate on ramps and turns, and retest as the surface wears in service.



Intermediate decks and ground-bearing slabs

01	**Intermediate decks**	Sheltered from sun and rain but not from salty drips; rigid systems often suit.
02	**Treat cracks first**	Seal static cracks, and add flexible detail strips where cracks still move.
03	**Ground-bearing slabs**	No soffit to dry through; check for rising moisture before sealing the top.
04	**Moisture-tolerant primers**	Use primers designed for damp substrates to avoid osmotic blistering.
05	**Low points**	Run-off from ramps collects at the lowest level; falls and drains matter most.

Fast-cure PMMA and asphalt over membrane

PMMA systems

- Cure in about one to two hours, even when cold
- Allow overnight or weekend bay-by-bay working
- Strong odour; manage ventilation and occupants
- Need strict mixing and trained applicators

Asphalt over membrane

- Robust wearing surface over a waterproof layer
- Falls can be adjusted within the asphalt
- Adds significant dead load; check the structure
- Membrane must tolerate hot-laid asphalt

Both suit refurbishment as well as new build; check structure, programme and occupation before choosing.

Line marking, colour coding and light

01

Compatible markings

Use marking materials compatible with the deck topcoat; some solvents attack resins.

02

Slip-resistant markings

Painted walkways and lines need grip equal to the surrounding deck.

03

Pedestrian routes

Coloured walkways separate people from vehicles and lead to stairs and exits.

04

Colour coding

Level and zone colours aid wayfinding and highlight accessible and EV bays.

05

Re-marking plan

Lines in wheel paths wear fastest; include re-marking in the maintenance cycle.

06

Light-reflective soffits

Light-coloured soffit and wall coatings raise light levels and improve security.

A helical ramp shows polished, slippery wheel tracks after a few years. What should the refurbishment specify?

A A wearing course with coarser, harder aggregate and a lighter seal

B A smooth self-smoothing epoxy finish for easier cleaning

C A silane impregnation to repel water from the surface

D A thicker glossy topcoat over the existing worn surface

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WHY Ramps need more aggressive texture than bays. Coarser, harder aggregate with a lighter seal restores grip and resists the scuffing that polished the original surface.

04

MODULE 04 · 11 MIN · LO4

Preparation, joints and drainage

Survey, substrate preparation, joint details and falls that keep decks dry

Survey the deck before you specify

01	**Visual and hammer survey**	Map cracks, spalls, leaks, ponding and delamination by sounding.
02	**Cover and chloride**	Measure cover depth and chloride profiles from dust samples or cores.
03	**Half-cell potential**	ASTM C876 mapping shows where active corrosion is more likely.
04	**Levels and falls**	Survey levels and watch ponding after rain to plan falls and drains.
05	**Existing coatings**	Identify old systems and test whether to remove or overcoat them.

Preparing the deck substrate



01 Repair first

Break out spalls to sound concrete, treat bars and reinstate with repair mortar.

02 Remove contaminants

Remove oil, rubber deposits and failing coatings; degrease stained bays.

03 Shot blast

Remove laitance and open the surface to the profile the system needs.

04 Test

Check pull-off strength, moisture and surface temperature against dew point.

05 Detail

Rout and seal cracks, lay detail strips, and install joints and nosings.

06 Prime

Prime promptly to seal pores and avoid recontamination.

Repairs should follow EN 1504-9 principles and use repair products to EN 1504-3.

BENCHMARKS

Typical acceptance values for decks

1.5 MPa

Typical minimum pull-off strength of the prepared deck concrete

1:60

Typical minimum fall for car park decks to avoid ponding

Typical values only. The system supplier and design guidance set the acceptance criteria to write into the specification.

Detailing joints and cracks on decks

Expansion joints

- Take structural and thermal movement
- Proprietary joint with elastomeric seal
- Flush nosings protect edges from tyres
- Terminate the membrane into the joint

Precast unit joints

- Sealant joints between precast units
- Move with deflection and temperature
- Replace failed sealant before overcoating
- Bridge with strip-reinforced membrane

Hogging cracks

- Form over columns and beams
- Open and close daily, worst on top decks
- Reinforcing strip set in membrane first
- Never cover with rigid resin alone

Details where deck systems usually fail

01

Upstands and kerbs

Turn the membrane up walls, kerbs and columns, typically 100 mm or more, over a fillet.

02

Drains

Bond the membrane into drain flanges; many leaks start around outlets.

03

Terminations

Chase or seal edges so water cannot run behind the system.

04

Penetrations

Barrier posts, lighting and sign fixings need sealed collars or plinths.

05

Day joints

Overlap and prepare previous work exactly as the system requires.

Drainage that actually drains

01	**Falls**	Typically no flatter than about 1:60, allowing for deflection, creep and tolerances.
02	**Drains at true low points**	Locate from the deflected shape, often mid-span on long-span decks.
03	**Outlet details**	Set outlets slightly below finished level, with flanges bonded to the membrane.
04	**Flood test**	Flood or observe after rain; correct ponds before the system goes down.
05	**Post-tensioned decks**	Scan to locate tendons before coring any new drains or fixings.

Hold points and tests for deck work

Stage	Test or check	Typical acceptance
Repairs complete	Hammer survey and repair records	No hollow areas; repairs cured as required
After shot blasting	Pull-off test (EN 1542 or ASTM D7234)	Typically 1.5 MPa or more
Before priming	Moisture, surface temperature and dew point	Within supplier limits; at least 3 °C above dew point
Membrane applied	Wet film gauge and consumption checks	Thickness as stated for the tested system
Completed deck	Flood test and wet pendulum test	No ponding or leaks; PTV target met

Write hold points, test frequencies and acceptance values into the specification so they are priced.

New drains are to be cored through a post-tensioned deck to cure ponding. What should the specification require first?

A Coring only in cool weather to limit thermal cracking

B A rigid epoxy patch around each new drain position

C Scanning to locate tendons before any drilling or coring

D Pull-off testing at every proposed drain position

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D. Pull-off testing at every proposed drain position

WHY Cutting a stressed tendon can release dangerous energy and reduce structural capacity. Tendons must be located by scanning before any coring or drilling.

05

MODULE 05 · 11 MIN · LO4, LO3

Maintenance and refurbishment

Keeping decks protected over their life and refurbishing while open

An inspection regime for car park decks

01	**Routine checks**	Frequent walk-round checks by the operator for spalls, leaks, ponding and damage.
02	**Annual inspection**	Typically yearly review of decks, joints, drains, system wear and markings.
03	**Detailed inspection**	Engineer-led inspection at longer intervals, with testing where needed.
04	**After events**	Inspect after severe winters, flooding, fires or vehicle impacts.
05	**Records**	Keep a log with photographs so deterioration trends can be tracked.

Maintenance that extends deck life

01

Wash-down

Remove salt and grit, typically after winter in cold regions and regularly on the coast.

02

Drains and gullies

Clear silt and debris so decks drain and ponds do not form.

03

Joint seals

Replace torn or debonded seals and damaged nosings promptly.

04

Wearing course renewal

Recoat worn wheel tracks and turns before the membrane is exposed.

05

Local repairs

Repair cuts, blisters and impact damage before water gets beneath the system.

06

Re-marking

Renew lines and walkway markings as they wear.

A typical deck maintenance schedule

Item	Typical frequency	Purpose
Operator checks	Weekly to monthly	Spot hazards: spalls, ponding, damaged joints
Wash-down	At least annually; more often in salty exposures	Remove chlorides and grit from the deck
Inspection	Typically annually	Assess deck system, joints, drains and markings
Detailed inspection	At intervals set by the engineer	Structural condition, testing and forward planning
Wearing course renewal	When inspection finds wear	Restore grip and protect the membrane

Agree frequencies with the owner and record them in the operation and maintenance manual.

Refurbishing while the car park stays open

01

Plan phases

Divide decks into zones that keep ramps, routes and exits working.

02

Isolate zones

Hoard work areas, divert vehicles and pedestrians, and sign clearly.

03

Manage hazards

Control dust, noise, odour and fumes; ventilate enclosed decks.

04

Fit cure times

Choose systems that cure within each closure window.

05

Reopen safely

Check cure, slip resistance and markings before handing back.

WORKED EXAMPLE

Refurbishing a coastal multi-storey car park

THE BRIEF

Structure

Flat-slab car park, five levels, about 25 years old

Exposure

Coastal, hot climate; airborne salts and large daily temperature range

Condition

Spalling at column heads, ponding, leaking top deck, worn ramps

Survey

High chlorides at top steel over columns; active corrosion indicated

Constraint

Must stay open, with no more than half a deck closed at a time

01 Repair and assess

Repair column-head spalls; consider galvanic anodes; check punching shear.

02 Correct drainage

Add drains at true low points; local screeds to remove ponds.

03 Protect the top deck

Flexible PU membrane, aggregate wearing course and UV-stable topcoat.

04 Lower decks and ramps

Rigid epoxy on intermediate decks; coarser aggregate on ramps and turns.

05 Phase and maintain

Half-deck phasing, then annual inspection and regular wash-down.

Common deck failures and their causes

01

Delamination

Weak surface, moisture or condensation at application; test before priming.

02

Reflective cracking

Rigid system laid over live hogging cracks or precast joints.

03

Worn-through wheel tracks

Wearing course too thin or aggregate too soft for ramps and turns.

04

Leaking joints

Seals not maintained, or membrane not terminated into the joint system.

05

Ponding

Flat falls, blocked drains, or deflection not allowed for in design.

06

Blistering on ground slabs

Rising moisture beneath an impermeable system without a suitable primer.

KEY MESSAGE

Protect, drain, detail and maintain

Durable car parks come from understanding how decks deteriorate, choosing a system for each zone, preparing and detailing the deck properly, and inspecting and maintaining it for its whole life.



A coastal car park owner asks how to limit chloride build-up on decks between inspections. Which measure is most effective?

A Adding a second coat of topcoat every single year

B Regular wash-down of the decks and clearing of drains

C Applying a silane impregnation to the soffits only

D Increasing the frequency of line re-marking

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WHY Wash-down removes deposited salt before it can be absorbed, and clear drains stop salty water ponding and concentrating on the deck.

SUMMARY

Four things to take away

LO1 Decks deteriorate as chlorides, water, cracks, thermal movement and traffic act together on the concrete

LO2 Rigid epoxy suits sound sheltered decks; flexible PU bridges live cracks; hybrids balance wear and movement

LO3 Select by zone: flexible on top decks, coarser grip on ramps, moisture-tolerant at ground, safe markings

LO4 Survey and repair first, detail joints and drains, set hold points, then inspect and maintain for life

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

LEU and AIA LU|HSW on your certificate

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Sign in to SpecWorld, open the course and take the assessment. Your certificate is issued on passing and kept in your Workdesk under CPD & Certificates.

Standards and references

ACI 362.1R

Guide for the design and construction of durable concrete parking structures

IStructE

Design recommendations for multi-storey and underground car parks

ICE

Recommendations for the inspection, maintenance and management of car park structures

EN 1504-2

Products and systems for the protection and repair of concrete structures. Surface protection systems

EN 1062-7

Paints and varnishes. Coatings for exterior masonry and concrete. Crack bridging properties

ASTM C1305

Standard test method for crack bridging ability of liquid-applied waterproofing membrane

EN 13036-4

Road and airfield surface characteristics. Test methods. Slip/skid resistance: the pendulum test

ASTM C876

Standard test method for corrosion potentials of uncoated reinforcing steel in concrete

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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.

