

Guidance Document

G050 Civil Engineering - Common Requirements

Issue No.: A4

Issue date: February 2013
Review date: February 2018

MAYOR OF LONDON

 **Documents**
Document Sharing Hub



Contents

1	Purpose	3
2	Scope	3
3	Guidance	4
3.1	Competence	4
3.2	Technical approval, processes and assurance	4
3.3	Design of service fixings and connections for new structures	7
3.4	Ground investigations	7
3.5	Management of sub-standard assets	12
3.6	Ground movement impact on railway and other structures	12
3.7	Use of tall plant on or near the railway	13
3.8	The use of temporary works, scaffolding and hoardings near the railway	18
3.9	Piling and similar processes	18
3.10	Adjacent structures	18
3.11	Asset and structure identification	18
3.12	Condition assessment and certification/reporting	19
3.13	Structural materials	19
3.14	Cutting, grinding, drilling, fixing to and supporting from existing structures and inspection access	47
3.15	Decommissioning, demolition and site clearance	48
3.16	Access covers	49
3.17	Service crossings	50
3.18	Evidence of compliance	50
3.19	Risk	50
4	Responsibilities	50
5	Supporting information	50
5.1	Background	50
5.2	Other information	51
6	References	53
6.1	Abbreviations	53
6.2	Definitions	54
6.3	Person accountable for the document	56
6.4	Document history	56
7	Attachments	57
7.1	Example of a civil engineering related conceptual design statement	57
7.2	Example of a civil engineering approval in principle of safe load assessment	61
7.3	Example of Maintenance Work Annual Handover Certificate	66
7.4	Typical condition survey report for assessing impact of works	67
7.5	Suggested typical defects to be recorded when assessing the impact of works	69
7.6	Risk assessment and method statement checklist for the operation of lifting appliances - example	73
7.7	Site operation checklist for the operation of lifting appliances - example	75



This document must not form part of Contractual terms and conditions between London Underground and Suppliers.

Neither London Underground nor Suppliers are bound to provide any of the items or services or follow any processes described in this document unless they are also required to provide them explicitly by other, contractually binding, documents.

The information within this document must not be used by London Underground or Suppliers to raise or moderate expectations of delivery by Suppliers or London Underground over and above Contractual requirements.

1 Purpose

- 1.1 The purpose of this Guidance is to support and give guidance on LU category 1 Standard S1050 "Civil Engineering - Common Requirements".

2 Scope

- 2.1 This Guidance applies to the application of the following generic requirements for LU owned civil engineering assets:

- a) Competence
- b) Technical approval, processes and assurance
- c) Design of service fixings and connections for new structures
- d) Ground investigations
- e) Management of sub-standard assets
- f) Ground movement impact on railway and adjacent structures
- g) Use of tall plant on or near the railway
- h) Use of temporary works, scaffolding and hoardings near the railway
- i) Piling and similar processes
- j) Adjacent structures
- k) Asset and structure identification
- l) Condition assessment and certification
- m) Structural materials
- n) Cutting, grinding, drilling, fixing to and supporting from existing structures and inspection access
- o) Decommissioning, demolition and site clearance
- p) Access covers
- q) Service crossings
- r) Evidence of compliance
- s) Risk

3 Guidance

3.1 Competence

3.1.1 No additional advice.

3.2 Technical approval, processes and assurance

3.2.1 General

3.2.1.1 Conceptual design statements - guidance for civil engineering works

Requirement for submitting a CDS

- a) A conceptual design statement (CDS) should be provided for all works, or parts of works requiring design.
- b) The CDS should recognise the impact of the proposed works on Outside Parties, third parties and other engineering disciplines (e.g. Power, Signals, Permanent Way, etc.).
- c) A separate CDS should be submitted for each distinct major section of the project (e.g. one CDS for a new footbridge and a separate CDS for platform reconstruction work which could both be part of a station refurbishment project).
- d) Temporary works on LU Operational property, whose failure would affect the safety of the public or operation of the railway, should be covered by a CDS. Examples could include temporary road or rail carrying structures, crash decks spanning the railway, scaffolding over the railway, propping or other temporary works that would affect the support of the track. LU Standard S1062 Temporary Works should be followed but judgement should be used where the design is very low risk, simple or makes use of standard or proprietary systems. A simplified design statement may be deemed adequate in these cases. This should be discussed and agreed with the LU accredited engineer at the earliest opportunity.
- e) Where applicable, demolition works should be covered by a CDS, with particular reference to design effects of demolition on other structures.

Definition of content

- a) Overall, the content of the CDS should be sufficient to demonstrate to the Profession Head or their accredited engineer that the proposed design is a safe and practical solution. The CDS should give confidence that the design will be undertaken to the correct standards and that adequate design checks will be followed. The CDS should also include details showing that the proposed construction can be satisfactorily completed.
- b) The detail required should reflect the complexity and significance of the work.
- c) The standard CDS should, where relevant to the particular project, include:
 - I) the design organisation: consultant or design team undertaking the design including address and contact name;
 - II) an identification of the structure: description of proposed structure, precise location, line, nearest station, km post or station room number,

- LCS code, nearest road name (or road crossing). If an existing structure, include LU asset number;
- III) the title of scheme: project title and project expenditure requisition number or title known to LU for Outside Party design. Include sub-title if part of a larger project;
 - IV) the name of sponsor: i.e. which company or department is paying for the project or promoting it, including contact details, name and title;
 - V) the proposed milestone programme: include design, procurement and construction stages through to completion;
 - VI) existing conditions: description of site or existing structure or both; Reference should be made to any Site Investigation, surveys, assessments or inspections, existing structural defects, environmental considerations, changes and hazards, third party services or structures and site restrictions (actual site reports do not need to be included but a summary will be required). Also include proposals for any further Site Investigation proposed during detail design;
 - VII) a description of the proposed works: introduction, including location plan to show boundaries and other affected land owners, and general arrangement drawings of the proposed works - no larger than A3 sized. These drawings or sketches can be attached as a loose appendix. Detailed design is not required at this stage. Foundation and support proposals; span arrangements, including bearings or articulation; special features or finishes (e.g. non-slip concrete, special corrosion protection); waterproofing performance;
 - VIII) alternative proposals: brief description of alternative structural forms considered and reason for rejecting these, e.g. pad foundations used instead of piled foundations due to buried obstruction. However if the solution was obvious it may not have been necessary to consider alternatives. If this is the case it should be stated;
 - IX) the proposed method of construction: this may be an assumed method at this stage, in outline format, but should note special construction sequences required by the design. Include significant temporary works (e.g. Bailey bridge, crash deck), road traffic constraints and effects on passenger flow, effects on operational railway (e.g. station closures, possessions), special methods of construction or materials to be used;
 - X) design criteria: schedule of loading, type and values with reference to relevant standards.. For bridges include kinetic loadings (e.g. speed for centrifugal force, provisions for abnormal load). Ensure that impact, wind and parapet loads are also noted. Also include design life, fatigue issues, soil, groundwater and other foundation related parameters;
 - XI) the proposed method of structural analysis: i.e. description of the structural model (e.g. simply supported, continuous, portal frame). Method of calculating forces (e.g. by statics, moment distribution, finite element, limit equilibrium). Include details of software analysis programmes;
 - XII) standards and codes of practice: list (principal) standards used, including departures from standards and a list of required concessions, if relevant. The list should always quote LU standards first. Other standards should only be listed if the LU standards do not cover the aspects in question.
 - XIII) safety consideration: this is relevant if the structure needs to incorporate special safety systems, (e.g. places of safety, maintenance access



systems), special risks in the construction or use of structure (e.g. working adjacent to operational railway, need for temporary speed restrictions, access difficulties for inspection), required changes to the railway safety case;

- XIV) clearances: for track clearances this should state either 'Clearance Approval is not required as the proposed work is more than 3 metres from the track' or 'A track clearance certificate will be gained before commencement of work on site'
 - XV) functional requirements: a description of the purpose and serviceability of the asset, including reference to the client's design brief or scope of work where exceptional requirements are specified;
 - XVI) maintenance issues: special maintenance requirements or liabilities, design life of the structure and special risks related to maintenance, demolition and renewal;
 - XVII) preliminary cost estimates: should state feasibility or budget construction figure for the work in question (this will not be the same as the total project value). This may be commercially sensitive and is optional for Outside Parties work;
 - XVIII) design check category: the proposed check category with reasons for selection. Where relevant include details of the proposed design check organisation;
 - XIX) list of appendices;
 - XX) signature sheet: sign off by the Design Engineer, manager of the design organisation, Supplier's Senior Accountable Engineer;
 - XXI) appendices: appendices (if included), separated from each other and the body of the CDS with clear divisions.
- d) Each page of the CDS should have a header or footer with the structure title, date, current revision, page number and total number of pages (e.g. page 2 of 5).
 - e) Optional information, for example Site Investigation reports, scheme drawings, architectural details, should be included in appendices, if submitted.

3.2.1.2 Timescales

- a) The design organisation should produce and submit the CDS before any detail design commences but after the scheme has been finalised. This will usually be between feasibility and detail design stages. Precise timescales need to be agreed with the Design Engineer and Project Manager.

3.2.1.3 Example CDS

- a) An example of a civil engineering related CDS is given in Attachment 7.1.

3.2.2 Analytical assessments

- 3.2.2.1 An example of an Analytical Assessment Approval in Principal (AIP) document is given in Attachment 7.2.

3.2.3 Completion and handover of maintenance and strengthening and renewal works

3.2.3.1 Signed handover certificates are required to demonstrate that maintenance works have been carried out in accordance with LU Standards and that they fulfil the intended purpose requirements of the user

3.2.3.2 An example of the Maintenance Work Annual Handover Certificate historically used by LU is given in Attachment 7.3.

3.2.4 Specific Requirements for Flooding Risk Management

LU carried out a process which was completed in 2001 to ensure that flooding risks across the whole network were as low as is reasonably practicable. Many changes on the system can alter the flooding risk profile such as lowering station thresholds creating new routes for water into the system or a new installation (e.g. large water main) that creates an additional water source. All works (whether flooding related or not) are required to demonstrate that flooding inundation risk remains ALARP and acceptable in terms of railway service reliability and performance. Due to the large library of information available regarding flooding, the following protocol is required with regard to flooding risks:

- a) Examine the Flood Mitigation Project archive and abstract the following information:
 - I) existing risk level;
 - II) water sources that could impact on the location, if any;
 - III) characteristics of the location that control inward water flow;
 - IV) existing control measures;
 - V) potential flow rates.
- b) Revise the risk estimate based on proposed changes;
- c) Confirm the risk remains ALARP and acceptable in terms of railway service reliability and performance;

3.3 Design of service fixings and connections for new structures

No additional advice.

3.4 Ground investigations

3.4.1 General

3.4.1.1 A Ground Investigation aims to determine the nature and behaviour of all aspects of a site and its environs that could influence or be influenced by a construction project. Without a properly procured, supervised and interpreted Ground Investigation, hazards which lie in the ground beneath or around the site cannot be known.

3.4.1.2 A Ground Investigation should include the following:

- a) desk study;
- b) site reconnaissance and walkover survey;
- c) location of buried services or tunnels that fall within the area being investigated;



- d) geomorphological mapping;
- e) ground investigation;
- f) laboratory test scheduling;
- g) instrumentation and monitoring;
- h) ground investigation factual reporting;
- i) Site Investigation interpretative reporting.

Note: This list is not exhaustive and other items may be required on a case-by-case basis.

3.4.1.3 The Supplier should conduct a risk assessment at the conceptual design stage and consistently review this assessment throughout the development of the design.

3.4.1.4 The Ground Investigation should be included in the specification and conditions of contract for the construction project and should emphasise matters affecting safety; these should include, for all phases of the work:

- a) effect of work on neighbouring land and structures;
- b) protection of railway and site staff and the public around the site;
- c) access for materials;
- d) access and manoeuvring space for plant;
- e) protection of trains and track during all stages of the works;
- f) accurate location of existing services, including LU tunnels, electrical, communication and signalling equipment;
- g) temporary works, including shoring of trial pits and scaffolding platforms for boring rigs;
- h) backfilling of exploratory holes and pits and the protection of monitoring installations;
- i) reference to British Drilling Association (BDA) guidelines for investigation in contaminated land, including the preparation of COSHH statements

Note: This list is not exhaustive and other items may be required on a case-by-case basis.

3.4.2 Conceptual design statement (CDS)

3.4.2.1 A Site Investigation conceptual design statement (CDS) should typically include:

- a) general description of project and location, parties and personnel, scope of proposed construction works;
- b) technical objectives and clearly defined purpose for the Site Investigation;
- c) the areas and depths of the ground to be investigated;
- d) deliverables required from the ground investigation contractor;
- e) deliverables to be produced by the designer including contents list of reports;
- f) key programme dates including time required for the ground investigation;
- g) safety considerations including a risk assessment;
- h) noise, environmental and archaeological constraints;
- i) existing contamination and pollution potential. Reference to relevant Statutory documents, Acts of Parliament etc.;

- j) track occupation, possession or speed restriction requirements;
- k) specific training required;
- l) outline method statements for carrying out the work;
- m) computer software for design or analysis including verification status.

Note: This list is not exhaustive and other items may be required on a case-by-case basis.

3.4.3 Desk study report for site investigation

3.4.3.1 The Supplier should prepare a desk study report and ensure that it is sufficient in its scope to provide the required information, especially where existing information is relied upon.

3.4.3.2 The desk study report should refer to available exploratory hole data from the British Geological Survey (BGS) and LU, large scale geological maps, aerial photography, old Ordnance Survey (OS) maps and LU construction and remedial works drawings.

3.4.3.3 A typical contents list for a desk study report is shown below:

- a) introduction;
- b) the site and proposed construction works;
- c) geology (including available existing borehole information);
- d) topography and geomorphology;
- e) drainage and hydrogeology;
- f) present land-use and site history;
- g) walk over survey;
- h) laboratory testing (from previous ground investigations);
- i) engineering considerations;
- j) conclusions;
- k) recommendations

Note: This list is not exhaustive and other items may be required on a case-by-case basis

3.4.4 Ground investigations on site

3.4.4.1 A Ground Investigation should be undertaken for sites where construction works or significant alterations to existing structures are proposed.

3.4.4.2 A site inspection and walkover survey should be carried out before the design of the Ground Investigation and the results included in the desk study report.

3.4.4.3 A site condition survey of property and structures adjacent to proposed access routes for the ground investigation plant and materials should be carried out where appropriate.

3.4.4.4 Geomorphological mapping of the site should be carried out where appropriate. The geomorphological mapping should be presented on drawings of sufficient scale to ensure that the features can be clearly identified.

3.4.5 Conceptual work statement

3.4.5.1 The Supplier should prepare a CWS which should address the following subjects:



- a) site description and access routes;
- b) site constraints including existing service locations and LU tunnels;
- c) exploratory hole location plan and schedule;
- d) methodology to satisfy LU contract safety conditions;
- e) general description of drilling and pitting techniques, sampling methods, in-situ testing and instrumentation;
- f) type of plant required to carry out the work;
- g) in-situ testing, laboratory testing or other techniques to obtain the required design properties;
- h) backfilling of exploratory holes and pits;
- i) monitoring requirements;
- j) programme for the Site Investigation and budget cost estimates;
- k) site supervision of the Ground Investigation, including qualifications and experience of the Suppliers site personnel and Contractor's Representatives to ensure that the required technical standards are met.

Note: This list is not exhaustive and other items may be required on a case-by-case basis.

3.4.5.2 Notification of the Ground Investigation site work should be given to LU to obtain information on any relevant LU services e.g. electrical, communication and signalling equipment, which may be jeopardised by the work.

3.4.5.3 Notification of all site work and exploratory hole positions should be given to all relevant statutory utility companies for the identification of main services affecting the Ground Investigation.

3.4.6 Scope of Site Ground investigation

3.4.6.1 The Supplier should determine the extent of the investigation, including special requirements for tunnels, cuttings, embankments and foundations for structures.

3.4.6.2 The exploratory hole positions should be referenced to the LU Grid Survey Control to an accuracy of $\pm 1\text{m}$ and where appropriate the full Location Coding System (LCS) reference, chainage and offset from the nearest running rail or track centreline as appropriate.

3.4.6.3 The datum should be LU Tunnel Datum (100m below Ordnance Datum) and the elevation of the ground at each exploratory hole should be established to the nearest 0.05m

Note: LU Standard 1-026 (Topographical Surveys and Mapping) gives details of LU Grid Survey Control and Tunnel Datum requirements.

3.4.7 Instrumentation and monitoring

3.4.7.1 The Supplier should ensure that reliable and applicable instrumentation methods are used during the Ground Investigation in order to detect:

- a) groundwater fluctuations;
- b) ground deformation;
- c) methane and other gases from the ground;
- d) damage to buildings, structures, utilities and facilities.



3.4.7.2 The Supplier should ensure that all relevant personnel are trained to read and monitor the instrumentation and should recommend responsibilities for post-ground investigation contract monitoring, reporting and interpretation.

3.4.7.3 Consideration should be given as to the post-contract availability and ownership of the relevant monitoring equipment and also whether LU track safety protection would be required when readings are to be taken.

3.4.8 Ground Investigation contractors

3.4.8.1 The Supplier should ensure that Ground Investigation works are undertaken by contractors that are competent and suitably qualified to undertake the works. Drillers should hold a certificate of competence for percussion boring or rotary drilling, as issued by the BDA under the Ground Investigation Drillers Accreditation Scheme.

3.4.9 Reporting

3.4.9.1 The factual and interpretive Ground Investigation information should be recorded in a report which is signed by the Supplier's Senior Accountable Engineer.

3.4.9.2 A typical contents list for a factual report is shown below:

- a) introduction;
- b) the site, referenced to LCS Code, LU Grid and OS grid reference;
- c) the Ground Investigation work carried out, including details of the methods of investigation, in-situ testing and sampling;
- d) the results obtained from the field work and laboratory testing;
- e) drawings, including key plan, exploratory hole location plans and geotechnical sections, where appropriate.

Note: This is not an exhaustive list and other items may be required on a case-by-case basis.
--

3.4.9.3 A typical contents list for an interpretive report is shown below:

- a) introduction - purpose of report, participants, scope of work;
- b) the site referenced to LCS code, LU grid and OS grid reference and proposed construction works;
- c) general geology, site conditions and history (brief summary of desk study);
- d) fieldwork;
- e) laboratory testing;
- f) ground and groundwater conditions;
- g) geotechnical parameters for design;
- h) monitoring results;
- i) methods of analysis;
- j) engineering considerations, including results of slope stability analysis, interpretation of failure mechanisms, possible remedial measures, ground improvement, tunnelling, foundation design, site preparation, re-use of materials and identification of environmental effects;

- k) provide a range of design solutions with guidance on which might be most appropriate in terms of cost, timing, ease of construction, future Maintenance, etc;
- l) recommendations and conclusions;
- m) references;
- n) drawings, including exploratory hole location plans and geotechnical sections.

Note: This is not an exhaustive list and other items may be required on a case-by-case basis.

3.5 Management of sub-standard assets

No additional advice.

3.6 Ground movement impact on railway and other structures

3.6.1 Condition surveys

- 3.6.1.1 It is often useful to record the Condition of neighbouring structures or other fixed assets in an agreed schedule of Condition before any works are begun. Both parties then have the means by which to monitor and measure the effects of the works. Without such a record it may be difficult to demonstrate whether or not damage to a property or structure was the result of those works being carried out. For this reason LU normally insists that a schedule of Condition is prepared and agreed where another party proposes to carry out works that could affect its assets. Similarly, LU strongly recommends that its neighbours do the same.
- 3.6.1.2 These schedules of Condition are additional to any assessments that LU may require to see in order to predict the effects of the works.
- 3.6.1.3 The schedule of Condition usually takes the form of a written report itemising any defects noted during an inspection of the asset. A suggested format for the schedule of Condition is given in Attachment 7.4. Where the asset is a building the parties may agree to use the format detailed in the Royal Institute of Chartered Surveyors' document 'Building Surveys and Inspections of Commercial and Industrial Property'.
- 3.6.1.4 Inspections are generally carried out jointly by the Proposer's and the Affected Party's Surveyors, with one being appointed to prepare the report. The parties may however choose to appoint an independent surveyor to act on both their behalves. Each party should retain a copy of the schedule of Condition signed by both parties.
- 3.6.1.5 The schedule of Condition should contain details of all defects visible on the date of the inspection. The inspection should be carried out prior to the works commencing. The description of each defect and its location should be sufficient to allow subsequent surveyors to identify any changes in the Condition of the asset.
- 3.6.1.6 All defects should be referenced to easily identifiable permanent features such as corners of buildings, tunnel headwalls or marker posts.
- 3.6.1.7 Photographs and video recordings may be included in the schedule where they will assist in describing the Condition of the asset.
- 3.6.1.8 Typical defects to be recorded for various asset types are listed in Attachment 7.5.
- 3.6.1.9 In most cases defects in the asset will be identified during a visual survey carried out jointly by the Proposer's and the Affected Party's Surveyors. This survey should be

conducted immediately before works are due to commence. It should be noted however that due to the long lead times required to gain access to many of LU's assets the survey should be arranged as far in advance as possible.

3.6.1.10 Further surveys may need to be carried out during the works, at the reasonable request of either party. A final survey will normally be carried out within six months of completion of the works. Where no changes in Condition are noted, this should be agreed in writing by both parties. Where changes have occurred details should be recorded and appended to the original schedule of Condition.

3.6.1.11 Where it is believed by either party that an existing defect may worsen during the course of the works consideration should be given to regular monitoring of the defect.

3.6.1.12 The contents of the schedule of Condition should be treated as confidential and should be used only for the purposes for which the schedule was prepared. No information contained in the schedule of Condition should be disclosed to any other party without the written consent of both the Proposer and the Affected Party.

3.7 Use of tall plant on or near the railway

3.7.1 This Section provides guidance on the use of cranes and mobile lifting appliances on or adjacent to the LU operational railway. An Application for Approval to use tall plant adjacent to the railway must be made, whenever there is a risk that use could affect the railway, in accordance with S1050.

3.7.1.1 The use of cranes and other mobile lifting appliances on construction sites provides a lift capability which is versatile and flexible. However, this flexibility requires consideration of the movement and operation of cranes and other mobile lifting appliances within the works site to ensure any risk to the general public, the railway, its passengers, its staff or property is as low as is reasonably practicable (ALARP).

3.7.1.2 The procedure for obtaining approval for the intended passage of abnormal load on the public highway within the LU network area is detailed in The Motor Vehicles (Authorisation of Special Types) General Order.

3.7.1.3 Due account should be taken of the Construction (Design and Management) Regulations. LU requires that consideration should be given, but not restricted to ensuring that risks are assessed during the design stage and the assessment is contained in the health and safety plan.

3.7.1.4 Due account should be taken of The Lifting Operations and Lifting Equipment Regulations (LOLER).

3.7.1.5 The following CIRIA documents provide useful guidance on the fundamental criteria, planning, issues and checks that are needed to ensure the safe use of cranes and that lifting operations proceed in a logical and stable manner.

- CIRIA C703 – Crane stability on site – an introductory guide
- CIRIA C654 - Tower Crane Stability

3.7.2 Operation of lifting appliances - General

3.7.2.1 It is recommended that checklists are used to assist in checking risk assessments, method statements and site operations. Sample checklists are included as Attachments 7.6 and 7.7. These checklists should not be considered definitive or exhaustive as each site will have particular requirements and constraints which must be addressed.

3.7.3 Operation of lifting appliances - Risk assessment

3.7.3.1 A risk assessment of the proposed lifting operations should be carried out covering the erection, use and dismantling of the lifting plant. The assessment should take regard of any possible hazards directly and indirectly to the railway and the control measures required to minimise the risks arising. Guidance is given later in this document on some of the controls which may be appropriate in particular circumstances.

3.7.3.2 Risks to be considered should include but not be limited to the following:

- a) site and surrounding geography;
- b) working radius available within the site boundaries;
- c) clearances available to allow the lifting appliance to work;
- d) lifting appliance type;
- e) load details;
- f) position and placing of loads;
- g) overhead clearance;
- h) access route, earth structures and retaining walls failure;
- i) lifting appliance foundation or track failure;
- j) lifting appliance failure;
- k) lifting appliance erection or dismantling problems;
- l) incorrectly or inadequately slung loads;
- m) sling or lifting point failure;
- n) lifting appliance overload;
- o) operator or banksman errors;
- p) communication failure;
- q) adverse weather conditions;
- r) control system failure;
- s) structural ties or guys failure;
- t) impact with other lifting appliances, plant or buildings;
- u) swinging loads;
- v) passenger and train operator concerns and other risks to the railway that may be relevant at a specific site;
- w) lifting appliance not correctly located on site;
- x) agreements with third parties on access, location and lifts over buildings;
- y) availability of high capacity lifting equipment and availability of its replacement in the event of a failure;
- z) unexpected extension of outriggers.

3.7.3.3 The risk assessment should be determined by a person experienced in both the use of lifting equipment and working with the railway. It may be appropriate for a small group of experienced engineers to meet to carry out a peer review of the proposal.

3.7.3.4 Each risk identified may have a number of failure modes. An assessment should be made to identify significant risks. Consideration should be given to the consequences to the railway from each of the identified risks.

3.7.4 Operation of lifting appliances - Method statements

3.7.4.1 A detailed method statement, the associated risk assessment and details of controls need to be submitted to, and accepted by, LU before works commence.

3.7.4.2 The following items should be considered for inclusion in the method statement:

- a) identification of the appointed person and other key personnel;
- b) training requirements;
- c) details of the arrangements for site supervision and safety including the operative's shift arrangements;
- d) a programme of works;
- e) the specification and uses of the proposed lifting appliance (including the load to radius graph for the crane);
- f) position of the loads being lifted;
- g) the operating limits of the lifting appliance and a dimensional plan identifying its position and its proximity to the railway its equipment and property;
- h) details of site features, layout and access, any building, plant, services or other obstruction on or near the site;
- i) special operating controls or limits or both fitted to the lifting appliance, e.g. telescopic travel limiters;
- j) control and communication systems including position of banksmen;
- k) design details and calculations for loadings on the ground - which may require proving of the ground, e.g. crane, crane foundations, bases, outriggers and spreader plates, spreader beams and track routes in the case of rail mounted cranes;
- l) design details and calculations for structural ties or guys for stabilising cranes;
- m) details of the manner in which the railway and associated equipment and property is to be protected during the lifting appliance operation;
- n) the erection and dismantling methods;
- o) the task lighting for working in the hours of darkness (if applicable);
- p) the testing and inspection arrangements for the lifting appliance, its supporting structures and lifting tackle;
- q) trial lift of heaviest component;
- r) position of outriggers or base frames;
- s) pre-lift preparation and site preparation, including the planned placement and location of outrigger spreader plates prior to the arrival of the lifting appliance to the site;
- t) method of slinging;
- u) any support plant required;
- v) maximum operating wind speeds and method of measurement;



- w) contingency plans to include support plant or repair times or both for breakdowns;
- x) last lift times to ensure plant can be secured as necessary before the start of traffic hours;
- y) details of the arrangements for checking and approving any plant to be secured close to the track during traffic hours.

3.7.5 Operation of lifting appliances - Changing the planned method of lift

3.7.5.1 Any alterations or proposed changes in the way a lift has been planned and defined in the method statement must be authorised by the crane co-ordinator who must have approval from the Appointed Person.

3.7.5.2 The Appointed Person should:

- a) satisfy themselves that these changes are quantified and included in the risk assessment;
- b) check that the method statement is amended to include these changes to the planned lift;
- c) ensure that the amended risk assessment and method statement have been submitted to, and approved by the Supplier, before the change in the planned method of lift is put to use.

3.7.6 Operation of lifting appliances - Foundations

3.7.6.1 Tests, inspection and investigation should be carried out to establish if the bearing capacity of the ground over which the lifting appliance has to travel or operate is sufficient to carry the anticipated loading. This investigation should include a check for underground hazards such as:

- a) cellars and basements (filled or not);
- b) recently filled excavations;
- c) ground which has been made-up to provide a base for the crane
- d) the condition of any materials used to provide foundation support, i.e. sleepers should be of sound Condition;
- e) tidal or floodwater areas where the ground water table is high;
- f) buried pipes and services;
- g) drainage culverts;
- h) tunnels and covered ways (LU and other railway);
- i) any other subterranean structure.

3.7.6.2 The loadings from the base frames, wheels, tracks, outriggers and jacks of the lifting appliances should be ascertained for appropriate loading cases.

3.7.6.3 The load from the lifting appliance should be spread over a sufficiently large bearing area to ensure the stability of the appliance. The use of outrigger spreader plates should also be considered. Calculations may be required to confirm the method of spreading the load.

3.7.6.4 Where cranes and other lifting appliances take support from an existing structure (including earth structures) a structural assessment should be prepared to show that the structure can safely carry the required loading.



3.7.6.5 Engineering design work for crane foundations is to be independently checked.

3.7.7 Operation of lifting appliances - Working limits

3.7.7.1 The lifting appliances wherever practicable should be positioned such that, in the event of collapse or failure of the lifting mechanism, neither the lifting appliance nor any carried load can foul the track or damage cable runs or other railway equipment.

3.7.7.2 Wherever practicable a 600mm wide clearance should be provided between any part of a travelling and slewing lifting appliance and any fixture (e.g. adjacent buildings, guard rails, access, and fences). During lifting operations access should be barred from the area affected by lifting and associated areas of operation (including the area of slewing).

3.7.7.3 During traffic hours, plant should be positioned such that it does not obscure any railway signals or operational signs or prevent access to any railway equipment or distract train drivers.

3.7.8 Operation of lifting appliances - Erection and testing

3.7.8.1 Overload testing of lifting appliances near the railway should be carried out during railway non-traffic hours.

3.7.9 Operation of lifting appliances - Slings, hooks, eye bolts and shackles

3.7.9.1 A thorough examination of lifting tackle is required before first use and at intervals not exceeding 6 months. It must also be tested after any repair before being used. Records of these examinations and test certificates should be made available to LU for inspection before use of the lifting gear on site.

3.7.10 Operation of lifting appliances - Protection decks

3.7.10.1 The suitability of and safeguards offered by protective decks over the railway need to be assessed having regard to the particular risks and circumstances at each site.

3.7.10.2 Highway structures may be considered as providing a reasonable degree of protection to the railway for most construction site incidents, except perhaps dropping of very heavy loads. The risk of the deck being damaged or failing should be considered in the risk assessment.

3.7.10.3 The risk assessment should take account of the number and size of the loads to be lifted over the protective deck.

3.7.11 Specific requirements for tower cranes - Tower cranes

3.7.11.1 A tower crane which on completion of its anticipated period of use on site will be greater than 10 years old should not be used near the railway. Exceptions may be considered where a written statement is obtained from the original manufacturer that the crane has been fully checked by them within the previous 6 months prior to the intended date of erection and that it has been found fit for its intended purpose.

3.7.11.2 Copies of record documents required under the Lifting Plant and Equipment (Records of Test and Examination etc.) Regulations should be provided to the appointed person who, on request will copy them or make them available for inspection by LU.

3.7.11.3 Guyed tower cranes should not normally be permitted because of the risk of the guys being struck, tampered with or removed. If guys are used they must be protected from unauthorised, or inadvertent, striking or removal. The function and suitability of

any structural ties proposed for stabilising the tower cranes should be demonstrated by calculation.

- 3.7.11.4 Tower cranes which are required to work over LU railway track during non-traffic hours should have special arrangements regarding the crane's slewing limit switches. Arrangements and procedures should be in place for switching on and off the crane's slewing limit switches during traffic hours and non-traffic hours. The Supplier needs to agree who should be responsible for the security of the keys to activate or deactivate the tower crane's limit switches.

3.8 The use of temporary works, scaffolding and hoardings near the railway

- 3.8.1 No additional advice.

3.9 Piling and similar processes

- 3.9.1 No additional advice.

3.10 Adjacent structures

- 3.10.1 No additional advice.

3.11 Asset and structure identification

Structure identification plates

- 3.11.1 The requirements for Signage for Operational Purposes are covered by LU Standard S1004. Detailed requirements for structure identification plates are included in section 3.6.2 of the standard.
- 3.11.2 Identification plate material
- Materials deemed to meet our requirements in the case of most structures are:
- a) Spheroidal graphite cast iron;
 - b) Sand cast silicon aluminium.
- 3.11.3 Where aluminium plates are used, an insulating membrane consisting of 1 mm thick polyethylene sheet should be bonded to the rear of the plate to prevent possible corrosion by salts exuded from brick or stone, or bimetallic corrosion with steel.
- 3.11.4 Identification plates for lighting standards should be made of aluminium complying with BS EN 485-1 Grade 5251 - H22.
- 3.11.5 Identification plates for Building and Station Structures and Deep Tube Tunnels should be made from 1.5 mm thick vitreous enamelled mild steel. Both sides of the plate should have a vitreous enamel ground coat and, in addition, the face side should have a finish coat.

Identification plate design

- 3.11.6 Structure identification plates should be designed as shown in S1004.

Fixing of identification plates



- 3.11.7 Identification plates should be fixed to structures with 10 mm diameter sheradised or cadmium plated mild steel bolts, nuts and washers.
- 3.11.8 If it is not possible to bolt directly to the structure without it being weakened, or if it is not possible to locate the bolts, then the identification plate should be fixed with hookbolts, clamps or steel strapping bent to suit.
- 3.11.9 Lighting standard identification plates should be fixed to the standards with stainless steel strapping 0.5 mm thick x 12 mm wide retained with an approved patent clip.
- 3.11.10 Building and Station Structures and Deep Tube Tunnel identification plates should be fixed to the structure with epoxy resin adhesive.

3.12 Condition assessment and certification/reporting

3.12.1 No additional advice.

3.13 Structural materials

3.13.1 General

No additional advice.

3.13.2 Concrete

3.13.2.1 Maintenance Work - Repair of concrete structures

British Standard EN 1504 contains information on the repair of concrete structures and defines and specifies products and systems for the repair and protection of concrete structures. The standard defines and specifies site application of these products and systems and the associated quality control activities.

Introduction

- a) When correctly designed, constructed with good quality materials and properly maintained, concrete structures have good durability. However, for numerous reasons deterioration of concrete structures can occur.
- b) Deterioration of concrete structures may be due to a number of possible causes including original design faults, the use of unsuitable materials, poor workmanship, a lack of proper Maintenance or a hostile environment.
- c) Corrosion of reinforcing steel, leading to cracking and spalling of the concrete, occurs where the concrete cover to the bar is either inadequate in terms of quality, or poorly compacted or insufficient in thickness. Atmospheric carbon dioxide penetrates the concrete cover, destroying the alkaline protection that the cement provides to the embedded reinforcing steel. In damp conditions corrosion of the bar will take place, exacerbated by leakage of water into the structure: lack of an effective waterproof membrane, blocked drainage outlets, leaking movement joints and spray from passing vehicles are common causes. Where the water contains chloride ions from de-icing salts used on roads or platforms, rapid and severe corrosion of the reinforcement can occur even in good quality, uncarbonated concrete. Deterioration can also occur by ASR, if reactive aggregates are present in a concrete with strongly alkaline cement.

- d) The first indications of serious deterioration can usually be identified in General or Principal Inspections. The visual signs are cracks, spalls and rust stains. However, local pitting corrosion can develop with no obvious signs and additional internal stresses may be induced by ASR. It is essential to determine the causes of deterioration and their consequences before deciding on the type and scale of concrete repairs.
- e) The object of any repair work is to restore structures to a condition where they can fulfil their intended load carrying function for the rest of their design life. It cannot be stressed too highly that to achieve this, the quality of workmanship must be of the highest order and it is important that all materials used must be compatible with each other and compatible in strength and ductility with the parent concrete. This is best assured by designing the concrete or mortar mix to suit the substrate.

Fault diagnosis

- a) Before carrying out any concrete repair, it is important to understand the causes of the deterioration. A purposeful diagnosis should enable the cause of the deterioration to be ascertained, whether by physical (e.g. frost) or chemical (e.g. de-icing salts) attack, or due to defects in original concrete quality.
- b) An initial survey of the whole of the damaged structure should be carried out, with reference to the original plans, if available, to establish suitable methods of testing and test locations. Other details such as the direction of the prevailing wind and the proximity of industrial plants may also be relevant and are worthy of consideration.
- c) Preliminary tests should be carried out in areas representative of the deterioration. Initially, samples should be taken for determination of depth of carbonation and chloride ion content of the concrete. Lump samples are sufficient, which can be sent to a testing laboratory for analysis. Once the nature of the problem has been identified, preliminary tests should be carried out in the sample areas to find the area of delaminated concrete and depth of cover to the bar, using a hammer rap survey and cover meter respectively. It may be convenient to mark the readings directly on the concrete, by appropriate means: the data should be recorded on plans of the structure.
- d) A full diagnostic survey should follow, using non-destructive and partially destructive techniques, to confirm the causes of the damage and the extent of the damage and contamination, from which a Bill of Quantities may be prepared. The survey will normally include testing to measure the depth of carbonation, chloride ion content, cover to reinforcement and corrosion activity by half-cell potential measurement, and confirm other deterioration processes such as ASR are not present. Guidance on test methods and interpretation for concrete buildings is given in BRE Report 254.
- e) Core samples should be taken for larger or safety critical structures in locations advised by a competent person. Information from the cores should be used to match the properties of repair material such as elastic modulus and thermal expansion with those of the original concrete.
- f) The results of these tests must be interpreted by a suitably experienced and qualified engineer who must determine the cause and extent of damage and the structural implications. He must also ensure that areas of latent damage are identified. In particular, when repairing load bearing elements, those situations where the load must be supported before removing concrete must be identified as well as areas that could deteriorate quickly.

- g) Structural repair also requires careful selection of repair material, as properties such as initial shrinkage and creep in compression members can result in over-stressing the parent concrete, both in the affected member and adjacent parts of the structure. In situations where large areas of repair are required, the weakening effect of extensive breakouts of the concrete on the structural performance must be considered and particularly in these cases electrochemical methods of repair should be considered.
- h) When degradation has taken place, the worst areas are apparent and can be located and repaired. The remaining concrete also needs protection to ensure that further degradation does not occur.
- i) Site observation will establish if cracks are live (i.e. moving under loading or temperature changes or dead (i.e. static). The implications of live cracks will need to be determined by an experienced engineer. It may be necessary to introduce a movement joint.
- j) Processes and methods of repair can be related as indicated below in the summary of processes and methods for repair:

Specific property	Repair principle
Ingress protection	Surface impregnation Surface coating Crack sealing
Moisture control	Surface treatment Surface coating
Concrete restoration	Bonding hand-applied mortar Recasting with concrete Spray applied concrete or mortar
Structural strengthening	Installing ties or anchors Steel plate bonding Adding mortar or concrete Injection
Concrete bonding	Injecting for continuity
Physical resistance	Overlays or coatings Impregnation
Chemical resistance	Overlays or coatings Impregnation
Restoring passivity	Replacing concrete Re-alkalisation by diffusion
Increasing resistivity	Limiting moisture content
Corrosion control	Limiting oxygen content
Control of anodic areas	Active reinforcement coatings Barrier coatings on reinforcement Anodic inhibitors in concrete

- k) A full repair specification should be prepared on the basis of the survey and diagnosis.

Concrete repair materials

- a) General

- I) A wide range of materials is available for repairing concrete, differing significantly in performance, with cost being a poor indicator of suitability. The choice depends upon many factors that need to be balanced and include ease of application, (especially where access is difficult), compatibility (thermal expansion, shrinkage and structural properties) and barrier resistance characteristics. The cost of small repairs depends more often upon the provision of access and labour costs than material costs and, therefore, performance should not be compromised for minor costs savings. For applications where reinforcement corrosion has occurred, cementitious materials should be used, with resin-based systems restricted to use in thin layer repairs or where speed of set is important for practical reasons
- II) It is important that any repair blends in with the rest of the structure and does not give a patchwork appearance.
- b) Cementitious repair concretes and mortars
 - I) These are generally mixtures of Portland cement and a suitable aggregate that can be placed either by hand or sprayed by dry or wet mix techniques. Portland cement based repair materials have the advantage of being readily available, easily prepared and relatively cheap but disadvantages include poor adherence to the substrate and high shrinkage after setting, which can lead to long-term problems of bond breakdown.
- c) Polymer modified repair concretes and mortars
 - I) These are concretes and mortars made with cement modified with styrene-butadiene rubber, acrylic and other polymers and copolymers. These are the most common materials used for concrete repair.
 - II) These polymeric additives have little or no cohesive properties and without the cement content they are unsuitable for application. However, in combination with cement, they do have a number of advantages as compared to basic concrete.
 - i) As the water content is reduced, the ultimate porosity is reduced and impermeability is increased.
 - ii) As the interstices between cement, sand and aggregates are filled, water absorption is reduced.
 - iii) Since the impermeability is increased and the cement particles are coated with polymer, chemical resistance to dilute acids and alkalis is improved.
 - iv) A dense surface layer is formed thereby improving the abrasion resistance and anti-dusting properties of the concrete.
 - v) The polymer modification reduces shrinkage and improves adhesion to the parent concrete, giving good performance under repeating thermal cycles.
 - III) A possible disadvantage with polymer modified materials is that, owing to their superior properties, the repairs react to moisture differently, and can darken or lighten in colour when wet. This effect can be reduced by overall application of a water-repellent treatment or a coating system.
 - IV) Polymer systems are of two types.
 - V) Polymer supplied in solid form, pre-mixed and pre-bagged with cement. Water is added in the conventional way for mixing.

- VI) Polymer supplied in liquid form as a low viscosity aqueous emulsion. The liquid either fully or partially replaces the gauging water in conventional mortars and screeds.
- VII) Dry powder polymer systems have the following characteristics.
- i) The materials are pre-bagged and generally manufactured to factory established quality control procedures. Therefore, errors in mixing on site are less likely. However, care must be taken to ensure that the mix is fully emulsified prior to application.
 - ii) The products require only the addition of water and often no primer is required. Therefore these systems are easy to use and can result in cost and time saving.
 - iii) They are often thixotropic allowing placement in thick layers.
 - iv) They can be sulphate resisting.
 - v) These systems can be superior in bonding to steel and existing concrete.
 - vi) Pre-bagged mixes can be made shrinkage compensating by the addition of small controlled amounts of appropriate fillers and additives.
 - vii) A high strength (about 70 MPa) can be obtained, with commensurate elastic modulus, but this may not be compatible with the parent concrete and cannot be varied, except by special formulation at premium cost.
 - viii) The polymer content is often lower than for liquid polymer systems, reducing cosmetic differences with the parent concrete.
 - ix) The material may be spray or trowel applied giving flexibility to suit site circumstances.
- VIII) Liquid polymer systems have the following characteristics.
- Liquid polymer systems are either pre-bagged formulations with a separate bottle of liquid polymer gauging liquid, or site gauged blends of sand/cement/polymer and water. While the performance of the former type is similar to dry powder polymer systems, the site mixed systems offer more flexibility but a reduced performance.
 - Site gauged mixes are much less costly than multi-component pre-bagged mixes, due to the simpler nature of the materials used.
 - Cement types and aggregates can be chosen for specific requirements, such as matching the colour and texture of the parent concrete, whereas pre-bagged formulations have a fixed colour and composition.
 - Site gauged mixes are easy to use, provided that mix designs are clearly specified for the thickness and type of repair being carried out, and that the materials are accurately proportioned, by using either gauge boxes (volume) or scales (weight). Note: proportions for volume and weight batching are not interchangeable.
 - The strength of repair mix can be adjusted by tailored design to suit the parent concrete, but the higher polymer content can adversely affect other properties such as elastic modulus and creep.

- A site laboratory is required when using site-batched materials to ensure the performance criteria are being consistently met, including tests such as adhesion to the substrate, compressive strength, shrinkage and thermal compatibility.
 - The end product is often inferior to controlled formulations, which normally include shrinkage compensating cements, gaseous expansion aids and special cements that resist the ingress of chloride ions. The cost saving must be carefully weighed against a possible reduced performance and the relevant site factors, such as aggressiveness of the environment, deterioration mechanisms, etc.
- d) Epoxy resin mortars and grouts
- I) Epoxy resin mortars and grouts are not recommended for concrete repair because of their alien nature with respect to the original base concrete. They are generally more difficult to use than materials based on Portland cement.
 - II) It is important that there is sufficient resin to fill the voids between aggregate particles to ensure an impermeable barrier. The use of primer coats to both concrete substrate and steel is necessary to ensure good bonding and the timing of application of the main repair to the bond coat is critical, being dependent upon temperature. Some epoxy resin systems have poor adherence to damp surfaces and their performance may be jeopardised in continuously wet situations.
 - III) Adequate cleaning of the steel is important because epoxy resin mortars do not provide corrosion inhibition which, in the case of Portland cements, would compensate for some effects of oxides, sulphates and chlorides on the steel surface.
 - IV) Epoxy resin systems develop high strength and have a shorter cure time than materials based on Portland cement (especially useful in adverse environmental conditions). They also have low shrinkage during and after curing.
 - V) Great care needs to be taken in handling the materials to prevent skin contact. They are considerably more expensive than repair systems based on Portland cement. It should be noted that the physical properties of these mortars are substantially different from the parent concrete.
- e) Polyester resin mortars and grouts
- I) Polyester resin mortars and grouts are not recommended for concrete repair because of their alien nature with respect to the parent concrete. Polyesters are more difficult to mix and handle than materials based on Portland cement, but the proportion of resin to hardener is less critical than those based on epoxy resins. Most polyesters cannot be bonded reliably to damp surfaces.
 - II) A major disadvantage is that they have a high shrinkage on setting and further long-term shrinkage but this can be overcome to some extent by building up the repair in thin layers. Their use is generally restricted to small repairs. Curing time is faster than for epoxy resin systems, particularly at low temperatures. Their cost is somewhat lower than epoxy resin systems.
- f) Site batched repair concretes and mortars