PCC Signature Bridge

Structures Options Report

Pembrokeshire County Council

June 2021

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Client signoff

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Introduction

Atkins have been commissioned by Pembrokeshire County Council to produce a Structures Option Report for a replacement structure for an existing footbridge in Haverfordwest town centre.

The existing footbridge is a utilitarian truss-type structure carrying a pedestrian route over the Cleddau River with a deck width of approximately 2.5m wide. The areas on both banks of the river at this location are undergoing redevelopment as part of the wider regeneration plans for Haverfordwest town centre creating new focal points for visitors.

The concept for the new structure is that of a “Signature bridge”, a mixed-use structure with an iconic character which would cater for a new pedestrian and cycle route and also be able to double as a space for public events and performances. The new bridge should have a sense of place and be a destination in and of itself.

This report presents the assessment of the Client’s aspirations, the functional requirements of the crossing and the key site constraints that the new footbridge structure will need to address. Three footbridge options with varying structural forms were prepared and their relative merits compared to support the choice of a preferred option.

This report is to be read in conjunction with the “Signature bridge Concept Design” report prepared by Atkins (Architecture).

1. Scheme overview

1.1. Background and Project Objectives

In recent years the town of Haverfordwest has declined as a centre due to economic downturn and social changes which have led to a perception of poor retail offer and poor quality of the built environment of the town centre. In 2016 the Pembrokeshire County Council (PCC) commissioned planners Nathaniel Lichfield and Partners to carry out a study for strategic development to underpin the regeneration masterplan for the town. Its findings and recommendations were captured in the "*Haverfordwest: A Vision for the Future*" Report. The report identified a set of flagship projects for the regeneration of the town centre (Figure 1-1):

- River Cleddau Corridor and Riverside Promenade – enhancing of riverside walks from centre of town out to the countryside with potential opportunities for footbridge connections;
- Western Quayside Redevelopment – conversion of the riverside market building to accommodate a new library, gallery space and a tourist information centre;
- Eastern Quayside Redevelopment – regeneration of the Riverside Quays Shopping Centre to accommodate a more contemporary town centre offer;
- Heritage Centre – establish a flagship heritage centre to showcase the county's heritage and culture.

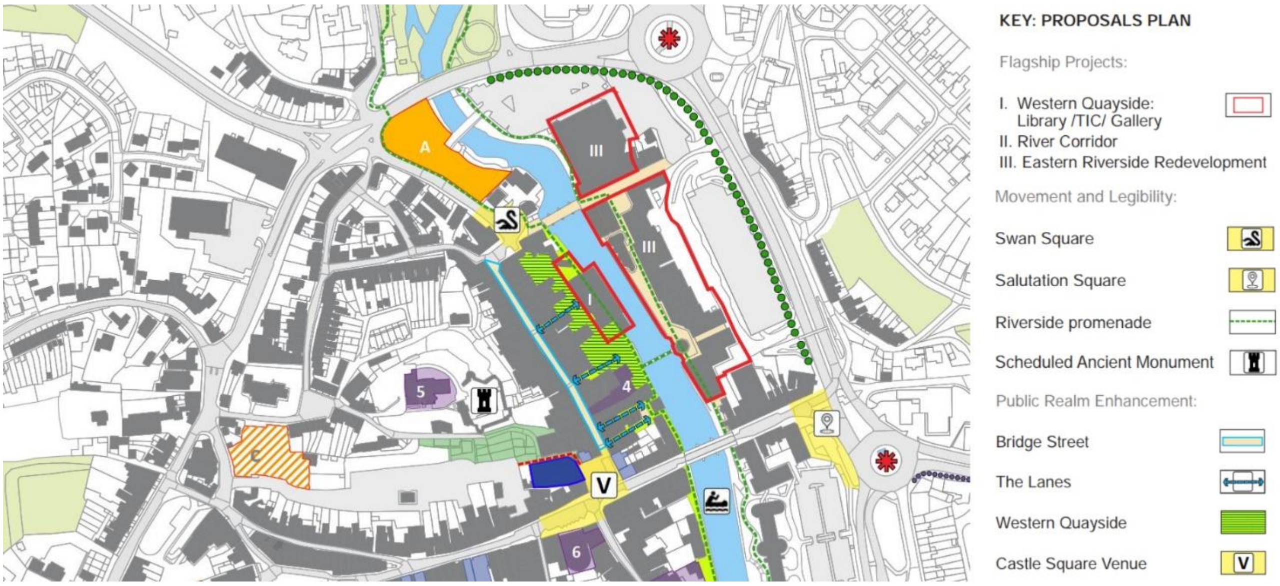


Figure 1-1 – Key proposals for Haverfordwest town centre.

With the flagship projects on Western Quayside and Eastern Quayside being notable trip attractors and both featuring public realm spaces, it was deemed that a new footbridge would be key to maximise the potential of the area. The aspiration for the new structure is that of a "Signature bridge" that would act as a destination in itself, whilst also accommodating Active Travel movements, improve connectivity between the new attractors and serve as an extension of public realm spaces over the Cleddau River.

The "Signature bridge" should have the flexibility for a variety of uses and configurations to enable it as a venue suitable for public events and performances. It is hoped that the footbridge itself will become an attractor and a destination, as opposed to a merely utilitarian piece of infrastructure as it is in it's current form.

1.2. Key Site Constraints

1.2.1. Active Travel interfaces

The Welsh Government, in its commitment to increase levels of walking and cycling to realise the benefits of active travel, introduced legislation in the form of the Active Travel (Wales) Act 2013. The Act received Royal Assent in November 2013 and came into force in September 2014. To achieve its stated policy objectives the Act mandates local authorities to continuously improve facilities and routes for pedestrians and cyclists and to prepare maps identifying current and potential future routes for their use.

Pembrokeshire County Council is currently developing the second phase of the Active Travel legislation which is to produce an Integrated Network Map. The maps will include existing and future routes to be developed over a 15year period. As part of the wider regeneration of the Haverfordwest town centre new active travel routes are being established that will enhance the connectivity of the existing route network with the aim of achieving a truly integrated network (Figure 1-2).

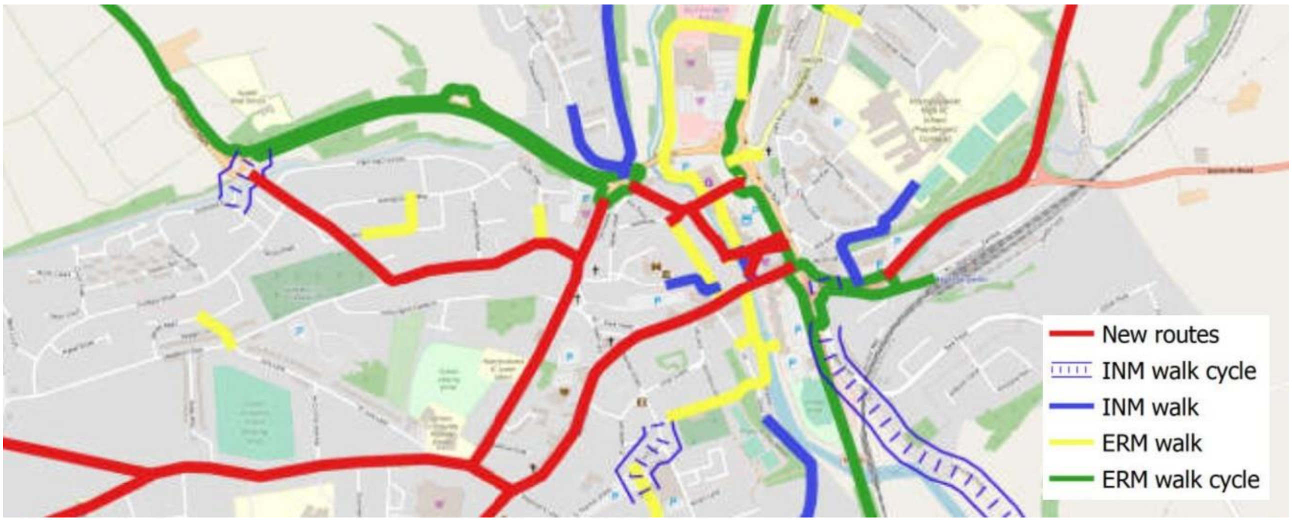


Figure 1-2 – Map of active travel route network at Haverfordwest.

It is anticipated that the new library and the Riverside commercial development will be notable trip attractors that will generate flows of visitors and commuters to the area. The proposed bridge represents an opportunity to become a third attractor in itself and support the new developments in attracting people to the area.

1.2.2. Events and performances

The aspirations for the Signature bridge are that it will not only serve its utilitarian function as an infrastructure asset to accommodate the pedestrian and cycle route in the area but to be an integral part of urban environment as a multi-functional space. The new footbridge should act as an extension of the public realm space on the Eastern Quayside and Western Quayside banks and be a suitable venue for events and performances (Figure 1-3), and support attraction of visitors to the area.

Figure 1-3 – Public realm areas connected by the Signature bridge.

1.2.3. Geology

At the time of writing of this report a Preliminary Sources Study Report (PSSR) for the new footbridge is not available. The British Geological Survey (BGS) maps and historical borehole records were the sole sources of information used at this stage to assess the site's likely ground conditions. The area of interest for the scheme is shown on sheet 228 of the 1:50.000 scale Geological Survey of England and Wales geological map series (Figure 1-4).

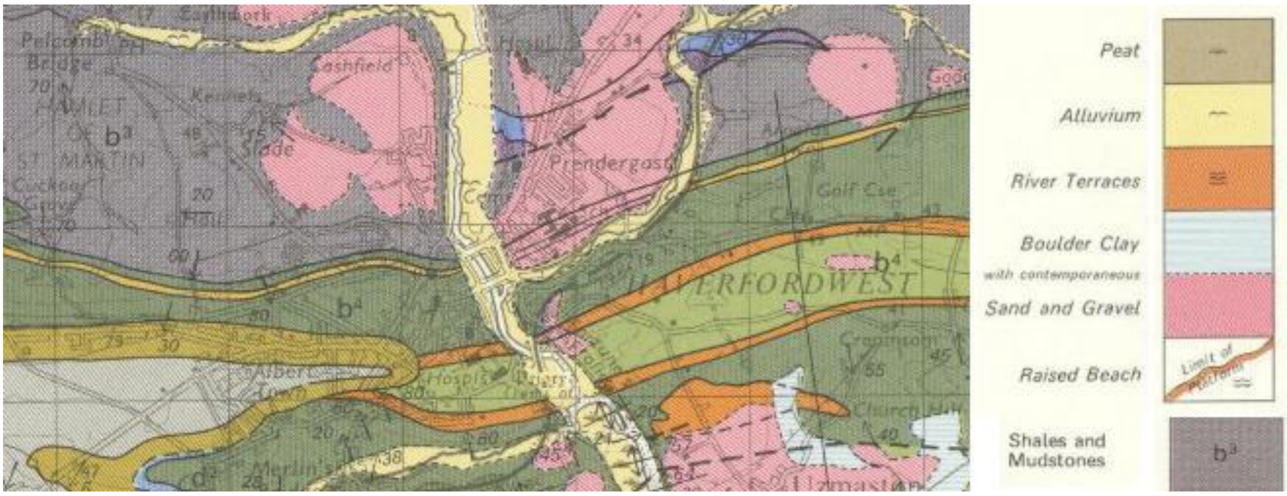


Figure 1-4 – Geology at Haverfordwest (from BGS map sheet 228).

From the BGS mapping and historical borehole records, it is reasonable to assume that the geological strata at the site will be comprised of:

- Localised made ground and embankment fill;
- Soft shaley clay and fine to coarse gravel;

- Dense, fine to coarse gravel with boulders and cobbles;
- Firm yellow/brown silty clay;
- Jointed, fine grained grey sandstone.

A review of the historical boreholes closest to the Signature bridge site (SM91NE85, SM91NE86 and SM91NE92) found that groundwater was encountered at depths between 2.00mbgl and 3.65mbgl. The grey sandstone deemed to be the competent foundation strata occurs at depths of approximately 9.00mbgl.

Historical coal mining workings are not anticipated based on the records retrieved from the web-based "Coal Authority Interactive Viewer". Although there are development high risk areas of surface coal resources south of Haverfordwest, the records show the town centre is clear of any past or present surface mining.

An Unexploded Ordnance (UXO) risk map was consulted together with a Preliminary Desk Study Assessment by Zetica to assess whether there was a significant risk that unexploded ordnance might be present on site. The area was deemed as low risk, with no available records found of any significant bombing or other military activity in the proximity of the footprint of the proposed footbridge.

1.2.4. Environmental constraints

The Signature bridge will connect the Western Quayside and Riverside areas of Haverfordwest town centre and will be located between the Old Bridge and the New Bridge historic masonry arch bridges over the Cleddau River. The areas on either bank of the river have been identified as Flood Zone 3 (1in100 or greater annual probability of river flooding), albeit with the Riverside area adjacent to the river's flood wall being above flood levels (Figure 1-5).

Figure 1-5 – Extents of Flood Zone 3 at Haverfordwest town centre.

The recent schemes undertaken in the Western Quayside area, namely the new Haverfordwest Library and the Ocky White redevelopment have been the subject of flood consequences assessments (FCA's). Given their proximity to the "Signature bridge" site these are deemed to provide relevant background information on flood levels. The "*Ocky White redevelopment, Haverfordewest FCA*" report dated January 2020 by JBA Consultants (doc. ref. No. COK-JBAU-XX-XX-RP-Z-0001-S1-P00.00-Ocky_White_FCA) provides the following levels:

- For the 1in100 year fluvial flood event, 5.22m AOD;
- For the 1in100 year fluvial flood event plus a 30% allowance for climate change, 6.27m AOD.

The 30% allowance for climate change is in line with the recommendations from Welsh Government's "*Technical Advice Note 15: Development and Flood Risk*" (TAN15) for total potential change by the 2080's for West Wales.

The guidelines from Natural Resources Wales (NRW) regarding new-build bridge structures recommends that the bridge soffit levels should allow for a 600mm freeboard level above the 1in100 year flood level plus allowance for climate change. In this case the desirable bridge soffit level would be 6.87m AOD.

It should be noted that the landing level of the existing footbridge on Western Quayside is 5.83m AOD. These levels were retained in the Ocky White public realm space masterplan dated August 2019 (drg. ref. No. OKW-ATK-ZZ-ZZ-DR-L-9105). Considering the shallow deck depth of the existing footbridge its soffit level should be approximately 5.60m to 5.65m AOD.

Since the Signature bridge will need to accommodate DDA compliant routes for pedestrians and cyclists connecting the public realm spaces of the Western Quayside and Riverside banks adhering to the 6.87m AOD soffit level is likely to pose a challenge. In this instance it will be necessary to liaise with NRW regarding the possibility of retaining existing soffit levels or adopt a suitable intermediate level.

Regarding biodiversity within or near the scheme footprint:

- The Western Cleddau river basin is listed as a Site of Special Scientific Interest (SSSI) and a Special Area of Conservation (SAC).
- The site is approximately 2.5km from the Western Cleddau estuary which is part of the Pembrokeshire Coast National Park;
- The site is less than 0.5km from a patch of ancient woodland located by Quay Street.

Since the proposed footbridge landings will be located outside the SSSI boundary and no construction works will be undertaken in the river channel the presence of the SSSI is not expected to pose significant constraints. A Construction Environmental Management Plan (CEMP) will detail the adequate pollution prevention measures and contingency that should be adopted for the construction phase.

1.2.5. Land and property constraints

Land use on the areas adjacent to the bridge on the Western Quayside and Riverside banks will be public realm connecting the future Riverside Quay Shopping Centre with the Haverfordwest library and commercial areas on Western Quayside.

The Western Quayside area has been the subject of redevelopment as part of the wider regeneration of the town centre in line with the aspirations laid out in the "*Haverfordwest: A Vision for the Future*" Report. The first phase of the redevelopment saw the conversion of the existing market building into the new county library and art gallery which opened to the public in December 2018. The second phase is ongoing and involves the redevelopment of the former Ocky White department store and the associated public realm. The land is currently under PCC ownership.

An options appraisal of a masterplan for Eastern Quayside Riverside Quay Shopping Centre was prepared in late 2019, and PCC purchased the Riverside Quay Shopping Centre in early 2021 to support the regeneration aspirations in the area.

1.2.6. Statutory undertakers

The location of public utilities within the area affected by the Riverside redevelopment scheme were obtained from existing records. The statutory undertakers whose equipment may require protection or diversion at the Signature bridge site are:

- Natural Resources Wales – Records show the presence of flood defences, i.e., the flood protection walls that limit the Cleddau River channel;
- Dŵr Cymru Welsh Water– Records designate the presence of surface water, foul water, and combined water sewers on both Western Quayside and Riverside;
- Wales and West Utilities – Records show presence of underground low-pressure gas network in the wider development area, but not in the immediate vicinity of the bridge site;
- Western Power Distribution – Records show the presence of underground low voltage cables on both Western Quayside and Riverside;
- British Telecom - Records denote presence of underground Openreach telecommunications routes on the Riverside bank.

2. Footbridge Options

2.1. General

The provision of a new footbridge to improve connectivity between Western Quayside and the new Eastern Quayside Riverside Quay Shopping Centre is a key part of the vision and aspirations for the regeneration of Haverfordwest town centre. The structure will not only provide a crossing for pedestrians and cyclists using the local active travel route network but also serve as an extension of the public realm space on either bank of the Cleddau River (Figure 2-1).

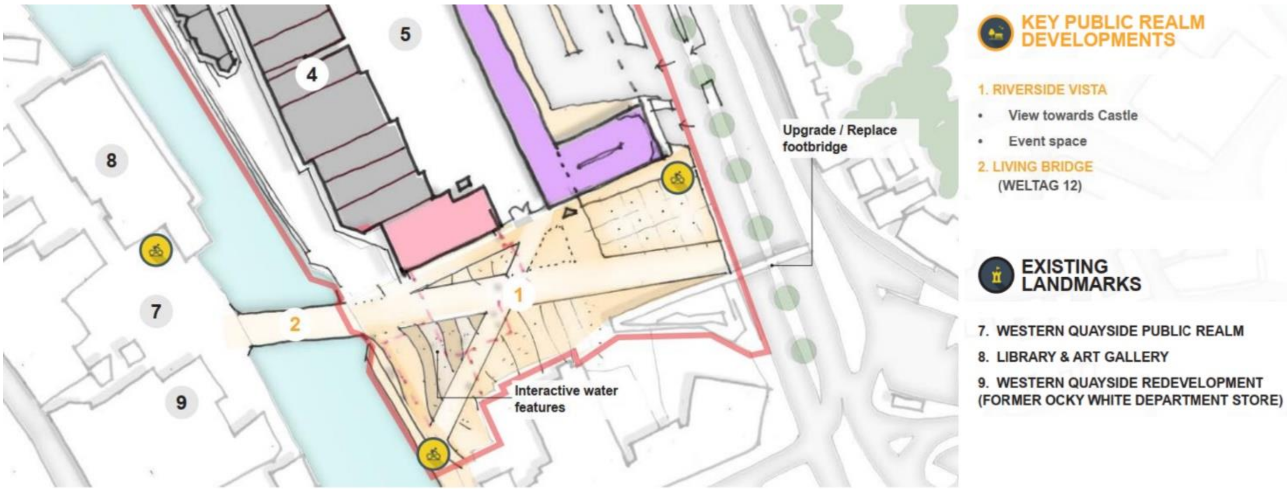


Figure 2-1 – Riverside masterplan at footbridge site.

2.1.1. Span arrangement, cross-section and headroom

In the definition of possible span arrangements for the footbridge only a single-span structure was considered given the requirement to avoid intermediate piers in the Cleddau River due to environmental constraints. From an aesthetic point of view a single-span arrangement has the benefit of producing a structure with a more "open feel" and which is clearly readable by the observer. At the proposed location for the Signature bridge the Cleddau River channel is approximately 30.0m wide. Given that the footbridge alignment is at a 20deg skew angle and bearing in mind the need to locate the foundations behind the existing river flood walls, a 36.0m skew span will be required.

The requirements for the design of walking and cycling routes on and adjacent to the all-purpose trunk road network are given in DMRB Volume 6, Section 3, Part 5, CD 143 "*Designing for walking, cycling and horse-riding*". The Wales National Application Annex to CD 143 is the Active Travel (Wales) Act Design Guidance. The cross-section requirements applicable to the segregated route connecting Western Quayside and the new Riverside Development are given in DE032 "*Cycle Track Away from Road, Separated from Pedestrians*":

- The footway width should reflect the type of use forecast with a minimum of:
  - 2.0m (absolute minimum);
  - 3.5m (desirable minimum where there's frequent use by groups).
- The width of the cycleway should be sufficient to accommodate the forecast level of:
  - 2.5m (absolute minimum for peak hour flow < 50/hr);
  - 3.0m (desirable minimum where peak hour flow is 50-150/hr);
  - 4.0m (for peak hour flow over 150/hr).

The aim would be that all new active travel routes in the area should be designed in accordance with the guidance, with 'desirable minimum' widths met or exceeded where possible. At the time being since no forecast of cyclist use is available a peak hour flow of 50-150/hr will be assumed. The aspirations for the Signature bridge to serve as a location for public events and performances, while maintaining the connectivity of the active travel route during these periods, will require an additional width to either side of the route channel.

Given that at this stage the usage levels for the route are not yet known, two cross-sections were defined:

- A "Do min" cross-section, catering for minimum widths only (Figure 2-2);
- A "Do max" cross-section, to accommodate desirable widths (Figure 2-3).

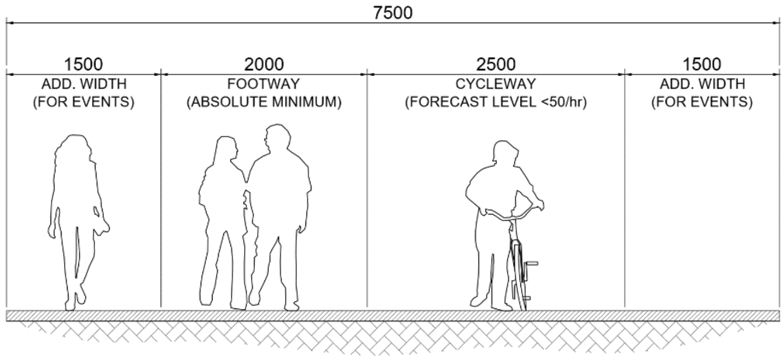


Figure 2-2 – "Do min" cross-section at footbridge

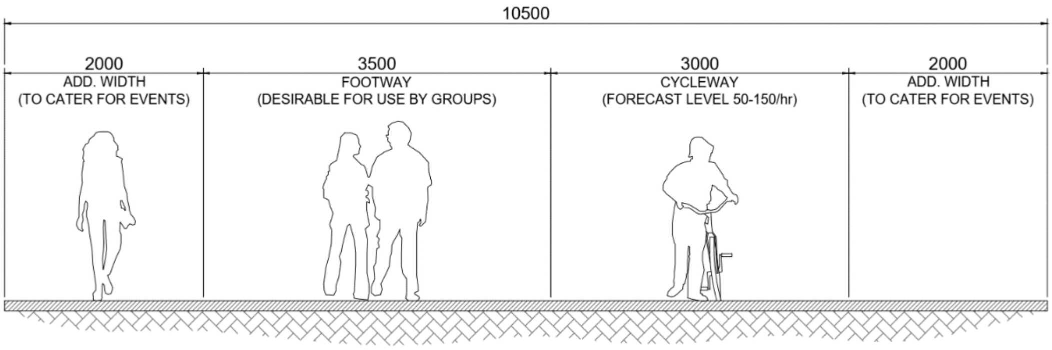


Figure 2-3 – "Do max" cross-section at footbridge

For the purpose of the feasibility study of the footbridge options the "Do max" cross-section will be considered.

The Cleddau River is not navigable at Haverfordwest hence no headroom requirements apply.

2.1.2. Design loadings

The design loadings to be considered for the design of new structures are detailed in the Eurocode suite, namely "Eurocode 1: Actions on structures" and its corresponding UK National Annexes. The relevant parts of Eurocode 1 to be considered in the design of the footbridge are listed in Table 2-1.

Table 2-1 - Actions for the design of footbridges

Type of action	Relevant part of BS EN1991
Self-weight of construction works	BS EN1991-1-1:2002 • Dead loads from self-weight of structural elements §5.2; • Dead loads from permanent non-structural elements §5.2.
Wind actions	BS EN1991-1-4:2005 • Wind forces on bridge decks §8.3; • Wind forces on bridge piers §8.4.
Thermal actions	BS EN1991-1-5:2003 • Uniform temperature component §6.1; • Temperature difference component §6.1.
Actions during construction	BS EN1991-1-6:2005 • Construction loads §4.11.
Actions on footways, cycle tracks and footbridges	BS EN1991-2:2003 • Static models for vertical loads §5.3; • Static models for horizontal loads §5.4. • Actions for accidental design situations §5.6.

The structure will be designed to cater for the presence on the deck of a vehicle for maintenance, emergencies or other services in accordance with the recommendations from BS EN1991-2 §5.3.2.3. The service vehicle dimensions and axle spacings will be as defined in §5.6.3 with its axle loadings modified in accordance with §NA.2.38 of the UK National Annex.

2.2. Structural Form Options

2.2.1. Form of construction

The key site constraints identified for the site highlighted that the construction works on the Cleddau River channel must be avoided. The footbridge's landings will need to lay outside the boundary of the Special Area of Conservation, i.e., behind the river flood walls. The existing buildings of the Ocky White development on Western Quayside pose a constraint on the space available to set up the construction site. The new footbridge will need to be assembled on the Eastern Quayside bank and subsequently craned into position.

Given the lift radius of over 20.0m required for cranage, preference should be given to lightweight forms of construction such as steel. The use of precast concrete solutions would require either a much heavier mobile crane or the lift of a number of small elements to be stitched together once in position. In the case of the latter, the risk of environmental contamination posed by the pouring of concrete over the river is deemed to be considerable. Considering the above constraints, the choice of a precast concrete form for the superstructure of the footbridge was deemed not suitable.

The use of glulam laminated wood was considered but discarded given the robustness required of the elements of the superstructure accessible to the public, which could easily be damaged by vandalism. The need for more stringent long-term maintenance requirements is also a drawback. Experience in recent decades from Continental Europe has seen a number of wooden bridges developing severe faults from deficient water proofing and/or water traps leading to rotting. Humid environments further accentuate the risk of attack by *ligniperdous fungi* (among other types of fungi) which degrade the wood section from within while leaving little to no visible marks on the outer surface.

New materials such as fibre reinforced polymers (FRP) would have the benefit of being fully fabricated off-site and, being extremely lightweight, ease of installation. However, being novel these types of footbridges don't yet have a proven track record regarding durability. They are also at greater risk from vandalism as they are susceptible to damage from impact and fire. Being an emerging technology, at the moment their cost comes with a considerable premium. Given the plan area of deck required to cater for the active travel route and event space the cost of an FRP footbridge would likely be prohibitive, exceeding the budget for the steel options several times over.

For the reasons highlighted above the footbridge options developed will all be construction forms using steel.

2.2.2. Superstructure

Option 1 – Bowstring Arch Bridge

The superstructure will consist of 2No. bowstring arches with a skew span of 36.0m between support centrelines and a rise of 4.5m, with the resulting span-to-rise ratio (f/L) being 8. The offset of the arches in the transverse direction will be 7.0m. The arch ribs will be made from flat plates and have continuous curvature. The ribs will be connected to the box beams at deck level by hangers with a radial arrangement spaced at 2.0m. The hangers will be made from flat plates and fully welded to the arch ribs and box beams. The box beams will also be built-up from flat plates (Figure 2-4).

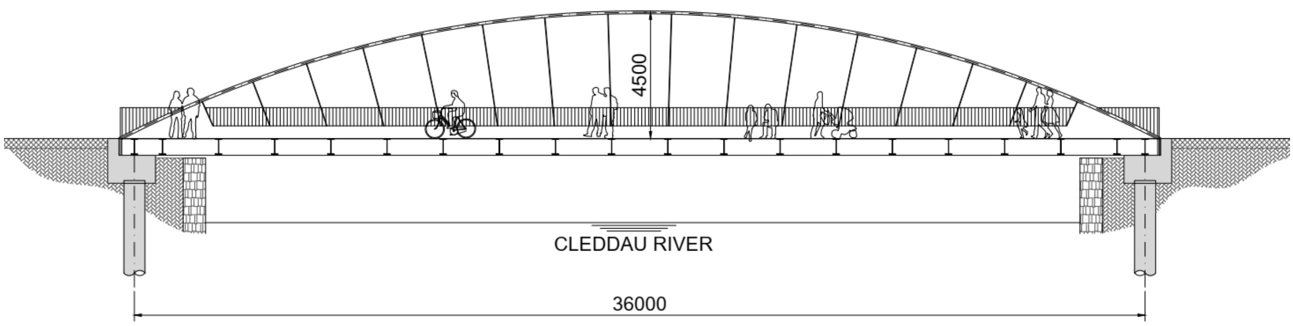


Figure 2-4 – Option 1 bowstring arch bridge long section.

The deck will be comprised by cross girders spanning the 7.0m between the bowstring arches and cantilevering out a further 2.5m. The cross girders will align with the skew angle of the deck and be at 2.0m spacings. A stiffened deck plate will span longitudinally between the cross girders. The channel defined by the vertical planes of the two arches will cater for the active travel route, whereas the width to the outside will serve as a viewing platform under normal use and as additional circulation during events (Figure 2-5). The top of the steel box beams is elevated 0.40m from the footway level and provide for continuous seating across the length of the bridge.

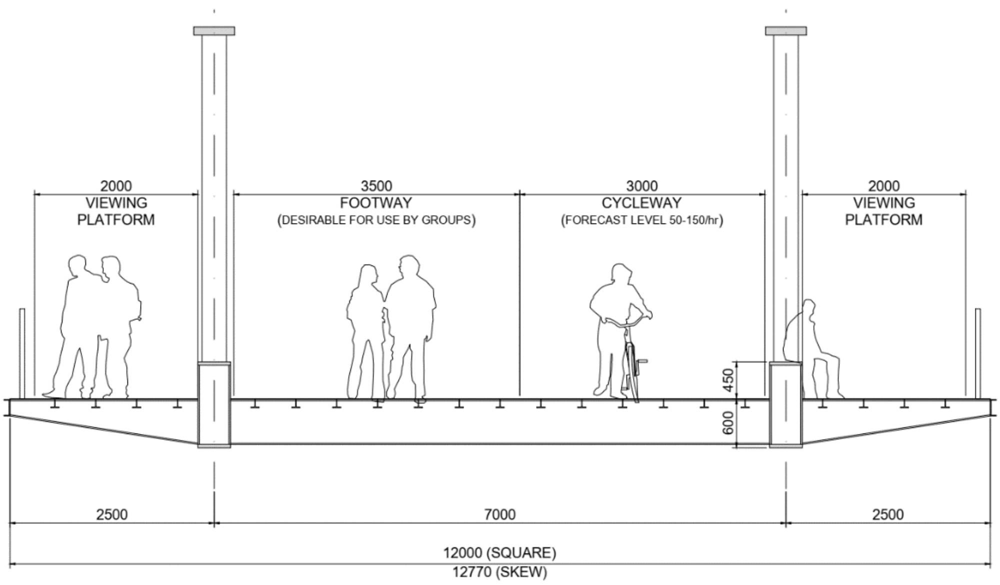


Figure 2-5 – Option 1 bowstring arch bridge cross section.

Option 2 – Cable-Stayed Bridge

The superstructure will consist of an asymmetric cable-stayed bridge with a skew span of 36.0m supported by two planes of stay cables radiating from 2No. 15.0m high pylons on the Eastern Riverside bank (Figure 2-6). The planes defined by the stay cables are offset 7.5m in the transverse direction. The height of the pylons is approximately 20% of the reference span which, in the case of an asymmetric design such as this, should be taken as double the span. The choice for an asymmetric stay arrangement is dictated by the lack of space to accommodate pylons and back stays on the Western Quayside bank.

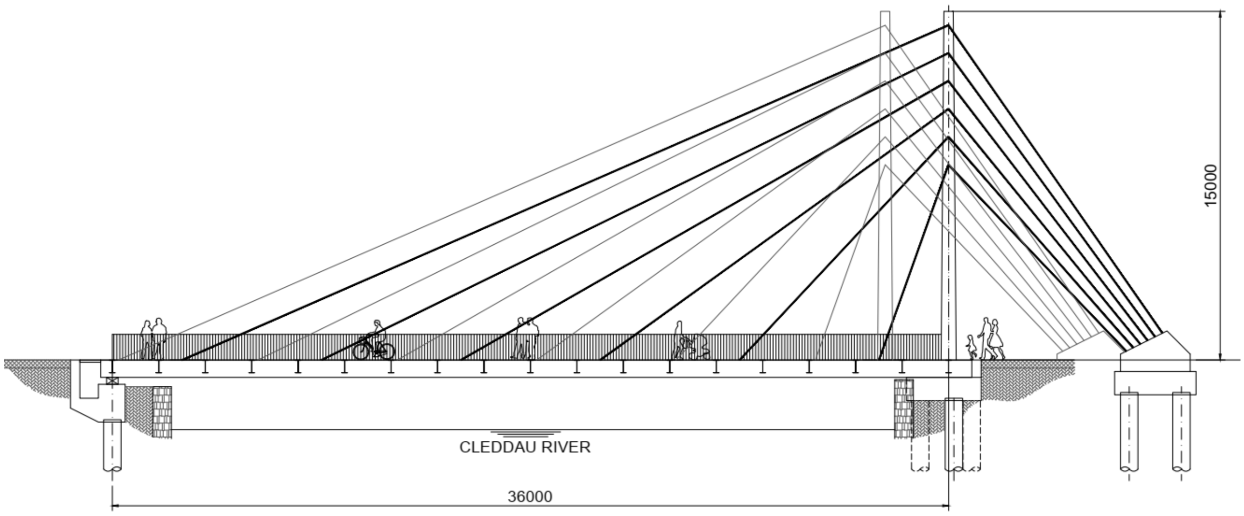


Figure 2-6 – Option 2 cable-stayed bridge long section.

The deck will feature 2No. main longitudinal trapezoidal box beams aligned with the stay cable planes, with the cable anchors spaced at 6.0m. A set of cross girders at 2.0m spacings will span the 7.5m between the box beams and cantilever out a further 2.5m. A stiffened deck plate will span longitudinally between the cross girders. The channel defined by the vertical planes of the stays will accommodate the active travel route, with the outer width to serve as a viewing platform under normal use and as circulation during events. The top of the trapezoidal box beams is flush with the footway level to allow for street furniture to be installed along the bridge deck as required.

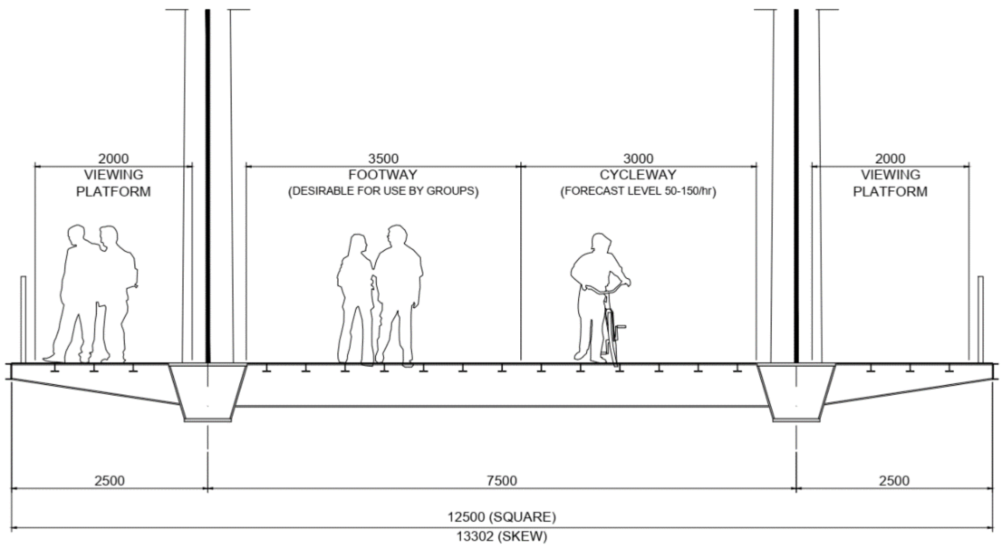


Figure 2-7 – Option 2 cable-stayed bridge cross section.

Option 3 – Haunched Girder Bridge

The superstructure will consist of 2No. longitudinal haunched girders with a skew span of 36.0m between support centrelines. The girder depth will vary between 0.90m at the abutments and 1.80m at midspan, corresponding to a span-to-depth ratio (L/h) of 20. The offset of the girders in the transverse direction will be 7.0m. The girders' web plate will be inclined at 1in3 splaying outwards and the flanges will take the form of triangular cells.

The channel between the longitudinal girders will accommodate the active travel route within a flat deck surface (Figure 2-8), whereas the additional outer deck width will follow an arched profile to create a split-level (Figure 2-9).

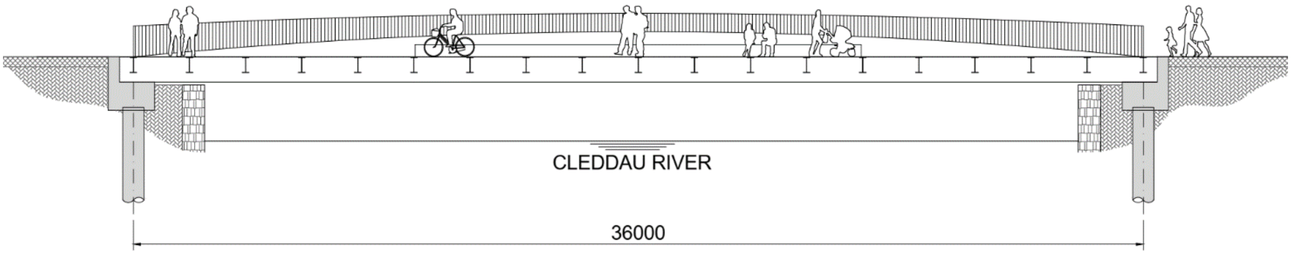


Figure 2-8 – Option 3 long section (through centreline).

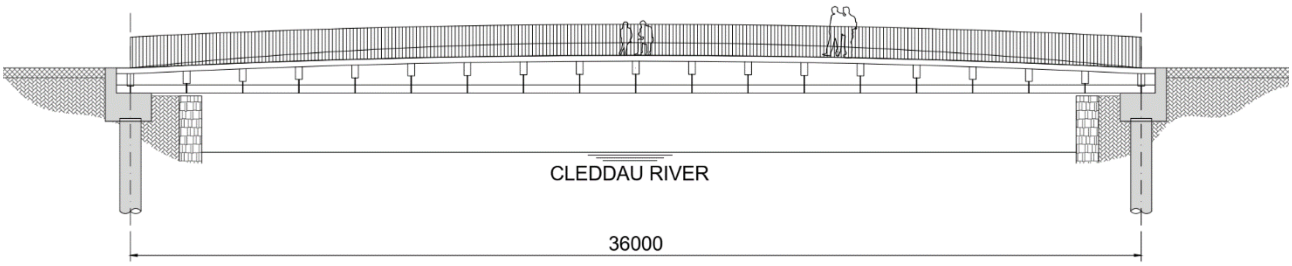


Figure 2-9 – Option 3 long section (through edge of deck).

The deck will be comprised by cross girders spanning the 7.0m between the main girders and cantilevering out a further 3.0-3.3m. The cantilevers on the outer face of the main girders will be positioned longitudinally along an arched profile so that the split-level difference is nil at the abutment, and then increasing gradually up to 0.45m at midspan. The cross girders will align with the skew angle of the deck and be at 2.0m spacings.

The channel between the main girders will cater for the active travel route, whereas the outer width will serve as a viewing platform under normal use and as circulation during events (Figure 2-10). The top flange of the main girders will be flush with the deck at the abutments and increase gradually towards the span, where it achieves a level difference of 0.90m on the inner channel (Figure 2-11). This split-level will be used to create an amphitheatre type stand.

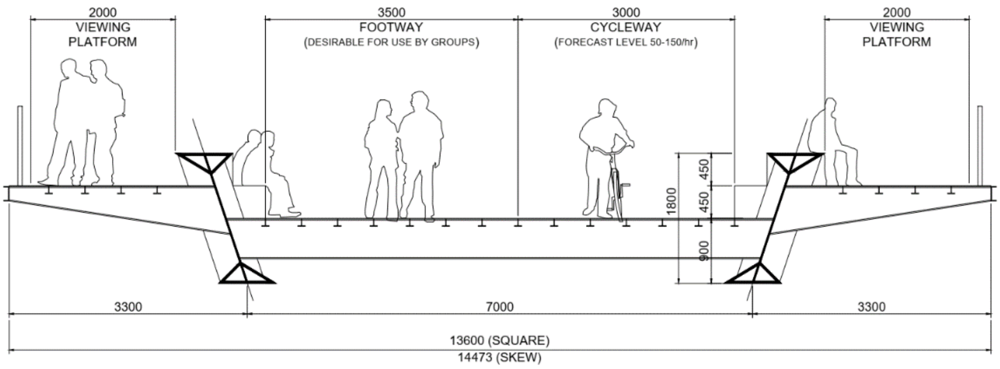


Figure 2-10 – Option 3 cross section (at midspan).

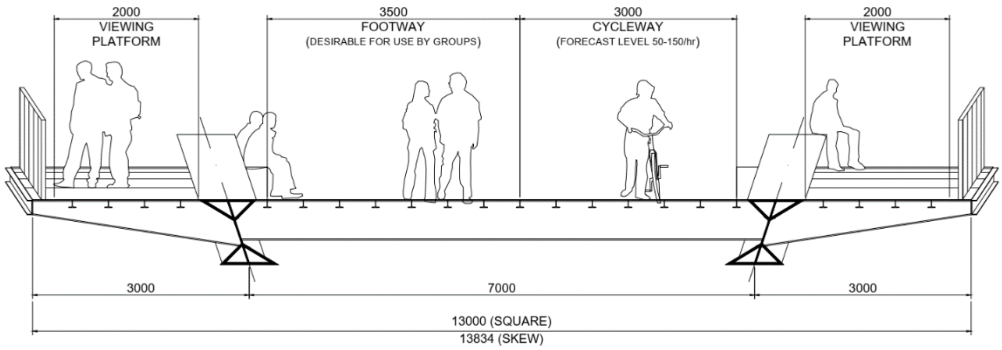


Figure 2-11 – Option 3 cross section (at abutment).

2.2.3. Substructure

Option 1 – Bowstring Arch Bridge

The superstructure will rest on reinforced concrete bank integral pad abutments (Figure 2-12). Insofar as possible preference will be given to integral abutments that dispense with bearings and expansion joints in order to minimise long-term maintenance requirements. In this instance the expansion and contraction movements of the deck will be accommodated by flexure of the foundation piles.

Should the ground conditions negate the possibility of adopting integral abutments then bearings and expansion joints will be required, and provisions will need to be made for their future inspection and replacement. To enable this a gallery will need to be provided to the back of the abutment for access to the bearing shelf (Figure 2-13). The bridge articulation would make use of pot bearings with the fixed point at one of the abutments and free longitudinal movement at the opposite end.

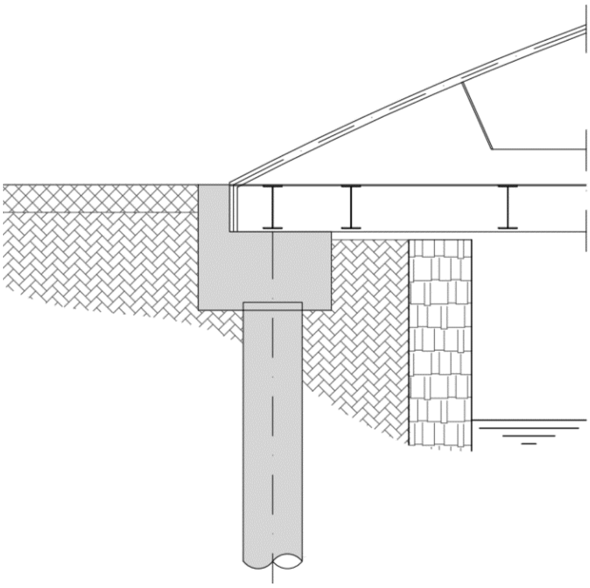


Figure 2-12 – Integral abutment

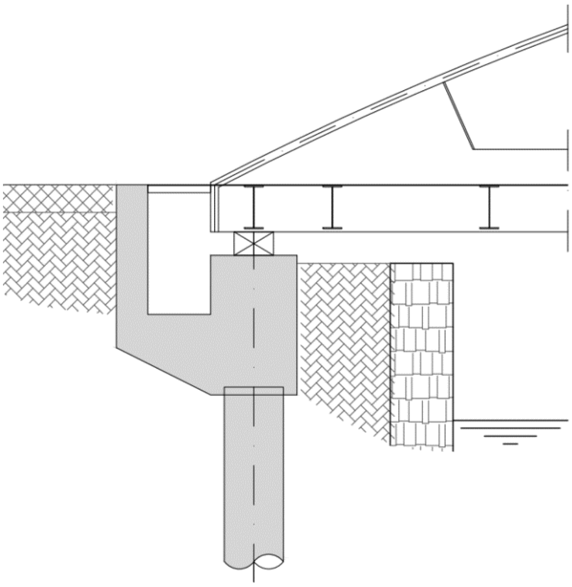


Figure 2-13 – Abutment with inspection gallery

Option 2 – Cable-Stayed Bridge

The superstructure will rest on reinforced concrete bank pad abutments on piled foundations. The abutment on the Western Quayside bank will be a bank pad abutment on a piled foundation (Figure 2-14). The abutment on the Eastern Quayside bank supporting the pylons will be integral with the superstructure. The anchor blocks for the back stays will also be integral with the foundation piles (Figure 2-15).

Given that the fixed point of the superstructure will be at the pylon supports, the expansion and contraction movement of the deck will need to be accommodated by bearings and an expansion joint on the abutment at the Western Quayside bank. To enable future inspection and replacement of the bearings and expansion joint a gallery will be provided to the back of the abutment.

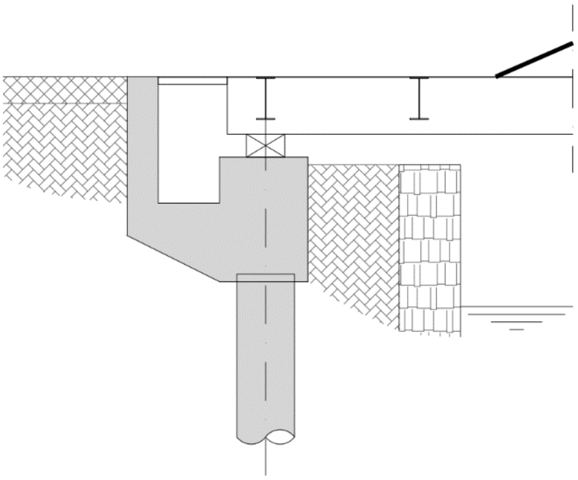


Figure 2-14 – Western Quayside abutment

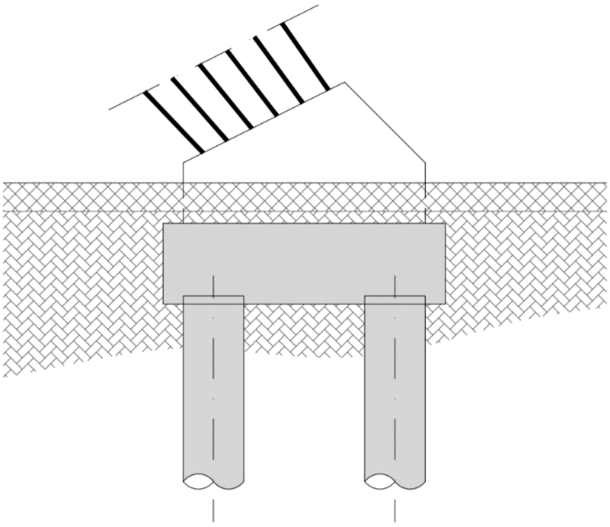


Figure 2-15 – Back-stay anchor block

Option 3 – Haunched Girder Bridge

The substructure for the haunched girder option will be similar to that of the bowstring arch option.

2.2.4. Foundations

At this stage geotechnical information of the Signature bridge site is limited to the BGS superficial and bedrock geology maps and existing boreholes records. Historical borehole logs SM91NE92 and SM91NE85 are located less than 20m away from the Western Quayside and Eastern Quayside landings respectively, and thus are deemed representative of the likely ground conditions at the abutments.

The borehole logs recorded the presence of a 3.5-4.0m layer of fill, underlain by a 5.0-6.0m thick layer of gravel with cobblestones interspersed with thin silty clay layers at varying depths. The bedrock occurs at depths of 9.0-12.0mbgl and consists of fine-grained grey sandstone.

Given the span and width of the superstructure it is anticipated that the magnitude of the vertical loads at the abutments will require that piled foundations 12-15m long down to the grey sandstone strata be adopted.

2.2.5. Aesthetics

Option 1 – Bowstring Arch Bridge

The option for a steel bowstring arch bridge would offer a modern interpretation of an arch type structure and present an interesting juxtaposition with the existing masonry arch bridges. By bridging the gap with a single-span the arch presents a clear and simple structural system, where the flow of forces from the span to the abutments can be readily perceived by the observer (Figure 2-16).

The arch will have a moderate span-to-rise (L/f) ratio of 8, which for the 36.0m skew span will result in a 4.5m rise. The hangers will follow a radial arrangement and will have a longitudinal spacing of 2.0m at deck level. This arrangement gives further emphasis to the regularity of the structure and to the function of its components. The height of the arches is consistent with the volumes of the buildings planned for both banks, hence the footbridge structure would fit-in well with its surroundings in terms of scale.

Figure 2-16 – Option 1 bowstring arch (view from library).

The channel between the 2No. bowstring arches will accommodate the footway and cycleway of the active travel route. The additional width provided outside the arches will serve as viewing platforms and activity zones during normal use conditions and as circulation space during events (Figure 2-17). The top of the box beams will provide seating along the length of the bridge which can be further complemented with other types of street furniture.

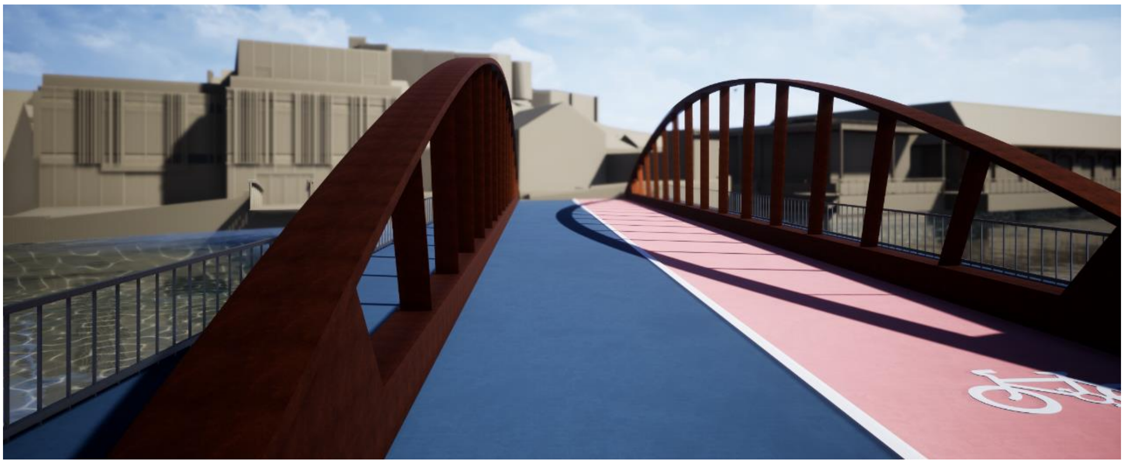


Figure 2-17 – Option 1 bowstring arch (view west from deck).

Option 2 – Cable-Stayed Bridge

The option for a cable-stayed structure would serve as a framing element to the views of the castle from Eastern Quayside and as a gateway to the new plaza when viewed from Western Quayside. The option for a cable-supported would represent a departure from the nearby historic masonry arch bridges and provide a focal point for the surrounding public realm spaces, maximising the opportunity for the bridge to be an attractor to the area.

Cable-stayed bridges typically have a visually open feel to them owing to the slenderness of the deck and small visual perception of the stay cables. Given their height, the pylons are the most prominent elements for this type of bridge. The 15.0m pylon height is derived from the rule of thumb 20% of the reference span which, for an asymmetric design such as this, is double the span. It should be noted that the pylon height would considerably exceed the neighbouring buildings and will require further design consideration to mitigate impacts on the surroundings (Figure 2-18).

Figure 2-18 – Option 2 cable-stayed (view from library).

The active travel route's footway and cycleway will be placed between the 2No. planes of the stay cables, with the additional width to the outside to serve as viewing platforms and activity zones during normal use conditions and as circulation space during events. Except for the stay anchors, the deck surface will be free from obstructions, providing flexibility for the installation of seating and other types of street furniture (Figure 2-19).

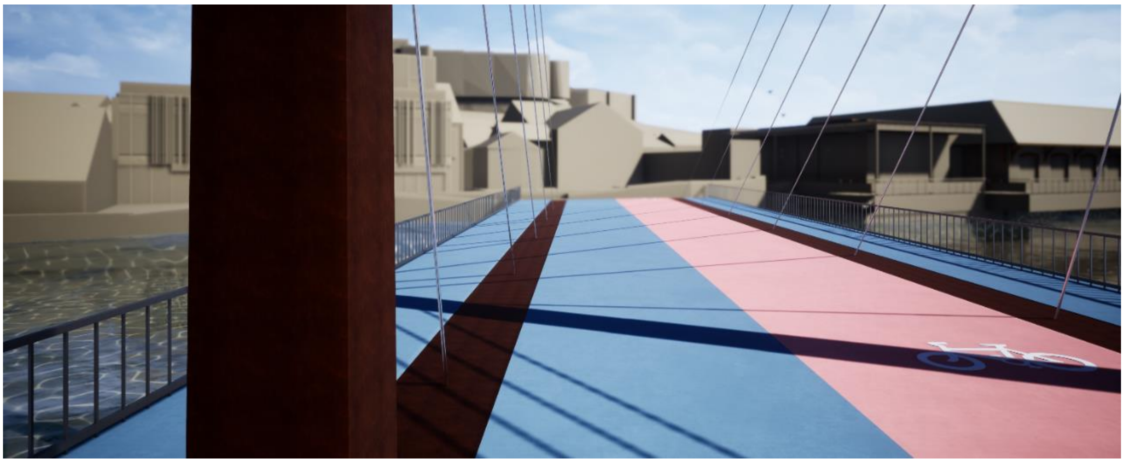


Figure 2-19 – Option 2 cable-stayed (view west from deck).

Option 3 – Haunched Girder Bridge

The option for a variable depth girder bridge would provide a flexible space capable of responding to multiple uses in an optimal way. The girder depth would have smooth transition from 0.90m at the supports to a maximum of 1.80m at midspan, corresponding to a span-to-depth (L/h) ratio of 20. The slenderness of the deck would be accentuated further by the shadow cast by the deck cantilevers which would partially conceal the main girder (Figure 2-20).

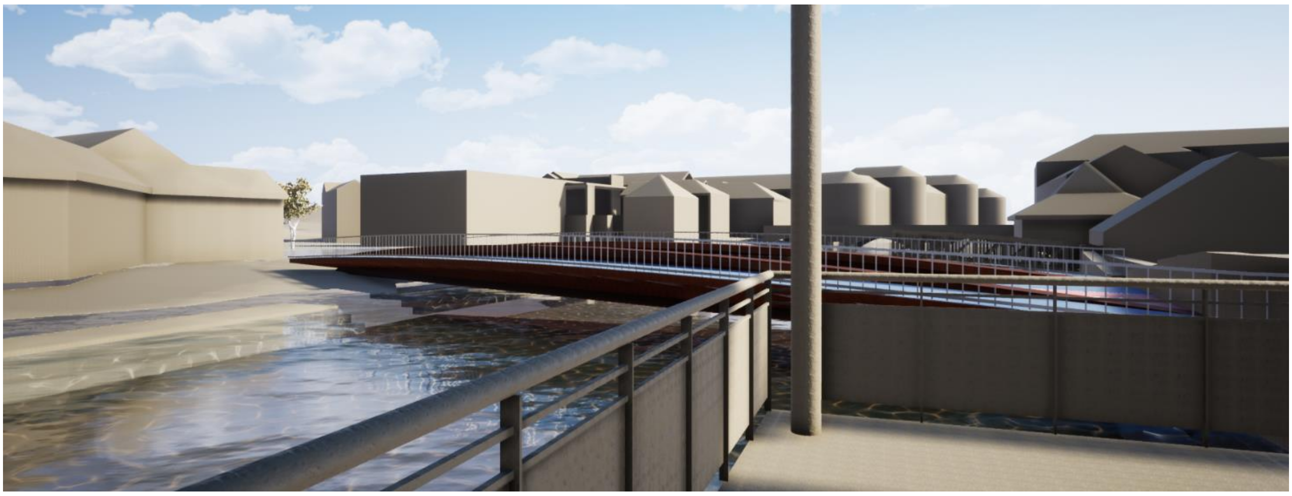


Figure 2-20 – Option 3 haunched girder (view from library).

The channel between the 2No. main girders will be flat to accommodate the footway and cycleway of the active travel route. The additional width provided outer cantilevers will follow an arched profile to create split levels which will serve as viewing platforms and activity zones during normal use conditions and as circulation space during events (Figure 2-21). The top flange and the inside face of the main girders will provide for an amphitheatre like seating to the central area of the deck which can be further complemented with other types of street furniture.

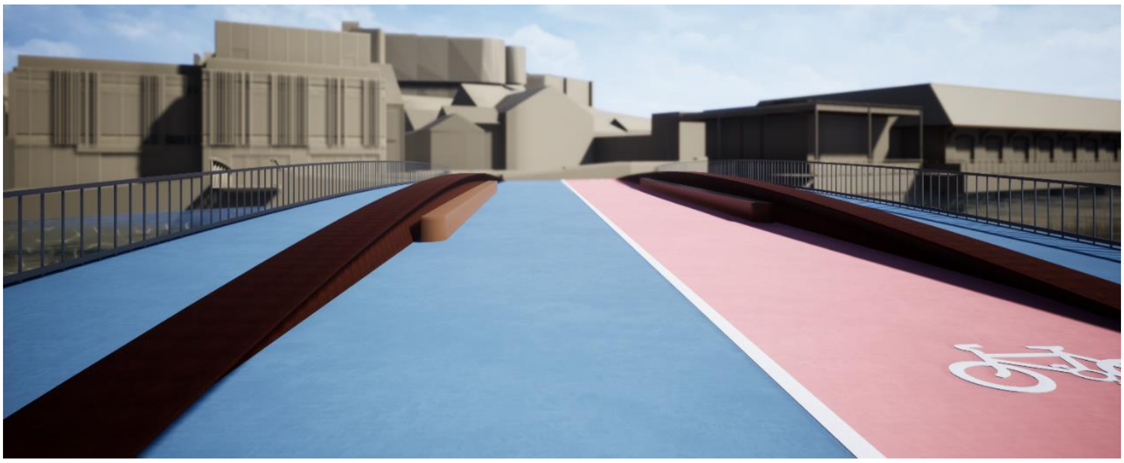


Figure 2-21 – Option 3 haunched girder (view west from deck).

2.3. Buildability and Maintenance

2.3.1. Buildability

The proposed solutions rely on standard construction techniques to simplify and speed up construction.

The construction of the foundations of the abutments is not likely to require temporary retaining structures given their shallow depth. The construction of a small piling platform of suitable granular material may be necessary. For the casting of the abutments the use of standard formwork shutters offers a cost-effective solution. Although with only two abutments to cast there is little opportunity for re-application of a set of formwork, the simple shapes proposed can be formed from standard elements and should provide an economical solution.

The steelwork of the footbridge would be fabricated off-site. Shop splices and connections should be fully welded with high strength friction grip bolted connections used for field splices. Given the restrictions to abnormal load movements the steelwork will need to be transported in sections for compliance with the requirements for Special Types General Order vehicles. The longitudinal members will need to be transported to site split in (at least) 2No sections to comply with the 27.4m maximum rigid length. The final assembly of the steel work will take place on site.

The erection of the footbridge steelwork will rely on mobile cranes to lift in place the fully assembled longitudinal members. Attending to the estimated lift weights of approximately 50 tonnes a mobile crane with a lift capacity of 500 tonnes will be required. It is assumed that the mobile crane will be positioned on the Eastern Quayside bank for lifting operations. With the main longitudinal members in place and temporary bracings installed (if necessary), the cross-girders will then be bolted to the longitudinal members and the deck plate fitted.

In the case of Option 2, a carefully planned tensioning sequence of the stay cables would be required to ensure the final geometry of the structure is achieved without overstressing of the longitudinal trapezoidal box beams and/or pylon.

Having adequate access to site is crucial to enable the construction works. The Eastern Quayside site has direct access from the A40 via Salutation Square roundabout and Cartlett Road.

2.3.2. Details and finishes

The proposed finishes for the concrete elements of the foundations and abutments are detailed in Table 2-2.

Table 2-2 – Finishes to concrete elements as per MCHW Series 1700.

Element	Surface	Finishes
Abutments	Buried vertical surfaces	F1
	Exposed vertical surfaces	F4
	Exposed horizontal surfaces	U3

The use of weathering steel and the corrosion allowances to be adopted shall be based in accordance with the requirements DMRB Volume 2, Section 3, CD 361 "*Weathering steel for highway structures*". A site-specific atmospheric corrosivity classification (C1 to CX) shall be determined prior to design, with the corresponding corrosion allowances for structures with a 120year design life as per Table 6.3.

The use of weathering steel without an additional corrosion protection treatment is not permitted where any of the following exposure conditions apply:

- The atmospheric corrosion classification has been determined as C5 or CX;
- The airborne salinity level has been determined as S3;
- The atmospheric pollution level has been determined as P3.

The surface preparation of the superstructure's steelwork will be in accordance with the provisions of Series 1800 of the MCHW "*Specification for Highway Works*":

- Uncoated surfaces of weather resistant steel – the surface shall be blast cleaned to grade Sa2 to BS EN ISO 8501-1 to achieve a uniform surface.
- Steel surfaces to receive paint applied protection systems - the substrate surface shall meet the requirements of BS EN ISO8501-3:2007 preparation grade P3.

The deck surfacing will consist of a 4mm thick waterproofing and skid resistant wearing course, by means of a proprietary resin-based screed combined with an aggregate over scatter and sealer.

Given that the structure will form part of an active travel route provisions for lighting will be necessary. The obstacle free route should be illuminated to a minimum of 100 lux measured at floor level.

2.3.3. Maintenance

Insofar as possible preference will be given to integral structures so that the maintenance works required throughout the 120 years' service life of the footbridge structure will be kept to a minimum.

If the atmospheric conditions on site negate the use of weathering steel without additional corrosion protection treatment, then normal steel with applied paint protective systems should be adopted. Such type systems will need re-application at regular intervals. In accordance with the Design Manual for Roads and Bridges (DMRB) Series NG1900 §11 types I and II protective systems should not require major maintenance for up to 20 years.

Alternatively, a fluoropolymer resin topcoat paint type such as "Lumiflon" could present a more durable option. This type of coating is immune to degradation from ultra-violet radiation and has improved colour and gloss retention over time. The product has an expected life time for bridge coatings of at least 60 years. It has been adopted extensively for use in bridges in Japan where it is the mandatory specification for bridge topcoats since 2005. Examples of previous application in the UK by local authorities include the Castle Bridge in Bristol, Somerset. The product is expected to obtain BBA certification this year.

Consideration should be given to the risk of graffiti, which is notoriously difficult to remove from weathering steel. In this instance it is recommend that the steelwork above deck be painted for protection against this type of vandalism.

The long-term performance of the reinforced concrete abutments will be assured by compliance with Serviceability Limit States criteria, namely the control of crack widths, together with adequate detailing of the reinforcement, good workmanship and construction practices. The use protective coatings to the exposed concrete surfaces will not be required. Buried concrete surfaces will receive bitumen coatings as per standard industry practice.

In the case of integral abutments, the reinforced concrete elements will be hidden below ground and not accessible for inspection. If instead bank pad abutments are adopted, their inspection will be possible from the gallery provided for access to the bearing shelves. Periodical inspection of the bearings and expansion joints will be required as well as their replacement when their 50-year design life expires. The bearings will likely be proprietary of the pot bearing type. For the expansion joints a durable solution would consist of textured steel cover plates bridging the gap between abutment and deck.

The periodic inspection of the stay cables and pylon anchorages of Option 2 would require the use of safe means for working at height, namely a mobile elevating work platform (MEWP) or a boom lift. Recent experience has shown risks of cable vibrations in high winds requiring remedial works to install cable damping. Attending to the footbridge location such risk is low, but it cannot be ruled out completely.

It is recommended that the inspection regime for the maintenance of highway structures is adopted. Periodic inspections should be in accordance with DMRB Volume 3, Section 1, Part 4, BD 63/17 “Inspection of Highway Structures”:

- General Inspections at 24-month intervals;
- Principal Inspections at 6-year nominal intervals.

2.3.4. Utilities and drainage

It is anticipated that the crossfall and longitudinal profile of the deck will allow surface water to run off the bridge deck and into drainage channels extending the full width of the deck at the abutments.

At the end of construction, the footbridge will not carry utilities or stakeholder’s apparatus and it is not expected that any will be required for future use.

2.3.5. Health and safety

Along with the typical risks associated with construction which a competent contractor should be able to identify, the construction of the new footbridge will need to consider the risks arising from working over a watercourse:

- The installation of the piles and the construction of the abutments must not destabilise or otherwise damage the existing river flood defence walls;
- Suitable control measures must be in place when casting the concrete of the foundations and abutments to avoid environmental contamination of the Cleddau River;
- The stability of the steelwork during construction needs to cater for any additional construction loads and consider the need for temporary bracings;
- The safety of the lifting operations must always be assured. The maximum lift weights must be compatible with the radius resulting from the crane’s positioning. Attention needs to be made to the location of the lifting points on the superstructure;
- Means of safe working over a watercourse will need to be in place for the installation of the cross girders and steel deck plate. Suitable measures will need to be in place to mitigate the risk of falls from personnel and/or equipment.

A Designer’s Hazard Risk Register is included in Appendix A.

2.3.6. Departures from standards

The combined thin surfacing / waterproofing of the footbridge is an aspect not covered by standards. A departure will be required for a BBA/HAPAS certified deck waterproofing and skid resistant surfacing system.

2.3.7. Drawings

A set of general arrangement drawings of the 3No. footbridge options is included in Appendix B.

3. Preferred Option

The 3No. structural form options proposed are all suitable solutions from an aesthetic point of view. The bowstring arch option results in a dynamic and visually appealing structure. Its arch ribs and hangers being made from flat plates give it an inherently light and open feel despite the considerable rise of the arches. The cable-stayed option has the slenderest deck and its hangers give it the highest degree of transparency. In contrast, the pylon height required may have the largest impact in terms of a ‘signature structure’, not withstanding the need to balance scale with the visual mass of the neighbouring buildings. The haunched girder option makes use of the gently arched footways of the viewing platforms to achieve a dynamic profile. The shadow line cast from their cantilevers partially hides the longitudinal girders enhancing the apparent slenderness of the structure.

The construction methods are identical for Option 1 and 3, with Option 2 being somewhat more complex, due to the nature of the structure. Both banks have ready access to enable a piling rig to install the foundation piles. It is anticipated that temporary retaining structures such as sheet pile walls will not be required for the construction of the abutments. Once the piles are installed the bank pad abutments can be built using standard formwork. The steelwork of the superstructure would be fabricated in the workshop and delivered to site in sections for final assembly. The lift in place of the main longitudinal members would be carried out with a 500-tonnes mobile crane positioned on the Eastern Quayside bank. The cross girders would then be installed starting from both abutments and followed by the fitting of the deck plate. In the case of Option 2, a careful tensioning sequence of the stay cables would be necessary to avoid overstressing during these stages. Construction would be complete with the surfacing of the deck and installation of parapets, lighting and street furniture. Despite the similar construction sequence required of all 3No. options, the simpler form of construction of the haunched girder would make it the preferred option in regard to buildability.

In regard to future maintenance requirements both the bowstring arch and haunched girder options have the considerable advantage of possibly using integral type abutments. This would allow them to dispense with bearings and expansion joints which would require periodic maintenance at regular intervals. Given their design life of 50-years, the bearings and expansion joints would need to be replaced at least twice during the 120-year design life of the bridge. The cable-stayed option does not lend itself to the adoption of an integral abutment at the Western Quayside bank. Although the stay cable design life is also 120-year, provisions for their replacement are necessary to future-proof against damage to one or more cables. It is also likely that re-tensioning of the stay cables will be required during the service life of the bridge.

The aspiration for Signature bridge to be a multi-functional space serving not only as a piece of infrastructure but also as a stage for public events and performances is one of the main goals of the scheme. This implies that the proposed footbridge options must possess enough flexibility to accommodate the diverse uses anticipated. While all 3No. options address this requirement, it is deemed that the haunched girder option offers the most versatility. By dispensing with hangers or stay cables the deck is left unencumbered. This feature, together with the interconnection of the route channel and viewing platforms by means of the amphitheatre seating, makes it the ideal option for hosting events.

Indicative costs for the structures were prepared based on experience from similar past projects and inquiries with steel fabricators. The reference rates per square metre obtained represent raw construction costs of the bridges from foundations, abutments, steel fabrication and installation. It is assumed that preliminaries and site overheads are covered elsewhere. The costs associated with ancillary items such as claddings and street furniture required by the architectural concept have also not been accounted for.

A set of lower/upper bound cost estimates of the footbridge options is provided in Table 3-1. For the lower bound estimates, the lowest rates and the “Do min” cross-section were used, whereas for the upper bound the higher rates and the wider “Do max” cross-section were considered.

Table 3-1 – Footbridge options cost estimates.

Option	Cost Rate [£/sqm]	Total Cost [£] "Do min" (lower bound)	Total Cost [£] "Do max" (upper bound)
1) Bowstring Arch	3000 to 4000	£1.000.000	£1.800.000
2) Cable-Stayed	5000 to 6000	£1.750.000	£2.775.000
3) Haunched Girder	2500 to 3000	£950.000	£1.500.000

To enable the identification of a preferred solution the merits of the 3No. footbridges options proposed were assessed against the scheme's objectives:

- **Increased connectivity between attractors on Eastern and Western Quayside** – All 3No options score high on this field as they provide a quality link between the public library and the Ocky White redevelopment on Western Quayside with the Riverside commercial development.
- **Enhance local character and a sense of place** – Option 1 provides an interesting contrast to the historic arch bridges but can be obtrusive of the castle view from deck level. Option 2 takes away from the nature of the site and could feel somewhat out of scale with its surroundings. Option 3 has a more subdued presence that opens views to and from either bank.
- **Promote healthy communities** – All 3No options promote the use of active travel routes by accommodating pedestrians and cyclists within dedicated channels.
- **Enhance cultural heritage and tourism** – All 3No options have the capability of being used as spaces for public events and performances. However, the box beams and stay cables of Option 1 and Option 2 can hinder this type of use. Option 2 presents the most 'eye-catching' design, which may lead to increased tourism as an attractor in itself. Option 3 is best suited in regard to cultural heritage since it provides an amphitheatre type setting.
- **Promote equality of opportunity amongst all social groups** – All 3No options accommodate pedestrian and cyclist routes whose gradients are compliant with the Disability Discrimination Act.
- **Enhance the natural environment in the urban area and create a link with the countryside** – All 3No options provide an opportunity to raise soffit levels and positively impact flood risk. The large plan area of the deck offers potential for SUDS to capture surface water for the landscaped areas on either bank.
- **Promote innovative design** – Option 1 use of flat plates to replace hanger cables is a novel feature that minimises maintenance requirements. Option 2 uses standard solutions and scores lowest in this regard. Option 3 makes an original combination of form and function by using inclined webs to create an amphitheatre space.
- **Encourage sustainable economic growth** – All 3No options will improve integration of new public facilities with key retail areas in the town centre. They will also serve as an attraction by providing a quality space on the river channel. Option 3 requires the lowest investment to achieve this.

Having evaluated the functionality, aesthetics, buildability, and future maintenance requirements of each of the footbridge options developed and compared their relative merits it is deemed that Option 3 "Haunched Girder" offers the best value for money. The deck cross-section requirements should be re-visited at the preliminary design stage once traffic modelling of the active travel routes has been undertaken and the usage levels by pedestrians and cyclists are confirmed. It is noted however that the wider aspiration for regeneration and high quality infrastructure within the areas surrounding the bridge, support the provision of an iconic attractive structure that is eye-catching and an attractor to the area, Option 2 scores well in this regard.

Appendices

Appendix A. Hazard Risk Register

Designers' hazard elimination and management record

Complete in Conjunction with guidance in PM/106/02

Project Title	**Project Number**	**Project Manager**
PCC Signature bridge	5190774	Jamie Lannen
	Division or Sub-Division Civil Structures and Geomatics	**Project Safety Advisor** David Rowlands
Scope of Design	Optioneering exercise for a footbridge structure.	**Form No/ Revision** A

(1) Hazard Ref. No.	(2) Activity/Process/ Material/Element - what is being undertaken?	(3) Hazard[1]	(4) Stage of Work	(5) Designer Risk Control Measures[2]: Design action taken, record of decision process including option considered, design constraints and justification for options/actions not having been taken.	(6) Is there a 'significant' residual risk to be passed on?[3] (Y/N)	(7) If answer to (6) is Yes, information flow: D/P/F[4]	(8) Status (Active / Closed)
1	Foundations and construction of abutments	Striking underground cables and/or pipes during piling or excavation works.	Construction	Location of underground cables and pipes to be requested from the Statutory Undertakers and identified in the drawings. Nonetheless unidentified features may be present on site. Contractor should proceed with due care during excavation works.	Yes	D, P	Active
2	Foundations and construction of abutments	Striking unexploded ordnances during excavation or drilling/driving works.	Construction	The Zetica's online risk map indicates the site as low risk. Its Pre-Desk Study Assessment considers that while a Detailed Desk Study is always prudent it is not essential in this instance.	Yes	P	Closed
3	Excavation for construction of abutments	Excavation for the construction of abutments may destabilise the existing flood defence wall.	Construction	Consider a staged excavation allowing wall movement to be monitored while the works progress. Contractor to develop a robust method statement to address wall stability.	Yes	D, P	Active
4	Works generating vibration – piling, drilling, ground compacting	Risk of damage to the existing buildings at site proximity.	Construction	Use of bored piles rather than driven piles. Design to consider keeping earthworks to minimum practicable.	Yes	P	Closed

5	Cranage operations (dismantling existing structure, installing new structure)	Crane failure.	Demolition, Construction	Temporary works design to include consideration of cranage requirements for dismantling of existing footbridge and lifting in place the new structure. The need for crane mats, pads or cribbing to ensure ground stability during lifting operations will be given due consideration.	Yes	P	Active
6	Cranage operations (dismantling existing structure, installing new structure)	Stability of flood defence wall	Demolition, Construction	Temporary works design to consider stability of the existing flood defence wall. Exclusion zone for the crane to be implemented.	Yes	D, P	Active
7	Lifting Operations (dismantling existing structure, installing new structure)	Steel structure failure during cranage.	Construction	Existing footbridge to be removed and new structure lifted in-place using a crane. Attention must be made to local effects due to the location of lifting points to ensure no failure from local overstressing may occur.	Yes	D, P	Active
8	Dismantling and removal of existing structure	Risk of falling structure parts into the river channel.	Demolition	Detailed Method Statement of dismantling works to ensure safe removal of all ‘loose’ structure parts prior to lifting of the existing deck. Consideration of appropriate lifting points. Emergency action plan in case any parts fell into the water.	Yes	P	Active
9	Works at deck level	Fall from height of equipment and/or personnel.	Construction	Contractor to provide edge protection where required and to ensure control measures are implemented. Where edge protection is not possible, works shall be conducted by adequately equipped and trained personnel.	Yes	P	Closed
10	Works at deck level	Fall of personnel into the river channel. Risk of drowning.	Construction	Contractor to provide edge protection or other suitable safe working means such as fall arrest equipment. Emergency plan must be in place.	Yes	P	Active
11	Work with bituminous and resin materials (deck surfacing)	Contact with bituminous/resin material affecting skin and eyes leading to burns, dermatitis and skin cancer. Risk of contamination of the river.	Construction	Bituminous and/or resinous materials should be applied at fabricator’s yard wherever possible. Where application on site is required the Contractor’s method statement will identify required PPE and provide safe working practices for site personnel.	Yes	D, P	Active

Checked and approved by (see notes 5 & 6):

Name :	**Jose Fernandes**	**Signature:**	**Date:** 20/03/2020

Notes

1 A hazard is something with the potential to cause harm, such as: working near live traffic, working at height, falling object etc.

2 Designer Risk Control Measures are to be based upon the Principles of Prevention - 'Eliminate, Reduce, Inform & Control'.

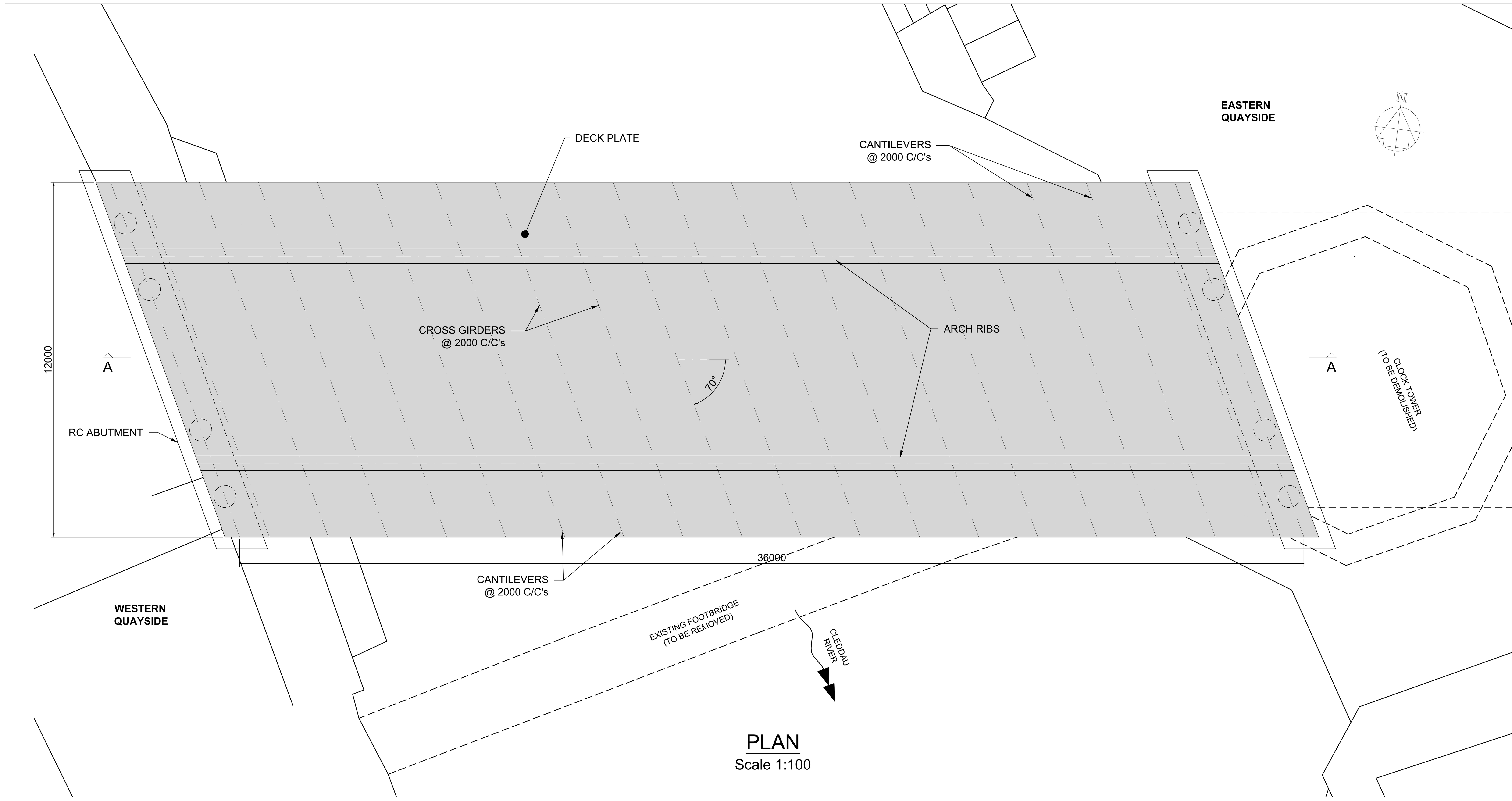
3 UK CDM ACOP defines 'significant' 'Significant risks are not necessarily those that involve the greatest risks, but those, including health risks that are: (a) not likely to be obvious to a competent contractor or other designers; (b) unusual; or (c) likely to be difficult to manage effectively.' Extract from ACOP clause 133.

4 Information codes: D = Information detailed on drawings (add drawing nos); P = to be communicated via Pre-Construction Information; F = information for the Health and Safety File. Please note that this information may also be relevant to specifications and/or reports.

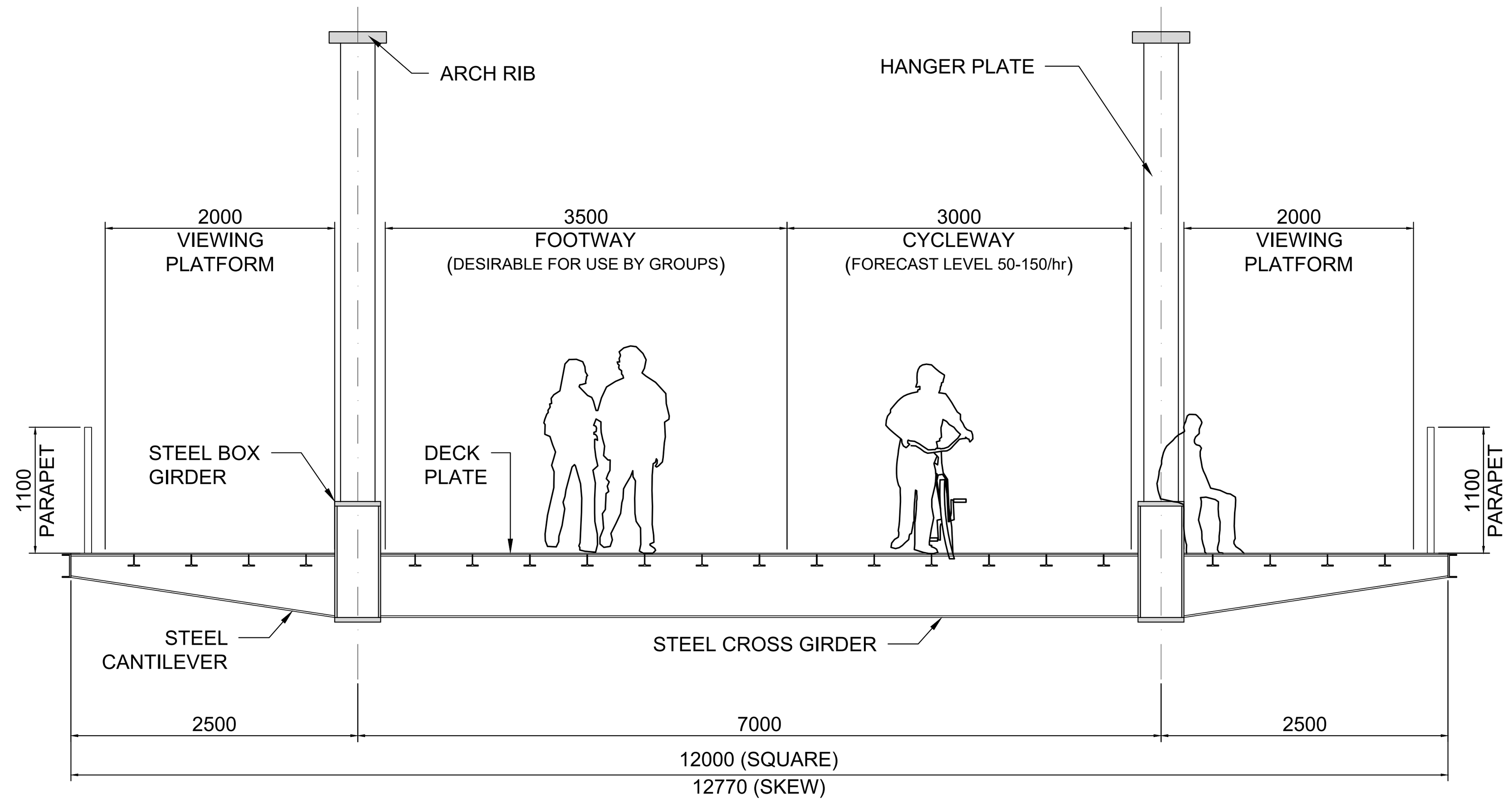
5 Project Manager (or Design Team Leader, as appropriate) to check and approve Record unless the design work has been carried out directly by the Project Manager (or Design Team Leader) in which case the Record is to be checked and approved by the Project Director (or Sub-Project Director, as appropriate).

6 This Form should be reviewed and revised as design changes are made and as the stages of design progress.

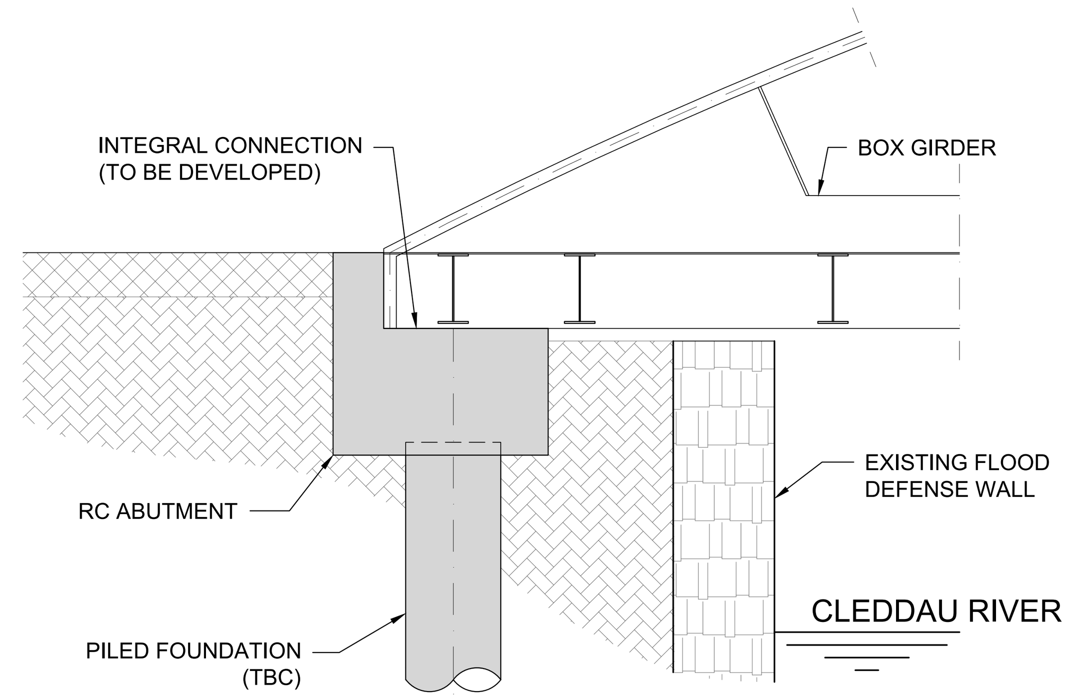
Appendix B. General Arrangement Drawings



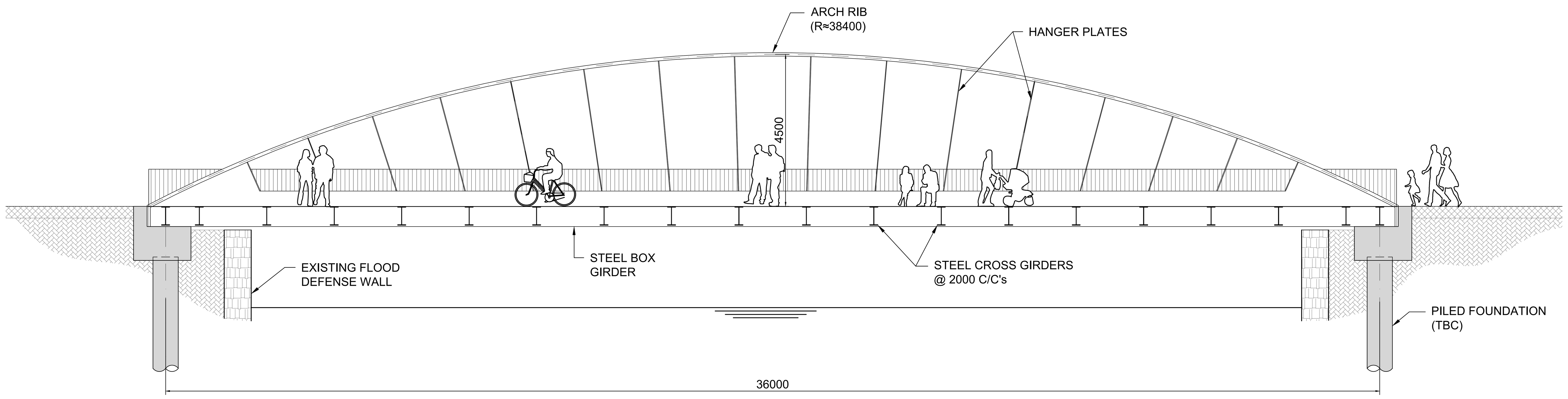
PLAN
Scale 1:100



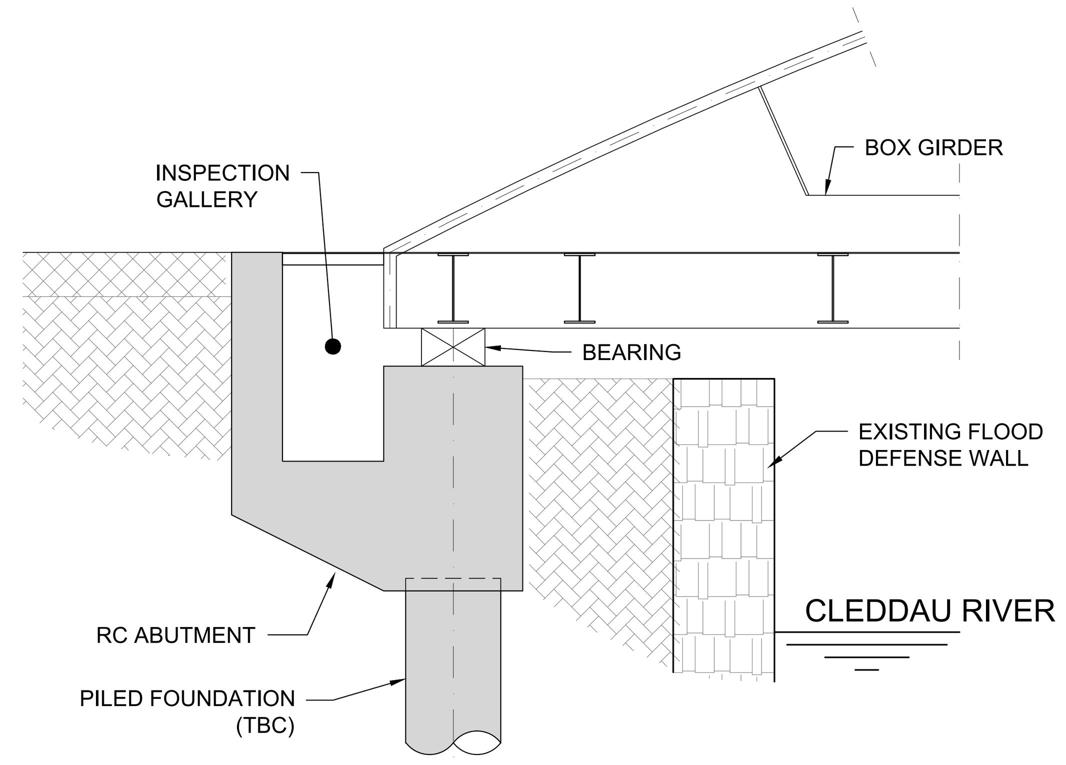
CROSS SECTION (AT MID-SPAN)
Scale 1:50



INTEGRAL ABUTMENT OPTION
Scale 1:50



SECTION A-A
Scale 1:100



ABUTMENT GALLERY OPTION
Scale 1:50

COMMENTS:
1. DO NOT SCALE FROM THIS DRAWING - USE ONLY VALUES OF STATED DIMENSIONS.
2. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN. ALL LEVELS ARE IN METERS ABOVE ORDNANCE DATUM UNLESS NOTED OTHERWISE.
3. ALL LONGITUDINAL AND TRANSVERSE DIMENSIONS ARE MEASURED IN PLAN UNLESS NOTED OTHERWISE.
4. DECK SURFACING WILL CONSIST OF A 4 mm THICK WATERPROOFING AND SKID RESISTANT WEARING COURSE, BY MEANS OF A PROPRIETARY RESIN BASED SCREED COMBINED WITH AN AGGREGATE OVER SCATTER AND SEALER.
5. PEDESTRIAN RESTRAINT SYSTEM IS STEEL CLASS 3 PEDESTRIAN PARAPET, WITH POSTS 1.1M HIGH AND FULL-HEIGHT VERTICAL INFILL BALUSTERS.
6. ALL VERTICAL EXPOSED CONCRETE SURFACES TO BE APPLIED A SACRIFICIAL WAX-BASED, WATER SOLUBLE, ANTI-GRAFFITI COATING SUCH AS WATCO ANTI-GRAFFITI WAX OR SIMILAR APPROVED.
7. ALL BURIED SURFACES SHALL BE PAINTED WITH 2 COATS OF BITUMEN EMULSION TO WITHIN 200mm OF GROUND LEVEL IN ACCORDANCE WITH SPECIFICATION CLAUSE 2006.
8. REINFORCEMENTS TO BE GRADE B500B TO BS 4449.
9. CONCRETE GRADES:
   - BLINDING: ST2
   - PIERS, PILE CAPS AND ABUTMENTS: C35/45
   - PILES: C32/40
11. CONCRETE FINISHES:
   - BURIED SURFACES: F1/U1
   - EXPOSED VERTICAL SURFACES: F4
   - EXPOSED HORIZONTAL SURFACES: U3
12. STEELWORK GRADES:
   - HOT ROLLED SECTIONS: S355 J2W+N TO EN 10025-1
   - PLATES AND STIFFENERS: S355 J2W+N TO EN 10025-1
   - ARCH RIBS: S355 K2W+N TO EN 10025-1
13. ALL INTERNAL SURFACES TO BE SEALED AIR TIGHT BY WELDING TO PREVENT INTERNAL CORROSION.

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:

CONSTRUCTION
WORKING OVER WATERCOURSE (SAFETY). CLEDDAU RIVER IS A SPECIAL AREA OF CONSERVATION (ENVIRONMENT).

MAINTENANCE/CLEANING
WORKING OVER WATERCOURSE (SAFETY). CLEDDAU RIVER IS A SPECIAL AREA OF CONSERVATION (ENVIRONMENT).

DECOMMISSIONING/DEMOLITION
WORKING OVER WATERCOURSE (SAFETY). CLEDDAU RIVER IS A SPECIAL AREA OF CONSERVATION (ENVIRONMENT).

It is assumed that all works will be carried out by a competent contractor working, where appropriate, to an approved method statement

Rev.	Date	Description	By	Chk'd	App'd
P1	19/03/20	FOR INFORMATION	MPD	JPF	DR

Drawing Status: **SKETCH FOR INFORMATION**
Suitability: **SO**

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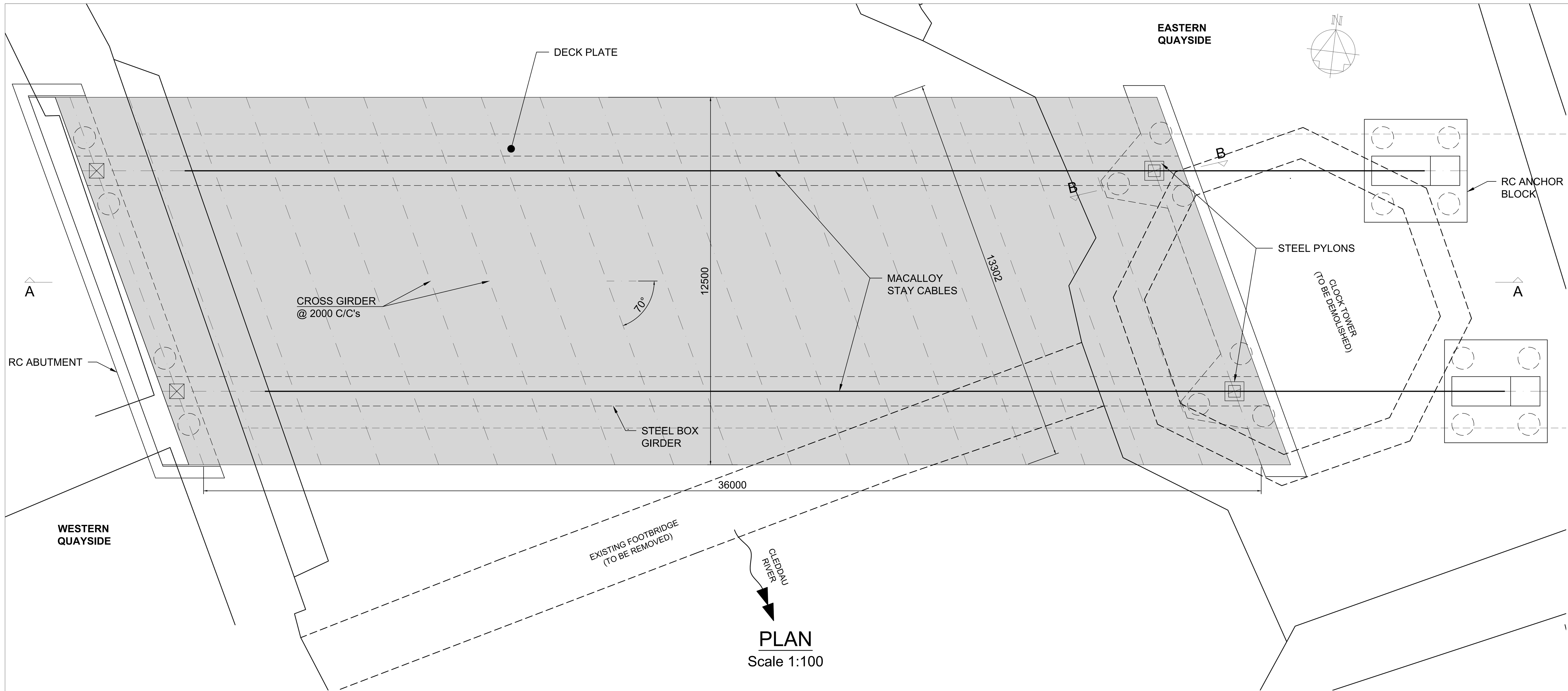
Client: **Pembrokeshire County Council Cyngor Sir Penfro**

Project Title: PCC SIGNATURE BRIDGE

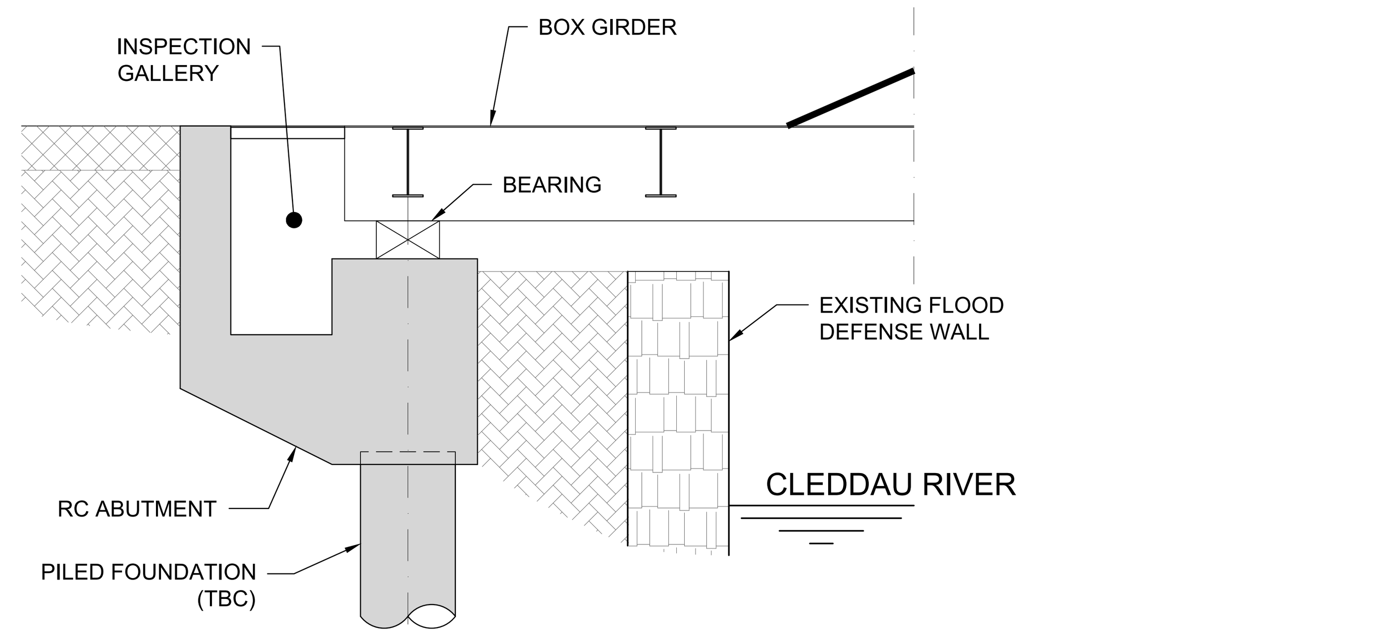
Drawing Title: OPTION 1 BOWSTRING ARCH FOOTBRIDGE

Scale	Designed	Drawn	Checked	Authorised
N.T.S	JPF	MPD	JN	DR
Original Size: A1	Date: 17/03/20	Date: 17/03/20	Date: 18/03/20	Date: 19/03/20

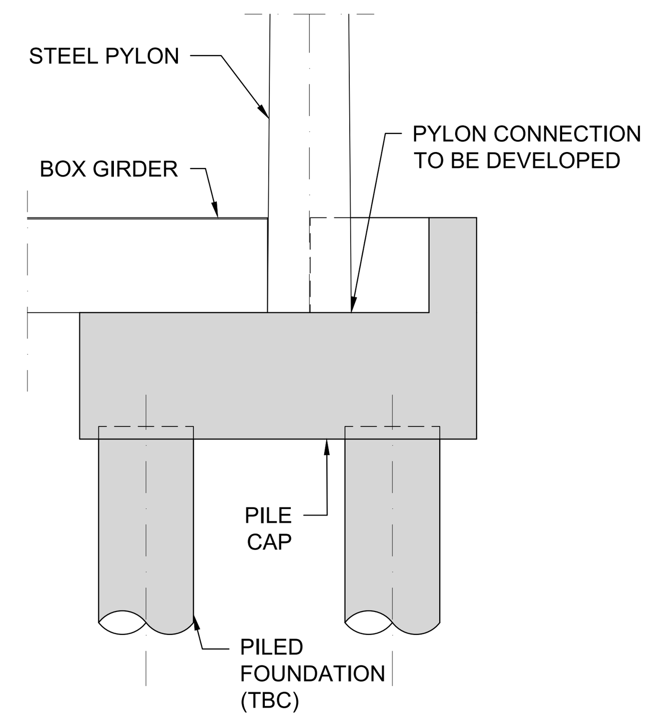
Drawing Number: 5190774-AKT-SBR-LIV-DR-CB-000101
Revision: P 1



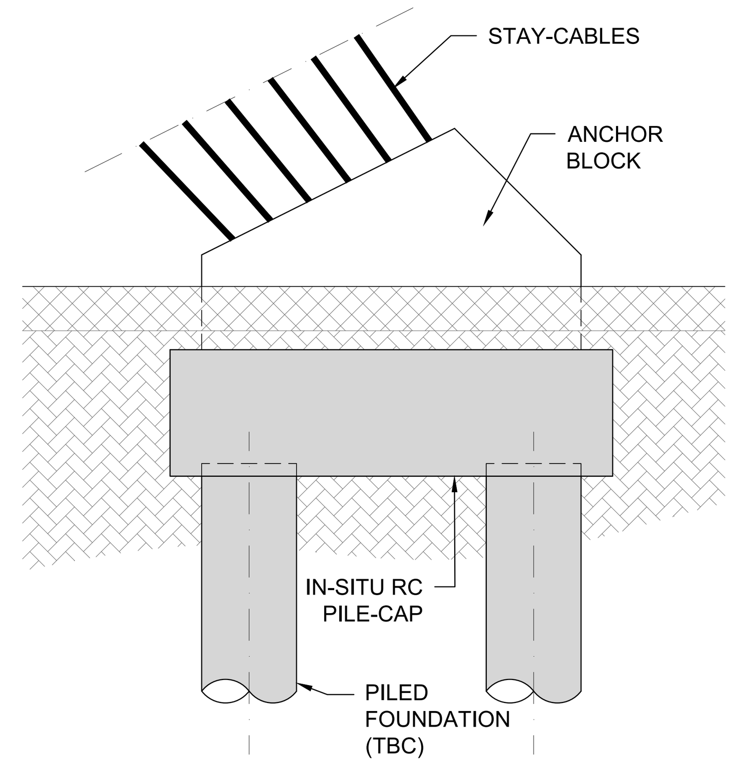
PLAN
Scale 1:100



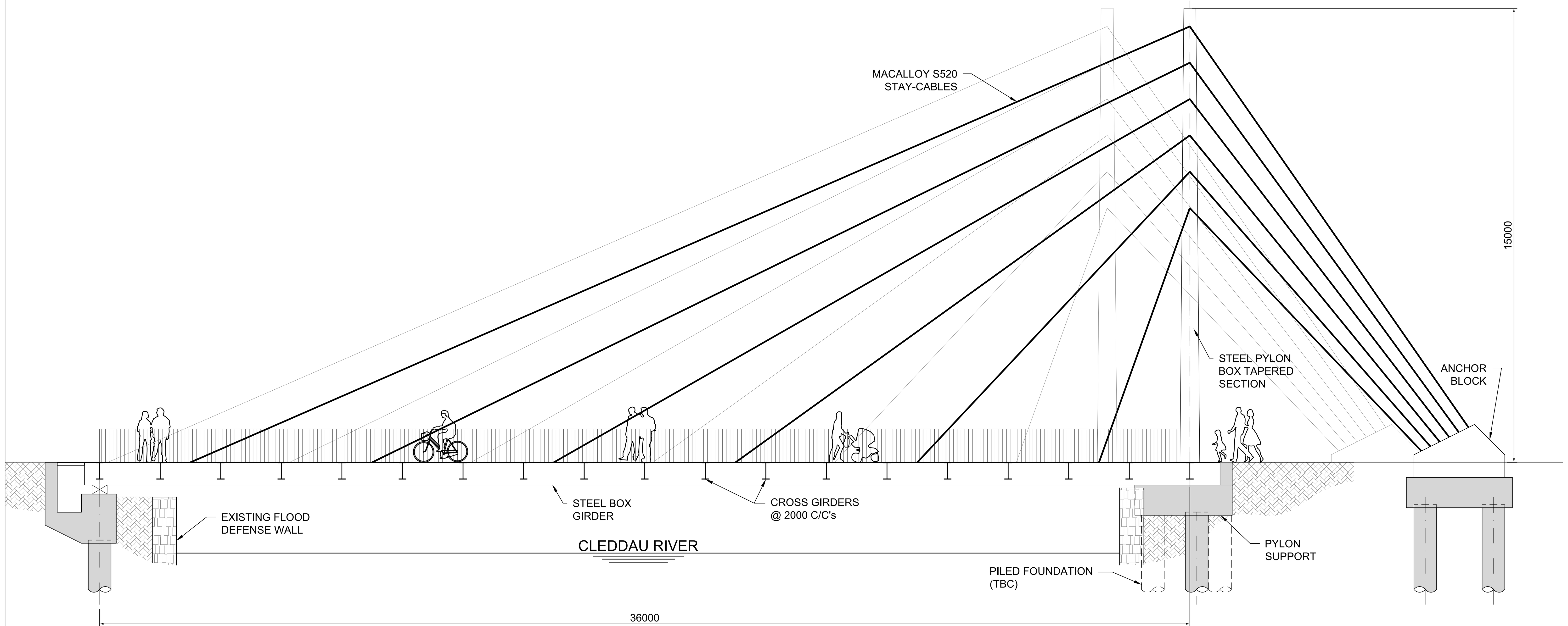
WEST ABUTMENT
Scale 1:50



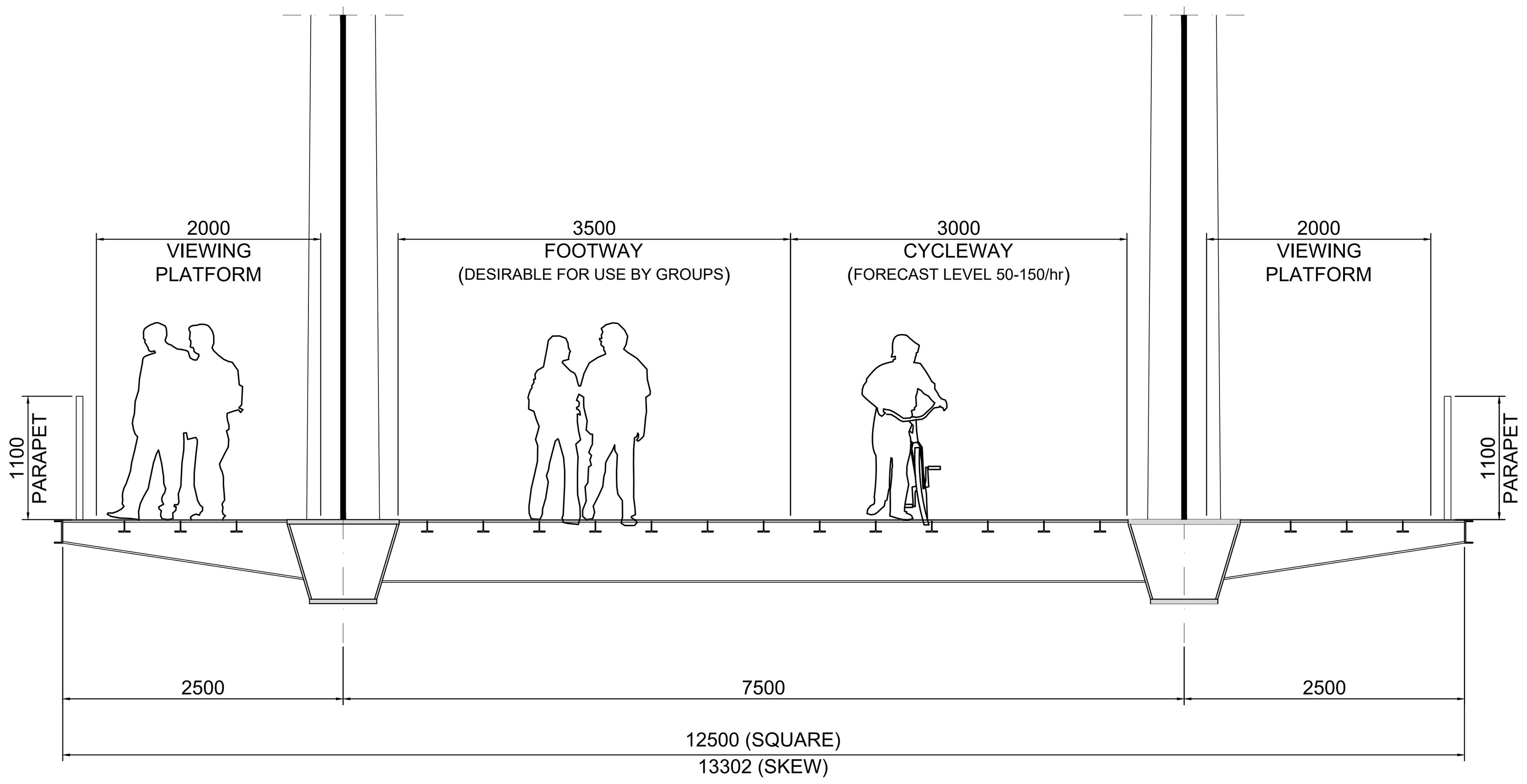
SECTION B-B
Scale 1:50



ANCHOR BLOCK
Scale 1:50



SECTION A-A
Scale 1:100



CROSS SECTION
Scale 1:50

COMMENTS:

1. DO NOT SCALE FROM THIS DRAWING - USE ONLY VALUES OF STATED DIMENSIONS.
2. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN. ALL LEVELS ARE IN METERS ABOVE ORDNANCE DATUM UNLESS NOTED OTHERWISE.
3. ALL LONGITUDINAL AND TRANSVERSE DIMENSIONS ARE MEASURED IN PLAN UNLESS NOTED OTHERWISE.
4. DECK SURFACING WILL CONSIST OF A 4 mm THICK WATERPROOFING AND SKID RESISTANT WEARING COURSE, BY MEANS OF A PROPRIETARY RESIN BASED SCREED COMBINED WITH AN AGGREGATE OVER SCATTER AND SEALER.
5. PEDESTRIAN RESTRAINT SYSTEM IS STEEL CLASS 3 PEDESTRIAN PARAPET, WITH POSTS 1.1M HIGH AND FULL-HEIGHT VERTICAL INFILL BALUSTERS.
6. ALL VERTICAL EXPOSED CONCRETE SURFACES TO BE APPLIED A SACRIFICIAL WAX-BASED, WATER SOLUBLE, ANTI-GRAFFITI COATING SUCH AS WATCO ANTI-GRAFFITI WAX OR SIMILAR APPROVED.
7. ALL BURIED SURFACES SHALL BE PAINTED WITH 2 COATS OF BITUMEN EMULSION TO WITHIN 200mm OF GROUND LEVEL IN ACCORDANCE WITH SPECIFICATION CLAUSE 2006.
8. REINFORCEMENT TO BE GRADE B500B TO BS 4449.
9. CONCRETE GRADES:
   - BLINDING: ST2
   - PIERS, PILE CAPS AND ABUTMENTS: C35/45
   - PILES: C32/40
11. CONCRETE FINISHES:
   - BURIED SURFACES: F1/U1
   - EXPOSED VERTICAL SURFACES: F4
   - EXPOSED HORIZONTAL SURFACES: U3
12. STEELWORK GRADES:
   - HOT ROLLED SECTIONS: S355 J2W+N TO EN 10025-1
   - PLATES AND STIFFENERS: S355 J2W+N TO EN 10025-1
   - CABLE STAYS: M48 DIAMETER STAINLESS MACALLOY S520.
13. ALL INTERNAL SURFACES TO BE SEALED AIR TIGHT BY WELDING TO PREVENT INTERNAL CORROSION.

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:

CONSTRUCTION

WORKING OVER WATERCOURSE (SAFETY). CLEDDAU RIVER IS A SPECIAL AREA OF CONSERVATION (ENVIRONMENT).

MAINTENANCE/CLEANING

WORKING OVER WATERCOURSE (SAFETY). CLEDDAU RIVER IS A SPECIAL AREA OF CONSERVATION (ENVIRONMENT).

DECOMMISSIONING/DEMOLITION

WORKING OVER WATERCOURSE (SAFETY). CLEDDAU RIVER IS A SPECIAL AREA OF CONSERVATION (ENVIRONMENT).

It is assumed that all works will be carried out by a competent contractor working, where appropriate, to an approved method statement

Rev.	Date	Description	By	Chk'd	App'd
P1	19/03/20	FOR INFORMATION	MPD	JPF	DR

Drawing Status: **SKETCH FOR INFORMATION**

Suitability: **S0**

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Client: **Pembrokeshire County Council**
Cyngor Sir Penfro

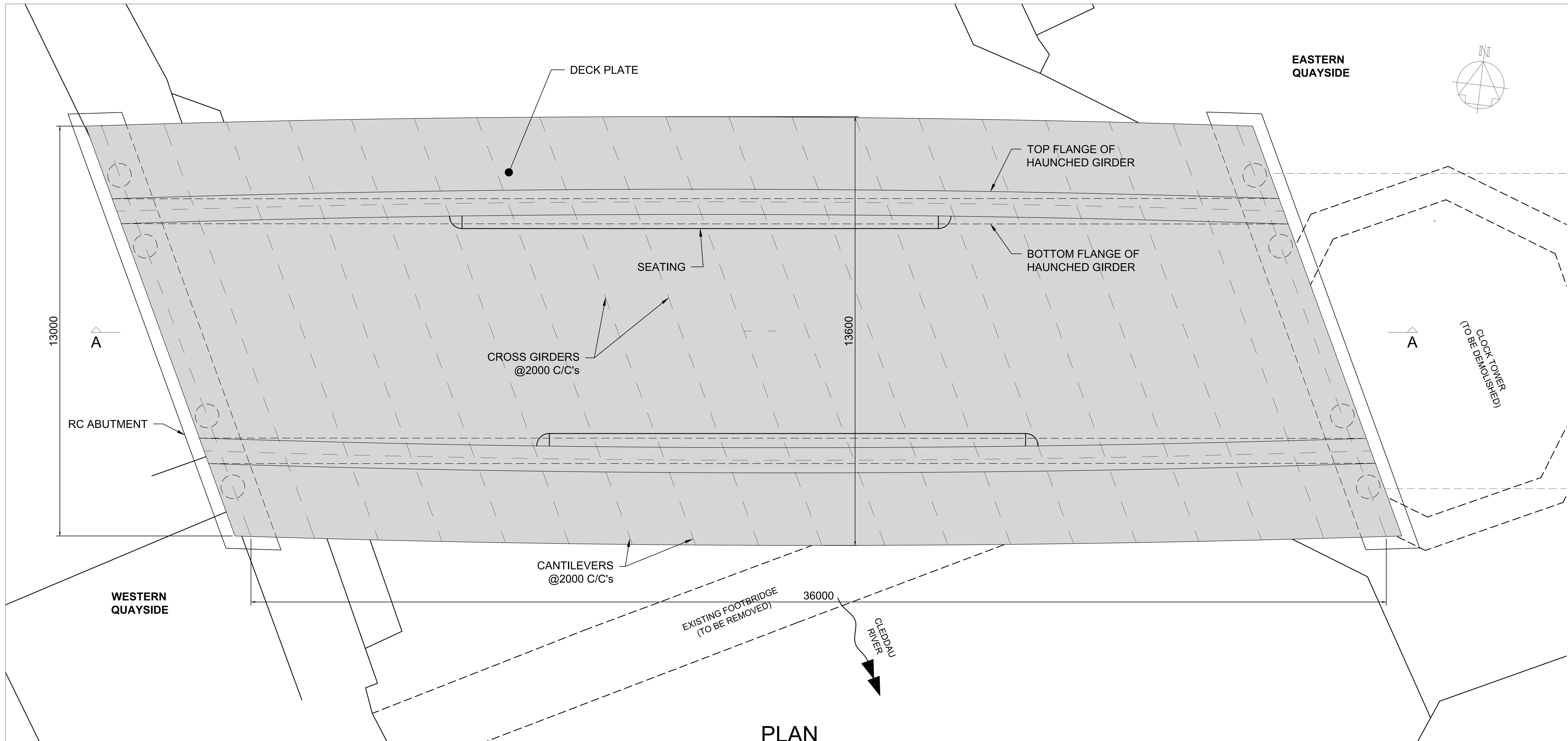
Project Title: PCC SIGNATURE BRIDGE

Drawing Title: OPTION 2
CABLE-STAYED FOOTBRIDGE

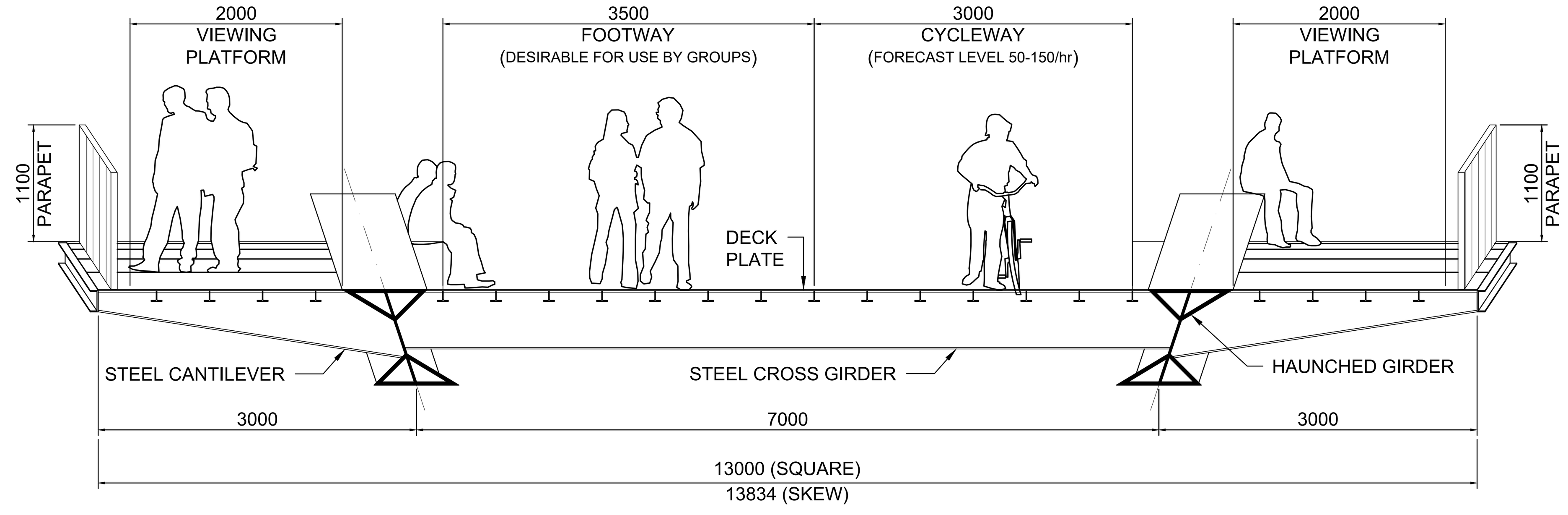
Scale	Designed	Drawn	Checked	Authorised
N.T.S	JPF	MPD	JN	DR
Original Size: A1	Date: 17/03/20	Date: 17/03/20	Date: 18/03/20	Date: 19/03/20

Drawing Number: 5190774-AKT-SBR-LIV-DR-CB-000201

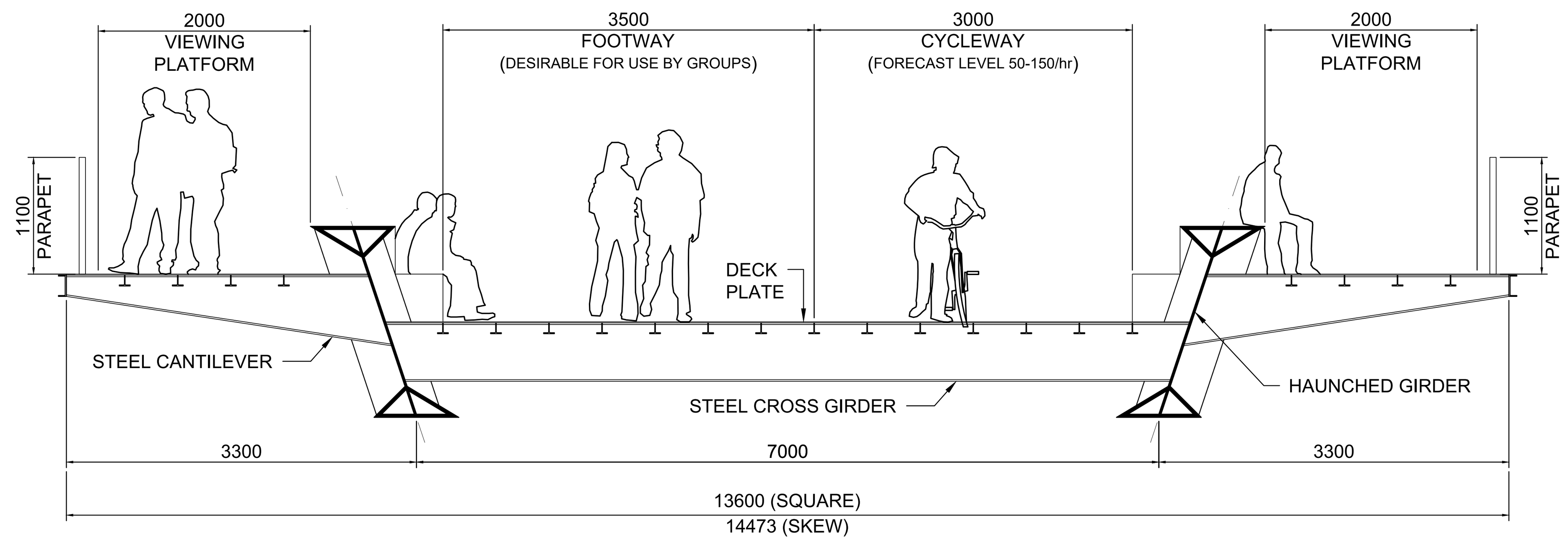
Revision: P 1



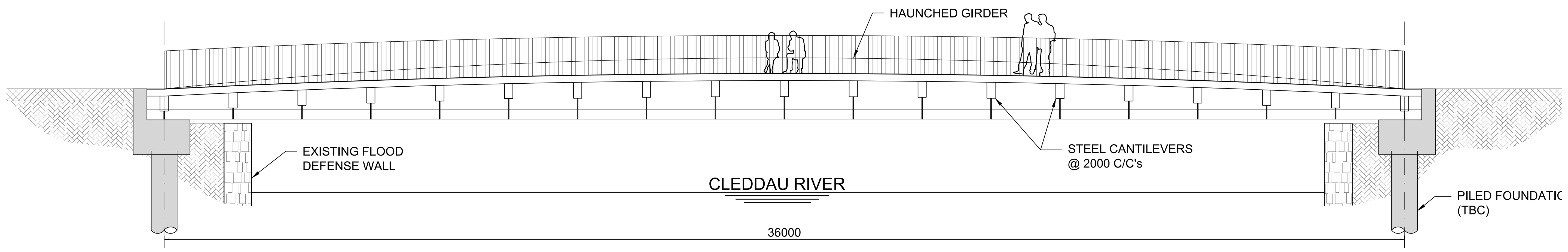
PLAN
Scale 1:100



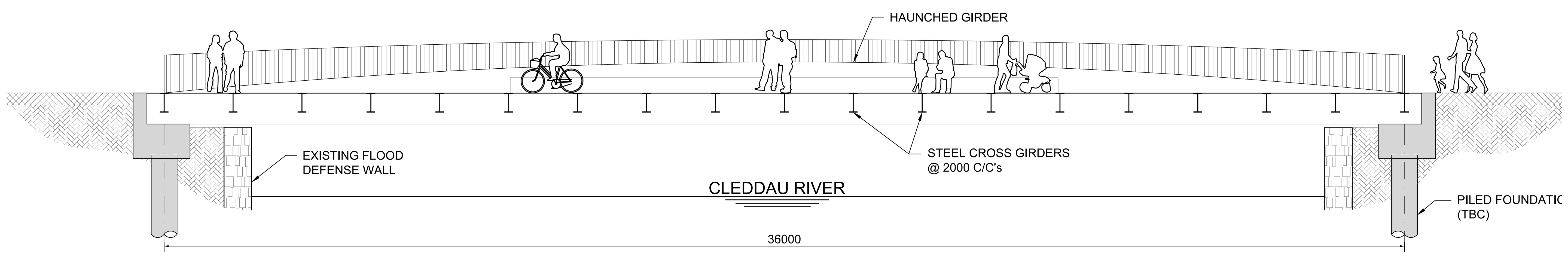
CROSS SECTION (AT ABUTMENT)
Scale 1:50



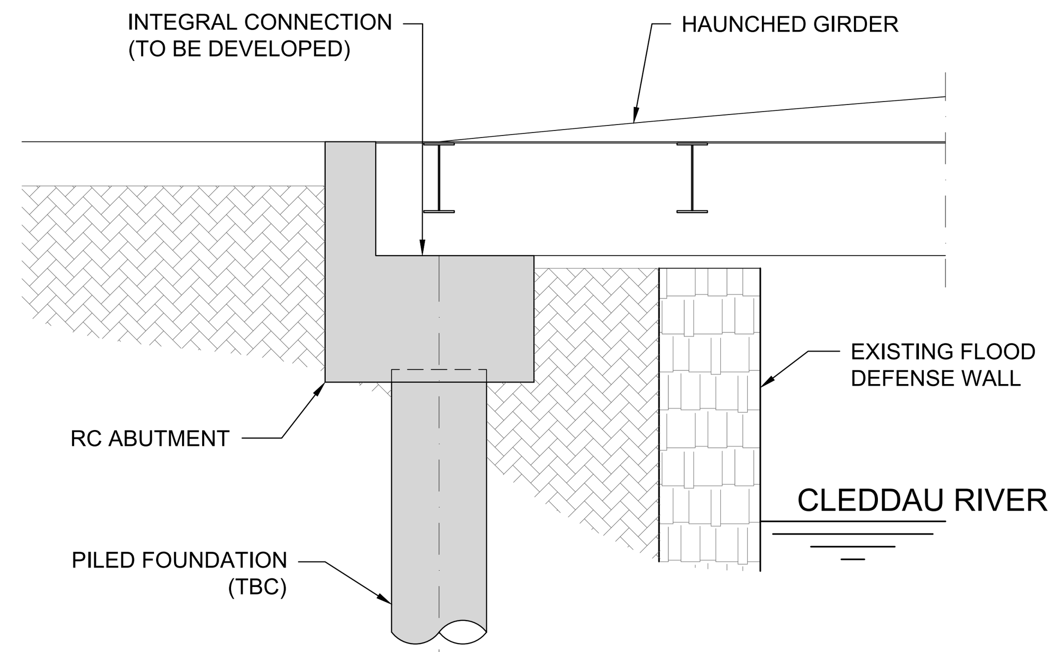
CROSS SECTION (AT MIDSPAN)
Scale 1:50



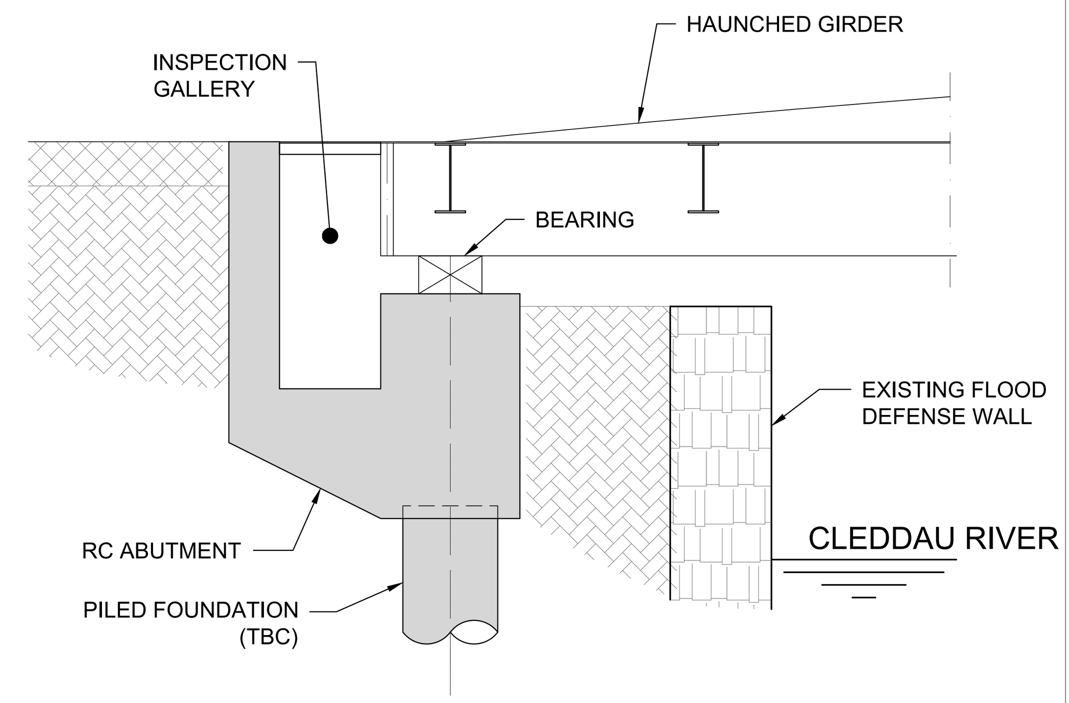
ELEVATION
Scale 1:100



SECTION A-A
Scale 1:100



INTEGRAL ABUTMENT OPTION
Scale 1:50



ABUTMENT GALLERY OPTION
Scale 1:50

COMMENTS:

1. DO NOT SCALE FROM THIS DRAWING - USE ONLY VALUES OF STATED DIMENSIONS.
2. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN. ALL LEVELS ARE IN METERS ABOVE ORDNANCE DATUM UNLESS NOTED OTHERWISE.
3. ALL LONGITUDINAL AND TRANSVERSE DIMENSIONS ARE MEASURED IN PLAN UNLESS NOTED OTHERWISE.
4. DECK SURFACING WILL CONSIST OF A 4 mm THICK WATERPROOFING AND SKID RESISTANT WEARING COURSE, BY MEANS OF A PROPRIETARY RESIN BASED SCREED COMBINED WITH AN AGGREGATE OVER SCATTER AND SEALER.
5. PEDESTRIAN RESTRAINT SYSTEM IS STEEL CLASS 3 PEDESTRIAN PARAPET, WITH POSTS 1.1M HIGH AND FULL-HEIGHT VERTICAL INFILL BALUSTERS.
6. ALL VERTICAL EXPOSED CONCRETE SURFACES TO BE APPLIED A SACRIFICIAL WAX-BASED, WATER SOLUBLE, ANTI-GRAFFITI COATING SUCH AS WATCO ANTI-GRAFFITI WAX OR SIMILAR APPROVED.
7. ALL BURIED SURFACES SHALL BE PAINTED WITH 2 COATS OF BITUMEN EMULSION TO WITHIN 200mm OF GROUND LEVEL IN ACCORDANCE WITH SPECIFICATION CLAUSE 2006.
8. REINFORCEMENTS TO BE GRADE B500B TO BS 4449.
9. CONCRETE GRADES:
   - BLINDING: ST2
   - PIERS, PILE CAPS AND ABUTMENTS: C35/45
   - PILES: C32/40
11. CONCRETE FINISHES:
   - BURIED SURFACES: F1/U1
   - EXPOSED VERTICAL SURFACES: F4
   - EXPOSED HORIZONTAL SURFACES: U3
12. STEELWORK GRADES:
   - HOT ROLLED SECTIONS: S355 J2W+N TO EN 10025-1
   - PLATES AND STIFFENERS: S355 J2W+N TO EN 10025-1
13. ALL INTERNAL SURFACES TO BE SEALED AIR TIGHT BY WELDING TO PREVENT INTERNAL CORROSION.

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:

CONSTRUCTION

WORKING OVER WATERCOURSE (SAFETY). CLEDDAU RIVER IS A SPECIAL AREA OF CONSERVATION (ENVIRONMENT).

MAINTENANCE/CLEANING

WORKING OVER WATERCOURSE (SAFETY). CLEDDAU RIVER IS A SPECIAL AREA OF CONSERVATION (ENVIRONMENT).

DECOMMISSIONING/DEMOLITION

WORKING OVER WATERCOURSE (SAFETY). CLEDDAU RIVER IS A SPECIAL AREA OF CONSERVATION (ENVIRONMENT).

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Rev.	Date	Description	By	Chk'd	App'd
P1	19/03/20	FOR INFORMATION	MPD	JPF	DR

Drawing Status: **SKETCH FOR INFORMATION**
Suitability: **SO**

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Client: **Pembrokeshire County Council**
Cyngor Sir Penfro

Project Title: PCC SIGNATURE BRIDGE

Drawing Title: OPTION 3
HAUNCHED BEAM FOOTBRIDGE

Scale	Designed	Drawn	Checked	Authorised
N.T.S	JPF	MPD	JN	DR
Original Size	Date	Date	Date	Date
A1	17/03/20	17/03/20	18/03/20	19/03/20

Drawing Number: 5190774-AKT-SBR-LIV-DR-CB-000301
Revision: P 1

This report is to be read in conjunction with the following drawings:

Drawing Ref. No.	Title
5190774-ATK-SBR-LIV-DR-CB-000101	Signature bridge Option 1 - General Arrangement
5190774-ATK-SBR-LIV-DR-CB-000201	Signature bridge Option 2 - General Arrangement
5190774-ATK-SBR-LIV-DR-CB-000301	Signature bridge Option 3 - General Arrangement