Selecting a strategy for dealing with accelerated low water corrosion (ALWC): Part 1

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Dr Jim Breakell is an independent corrosion control and materials consultant with a particular interest and expertise in marine corrosion and its control, including for ALWC. He was the principal author of CIRIA guidance Management of Accelerated Low Water Corrosion in steel maritime structures (C634). Here, in the first of a two-part article for Port Technology International, Dr Breakell examines why ALWC is a problem, what needs to be done and summarises the more common types of repair techniques.

The problem

ALWC is a particularly aggressive, localised corrosion phenomenon that can occur on unprotected or inadequately protected steel, maritime structures. It results in patches of accelerated metal wastage typically in the low water zone just above the lowest astronomical tide (LAT) or, on some structures, in the immersed zone. ALWC is probably now the most likely and aggressive form of localised attack that can occur within these zones. Its consequence can be extensive, unbudgeted and costly remedial repair resulting in maintenance works at an unexpectedly early stage in the life of a structure and the potential for premature collapse of those structures badly affected by the problem. The ICE Maritime Board has estimated that repair costs resulting from ALWC on structures in the UK alone will be in excess of £250 million to save assets with capital value in billions of pounds.

ALWC can be recognised by the combination of its visual features, characteristic pattern of damage and unusually high rates of localised metal loss. Average corrosion rates up to 1.0 mm/wetted side/year are typically reported but higher instantaneous rates are probable once ALWC has initiated on a structure. The detailed mechanism of ALWC is still unclear but it is most likely caused by a combination of microbiological and corrosion processes which probably explains its apparent unpredictable behaviour both within and between maritime installations. No accurate model is currently available to predict the risk of ALWC occurring at any particular geographic location. It is essential, therefore, that the possibility of this problem occurring is taken into account in all design, inspection, structural analysis, repair, protection and on-going monitoring for all maritime structures with due regard to relevant health and safety legislation and environmental responsibilities.

What needs to be done?

Management of ALWC for an existing structure requires taking appropriate action to ensure that structural integrity and operational ability are maintained for its required remaining service life. In general, the earlier ALWC is detected and addressed the less extensive (and hence less expensive) the remedial solution will be. It is essential, therefore, that a diligent

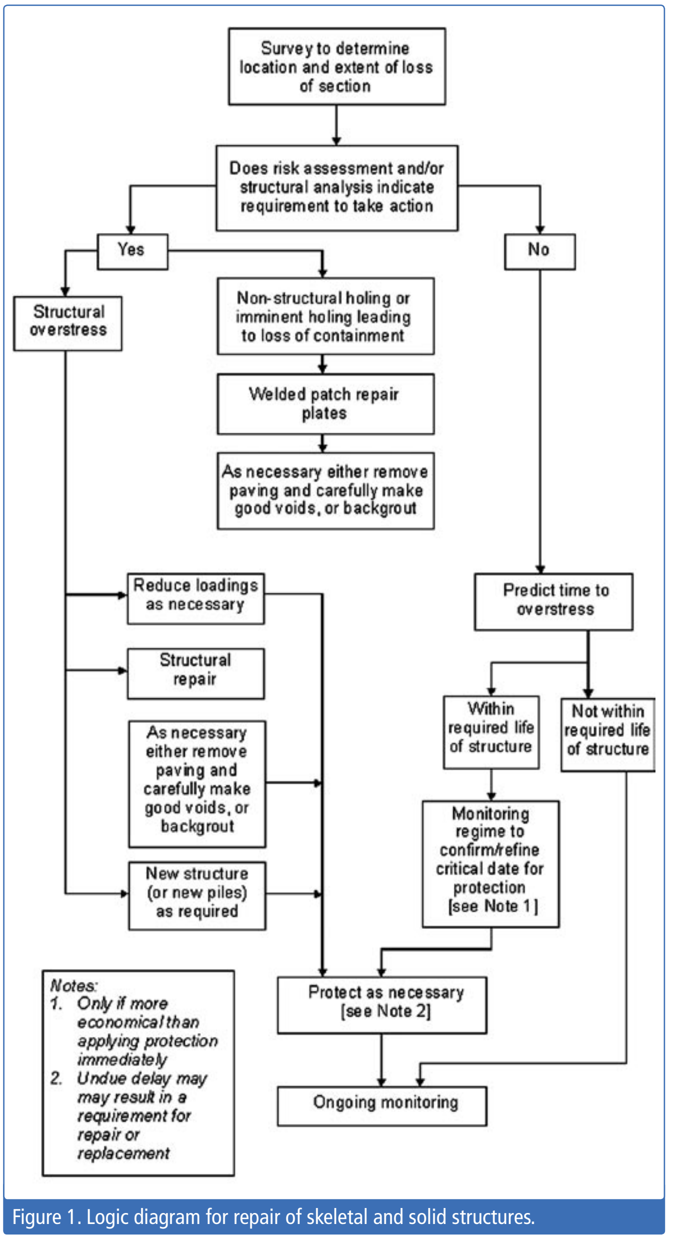

Figure 1. Logic diagram for repair of skeletal and solid structures.

inspection is first carried out in the susceptible zones. Such initial inspections and subsequent more detailed surveys provide the information needed to:

- Identify if there is an ALWC problem or the potential for one on a particular structure. Note that competent inspection is required for the identification of ALWC. Possible outcomes are that ALWC is found (1) to be absent, (2) to be present in an early to intermediate stage or (3) to have progressed to an advanced stage where significant metal thinning and holing is present.

TABLE 1: REPAIR TECHNIQUES FOR ALWC AFFECTED STRUCTURES		
Repair Technique	**Skeletal Structures**	**Solid Structures**
Welded patch repair plate (to make good localised thinning/holing or to add extra steel to vulnerable areas)	X	X
Welded strengthening plate (used for more extensively corroded areas)	√	√
Plating plus reinforced concrete infill	NA	√
Reinforced concrete collar / encasement	√	NA
Concrete pile infill	√	NA
Reinforced concrete facing	NA	√
Spliced in replacement length of pile	√	NP
Replacement pile or steel sheet pile	√	NP

Key:
X Not suitable for structural repair
√ Suitable for structural repair
NA Not applicable
NP Not (normally) practical

- Evaluate the extent and nature of the problem so that the structure's remaining serviceable life can be predicted, based on the risk or impact that it might have for one or more components of that structure.
- Develop a strategy (i.e. identification and prioritisation of any remedial measures that may be required, including budgetary considerations) for repairing and protecting the structure in order to limit or avoid any further deterioration. The design of repairs and protection systems requires the involvement of both structural and corrosion engineers with experience of maritime facilities and ALWC. A business and safety risk assessment should be carried out both to determine when action should be taken and to ensure mitigation measures are carried out in a safe manner.

The affects of severe corrosion.

Selection of the correct strategy will principally be determined by factors such as:

- the economics and availability of funding; some work may have to be deferred subject to ensuring that safety and structural capacity are not compromised
- the shortfall between the required and predicted remaining life of the facility
- any reduction that may have to be imposed on operational loads
- the usage of the facility
- the cost of repair and/or protection; if steel section loss is severe and/or if holes have become unmanageably numerous or large then repairs can become uneconomical
- selection of the most cost-effective solution and resources
- whether access to the damaged areas can be achieved safely and practicably
- future maintenance requirements
- rapid versus cheaper methods

A typical logic sequence for selection of a strategy for both skeletal and solid structures is given in Figure 1.

TABLE 2: COMPARISON OF UNDERWATER VERSUS DRY REPAIR METHODS	
Underwater Repairs	**Dry Repairs**
Access to affected areas at most states of the tide	Access to the affected areas at any state of tide
Quantification of damage less accurate than in the dry	Accurate quantification of corrosion damage
Work can be prevented by poor underwater visibility	Work not affected by poor underwater visibility
Work can be prevented by currents or waves	Work not affected by currents
Quality of work can only be verified by a qualified diver/inspector	Quality of work can be verified by Owner's or Engineer's usual qualified inspectors
Quality limited to underwater standards	Better quality of repairs
Flexible location of working	Location limited to a discrete length of quay at any one time
No additional loading on the structure	Requires the structure to be able to support the uninstalled weight of the cofferdam, operational loadings and of the crane needed to lift it into place
Safety zone required between port operations and divers	Minimal disruption to port operations due to the flexibility of movement
Low mobilisation costs	High mobilisation costs – not cost effective for small repairs
Not possible to recover any possibly contaminated washings from going into seawater	Any contaminated washings can be collected


Corrosion can be found in many different types of low water areas.


Example of corrosion holing at low water on typical maritime structure.


Close up of a typical ALWC patch.

Repair techniques for ALWC

A summary of the more common types of repair techniques for ALWC for both skeletal structures (with steel tubular, box and other pile sections including jetties, piers, etc.) and solid structures (with steel retaining structures including wharves, quays, retaining walls, flood defence structures, etc.) and their suitability for structural purposes is given in Table 1.

Note that many types of repairs such as the welding of new steel plate or partial jacketing with reinforced concrete onto a structure can introduce new corrosion cells and, in some circumstances, locally increase corrosion rates. It is, therefore, important that appropriate measures are taken, as necessary, to minimise such risks whilst also ensuring that methods of safe access to carry out such repair works are also fully considered. Since any repair work arising from ALWC will need to be performed in the low water and/or immersed zones and will be severely restricted by tides, the available options for carrying out such repair work are:

(1) Underwater repairs by experienced welder/divers using specialised tools and techniques.

(2) Dry repairs undertaken within a temporary dry environment formed using a limpet dam or cofferdams.

The perceived advantages and disadvantages of these two options are summarised in Table 2.

Part two if this article (to appear in edition 33 of Port Technology International) will examine how to protect structures against ALWC, on-going monitoring methods and conclusions.

ABOUT THE AUTHOR

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ABOUT THE ORGANISATION

CIRIA is a member-owned organisation that works with the construction industry, government and academia to provide performance improvement products and services in the construction and related industries. It was founded in 1960 and currently engages with around 700 subscribing organisations. Activities include collaborative projects, networking, publishing, workshops, seminars and conferences. About 40 projects are run at any one time, about 100 events are staged every year, and twenty five books published per annum.

ENQUIRIES

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More detailed guidance can be found in CIRIA's Management of Accelerated Low Water Corrosion in steel maritime structures (C634), available from www.ciriabooks.com