

Guidance Document

G0053

Civil Engineering – Building and Station Structures

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1 Purpose

1.1 The purpose of this Guidance is to support LU Standard S1053 (Civil Engineering – Building and Station Structures) and give guidance on established good practice solutions that meet the requirements of that standard. The Building and Station Structure assets comprise:

- a) Building structures:
 - I) Office blocks;
 - II) Storage buildings;
 - III) Workshops;
 - IV) Depots;
 - V) Train washing facilities;
 - VI) Sub-stations;
 - VII) Roof structure and support
- b) Station structures:
 - I) Station buildings;
 - II) Ticket Halls;
 - III) Platforms;
 - IV) Canopies (Entrance and Platform);
 - V) Pump rooms;
 - VI) Equipment rooms;
 - VII) Control rooms;
 - VIII) Staff mess and locker rooms.
- c) Building and station ancillary structures:
 - I) Stairs;
 - II) Ramps;
 - III) Ladders;
 - IV) Handrails;
 - V) Barriers;
 - VI) Impact protection;
 - VII) Escalator support structures;
 - VIII) Lift support structures.

2 Scope

2.1 The Scope of this Document is to provide guidance on the application of the requirements for the life cycle of Building and Station Structure assets owned by LU for:

- a) Inception and design
- b) Construction, installation, testing and commissioning
- c) Inspection
- d) Analytical assessment
- e) Condition assessment and certification
- f) Maintenance
- g) Strengthening and renewal
- h) Decommissioning

2.2 This Guidance mirrors the sub-section headings of LU standard S1053 (Civil Engineering – Building and Station Structures) at the start of each life cycle section, but additionally has further sub-sections added to each life-cycle section where there is further guidance material available to LU that does not specifically relate to the sub-section headings used in the standard, or is better set out separately.



- 2.3 The information contained in this Guidance is derived mainly from historical information contained in existing LU documents and therefore does not necessarily reflect current good practice. Where possible existing historical information has been supplemented by references to current good industry practice.
- 2.4 This Document replaces G-053 A3

3 Guidance

3.1 Inception and design

3.1.1 General

- 3.1.1.1 The standard sets out the design requirements in terms of the Required Duty of new and Strengthened and Renewed assets.
- 3.1.1.2 LU require the design and construction of stations, subways and other structures to meet the requirements of the Building Regulations.
- 3.1.1.3 In the design of Building and Station Structures the safety considerations should include (but not be limited to):
- a) protection of LU staff and the public around the site;
 - b) protection of railway and construction work;
 - c) temporary works;
 - d) alternative routing and signing;
 - e) demolition removal of existing materials;
 - f) access for new materials;
 - g) temporary storage;
 - h) access and manoeuvring space for plant;
 - j) work sequence;
 - k) maintenance;
 - m) fire resistance
- 3.1.1.4 In the design of Building and Station Structures the following conditions and provisions should be considered (but not be limited to):
- a) Station Planning Guidelines;
 - b) passage ways, lifts, escalators;
 - c) fire resistance;
 - d) fire safety and precautions;
 - e) realistic estimates of peak hour travelling public traffic;
 - f) means of escape routes;
 - g) health and safety including the requirements of HMRI;
 - h) criteria for loading;
 - j) structure gauge;
 - k) dealing with water ingress;
 - m) provision for ductwork and services;
 - n) materials performance and design life of finishes;
 - o) contract strategy;
 - p) geotechnical aspects together with ground movement effects;



- q) effects on adjacent buildings, permanent way and services;
- r) inspection and maintenance to tunnel shaft linings and enclosures;
- s) noise and other environmental consideration;
- t) access, temporary works, scaffolding support;
- u) demolition and site clearance;
- w) track possessions or restrictions;
- x) buildability;
- y) hazardous or safety aspects;
- z) prefabricated roof and floor elements;
- aa) maintenance with respect to tunnel or shaft linings and confined spaces;

3.1.2 Inception

The inception and subsequent design processes for Building and Station Structure assets are set out in LU Standard E1008 (New or Altered Assets – Approvals Prior to Bringing Into Use).

3.1.3 Design process

3.1.3.1 Design concessions are required to cover any non-compliance of the submitted design with LU Standards and requirements. These design concessions are requested by the design organisation in accordance with 1-641 (Concessions to Category 1, Mixed Category and Category 5 Standards) and the need to be formally approved by LU before becoming part of the design.

3.1.3.2 Prior to starting detailed design for new construction or renewal, the appointed design organisation is required to create a Conceptual Design Statement (CDS). Detailed guidance on the creation of CDS is given in LU Manual of Good Practice G-050 (Civil Engineering – Common Requirements).

3.1.4 Ground investigation information

3.1.4.1 Ground Investigation should be carried out with reference to LU standard 1-050.

3.1.4.2 The Ground Investigation data should include as a minimum, soil strength, stiffness and consolidation behaviour. An interpretive Ground Investigation report should be available for consideration prior to the commencement of detailed design.

3.1.5 Design standards

3.1.5.1 The works should be designed in accordance with the design standards specified in LU standard S1053 (Civil Engineering – Building and Station Structures).

3.1.5.2 Guidance should also be taken from CIRIA Report R146 Design and Construction of joints in concrete structures.

3.1.6 Design life

For concrete structures reference should be made to Concrete Society Report CS109 'Developments in Durability Design and Performance Based Specification of Concrete'.

3.1.7 Structure gauge and clearance

No specific advice.

3.1.8 Service fixings and connections

No specific advice



3.1.9 Finishes

No specific advice

3.1.10 Fire resistance

No specific advice

3.1.11 Groundwater

Reference should be made to CIRIA Report No. 81.

3.1.12 Impact on operational railway and adjacent structures

No specific advice

3.1.13 Water resistance and drainage

General

Reference should be made to CIRIA Reports 139 and 140 which give guidance on water resisting basement construction.

Platform waterproofing

- 3.1.13.2 Platforms should be designed to be waterproofed in accordance with DoT Technical Memorandum (Bridges) BE 27, except that a protective layer should always be applied irrespective of waterproofing thickness.

New and existing waterproofing junctions

- 3.1.13.3 The junction between new and existing waterproofing is a potential source of leakage. The following precautions should be taken:

- a) New work should be taken to a point which will provide a strong waterproof joint, e.g. the finished structure levels must be the same to prevent a 'well' or 'dam' forming.
- b) The new and existing waterproofing must be compatible. If the new waterproofing is a repair then spray applied membranes are recommended.
- c) The junction of new and existing waterproofing should be tested by damming the junction and filling with water to a depth of 150mm. The junction should show no visible seepage after a period of 24hours from filling the dam.

Drainage

- 3.1.13.4 Railway and Commercial buildings should have independent drainage systems to the point where they enter the public sewer system.
- 3.1.13.5 Drainage and service routes should be designed such that wherever possible they are independent and only run through the routes provided for within the lease document together with the building they serve. Access where required within the drainage and service routes should be allowed for in the design.

3.1.14 Stray currents

Introduction

- 3.1.14.1 Stray electrical currents can give rise to accelerated corrosion of metal structures. Examples are found in buried metallic structures, such as pipelines and footings of support stanchions or cable bridges, which may carry stray currents from railway traction supplies and other distribution systems. Damage occurs at the anodic area of the structure, where neutral atoms form positive ions which pass into solution in the electrolyte, usually the surrounding soil.
- 3.1.14.2 The magnitude of the stray currents and, consequently, the severity of this type of corrosion, are influenced by the composition of the soil and its water content. Stray currents are controlled by the degree of isolation between the current source, e.g. conductor rails, and earth.



Critical Locations

3.1.14.3 Where structures are to be placed within 3 metres of any LU conductor rails, the likelihood of damage being caused due to stray electrical currents should be assessed. Factors to be taken into account should include:

- a) the condition of conductor rail insulators;
- b) whether or not the area is particularly damp or prone to flooding.

3.1.14.4 Where structures are to be placed in areas which also contain 750V third-rail electrified railways or 25kV overhead line electrified railways, details of which are shown in Attachment 7.1, the likelihood of damage being caused by stray electrical currents should be assessed. Factors to be taken into account should include:

- a) the location of structures relative to other electrified railways;
- b) the form of return conductor system employed by other electrified railways and the form of any special provision used to minimise stray electrical currents;
- c) the condition of any insulation provided on the return conductor systems of the other electrified railways;
- d) whether or not the area is particularly damp or prone to flooding.

Protection against stray current corrosion

3.1.14.5 The essential requirement is to protect the vital parts of structures by measures to eliminate the danger of corrosion caused by stray electrical currents.

3.1.14.6 To reduce the incidence of corrosion due to the effect of stray electrical currents all vulnerable metal structures including, where relevant, concrete reinforcement should be earthed.

3.1.15 Structural design

Structural independence

3.1.15.1 Where a shared structural element occurs it is essential that any common element is designed such that, upon demolition of either building, that element can remain largely undisturbed, leaving the retained structure intact.

3.1.15.2 The design of the structures should at all times consider that the ease and simplicity of access for maintenance, repair, replacement and structural independence is of paramount importance.

3.1.15.3 Commercial buildings should be so designed as to minimise any vibration or noise from the railway.

Foundations – fundamental requirements

3.1.15.4 Foundations should be designed and constructed in such a way that they will, during their intended design life, with appropriate degrees of reliability and in an economic way:

- a) remain fit for the use for which they are required; and
- b) sustain all loads and influences likely to occur during their construction and use.

Due regard should be given to structural safety and serviceability, including durability.

3.1.15.5 Foundations should also be designed and constructed in such a way that they should not be damaged by events like fire, explosion, impact or consequences of human errors, to an extent disproportionate to the original cause. The potential damage should be avoided or limited by appropriate choice of one or more of the following:

- a) avoiding, eliminating or reducing the hazards which the structure may sustain;
- b) selecting a structural form which has low sensitivity to the hazards considered;



- c) selecting a structural form and design that can survive adequately the accidental removal of an individual element or a limited part of the structure, or the occurrence of acceptable localised damage;
- d) avoiding as far as possible structural systems which may collapse without warning.

Foundations – design standards

3.1.15.6 Foundation design should be carried out in accordance with one of the following codes of practice and Industry guidance:

- a) ENV 1997-1 - Eurocode 7;
- b) BS 8004;
- c) Ciria Report C569 – Concrete technology for cast insitu foundations.

3.1.15.7 The partial factor analysis method of ENV 1997-1 - Eurocode 7 should generally be used in preference to the 'lumped' factor of safety approach used in BS 8004.

3.1.15.8 Structures which are to retain water should be designed in accordance with BS 8007.

3.1.15.9 Ground anchors should be designed in accordance with BS 8081.

3.1.15.10 The specification for the construction of foundations should be in general accordance with the Department of Transport Manual for Contract Documents for Highway Works.

Foundations - design principles

3.1.15.11 The design of foundations should be undertaken using limit state design principles. The foundation should be designed for both ultimate and serviceability limit states. A list of limit states to be considered should be compiled by the designer. As a minimum the following ultimate and serviceability limit states affecting the ground, adjacent and supported structures and the structural elements should be considered for all types of foundations:

- a) loss of overall stability;
- b) bearing resistance failure;
- c) failure by sliding;
- d) overturning failure;
- e) combined failure in ground and the structure;
- f) structural failure due to foundation movement;
- g) excessive settlement;
- h) excessive heave;
- j) unacceptable vibrations.

3.1.15.12 The following limit states should also be considered for piled foundations:

- a) uplift or insufficient tensile resistance of the pile foundation;
- b) ground deformation due to transverse loading of the pile foundation.

For all types of foundations, combination of the above limit states should also be considered.

3.1.15.13 The design should demonstrate that deformation of the foundations under the design loading should not cause loss of serviceability in structures, track or services sited on or near the foundations.

3.1.15.14 The use of numerical analytical methods should be considered where appropriate in addition to simple limit equilibrium design methods.

Foundations – settlement

3.1.15.15 The construction of all foundations and associated temporary or permanent works should be designed and sequenced such that movements of the surrounding ground is minimised and in no case is greater than 25 mm in the long term.



3.1.15.16 Under no circumstances should movement result in a degree of damage to adjacent buildings, structures, and utilities greater than category 2 in accordance with the definitions given in Table 1. Assessment of the effects of settlement on movement and serviceability of adjacent buildings, structures and utilities will be carried out in consultation with the owners of these facilities.

3.1.15.17 The designer should propose methods for the prediction of ground movements and the assessment of potential damage to structures.

3.1.15.18 Consideration should be given to the possibility that more onerous loading conditions may result from surcharge loading being applied to one side of the foundation only.

Category of damage	Description of typical damage	Approx. crack width (mm)	Limiting tensile strain (%)
1. Very Slight	Fine cracks which can easily be treated during normal decoration. Perhaps isolated slight fracture in buildings. Cracks in external brickwork visible on inspection.	1	0.05 - 0.075
2. Slight	Cracks easily filled. Redecorating probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repainting may be required externally to ensure weather tightness. Doors and windows may stick slightly.	5	0.075 - 0.15
3. Moderate	Cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repainting of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weather tightness often impaired.	5 - 15 or a number of cracks >3	0.15 - 0.3
4. Severe	Extensive repair work involving breaking out and replacing sections of walls, especially over doors and windows. Windows and door frames distorted, floor sloping noticeably. Walls leaning and bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15 - 25 but also depends on number of cracks	> 0.3
5. Very severe	This requires a major repair job involving partial or complete rebuilding. Beams lose bearing, walls lean badly and require shoring. Windows broken due to distortion. Danger of instability.	Usually 25 but depends on number of cracks	

Table 1 - Damage Risk Classification, after Burland et al, 1974

Precast concrete nosing slabs

3.1.15.19 No specific advice

3.1.16 Loading

3.1.16.1 Handrails, barriers and stairways

General

- a) The guidance below applies to stairways and ladders used primarily by staff and contractors for servicing and maintenance purposes. It is not intended for use in connection with stairs used by the public.



- b) The design and installation of metal stairways, ladders and handrails should generally be in accordance with the recommendations of the current edition of the Engineering Equipment Users Association Handbook No. 7 'Factory Stairways, Ladders and Handrails' but with the following variations:
- c) Section Two: REGULATIONS AND CODES should be deleted and replaced by the following:-

The design and manufacture of metal stairs, ladders and handrails should comply with the requirements of the following Building Regulations and British Standards, as appropriate.

The Building Regulations, particularly Approved Document K;

- d) Dissimilar metals which would otherwise be in contact should be separated by a suitable insulating medium to prevent electrochemical corrosion (see PD 6484: Corrosion at bimetallic contact and its alleviations - British Standards Institution).
- e) Protective coating should be applied after installation in all exposed and damp underground locations in accordance with the Standard T005. Bridges & Structures – Materials & Workmanship.

3.1.17 Provision for maintenance

No specific advice.

3.1.18 Temporary works

No specific advice.

3.1.19 Design documents

Following completion of detailed design, the designer should prepare a design report outlining the final design adopted including all calculations. The following subjects may be included in the design report:

- a) existing information including site investigation results;
- b) quantified design criteria for the building and station structures and shafts, including design standards, design life, limit state performance, constraints and capacity;
- c) general description and drawings of the proposed design including geometric form layout, construction method, durability;
- d) interfaces with the operating railway, adjacent works and adjacent planned works including predictions of ground movements and assessment of potential damage to the railway and adjacent structures;
- e) methods for minimising settlement, differential settlement and heave;
- f) safety considerations;
- g) outline method statement including temporary works requirement;
- h) restraints imposed by design, plant restrictions or any other special conditions and factors;
- j) future maintenance requirements to achieve the design life.

3.1.20 Construction documents

No specific advice.



3.2 Construction, installation, testing and commissioning

3.2.1 Code of Construction Practice

- a) The supplier should prepare a code of construction practice.
- b) The code of construction practice should be produced in two sections.
 - I) Section A /General; which covers all general aspects of work possibly impacting on local communities and the environment throughout the construction phase of the project.
 - II) Section B / Specific work sites: a specific document in which the particular environmental issues appertaining to each work site are evaluated and listed.
- c) The code of construction practice should provide guidance to the Supplier's Contractors and Project Managers on the legislative requirements and constraints that the Supplier and his staff, consultants and Contractors must observe when undertaking construction works. In the event of any discrepancy between this document and legislation, the legislative requirements take precedence.
- d) Prior to the commencement of works the Supplier should hold discussions with the relevant local authorities and other statutory bodies to explain the purpose of the code of construction practice and to listen to their concerns which may be incorporated into an addendum to the code.

3.2.2 Work site and access

Control of noise

- 3.2.2.1 The Supplier should ensure that, wherever practical, noise from the works and ancillary activities is not audible at the site boundary other than between the hours of 8 am and 6 pm on Monday to Friday and 8 am to 1 pm on Saturday. Any special measures, agreed with the local authorities to mitigate construction noise at night may be included in the environmental statement.
- 3.2.2.2 Prior to commencement of works at any site, the Supplier should prepare:
 - a) a method statement (in accordance with the principles described in BS 5228), stating precisely the type of plant to be used and the proposed noise control methods;
 - b) a programme of work indicating the sound level and location for each activity on the programme;
 - c) documentation from manufacturers' literature establishing the sound power level of plant;
 - d) calculations of LAeq - the continuous A-weighted sound pressure level (in dB) determined at a distance of 10m from and during the period of a given activity, and maximum sound levels at specified buildings.
- 3.2.2.3 Before the commencement of the works the Supplier should initiate background baseline noise surveys in order to formally establish noise levels for each specific site.
- 3.2.2.4 In assessing the impact of any piling operations, the Supplier should comply with the recommendations set out in BS 5228: Parts 1 and 4.
- 3.2.2.5 Local authorities should be given access to all noise readings, if required, as soon as they become available.
- 3.2.2.6 Vehicles and mechanical plant used for the purpose of the works should be fitted with effective exhaust silencers and should be maintained in good and efficient working order and operated in such a manner as to minimise noise emissions.
- 3.2.2.7 On surface sites:



- a) compressors should be 'sound reduced' models fitted with properly lined and sealed acoustic covers which should be kept closed whenever the machines are in use;
- b) pneumatic percussive tools should be fitted with an effective muffler or silencer suitable for use with each particular item of plant.
- c) Plant and equipment liable to create noise whilst in operation should be sited as far away as is practicable from noise sensitive locations. The use of barriers, e.g. soil mounds, site huts, acoustic sheds or partitions to deflect noise away from noise sensitive areas should be employed wherever practicable.

3.2.2.8 Care should be taken when loading or unloading vehicles, dismantling scaffolding or moving materials and equipment to reduce impact noise.

Vibration

3.2.2.9 Measures should be taken to protect the residents and users of buildings in the vicinity of the works and passers-by from nuisance or harm from vibrations and protect buildings from physical damage.

Air Pollution

3.2.2.10 All necessary precautions should be taken to prevent the occurrence of smoke emissions or fumes from site plant or stored fuel oils for safety reasons and to prevent such emissions or fumes drifting into residential areas. In particular, plant is to be well maintained and measures taken to ensure that it is not left running for long periods when not directly in use.

3.2.2.11 The burning of any material on the site should not be permitted.

Dust

3.2.2.12 All necessary measures should be taken to avoid creating a dust nuisance. A statement identifying proposed measures for the limitation of dust should be prepared prior to the commencement of work.

3.2.2.13 The effectiveness of the measures should be monitored frequently.

3.2.2.14 The Local authorities concerned should be informed of the measures being taken to conform with the above.

Equipment

3.2.2.15 Attention is drawn to the presence within the area of the Works of cables, lighting, signalling apparatus, machinery and other railway equipment which must be maintained in operation during the course of the works. Adequate access and space for inspection and maintenance of such equipment should be allowed.

Sightlines

3.2.2.16 Where sightlines access points are sub-standard (or where vehicles will be required to move in reverse), as defined in Traffic Advice Note TA20/84, vehicles entering or leaving the site should only be allowed to cross footways under the control of a competent person.

Temporary footways

3.2.2.17 Temporary footways should be provided to ensure safe passage and access for people, including those with disabilities, wheelchairs and pushchairs.)

3.2.2.18 Temporary footways and ramps should be constructed in concrete, macadam or other suitable material.

3.2.3 Concrete construction

3.2.3.1 Reference should be made to the following CIRIA reports.

- a) CIRIA Report C511 – Controlled permeability concrete
- b) CIRIA Report C530 – On-site curing of concrete



- c) CIRIA Report C559 – Freeze thaw resisting concrete
- d) CIRIA Report R135 – Concreting deep lifts and large volume pours
- e) CIRIA Report R136 – Formwork striking times

3.3 Inspection

3.3.1 General

- 3.3.1.1 Structural assets form a fundamental part of the London Underground system. The ability to maintain these relies to a large extent on effective regular inspections.
- 3.3.1.2 Effective inspection requires an understanding of the structural assets encountered, how they work, their possible weaknesses together with a knowledge of tell-tale signs of problems and often where to look for them. In addition to these requirements effective inspections shall gather detailed, accurate, well presented, and objective information to permit other members of staff (not directly involved in the inspection) to understand the problems, draw conclusions and take action where necessary. Even when no action is taken after an inspection a complete and objective record of what was found is essential to permit the next inspection to measure or assess any deterioration during the intervening period.

3.3.2 Guidance on inspection

Preparation

- 3.3.2.1 Good preparation is essential to the carrying out of safe, effective and efficient inspection work. Due to the numerous constraints of working on or near the railway, the demand for observance of safe working and the cost of site inspection work is high, whilst the time available usually very limited. It is therefore important that time and resources be used safely and productively.
- 3.3.2.2 Preparation involves familiarisation with the structure (known by its discrete asset identification number), its scale and the type and location of access. The inspection history should be investigated by reference to the previous inspection reports so that equipment required on site or any special access requirements, can be identified. Where staff involved in a previous inspection are available, consultation with them may prove of benefit to identify any special provisions necessary for the work. In advance of inspection, arrangements should be made for the following requirements and equipment:
 - a) safe working;
 - b) engineering hours, traffic circular and special notices;
 - c) line clear and line safe procedures;
 - d) access equipment;
 - e) inspection equipment;
 - f) access approval from Line Operating Access Planner.
- 3.3.2.3 Final preparation work before the inspection should include further detail reference to the inspection records from which the following should be acquired:
 - a) the form and extent of the structure (a number of complicated, often interconnected and similar structures can lead to confusion, with whole or parts of structures being incorrectly inspected or not being inspected at all);
 - b) copies of outline drawings (preferably to a known scale upon which inspection details can be marked on site);
 - c) copies of relevant detail information from earlier reports (e.g. locations of cracks and measurements);
 - d) copies of relevant report pro-forma (the appropriate section of this manual for the structures to be inspected gives the description and reference numbers of relevant report pro-forma);



- e) confirmation of all the arrangements described in 3.3.2.2 revised where necessary to take account of the review of records.
- 3.3.2.4 All arrangements for the inspection should be made known to the inspection supervisor and all necessary preparations and provisions for safe working confirmed.
- 3.3.2.5 Confirmation should be obtained prior to inspection that all personnel involved in the work have attended the LU safety and training courses mandatory for work on or near the railway. These should include the Site Person in Charge course where the inspector or other member of staff is to perform this role during the inspection.
- 3.3.2.6 A complete and thorough file record check of the structures to be inspected should be made to the satisfaction of the inspection supervisor and all relevant information abstracted from them. Any shortfalls of information in the inspection records and checks on their authenticity should be completed. (The inspector should note that no original files or record material should be removed from the office without the express permission of the engineer in charge or the inspection supervisor.) In pre-inspection discussions particular problems and peculiarities relating to the inspection should be raised so that potential difficulties can be resolved before embarking on the site work.
- 3.3.2.7 Checks should be made before proceeding to site that all necessary equipment, notes and other material to carry out the inspection are available (see Table 2). Any additional keys that are required to gain access to stations or other closed areas should be collected and correctly signed out. Arrangements made with third parties (e.g. to gain access to commercial premises for inspection) should also be confirmed. In addition a detailed programme of the work intended to be undertaken should be left with the inspection supervisor including the date, time and location of the proposed activities.

Early arrangements

- 1) Safe working requirements
- 2) Engineering hours, traffic circular and special notices
- 3) Line clear and line safe procedures
- 4) Access equipment and arrangements
- 5) Inspection equipment

Later arrangements and information

- 1) Structure details
- 2) Outline drawings
- 3) Previous inspection details
- 4) Report pro-forma
- 5) Confirmation of early arrangements

Table 2 - Preparation checklist

Access Equipment

- 3.3.2.8 Whilst the range and capabilities of modern access plant has advanced greatly in recent years, the scope for use of these machines on the system is limited. These limitations are generally associated with time and actually getting such machines to the site. The range of access equipment generally used in the course of inspection work on London Underground property should therefore be simple, quick to erect and readily transportable.
- 3.3.2.9 Experience has shown that inappropriate or inadequate access provisions are probably the greatest source of potential danger and delay in the course of inspection work. To avoid these problems, care and planning should be exercised in the selection of access equipment and observance of all safety guidelines should be exercised when the equipment is actually in use.



3.3.2.10 The ideal method of inspection is to gain 'hands on' contact with all accessible parts of a structure. The feasibility of achieving such close contact should depend on it being:

- a) safe;
- b) practical;
- c) efficient.

The access equipment that best satisfies these criteria should be selected, with the emphasis on safety.

3.3.2.11 The supervisor's decision should be sought where scaffolding or other special access provisions are needed (e.g. high roofs, chimneys and confined spaces).

3.3.2.12 Certain structures with access problems may be scaffolded out periodically for renovation work. A detailed inspection of these structures should be made when such scaffolding is in place.

Category of access	Height range (m)	Typical application
Foot access	0 - 2.5	Subways, pedestrian tunnels, station structures, small retaining walls, roadside elevations (e.g. of parapets)
Folding ladders	2.5 - 3.5	Tube running tunnels, pedestrian tunnels, station ceiling structures, slab soffits
Extending ladders: common types	2.5 - 8	Retaining walls, bridge spandrels, girdering, covered ways, bridge and tunnel abutments, tunnel headwalls, building walls, station structures, platform canopies
Scaffold towers: various types with range of maximum working heights	2.5 - 6	Station ceiling structures, slab soffits, soffits of bridges over highways; platform structures, walls adjoining horizontal paved surfaces
Track trolley mounted scaffold tower	2.5 - 4	Soffits of bridges, tunnels, girderings, covered ways and tube running tunnels
Lorry mounted and mobile access: various types including scissor, elbow and telescopic boom, with range of maximum working heights and reaches	2.5 - 20	Soffits, elevations and abutments of bridges over highways and some chimneys

Category of access	Height range (m)	Typical application
Boat access: including inflatables	0 - 2 (above water level)	Soffits, elevations and abutments of bridges over watercourses and waterways
Boat access equipped with access platform	2 - 10 (above water level)	Soffits, elevations and abutments of bridges over rivers and waterways



Special access: including roped access techniques, confined spaces, underwater and diving inspections	Not applicable	No typical applications, use subject to special requirements including confined spaces, cable and ventilation shafts and chimneys, culvert and pipe installations, roof structures, river piers
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Table 3 - Access categories

- 3.3.2.13 Access may be summarised into the categories shown in Table 3 with approximate maximum height ranges. Typical applications are also shown.
- 3.3.2.14 Permanent access provisions fixed or adjacent to a structural asset are not included in Table 3. All such permanent means of access should be used with caution, their existence does not necessarily guarantee their safety. The types of permanent access that may be encountered include fixed ladders, staging, climbing rungs, gantries, cat walks and suspended platforms. All such permanent access provisions should form part of the inspection and should be inspected before use. In all cases where the safety of a permanent access provision is in doubt an alternative must be found.
- 3.3.2.15 At the site of the inspection all reasonable efforts should be made to check and satisfy that access facilities are adequate and safe (see Table 4). Access equipment should be used strictly in accordance with current standards and the Infracore Health, Safety and Environmental Management System. Where access involves gaining entry to other areas such as commercial premises under, over or adjacent to structures, arrangements should be made in advance with the occupiers and tenants of the premises. Where access from the public highway is required then arrangements should be made in advance with the highway authority responsible for traffic management.
- 3.3.2.16 Where the inspection involves access from a public highway then particular care must be taken to ensure the safety of both the inspectors and the public. Where reasonably practicable, inspections should be designed to avoid or minimise the need for traffic management. If this is unavoidable then the highway authority should be consulted regarding the protection arrangements required to ensure safe working for the inspection staff and safe conditions for the highway users. In any situation where there is considered to be a danger to either members of the inspection team or to other highway users then work should stop and advice be sought on how to proceed safely. All those persons involved with the inspection within the highway boundary should wear high visibility outer clothing.

Basic requirements

- 1) Safety
- 2) Practicality
- 3) Efficiency

Additional requirements

- 1) Height (or depth)
- 2) Reach
- 3) Environment
- 4) Transportation to site

Table 4 - Access equipment checklist

**Inspection Equipment**

3.3.2.17 The choice of equipment should be tailored to some extent to suit the inspection work being undertaken. Some items of equipment may however be classed as essential in all circumstances, namely:

- a) personal protective equipment;
- b) a note book and pen (or other means of recording information);
- c) a watch or clock;
- d) Vulnerable Structures notice and red/white hazard tape

3.3.2.18 The minimum requirement for equipment taken to site for inspection work should be all the items that could be used during that particular inspection shift or visit (see Table 5).

3.3.2.19 Table 6 shows a typical range of standard inspection equipment with appropriate notes. It is not designed to be definitive but to illustrate the standard equipment used for inspection purposes on the system.

Basic requirements

- 1) Safety equipment
- 2) Note book
- 3) Watch
- 4) Warning sign and hazard tape

Additional requirements

- 1) Lighting
- 2) Reporting materials
- 3) Measuring tools
- 4) Marking materials
- 5) Camera and flash
- 6) Binoculars
- 7) Hand tools
- 8) Hand held computer

Table 5 - Inspection equipment checklist

Inspection equipment	Notes
Lighting Torches and equipment	Essential equipment for working in tunnels and other dark or poorly illuminated locations
Reporting material Report pro-forma and outline sketches, sketch and clipboard, additional stationery and hand held computer	Sufficient material to accurately and efficiently record all necessary information
Measuring tools Tapes (8m steel and 'fibron' varieties), height pole (minimum extension 8m), callipers, spirit level, plumb bob, string line, graduated tell-tales, crack width gauge Hand held electronic distance measurer (EDM) with a 30m to 50m range and accurate to 1mm	Sufficient to record basic dimensions of structure and elements, also to measure extent of defects e.g. crack widths, out of plumb, bow. One person operated with the advantage of measuring across tracks when the traction current is on. Also suitable for measuring heights.
Marking material	Sufficient for purpose ranging from temporary measurement



Inspection equipment	Notes
French chalk, wax crayons, masonry, nails, paint	or numbering marks to permanent monitoring locations
Camera and flash Usually digital format with photograph dating facility	Cameras should be sturdy and simple to operate. Photography is a comparatively cheap method of recording information. Additional batteries (and camera film if necessary) should be carried. Special note A flash should not be used in the vicinity of moving trains or other traffic unless prior arrangements have been made with local operating managers. Flash photography should also be avoided facing customers especially near stairs and escalators.
Binoculars	Useful for superficial inspections and to reduce the need to get close to structures for inspection. Significant defects identified with binoculars need more detailed inspection.
Hand tools Wire brush, hammers (club, chipping and light long-handled 'drummy' hammers), screwdrivers, cold chisels	For cleaning, chipping (e.g. to reveal sound metalwork) sounding for delamination of brick, masonry and concrete and dislodging loose, unstable material (but only when safe to do so).
Warning sign and hazard tape	For warning others of a potential hazard or danger. A Vulnerable Structures notice must be displayed in a prominent position and hazard tape placed around the potentially dangerous area (refer to plates 1 and 2).

Table 6 - Standard inspection equipment and purpose



Figure 1 - Structure No. TTR9 - Vulnerable Structure notice attached to loose ladder leading down to platform invert



Figure 2 - Structure No. VP84D - Vulnerable Structure notice and hazard tape placed at top of segmental ringed shaft. Notice also placed at base of shaft.

3.3.2.20 The inspection equipment should be safely transported to the working site. All drivers of road vehicles must have the prior approval of a supervisor and be the holder of a current Department of the Environment, Transport and the Regions driving licence that covers the motor vehicle group being driven.

Inspection

3.3.2.21 On arrival at site the extent and nature of the structure should be ascertained and checks made that this conforms to the file records. Any apparent discrepancies should be noted immediately. The less frequently used inspection equipment should be deposited at a central, safe location to avoid scattering and possibly mislaying items as the inspection progresses.

3.3.2.22 The first stage of the inspection proper should comprise a preliminary review of the structure, checking its general form, component parts and evidence of any repairs or alterations that may have been carried out since the last inspection. In all events, essential details as given in Table 7 should be recorded

Essential details		Notes
1)	Preliminary details:	including structure number and location, date, weather and temperature, inspectors' names
2)	Minimum headroom measurement:	bridges and structures over roads and track. Position of minimum headroom should be located.
3)	Low bridge and restricted width signs:	position, nature and condition of such signs on highways as well as the track
4)	Type of track:	including method of retention and support
5)	Presence and extent of cladding or hoarding:	including the nature of structure or concealed components if known
6)	Concealed metalwork:	where partially embedded or concealed making particular note of condition at interface
7)	Any confined spaces:	including facilities for ventilation (if any) and general condition where this can be verified without entering



8)	Any repairs, outstanding or completed since the last inspection:	including location and extent
9)	Fencing, wall and entry/exit provision defects:	especially those that permit trespass onto the railway
10)	Change in road use or name:	including pedestrianisation, closure or width and loading restrictions
11)	The presence of rail joints over underbridges, subway (including tube) and culverts:	including the location and number
12)	Signs of vandalism and graffiti (notify the line operator if graffiti is offensive):	especially within London Underground Property
13)	Structures or parts of structures over sidings or other areas subject to unusual current on/off times:	including any local variation of engineering hours
14)	Areas not visible for inspection:	including those areas covered by vegetation, dirt and other deposits
15)	Change of use or deposition of material:	including building works on or adjacent to the structure, storage of materials

Table 7 - Essential inspection details

- 3.3.2.23 The list in Table 7 should not be seen as exhaustive and discretion should be used to add any further information seen as relevant. This information should be recorded during the preliminary review of the structure.
- 3.3.2.24 On completion of the preliminary review a close examination of all accessible and visible parts of the structure is begun. This work should be undertaken in a systematic and deliberate fashion, aided where appropriate by numbering repetitive structure components (e.g. beam no. 1, 2) or naming elements in relation to location (e.g. north west wing wall, south abutment). Tube tunnels and shafts, where lined with segmental rings, should have each lining ring numbered. For tunnels this should be done from the station tunnel headwall in the direction of regular traffic. Shaft rings should be numbered from the lowest end point of the shaft. Naming or numbering of structural elements should be consistent with that employed for previous inspections (if still appropriate). Otherwise it should comply with the requirements defined in engineering specification G3004 to ensure consistency of the data capture. Any serious problems are likely to have been identified during the preliminary review of the structure.
- 3.3.2.25 The purpose of the close examination is not only to further investigate these areas but to reveal those not so readily evident, the latter in particular requires alertness and vigilance throughout the inspection. Checks should be made that all component parts (where visible and accessible) have received a detailed inspection, and all relevant notes and photographs have been taken. Sufficient information should be held to complete fully the report pro-forma. Physical conditions prevailing at the site of the structure may make close examination very difficult (refer to Figure and Figure for examples).
- 3.3.2.26 The inspection work should be concluded with a final view of the structure. Close examination can occasionally result in some areas being missed or inspected out of sequence. The inspector should determine from his final review whether the inspection is complete and, if not, the extent and duration of further inspection work. Should such work require the assistance or input of others or additional equipment, notes to this effect should be conveyed to the inspection supervisor so that necessary arrangements can be made. On railway bridges over highways the structure should be inspected at both railway and highway levels. Highway bridges over the railway should be similarly inspected.
- 3.3.2.27 Completion of site inspection work should be followed by clearance of the site. Sufficient time to clear the site and check through the notes and inspection equipment should always be allowed. A final check should be made to satisfy that all site notes, which are now valuable

documents, are accounted for and nothing has been left behind, especially where this may represent a hazard to traffic. Following all site clearance checks the inspector should inform the SPIC (unless he is performing this role) that work is finished and that the track possession can be lifted (Table 8).

- | | |
|----|--|
| 1) | Establish site |
| 2) | Preliminary review, recording essential details, general photographs |
| 3) | Close examination, defect photographs |
| 4) | Final review |
| 5) | Clear site |

Table 8 - Inspection procedure checklist

3.3.2.28 Clearance of the site should be followed where necessary by confirming arrangements for future work with site personnel (Figures 3 & 4). The supervisor should be informed of all such arrangements.



Figure 3 - Structure No. S15 - anti-pigeon mesh prevents access for inspection