Asset engineering

Life-care planning for car-park structures

Risk	Remaining life	Whole-life cost	Asset management	Maintenance optimisation	
Materials	Durability	Quality	Assessment	Repair	Cathodic protection

Assets

Buildings

Hotels; schools

Shopping malls

Basements

Car parks

Highways

Bridges

Tunnels

Airports

Pipelines

Storage tanks

Water treatment works

Desal plants

Power plants

Ports, harbours

Jetties

Dry docks

Oil refineries

Chemical plants

Historic structures

Materials

Concrete

Metals

Plastics

Masonry

Timber

Coatings

Facades

Flooring; roofing

The partial collapse of Wolverhampton's Pipers Row car park in 1997 triggered several initiatives concerning the safety of concrete in multi-storey car parks. The Institution of Civil Engineers (ICE) responded by forming a national steering committee (NSC), responsible for producing recommendations for the inspection, maintenance and management of car park structures.

The resulting *Recommendations for the inspection, maintenance and management of car park structures, Thomas Telford, 2002*, is a practical guide for owners and operators and their professional advisors. As a member of the NSC, Halcrow helped to prepare this.

A key recommendation was that a life-care plan (LCP) should be produced for each structure. An LCP is a statement of the present and predicted condition of the car park, based on regular inspection, structural assessment and maintenance needs. It also sets out a management strategy for achieving long-term serviceability and safety, with minimum cost and disruption.

To comply, owners and operators must:

- appoint engineers to advise on structural safety, inspection, maintenance and repair, to industry standards
- instruct engineers to prepare LCPs for each structure and provide the resources needed for this
- keep records up to date and available

The ICE document introduces the following terms and actions, which should form the basis of an LCP:

- initial review
- condition survey

The LCP establishes requirements for planned preventative maintenance, often at a low whole-life cost.

Where essential works are identified, owners and operators can avoid loss of service and revenue through careful implementation and timing. This improved control over maintenance costs helps deliver a best-value solution.

Halcrow's approach to life-care plans

The requirements in the ICE recommendations clearly demarcate the responsibilities of the car-park owner and operator, in terms of maintaining their structures in a safe and serviceable condition. The maintenance regimes employed must be safe for the structure and for users.

The recommendations set out how this can be achieved by preparing an LCP. This process demonstrates that the safety and serviceability of the structure is verifiable and that there is evidence of action for that facility.

The recommendations also stipulate that the owner or operator of the car park should appoint an experienced engineer to advise on all aspects of material durability, structural safety and maintenance or repair, for the primary structure, cladding and edge protection.

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- structural appraisal
- special inspection
- maintenance and repair

In Halcrow's experience, preparing an LCP has two distinct stages:

1. Initial review: data gathering, inspection of the structure and limited testing, followed by a gap analysis and recommendations.
2. Development: work to fill the gaps in knowledge from the initial review, which may include a structural appraisal, targeted inspection and testing, life-cycle estimates, planned preventive maintenance and remedial works designs.

The initial instructions from owners or operators relating to LCPs almost exclusively refer to the initial review, as insufficient information will be available to scope and price the development stage.

The initial review is based on visual inspection and existing structural drawings, records of repair or modification, inspection reports and structural appraisals. The gap analysis identifies the extent of the information held and the work required to complete the LCP and includes:

- recommendations for immediate actions
- a plan for scheduled future actions, such as further surveillance, inspection or repair

As part of the LCP's development, additional work may be required to fill any information gaps before preparing the final plan. The content of the final LCP is directly applicable to each structure and client and may include:

- daily surveillance, usually by car park operator staff
- routine inspections, typically every six months
- periodic initial appraisal and condition survey of key components, eg cladding and edge protection, with special inspections as required
- structural appraisal at intervals of ≤16 years
- maintenance and repair works, including routine and protective or preventive works
- maintaining a site log of all works and inspections

If the car park is older than three years, a structural appraisal may be required. This is essential to benchmark the structural capacity and any future changes. The extent of the appraisal is determined once the initial review has been completed and past works identified.

Typical initial LCP review

A typical initial LCP review includes:

1. Immediate review of all documentation, including drawings, calculations, structural assessments and previous investigations. Identification of construction-related factors relevant to future service, investigation and appraisal of things like age, the form and sequence of construction and types of concrete, and identification of the critical elements and details.

2. A walk-over survey noting the number of spaces and levels. This will identify potential problems, including areas of high chloride ion build-up, areas of reinforcement corrosion, the condition of edge restraints and cladding, impact or fire damage and other relevant features. Defects are measured and recorded using digital photography.

3. A testing team will complete a sampling and testing regime in areas with defects, which includes:

- depth of cover to the top of the slabs and soffits
- depth of carbonation
- chloride ion content profile
- half-cell potential

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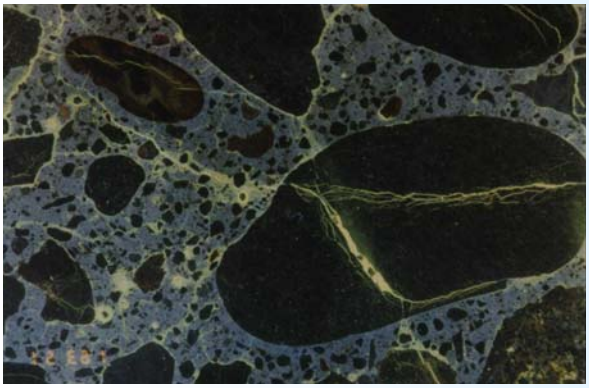
4. Where appropriate, we take 100mm-diameter cores from walls, columns, beams or decks, using a standard water-flush diamond-tipped core barrel.

These are tested:

- for compressive strength and density
- to provide detailed information on the microstructure and evidence of deterioration, such as alkali silica reaction and sulphate attack, and presence of high alumina cements and entrained air



5. Testing and reporting can begin immediately, including:

- a gap analysis to highlight any information needed to complete the LCP and price estimates for this work
- categorising immediate, short-term, medium-term" and long-term remedial work
- notes and recommendations for a follow-up special inspection to quantify the extent of works, where they are extensive
- Producing a factual report, from which the LCP is prepared

Our experience

Halcrow specialises in the provision of professional planning, design and management services for infrastructure development worldwide.

One of the UK's leading consultancies, we employ nearly 6,500 people and generate an annual turnover in excess of £200 million in a network of over 70 offices around the world.

We have an enviable breadth of skills and expertise at our fingertips and we pride ourselves on our ability to listen to clients and understand their needs.

Halcrow has considerable experience in the management and engineering of roads, bridges and other structures. We use our knowledge management and project management systems to provide solutions and to strive for continuous improvement.

We appreciate the importance of effective documents when applying LCP principles and practice to the safety and performance of car parks. Halcrow has proven experience in developing advice notes, codes of practice, manuals, specifications and other documents relating to a wide range of assets.

Examples include:

- Highways Agency – performance specification for management of trunk road networks by joint managing agents and contractors
- Highways Agency – guides on management of street works on all-purpose trunk roads
- Gloucestershire County Council – assistance with highway maintenance handbook, transport asset management plans and technical guides on operational management
- Highways Agency – revision of volume ten of the Design Manual for Roads and Bridges (Environmental Design and Management)
- Transport for London – notice and permits code of practice, now adopted by the Department for Transport for road works and street works
- Severn Crossing Company UK – maintenance manuals for major cable-stayed bridge across the River Severn and its approach roads

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Our technical expertise

Key people involved in life-care planning include:

Project director – Peter Robery
Peter has a long history of work in asset engineering and management. Peter served on the NSC and the IStructE Car Parks Task Group, producing *Design recommendations for multi-storey and underground car parks (3rd Edition) 2002*.

He is a specialist in the inspection, durability, maintenance and repair of concrete assets and has served as an expert witness on car park disputes. He is the UK's principal technical expert to the British Standards Institution, finalising BS EN 1504, the new European standard on structural and non-structural concrete repair.

Project manager – Robin Baldwin
Robin is a senior materials engineer with extensive experience of the investigation and remediation of concrete structures. He has detailed knowledge of the investigation of car parks, tunnels, bridges, dams, waste, oil, nuclear and military facilities, building and coastal structures, roads, floors and pavements.

Project specialist – Kate Turnpenny
Kate is a principal engineer with 15 years' experience in inspection and condition surveys for a wide range of civil engineering structures, including car parks, tunnels, ports, marinas and historic buildings.

Kate specialises in the investigation of materials and metallurgical and processing evaluations and has prepared LCPs for local authority clients including Wycombe District Council and Norwich City Council.

Project specialist – Elena Browne
Elena is an asset and materials engineer with 9 years' experience in civil structural engineering design and assessment, asset management and concrete technology. She specialises in durability of concrete structures, specification, investigation and testing of concrete, inspection, rehabilitation, maintenance and repair of concrete structures.

Recent experience with car park investigations:

Date	Project	Client	Value	Description
2003	Europcar, Hertfordshire	Europcar	c£30k	Expert witness services, remedial options
2004	Nationwide car park, Swindon	Nationwide Building Society	c£25k	Inspection, specification for remedial works
2005	Car park, UK south coast	Leading industrial company	c£40k	Inspection, calculations, remedial options
2006	Lincoln multi-storey car park surveys	City of Lincoln Council	c£15k	Inspections, assessments, and life-care plans for three multi-storey car parks.

For more information on our life care planning services, please contact:

Elena Browne
Lyndon House
62 Hagley Road
Birmingham
B16 8PE

T. +44 (0)121 456 0674
E. brownee@halcrow.com

Robin Baldwin
Burderop Park
Swindon
Wiltshire
SN4 0QD

T. +44 (0)179 3816 647
E. baldwinr@halcrow.com

Andrew Ardrey
22 Cortlandt Street
New York
10007
United States of America

T. +1 212 608 4963
E. ardreyag@halcrow.com

David Pocock
PO Box 360
Dubai
United Arab Emirates

T. +971 433 70380
E. pocockdc@halcrow.com

For details of your nearest Halcrow office, please visit our website at halcrow.com