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M4 Corridor around Newport

SBR 1000 – River Usk Crossing Future Maintenance Report

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Contents

1 The Project

1.1 Context

1.1.1 The Welsh Government has awarded a Professional Services Contract for the next stage of Scheme development and environmental surveys for the M4 Corridor around Newport (M4CAN) up to publication of draft Orders and an Environmental Statement. The contract has been awarded to a Joint Venture of Costain, Vinci and Taylor Woodrow with consultants Arup and Atkins, supported by sub-consultant RPS. The team shall be developing proposals in anticipation of publishing draft Orders and an Environmental Statement in Spring 2016 and a Public Local Inquiry later that year. This process will then inform the next stage of Ministerial decision making.

1.1.2 Since 1989 there have been various studies to identify the problems and propose possible solutions. The M4 Corridor around Newport WelTAG Stage 1 (Strategy Level) Appraisal concluded that a new section of 3-lane motorway to the south of Newport following a protected (TR111) route, in addition to complementary measures, would best achieve the goals and address the problems of the M4 Corridor around Newport and should be progressed for further appraisal. These options have subsequently formed the basis for the development of the draft Plan, which was published in September 2013 and was the subject of public consultation from September to December 2013.

1.1.3 Having taken into account the responses to this participation process, as well as the assessments of the draft Plan, the Welsh Government has decided to publish a Plan for the M4 Corridor around Newport. Alongside this Plan, the Welsh Government has published updated strategy-level reports, including a Strategic Environmental Assessment Statement, to demonstrate how the participation process has informed its decision making. It also announced in July 2014 a revised preferred route, which will protect a corridor for planning purposes. These documents can be accessed from the website http://m4newport.com.

1.2 Scheme objectives and reason for the scheme

1.2.1 The aims of the Welsh Government for the M4 Corridor around Newport are to:

a) Make it easier and safer for people to access their homes, workplaces and services by walking, cycling, public transport or road.

b) Deliver a more efficient and sustainable transport network supporting and encouraging long-term prosperity in the region, across Wales, and enabling access to international markets.

c) To produce positive effects overall on people and the environment, making a positive contribution to the over-arching Welsh Government goals to reduce greenhouse gas emissions and to making Wales more resilient to the effects of climate change.

1.2.2 The Scheme aims to help to achieve or facilitate these aims as part of a wider transport strategy for South East Wales, as outlined within the Prioritised National Transport Plan.

1.2.3 The Transport Planning Objectives (TPOs), or goals, are:

TPO 1: Safer, easier and more reliable travel east-west in South Wales.

TPO 2: Improved transport connections within Wales and to England, the Republic of Ireland and the rest of Europe on all modes on the international transport network.

TPO 3: More effective and integrated use of alternatives to the M4, including other parts of the transport network and other modes of transport for local and strategic journeys around Newport.

TPO 4: Best possible use of the existing M4, local road network and other transport networks.

TPO 5: More reliable journey times along the M4 Corridor.

TPO 6: Increased level of choice for all people making journeys within the transport Corridor by all modes between Magor and Castleton, commensurate with demand for alternatives.

TPO 7: Improved safety on the M4 Corridor between Magor and Castleton.

TPO 8: Improved air quality in areas next to the M4 around Newport.

TPO 9: Reduced disturbance to people from high noise levels, from all transport modes and traffic within the M4 Corridor.

TPO 10: Reduced greenhouse gas emissions per vehicle and/or person kilometre.

TPO 11: Improved travel experience into South Wales along the M4 Corridor.

TPO 12: An M4 attractive for strategic journeys that discourages local traffic use.

TPO 13: Improved traffic management in and around Newport on the M4 Corridor.

TPO 14: Easier access to local key services and residential and commercial centres.

TPO 15: A cultural shift in travel behaviour towards more sustainable choices.

1.2.4 The scheme-specific environmental objectives (EO), as set out in the Strategic Environmental Assessment of the Plan, are as follows:

EO1 - Improved air quality in areas next to the existing M4 around Newport;

EO2a - Reduce greenhouse gas emissions per vehicle and/or person kilometre;

EO2b - Ensure that effective adaptation measures to climate change are in place;

EO3 - Reduce disturbance to people from high noise levels, from all transport modes and traffic within the existing M4 Corridor;

EO4 - Ensure that biodiversity is protected, valued and enhanced;

EO5 - Improved access to all services and facilities and reduce severance;

EO6 - Protect and promote everyone's physical and mental wellbeing and safety;

EO7 - Reduce transport related contamination and safeguard soil function, quality and quantity;

EO8 - Minimise transport related effects on surface and groundwater quality, flood plains and areas of flood risk;

EO9 - Ensure the prudent and sustainable use of natural resources and energy;

EO10 - Ensure that diversity, local distinctiveness and cultural heritage are valued, protected, celebrated and enhanced;

EO11 - Ensure that landscape and townscape is properly valued, conserved and enhanced;

1.2.5 In addition, the Wales Transport Strategy includes the following environmental outcomes (WTSEO):

Outcome 11: The sustainability of the transport infrastructure - Increase the use of more sustainable materials in our country's transport assets and infrastructure;

Outcome 12: Greenhouse gas emissions - Reduce the impact of transport on greenhouse gas emissions;

Outcome 13: Adapting to climate change - Adapt to the impacts of climate change;

Outcome 14: Air pollution and other harmful emissions - Reduce the contribution of transport to air pollution and other harmful emissions;

Outcome 15: The local environment - Improve the positive impact of transport on the local environment;

Outcome 16: Our heritage - Improve the effect of transport on our heritage;

Outcome 17: Biodiversity - Improve the impact of transport on biodiversity.

2 Scope of this Report

2.1.1 The scope of this report is to set out the future maintenance strategy for the River Usk Crossing, approach spans and abutments. This is a requirement of Key Stage 3, as detailed in the Works Information Clause 4.3.1.

2.1.2 The design of the Bridge is in accordance with Eurocodes, which establishes principles and requirements for safety, serviceability and durability. The objective of the maintenance strategy presented in this report therefore is to ensure that inspection and maintenance activities are performed during the working life of the bridge in order to fulfil the requirements for reliability.

2.1.3 Specific aims for the inspection and maintenance of the River Usk Crossing and approach spans include:

a) To plan and carry out inspection and maintenance activities so that disruption to bridge users is minimised. This includes planning maintenance activities so that any known faults are not allowed to develop to a stage where the remedial works required to resolve them would cause disproportionately greater disruption than if they had been dealt with more promptly. The repair or replacement of critical or vulnerable parts of the structure which needs to be carried out as soon as possible for reasons of safety may cause unavoidable disruption to bridge users.

b) To preserve the integrity and safety of the structure while carrying the loads for which it has been designed. For components of the structure that are subject to wear or may reach the end of their service life during the lifetime of the bridge (e.g. stay cables, bearings, movement joints, deck surfacing, etc.) maintenance includes replacement.

c) To maintain mechanical, electrical and control systems in satisfactory operating condition by routine inspection and maintenance and by the replacement of parts either as recommended by the manufacturer or as otherwise necessary.

2.1.4 This report informs how the Scheme would deliver principally on the following Scheme objectives: Transport Planning Objective 1 and Wales Transport Strategy Environmental Outcome 11.

2.1.5 The Works Information stipulates that: -

4.23.70) If the Usk crossing is designed as a cable supported bridge, the principles and objectives regarding replacement and maintenance given in Article 3.4 and Article 13.1 of SETRA (Cable Stays – Recommendations of French Interministerial Commission on Prestressing (2002), France) shall be adopted. The Contractor shall prepare the equivalent of the Project Maintenance and Inspection file referred to in Article 13.2.

4.23.71) The contractor shall provide a design that allows for a means of access for inspection and maintenance to all parts of the River Usk crossing and approach viaducts inclusive of piers, towers, cables and deck soffit as appropriate to the form of bridge design. The provision of permanent mobile gantries is not favoured, nor is reliance on roped access techniques and therefore the geometry of the structures shall allow for access using mobile elevated work platforms, underbridge access units or similar.

4.23.72) The Contractor shall determine the future maintenance requirements for the structure including any specific requirements for a specialist team or Bridge Master to manage and maintain the structure. Any maintenance requirements for any local offices to be built or land required adjacent to the bridge shall also be determined. These aspects will need to be developed early in the Technical Approval Process with Whole Life Costs for various structural options clearly identified.

Therefore the inspection and maintenance plan must be developed in accordance with this specification, and also early in the Technical Approval process so that key requirements can be identified and appropriately allowed for within the design.

2.1.6 The objectives of this report are to: -

a) Identify primary inspection and maintenance activities required over the life of the structure with a focus on the River Usk Crossing unique items.

b) Identify subsequent access requirements.

c) Determine appropriate access solutions for each element of the structure.

d) Carry out whole life costing where access and maintenance options exist to determine the most appropriate solution. Also provide an estimate of the maintenance costs over the first 30 years of the Crossing to assist in planning maintenance budgets. Access options are specifically for the cable stay bridge and ladder deck design being developed. Further access options associated with different types of bridge structure, span arrangement or alignment have not been included as this is deemed to be within the scope of the KS3a value engineering exercise.

e) Consider need for a dedicated maintenance team or Bridge Master.

f) Consider requirements for a local office or depot adjacent to the bridge.

2.1.7 Abbreviations and definitions used within the report can be found in the Glossary in Appendix A1.

3 Inspection and maintenance standards

3.1 General

3.1.1 The inspection and maintenance strategy for the River Usk Crossing and approach spans presented in this report is based upon the requirements of BD 63/07 'Inspection of Highway Structures', in 'The Inspection Manual for Highway Structures' publication. This is implemented by Welsh Government Trunk Road Maintenance Manual (WGTRMM) which sets out the operational objectives and the performance, inspection and service requirements in maintaining the network in a safe and serviceable condition. It also presents guidance on anticipated defects and how these should be avoided or remediated. The Welsh Government Inspection Manual must also be complied with and this details requirements for how inspections should be carried out including methods, referencing systems, the recording of defects and the reporting of results.

3.1.2 Five types of maintenance inspection are defined in BD 63/07. These are:

a) Safety Inspection;

b) General Inspection;

c) Principal Inspection;

d) Special Inspection;

e) Inspection for Assessment.

Detailed requirements for inspection and maintenance are given in Section 4 and Section 5, respectively, of this report.

3.1.3 For each major element of the crossing, approach spans and abutments, the Contractor would be required to produce an Inspection & Maintenance Plan (IMP). The Inspection & Maintenance Organisation would work to these IMPs and continue to develop them throughout the service life of the Bridge.

Each IMP would include the requirements for Safety, General, Principal and Special Inspections together with requirements for maintenance.

The Inspection & Maintenance Organisation would be required to operate using specific IMPs for special elements of the River Usk Crossing and approach spans (e.g. stay cables, bearings, bridge deck movement joints, gantries, etc.) which would include all relevant manufacturer's requirements.

3.1.4 The aim of inspection is the timely identification of all significant defects and deterioration of the bridge to enable the structure to be maintained in a sound and safe condition and to allow traffic to be carried safely in accordance with the Welsh Government Statutory requirements. This is achieved by means of the planned implementation of appropriate inspection procedures.

3.1.5 Classification, recording and reporting of defects and the recording of maintenance work should be in accordance with the IMP and with the requirements of the Welsh Government.

3.2 Consideration of current SWTRA maintenance organisational structure

3.2.1 The South Wales Trunk Road Agency (SWTRA) currently manage approximately 1800 structures, of which approximately 600 are bridges, although none of a similar scale to the proposed River Usk Crossing. Maintenance work is procured through a Contractor framework, with inspections conducted by an inspection framework.

3.2.2 It has been assumed in this report that maintenance of the River Usk Crossing will be carried out in accordance with the applicable maintenance standards so that components will reach their intended design life.

3.2.3 If the actual maintenance regime carried out is less than the requirements then this may lead to deterioration of the structure and therefore more major maintenance works when they do eventually occur. There is also an increased risk of the element not reaching its intended design life. Where relevant the risks of not carrying out maintenance have therefore been identified throughout the report.

4 Inspection requirements

4.1 Inspection categories

The Inspection Categories for the River Usk Crossing and approach spans are as defined in BD 63/07:

a) Safety Inspection;

b) General Inspection;

c) Principal Inspection;

d) Special Inspection;

e) Inspection for Assessment.

4.2 Safety inspection

4.2.1 The purpose of a Safety Inspection is defined in BD 63/07, Section 3.10, as '… to identify obvious deficiencies which represent, or might lead to, a danger to the public and, therefore, require immediate or urgent attention.'

4.2.2 Safety Inspections should take the form of a visual inspection normally carried out by trained highway maintenance staff. They may be made from a slow moving vehicle passing over the bridge, or where circumstances dictate, inspection staff may need to proceed on foot. All staff accessing the bridge for inspection or maintenance purposes must be inducted onto the site to ensure they are knowledgeable of all health and safety procedures. The objective of safety inspections is to identify defects visible on the carriageway. Inspectors must therefore be competent and vigilant, although they may not necessarily be trained structures inspectors.

4.2.3 The M4 is considered to be within Inspection Priority A in accordance with the WGTRMM and therefore safety inspections must be carried out every 24 hours.

4.2.4 The scope of Safety Inspections should be in accordance with the requirements in the Inspection & Maintenance Plans.

Safety Inspections should include, but not be limited to:

a) carriageway surfacing;

b) road markings;

c) vehicle restraint systems, parapets and safety fences;

d) wind shields;

e) gantries, signs & VMS;

f) marine navigation lights;

g) aviation warning lights;

h) carriageway lighting systems.

4.2.5 Any defects, damage or debris which may present a hazard to bridge users or others should be recorded and reported for immediate remedial action. Any instances of structural deterioration or damage likely to indicate reduced load capacity or safety should be reported to the Operating Authority.

4.3 General inspection

4.3.1 The purpose of a General Inspection is defined in BD 63/07, Section 3.18, as '… to provide information on the physical condition of all visible elements of a highway structure.'

4.3.2 General Inspections should provide information on the physical condition of all visible elements on a highway structure that can be inspected without the need for special access equipment or traffic management arrangements.

4.3.3 The scope of General Inspections should be in accordance with the requirements in the Inspection & Maintenance Plans.

General Inspections should include, but not be limited to:

a) Abutments;

b) Piers;

c) Deck soffit and parapet edge beams;

d) Towers (Internal and external);

e) Reinforced soil walls;

f) Cable stays and anchorages;

g) Bearings;

h) Joints;

i) Corrosion protection system (steelwork paint system is assumed);

j) Vehicle restraint systems, parapets and safety fences;

k) Wind shields;

l) Carriageway surfacing;

m) Deck drainage systems;

n) Permanent access equipment.

4.3.4 General Inspections should include earthworks and marine works where these are relevant to the behaviour or stability of the structure.

4.3.5 Before undertaking a General Inspection the bridge inspection staff should review the structure records in order to become familiar with the characteristics of the structure and of the condition of the bridge at the last inspection, including any significant maintenance and modifications works.

4.3.6 Any damage, defects affecting long-term durability, deterioration affecting proper functioning of the structure or any matter which may cause potential hazards to bridge users or others should be quantified, recorded and reported for remedial action. Any instances of structural deterioration or damage likely to indicate reduced load capacity or safety should be reported to the Operating Authority.

A General Inspection may give rise to the need for a Special Inspection or Scheme of Monitoring to investigate a particular defect.

4.4 Principal inspection

4.4.1 The purpose of a Principal Inspection is defined in BD 63/07, Section 3.25, as '… to provide information on the physical condition of all inspectable parts of a highway structure. A Principal Inspection is more comprehensive and provides more detailed information than a General Inspection.'

4.4.2 For the River Usk Crossing and approach spans, Principal Inspections should comprise a close visual inspection carried out from within touching distance of all inspectable parts of the structure. Special access arrangements (mobile underbridge units, stay cable inspection robots) may be required to allow close inspection of the structure. Traffic management arrangements may also be required.

4.4.3 The scope of Principal Inspections should be in accordance with the requirements in the Inspection & Maintenance Plans. They should include the same structural elements as listed in Section 4.3.3 of this report for General Inspections.

4.4.4 Principal Inspections should examine in detail the functional, durability and safety aspects of all inspectable components of the structure. Suitable inspection techniques should be considered (e.g. tapping hammer, endoscope, feeler gauges, etc.). Testing is not generally required for Principal Inspections.

4.4.5 Before undertaking a Principal Inspection the bridge inspection staff should review the structure records in order to become familiar with the characteristics of the structure and of the condition of the bridge at the last inspection, including any significant maintenance and modifications works.

4.4.6 Any damage, defects affecting long-term durability, deterioration affecting the proper functioning of the structure or any matter which may cause potential hazards to bridge users or others should be quantified, recorded and reported for remedial action. Any instances of structural deterioration or damage likely to indicate reduced load capacity or safety should be reported to the Operating Authority.

A Principal Inspection may give rise to the need for a Special Inspection or Scheme of Monitoring to investigate a particular defect.

4.4.7 For areas of difficult or dangerous access (e.g. obscured parts, confined spaces, working at height, etc.) alternatives to close visual inspection may be used such as CCTV, drones. Alternatives must provide comparable quality of inspection information to close examination.

4.5 Special inspection

4.5.1 The purpose of a Special Inspection is defined in BD 63/07, Section 3.39, as '… to provide detailed information on a particular part, area or defect that is causing concern, or inspection of which is beyond the requirements of the General/Principal inspection regime.'

4.5.2 Special Inspections are carried out when a need is identified and are tailored to meet specific needs and circumstances. A special Inspection may comprise a single inspection, a series of inspections or an ongoing programme of inspections. Special Inspections may comprise Close Visual Inspection, Detailed

Visual Inspection, Non-Destructive Testing, Destructive Testing or Scheme of Monitoring.

4.5.3 The scopes of all Special Inspections should be agreed in advance with the Welsh Government.

4.5.4 Circumstances in which a Special Inspection may be required include:

a) Exposure to an extreme environmental condition (e.g. very high wind).

b) After a lightning strike.

c) After a major incident or accident (fire / impact / chemical spillage) on, in or adjacent to the structural components.

d) Following the discovery of a significant defect which is potentially of a repetitive nature.

e) Structural defects or anomalies (including indications of weld cracks) arising from accidental damage or found during routine inspections or other inspections and which require more detailed investigation or inspection.

f) The accumulated or sudden settlement of part of the structure by more than allowed for within the design.

g) After the passage of an abnormal load across the bridge without prior notification and approval and /or the necessary escort and clear carriageway arrangements in front and behind the vehicle.

h) After a ship / barge impact to the deck.

i) If any of the following is found during routine inspections / maintenance:

    a) Bearings: tilted, protruding PTFE, steel component cracked / fractured / loose.

    b) Movement joints: cracking / deformation of structural member, cracks on welded joints, damage to control springs, restricted movement, ‘spring effect’ on movement joint.

    c) Stay Cable system: slippage / breaking of stressed strand, abnormal vibration, damage to HDPE sheath, fire.

    d) Deformation / deviation / lamination found to main structural elements i.e. webs, bottom flange, deck slab, etc.

    e) Abnormal movement to the structure or propagation of cracks.

j) Permanent access gantries, hoists, winches and associated cables would also require special inspection before being used and at regular intervals as specified by the manufacturer.

4.6 Inspection for assessment

4.6.1 The purpose of an Inspection for Assessment is defined in BD 63/07, Section 3.50, as ‘… to provide information required to carry out a structural assessment.’

4.6.2 Inspections for Assessment should be carried out in accordance with the requirements of BD 63 and BD21/01, and where possible should be carried out simultaneously with a Principal inspection.

4.7 Frequency of inspections

4.7.1 The frequency of the various Categories of Inspection is set out in BD 63/07 and the WGTRMM and is summarised in the following table.

Inspection Type	Minimum Frequency
Safety Inspection	Daily
General Inspection	2 years. Where this coincides with a principal inspection a general inspection is not required.
Principal Inspection	6 years.
Special Inspection	As required.
Inspection for assessment	As required.

Table 1: Inspection types and frequency

4.7.2 The Welsh Government also use a risk based approach in accordance with the Welsh Government Trunk Road Maintenance Manual and IAN 171/12 to determine inspection priorities and whether a lower inspection frequency may be justifiable. The risk based assessment accounts for the historical performance of that type of structure, the reliability of the inspection data, the recorded condition of the structure, the impact of a loss of capacity and its detectability. After construction it may therefore be appropriate to use a risk based analysis to reduce the inspection frequency of some elements, provided there are no specific quality issues that would need ongoing monitoring.

4.7.3 The detailed design phase should be carried out with the aim of using appropriate design details or products to increase the inspection frequencies through a risk based approach.

4.7.4 Principal Inspection intervals determined through risk assessment must not exceed twelve years as stipulated by BD63/07.

4.8 Access required for inspections

4.8.1 Reviewing the inspection requirements, access is therefore required to the following structural elements. The majority of these would need to be accessed every 2 years for a general inspection, although more frequent access may be required for safety or special inspections, or prior to an assessment. For principal inspections every 6 years these elements would need to be accessed within touching distance.

a) Abutments;

b) Piers;

c) Deck soffit and parapet edge beams;

d) Towers (Internal and external);

e) Cable stays and anchorages;

f) Bearings;

g) Joints;

h) Reinforced soil walls;

i) Vehicle restraint systems, parapets and safety fences;

j) Wind shields;

k) Carriageway surfacing;

l) Deck drainage systems;

m) Permanent access equipment;

n) Carriageway surfacing;

o) Road markings;

p) Gantries, Signs & VMS;

q) Lighting systems.

4.9 Structural health monitoring systems

4.9.1 A structural health monitoring system (SHMS) collects data from sensors on the bridge of various types - anemometers, barometers, rain gauges, accelerometers, temperature sensors, strain gauges, displacement transducers, corrosion sensors etc. This information can then be used to monitor the performance of the bridge and its surroundings in terms of environment and status, traffic loads, bridge characteristics and bridge response. Comparing measured or derived bridge performance results with the designated structural performance criteria is one of the major objectives of the SHMS.

Works Information clause 4.23.69 refers to UKNA to BS EN 1993-1-11 for the structural health monitoring system (SHMS) requirements.

The sensory equipment proposed as a minimum are:

a) An anemometer which would continuously monitor wind speed and direction, as well as a data acquisition system, communication back to the operations centre and data storage to archive monitoring data at reasonable sampling rates.

b) Sufficient stay cable load indicators to effectively monitor the deck erection and ensure that the design geometry/stay cable forces.

c) The installation of accelerator housing units at each stay cable and the provision of two portable accelerometers and two portable data acquisition units with battery power supply.

d) Acoustic monitoring system for a single cable, including local data acquisition, storage and power supply with sufficient data storage to allow download and interrogation of data at regular intervals.

4.9.2 The following design assumptions would be confirmed by these monitoring activities:

a) At KS3 a wind climate study is to be produced, based on locally available anemometer data. Sectional model wind tunnel testing is also to be carried out to confirm the aerodynamic performance of the deck. The Inspection and Maintenance Organisation should review wind data at 6 year intervals to review the design assumptions and the potential impact of climate change.

b) Following completion of the deck construction, stay cable loads and deck geometry should be surveyed by the Inspection and Maintenance Organisation to ensure time dependent effects, including creep and shrinkage of concrete, do not affect the operation of the bridge.

c) Long-term load paths in the structure, can be confirmed by the Inspection and Maintenance Organisation by regular field surveys, to coincide with the principle inspections, through the monitoring of forced accelerations on each stay cable, using the portable accelerometers and the post processing of this data to determine the dynamic characteristics and the forces in the stay cables.

d) During KS3 and KS4 analytical studies are to be carried out to reduce the risk of stay cable vibrations due to wind/rain, vortex shedding and parametric excitation. Internal and external stay dampers are options to design out potential problems. However to mitigate the residual risk of untoward vibrations/oscillations in the stay cables, it should be possible for the Inspection and Maintenance Organisation to carry out investigations using portable accelerometers.

4.9.2.1 The SHMS systems required should not be assumed to be limited to those stated in the Works Information, and the adoption of further systems may also be requested by the Welsh Government should they provide information that is important for future maintenance of the structure.

The following monitoring equipment could also be provided: -

Equipment	Key benefit				
	Identify when inspections required following extreme events	Develop fatigue model and therefore predict service life of structure	Monitoring of long term effects	Predict remaining service life of bearings and possible future reduction in bearing/joint size	Determine reinforcement and steel corrosion
Displacement transducers	Y	Y	Y		
Strain gauges	Y	Y	Y		
Full weather station	Y	Y			
Lateral bearing sensors			Y	Y	
Tiltmeters	Y	Y	Y		
GPS displacement trackers	Y	Y	Y		
Dynamic weigh in motion sensor	Y	Y			
Corrosion sensor					Y

4.9.2.3 All SHMS systems should follow current best practice for structural monitoring techniques to ensure that the data collected is relevant and usable. In particular the Centre for Smart Infrastructure and Construction are carrying out research into this to identify what parameters should be measured and why, how to measure these parameters, and what should be done with the data that is obtained. When determining the data that is to be collated the objective of the data should first be identified and the value of it quantified through a cost benefit analysis.

4.9.2.4 In February 2009 there was the first recorded instance of ice falling from the cables of the Severn Bridges. The only other occurrence was the following year. The ice formed and fell due to a combination of very specific weather conditions of temperature, humidity and wind. Given the proximity of the River Usk Crossing to the Severn Bridges it can be inferred that the River Usk Crossing also has a small risk of ice falling onto the carriageway during cold weather. As adopted for the Severn Bridges, data from the weather monitoring system should be used to raise an alarm when specific conditions may lead to the formation of ice on the towers or cable stays. A special inspection can then be carried out to determine whether there is a risk of ice fall, and if necessary instigate closure of the carriageway via the Operating Authority.

5 Maintenance requirements

5.1 General

5.1.1 The aims of maintenance are:

a) By preventative action to limit deterioration or malfunctioning of parts and equipment to safe and economical levels.

b) By replacement of worn or damaged parts to ensure continuity of desired performance.

c) By remedying recorded defects to ensure continued structural integrity and public safety.

5.1.2 All parts of the River Usk Crossing and approach spans should be maintained, including replacement or repair as necessary, to ensure that these aims are achieved.

5.2 Compliance

5.2.1 Maintenance operations must comply with those requirements specified by the Welsh Government or their consultants.

5.2.2 Maintenance operations must comply with British Standard, EN and other relevant specifications and the requirements of the DMRB and Interim Advice Notes.

5.2.3 At the end of construction “as-constructed” drawings of the bridge and related specifications should be produced. Maintenance arrangements must comply with the requirements given on these documents.

5.2.4 Maintenance arrangements must conform to component manufacturers’ specifications and recommendations.

5.2.5 Maintenance operations must conform to statutory safety standards and other non-contradictory accepted safety standards as specified by the Welsh Government and/or the Inspection and Maintenance Organisation.

5.2.6 If the actual maintenance regime carried out is less than the requirements then this may lead to deterioration of the structure and therefore more major maintenance works when they do eventually occur. There is also an increased risk of the element not reaching its intended design life and undergoing premature failure. Where relevant the risks of not carrying out maintenance have therefore been identified throughout the report.

5.3 Maintenance following inspection

5.3.1 The scope and programme of non-routine maintenance should be as required by the results of inspections and should be agreed with the Welsh Government.

5.4 Frequency and scope of anticipated maintenance regimes

5.4.1 Ongoing maintenance

5.4.1.1 The following ongoing maintenance, taken from the WGTRMM, is required throughout the lifetime of the structure, and may be identified from safety, general and principal inspections.

a) Remove graffiti.

b) Remove vegetation, e.g. that blocks drainage, may cause structural damage or restricts access.

c) Remove debris, bird droppings and other detritus that blocks drainage and promotes corrosion or other deterioration.

d) Clear and ensure correct operation of drain holes, drainage channels and drainage systems.

e) Repair defective gap sealant to movement joints.

f) Check operation of flap valves and grease where required.

g) Remove general dirt and debris from bearings and bearing shelves. Where appropriate, clean sliding and roller surfaces if accessible and re-grease. Follow any additional advice contained in the bearing manufacturer’s recommendations. Where bearings cannot be accessed without specialist equipment, the Maintainer shall employ judgement to determine the appropriate frequency of bearing cleansing to minimise whole-life cost. This may mean combining the Principal Inspection with bearing maintenance or vice-versa as a minimum frequency.

h) Ensure free flow of water through culverts.

i) Ensure correct operation of ancillary equipment (e.g. drainage pumps and associated sumps and pipework) and maintain certification of lifting devices. The Maintainer should assume that the operation of ancillary equipment and maintaining the certification of lifting devices will be done under cyclic maintenance. However, if the Maintainer considers there is a more appropriate frequency and delivery mechanism the Maintainer should present a proposal for agreement by the TAA. The default minimum shall be that included in the operation manual.

j) Check (and rectify where necessary) seating of drainage gratings or covers, replace missing or defective items.

k) Check, clean and repair where necessary pedestrian security and safety measures (e.g. mirrors, handrails, non-slip surfaces).

l) Check for scour damage. At the East Tower this can be carried out during low tide from the salt marshes.

m) Check holding down assemblies for loose or missing bolts.

n) Superficial defects in surface protection systems (defects to be reported for specialised repairs).

o) Ensure special finishes are clean and perform to the appropriate standards.

5.4.1.2 The frequency of ongoing maintenance for different highway elements and the time limit over which hazards must be mitigated and then repaired permanently is given in the WGTRMM and depends on the category of the hazard.

5.4.1.3 If ongoing maintenance regimes are not adhered to then they will lead to deterioration of the structure and the possibility of more significant repairs in the future which could reduce lane availability. For example if maintenance to drainage systems is not carried out this could lead to reinforcement corrosion and the spalling of concrete over time, which would then require remediation. During detailed design phase the durability of the structure should therefore be considered and agreement sought with the Welsh Government for the adoption of any options which could reduce the maintenance demands of the structure. Safety related defects however must always be repaired in accordance with the Standards.

5.4.2 Planned maintenance

The scope and exact frequency of the planned maintenance would depend on the supplier eventually chosen for that element. However, the details stated in the following sections are typical of these systems.

5.4.3 Multi element movement joints

5.4.3.1 Multi element joint components should be inspected approximately every 2 years for the following defects: -

a) Sealing profiles for dirt, damage, secure hold, tightness, regular and sufficient gap widths.

b) Joint profiles for deformation, condition of corrosion protection system.

c) Sliding elements for dirt, wear, surface damage, fixity, rubbing between removable parts.

d) Bearing and spring elements for correct position, damage, cracking, noise development, fixity.

e) Corrosion protection underneath sealing profiles, in the footway area and underneath steel cover plates.

f) Steel supporting structure for cracks, connections, weld checks, butt joints, anchorage of edge rails, condition of concrete under joist boxes, free movement of lamellas and joists.

g) Resin seal between edge rail and carriageway for formation of ruts, levelling of joint, deformation of edge rails, condition of resin seal.

h) Footway cover plates for corrosion, fixity, noise production and positioning.

5.4.3.2 The replacement of sealing profiles may be required after approximately 20 years by the following method: -

a) Opening of joint gap using jacks;

b) Dismounting of old sealing profile;

c) Renewal of corrosion protection system if necessary;

d) Vulcanising the butt joint between the remaining sealing profile and the profile to be replaced;

e) Greasing of steel claws which hold the sealing profiles;

f) Fitting new sealing profile.

5.4.3.3 The replacement of sliding bearings and springs may be required after approximately 20 years by the following method: -

a) Remove sealing profiles in the lifting area;

b) Enlarge the gap between the rails using jacks;

c) Lift the joint rail using lifting gear;

d) Dismount the sliding bearing and spring;

e) Install new sliding bearing and spring;

f) Lift the joint rail back into position;

g) Re-adjust the gap between joint rails;

h) Reinstall the sealing profile.

5.4.3.4 The replacement on control springs may be required after approximately 20 years by the following method:-

a) Jack together neighbouring joint rails linked by the control spring;

b) Remove bolts holding the control spring;

c) Remove the control spring and install new spring;

d) Reinstall bolts holding down the control spring;

e) Reset the gap between joint rails.

5.4.3.5 It is anticipated that after 40 years the complete joint system would require full replacement. During full replacement the deck would need to be broken out to allow the control boxes of the old joint to be removed. The new joint would then need to be tied into the existing deck steel and concreted into the joint recess. Due to the need for concrete break out and recasting of the deck concrete around the new joint, each joint replacement is anticipated to take 12 weeks.

To avoid having to close the carriageway throughout this period due to the presence of the void in the deck, a ramping plate system has been developed and used elsewhere on the UK Road Network which spans over the void and allows vehicles to travel over the joint replacement works during daytime hours at 70mph. At night this ramp is then lifted to allow replacement works to continue, and hence only night time carriageway closures are required to carry out the works. Installation of the ramp plate itself prior to the work is also carried out in stages under several night closures.

Replacement of elements of the joint as detailed in the previous sections can be carried out under several night closures of the carriageway, without the need for a ramp.

To increase the service life of the joint there are several options proposed by various joint suppliers which can be adopted, including the use of stainless steel joint rails, galvanising joint sections, use of betoflex supporting ribs in the approach asphalt to reduce vehicle loading and the adoption of low friction sliding materials. These can be investigated further with the joint supplier during detailed design.

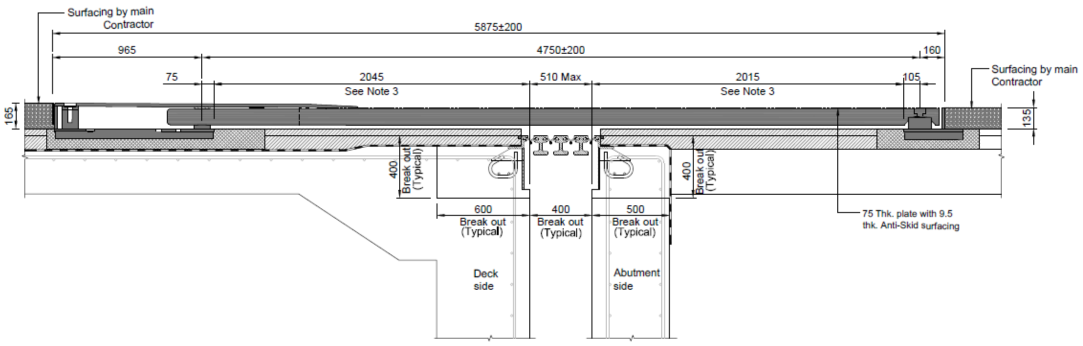


Figure 1: Typical ramp detail spanning over joint during replacement works

5.4.3.6 Deferral of the joint maintenance regime is a possibility but the main risks that would result from this are given below: -

a) Displacement of bearing pads leading to steel on steel contact between joint rail/support rail/joist box. This could lead to brittle fracture of the joint elements and in turn a potential hazard to running traffic if an element were to become displaced.

b) Steel on steel contact will also lead to increase noise levels from the joint which would cause disturbance to neighbours.

c) Displacement or hardening of the joint springs restricting movement of the joint. This would lead to the joint seal pulling out of the joint rails, a loss of watertightness and in turn increased corrosion of the bearings.

d) Water accumulating around the joint units leading to a corrosion of the joint rails, and in turn a shortening of the design life.

5.4.4 Bearings

5.4.4.1 Bearings must be inspected approximately every 6 years for the following defects: -

a) Insufficient PTFE thickness remaining;

b) Displacement of bearing components;

c) Loosening of bolts or dowels;

d) Bearing exceeding its translation or rotational limits;

e) Warping of sliding surfaces;

f) Year on year reduction in bearing movement suggesting bearing seizure;

g) Defects to corrosion protection system.

5.4.4.2 During the design life of the bearing the following maintenance may be required after approximately 20 years: -

a) Repairs to the corrosion protection system;

b) Tightening of holding down system;

c) Replacement of sliding plates, PTFE layer or elastomer;

d) Re-greasing of bearing.

5.4.4.3 Full bearing replacement is likely to be required after approximately 50 years. During bearing replacement the bridge would need to be jacked up. The carriageway would remain open but some traffic management would be required to control the live load distribution.

For replacement of wearing components of the bearing such as the sliding plates, PTFE layer and elastomer, jacking of the deck structure would also be required.

For replacement of each bearing at tie-down piers E1 and W1, one of the tie-down cables shall be de-stressed from the deck anchorage using a mono strand jack. The deck should then be jacked up which will increase the cable load generated in the remaining tie-downs, which must be accounted for in their design. Then replace the bearing and de-jack the deck, grouting the bearing in. Finally the tie-down cable should be re-stressed strand by strand.

5.4.4.4 Once the bearing is exchanged the deck shall be lowered and the third tie-down shall be re-stressed. A special procedure has to be in place to make sure no wedge bites will occur on the stressed length of the tie-down strands.

5.4.4.5 Deferral of the bearing maintenance regime is a possibility but the main risks that would result from this are given below: -

a) Excessive wearing of the PTFE sliding layer leading to the bearing seizing and a restraint to movement.

b) Excessive wearing of the PTFE sliding layer leading to steel on steel contact and therefore deformation of the sliding surfaces, which will shorten the design life of the bearing.

c) Leakage of the elastomer from the pot which will reduce the rotational capacity of the bearing.

d) Corrosion and delamination of the steel sliding surfaces which will lead to the bearing seizing and a restraint to its movement. It will also shorten the design life of the bearing unit.

e) Loss of fixity of the bearing from loosening of bolts or deterioration of grout pad, leading to displacement of the bearing unit.

It is noted that a restraint to the translational or rotational capacity of the bearing will generate stresses in the substructure and deck for which it has not been designed for, which could lead to further serviceability problems such as excessive displacement or concrete cracking.

5.4.5 Steelwork corrosion protection system

5.4.5.1 In developing the maintenance requirements it has been assumed that the corrosion protection system would be painted. A weathering steel option however is currently being considered as a value engineering alternative, which if adopted, would remove most of the requirements for paint maintenance.

5.4.5.2 Repairs to the paintwork may be required after 15 years and would involve: -

a) Removing grease and loose debris;

b) Mechanically preparing the steel substrate surface;

c) Feathering back paint surrounding the area to be repaired;

d) Application of primer and paint system in accordance with the paint repair specification.

5.4.5.3 Renewal of the whole system would be required after approximately 25 years. A temporary scaffold platform built from ground level or suspended under the deck would need to be constructed under the bridge deck to facilitate these works. All platforms would need to be enclosed to contain the shot and grit blasting debris required to remove the existing paint system and prepare the steel substrate. Traffic management works would not be required during these works.

5.4.5.4 An alternative to the removal of paint grit blasting would be to use heat treatment techniques. Heat is applied through an induction generator and sensors are used to monitor the steel temperature. Application of this technology to remove paint is relatively new, but there is a past example of it having been used on a steel bridge with a surface area of approximately 50,000m^2. If it was adopted it would eliminate the generation of grit blast debris which is of environmental benefit. It would also negate the need for an enclosed platform to contain the grit debris, representing a significant cost saving in the temporary works.

5.4.5.5 Deferral of the painting maintenance regime is a possibility but this would lead to increased corrosion of the steel and over time a loss of section would could affect the structure in the ultimate limit state. Furthermore a lack of repairs to the paint system would be detrimental to the aesthetic appearance of the bridge.

5.4.6 Cable stays

5.4.6.1 In accordance with the SETRA guidance for cable stays, it is recognised that there are some uncertainties over the future ageing of the cable stays. There must therefore be adequate provision for the stay cables to be replaceable and easily inspectable to facilitate maintenance works. This requirement must be considered when developing the designs for the cable stays, for example adopting threaded rather than welded connections for elements protecting the anchorage. The anticipated maintenance and inspection of the cables is detailed in this section, with a discussion on access to the cables in Section 8.5.

5.4.6.2 Typically, recommendations propose a design life of 50 years for replaceable systems and 100 years for non-replaceable systems based on a defined maintenance interval. The long term performance of the stay cables, tensile members and anchorages would be demonstrated by prequalification testing of the stay cable system to ensure that the fatigue and tensile performance of the stay cable system provides the required service life. As the anchorage is the most vulnerable part of a modern stay cable system in terms of durability, leak tightness testing according to FIB or SETRA requirements should be undertaken to verify that the anchorages (particularly the lower deck anchorage) are fully resistant to any ingress of water.

5.4.6.3 The service life of the stay cables would be further confirmed by the Inspection and Maintenance Organisation by verification testing of stay cable strand samples. The ability to remove the tension members strand by strand would enable them to remove and inspect in detail and thus make an assessment of the future ageing of the stay cable. This would be undertaken at regular intervals or after a major incident such as a vehicle collision or fire. This specific inspection regime would be complemented by the structural health monitoring system through the use of acoustic monitoring, load indicators and accelerometers to monitor stay cable loads and strand breaks.

5.4.6.4 An inspection program is to be fully developed in the Inspection Management Plan for the stay cable system defining the inspection intervals for the individual components. A typical example is given on the following page;

	Element	Frequency of inspection		Percentage to be checked	Parts to check	Observations
		First inspection	Following inspections			
Inspection at deck edge	Lower steel tubes	12		33%	Formwork tube (stay cables) Anti-vandalism tube Guide tube Accessible part of steel pipe (tie-downs)	Corrosion protection Bolts tightening Tightness Drainage
	Bottom anchorage external	12		33%	Cap Bearing plate Flange Drainage tube or hole	Corrosion protection Bolts tightening Signs of damper leakage Drainage obstruction
	Bottom anchorage internal	24	36	25%	Cap Flange Block Strands Wedges	Corrosion protection Strands missing or sliding Wedges breaking
	HDPE duct	12		33%	HDPE expansion sleeve	Unscrewing of anchorage Duct general details – colour, fillet, joints
	Internal damper (radial or hydraulic)	24		25%	Guide tubes Caps Pistons Steel collar	Corrosion protection Bolts tightening Signs of oil leakage General condition of all damper components
Inspection at pylon	Top anchorage external	12		33%	Cap Bearing plate Nut Drainage tube or hole	Corrosion protection Bolts tightening Cap stuffing box bolts tightening Drainage obstruction
	Top anchorage internal	24	36	25%	Cap Nut Block Strands Wedges	Corrosion protection Strands missing or sliding Wedges breaking
	Top steel tubes external	12		33%	Formwork tube	Visual inspection with binoculars Corrosion protection Bolts tightening

Table 2: Cable stay inspection checklist

5.4.6.7 As well as the inspection and monitoring regime, cable stay sheaths should be replaced when they show signs of distress and cracking. Damper systems may need to be replaced after approximately 40 years. Cable replacement would then be required once the system has reached its intended design life.

5.4.6.8 In order to facilitate the replacement of the stay cables, the bridge should be designed to accommodate the removal and replacement of a single stay cable. Works Information clause 4.23.69 does not permit any restrictions to the traffic during this event. In practice, the replacement of the stay cables can be done strand by strand or as whole cable replacement.

5.4.6.9 For strand by strand replacement the hard shoulder is to be closed to park a vehicle with a drum of strand to feed into the lower stay anchorages as well as take away the old strands. Stressing takes place at the tower anchorage.

5.4.6.10 For whole cable replacement, the hard shoulder is to be closed to assemble the new stay pipes whilst old stay strands are removed from the stay to be replaced. During a night time closure of the carriageway the old stay pipe is removed and a new stay pipe is lifted and fixed into position. With the exception of the hard shoulder the carriageway can then re-open and strand installation is then much like strand by strand replacement with individual strands inserted from a vehicle with a drum on the closed hard shoulder.

5.4.6.11 Deferral of the cable inspection regime is a possibility but has the following risks: -

a) Breaking of strands which is undetected, leading to higher loads on the remaining cables.

b) Issues with water ingress into the anchorages not identified, leading to corrosion of the anchorage and a possible loss of stay cable loads, leading to higher loads on the remaining cables.

c) Dampers not performing as intended leading to higher frequency and/or higher amplitude stay cable vibrations which could impact on the stay cable loads and service life.

5.4.7 Bridge deck surfacing and waterproofing

5.4.7.1 It is anticipated the carriageway surfacing would require renewal every 15 years due to cracking, breaking up and depressions forming in the asphalt. This work would include planing out and reinstatement of the upper surface course, but not the lower base layers or down to the waterproofing layer. During these works the depth of the surfacing must be tightly controlled due to the sensitive geometry control of a cable stayed bridge. Before the laying of new asphalt the same thickness must first be planed out from the existing surfacing to ensure that there is no increase in the overall depth of surfacing.

5.4.7.2 The deck waterproofing system would also require renewal after approximately 30 years. Past experience from the Network suggests however that waterproofing renewal schemes are often deferred due to restricted access to the Network. The main risks from doing nothing are: -

a) Water ingress to the top of the deck slab leading to corrosion of the reinforcement which could affect the structure in the ultimate limit state.

b) Corrosion of reinforcement leading to spalling and delamination of the concrete, and in turn surfacing defects.

5.4.7.3 To reduce the risk of corrosion to the deck reinforcement it is possible to use products such as potassium acetate or calcium magnesium acetate containing de-icing solutions, which will reduce the exposure of the concrete to chloride containing de-icing salts.

5.4.8 Structural health monitoring systems

5.4.8.1 The structural health monitoring system would require regular maintenance to ensure that they continue to function correctly. This primarily consists of electrical repairs to the system, maintenance and recalibration of sensors and cabling repairs. The need to undertake repairs should be identified by erroneous data being produced or system errors output in the data reports. These repairs will likely be undertaken by the manufacturer who is most familiar with the system.

5.4.8.2 It is anticipated that the software and hardware will also require updating approximately every 10 years to ensure that the data produced can be processed by current technology systems.

5.4.9 Maintenance of intelligent transport systems (ITS)

5.4.9.1 The intelligent transport systems would require regular maintenance to ensure that they continue to function correctly. In order to monitor traffic flows on the motorway, the following ITS systems are listed in the Works Information as being required: -

a) Gantry mounted advanced motorway indicators (AMIs);

b) Gantry mounted variable Message MS4;

c) Motorway Incident Detection and automatic signalling (MIDAS) Loops in the carriageway;

d) HADECS3 Cameras;

e) CCTV cameras;

f) Emergency Roadside Telephones (ERT) in the verge;

g) High Speed Weigh In Motion (WIM) installations in the carriageway.

5.4.9.2 Maintenance of ITS systems primarily involves electrical repairs to the systems when they develop faults. Gantries are intended to be accessible to enable the maintenance of gantry mounted signs and cameras. For inspections these would be done without traffic management. MIDAS loops and WIM installations are to be located in the carriageway surfacing and therefore would require lane or carriageway closures to enable maintenance. ERT cameras in the verge are to be located behind the safety barrier and accessed via the maintenance walkway.

5.4.9.3 Technology cabinets and chambers located in the verge would be accessed from the maintenance walkway. Electrical faults in plant room based systems are to be accessed and repaired in the plant rooms.

5.4.9.4 Replacement of any out of date ITS systems would require night time lane closures to enable the old technology to be replaced. The gantry supporting system should be designed for a 120 year design life and therefore should not require replacement. Maintenance of the gantry steelwork and corrosion protection system is to be carried out under night time traffic management to reduce disruption to road users.

5.4.10 Maintenance of electrical and communications networks

5.4.10.1 The electrical and communications networks associated with the technology in the bridge and also any utility providers also require maintenance. In accordance with the Works Information Cl4.23.31, 2x100mm diameter ducts are required across the length of the scheme with chambers at 250m centres, coinciding with cross carriageway ducts at 500m centres. These chambers require inspection. As well as the cabling system and chambers, access must also be gained to cabinets located in the verge or maintenance walkway located behind the vehicle restraint system (VRS).

5.4.11 Maintenance of access facilities

5.4.11.1 The Inspection and Maintenance Organisation must reduce the risks to the health, safety and welfare of their employees and others who may be affected by their operations in the bridge and depots. They must therefore comply with the general duties and specific requirements of the Provision and Use of Work Equipment Regulations (PUWER). The Service Provider must further ensure compliance with Regulations for specific work equipment and its use, for example, Lifting Operations and Lifting Equipment Regulations (LOLER).

5.4.11.2 Regulations state that all plant, machinery and equipment must be fit for purpose, properly maintained and safe. Equipment must therefore be inspected, maintained and used in accordance with the manufacturer's recommendations and BS6037. This includes access facilities such as the tower inspection gondola, deck inspection walkway and abseiling anchor points, as well as plant around the bridge and in the depot. Suspended access equipment must be inspected every 6 months and load tested annually. When a defect is identified in the operation or maintenance of such equipment, it must be put out of use immediately.

5.5 Access required for maintenance

5.5.1 To fulfil the maintenance requirements, access is therefore required for the following structural elements. The majority of these require ongoing maintenance to repair defects except for joints, bearings, stay cables and corrosion protection systems, which require regular maintenance in accordance with the manufacturers' specifications.

a) Exposed concrete surfaces;

b) Exposed steelwork;

c) Corrosion protection systems;

d) Bearings;

e) Joints;

f) Stay cables and anchorages;

g) Top of tower housing structural monitoring systems;

h) Carriageway surfacing;

i) Drainage kerbs, channels and pipes;

j) Gantries and associated intelligent transport systems;

k) Electrical and communications cables, chambers and cabinets;

l) ITS and SHMS technology systems;

m) Permanent access routes.

6 Key considerations when carrying out inspection and maintenance

6.1 Health and safety

6.1.1 The Inspection & Maintenance Organisation would be required to operate an independently verified Occupational Health & Safety Management System that complies with OHSAS 18001.

6.1.2 All inspection and maintenance work should be planned and carried out in accordance with the relevant Health & Safety law and regulations and should take into account the practices, procedures and site rules of the Inspection & Maintenance Organisation.

In particular, in advance of any inspection or maintenance work being carried out:

a) Reference should be made to the Health & Safety File for ‘as constructed’ records and all other relevant information. Attention should be given to any particular risks identified in the Health & Safety File.

b) The applicability of the CDM Regulations should be checked in relation to the proposed work.

c) For each activity, a method statement should be prepared in conjunction with a risk assessment addressing all relevant hazards, risks and mitigation measures. Account should also be taken of access requirements and of the equipment required to carry out the work.

6.1.3 The planning and execution of all inspection and maintenance work should only be undertaken by personnel with the relevant Health & Safety training and qualifications. All personnel must be inducted onto site prior to starting works.

6.2 CDM regulations

6.2.1 All inspection and maintenance activities should be carried out in accordance with the Construction (Design and Management) Regulations 2015, and any subsequent revisions and amendments to these regulations, where these regulations apply.

6.3 Quality assurance

6.3.1 The Inspection & Maintenance Organisation would be required to operate an independently verified Quality System that complies with BS ISO 9001.

6.3.2 All inspection, testing, maintenance and other related activities should be in accordance with written method statements prepared by the Inspection & Maintenance Organisation.

6.3.3 All materials, methods and procedures used in the maintenance of the River Usk Crossing should be of the quality defined in the Employer's Requirements and Specification for the project.

6.3.4 All inspection, maintenance and other related work should only be carried out by personnel with appropriate training and qualifications for the particular type of work to be carried out, including all relevant matters relating to Health & Safety. Appropriate levels of technical supervision should be provided to ensure that the quality of the work is to the required standard.

6.3.5 Records of inspection, maintenance and other works are required to be kept and stored in a manner to be agreed with the Welsh Government.

6.4 Environmental management

6.4.1 The Inspection and Maintenance Organisation should operate a project-specific Environmental Management System (EMS) in compliance with BS EN ISO 14001.

6.5 Other requirements

6.5.1 Safe access around the bridge would require all staff to be contactable. If mobile phone communications are not available in all parts of the structure then staff should carry personal radio transceivers. Sufficient repeater stations may need to be provided within the interior of structural elements to ensure full radio coverage. The repeater stations could include a personal locator system to identify the approximate location of the personal radio transceivers, if required. The repeater stations would be considered part of the vital electrical load and would be connected to an uninterruptible power supply (UPS) system.

6.5.2 The design should seek to avoid that the main access thoroughfares are classified as confined spaces. However, where an area is classified as a confined space then portable breathing sets and hand torches are envisaged for confined spaces where necessary. Automatic gas monitoring may be considered. It is also noted that contractors may also treat an area as a confined space even where it is not classified as such.

6.5.3 Orientation maps should be provided to enable maintenance personnel to identify their location within the structure. The maps should be mounted at key locations with unique identifiers. The maps should identify any confined spaces.

6.5.4 Internal lighting and small power (110V AC) should be provided throughout the tower and any other internal spaces, such plant rooms within the abutment. Some internal spaces may be unlit provided that they are infrequently visited and do not provide through access or emergency escape.

Where it is otherwise difficult to gain access externally, functional and architectural lighting should be designed to facilitate changing of the luminary from a position of safety (e.g. aircraft warning lights on the towers and navigation lights on deck soffit which should be detailed to be withdrawn into the structure, luminary changed within the safe internal working environment and then replaced in position).

6.5.5 Where lockable doors or hatches are specified it should be possible to lock the door from either inside or outside. The locking mechanism should only prevent unauthorised access from the outside and all doors / hatches should be easily opened from the inside without any key or other security device to facilitate emergency escape.

Where the weight of a hatch would make it difficult to operate, the hatch should be provided with a counterweight or hydraulic device to make it easier to open. The counterweight is preferred as it is more reliable. A device should be provided for the hatch to prevent it blowing shut when open. Where a ladder accesses a hatch, a fixed railing above the hatch, or retractable stringers should be installed at the top of ladders to assist with climbing through the hatch from the ladder.

6.5.6 Where a ladder accesses a walkway or platform, a spring loaded gate should be provided to prevent accidental falls into the ladder.

6.6 Roped access

6.6.1 It is recognised the intention to avoid roped access as this is not a preferred method for the Client. Nevertheless, CIRIA C686 states that rope access and abseiling is statistically one of the safest modes of access. Rope access is also considered to be cost effective to carry out light duty inspection and maintenance works in view of capital and future maintenance cost.

6.6.2 Personnel who do not have roped access training can still gain access by being accompanied and attached to a trained person. Thereby specialist inspectors or engineers can still gain access to elements requiring roped access without being trained.

6.6.3 The configuration of the bridge would require some rope access where MEWPS, walkways and underbridge inspection vehicles have difficulty with access. An abseil access assessment would identify specifically where abseiling is required and the anchor points required.

6.6.4 Where cantilever platforms are provided to facilitate abseiling, the assessment should also address the detailing of the platforms and handrails with respect to the requirements for abseiling. The abseil access assessment should also address safety inspections of the access points. It is anticipated that the safety critical top anchors would require regular inspection and some redundancy may be required. However the top anchors by necessity are easily accessible. It is possible that intermediate anchors which are not safety critical may be inspected on an as-used basis.

6.7 Drone inspections

6.7.1 Recent technological advancements have seen the use of drones for carrying out visual inspections. These could be used for inspection of the tower to minimise the need for personnel to use the gondola, unless maintenance is required. They have also been considered for the stay cables. The drone is fitted with a high resolution camera so that visible inspection defects can be identified.

Figure 2: Example of a drone with camera mounted equipment to enable visual inspections without working from height

The use of drones would be used to replace Principal Inspections, as the quality of the image would be sufficient to carry out a visual inspection. Where a defect was found further principal or special inspections would be required utilising a manned inspection carried out within touching distance. However, as visible defects to the external faces of the tower and stay cable pipes are not anticipated, it is likely that in most instances the use of a drone to undertake a Principal Inspection would be sufficient, and would therefore represent a significant cost saving. The use of drones for General Inspections is not necessary, as inspection from ground or deck level with the aid of binoculars is sufficient.

At this stage we have not assumed the use of drones in inspections due to the risk of clashes with the stay cables, traffic safety below and the effect of wind causing an accident. However we will monitor the situation to see if drone inspections will come to the fore as the technology develops.

7 Particular constraints specific to the River Usk Crossing and approach spans

7.1 Existing utilities

7.1.1 There are a number of existing utilities at the site which must be considered when planning inspection and maintenance activities. Known utilities include: -

East approach

a) Buried 100mm diameter oxygen pipeline;

b) Buried 150mm diameter HDPE Nitrogen and 75mm diameter CSTL hydrogen pipeline;

c) 1830mm diameter concrete sewer pipe;

d) Water mains of various diameters;

e) Copper coaxial communications cables;

f) 132kV overhead power lines. These will be diverted prior to the works commencing;

g) Buried high voltage 11kV cables.

West approach

a) Water mains of various diameters;

b) Copper coaxial communications cables;

c) Storm and foul water systems;

d) High and low voltage electricity supplies;

e) Petrol interceptors;

f) Drainage outfalls.

7.1.2 Further privately owned utilities are also present such as those held by the Welsh Government and Associated British Ports (ABP).

7.1.3 An as-built utility plan will be developed throughout the project.

7.2 Newport Dock operations

7.2.1 The Newport docks are an operating dock, and therefore any inspection and maintenance activities must consider dock activities that could be taking place. During the planning phase, work plans should be agreed with the port owner and other land owners who operate the docks.

7.2.2 As operations and maintenance work would be occurring regularly, a dedicated maintenance access track should be set up which runs underneath the centreline of the deck. A protocol should be agreed with the land owners so that dock activities operate around the access track, with dedicated crossing points. This would allow bridge personnel to move within an agreed safe zone, rather than moving around dock operations, which they would not be familiar with.

7.2.3 A restrictive covenant must also be agreed with adjacent land owners to restrict how the land under the deck can be used. This would include: -

a) Agreement that no further permanent works will be built under the deck so that access to the soffit can be gained at short notice.

b) The type of materials that can be stored, such as restrictions on explosive, flammable and toxic substances.

c) The surcharge loading exerted by the materials, which will affect the performance of foundations and substructures.

7.3 Rail operations

7.3.1 The Uskmouth Railway is a single track line that runs between piers E9 to E11, with a further train loading facility also adjacent to pier E11. It is assumed that this line will be increased to a twin track in the future, and therefore this arrangement has been assumed in the design development. The freight line serves Mir Steel and Uskmouth 'B' Coal-fired power station and is operated by Network Rail. As the track is still operational any work plans must be agreed with the track operator.

7.3.2 The West Port Rail Line is a twin track line which runs between piers W6 to W7. This is privately owned and operated by Newport Docks. As the track is still in operation any works plans must be agreed with the track operator.

7.3.3 The East Port Rail Line is a twin track line which runs past the west tower on the north eastern side. This is privately owned and operated by Newport Docks. As the track is still in operation any works plans must be agreed with the track operator.

7.3.4 As the rail lines are privately owned the standards and constraints on working adjacent to these tracks will need to be established and adhered to. Any inspection and maintenance operations taking place in the vicinity of rail lines may also need to follow Network Rail standards for working on or adjacent to live tracks.

7.4 Assumptions

In developing the maintenance and access provisions for the design the following assumptions have been made: -

a) The scheme would be able to acquire the land necessary from land owners, and hence in the first instance allowance has not been made for accommodating existing port facilities and buildings.

b) Permanent access is not permissible over the salt marshes which lie between the east tower and pier E1 on the east bank of the River Usk.

c) No permanent access is possible for medium to heavy plant over the PCB cell between piers E11 to E13.

d) Existing level crossings and bridges over railway tracks within the Newport Docks area can be used by bridge inspection and maintenance teams.

Although these assumptions have been made in order to develop the access provisions, alternative arrangements will also be outlined within the report if these assumptions are found to be incorrect later in the scheme.

8 Access provisions

8.1 Main bridge entry points and access summary

The main access to the Bridge site should be via a dedicated 2-lane maintenance track starting at the west abutment which is independent of the main carriageways. The track would be accessed from West Way Road adjacent to the west abutment and should run underneath the deck to minimise land take, continuing to the dock cut beyond Pier W4. At the West Dock Rail Line between piers W6 and W7 the maintenance track would need to terminate either side of the rail line, with the level crossing north and south of the bridge used instead. It is noted that West Way Road is within the ABP Port Facility, and access to it is gained via the ABP security gate on the Southern Distribution Road, which is a public highway.

Drawings of this access track and other access arrangements are provided in Appendix A2, and are correct at the time of report issue. The latest versions of these drawings are stored on Projectwise.

The remaining piers and tower on the west approach viaduct beyond the dock cut would be reached via a separate maintenance track which would be accessed via the existing East Way Road. As for West Way Road, this is located within the ABP Port Facility, and access to it is gained via the ABP security gate on the Southern Distribution Road, which is a public highway. To minimise land take and the need to demolish existing buildings it is intended to use the existing access track between the west tower to Pier W3, rather than providing a dedicated track. The maximum distance from this track to the deck soffit is 25m, which is within the outreach limits of available MEWPs. It is noted that some of the buildings between W1 to W2 are of historical significance, notably the general office, central office and customs house.

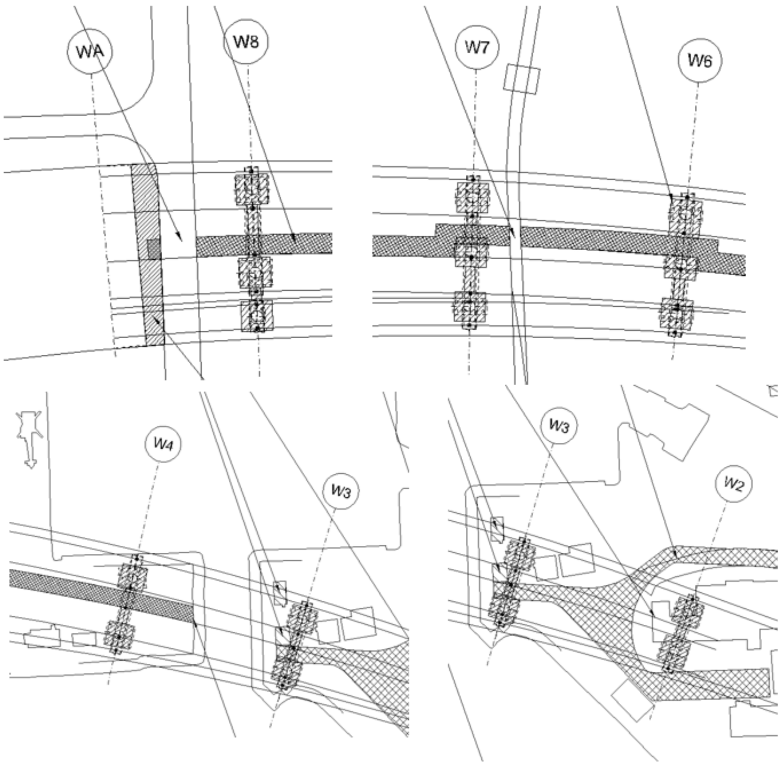


Figure 3: Clockwise from top left – a) Access track at west abutment, b) West Port Rail Line level crossings north and south of the bridge between W6 and W7, c) Dock cut between pier W3 and W4, d) Existing access track between the west tower and pier W2 that could be used for access

8.1.1 A 2-lane maintenance track is also to be provided under the centreline of the deck on the east approach viaduct. An area of salt marsh with a public footway running at its edge extends from the east bank of the River Usk to midway between the East Tower and Pier E1. The access track will terminate at the boundary of the salt marsh to avoid siting permanent works on this land. Subsequently access to the inside of the east tower will be obtained from deck level rather than ground level.

The Uskmouth Rail Line also passes under the deck between Piers E9 to E11. The access track would terminate either side of the rail line with the existing bridge to the north west of Pier E9 used to access both parts of the track. Finally, the deck is located directly above the PCB cell between piers E11 to E13. The access track is to terminate either side of the storage cell with a hardstanding provided to the north of the PCB cell. Access over the PCB cell is permissible on foot for inspection and maintenance of the crosshead at E12. Loading of the PCB cell by plant is not permitted, and access to the deck soffit will instead be gained through the use of lightweight scaffold systems or an underbridge inspection vehicle on the deck. Any access on the PCB cell must be agreed and authorised by Solutia, who own the storage facility. It is noted that the Wales Coast Path also passes through the area between E9 to EA, and hence possible closures of the Path to enable works would require approval.

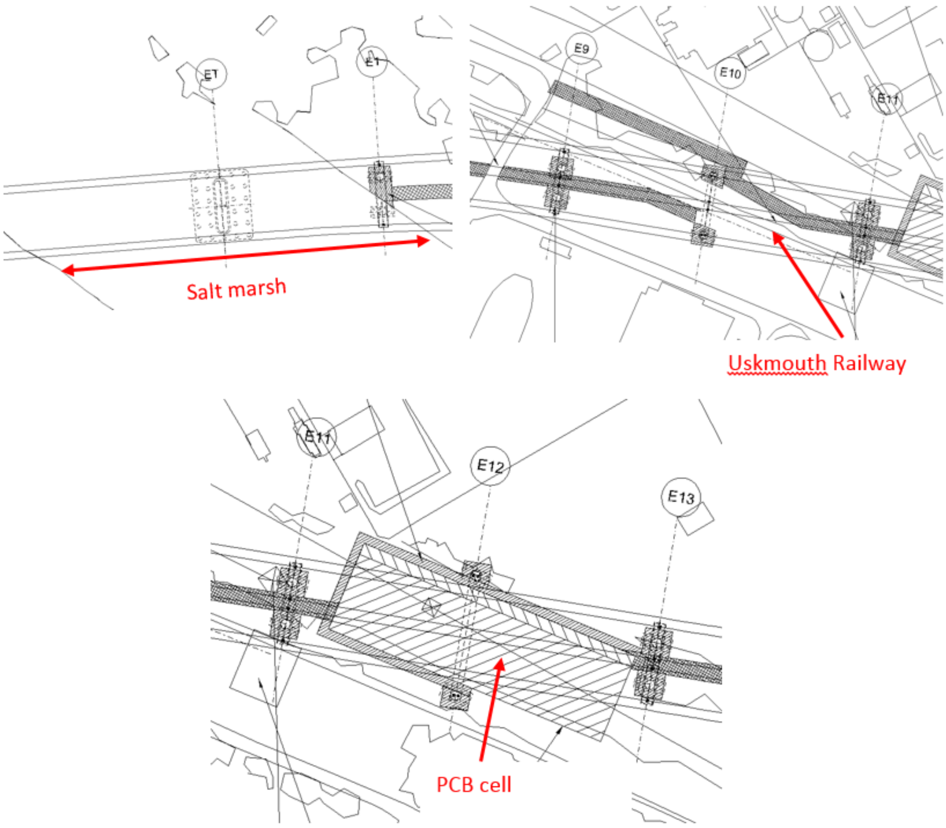


Figure 4: Clockwise from top left – a) Salt marsh and public footway between East tower and Pier E1, b) Uskmouth railway between piers E9 and E11 with bridge over the railway to the north west of Pier E9, c) PCB cell directly beneath the deck between piers E11 to E12

8.1.2 A protocol should be agreed with adjacent land owners so that dock activities operate around the access track, with dedicated crossing points. This would allow bridge personnel to move within an agreed safe zone, rather than moving around dock operations, which they would not be familiar with. A restrictive covenant under the deck on future permanent works, permissible stored materials and surcharge loadings arising from this should also be agreed as discussed in Section 7.2.

8.1.3 The option to have a dedicated access track is a compromise between the ideal access provision and the 'do minimum'. It could instead be agreed with land owners that maintenance personnel are able to access under the plan area of the deck at all times. Although this would simplify maintenance and inspection works, this was not deemed necessary due to the limited time and frequency over which access would be required. The 'do minimum' option would be to eliminate any permanent access track and instead have an agreement with landowners that this zone can be accessed with limited notice. Although this access would be sufficient this option was also discounted due to the inefficiency with repeatedly agreeing a work plan with various parties for any maintenance or inspection activity, regardless of its scale. However, the access track option selected will depend upon the strategy that the Welsh Government wish to take regarding land take from ABP and other existing land owners.

8.1.4 Access into the west tower is provided via an access door into the tower leg at ground level. The remaining height of the tower can be accessed from this location via stairways in each of the tower legs. A second access is also to be provided at deck level linking between each carriageway and the adjacent tower leg. At the east tower this will provide the only form of access, as the base of this tower is located below the flood water level preventing access from ground level.

8.1.5 The piers are to be accessed using a MEWP and scaffold towers from ground level. Piers E1 and W1 are voided and would also require ladder access within the void.

8.1.6 Access to the abutments is to be provided at ground level, with stairs leading up to the bearing inspection gallery. There would be no access provision linking the abutment to the deck.

8.1.7 Access to the deck soffit would instead be provided through a combination of an underbridge inspection vehicles, permanent deck soffit walkway, roped access, MEWPs and scaffold towers depending on constraints.

8.1.8 For inspection of the cable stays a remotely operated vehicle attached to the cable is proposed.

8.1.9 A general arrangement drawing of the access provisions to be provided for the River Usk Crossing and approach spans is given in Appendix A2.

8.2 Abutment and expansion joint access

8.2.1 East abutment

8.2.1.1 Vehicular access to the east abutment is via the maintenance access track from the Solutia site to a hardstanding in front of the abutment. Entrance into the abutment structure would be at ground level via an access shutter in the front face of the abutment. The shutter can be raised to allow equipment to be brought into the abutment. There would be a door in the shutter for personnel access, beyond which the plant rooms are located and stairs up to bearing inspection corridor behind the bearing plinths.

The corridor is also to be used for inspection and maintenance of the movement joint, therefore minimising the need to close the carriageway above for these works. The structural gap is to be a minimum of 800mm at all times of the year to ensure it can be accessed throughout the year. The cross section below shows a proposed section through the abutment.

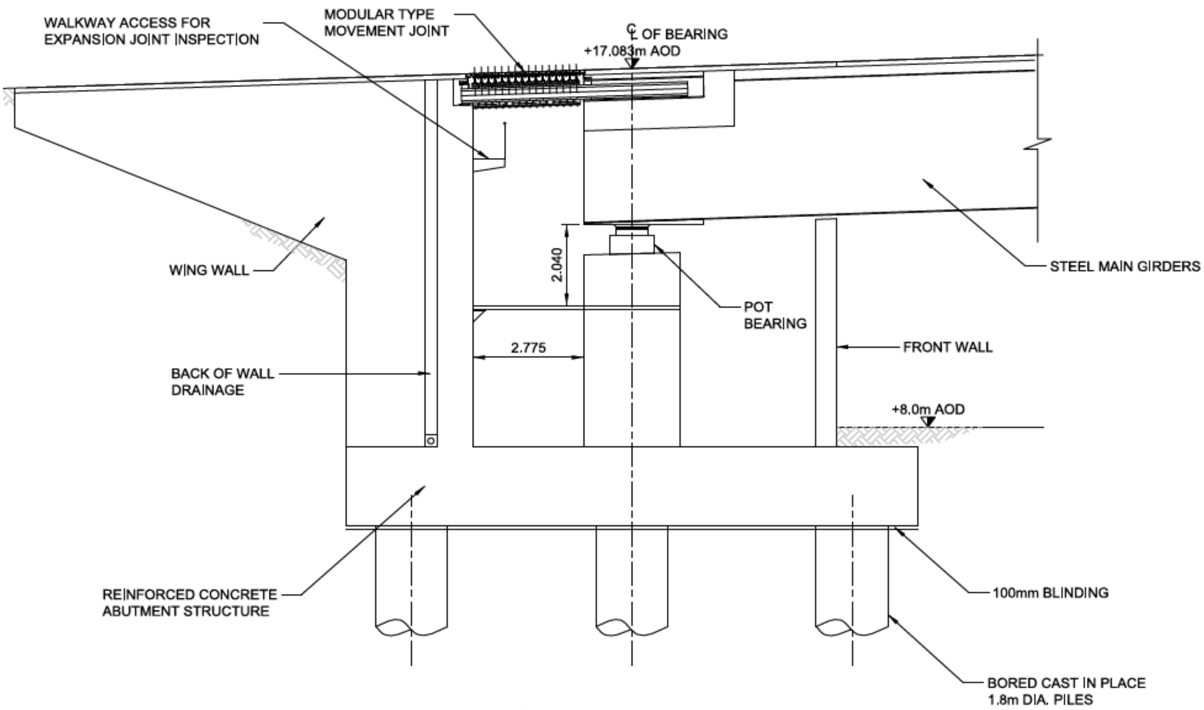


Figure 5: Cross section through proposed east abutment with an inspection walkway behind the bearing plinths

8.2.1.2 Anchors should be provided from the soffit of the slab to allow the lifting of material up to bearing level. The provision of permanent lifting equipment at the abutment is not considered to be appropriate due to their need for regular maintenance, whilst the equipment is likely to be used only during major bearing replacement every 50 years.

8.2.1.3 No access is to be provided to the deck structure from the abutment.

8.2.2 West abutment

8.2.2.1 Vehicular access to the west abutment is directly from West Way Road to a hardstanding in front of the abutment. The west abutment structural form consists of a reinforced earth wall in front of the abutment. The abutment columns will be sleeved with reinforcing straps passing around the columns, thereby ensuring the abutment is not laterally loaded with the retained fill.

8.2.2.2 Entrance into the abutment structure would be at ground level via an access shutter in the front face of the abutment. The shutter can be raised to allow equipment to be brought into the abutment. There would be a door in the shutter for personnel access, beyond which stairs are located giving access up to the plant rooms and bearing inspection corridor behind the bearing plinths. The stairs would be located in a recess into the reinforced earth wall

The structural gap between the back of the deck and the abutment structure is also to be used for inspection and maintenance of the movement joint, therefore minimising the need to close the carriageway above for these works. The gap is to be a minimum of 800mm at all times of the year to ensure it can be accessed throughout the year.

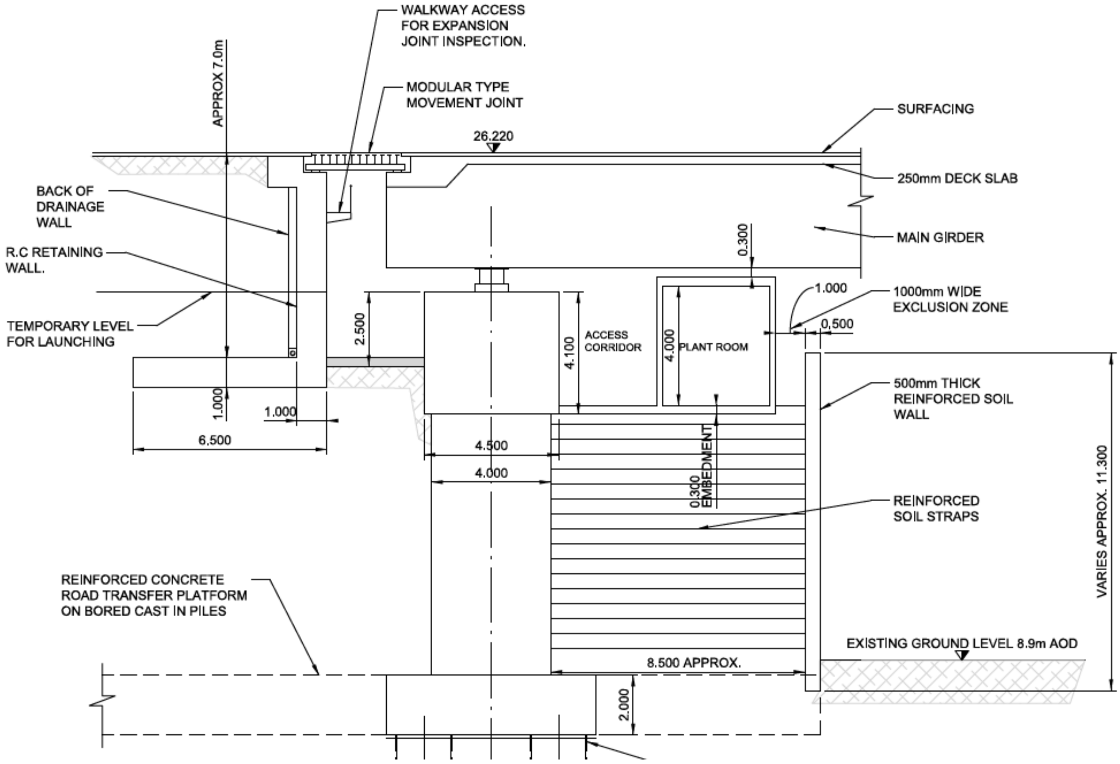


Figure 6: Cross section through proposed west abutment

8.2.2.3 Anchors should be provided from the soffit of the slab to allow the lifting of material up to bearing level. The provision of permanent lifting equipment at the abutment is not considered to be appropriate due to their need for regular maintenance, whilst the equipment is likely to be used only during major bearing replacement every 50 years.

8.2.2.4 No access is to be provided to the deck structure from the abutment.

8.3 Access to Piers

8.3.1 Pier exterior and pier top

8.3.1.1 As all the piers are located over ground, access to the top of the piers at W1-W8 and E1-E13 is generally to be obtained through the use of MEWP, scaffold or similar access equipment. Vehicular access to each pier is provided using the dedicated maintenance track.

8.3.1.2 All piers consist of a portal frame structure with two or three support columns and bearings located directly below the main girders. The only exception to this is at Pier E10 over the Uskmouth Railway and E12 over the PCB cell. At this location a steel box girder will be provided spanning transversely to the bridge centreline to enable foundations to be located away from the rail line and PCB cell respectively.

8.3.1.3 In general piers and crossheads will be accessed from ground level using scaffold or MEWP access. A rail will be provided along the top of the crosshead to allow personnel to clip onto the rail and walk along the top of the crosshead for inspection of bearings.

8.3.1.4 Details of particular access constraints at the piers are tabulated below: -

Pier	No. of bearings	Particular access constraints	Internal access required
W1	2	The buildings under the deck soffit between the west tower and W2 should only be demolished as a last resort to enable bridge construction to take place. For inspection MEWPs could be used to cantilever over the buildings. Alternatively an underbridge inspection vehicle could be used here between the cable stays.	✓
W2	4	The buildings under the deck soffit between the west tower and W2 should only be demolished as a last resort to enable bridge construction to take place. For inspection MEWPs could be used to cantilever over the buildings. Alternatively an underbridge inspection vehicle could be used here between the cable stays.	×
W3	4	Pier is located adjacent to the dock wall and therefore use of a MEWP adjacent to the dock edge would be restricted. The access track would need to stop either side of the dock wall. To move between W4 and W3 personnel would need to use the existing East/West Way Road approximately 750m to the north which passes around the dock. Buildings adjacent to the pier should only be demolished as a last resort to enable bridge construction and subsequent access.	×
W4	4	Pier is located adjacent to the dock wall and therefore use of a MEWP adjacent to the dock edge would be restricted. The access track would need to stop either side of the dock wall. To move between W4 and W3 personnel would need to use the existing East/West Way Road approximately 750m to the north which passes around the dock.	×
W5	4	Pier is located adjacent to West Way Road, and therefore traffic management would be required to enable operation of the MEWP.	×
W6	8	The maintenance access track would need to terminate either side of the West Port Rail Line, with existing level crossings to the north and south of the bridge used instead.	×

W7	8	Pier is located approximately 15m west of the West Port Rail line and therefore a work plan would need to be agreed with the rail operator so that the works can progress, and if necessary a track possession order. The maintenance access track would need to terminate either side of the West Port Rail Line, with existing level crossings to the north and south of the bridge used instead.	×
W8	8	Pier is located adjacent to West Way Road, and therefore traffic management would be required to enable operation of the MEWP.	×
E1	2	Due to the presence of the salt marsh a MEWP will be required to outreach over the marsh in order to reach the southern end of the pier crosshead and pier column. Alternatively roped access can be used from crosshead level to gain access to the south column.	✓
E2	4	None	×
E3	4	None	×
E4	4	Presence of local access road may require traffic management to enable access.	×
E5	4	Buildings adjacent to the pier may restrict positioning of the MEWP. However, these structures should be retained and only demolished as a last resort to enable bridge construction and subsequent maintenance access. Presence of local access road may require traffic management to enable access.	×
E6	4	None	×
E7	4	Buildings adjacent to the pier may restrict positioning of the MEWP. However, these structures should be retained and only demolished as a last resort to enable bridge construction and subsequent maintenance access.	×
E8	4	None	×

E9	4	The pier passes adjacent to the Uskmouth railway and therefore a work plan would need to be agreed with the rail operator so that the works can progress, together with a track possession order if necessary.	×
E10	4	The pier passes over the Uskmouth railway and therefore a work plan would need to be agreed with the rail operator so that the works can progress, together with a track possession order if necessary.	×
E11	4	The pier passes adjacent to the Uskmouth railway and therefore a work plan would need to be agreed with the rail operator so that the works can progress, together with a track possession order if necessary. Works must be agreed with the Solutia plant to the north of the pier. The freight handling facility to the south of pier E11 would need to be demolished prior to construction.	×
E12	4	The pier passes over the PCB cell. Foot access and the use of lightweight scaffold systems is permitted over the PCB cell. However, the cell must not be loaded with plant and machinery, and therefore further access would need to be obtained using a MEWP with sufficient outreach to cantilever over the PCB cell. Alternatively access can be gained from an underbridge inspection vehicle located on the deck. Works must be agreed with the Solutia plant to the north of the pier, where hazardous substances are stored.	×
E13	4	None	×

Table 3: Particular constraints at piers

8.3.1.5 The alternative option to construct a concrete parapet wall or ‘bathtub’ along the perimeter of the crosshead to form a bearing inspection pit has been discounted for the following reasons: -

a) The pit would still need to be accessed at height through the use of a ladder or MEWP. If MEWP access is required the advantages of the inspection pit would be negligible. Use of a ladder is not favoured due to safety risks posed to the public, particularly as the site is located within the Newport Docks. A non-access gate would therefore be required and there would also be a need to maintain and inspect the ladder.

b) The pit would not allow inspection of the external faces of the pier and crosshead unless roped access was used. Therefore MEWP or similar access would still be required for inspection of the external faces of the pier.

c) Presence of the inspection pit would also increase the complexity of bearing replacement due to the difficulty in movement of plant and materials.

d) The whole life cost of accessing the crosshead using an inspection pit is greater than having a flat top with access using a MEWP, due to the higher capital costs, as reported in Section 9.

e) An alternative access would be to provide entry into the pit from the deck above via a walkway. However, no permanent soffit inspection walkways are proposed along the approach viaducts.

8.3.2 Additional requirements for W1 and E1

8.3.2.1 These hollow pier columns have a set of tie down cables, the anchorages and sheath for which would require inspection. The top of the tie down cable is to be inspected using a MEWP or scaffold tower from ground level. The bottom of the tie down cable is anchored in a void in the pier column above the pilecap. A 750mm x 750mm access hatch with a lockable watertight door is to be provided into the void from pilecap level to enable the inspection of these anchors and the pier column above.

8.3.2.2 Internal vertical access is provided through the height of the pier column by a series of ladders. Platforms are to be provided at approximately 6m intervals to facilitate access within touching distance of the internal faces. The platforms are to extend across the whole internal plan area of the pier column. Permanent ladders are to be provided to enable personnel to reach intermediate heights between the platforms.

8.3.2.3 Ventilation holes with mesh covers are to be provided to vent the air within the pier. These covers need to ensure that wildlife such as bats cannot enter through these holes.

8.3.2.4 Access to the external walls and top of the pier is as discussed in Section 8.3.1.

8.4 Tower access

8.4.1 General

8.4.1.1 Within the towers, the main items to be inspected and maintained are the stay cable anchor boxes and anchorages. There is also equipment at the top of the tower which would require maintenance (anemometer, aircraft warning lights, CCTV etc.). Below deck there is little to inspect and maintain. The main entry point to the towers is at ground level.

8.4.1.2 The external faces of the tower are reinforced concrete and are unlikely to require much maintenance. Nevertheless, the Principal Inspection requirements of gaining access within touching distance are considered and in particular the points where the stay cables exit the tower may require regular inspection.

8.4.1.3 Lighting is to be provided in the tower interior and sufficient lux provided at the stairways and platforms. Emergency lighting connected to the UPS should also be provided to facilitate escape from inside the tower in case of power failure.

8.4.2 Access into the towers

8.4.2.1 The principal access route to the west tower is from an access door at the base of the tower leg at ground level. This arrangement allows the towers to be accessed without stopping on the live carriageway, although access would need to be obtained through the ABP Security Gate as described in Section 8.1. Access to this door should be obtained via an access track directly from the adjacent plant depot. Buildings adjacent to the west tower should be retained and only be demolished as a last resort to enable bridge construction and subsequent maintenance access.

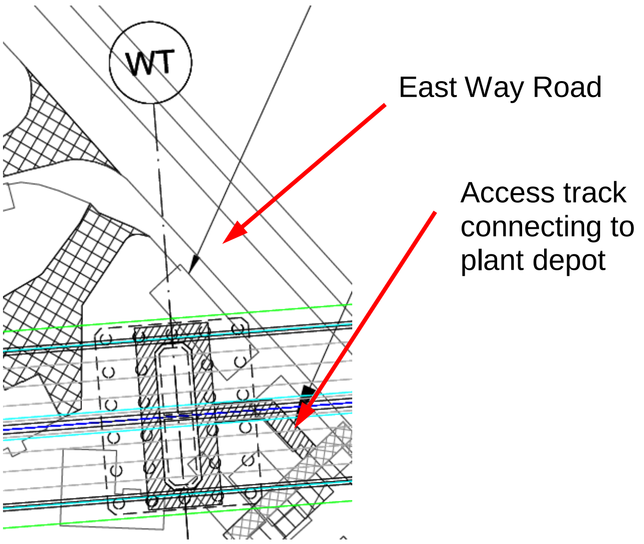


Figure 7: Proximity of west tower to East Port Rail Line

Secondary access should be provided at deck level via a door in the wind shield and a gangway spanning over to an access door in the tower wall. At the east tower this will form the only means of access into the tower as ground level is within the flood channel and therefore a door can not be provided here.

8.4.3 External openings and doors

8.4.3.1 All doors into the tower are to be lockable watertight doors. The seals should be tested using hose tests or ultrasonic testing to check their integrity. If watertightness is lost then the ingress of water would lead to higher levels of moisture inside the tower, and hence an increased rate of corrosion in the long term if the defect was not repaired. Openings in the towers are provided at the following locations:

a) Access into the tower bases from ground level at the West Tower: The tower leg would have a 1.0m x 2.0m door in the side face providing the principal access into the tower. There must be sufficient security at the door to prevent unauthorised access by persons who have passed through the ABP Security Gate.

b) Access to top of tower cross beams and deck walkway: A pair of 1.0x2.0m doors are provided in the side faces of the tower at a level coinciding with the top of the tower cross beam. From here access can then be gained into the deck soffit permanent walkway. This would also assist with the movement of equipment during bearing replacement.

c) Deck level: Pair of 1.0 m x 2.0m doors leading to a gangway spanning to the deck as described previously.

d) Tower top: At each tower there is a 750 mm x 750 mm opening with watertight hatch in the roof slab for the access to the top of roof slab.

8.4.3.2 In addition, ventilation holes are provided as follows:

a) At the tower top, a motorized louvre is proposed. These louvres should be watertight in the closed position. These louvres should be operable from a switch located by the deck level access doors. Prior to entry into the tower a check should be made for noxious gases and if present the louvres may be opened to naturally ventilate the tower by chimney action. However, the operation & maintenance manual should make clear that the louvres should not generally be opened as a simply precautionary measure to avoid unnecessary ingress of rainwater.

b) One additional opening in each leg should be provided at an elevation of approximate +10.0 mOD, close to the bottom of the tower. An open mesh is provided to the opening to prevent birds nesting within or entering through the hole but to allow the free passage of air.

Any holes will need to be provided with covers to ensure that wildlife such as bats cannot enter through these holes.

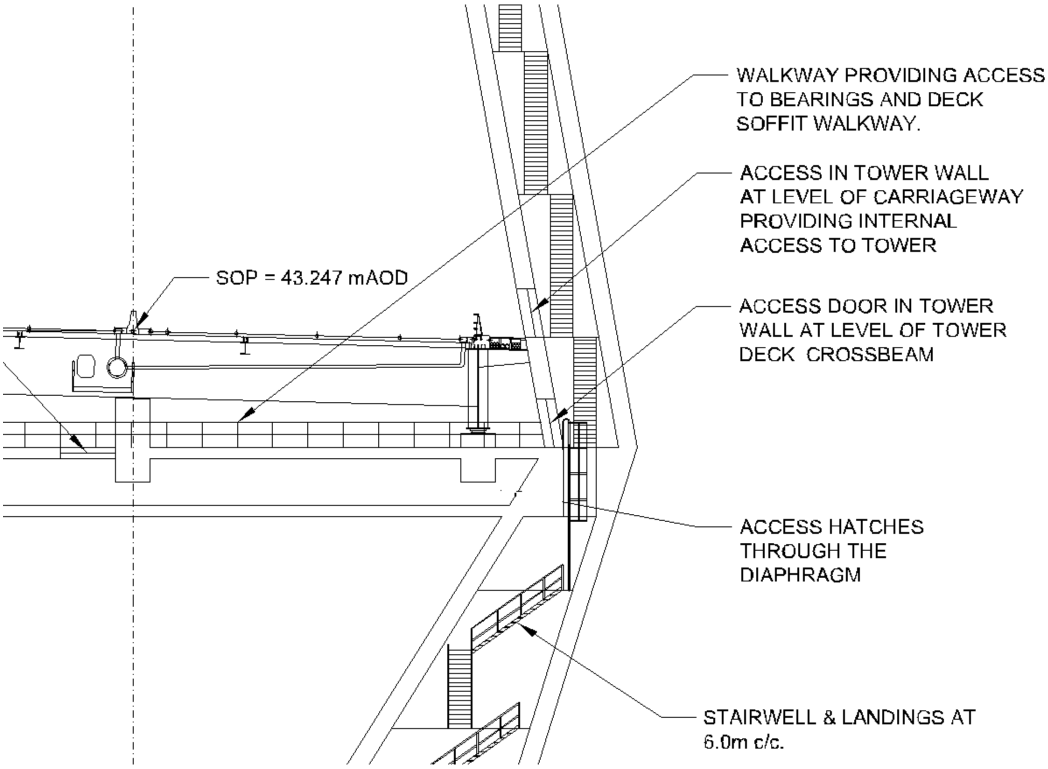
8.4.4 Internal tower access above deck level

8.4.4.1 A centrally located series of ladders are to provide access inside the tower above deck level and provide:-

a) an evacuation route leading to tower access points at deck level and top of pilecap level.

b) close range visual inspection of all concrete faces. Platforms would be provided in the width of the tower at 6m intervals, with portable ladders used to enable the intermediate wall faces to be reached within touching distance.

8.4.4.2 Where space permits, stairs instead of ladders would be provided with a clear width of 1000 mm. This is greater than the 600 mm required by BS 5395-3 for occasional one-way traffic. The additional width has been provided to facilitate



carrying a casualty. The pitch of the stairs is generally 42° (occasional access). As the tower narrows ladders would be reduced to 600mm width due to space constraints. This would occur at approximately 125m above ground level.

Figure 8: Proposed internal tower access

8.4.5 Rack and pinion lift

8.4.5.1 A rack and pinion tower lift is not to be provided at this stage, as this provision is not included within the Works Information.

8.4.5.2 Nevertheless, the client has the option of providing a single rack and pinion lift within each tower that would provide access to the interior tower from deck level to the lower stay anchorage. Although this has a higher cost than only providing step access it would avoid the need for personnel to climb ladders and stairs to a height of approximately 100m to reach the tower anchorages. It would also enable the transportation of materials and equipment for inspection and maintenance to the top of the tower. Experience from similar schemes shows that these lifts are used regularly by maintenance teams, and are reliable systems. Lift stops would be provided at 6m centres to coincide with the stairwell landings.

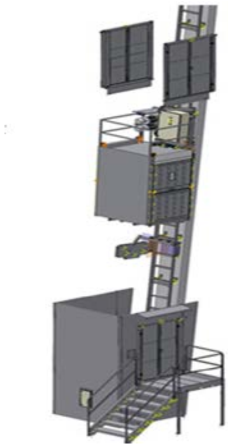


Figure 9: Rack and pinion lift installed on an incline

8.4.5.3 A specification for the lift is given below: -

a) Incline of 9.87 degrees to vertical, in one direction only;

b) Variable speed drive up to 1.0m/s;

c) Internal car dimensions adequate for 2 passengers;

d) Overload sensing system;

e) Landing enclosure every 6m centres;

f) Centrifugal brake operated from inside the car to allow the car to be lowered in case of a power failure;

g) Emergency telephone;

h) CCTV system.

8.4.5.4 The costs of two different lift options obtained from the supplier Alimak are tabulated below: -

Option description	Payload capacity	Lift shaft dimensions	Capital cost / lift
A) Lifting height to lowest stay cable anchorage	400kg	1.495m x 1.330m	£163,330 (no intermediate landings)
B) Lifting height to top of tower			£221,400 (intermediate landings in stay anchorage region only)

The increase in lift cost by extending it to the top of the tower is only 35%, and therefore if a lift was provided it would be most cost effective to choose Option B. Lift details for this option obtained from Alimak are provided in Appendix A5. This lift would also be sufficient to take the strand jack, which can be transported in separate parts with an approximate maximum load of 200kg.

8.4.5.7 As a minimum a winch system would need to be provided for the transportation of heavy equipment up the tower as discussed in Section 8.4.11, if a lift is not installed.

8.4.6 Internal tower access below deck level

8.4.6.1 A centrally located stairway is to be provided inside the towers below deck level as the primary vertical access for inspection. The stair width and pitch is as for the stairs in the tower above deck. Platforms would be provided the width of the tower at 6m intervals, with portable ladders used to enable the intermediate wall faces to be reached within touching distance. A rack and pinion lift in the tower below deck level would not be cost effective due to the limited height.

8.4.6.2 Access to inside the tower deck cross beam is to be provided through an access hatch through the top face of the tower deck cross beam. A walkway running the length and width of the cross beam would allow personnel to be within touching distance of the internal walls.

8.4.7 External tower faces

8.4.7.1 Although the plain concrete surfaces do not require much maintenance, the Principal Inspection requires a close examination, within touching distance, of all accessible parts of the structure.

8.4.7.2 Inspection of the external faces above deck would be facilitated by the use of a tower top gondola. For the main gondola, a pair of steel beams would be provided at the top of each tower. The beams can be extended through the openings on the concrete parapet at tower top and suspension ropes can be lowered to deck level and secured to a gondola which is delivered at deck level. The steel beams would rotate to enable the gondola to reach each external face. Anchors would be provided to limit the wind induced movement of the cradle. Wheels on the cradle would ensure the smooth movement and prevent damage to the concrete faces. The image below shows a similar system being used on the San Francisco-Oakland Bay Bridge. To minimise the use of the gondola and therefore working from height it is also possible to use a drone for principal inspection work as described in Section 6.7. If any defects are found the gondola could then be used for closer visual inspection and any necessary maintenance.

Figure 10: Use of inspection gondola on inclined tower faces of San Francisco-Oakland Bay Bridge

8.4.7.3 Abseiling from the top of the tower may also be required to reach some parts of the external tower face, although it should be avoided wherever access can be provided by alternative means such as the tower top gondola or MEWP access. As a contingency, sets of structural anchors would be arranged on the tower wall at 1m intervals around the entire perimeter of the tower. All anchors should be of the removable cast-in Type A1 in accordance with BS EN 795:1997, or be structural elements of 'unquestionable strength'. They must be inspected on a six-monthly basis or 'prior to use' if the six month period has lapsed. As part of the detailed design of the River Usk Crossing, we would undertake an abseil access assessment. The detailed strategy for abseiling access should be determined, and appropriate anchors included in the design. Procedures for undertaking rope access should be included in the Inspection and Maintenance Manual to be produced by the Contractor.

8.4.7.4 At the west tower, external tower faces nearer the ground can be reached by MEWP or scaffold tower to minimise the need for gondola or roped access. Commercially available truck mounted platforms are available with a lift height in the region of 70m. This is not possible at the east tower due to the presence of the salt marsh.

8.4.7.5 Access to the outside of the tower deck cross beam would be gained using the access hatch from the tower onto the top of the cross beam, as described previously. MEWP access from ground level can be used to inspect the remaining faces of the cross beam.

8.4.7.6 It is noted that for any inspection or maintenance above deck, lane closures may be required, unless a safe system of work is enforced that does not permit dropped objects.

8.4.7.7 For general inspections access from the ground using a MEWP and binoculars would enable a sufficient level of inspection to be carried out.

8.4.8 Top of tower

8.4.8.1 A ladder and watertight hatch provides access to the external tower top platform which has a 1.5 m high perimeter wall all round.

8.4.8.2 Draining water from a height above +145 m AOD is problematic. The solution of taking the water by drainpipe down the full height of the tower has been rejected, since this represents a significant maintenance burden and therefore the solution is to discharge the water externally to the tower faces. As the water is rainwater and approximately 100m above the carriageway, the water should not contain any contaminants which would stain the tower. Furthermore detailing of the drainage is to be developed to provide a sufficient number of small diameter drainpipes and falls in the roof slab to prevent ponding and the built up of debris or contaminants. Due to the height of the tower top and the fact that only rainwater is collected, the drains would require minimal maintenance in order to keep them unblocked. The outfalls can also have a sprinkler system so that water is carried in the wind and prevents staining of the tower.

8.4.8.3 Equipment located on the tower top (e.g. monitoring equipment, aircraft warning lighting etc) should also require regular access to repair electrical and system faults.

8.4.9 Tower anchor box

8.4.9.1 Access is provided into each anchor box through openings in the floor. A 1.0 m x 1.0 m floor opening is provided through the full height of the anchor box to allow a stay cable jack to be hoisted vertically using a beam or frame in the internal tower top chamber.

8.4.9.2 Load points are required in the floor of the tower top chamber. The through floor openings within the anchor box would generally be closed by secure covers which would only be removed for stay cable replacement or similar major maintenance.

8.4.10 Heavy equipment transportation route

8.4.10.1 Heavy equipment, such as the strand jack for stay cable force adjustment and cable replacement, would be hoisted up by a winch installed at the tower top chamber. The need for a hoist is deemed to be the minimum necessary requirement.

8.4.10.2 At the towers heavy equipment would be transported by vehicle at deck level and it would then be moved into the tower interior through the door at deck level. In order to guide the equipment a guide rope with tirfor or similar would be attached to the equipment to control the initial lifting. A strong point with lifting hook should be provided in the wall of the tower to pull against. The landing enclosure at both the deck +6m level and the tower top chamber as well as some flooring panels of the platform at the deck +6m level should be removable to avoid conflict with the transportation path of the heavy equipment. The equipment would be hoisted up to the tower top chamber where it can then be laterally moved and lowered down to the designated position inside the anchor box through the floor openings. If a lift shaft is provided the hoisting of heavy equipment could be done through the shaft.

8.4.10.3 The heavy equipment transportation route would need to carry strand cable jacks. The dimensions of a 127 strand jack are up to 0.94 m diameter x 0.71 m long. The jack can be transported in separate parts with an approximate maximum weight of 200kg. It is therefore recommended that the maximum hoist capacity is 500kg. Several hoists may be needed over the height of the tower due to the incline of the leg axis in order to limit the horizontal deviation of the hoist.

8.5 Access to stay cables

8.5.1 Use of remotely operated inspection vehicle

8.5.1.1 The Principal Inspection requirements allow for the use of close circuit television for areas of difficult or dangerous access. Whilst manned stay cable inspection gantries are available there is no doubt that the operation involves some difficulties and risks which must be carefully controlled. An unmanned inspection vehicle is recommended to eliminate exposure to these risks. These devices take images of the stay cable as well as perform minor repairs. Details of a possible stay cable vehicle are given in Appendix A5.

Further benefits of an unmanned vehicle are that it would be lightweight and could travel along the cable without the need to deploy a wire rope. Although traffic control measures would still be required during its use, the work can be undertaken at night and the unit can be deployed in under an hour to reduce disruption to traffic.

8.5.1.2 Despite the benefits of using an unmanned vehicle to locate and repair small defects in the stay cables, it would still be necessary, in rare circumstances, to use roped access or MEWP to look at damage to the stay pipe of concern.

Figure 11: Stay cable remote operated vehicle

8.5.2 Stay cable gantry

8.5.2.1 A manned stay cable gantry is a possible alternative means of inspecting the cables. However, the benefit of providing this gantry is limited as defects on the cable sheaths are not anticipated, unless they are the result of an incident. Furthermore the gantry is likely to require carriageway closures below due to the distraction the work would cause to drivers, although this could be mitigated by undertaking inspections at night. If a gantry were to be provided the system would consist of a cradle suspended from a hoist unit which runs along a tensioned guide rope installed above the cable. It would run along the full length of the cable and allow both sides to be inspected.

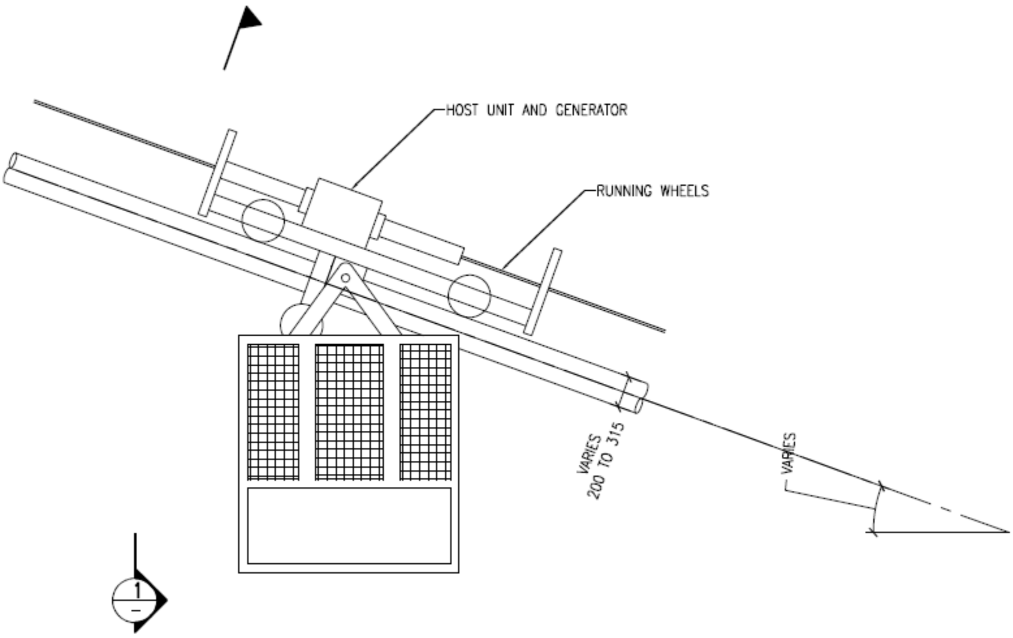


Figure 12: Alternative option of providing stay cable gantry

8.6 Deck soffit

8.6.1 General

8.6.1.1 The deck of the cable stayed bridge section is to be a ladder beam deck in the main span and back span with cross beams at 4.125m spacing and a 250mm deep slab. The main span crosses over the River Usk, whilst the west back span crosses over the Newport Docks and the east back span crosses over salt marshes.

8.6.1.2 For the cable stay bridge, discussions with suppliers has shown that underbridge inspection vehicles are available which can be used in conjunction with the inclined externally anchored cable stays. A suspended walkway below the centreline of the deck running between the towers would also be required to provide access to the centre of the deck and for ease of access during General Inspections.

8.6.1.3 Although it would be possible to use MEWPs for the west back span, this is complicated by the constraints of existing buildings below the deck. It is therefore recommended that the underbridge inspection vehicle is also used over these back spans with a walkway extending along the centreline of the deck.

8.6.1.4 Over the east back span permanent access provisions over the salt marsh should be avoided for environmental reasons. Therefore it is also recommended that the underbridge inspection vehicle is used over this back span with a walkway extending along the centreline of the deck.

8.6.1.5 Over the remaining approach spans access can also be gained through the use of MEWPS and scaffold towers under the bridge deck. An alternative option here is also the use of an underbridge inspection vehicle. The only exceptions to these arrangements are where there are particular constraints at certain spans which dictate the access method, as discussed in 8.6.2 below.

8.6.2 Particular constraints at approach spans

8.6.2.1 There are particular constraints at certain spans as discussed previously in Section 8.3. These dictate the method of access as summarised in the table below.

Span	Constraint	Deck soffit access required
W3 to W4	Dock Cut	Access by a MEWP is still possible although working plans would need to be agreed with ABP, as the plant would encroach into the clearance envelope. An underbridge inspection vehicle can also be used to minimise disruption.
W6 to W7	West Port Rail Line	Access by a MEWP is still possible although working plans would need to be agreed with the rail operator. Alternatively an underbridge inspection vehicle can be used to minimise disruption
E9 to E11	Uskmouth Railway	Access by a MEWP is still possible although working plans would need to be agreed with the rail operator. Alternatively an

		underbridge inspection vehicle can be used to minimise disruption
E11 to E13	PCB cell directly below deck	Use of an underbridge inspection vehicle is required. Alternatively light scaffold platforms can be used over the PCB cell.
E13 to EA	Close proximity to ground	MEWP or scaffold access would be required as there is insufficient clearance to the deck soffit to enable use of underbridge inspection vehicle

Table 4: Access constraints to deck soffit

8.6.3 Deck gantry for major repainting works

8.6.3.1 Major maintenance of the paint system involves shot blasting to prepare the steel surface and therefore requires an enclosed scaffold system below the deck. This will either be built up from ground level or suspended from the deck structure.

8.6.3.2 Provision of a heavy duty maintenance gantry was discounted for the same reasons as identified in Section 8.6.4.3.

8.6.4 Permanent walkway and underbridge inspection vehicle for cable stay bridge

8.6.4.1 A permanent walkway located under the centreline of the deck would be provided for inspection of the main span and back span soffits. Further advantages of the walkway is that it can be used to route services, inspect the suspended drainage pipe beneath the deck centreline and also provide first safe access to the deck soffit when installing a suspended scaffold system required for major maintenance works, such as repainting. Access via the walkway would be sufficient for General Inspections. For Principal Inspections an underbridge inspection vehicle would be required in order to reach the remainder of the deck soffit out to the external edges of the deck. This will also allow inspection of the lower cable stay anchorages and wind shield. Discussions with suppliers has shown that for the deck cross section detail and cable stay arrangement proposed it would be possible to use an inspection unit through the inclined cable stays. The product currently identified to be suitable is the Moog 1750T, details for which are provided in Appendix A5, which has a purchase price of approximately £450,000. A cross section through the vehicle is given below.

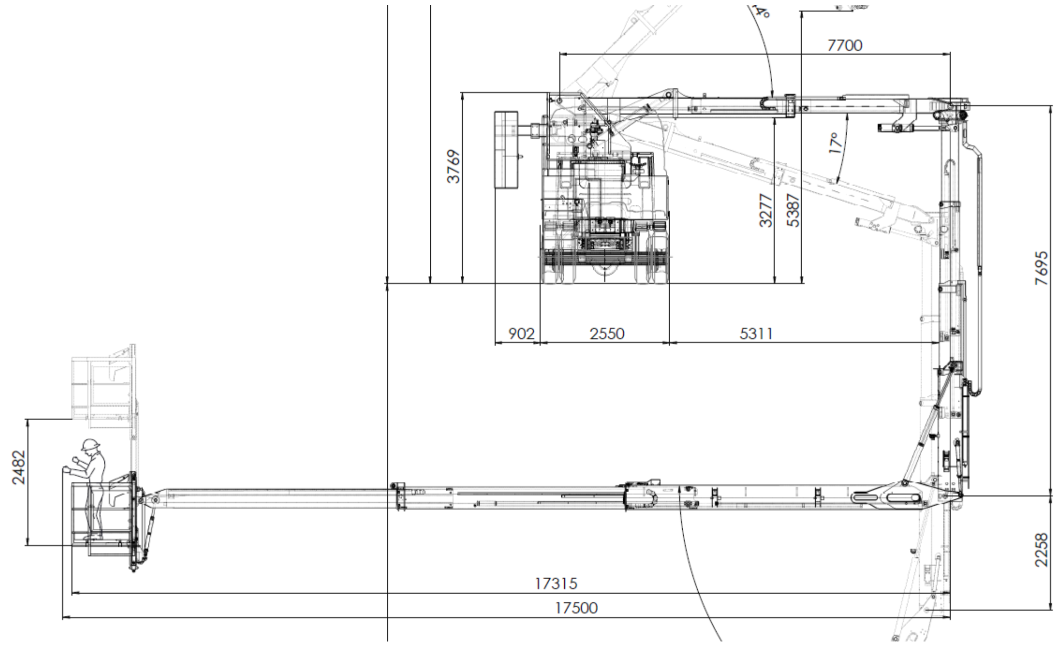


Figure 13: Cross section through underbridge inspection vehicle

8.6.4.2 The vehicle has a width of 3452mm including the counterbalance weight which is required when the inspection basket is fully extended under the deck. Assuming a working width of 600mm the vehicle could therefore be operated under a hard shoulder and lane 1 closure. Works could take place during the night to minimise disruption to traffic.

8.6.4.3 The use of a permanent deck inspection gantry under the main span was discounted due to the need to need to inspect and maintain this throughout its design life at a greater frequency than at which it would be used for a principal inspection occurring every 6 years. It would therefore not be cost effective to install this gantry, which would cost in the region of £1million. Furthermore it would need to be supported by steel beams which are attached to the deck soffit. An articulation system would need to be provided for the rails to prevent them from attracting longitudinal stresses under expansion and contraction of the deck, generating additional costs. Finally, the gantry could not be used for replacement of the whole paint system, as a heavy duty enclosed gantry would be required for these works.

8.6.5 MEWP/scaffold access versus underbridge inspection vehicle for approach spans

8.6.5.1 Over the approach spans a MEWP and scaffold access can instead be utilised, as these spans are above ground. Alternatively an underbridge inspection vehicle could also be used for the approach spans only. The vehicle would need to pass up and over the wind shield and have sufficient depth so that the inspection floor has a vertical clearance of 1.6m to the soffit of the main girder. Traffic management in the hard shoulder would also be required to provide sufficient working width to the vehicle. The figure below shows a section through a typical underbridge inspection vehicle. Note that the choice of access options does not exist at several spans where they are dictated by particular constraints as listed in Section 8.6.2.

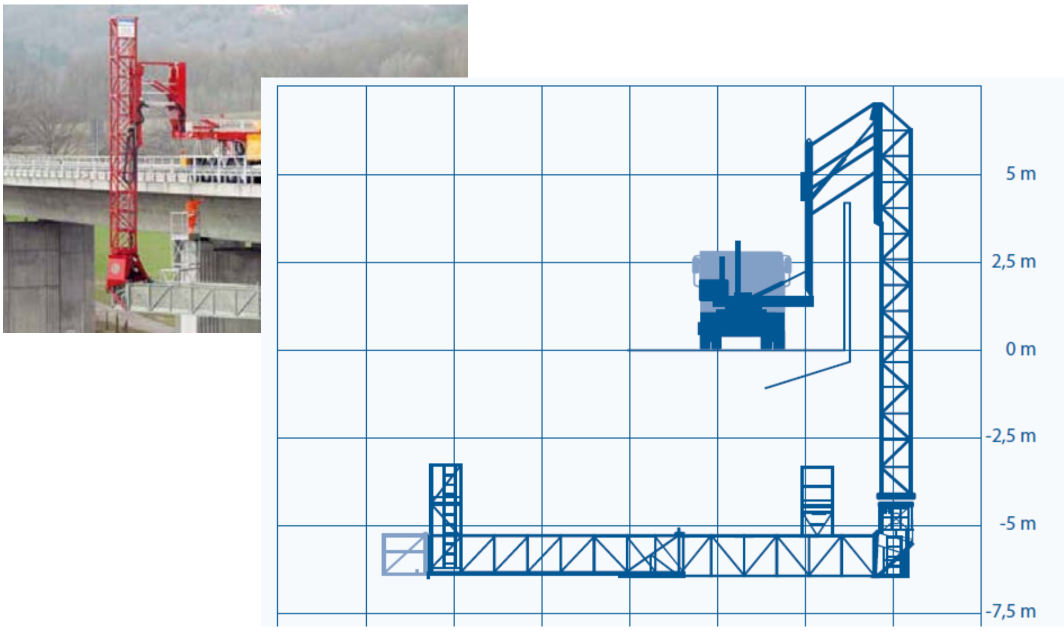


Figure 14: Example of underbridge inspection vehicle

8.6.5.2 A whole life costing of both options, as reported in Section 9, has found that over the life of the structure it would be more cost effective to carry out the inspection using a MEWP due to comparatively higher cost of hiring the underbridge inspection vehicle. This analysis excludes span lengths noted in 8.6.2, where particular constraints dictate the most appropriate form of access. Inspection and maintenance of the piers, bearings and deck soffit should be carried out simultaneously to minimise the cost of providing temporary access arrangements. If this is done then the use of MEWPs would be significantly cheaper, as it would allow inspection of all three elements.

The whole life costing analysis has only been applied to spans where there are no access constraints. Where constraints do exist as listed in 8.6.2 the most appropriate access is as listed in the table.

8.7 Deck top side

8.7.1 A maintenance walkway is proposed behind the VRS as a feature to allow maintenance staff to walk the length of the bridge from a relative position of safety.

8.7.2 The walkway will provide a safe means of access to electrical cabinets, gantry legs, lighting columns, cable troughs and other utilities located within the verge. Use of roped access and/or hatches could also enable the lower cable stay anchorages to be inspected.

8.8 Jacking positions during bearing replacement

8.8.1 The provision of a 4m wide crosshead for the pier portal frames provides sufficient width on which to locate jacks during future bearing replacement. These would be located up and down chainage from the permanent bearings directly underneath the main girders. The need for widening of the crosshead, provision of concrete corbels or temporary trestles on which to jack from are therefore not required.

8.9 Intelligent transport systems

8.9.1 In order to monitor traffic flows on the motorway, the following ITS systems as listed in the works information is required, together with the intended access: -

a) Advanced motorway indicators (AMIs) – These AMI signals would be located on gantries, with access gained from the maintenance walkway. The gantries can be reached with short stops (less than 15 minutes in accordance with IAN 115/08) on the hard shoulder to drop off and pick up maintenance personnel. Alternatively access can be gained to the maintenance walkway from ground level at the west tower, up through the tower leg stairwell and through the access door from the tower to the deck.

b) Variable Message MS4 - These MS4 signs would be located on accessible gantries, with access gained from the verge. The gantries can be reached with short stops on the hard shoulder to drop off and pick up maintenance personnel. Alternatively access can be gained to the verge from ground level at the west tower, up through the tower leg stairwell and through the access door from the tower to the deck.

c) Motorway Incident Detection and automatic signalling (MIDAS) Loops – The Midas loop detection equipment for monitoring traffic flows would be located in the carriageway surfacing. Access to these for maintenance would require closure of the carriageway in one direction.

d) HADECS3 Cameras – The enforcement cameras would be located either on accessible gantries or mast arms located in the verge. The gantries can be reached with short stops on the hard shoulder to drop off and pick up maintenance personnel. Alternatively access can be gained to the verge from ground level at the west tower, up through the tower leg stairwell and through the access door from the tower to the deck.

e) CCTV cameras – Traffic surveillance cameras would be located either on accessible gantries or masts located in the verge. The gantries can be reached with short stops on the hard shoulder to drop off and pick up maintenance personnel. Alternatively access can be gained to the verge from ground level at the west tower, up through the tower leg stairwell and through the access door from the tower to the deck.

f) Emergency Roadside Telephones (ERT) – The telephones would be located in the verges and can be reached with short stops on the hard shoulder to drop off and pick up maintenance personnel.

g) High Speed Weigh In Motion (WIM) installations – The inductive loops and sensors for monitoring traffic flows would be located in the carriageway surfacing. Access to these for maintenance would require closure of the carriageway in one direction.

8.9.2 Communications, power and lighting equipment

8.9.2.1 Communications, lighting and power cabling servicing the ITS, SHMS and other systems would be located in the cable trough below the deck maintenance walkway.

8.9.2.2 Any lighting columns proposed would be in the maintenance walkway at approximately 25m centres and can be accessed from the walkway itself. Where access is required to the lamps this can be achieved using MEWPs combined with closure of the hard shoulder.

8.9.3 Other highway furniture

8.9.3.1 Surfacing, waterproofing, vehicle parapets, safety barriers, wind shields and deck drainage should be inspected from the carriageway verges. Where necessary lane or carriageway closures would also be required, such as for the inspection of the central reserve barrier and kerb drainage units. For drainage inspections rodding units should be provided as appropriate to ease maintenance of the system. Due to the large movements of 1250mm at the expansion joints it is anticipated that the drainage expansion system in the abutments would have additional inspection and maintenance requirements to those usually expected. Possible options for accommodating movement in the drainage system is to provide a hopper of sufficient size to collect water from a shifting drainage outfall. Alternatively a connecting pipe with rubber joints could be provided.

8.9.3.2 The external face of the wind shield should be inspected simultaneously with the deck soffit inspection using MEWPS or the underbridge inspection vehicle, as discussed previously.

9 Whole life costing

9.1 Introduction

9.1.1 As identified in Section 8 a number of options exist for access and maintenance of the River Usk Crossing and approach spans. A whole life costing analysis has therefore been carried out in accordance with the approach given in BD36/92 to determine the most appropriate option. This considers the initial cost of various types of permanent access provision, and subsequent maintenance costs using that form of access.

9.1.2 The following options are included within the whole life cost exercise: -

a) Inspection of deck soffit by either MEWP or underbridge inspection vehicle. Although there are no capital costs associated with either option, comparison of them is still necessary at this stage of the design, as use of the MEWP would require the availability of land under the bridge deck for siting the MEWP.

b) Inspection of bearings by MEWP to gain access to the top of the pier cross head, clipping into the safety rail and then walking along the top of the crosshead to access the piers. Alternatively a permanent inspection pit could be provided at the top of the pier crosshead which can be accessed from ground level via a MEWP or ladder, or from deck level via access hatches.

9.1.3 An estimation of the cost of maintaining the structure over the first 30 years has also been made to assist in planning of maintenance budgets.

9.1.4 Access options considered are specifically for the cable stay bridge and ladder deck design being developed. Further access options associated with different types of bridge structure, span arrangement or alignment have not been included as this is deemed to be within the scope of the KS3a value engineering exercise, the outcomes of which are reported in the AIP document reference M4CaN-DJV-SBR-Z3_1000-RP-CB-0001.

9.2 Methodology

9.2.1 In the following whole life costing analyses, only costs which vary between options have been included, and not those which are identical across all options. The total costs therefore are not reflective of those that would be incurred if the work was carried out.

9.2.2 Costs are compared on the basis of their Net Present Value (NPV), excluding VAT.

9.2.3 Whole life costs have been calculated assuming the following discount rates from the HM Treasury Green Book. The discount rate is used to convert all costs and benefits to net present value at 2014Q4 so that they can be compared.

3.50% for 0 to 30 years

3.00% for 31 to 75 years

2.50% for 76 to 125 years

9.2.4 The traffic management costs included within the analysis are for the costs of setting up the traffic management. Lane availability charges have not been included as there would be no charges for this applied by the Operating Authority. The economic costs due to traffic delay have not been included as this would require data such as the duration of the delay and the number of vehicles using the bridge, for which insufficient information exists at this stage of the project to make a meaningful judgement.

9.2.5 The following rates have been assumed for these calculations. These have been obtained from experience from other projects and information provided by suppliers, and have also been reviewed by the CJV.

Activity/Item	Cost excluding VAT
Mobilisation and establishment of plant for inspections	£300 / inspection
Contractor's running costs for inspections	£100 / day
Contractor's daily running costs for bearing replacements	£300 / day
Supervision and attendance for inspections	£500 / day
Supervision and attendance for bearing replacements	£720 / day

MEWP hire costs	£120 / day
Personnel costs	£300 / day / person
Traffic management (set up costs only, lane availability assumed to incur no charges)	£1750 / day
Underbridge inspection vehicle	£1110 / day
Scaffold system hire costs	£100 / day
Trestle for bearing replacement	£300 / day

Table 6: Assumed rates used in whole life costing analysis

9.2.6 The full whole life costing breakdown is provided in Appendix A3.

9.3 Principal inspection of soffit of approach spans by either MEWP or underbridge inspection vehicle

9.3.1 The results of a whole life costing analysis on whether to inspect the approach spans by MEWP or underbridge inspection vehicle is detailed below, along with the key assumptions. Only the cost of each inspection has been stated as both options have zero capital cost, and therefore allowance for discount rates over the whole life of the structure would not change the outcome of the analysis.

9.3.2 Key assumptions:

a) 944m length of deck assumed, which does not include the main span, back spans, or approach spans where there are cable stays or particular access constraints which dictate the access method as reported in 8.6.2. It also does not include the slip roads, as due to their relatively low height it would be easier to inspect these using MEWPs.

b) Using 1 MEWPs for 944m of deck, 200m is inspected per day, therefore 5 days are required.

c) Using 1 underbridge inspection vehicle for 944m of deck, 400m is inspected per day, therefore 3 days are required.

d) 3 personnel are required for MEWP access and 4 personnel are required for underbridge inspection vehicle access.

e) No traffic management is required for inspection with a MEWP.

	Cost per principal inspection
Principal inspection using MEWPs	£5,900
Principal inspection using underbridge inspection vehicle	£12,780

Table 7: Inspection costs for principal inspection of deck soffit

9.3.3 This shows that inspection of the deck soffit using MEWP access is less than that required for inspection using an underbridge inspection vehicle. Furthermore, inspection and maintenance of the piers, bearings and deck soffit should be carried out simultaneously to minimise the cost of providing temporary access arrangements. If this is done then the use of MEWPs would also be preferred, as it would allow inspection of all three elements. It is highlighted that this does still not negate the use of any underbridge inspection vehicle, as this form of access would still be required on the cable stay bridge and at approach spans where there are access constraints, as detailed in 8.6.2.

9.4 Pier bearing principal inspection either by MEWP or use of inspection pits

9.4.1 The results of a whole life costing analysis on whether to inspect the pier bearings by MEWP or use of a pier top inspection pit is detailed below, along with the key assumptions.

9.4.2 Key assumptions:

a) Using 1 MEWP for 21 pier locations, bearings at 4 piers are inspected per day, therefore 6 days are required.

b) Using inspection pits and an access ladder, bearings at 6 piers are inspected per day, therefore 4 days are required .

c) 3 personnel are required for MEWP access and 2 for the use of inspection pits.

d) The capital cost of providing the inspection pit per bearing is estimated as a 1.0x20.0x4.0m3 volume of concrete per pier location requiring more complex reinforcement, at an additional cost of £100/m3 of reinforced concrete.

e) No traffic management is required for either option.

f) Principal inspection carried out every 6 years over 120 year design life.

	Whole life cost	
	Without discount rates	With discount rates from HM Treasury Green Book
Principal inspection using MEWPs	£147,420	£40,111
Principal inspection using inspection pit	£233,100	£185,713

Table 8: Whole life costing results for inspection of pier bearings

9.4.3 This shows that inspection from a dedicated inspection pit at the top of the pier crosshead would be more expensive than a MEWP over the whole life of the structure, due to the increased capital cost of constructing the inspection pit. As before an additional benefit of using a MEWP is that the external faces of the pier columns can also be inspected at the same time. This is therefore the preferred option for access.

9.5 Estimation of maintenance costs for first 30 years

9.5.1 The Bridge will represent a significant increase in the amount of maintenance undertaken by the SWTRA. To assist in future planning of maintenance budgets an estimation has been made of the costs of maintaining the River Usk Crossing and approach viaducts over the first 30 years of its service life. The results of this whole life costing analysis is detailed below, along with the key assumptions.

9.5.2 Items included within the 30 year whole life costing analysis: -

a) Bridge Master;

b) Management of SHMS system;

c) Cyclic maintenance;

d) Maintenance of access walkways;

e) General inspection;

f) Principal inspection;

g) Costs of a bridge maintenance team from Year 20 onwards;

h) Minor maintenance to expansion joint, bearings, corrosion protection system, stay cables and dampers;

i) Major maintenance to corrosion protection system;

j) Replacement of waterproofing systems and surfacing;

k) Maintenance of architectural lighting;

l) Replacement of drainage expansion components;

m) Renewal of SHMS system technology.

9.5.3 Key assumptions:

a) Inspection and maintenance will be undertaken in accordance with the Standards. Different commitments to the maintenance regime could be assumed in a more detailed whole life cost exercise to be undertaken in a later Key Stage.

b) Traffic management costs include costs of setting out the system, but not penalties associated with reduction in lane availability.

c) Costs do not include inspection and maintenance of scheme wide systems eg ITS, lighting system etc.

d) Expansion joint minor maintenance assumes 5% of elements require replacement.

e) Paint system minor maintenance assumes 5% of paint area requires replacement.

f) Paint system full replacement assumed to cost £56/m2 which includes access provision.

g) Ongoing maintenance of structure assumed to require 2 people for 3 days/month.

h) Electrical repairs to SHMS system assumed to cost £5,000/year.

i) Repairs to cable stays, anchorages and dampers assumed to cost £10,000/year

j) Cyclic maintenance items include concrete repairs, minor paint repairs, weld repairs in anchor boxes, local waterpoofing and surfacing repairs etc and are assumed to increase from Year 2022 to Year 2041, at which time a full time maintenance team is also required.

k) Routine maintenance items required scheme wide such as vegetation clearance, white line painting, ITS maintenance etc. not included in costs.

l) Pavement assumed to need replacement every 15 years, with waterproofing replacement also carried out on alternate interventions.

m) Minor drainage maintenance is assumed to be required every 10 years to replacement expansion components which will undergo wear.

n) SHMS systems assumed to require updating with new technology every 10 years.

o) Resurfacing rate of £21.5/m^2 assumed to include cold milling, tack coat and resurfacing. Resurfacing and waterproofing rate of £85m/^{2} assumed to also include removal of waterproofing and application of a spray applied system.

p) The underbridge inspection unit has been assumed to be hired, with costs based on similar units currently available to hire in the UK. However, the Moog 1750T vehicle identified as being suitable for use on the structure is not believed to be available for hire currently in the UK. Therefore the unit may instead need to be purchased directly from the manufacturer at a cost of approximately £450,000, as previously stated in section 8.6.4. If the unit were purchased the annual cost of principal inspections would decrease from £208,000 to £184,000, and the cost of minor repairs to the corrosion protection system would decrease from £1,050,880 to £666,850, with an initial capital cost to purchase the unit.

9.5.4 Outcomes of 30 year whole life cost analysis

The results show that over the first 30 years inspection, maintenance and replacement costs will sum to approximately £37.9million ignoring discount rates. Once discount rates from the HM treasury Green Book are applied the total cost is approximately £17.8million. Actual costs within each year fluctuate depending on the activities within that year. A full breakdown of the 30 year whole life cost analysis is provided in Appendix A4.

10 Requirement for bridge maintenance team or bridge master

10.1 Ongoing maintenance and integration with SWTRA activities

10.1.1 The current South Wales Trunk Road Agency (SWTRA) carries out general maintenance operations through a Contractor framework, with inspections conducted by an inspection framework. They manage approximately 1800 structures, of which approximately 600 are bridges, although none on the scale of the proposed River Usk Crossing.

10.1.2 As detailed in section 5 ongoing maintenance is required for various elements of the structure, such as drainage clearance and local surfacing repairs. This requires a general maintenance team which would operate scheme wide. These ongoing maintenance activities would therefore either need to be incorporated into a maintenance package, or a separate maintenance team would be required to undertake ongoing maintenance of the scheme. This requirement is not included within the Bridge Master discussion given in the following section, which is specific to the Usk Crossing structure.

10.2 Frequency of inspection and maintenance activities

10.2.1 As discussed previously, planned maintenance is also required for the joints, bearings, cable stay and corrosion protection system. This is in addition to the inspection schedule listed below, for which estimates of the duration have been obtained from the CJV.

	General Inspection (every 2 years)		Principal inspection (Every 6 years)	
Element	Number of people assumed	Total man hours (hours)	Number of people assumed	Total man hours (hours)
Towers	2	48	4	192
Abutments and joints	2	16	2	32
Deck soffit	3	64	4	760
Cable stays	2	64	3	384
Pier and bearings	3	48	3	144

Total		**240 hrs (6 weeks)**		**1512 hrs (38 weeks)**

Table 10: Duration of general and principal inspections

10.2.2 In total, the number of weeks the general inspections would take is approximately 6 weeks of man hours, whilst for principal inspections would take 38 weeks of man hours. On average inspections would be undertaken by 3 person teams for safety and plant operation reasons. Furthermore, these inspections would only occur every other year for general inspections, and every 6 years for principal inspections. The time requirement therefore is not sufficient to have a dedicated maintenance team for these activities.

10.2.3 The durations of anticipated maintenance to the cables, joints, bearings and corrosion protection system has not been considered due to the infrequency of this work and the need to use specialist staff and contractors. This work does therefore not provide justification for a dedicated maintenance team.

10.3 Requirement for specialist knowledge

10.3.1 Specialist knowledge is required for inspection, maintenance and replacement of the bearings, joints, cables and corrosion protection system, as described in section 5.6. However, the frequency of these activities does not warrant a dedicated maintenance team, as specialist teams can be employed when the activity is required. In particular, this is true over the first 20 years of the structure, where it is anticipated that the main requirement would only be for inspections, with minimal maintenance needed. After this period elements of the structure would be nearing the end of their design life, at which stage a dedicated maintenance team would be more justifiable to monitor the deterioration of components and carry out repairs.

10.3.2 Another key area where specialist knowledge is required for this structure is for review of the data from the structural health monitoring systems. A member of the maintenance team would need to be familiar with these systems to enable them to identify when a parameter is outside of normal limits, or when a sensor is giving incorrect readings indicating a fault in the system. Because of this need, it is recommended that a Bridge Master is employed specifically for the River Usk Crossing to monitor data from the SHM system and coordinate the inspection and maintenance. A further benefit of having a permanent bridge master is that they would gain knowledge of the structure over time, which would enable them to understand the data better and also share this information with inspection and maintenance teams working on similar structures.

10.3.3 Inspection of structural elements such as piers, towers, deck soffit, ITS systems and road furniture do not require specialist knowledge to inspect and maintain them. These works can therefore be carried out by the general maintenance team responsible for the whole scheme and surrounding structures.

10.4 Emergency events

10.4.1 In the event of an emergency occurring on the bridge it would be pertinent to ensure that there is a team which is familiar with the emergency protocols. As such an event would be rare, a specialist team would not need to be provided for this reason. However, members of the general maintenance team should have the necessary training to deal with an emergency event should It arise. The response can be coordinated by the Bridge Master, who would be most familiar with the structural elements, technology and access arrangements.

10.5 Recommendation

10.5.1 Considering the issues discussed in the previous sections it is recommended that a dedicated Bridge Master is employed who is able to understand and react to data from the structural health monitoring systems, which have been specified in the Works Information. They can also coordinate other maintenance personnel during emergency events, inspections and maintenance operations, as they would be most familiar with the structure and access provisions. The role of the Bridge Master could either be taken by a single person or shared among a small team of people for robustness.

10.5.2 In addition to the Bridge Master, select members of the general maintenance team for the whole region/scheme can be trained in order to carry out ongoing maintenance and regular inspections of the bridge as necessary. As well as being familiar with the structural details and access provisions the team would have people trained in areas such as abseiling, electrical repairs and welding. A consistent team would also be better able to monitor deterioration of any structural elements. However, due to the limited time needed to carry out inspections, and the fact that major maintenance is not anticipated, it is not necessary to have a dedicated maintenance team working on the bridge full time.

10.5.3 After 20 years of service life, once bridge components begin to reach the end of their design life and repairs or partial or full replacements are likely to be needed, there would be justification for providing a full time maintenance team to carry out inspection, minor maintenance and monitoring. Furthermore, if a painted corrosion protection system is adopted it would be reaching the end of its serviceable life, and hence continuous paint repairs are likely to be required over the 2.15km length of the structure. It is estimated that a maintenance team of 3 people would be required. However, specialist teams and contractors would still be required to carry out major repairs and replacements to joints, bearings, cable stays and corrosion protection system. It is noted that a weathering steel option is currently being considered, which if adopted would remove the need to carry out remedial paint works.

11 Requirement for dedicated bridge maintenance depot

11.1.1 From a review of the structure and associated technology the following plant and maintenance rooms listed in the table are deemed to be required. The area requirements have been obtained from a review of existing plant and maintenance depots for similar structures. These however are subject to the specifications of the exact plant which is specified for this bridge, which would be determined as the design develops. Plant areas have been subdivided into those required in a plant depot adjacent to the west tower, within each tower, within each abutment and those required at a separate maintenance depot.

Purpose	Minimum Area required (m^2)

Transformer room	56
Generator room	56
High voltage switch room	56
Low voltage room	28
Uninterruptible power supply (UPS) room	28
Scada system equipment room	28
Office	20
Welfare facilities	20
Maintenance vehicle parking (2 spaces assumed of 12mx3.5m)	84
General parking (7 spaces assumed of 5.0mx2.5m)	87.5
Area of uncovered parking	**171.5m^2**
Area of plant rooms	**292m^2**
Total area	**463.5m^2**

Table 11: Plant room area requirements adjacent to the west tower

Purpose	Minimum Area required (m^2)
ITS technology room	10
M&E technology room	10
Area of rooms that must be contained in each tower	**20m^2**

Table 12: Plant room area requirements at each tower

Purpose	Minimum Area required (m^2)
Cable room	50
Drainage Room	18
Transformer Room	56
ITS technology room	10
M&E technology room	10
Area of rooms that must be contained in abutment	**144m^2**

Table 13: Plant room area requirements at each abutment

Purpose	Minimum Area required (m^2)
SHMS/SCADA server room and workstation space	40
Store for flammable and hazardous substances	48
General store	172
Workshop	30
Office	35
Toilet	20
General parking (4 spaces assumed of 5.0mx2.5m)	50

Inspection vehicle parking (1 space)	105
Area of plant/store rooms	**290m^2**
Area of office/welfare rooms	**55m^2**
Area of uncovered parking	**50m^2**
Area of covered parking	**105m^2**
Total area	**500m^2**

Table 14: Maintenance room area requirements

11.1.2 The plant room adjacent to the Bridge must be sited at the west tower due to the presence of the salt marsh at the east tower. It is recommended that a plant depot area of 40.0m x 25.0m = 1000m^2 is allowed for adjacent to the west tower. This is sufficient to house the area tabulated above with an access track to enable plant to be delivered directly into the plant rooms, and a 3.5m wide perimeter all around. The plan layout of the depot is shown in the figure below.

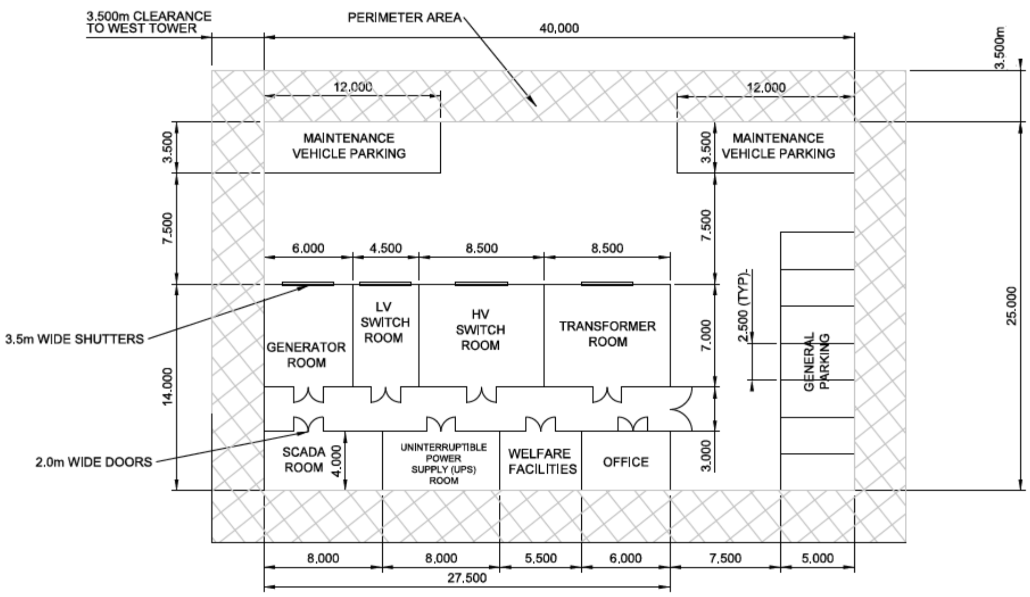


Figure 15: Proposed plant depot adjacent to west tower

11.1.3 The technology rooms located within the tower should be sited at deck level to enable ease of maintenance of electrical systems associated with highway technology.

11.1.4 The abutment plant rooms must be located within each abutment, as there will be an expansion joints and therefore cable and drainage rooms at both locations. The width of the deck means that the stated rooms can easily be accommodated within the proposed abutment structure. Maintenance vehicles can park on the hardstanding provided in front of the abutment.

11.1.5 The maintenance rooms do not need to be located at the bridge, although doing so would minimise travel times for maintenance staff. They could also be used during major cable, joint and bearing replacement works later in the service life of the structure. Considering the relative infrequency and duration of inspection and maintenance events though, as discussed in section 10.1, it is recommended that the maintenance rooms are located within the scheme/area wide maintenance depot located at Glan Llyn Junction approximately 3 miles east of the Bridge. This minimises land take and is also more cost effective. It is noted that all the maintenance rooms, with the exception of the SHMS room, are also required scheme wide and therefore these areas can be incorporated into those needed for the rest of the scheme for efficiency. The land take defined for the Glan Llyn Junction depot includes space for further increase to maintenance areas which may be identified in the future.

11.1.6 Any depots must provide a facility which complies with the Health and Safety at Work Act 1974. A monthly health and safety inspection of the depot and a quarterly health and safety review must also be undertaken. Specific health and safety requirements for the depot are listed in the Network Management Manual Part 3.

A1 Glossary

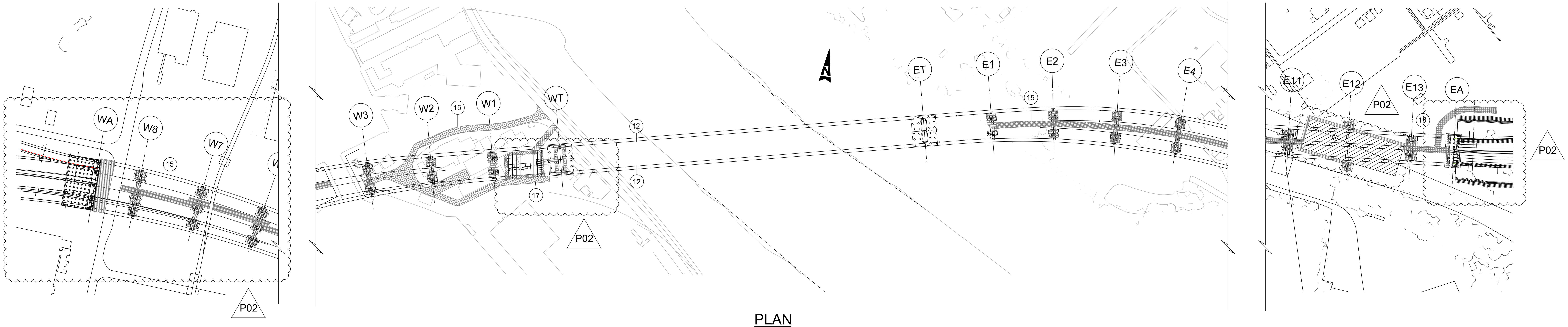
ABP	Associated British Ports
AMI	Advanced motorway indicator
CJV	Construction Joint Venture
ERT	Emergency Roadside Telephone
HDPE	High density polyethylene
IMP	Inspection Maintenance Plan
Inspection and Maintenance Authority	The organisation responsible for the inspection and maintenance of the River Usk Crossing, including the cable stayed bridge, approach span, abutments and associated systems. This organisation may also be responsible for other sections on the M4 CaN.
ITS	Intelligent Transport Systems
MEWP	Mobile elevated working platform
MIDAS	Motorway incident detection and automatic signalling
MS4	4^{th} Generation Variable Message Sign Version
NPV	Net present value – The discounted value of a stream of either future costs or benefits.
Operating Authority	The organisation responsible for the day-to-day operation of the highway.
PCB	Polychlorinated biphenyl
PTFE	Polytetrafluoroethylene
SHMS	Structural Health Monitoring System
SWTRA	South Wales Trunk Road Agency

TW	Transport Wales
VMS	Variable Message Sign
WIM	Weigh in Motion Sensor

A2 Access drawings

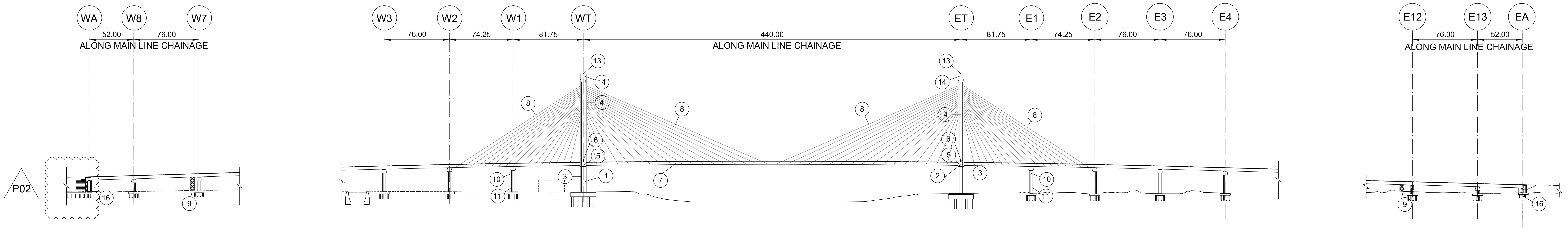
DO NOT SCALE

Millimetres 0 10 100



PLAN

SCALE 1:2500



SECTION ALONG MAINLINE CHAINAGE

SCALE 1:2500

NOTES:

1. TOWER ACCESS DOOR AT GROUND LEVEL IN WEST TOWER PROVIDING PRIMARY ACCESS INTO THE TOWER.
2. TOWER ACCESS DOOR AT DECK LEVEL AT EAST TOWER PROVIDING PRIMARY ACCESS INTO THE TOWER.
3. ACCESS STAIRS IN EACH TOWER LEG FROM PILECAP LEVEL TO DECK LEVEL WITH PLATFORMS EVERY 6M.
4. ACCESS LADDERS IN EACH TOWER LEG FROM DECK LEVEL TO TOWER TOP WITH PLATFORMS EVERY 6M.
5. ACCESS DOOR ON INSIDE FACE OF EACH TOWER LEG FROM TOWER INTERIOR TO TOP EXTERNAL FACE OF TOWER DECK CROSSBEAM.
6. ACCESS DOOR ON INSIDE FACE OF EACH TOWER LEG FROM TOWER INTERIOR TO DECK LEVEL VIA WALKWAY AND ACCESS DOOR IN WIND SHIELD.
7. PERMANENT WALKWAY SUSPENDED BELOW CENTRELINE OF DECK BETWEEN W2 AND E2 TO PROVIDE ACCESS TO DECK SOFFIT. ACCESS OBTAINED FROM TOP OF TOWER DECK CROSSBEAMS. ACCESS TO REMAINING WIDTH OF DECK SOFFIT AND SIDE ELEVATIONS OBTAINED USING UNDERBRIDGE INSPECTION VEHICLE WORKING BETWEEN CABLE STAYS.
8. REMOTELY OPERATED STAY CABLE INSPECTION VEHICLE.
9. MEWP, SCAFFOLD TOWER OR UNDERBRIDGE INSPECTION VEHICLE AS APPROPRIATE TO REACH DECK SOFFIT IN APPROACH SPANS AND EXTERNAL FACES OF ALL PIERS.
10. ACCESS LADDERS IN PIER VOIDS AT E1 AND W1.
11. ACCESS DOOR INTO PIER VOIDS AT E1 AND W1.
12. MAINTENANCE WALKWAY ON BOTH SIDES OF CARRIAGEWAY BEHIND VEHICLE RESTRAINT SYSTEM TO ACCESS ROAD FURNITURE IN VERGES.
13. TOWER TOP INSPECTION PIT WITH CONCRETE PARAPET WALL FOR HOUSING OF RETRACTABLE TOWER CRADLE.
14. TOWER TOP ACCESS CHAMBER FOR HOUSING OF MONITORING EQUIPMENT AT TOWER TOP AND WINCH.
15. 7.0M WIDE DEDICATED MAINTENANCE ACCESS TRACK.
16. ACCESS STEPS AND DOOR FRONT FACE OF ABUTMENT TO REACH BEARING INSPECTION CORRIDOR.
17. BUILDING SERVICES BUILDING ADJACENT TO WEST TOWER.

P02

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. ONLY WRITTEN DIMENSIONS SHALL BE USED, DO NOT SCALE.
3. REFER TO DRAWING 1001 FOR ABBREVIATIONS

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
None

Maintenance / Cleaning
None

Use
None

Decommissioning / Demolition
None

Rev.	Date	Description	By	Chk'd	App'd
P01	24/07/15	FIRST ISSUE	SKA	MAH	MYG
P02	16/10/15	FINAL ISSUE	DAW	MAH	MYG

Drawing Status: FOR REVIEW AND COMMENT

Suitability: S3

Project Team

Client: Llywodraeth Cymru Welsh Government

Project Title: M4 CORRIDOR AROUND NEWPORT

Drawing Title: SBR 1000 - RIVER USK CROSSING ACCESS FACILITIES

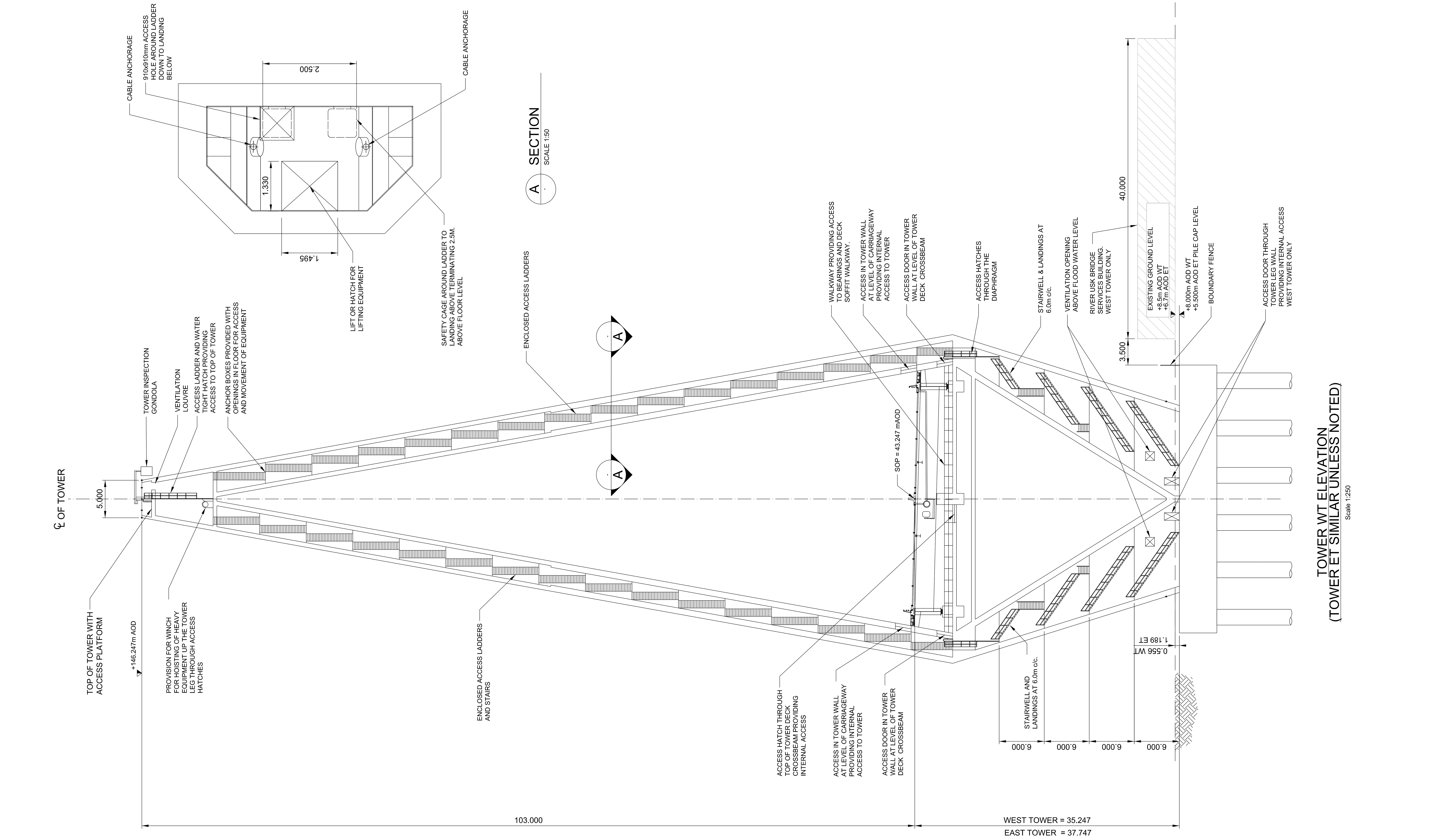
Scale	Designed / Drawn	Checked	Approved	Authorised
1:1	DAW	MAH	MYG	PHP
Original Size A1	Date 09/10/15	Date 12/10/15	Date 13/10/15	Date 16/10/15

Drawing Number (Project | Originator | Volume | Location | Type | Role | Number): M4CaN - DJV - SBR - Z3_GEN - DR - CB - 2001

Revision: P02

DO NOT SCALE

Millimetres 0 10 100



GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. ONLY WRITTEN DIMENSIONS SHALL BE USED, DO NOT SCALE.
3. REFER TO DRAWING 1001 FOR ABBREVIATIONS.
4. ALL DOORS INTO TOWERS TO BE LOCKABLE DOORS STAIR'S LADDERS AND WALKWAYS IS TO COMPLY WITH REQUIREMENTS OF BS5395.
5. ACCESS ARRANGEMENTS ARE INDICATIVE.

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
None

Maintenance / Cleaning
None

Use
None

Decommissioning / Demolition
None

Rev.	Date	Description	By	Chk'd	App'd
P01	24/07/15	FIRST ISSUE	SKA	MAH	MYG
P02	16/10/15	FINAL ISSUE	DAW	MAH	MYG

Drawing Status: FOR REVIEW AND COMMENT

Suitability: S3

Project Team

Client: Llywodraeth Cymru / Welsh Government

Project Title: M4 CORRIDOR AROUND NEWPORT

Drawing Title: SBR 1000 - RIVER USK CROSSING TOWER ACCESS

Scale	Designed / Drawn	Checked	Approved	Authorised
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Original Size: A1	Date: 09/10/15	Date: 12/10/15	Date: 13/10/15	Date: 16/10/15

Drawing Number (Project | Originator | Volume / Location | Type | Role | Number): M4CaN - DJV - SBR - Z3_GEN - DR - CB - 2002

Revision: P02

DO NOT SCALE

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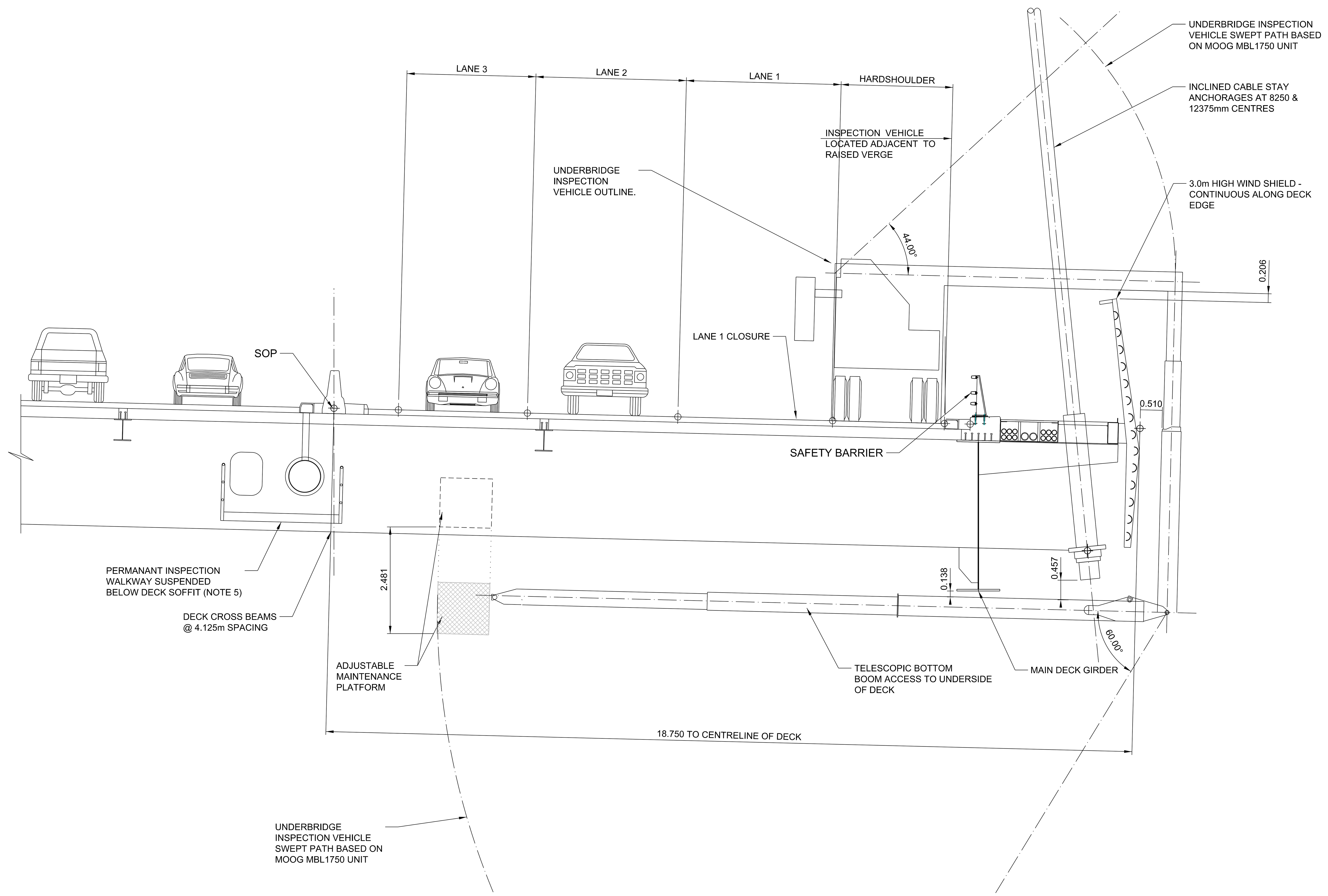


TYPICAL SECTION THROUGH UNDERBRIDGE INSPECTION VEHICLE

Scale 1:50

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. ONLY WRITTEN DIMENSIONS SHALL BE USED, DO NOT SCALE.
3. REFER TO DRAWING 1001 FOR ABBREVATIONS.
4. UNDERBRIDGE INSPECTION VEHICLE AT LEAST REQUIRED FOR THE MAIN SPAN AND BACK SPANS OF THE CABLE STAYED BRIDGE SECTION.
5. CLEARANCES TO STRUCTURE HAVE BEEN BASED ON DIMENSIONS OF MOOG MBL 1750 UNDERBRIDGE INSPECTION VEHICLE.
6. PERMANENT INSPECTION WALKWAY ONLY PROVIDED ALONG THE BACK AND MAIN SPANS OF THE CABLE STAYED BRIDGE. ACCESS TO THE WALKWAY IS FROM THE EAST AND WEST TOWERS.
7. GANTRY ARRANGEMENT IS INDICATIVE.
8. STAIRS, WALKWAYS AND LADDERS TO COMPLY WITHTHE REQUIREMENTS OF BS5395

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
None

Maintenance / Cleaning
None

Use
None

Decommissioning / Demolition
None

Rev.	Date	Description	By	Chk'd	App'd
P01	24/07/15	FIRST ISSUE	SKA	MAH	MYG
P02	16/10/15	FINAL ISSUE	DAW	MAH	MYG

Drawing Status: FOR REVIEW AND COMMENT

Suitability: S3

Project Team

Client: Llywodraeth Cymru Welsh Government

Project Title: M4 CORRIDOR AROUND NEWPORT

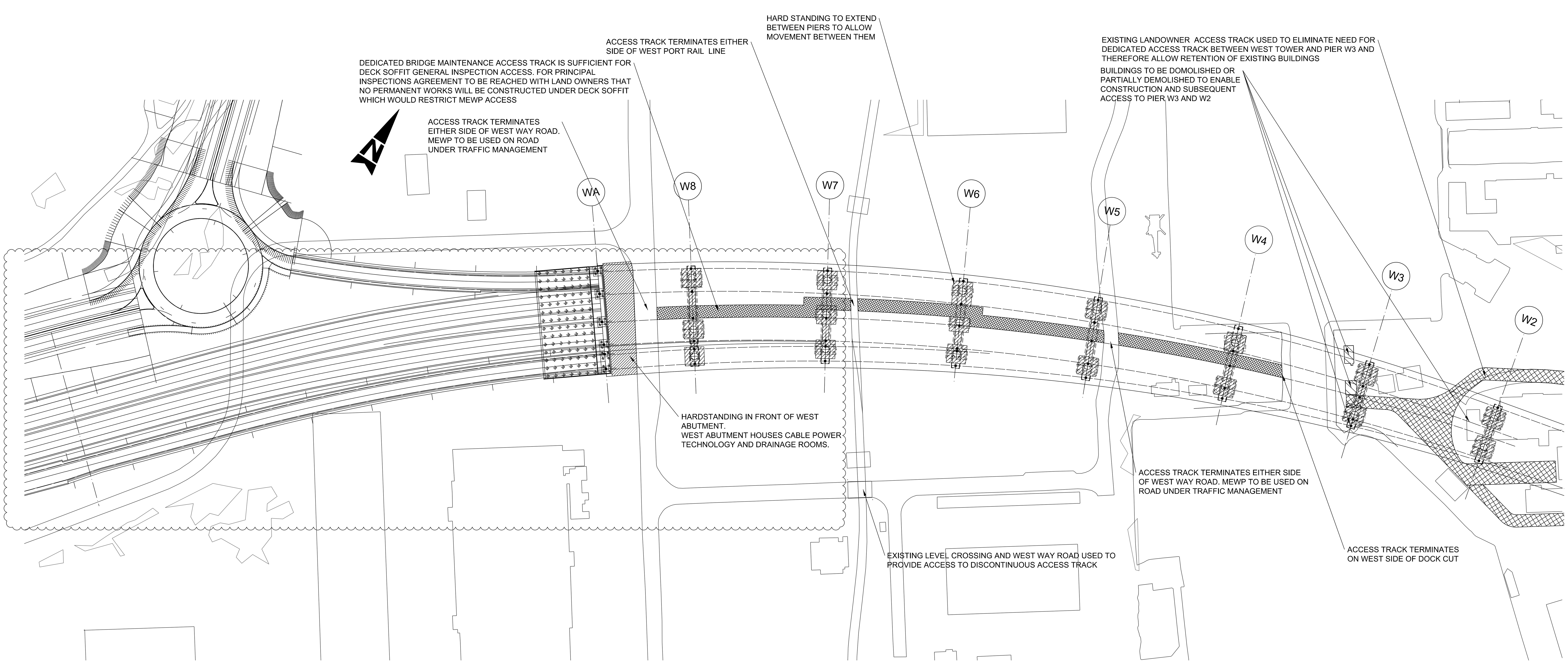
Drawing Title: SBR 1000 - RIVER USK CROSSING CABLE STAYED BRIDGE DECK ACCESS

Scale	Designed / Drawn	Checked	Approved	Authorised
1:1	DAW	MAH	MYG	PHP
Original Size	Date	Date	Date	Date
A1	09/10/15	12/10/15	13/10/15	16/10/15

Drawing Number (Project | Originator | Volume | Location | Type | Role | Number): M4CaN - DJV - SBR - Z3_GEN - DR - CB - 2003

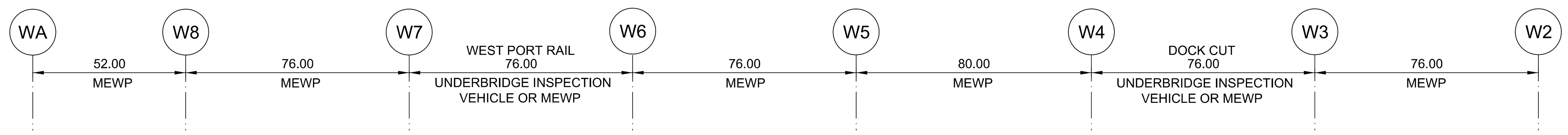
Revision: P02

DO NOT SCALE



PLAN

Scale 1:1250



SPANS ALONG MAINLINE CHAINAGE PROPOSED DECK SOFFIT ACCESS

Scale 1:1250

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. ONLY WRITTEN DIMENSIONS SHALL BE USED, DO NOT SCALE.
3. REFER TO DRAWING 1001 FOR ABBREVIATIONS.
4. RESTRICTIVE COVENANT TO BE AGREED WITH ADJACENT LANDOWNERS TO LIMIT FURTHER PERMANENT STRUTURES UNDER THE DECK AND ALLOW EMERGENCY ACCESS TO THE SOFFIT AT SHORT NOTICE.
RESTRICTION ON STORAGE OF EXPLOSIVE, FLAMMABLE, HAZARDOUS MATERIALS AND SIMILAR ALSO TO BE AGREED, TOGETHER WITH MAXIMUM PERMISSABLE SURCHARGE LOADING.

KEY

- HARDSTANDING PROVIDED IN FRONT OF ABUTMENT AND AROUND PIER COLUMNS TO BE A MINIMUM OF 3.5M WIDE TO ALLOW USE OF TRUCK MOUNTED MEWP
- 7M WIDE 2-LANE DEDICATED BRIDGE MAINTENANCE ACCESS TRACK. PROTOCOL TO BE AGREED WITH LAND OWNER SO THAT OWNER ACTIVITIES OPERATE AROUND THE ACCESS TRACK, ALLOWING BRIDGE PERSONNEL TO MOVE WITHIN AN AGREED SAFE ZONE
- PROPOSED SHARED USE OF EXISTING LAND OWNER ACCESS TRACK

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
Clearance of 4.5m to railway track to be maintained at all times. Work plans to be agreed with track owner prior to starting works and track posession obtained if required

Maintenance / Cleaning
See Construction SHE box

Use
Restrictive convenant to be agreed with adjacent land owners, see note 3.

Decommissioning / Demolition
See Construction SHE box

Rev.	Date	Description	By	Chk'd	App'd
P01	24/07/15	FIRST ISSUE	SKA	MAH	MYG
P02	16/10/15	FINAL ISSUE	DAW	MAH	MYG

Drawing Status: FOR REVIEW AND COMMENT
Suitability: S3

Project Team

Client: Llywodraeth Cymru Welsh Government

Project Title: M4 CORRIDOR AROUND NEWPORT

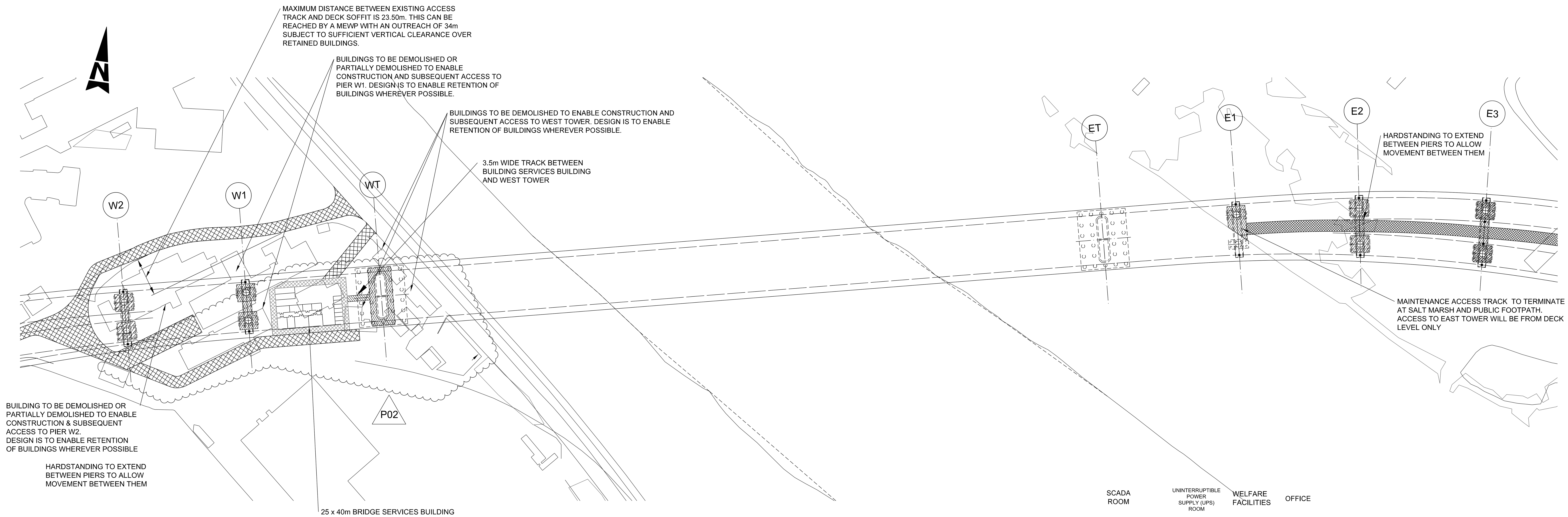
Drawing Title: SBR 1000 - RIVER USK CROSSING MAINTENANCE ACCESS TRACK SHEET 1 OF 3

Scale	Designed / Drawn	Checked	Approved	Authorised
1:1250	DAW	MAH	MYG	PHP
Original Size A1	Date 09/10/15	Date 12/10/15	Date 13/10/15	Date 16/10/15

Drawing Number (Project | Originator | Volume / Location | Type | Role | Number): M4CaN - DJV - SBR - Z3_GEN - DR - CB - 2007

Revision: P02

DO NOT SCALE

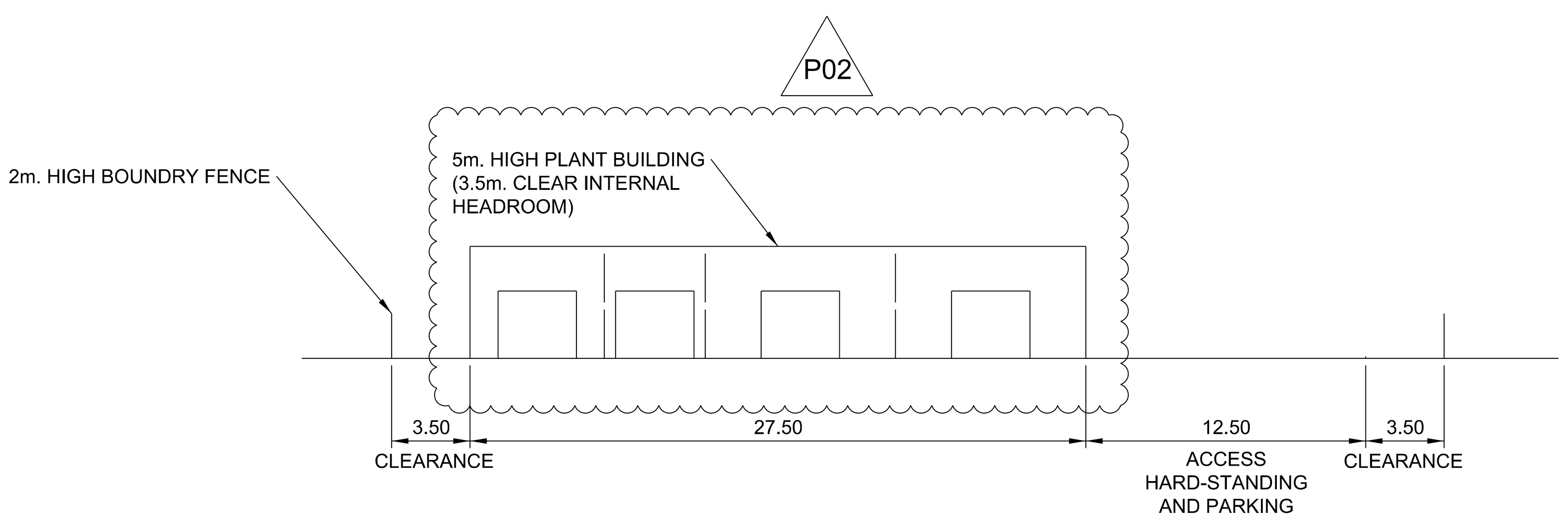


PLAN

Scale 1:1250

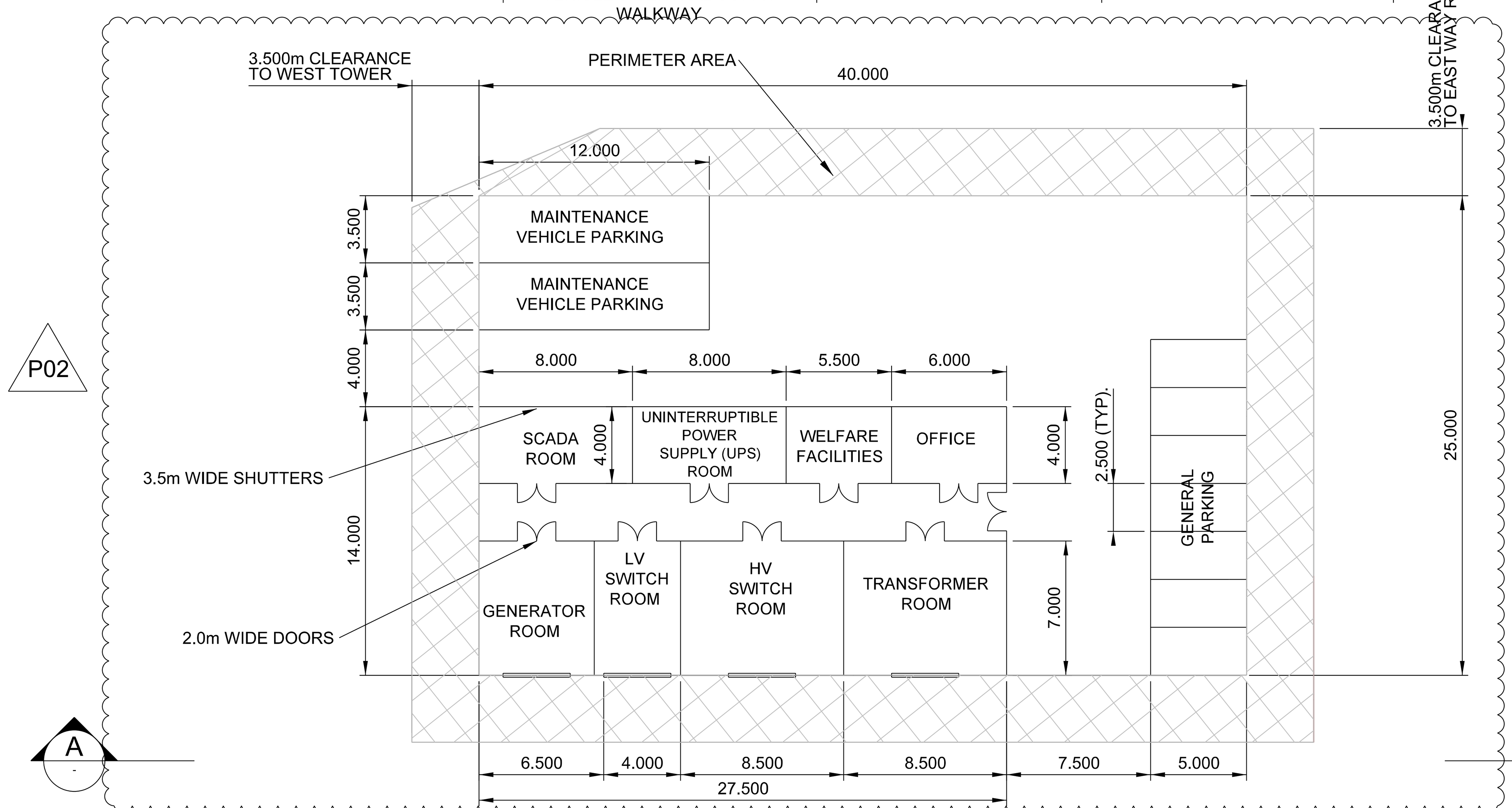
SPANS ALONG MAINLINE CHAINAGE PROPOSED DECK SOFFIT ACCESS

Scale 1:1250



A SECTION

SCALE 1: 1:250



DETAIL 1 - BRIDGE SERVICES BUILDING

Scale 1:250

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. ONLY WRITTEN DIMENSIONS SHALL BE USED, DO NOT SCALE.
3. REFER TO DRAWING 1001 FOR ABBREVIATIONS.
4. RESTRICTIVE COVENANT TO BE AGREED WITH ADJACENT LANDOWNERS TO LIMIT FURTHER PERMANENT STRUTURES UNDER THE DECK AND ALLOW EMERGENCY ACCESS TO THE SOFFIT AT SHORT NOTICE. RESTRICTION ON STORAGE OF EXPLOSIVE, FLAMMABLE, HAZARDOUS MATERIALS AND SIMILAR ALSO TO BE AGREED, TOGETHER WITH MAXIMUM PERMISSABLE SURCHARGE LOADING.

KEY

- HARDSTANDING PROVIDED IN FRONT OF ABUTMENT AND AROUND PIER COLUMNS TO BE A MINIMUM OF 3.5M WIDE TO ALLOW USE OF TRUCK MOUNTED MEWP
- 7M WIDE 2-LANE DEDICATED BRIDGE MAINTENANCE ACCESS TRACK. PROTOCOL TO BE AGREED WITH LAND OWNER SO THAT OWNER ACTIVITIES OPERATE AROUND THE ACCESS TRACK, ALLOWING BRIDGE PERSONNEL TO MOVE WITHIN AN AGREED SAFE ZONE
- PROPOSED SHARED USE OF EXISTING LAND OWNER ACCESS TRACK

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
Clearance of 4.5m to railway track to be maintained at all times. Work plans to be agreed with track owner prior to starting works and track posession obtained if required

Maintenance / Cleaning
See Construction SHE box

Use
Restrictive convenant to be agreed with adjacent land owners, see note 3.

Decommissioning / Demolition
See Construction SHE box

Rev.	Date	Description	By	Chk'd	App'd
P01	24/07/15	FIRST ISSUE	SKA	MAH	MYG
P02	16/10/15	FINAL ISSUE	DAW	MAH	MYG

Drawing Status: FOR REVIEW AND COMMENT
Suitability: S3
Project Title: M4 CORRIDOR AROUND NEWPORT
Project Team
Drawing Title: SBR 1000 - RIVER USK CROSSING MAINTENANCE ACCESS TRACK SHEET 2 OF 3

Scale	Designed / Drawn	Checked	Approved	Authorised
1:1250	DAW	MAH	MYG	PHP
Original Size	Date	Date	Date	Date
A1	09/10/15	12/10/15	13/10/15	16/10/15

Client: Llywodraeth Cymru Welsh Government

Drawing Number (Project | Originator | Volume | Location | Type | Role | Number): M4CaN - DJV - SBR - Z3_GEN - DR - CB - 2008
Revision: P02

DO NOT SCALE

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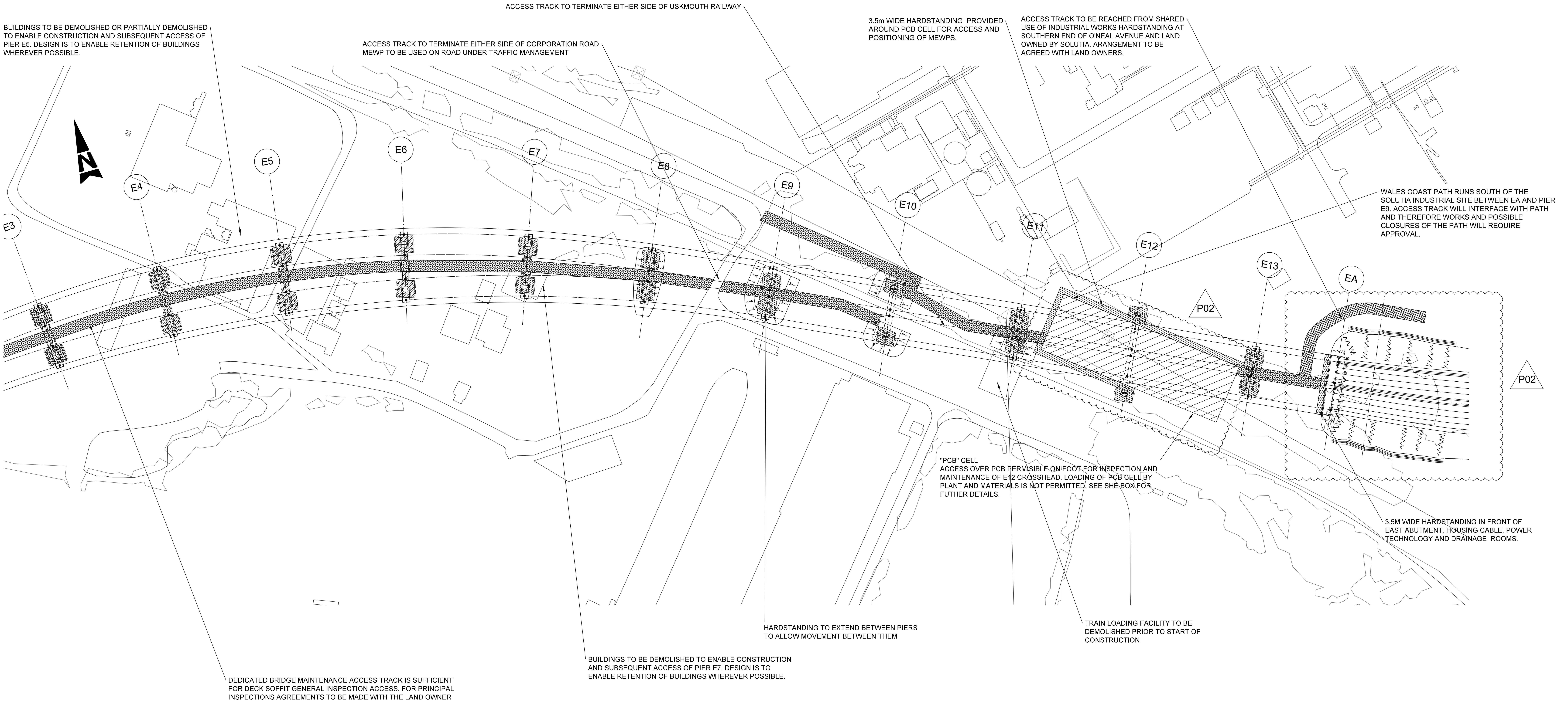
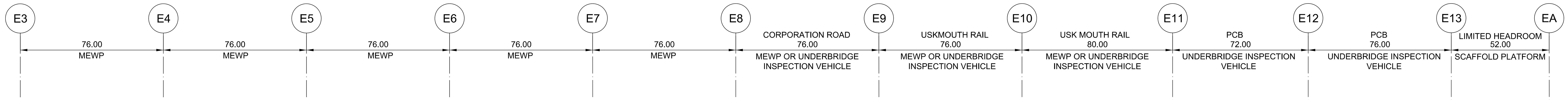


PLAN

Scale 1:1250



SPANS ALONG MAINLINE CHAINAGE PROPOSED DECK SOFFIT ACCESS

Scale 1:1250

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. ONLY WRITTEN DIMENSIONS SHALL BE USED, DO NOT SCALE.
3. REFER TO DRAWING 1001 FOR ABBREVIATIONS.
4. RESTRICTIVE COVENANT TO BE AGREED WITH ADJACENT LAND OWNERS TO LIMIT FURTHER PERMANENT STRUTURES UNDER THE DECK AND ALLOW EMERGENCY ACCESS TO THE SOFFIT AT SHORT NOTICE.
   RESTRICTION ON STORAGE OF EXPLOSIVE, FLAMMABLE, HAZARDOUS MATERIALS AND SIMILAR ALSO TO BE AGREED, TOGETHER WITH MAXIMUM PERMISSABLE SURCHARGE LOADING.

KEY

- HARDSTANDING PROVIDED IN FRONT OF ABUTMENT AND AROUND PIER COLUMNS TO BE A MINIMUM OF 3.5M WIDE TO ALLOW USE OF TRUCK MOUNTED MEWP
- 7M WIDE 2-LANE DEDICATED BRIDGE MAINTENANCE ACCESS TRACK. PROTOCOL TO BE AGREED WITH LAND OWNER SO THAT OWNER ACTIVITIES OPERATE AROUND THE ACCESS TRACK, ALLOWING BRIDGE PERSONNEL TO MOVE WITHIN AN AGREED SAFE ZONE
- PROPOSED SHARED USE OF EXISTING LAND OWNER ACCESS TRACK

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction, Maintenance And Demolision

Loading or disturbance of PCB cell between E11-E13 not permitted. Clearance of 4.5m to railway track to be maintained at all times. Work plans to be agreed with track owner prior to starting works and track posession obtained if required

Maintenance / Cleaning

See Construction SHE box

Use

Restrictive convenant to be agreed with adjacent land owners, see note 3.

Decommissioning / Demolition

See Construction SHE box

Rev.	Date	Description	By	Chk'd	App'd
P01	24/07/15	FIRST ISSUE	SKA	MAH	MYG
P02	16/10/15	FINAL ISSUE	DAW	MAH	MYG

Drawing Status: FOR REVIEW AND COMMENT

Suitability: S3

Project Team

Client: Llywodraeth Cymru Welsh Government

Project Title: M4 CORRIDOR AROUND NEWPORT

Drawing Title: SBR 1000 - RIVER USK CROSSING MAINTENANCE ACCESS TRACK SHEET 3 OF 3

Scale	Designed / Drawn	Checked	Approved	Authorised
1:1250	DAW	MAH	MYG	PHP
Original Size	Date	Date	Date	Date
A1	09/10/15	12/10/15	13/10/15	16/10/15

Drawing Number (Project | Originator | Volume | Location | Type | Role | Number): M4CaN - DJV - SBR - Z3_GEN - DR - CB - 2009

Revision: P02

A3 Comparison of access options using whole life costing analysis

Capital costs and annual inspection/maintenance costs

Option 1: Deck soffit principal inspection using MEWPs (assumes 944m of deck, 200m inspected per day)

	Days	QUANTITY	RATE	PRICE
Mobilisation and establishment of plant	1	1	£ 300.00	300.00
Contractor's daily running costs	5	1	£ 100.00	500.00
MEWP	5	1	£ 120.00	600.00
Personnel	5	3	£ 300.00	4,500.00
Traffic Management (set up only, no lane rental assumed)	5	0	£ 1,750.00	0.00
TOTAL				**£5,900**

Optopn 2: Deck soffit principal inspection using underbridge inspection vehicle (assumes 944m of deck, 100m inspected per day)

	Days	QUANTITY	RATE	PRICE
Mobilisation and establishment of plant	1	1	£ 300.00	300.00
Contractor's daily running costs	3	1	£ 100.00	300.00
Underbridge inspection vehicle	3	1	£ 1,110.00	3,330.00
Personnel	3	4	£ 300.00	3,600.00
Traffic Management (set up only, no lane rental assumed)	3	1	£ 1,750.00	5,250.00
TOTAL				**£12,780**

Option 1: Principal bearing inspection using MEWPs (assumes 21 pier locations, bearings at 4 piers inspected per day)

	Days	QUANTITY	RATE	PRICE
Mobilisation and establishment of plant	1	1	£ 300.00	300.00
Contractor's daily running costs	6	1	£ 100.00	600.00
MEWP	6	1	£ 120.00	720.00
Personnel	6	3	£ 300.00	5,400.00
Traffic Management (set up only, no lane rental assumed)	6	0	£ 1,750.00	0.00
TOTAL				**£7,020**

Option 2: Principal bearing inspection using inspection pits (assumes 21 piers, bearings at 6 piers inspected per day

	Piers	Volume (m3)	RATE	PRICE
Increased cost of reinforced concrete due to complexity of pit and access ha	21	80	100	**£168,000**
	Days	**QUANTITY**	**RATE**	**PRICE**
Mobilisation and establishment of plant	1	1	£ 300.00	300.00
Contractor's daily running costs	4	1	£ 100.00	400.00
MEWP	4	0	£ 120.00	0.00
Personnel	4	2	£ 300.00	2,400.00
Traffic Management (set up only, no lane rental assumed)	4	0	£ 1,750.00	0.00
TOTAL				**£3,100**

Whole life costing of deck soffit inspection access options

Without applying discount rates		Annual Cost in Year (£)																					
	Capital cost (£)	1	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	**Whole life cost**
Option 1: Deck soffit principal inspection using MEWPs (assumes 944m of deck, 200m inspected per day)	0	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	5,900	£5,900	£5,900	£5,900	£5,900	£5,900	£123,900
Optopn 2: Deck soffit principal inspection using underbridge inspection vehicle (assumes 944m of deck, 100m inspected per day)	0	12,780	12,780	12,780	12,780	12,780	12,780	12,780	12,780	12,780	12,780	12,780	12,780	12,780	12,780	12,780	12,780	£12,780	£12,780	£12,780	£12,780	£12,780	£268,380
Assuming discount rates from HM Treasury Green Book		Annual Cost in Year (£)																					
	Capital cost (£)	1	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	**Whole life cost**
Discount Rate from HM Treasury Green Book		3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	
Reduction factor		1	0.842	0.68495	0.5572	0.45329	0.3687	0.30882	0.25863	0.2166	0.1814	0.1519	0.12723	0.10655	0.0905	0.0781	0.06733	0.058057	0.05006	0.04317	0.03722	0.032098	
Option 1: Deck soffit principal inspection using MEWPs (assumes 944m of deck, 200m inspected per day)	0	5,900	4,968	4,041	3,288	2,674	2,176	1,822	1,526	1,278	1,070	896	751	629	534	461	397	343	295	255	220	189	£33,712
Optopn 2: Deck soffit principal inspection using underbridge inspection vehicle (assumes 944m of deck, 100m inspected per day)	0	12,780	10,760	8,754	7,121	5,793	4,713	3,947	3,305	2,768	2,318	1,942	1,626	1,362	1,157	998	860	742	640	552	476	410	£73,023

Whole life costing of bearing inspection access options

Without applying discount rates	Capital cost (£)	Annual Cost in Year (£) 1	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	Whole life cost
Option 1: Principal bearing inspection using MEWPs (assumes 21 pier locations, bearings at 4 piers inspected per day)	0	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	£7,020	£7,020	£7,020	£7,020	£7,020	£147,420
Option 2: Principal bearing inspection using inspection pits (assumes 21 piers, bearings at 6 piers inspected per day	168000	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	£3,100	£3,100	£3,100	£3,100	£3,100	£233,100

Assuming discount rates from HM Treasury Green Book	Capital cost (£)	Annual Cost in Year (£) 1	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	Whole life cost
Discount Rate from HM Treasury Green Book		3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	
Reduction factor		1	0.842	0.68495	0.5572	0.45329	0.3687	0.30882	0.25863	0.2166	0.1814	0.1519	0.12723	0.10655	0.0905	0.0781	0.06733	0.058057	0.05006	0.04317	0.03722	0.032098	
Option 1: Principal bearing inspection using MEWPs (assumes 21 pier locations, bearings at 4 piers inspected per day)	0	7,020	5,911	4,808	3,912	3,182	2,589	2,168	1,816	1,521	1,273	1,066	893	748	636	548	473	408	351	303	261	225	£40,111
Option 2: Principal bearing inspection using inspection pits (assumes 21 piers, bearings at 6 piers inspected per day	168000	3,100	2,610	2,123	1,727	1,405	1,143	957	802	671	562	471	394	330	281	242	209	180	155	134	115	100	£185,713

A4 30 year maintenance cost

Item	Cost
Personnel cost/day	£300
Specialist personnel cost/day	£400
Personnel cost/night	£450
Specialist personnel cost/night	£600
MEWP hire/day	£120
UB inspection vehicle (with cradle) hire/day	£1,500
UB inspection vehicle (with gantry) hire/day	£1,110
Traffic management costs/day	£1,750
Cable ROV hire / day	£500
Joint maintenance team/day	£2,800
Mobilisation for inspection works	£300
Mobilisation for minor maintenance works	£2,000
Mobilisation for major maintenance works	£5,000
Contractor daily running costs for inspections	£100
Contractor daily running costs for minor main	£200
Contractor daily running costs for for major m	£300

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Assumptions

Traffic management costs include costs of setting out the system, but not penalities associated with reduction in lane availability
Costs do not include inspection and maintenance of scheme wide systems eg ITS, lighting system etc
Expansion joint minor maintenance assumes 5% of elements require replacement
Paint system minor maintenance assumes 5% of paint area requires replacment
Paint system full replacement assumed to cost £56/m2 which includes access provision
Ongoing maintenance of structure assumed to require 2 people for 3 days/month
Electrical repairs to SHMS system assumed to cost £5000/year
Cyclic maintenance items include concrete repairs, minor paint repairs, weld repairs in anchor boxes, local waterpoofing and
surfacing repairs etc and are assumed to increase from Year 2022 to Year 2041, at which time a full time maintenance team is also required
Routine maintenance items required scheme wide such as vegetation clearance, white line painting, ITS maintenance etc. not included in costs
Pavement assumed to need replacement every 15 years, with waterproofing replacement also carried out on alternate interventions
Minor drainage maintenance is assumed to be required every 10 years to replacement expansion components which will undergo wear
SHMS systems assumed to require updating with new technology every 10 years
UB inspection vehicle (with cradle) assumed to be hired. If this was not possible the cost of purchasing the 1750T vehicle is approximately £450,000

General inspection: **13** **days**

Activity	Inspection rate		Total number of elements		days	Number of inspection personnel	Inspector Rate/day (£)	Number of plant	Plant rate/day	Traffic management required?	Cost (£)	Cumulative cost (£)	
Pier and bearing inspection using MEWP	12	pier locations /day	21	pier locations	2	3	£300	1	£120	No	£2,040	£2,040	
Deck inspection using MEWP	1000	m of deck/day	1400	m of deck	2	3	£300	0	£120	No	£1,800	£3,840	
Deck inspection using walkway	1000	m of deck/day	752	m of deck	1	2	£300	0	£0	No	£600	£4,440	
Tower external face inspection from ground level using binoculars	2	tower/day	2	towers	1	2	£300	0	£0	No	£600	£5,040	
Tower internal face inspection using stairway	1	tower/day	2	towers	2	2	£400	0	£0	No	£1,600	£6,640	
Cable stay inspection from ground level using binoculars	34	cables/day	136	cables	4	2	£300	0	£0	No	£2,400	£9,040	
Abutment and expansion joint inspection using access walkway	4	abutments/day	4	abutments	1	2	£300	0	£0	No	£600	£9,640	
Review by senior engineer					5		£650				£3,250	£12,890	
Inspection report											£5,000	£17,890	**TOTAL**
Mobilisation of inspection											£300	£18,190	
Contractor daily running costs for inspections											£1,300	£19,490	**£19,490**

Principal inspection: **61** **days**

Activity	Inspection rate		Total number of elements		days	Number of inspection personnel	Inspector Rate/day	Number of plant	Plant rate/day	Traffic management required?	Total (£)	Cumulative total (£)	
Pier and bearing inspection using MEWP	4	pier locations /day	21	pier locations	6	3	£300	1	£120	No	£6,120	£6,120	
Deck inspection using MEWP	200	m of deck/day	944	m of deck	5	3	£300	1	£120	No	£5,100	£11,220	
Deck and lower anchorage inspection using UB inspection vehicle and walkway in main span and back spans	50	m of deck/day	752	m of deck	16	4	£600	1	£1,500	Yes	£90,400	£101,620	
Deck inspection using UB inspection vehicle in approach spans with constraints	150	m of deck/day	456	m of deck	4	4	£600	1	£1,110	Yes	£21,040	£122,660	
Tower external face inspection using tower cradle	0.5	tower/day	2	towers	4	4	£600	0	£0	Yes	£16,600	£139,260	
Tower internal face inspection using stairway	0.5	tower/day	2	towers	4	2	£300	0	£0	No	£2,400	£141,660	
Cable stay inspection using ROV	17	cables/day	136	cables	8	3	£600	1	£500	Yes	£32,400	£174,060	
Inspection of upper cable anchorage from inside tower	12	cables/day	136	cables	12	2	£400	0	£0	No	£9,600	£183,660	
Abutment and expansion joint inspection using access walkway and MEWP	2	abutments/day	4	abutments	2	2	£300	1	£120	No	£1,440	£185,100	
Engineer support during inspection					10		£650				£6,500	£191,600	
Inspection report											£10,000	£201,600	
Mobilisation of inspection											£300	£201,900	**TOTAL**
Contractor daily running costs for inspections											£6,100	£208,000	**£ 208,000**

Expansion joint minor maintenance	**28**	**days**												
Activity	Replacement rate		Total number of elements replaced		days	Maintenance team	Maintenane team rate/day	Number of plant	Plant rate/day	Traffic management required?	Cost of component (£)	Total (£)	Cumulative total	
Horseshoe weld repair	8	welds	4	welds	1	1	£2,800	0	£0	Yes	£195	£5,330	£5,330	
Guide tube housing brushes	4	brushes	35	brushes	9	1	£2,800	0	£0	Yes	£27	£41,895	£47,225	
Elastomeric bearings	20	bearings	35	bearings	2	1	£2,800	0	£0	Yes	£108	£12,880	£60,105	
Elastomeric springs	20	springs	35	springs	2	1	£2,800	0	£0	Yes	£98	£12,530	£72,635	
Control springs	15	springs	35	springs	3	1	£2,800	0	£0	Yes	£92	£16,870	£89,505	
Retaining rods	15	rods	35	rods	3	1	£2,800	0	£0	Yes	£22	£14,420	£103,925	
Corrosion protection system	10	m	3	m	1	1	£2,800	0	£0	Yes	£20	£4,610	£108,535	
Stainless steel slide plates	10	plates	35	plates	4	1	£2,800	0	£0	Yes	£32	£19,320	£127,855	
Verge cover plates	4	plates	4	plates	1	1	£2,800	0	£0	Yes	£245	£5,530	£133,385	
Neoprene elements	25	m	47	m	2	1	£2,800	0	£0	Yes	£170	£17,090	£150,475	
Mobilisation of maintenance works												£2,000	£152,475	**TOTAL**
Contractor daily running costs for maintenance												£5,600	£158,075	**£158,075**

Pavement replacement	**22**	**days**												
Activity	Replacement rate		Total number of elements replaced		days	Number of maintenance personnel	Maintenane personnel rate/day	Number of plant	Plant rate/day	Traffic management required?	Cost of component (£)	Total (£)	Cumulative total	
Planing out,repaving	2520	m2	54230	m2	22	8	£450	2	£100	Yes	£21.5	£1,288,045	£1,288,045	
Mobilisation of maintenance works												£5,000	£1,293,045	**TOTAL**
Contractor daily running costs for maintenance												£6,600	£1,299,645	**£1,299,645**

Pavement and waterproofing replacement	**44**	**days**												
Activity	Replacement rate		Total number of elements replaced		days	Number of maintenance personnel	Maintenane personnel rate/day	Number of plant	Plant rate/day	Traffic management required?	Cost of component (£)	Total (£)	Cumulative total	
Planing out,repaving	2520	m2	54230	m2	22	8	£450	2	£100	Yes	£21.5	£1,288,045	£1,288,045	
Removal of old waterproofing system, tack coat, application of new system	2520	m3	54230	m2	22	8	£450	0	£0	Yes	£85	£4,727,250	£6,015,295	
Mobilisation of maintenance works												£5,000	£6,020,295	**TOTAL**
Contractor daily running costs for maintenance												£13,200	£6,033,495	**£6,033,495**

Bearings minor maintenance	**26**	**days**												
Activity	Replacement rate		Total number of elements replaced		days	Number of maintenance personnel	Maintenane personnel rate/day	Number of plant	Plant rate/day	Traffic management required?	Cost of materials	Total (£)	Cumulative total	
Repairs to corrosion protection system from MEWP	8	bearings	106	bearings	14	3	£400	1	£120	No	£20	£20,600	£20,600	
Cleaning of debris from MEWP	20	bearings	106	bearings	6	3	£300	1	£120	No	£0	£6,120	£26,720	
Tightening of bolts from MEWP	20	bearings	106	bearings	6	3	£300	1	£120	No	£0	£6,120	£32,840	
Mobilisation of maintenance works												£2,000	£34,840	**TOTAL**
Contractor daily running costs for												£5,200	£40,040	**£40,040**

Corrosion protection system - minor replacement	**256**	**days**												
Activity	Replacement rate		Paint area to be repaired		days	Number of maintenance personnel	Maintenane personnel rate/day	Number of plant	Plant rate/day	Traffic management required?	Cost of component (£)	Total (£)	Cumulative total	
Repairs to paint system from roped scaffold towers and UB inspection vehicle	40	m2/day	10204	m2	256	4	£400	1	£1,500	No	£20	£997,680	£997,680	
Mobilisation of maintenance works												£2,000	£999,680	**TOTAL**
Contractor daily running costs for maintenance												£51,200	£1,050,880	**£1,050,880**
Corrosion protection system - full replacement	**2041**	**days**												
Activity	Replacement rate		Total area replaced		days	Number of maintenance personnel	Maintenane personnel rate/day	Number of plant	Plant Capital cost	Traffic management required?	Cost of component (£)	Total (£)	Cumulative total (£)	
Replacement of paint system from heavy duty gantry	100	m2/day	204080	m2	2041	10	£400	0	£0	No	£56	£19,592,480	£19,592,480	
Mobilisation of maintenance works												£5,000	£19,597,480	**TOTAL**
Contractor daily running costs for maintenance												£612,300	£20,209,780	**£20,209,780**
Cost of maintaining deck soffit walkway under cable stay structure														
	Inspection rate		Total number of elements		days	Number of inspection personnel	Inspector Rate/day	Number of plant	Plant rate/day	Traffic management required?	Total (£)	Cumulative total		
Inspection (twice annual inspection assumed)	200	m of walkway/day	752	m of walkway	4	2	£400	0	£0	No	£3,200	£3,200		**TOTAL**
Materials for minor maintenance per year											£1,000	£4,200		**£4,200**
Other costs														
	Number of people	Rate/week	Total											**TOTAL**
Bridge master	1	£2,000	£104,000											**£104,000**
Bridge maintenance team	3	£867	£135,200											**£135,200**
	Number of people	Personnel rate/day	Number of days per month	Material costs/year	Total									
Cyclic maintenance	2	£200	7	£15,000	£48,600									**£48,600**
SHMS annual management per year ie. electrical repairs	£5,000													**£5,000**
	Total/year													
Maintenance of architectural lighting	£5,000													**£5,000**
Minor maintenance to drainage	£20,000													**£20,000**
Replacement of SHMS technology	£500,000													**£500,000**
Repairs to stay cables, anchorages and dampers	£10,000													**£10,000**

Costs without applying discount rates

Years after completion		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Calendar year	Cost per intervention	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
ROUTINE MAINTENANCE (excluding items not specific to the bridge i.e. carriageway cleaning and marking, parapets, ITS and lighting maintenance etc…)																
Bridge Master (cl. 10.4.1)	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000
Bridge maintenance team	£135,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHMS – annual management	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000
Cyclic maintenance (cl. 5.4.1)	£48,600	£2,430	£4,860	£7,290	£9,720	£12,150	£14,580	£17,010	£19,440	£21,870	£24,300	£26,730	£29,160	£31,590	£34,020	£36,450
Stay cable minor maintenance	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000
Access walkways annual maintenance	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200
INSPECTIONS																
General Inspection	£19,490	0	£19,490	0	£19,490	0	0	0	£19,490	0	£19,490	0	0	0	£19,490	0
Principal Inspection	£208,000	0	0	0	0	0	£208,000	0	0	0	0	0	£208,000	0	0	0
SIGNIFICANT MAINTENANCE																
Expansion joint - minor maintenance	£158,075	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Expansion joint replacement	NA - occurs after 40 years	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Replacement of pavement	£1,299,645	0	0	0	0	0	0	0	0	0	0	0	0	0	0	£1,299,645
Replacement of pavement and waterpoofing	£6,033,495	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bearings – minor maintenance	£40,040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bearing replacement	NA - occurs after 50 year	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corrosion protection system – minor maintenance	£1,050,880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	£1,050,880
Corrosion protection system full renewal	£20,209,780	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maintenance of architectural lighting	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000
Replacement of drainage expansion components	£20,000										£20,000					
Renewal of SHMS system technology	£500,000										£500,000					
	Total per year	£130,630	£152,550	£135,490	£157,410	£140,350	£350,780	£145,210	£167,130	£150,070	£691,990	£154,930	£365,360	£159,790	£181,710	£2,515,175

Costs without applying discount rates

Years after completion		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Calendar year	Cost per intervention	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	
ROUTINE MAINTENANCE (excluding items not specific to the bridge i.e. carriageway cleaning and marking, parapets, ITS and lighting maintenance etc…)																	
Bridge Master (cl. 10.4.1)	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	£104,000	
Bridge maintenance team	£135,200	0	0	0	0	£135,200	£135,200	£135,200	£135,200	£135,200	£135,200	£135,200	£135,200	£135,200	£135,200	£135,200	
SHMS – annual management	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	
Cyclic maintenance (cl. 5.4.1)	£48,600	£38,880	£41,310	£43,740	£46,170	£48,600	£48,600	£48,600	£48,600	£48,600	£48,600	£48,600	£48,600	£48,600	£48,600	£48,600	
Stay cable minor maintenance	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000	
Access walkways annual maintenance	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	£4,200	
INSPECTIONS																	
General Inspection	£19,490	£19,490	0	0	0	£19,490	0	£19,490	0	0	0	£19,490	0	£19,490	0	0	
Principal Inspection	£208,000	0	0	£208,000	0	0	0	0	0	£208,000	0	0	0	0	0	£208,000	
SIGNIFICANT MAINTENANCE																	
Expansion joint - minor maintenance	£158,075	0	0	0	0	£158,075	0	0	0	0	0	0	0	0	0	0	
Expansion joint replacement	NA - occurs after 40 years	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Replacement of pavement	£1,299,645	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Replacement of pavement and waterpoofing	£6,033,495	0	0	0	0	0	0	0	0	0	0	0	0	0	0	£6,033,495	
Bearings – minor maintenance	£40,040	0	0	0	0	£40,040	0	0	0	0	0	0	0	0	0	0	
Bearing replacement	NA - occurs after 50 year	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Corrosion protection system – minor maintenance	£1,050,880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Corrosion protection system full renewal	£20,209,780	0	0	0	0	0	0	0	0	0	£20,209,780	0	0	0	0	0	
Maintenance of architectural lighting	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	£5,000	
Replacement of drainage expansion components	£20,000					£20,000										£20,000	
Renewal of SHMS system technology	£500,000					£500,000										£500,000	
	Total per year	£186,570	£169,510	£379,940	£174,370	£1,049,605	£312,000	£331,490	£312,000	£520,000	£20,521,780	£331,490	£312,000	£331,490	£312,000	£7,073,495	**£37,916,315**

Costs after applying discount rates from HM Treasury green Book																
	Discount rate	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%
	Multiplier for discount	1	0.966183575	0.9335107	0.901942706	0.871442228	0.841973167	0.813500644	0.785990961	0.759411556	0.733730972	0.708918814	0.684945714	0.661783298	0.639404153	0.61778179
Years after completion		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Calendar year	Cost	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
ROUTINE MAINTENANCE (excluding items not specific to the bridge i.e. carriageway cleaning and marking, parapets, ITS and lighting maintenance etc…)																
Bridge Master (cl. 10.4.1)	£104,000	£104,000	£100,483	£97,085	£93,802	£90,630	£87,565	£84,604	£81,743	£78,979	£76,308	£73,728	£71,234	£68,825	£66,498	£64,249
Bridge maintenance team	£135,200	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
SHMS – annual management	£5,000	£5,000	£4,831	£4,668	£4,510	£4,357	£4,210	£4,068	£3,930	£3,797	£3,669	£3,545	£3,425	£3,309	£3,197	£3,089
Cyclic maintenance (cl. 5.4.1)	£48,600	£2,430	£4,696	£6,805	£8,767	£10,588	£12,276	£13,838	£15,280	£16,608	£17,830	£18,949	£19,973	£20,906	£21,753	£22,518
Stay cable minor maintenance	£10,000	£10,000	£9,662	£9,335	£9,019	£8,714	£8,420	£8,135	£7,860	£7,594	£7,337	£7,089	£6,849	£6,618	£6,394	£6,178
Access walkways annual maintenance	£4,200	£4,200	£4,058	£3,921	£3,788	£3,660	£3,536	£3,417	£3,301	£3,190	£3,082	£2,977	£2,877	£2,779	£2,685	£2,595
INSPECTIONS																
General Inspection	£19,490	0	£18,831	0	£17,579	0	0	0	£15,319	0	£14,300	0	0	0	£12,462	0
Principal Inspection	£208,000	0	0	0	0	0	£175,130	0	0	0	0	0	£142,469	0	0	0
SIGNIFICANT MAINTENANCE																
Expansion joint - minor maintenance	£158,075	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Expansion joint replacement	NA - occurs after 40 years	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Replacement of pavement	£1,299,645	0	0	0	0	0	0	0	0	0	0	0	0	0	0	£802,897
Replacement of pavement and waterpoofing	£6,033,495	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bearings – minor maintenance	£40,040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bearing replacement	NA - occurs after 50 year	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corrosion protection system – minor maintenance	£1,050,880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	£649,215
Corrosion protection system full renewal	£20,209,780	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maintenance of architectural lighting	£5,000	£5,000	£4,831	£4,668	£4,510	£4,357	£4,210	£4,068	£3,930	£3,797	£3,669	£3,545	£3,425	£3,309	£3,197	£3,089
Replacement of drainage expansion components	£20,000	0	0	0	0	0	0	0	0	0	£14,675	0	0	0	0	0
Renewal of SHMS system technology	£500,000	0	0	0	0	0	0	0	0	0	£366,865	0	0	0	0	0
	Total per year	£130,630	£147,391	£126,481	£141,975	£122,307	£295,347	£118,128	£131,363	£113,965	£507,734	£109,833	£250,252	£105,746	£116,186	£1,553,829

Costs after applying discount rates from HM Treasury green Book																	
	Discount rate	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	
	Multiplier for discount	0.596890619	0.576705912	0.557203779	0.53836114	0.52015569	0.502565884	0.485570903	0.469150631	0.453285634	0.437957134	0.423146989	0.408837671	0.395012242	0.38165434	0.368748155	
Years after completion		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Calendar year	Cost	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	
ROUTINE MAINTENANCE (excluding items not specific to the bridge i.e. carriageway cleaning and marking, parapets, ITS and lighting maintenance etc…)																	
Bridge Master (cl. 10.4.1)	£104,000	£62,077	£59,977	£57,949	£55,990	£54,096	£52,267	£50,499	£48,792	£47,142	£45,548	£44,007	£42,519	£41,081	£39,692	£38,350	
Bridge maintenance team	£135,200	£0	£0	£0	£0	£70,325	£67,947	£65,649	£63,429	£61,284	£59,212	£57,209	£55,275	£53,406	£51,600	£49,855	
SHMS – annual management	£5,000	£2,984	£2,884	£2,786	£2,692	£2,601	£2,513	£2,428	£2,346	£2,266	£2,190	£2,116	£2,044	£1,975	£1,908	£1,844	
Cyclic maintenance (cl. 5.4.1)	£48,600	£23,207	£23,824	£24,372	£24,856	£25,280	£24,425	£23,599	£22,801	£22,030	£21,285	£20,565	£19,870	£19,198	£18,548	£17,921	
Stay cable minor maintenance	£10,000	£5,969	£5,767	£5,572	£5,384	£5,202	£5,026	£4,856	£4,692	£4,533	£4,380	£4,231	£4,088	£3,950	£3,817	£3,687	
Access walkways annual maintenance	£4,200	£2,507	£2,422	£2,340	£2,261	£2,185	£2,111	£2,039	£1,970	£1,904	£1,839	£1,777	£1,717	£1,659	£1,603	£1,549	
INSPECTIONS																	
General Inspection	£19,490	£11,633	0	0	0	£10,138	0	£9,464	0	0	0	£8,247	0	£7,699	0	0	
Principal Inspection	£208,000	0	0	£115,898	0	0	0	0	0	£94,283	0	0	0	0	0	£76,700	
SIGNIFICANT MAINTENANCE																	
Expansion joint - minor maintenance	£158,075	0	0	0	0	£82,224	0	0	0	0	0	0	0	0	0	0	
Expansion joint replacement	NA - occurs after 40 years	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Replacement of pavement	£1,299,645	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Replacement of pavement and waterpoofing	£6,033,495	0	0	0	0	0	0	0	0	0	0	0	0	0	0	£2,224,840	
Bearings – minor maintenance	£40,040	0	0	0	0	£20,827	0	0	0	0	0	0	0	0	0	0	
Bearing replacement	NA - occurs after 50 year	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Corrosion protection system – minor maintenance	£1,050,880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Corrosion protection system full renewal	£20,209,780	0	0	0	0	0	0	0	0	0	£8,851,017	0	0	0	0	0	
Maintenance of architectural lighting	£5,000	£2,984	£2,884	£2,786	£2,692	£2,601	£2,513	£2,428	£2,346	£2,266	£2,190	£2,116	£2,044	£1,975	£1,908	£1,844	
Replacement of drainage expansion components	£20,000	0	0	0	0	£10,403	0	0	0	0	£0	0	0	0	0	£7,375	
Renewal of SHMS system technology	£500,000	0	0	0	0	£260,078	0	0	0	0	£0	0	0	0	0	£184,374	
	Total per year	£111,362	£97,757	£211,704	£93,874	£545,958	£156,801	£160,962	£146,375	£235,709	£8,987,660	£140,269	£127,557	£130,943	£119,076	£2,608,338	**£17,845,513**

A5 Supplier information

Underbridge inspection unit
MBI 210-2/S

Self-propelled working unit

Horizontal outreach below construction	21.00-25.00 m	Dry weight	35,000-36,000 kg
Width of platform (basic / telescopic)	2,00/1,85 m	Total length	14.00/17.20 m
Max. lowering depth	9.50 - 10.00 m*	Total width	2.55 m
Max. vertical overbridging (noise-barrier)	4.00 m*	Total height	4.00 m
Max. horizontal overbridging (sidewalks)	2.55 m		
Max. load on platform (incl. equipment)	1,000 kg		
Max. load on telescopic platform	500 kg		
Rotation area of platform	180°		
Space required on bridge	3.00 m		

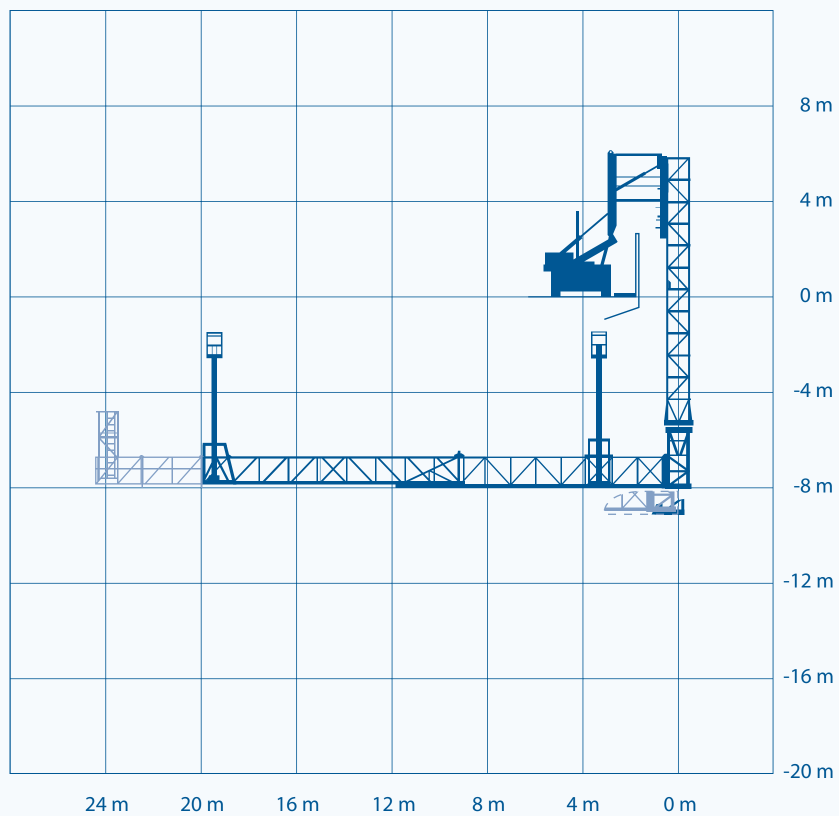
Light barrier, crane for pier inspection, front- and rear view camera control, ultrasound, diesel power unit 25 kVA

Permissible up to max. wind speed of 14 m/s.

Equipment on platform

Power outlet 220/380 V, 2 hydraulic lift,

* as per construction



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Tel.: +49 66 59 / 86-201 - Fax: +49 66 59 / 86-299
bu-geraete@wemo-tec.com - **www.wemo-tec.com**

Subsidiaries:
Italy, Netherlands, Poland, Portugal
Spain, United Kingdom

Representative:
Scandinavia

SAFETY AT ALL HEIGHTS!

Underbridge inspection unit MBL 1.600T/1.750T

Self-propelled working unit

Horizontal outreach below bridge	16.00/17.50 m*
Max. lowering depth	19.50/18.40 m*
Max. working height	21.00/22.50 m*
Max. horizontal overbridging (sidewalks)	4.50 m
Rotation area	2 x 180°
Space required on bridge :	
Overbridging of sidewalk > 3.50 m	3.60 m
Overbridging of sidewalk < 3.50 m	3.10 m
Basket dimensions	1.35 x 1.25 m
Max. load on basket	280 kg

Dry weight	27,500 kg
Total length	11.20 m
Total width	2.55 m
Total height	4.00 m

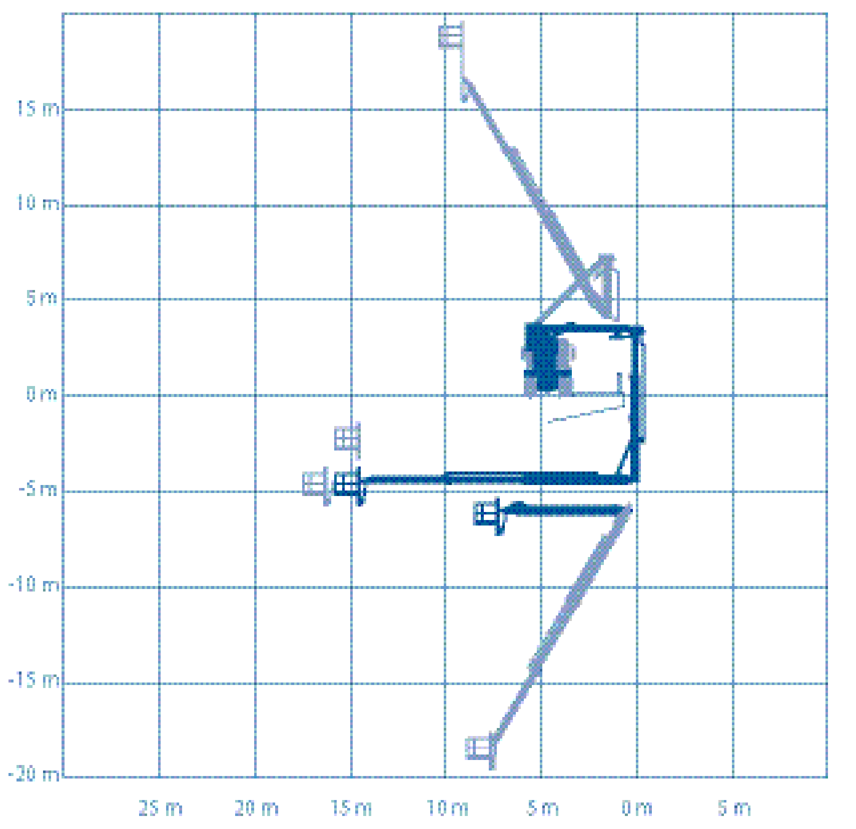
Power set, lighting on arm system, no struts

Permissible up to max. wind speed of 14 m/s.

*as per construction

Equipment on platform

Power outlet 220 V, lighting for night work



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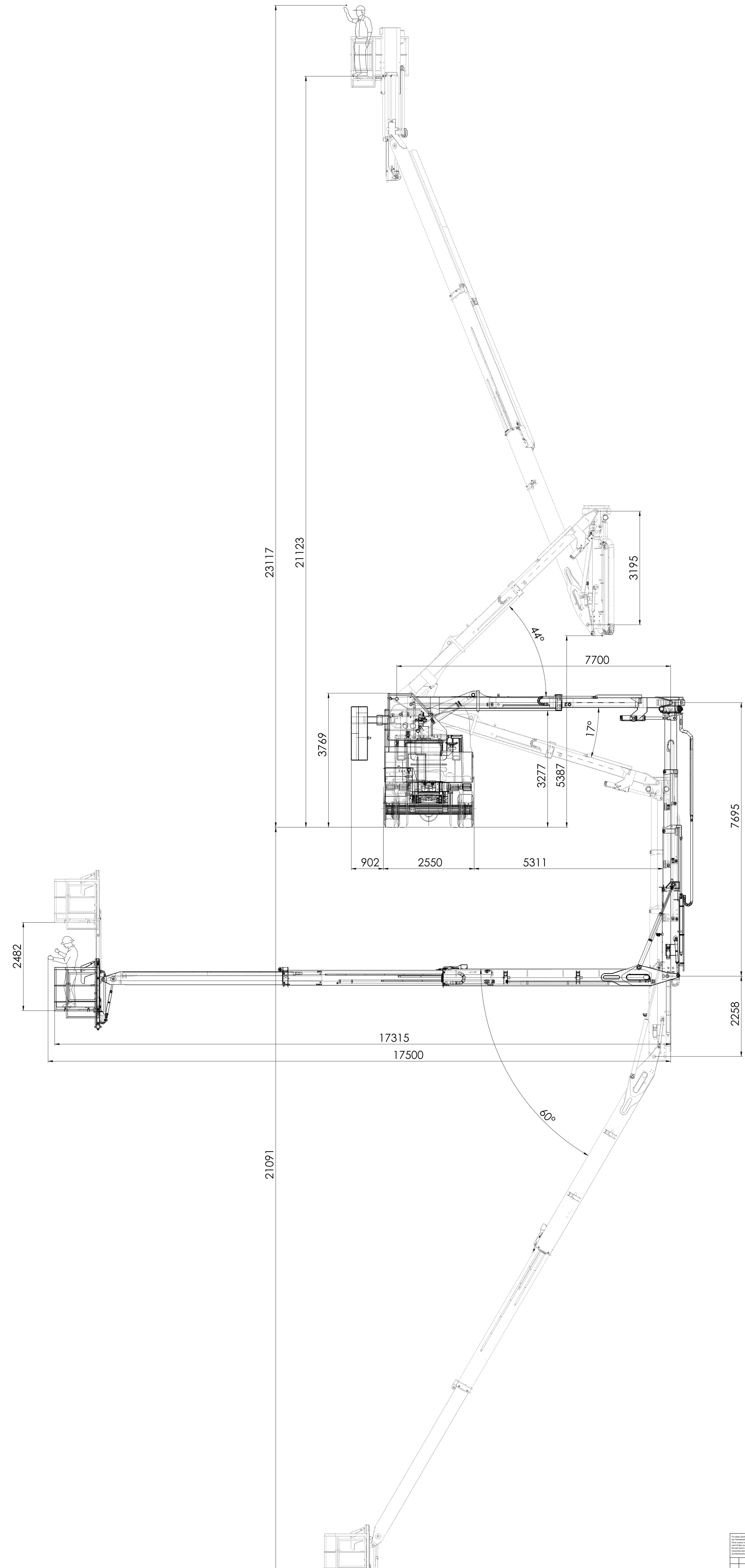


MOOG GMBH
Brückenuntersichtgeräte + Hocharbeitsbühnen
D- 88693 Deggenhausertal
Telefon: +49 (0) 7555- 933-0 Telefax -933- 66

Maßstab: 1:40 | Gewicht: 16583.26 kg

Kunde: Hiab Dubai

	Datum	Name
Erst.	17.11.2014	mschweizer
Bearb.	18.03.2015	MSchweizer
Gepr.		

MBL 1750
Working position

Seriennummer: 01.0507.15

Zeichnungsnummer: MOOG-004885-

Blatt 1 von 2

Zust	Änderung	Datum	Name

Material:

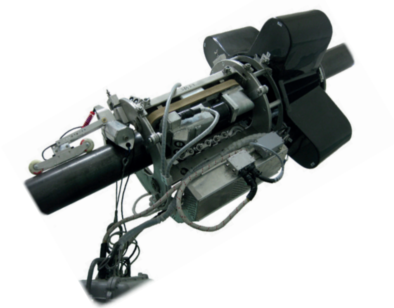
Speicherpfad: C:\MOOG-PDM\Projekte\MBL1750_0507\Zeichnungen\Einsatz\

CONCEPT

ATIS cable robot and diverse panorama image modules used

- no scaffolding, no crane
- short erection time (10 – 40 minutes)
- fast recording time (0,1m/s – 0,5 m/s)
- distance to the object bigger 50 cm

Tunnel- and facade modul



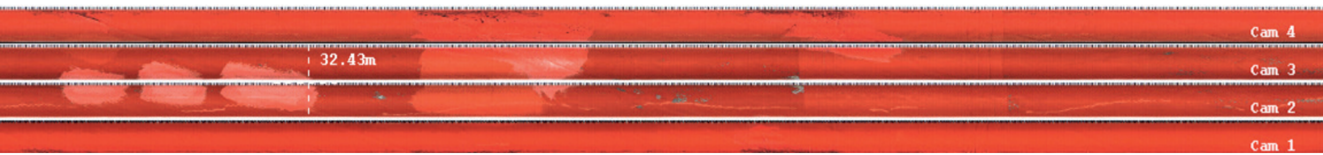
Cable module

Stack module

CONCEPT

All recorded data are provided in one panorama image

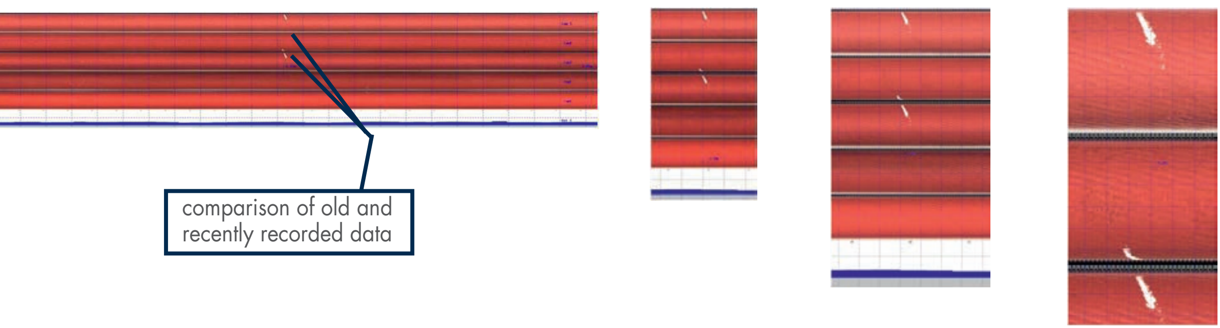
- 200 m cable – 200 m panorama image showing the whole surface (360°)
- 7000 m tunnel – 7000 m panorama image showing the whole surface (360°)
- The panorama image is easy to handle by sliding, zooming and marking.



CONCEPT

The inspected surface of structure is shown in high quality

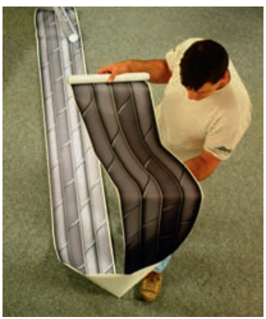
- high resolution zoom levels from 1 % – 400 % implemented
- clear images, no blurring due to high speed cameras
- special data processing of panorama image with no compression

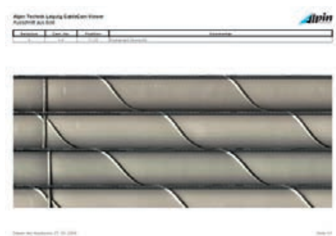


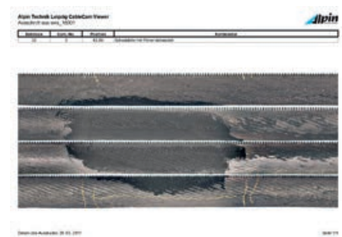
CONCEPT

The panorama data are easy to handle and are comparable

- **ATIS Viewer** with mapping and reporting tool implemented
- after evaluation of the panorama image, reports and extracts can be printed
- data from old inspections can be easily compared with recent data

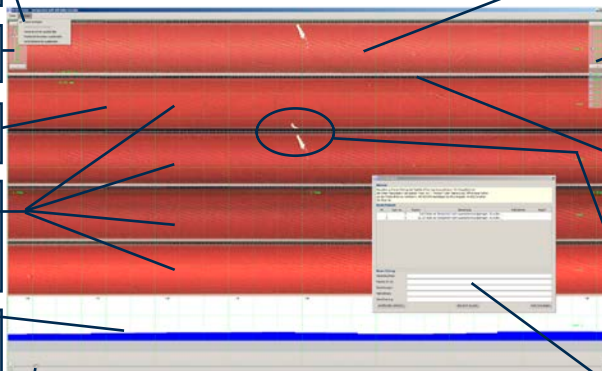






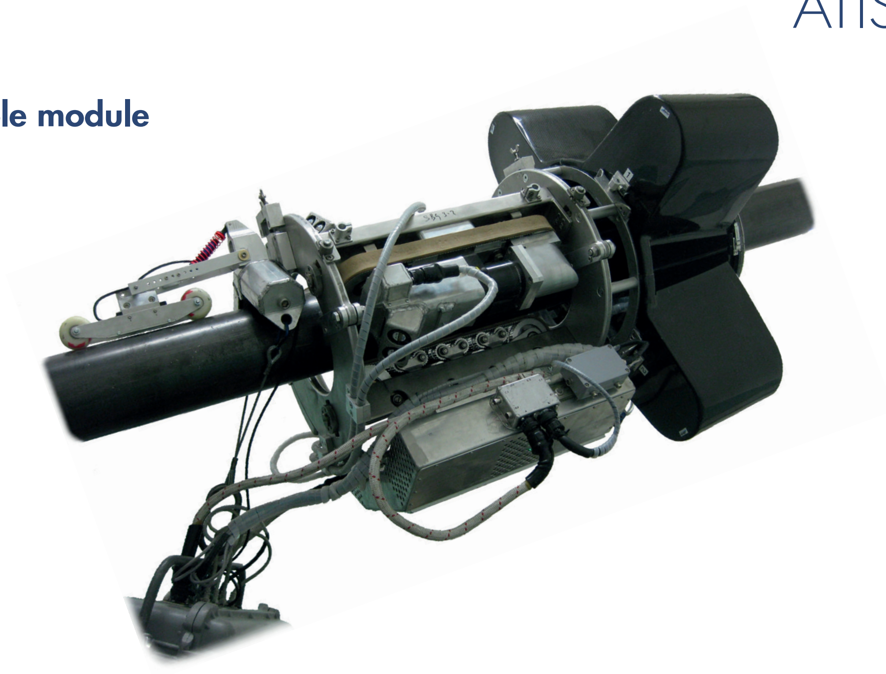
ATIS VIEWER

Evaluation of panorama images



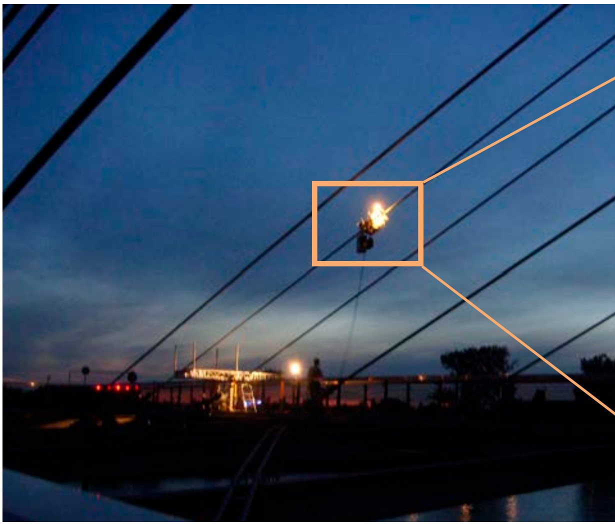
ATIS SVT

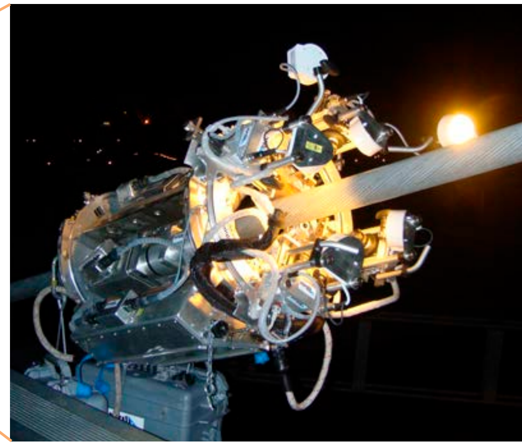
Cable module



ATIS SVT

Work at night





General Description

Alimak SE 300-2000 kg

General

The ALIMAK SE rack & pinion driven passanger and freight elevator range is developed and designed for use in industrial environments. The elevators are suitable for installation outdoors as well as indoors and do not require any enclosed elevator shaft or separate machine room.

Car

The car is constructed of galvanized steel with wall panels of anodized, extruded aluminium (stainless steel as option). The car is well adapted for demanding industrial environments.
The roof of the car has anti-slip strips and is surrounded by a safety railing. A trap door in the roof and a ladder inside the car allows access to the roof from the car. All controls are logically positioned in the car. Ventilation grids contribute to creating a user friendly environment.

Car door

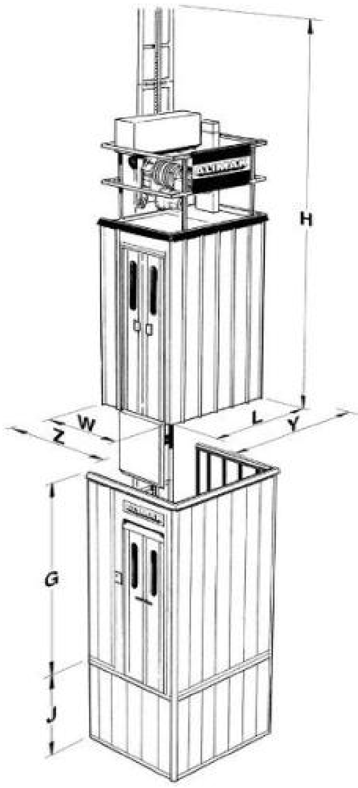
The car door(s) can either be a bi-folding door (available for the smallest door size only, 660 mm) or a horizontal sliding door that wraps around the corner of the car. The sliding door can be chosen for a number of door sizes, from 660 mm to 1530 mm. Both types of doors are made of aluminium (stainless steel as option) and electrically as well as mechanically interlocked which means that the elevator cannot operate unless the doors are securely closed. The doors can be positioned on any of the three car sides away from the mast.

Drive unit

The drive unit on top of the car consists of one or two gear boxes with drive pinion, electric motor, an electro-mechanical disc brake and a centrifugal brake. The drive unit is either equipped with direct-on-line motor controller (DOL) or a variable frequency control (FC). The FC offers smooth starts and stops, accurate floor leveling and generally a higher travelling speed. The centrifugal brake allows the car to be brought down to the next landing at a controlled speed in case of a power failure.

Project Name:	M4 Bridge	Quotation No.:	SAI15-143	Order No.:
		Quotation Date:	2015-06-30	
Your Inquiry:		Quotation Ver. No.:	-	Order Date:

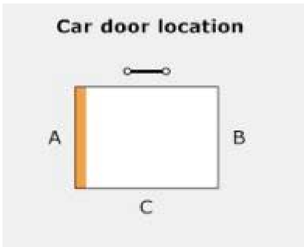
Technical Data SE300FC



GENERAL	
Pay load capacity	300 kg
Number of persons	4 pcs
Average speed up/down at rated pay-load	0.60-1.0 m/s
Lifting height	63 m & 111m
Lift calculated according to:	EN 81.1/A3
Area Classification	Safe area
Total weight	6470 kg

CAR	
Internal car height	2170 mm
Internal car length (L)	1040 mm
Internal car width (W)	780 mm
Car door location	A-side
Min. entrance height car/landing	2010 mm
Min. entrance width car/landing	675 mm
Min shaft length (Y)	1330 mm
Min shaft width (Z)	1495 mm
Total car weight	952 kg

DRIVE UNIT	
Number of motors	1 pcs
Motor control	VFC
Safety device	GF
Safety device tripping speed	0.90 m/s
Cable guiding system	Trolley, left
Cable guiding distance	6 m



MAST	
Total mast length	67890 mm
Type of mast	FE 76.1x4.2
Overhang	1890 mm
Pit depth (J)	1100 mm
Headroom (H)	4230 mm

LANDINGS	
No.of landings (incl. bottom)	2 pcs
Bottom enclosure height (G)	3500 mm

ELECTRICAL DATA	
Control system	Full collective
Voltage	400 V
Frequency	50 Hz
Recommended power supply fuses	20 A
Separate voltage supply	230 V
Starting current	17 A
Power consumption	10 kVA
Location of base panel	Bottom

This data is for information only, it is not intended to be used for design or construction purposes.

Project Name:	M4 Bridge	Quotation No.:	SAI15-143	Order No.:
		Quotation Date:	2015-06-30	
Your Inquiry:		Quotation Ver. No.:	-	Order Date:

Tie and Foundation Forces SE300FC

GENERAL

Main program ALISE Revision	2011.1 .
Lift calculated according to:	EN 81-1:1998

DESIGN CRITERIA, operating condition

DESIGN CRITERIA, not operating condition

FOUNDATION FORCES, operating condition case 1*

Pv	73405 N

FOUNDATION FORCES, buffer collision case 2**

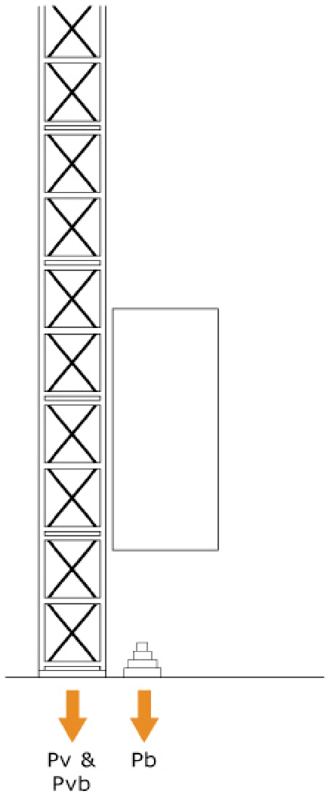
Buffer 9016730-000	2 pcs
Pvb	-5329 N
Pb	77599 N

MAXIMUM TIE FORCES

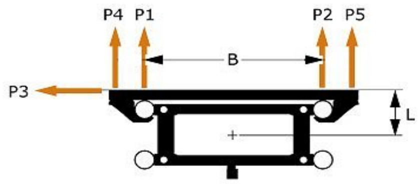
Tie force P1	2151 N
Tie force P2	1959 N
Tie force P3	347 N
Tie force P4	4326 N
Tie force P5	4322 N

TIES

Tie distance 1	6000 mm
Number of ties 1	11 pcs
Distance to structure (L)	180 mm
Outher tie-in fix points (B)	650 mm



Maximum Tie Forces



* [Pv] Total load on base frame from weight of mast, cage, payload and including impact.

** [Pb & Pvb] Vertical forces on base frame due to the car striking the buffer.

Note! The load cases defined do not occur simultaneously.

For a detailed printout of the document "Tie and foundation forces" please contact Alimak Hek AB.

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Fax: +44 (0) 1933 410600

OPTION 2 – 111m Travel. Serving Base + 9 landing.

Based on;-
Base landing @ 0m
First upper landing @ +63m
8 landings @ 6m to 111m total lifting height

ALIMAK SE300FC GOODS/PASSENGER LIFT, generally as per the following:

Lift Type:	SE300FC.
Load Type:	Goods/Passenger.
Capacity:	300kg / 4 passengers.
Car Size (W x D x H):	0.78m x 1.04m x 2.15m.
Car Door:	675mm manual sliding door fitted to 'A' side.
Speed:	1.0 metres/second.
Lifting Height:	Approximately 111 metres.
Pit Depth:	1100mm.
Number of Landings:	10 (Ground plus 9) on the same sides of the lift car.
Landing Doors (Base + 1):	Twin leaf manual swing type, with 675mm opening.
Car & Landing Door Finishes:	Anodised aluminium.
Lift Car Floor:	Aluminium chequer-plate.
Base & Landing Enclosure:	Not included. See options.
Lift Control:	Fully automatic from lift car and both landing levels.
Motor Control:	Variable frequency control.
Remote Diagnostics:	1st year contract included.
Features Included:	~ Centrifugal emergency lowering ~ Overspeed safety device ~ Overload sensing system ~ Emergency telephone
Standard / Regulation:	EN81 / Lift Regulations 1997

Option 2, Pricing Schedule

Hardware price, including the following:

~ Mechanical & electrical design in Sweden.
~ Interface drawings in UK.
~ Compilation of standard manuals and documentation.
~ Manufacture of equipment.
~ Procurement and interface of specialist lift items.
~ Final assembly and testing in Sweden.
~ Pre-delivery client inspection in our Swedish factory, if required.
~ Packing in accordance with our standard procedures.
~ Loading and delivery to UK Site.

Total purchase price:………………………………………………………… £ 189,500.

Installation

Installation, commissioning & testing price, including the following:

~ Pre-installation site visit, including survey inspection of lift area.
~ Compilation of a Safe System of Working.
~ Installation & lift layout drawings.
~ Provision of certification for Alimak Hek personnel, lifting slings, etc.
~ Attendance at site inductions by Alimak Hek personnel (max. 2 hours).
~ Inspection test by Alimak Hek & inspection by a third party inspector.
~ Inspection by the client's representative (maximum one day).
~ Basic operator familiarisation (maximum 6 people.).
~ All labour, transport & expenses associated with the above tasks.

Total installation price: ……………………………………………………...
£ 45,000

Landing Enclosures

Supply & Install, 3–sided landing enclosures 3,500mm high incorporating landing door support frame.

Total supply & installation price per landing …………………………………. £ 2,740

From: Stähle Anna [mailto:astaehle@moog-online.de]
Sent: 22 July 2015 13:30
To: Man, Louisa
Cc: Martin Hooton
Subject: AW: Technical query on underbridge inspection vehicles for cable stay bridge

Dear Louisa,

we herewith confirm that our Under-Bridge Unit MOOG MBL 1750 meets the requirements as shown in the drawing you sent us.

Best regards,
Mit freundlichen Grüßen,
i.A. **Anna Stähle**
Geprüfte Wirtschaftsfachwirtin
Auftragsabwicklung

MOOG GmbH
Brückenzugangstechnik

Im Gewerbegebiet 8
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Tel.: +49 / 7555 / 933-0
Fax: +49 / 7555 / 933-66
email: astaehle@moog-online.de
www.moog-online.de

Von: Man, Louisa [mailto:Louisa.Man@atkinsglobal.com]
Gesendet: Dienstag, 21. Juli 2015 11:04
An: Stähle Anna
Cc: Martin Hooton
Betreff: RE: Technical query on underbridge inspection vehicles for cable stay bridge

Hi Anna

We have now drawn up the proposed arrangement of the MBL1750 unit on our deck cross section to check the interface between the structure and the inspection unit.

I would be grateful if you could review the attached drawing of the deck cross section (drg1010), and also the positioning of the inspection vehicle within that deck cross section (drg2003). We believe that there is sufficient vertical clearance to the wind shield and soffit of the beam in order for the MBL vehicle to operate. As you stated in your previous email the unit will also be able to work between the inclined cable stays (drg1005). However, I would appreciate if you could confirm that the proposed arrangement is still feasible now that we have formalised it on a drawing.

Please could you not circulate these drawings to any other parties, as the design of this structure is still currently being progressed and all information is at draft status.

Many thanks,
Louisa

Louisa Man
Engineer, Transportation
ATKINS

Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW
Atkins Tel: 01372 756085
Arup Tel: 0207 755 5601
Email: louisa.man@atkinsglobal.com **|** Web: www.atkinsglobal.com

From: Stähle Anna [mailto:astaehle@moog-online.de]
Sent: 23 June 2015 16:22
To: Man, Louisa
Cc: Martin Hooton
Subject: AW: Technical query on underbridge inspection vehicles for cable stay bridge

Dear Louisa,

we had a look at the drawings and your explanation.

We also recommend our MBL 1750 unit as it nearly meets all requirements (see drawing attached):

- The required crossing of the wind shield and the lowering depth are no problem for the machine.
- Please note that if you use the max. range of crossing wind shields you have to extend the counter weight on the other side of the truck, as shown in attached drawing. The space required on the bridge would be 902 cm more.
- The only range that does not meet your requirements is the horizontal range under the bridge. This range of our MBL 1750 is up to 17,5 m. As this is a standard unit and all ranges are fully exploited we cannot extend the horizontal range.

Please let us know if you need any further information.

Best regards,
Mit freundlichen Grüßen,
i.A. Anna Stähle

MOOG GmbH
Brückenzugangstechnik

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email: astaehle@moog-online.de
www.moog-online.de

Von: Man, Louisa [mailto:Louisa.Man@atkinsglobal.com]
Gesendet: Dienstag, 23. Juni 2015 11:48
An: Stähle Anna; info@moog-online.de
Cc: Martin Hooton
Betreff: RE: Technical query on underbridge inspection vehicles for cable stay bridge

Anna

Thanks for looking into this. Please assume for now that we want to buy the unit. We would want to have the most cost effective solution though, so whether we buy or rent it would really depend on how much of the deck soffit the vehicle could access.

Regards,
Louisa

From: Stähle Anna [mailto:astaehle@moog-online.de]
Sent: 23 June 2015 07:00
To: Man, Louisa; info@moog-online.de
Cc: Martin Hooton
Subject: AW: Technical query on underbridge inspection vehicles for cable stay bridge

Dear Louisa,

thank you very much for your enquiry.

Before defining the best unit for the bridge access we would like to kindly ask you whether you would like to rent an under-bridge unit or if you want to buy it.
We are looking forward hearing from you soon.

Best regards,
Mit freundlichen Grüßen,
i.A. Anna Stähle

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Brückenzugangstechnik

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Von: Man, Louisa [mailto:Louisa.Man@atkinsglobal.com]
Gesendet: Montag, 22. Juni 2015 17:13
An: info@moog-online.de
Cc: Martin Hooton
Betreff: Technical query on underbridge inspection vehicles for cable stay bridge

Hi there

I have a technical query regarding your underbridge inspection vehicles and its suitability for inspecting the deck soffit of a cable stayed bridge. We are currently developing the access arrangements for a cable stayed bridge located in Wales. The bridge deck is a ladder beam arrangement with a total verge width of 4550mm beyond the edge of the hard shoulder to the edge of the deck. At the deck edge there is a 3000mm high continuous wind shield, which also extends 2775mm below the deck. The inspection unit would therefore need to have an outreach of 4550mm and a lowering depth of 3000+2775=5775mm in order to clear the edge of the deck and the wind shield. Furthermore, the cable stays are anchored to the outside of the deck between the safety barrier and the wind shield. These are anchored at either 8250mm centres (with an incline of 13.23 - 57.65° to the vertical) or 12375mm centres (with an incline of 13.29 - 66.43° to the vertical). The inspection unit would therefore also need to operate within the space between adjacent inclined cable stays.

I have attached a sketch which shows the deck edge cross section and cable stay arrangement which helps to explain the arrangement.

Looking through the range of products on your website, in particular the MBL 1750T vehicle, you have units which can operate on cable stay bridges with external inclined cables. Reviewing the arrangement that exists at this bridge, do you have any vehicles that could operate within the constraints given? We would ideally want to inspect as much of the deck soffit as possible using the unit. Would it therefore also be able to lower beyond the main deck girder, which is 3875mm below the carriageway, and what horizontal range could it reach under the deck? An outreach of 18750mm would be required in order to reach the centreline of the deck cross section.

I would be grateful if you could give me any feedback on the above proposals, and any further information you have on the working envelope of suitable vehicles. It may be that the vehicle will only work for cable stays closest to the tower where the incline of the cable stays is less. If so, do you have a limit on the maximum stay cable incline and minimum cable separation distances over which it can work?

Many thanks in advance for your help.

Kind
regards,

Louisa

Louisa Man
Engineer, Transportation
ATKINS

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Arup Tel: 0207 755 5601
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