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# Introduction

The Canal & River Trust (the Trust) cares for over 2,000 miles of waterways in England and Wales. The Trust believe that the design and construction of the HS2 line should showcase the very best in contemporary architecture and engineering, creating structures that contribute positively to the multiple layers of transport history that are evident throughout the canal corridor.

The Design Principles have been developed in conjunction with the IWA, with special thanks to the IWA's HS2 liaison members

*This document has been produced by Knight Architects and the Canal & River Trust as a general recommended approach to design principles for HS2 bridge and viaduct crossings over Canal & River Trust waterways. It is not intended to serve as a detailed basis of actual design or specification for any particular location, either in the context of HS2 or elsewhere.*



# Purpose of this document

Fundamentally, there is a concern that HS2 will have an irrevocable, negative impact upon the waterways in its vicinity. This impact can be broadly defined in two key categories which will form the primary sections of this document:

1 - [What HS2 will affect](#)

2 - [What HS2 will introduce](#)

This document describes a series of general design principles that should be adopted by HS2 Ltd. to guide the development of HS2 design within the corridor of the waterways.

The section '[What HS2 will affect](#)' outlines the qualities and amenities of the waterways which the Trust is tasked with protecting, which will be removed or otherwise adversely affected. HS2 will have a significant impact on the views, character, environment, scale and tranquillity that the users of the waterways currently enjoy. This section describes the key concerns of how HS2 threatens these amenities, and outlines the Trust's requirements as to how they must be protected.

The section '[What HS2 will introduce](#)' addresses the infrastructure that HS2 will introduce to the waterway's environment. The scale, material, quality and character of the new infrastructure will have a crucial relationship with that of the existing waterways. This section outlines the constraints and requirements that HS2 infrastructure must meet, and offers guidance as to how it may best respond to the waterway environment.

Each crossing will be subject to careful individual assessment and consideration to establish the suitability of the design response to the locale. The Trust require that individual bridge designs at each crossing; reflect the character of each area, contribute positively to the waterway environment, and meet our expectations for high quality structures and spaces.

This document includes examples of structures and associated elements that illustrate what is acceptable and what should be avoided in the design of HS2 crossings. These are identified with a green tick or a red cross as appropriate for different waterside environments.

Technical design standards to be applied throughout the United Kingdom are given in the Design Manual of Roads and Bridges (the DMRB).



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# A1 Appeal

The waterways are home to a variety of uses including boating, cycling, walking and fishing, as well as providing a rich habitat for wildlife and plants. Of primary concern is the detrimental impact that HS2 may have on these uses and habitats. 50% of the population live within 5 miles of one of the Trust's waterways, enabling approximately 270 million visits per year. It is therefore essential that the waterways remain attractive, welcoming and beautiful places for leisure users to enjoy, and must not be adversely affected where there are HS2 crossings.

It is important to recognise that the HS2 bridges will be primarily experienced by those passing under the structures as opposed to those travelling on them. Passengers on the trains will experience most crossings for a split second through an insulated glass window, yet the users of the waterways travelling slowly by boat, foot or cycle will view them for significantly longer and in a direct and intimate manner, fully experiencing the noise and vibration of passing trains.

Those passing under the bridges can appreciate the full form of the structures within their surrounding context. As such, the users of the waterways should be provided with an environment that welcomes them rather than something that appears threatening or disconnected. This is particularly true for pedestrians and cyclists who generally have much more time to take in the structure and view it at close quarters.

A successful public realm requires the design to embrace considerations beyond the simple physical connection between two points. How the connection is expressed and presented will either encourage or deter public use.



Fig.A1.1 - Characterful locks add to the appeal of the waterways

## A2 Views

The waterways are experienced in a dynamic way, by people moving through the landscape as a series of views. HS2 will have an impact on these views throughout its route. In the waterway environment, each crossing must be assessed individually, so as to ensure current views are protected, and the proposed structures are carefully integrated into their setting.

Broadly speaking, urban and rural contexts will have different priorities that must be addressed. Throughout the rural settings of the waterways, there are many expansive views and open vistas. HS2 structures must recognise this, and seek to maintain these distant views, with the structure passing through the landscape as lightly as possible. The crossings should be predominantly recessive (they will not be 'feature bridges') and measures to reduce their visual impact should be taken.

In urban environments distant views are often much more limited. Views are primarily at a relatively short range, and the environment is more enclosed. The structure itself becomes the focus, and must be detailed as such. Whilst in rural settings the HS2 structures will be read against a natural backdrop, in urban settings the scene is likely to already comprise of a tapestry of infrastructure. Here, the focus should be on the visual integration of this 'layer' of infrastructure with that of the existing.

Subsequent chapters will outline how HS2 structures may be designed to minimise their impact on the existing views.

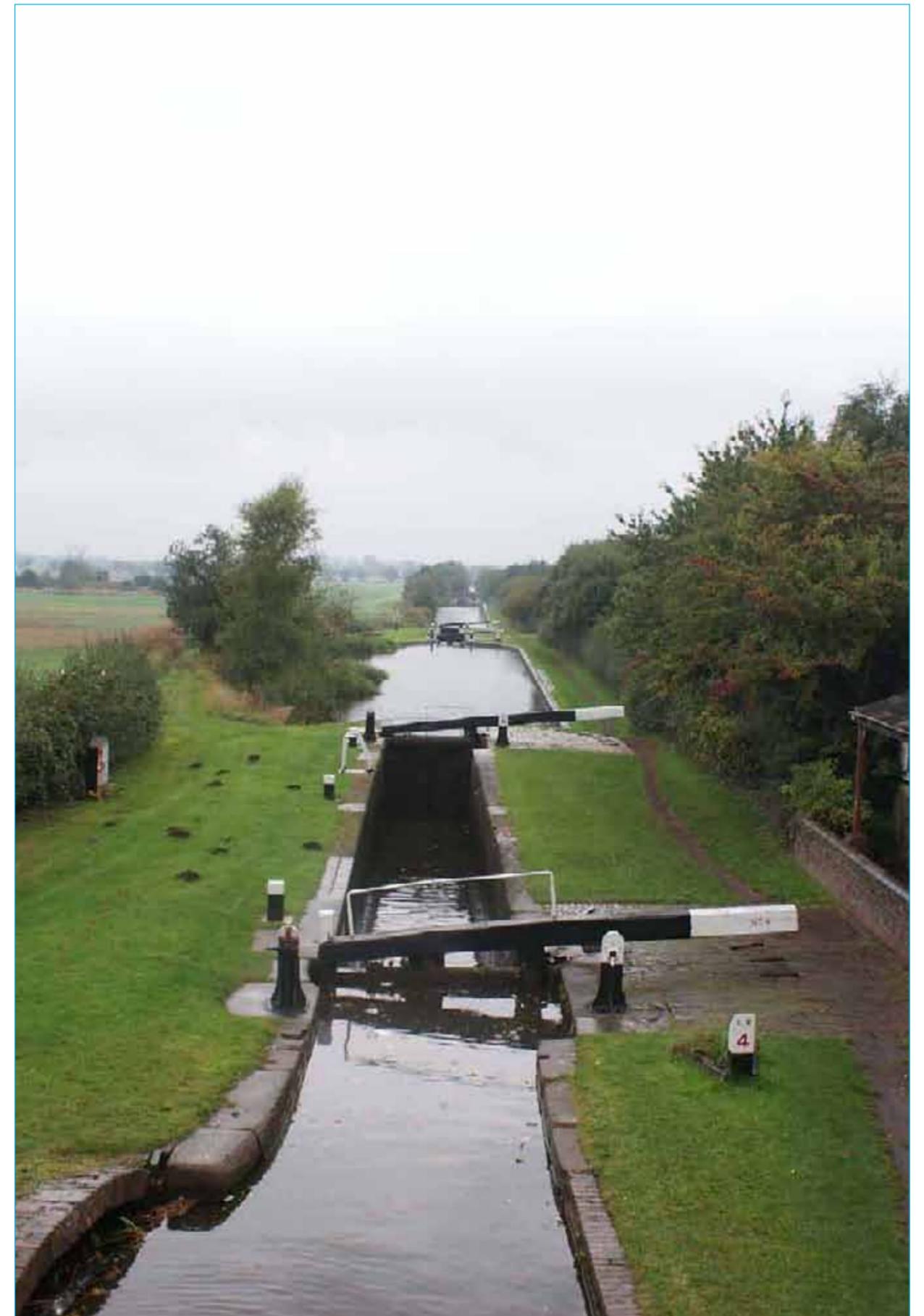


Fig.A2.1 - High-level views permit vistas outside of the waterway environment

# A3 Horizon

The characteristic slow horizontal animation of the horizon against the canal is occasionally punctuated by the requirements for roads, rail lines and services to pass above. Routes through these structures should be clearly legible - it is important the pedestrian experience begins and ends where they expect it to and the whole route in between is clearly visible.

Whilst HS2 is typically kept low to minimise the wider visual impact on the landscape, distant views of the horizon are one of the most important aspects of the relatively narrow, linear waterway environment. They give context to the journey, and the landscape through which the canals and rivers pass. They allow progress along the canal, as well as changes in height to be measured.

The impact of screening HS2 from onlookers serves to further narrow the visual envelope of the canal. As such, the long views of the horizon must be protected. As you can see from the illustrations opposite, the vertical alignment of the crossing plays a significant role in the composition of the view at that point. By raising the height of the crossing, those on boats and the towpath can see the progression of their route beyond (Fig.A3.2). This helps to draw the focus beyond the rail bridge, and maintains a welcoming environment. This visual deference, framing the landscape rather than breaching the horizon, ensures that the structures will form a part of the canal environment.

As you can see from Fig.A3.1, where the horizon is obscured by HS2, the structure of the crossing itself becomes the focus, and the view for the user is greatly compromised - appearing both stunted and even claustrophobic, failing to recognise the character of the waterway.

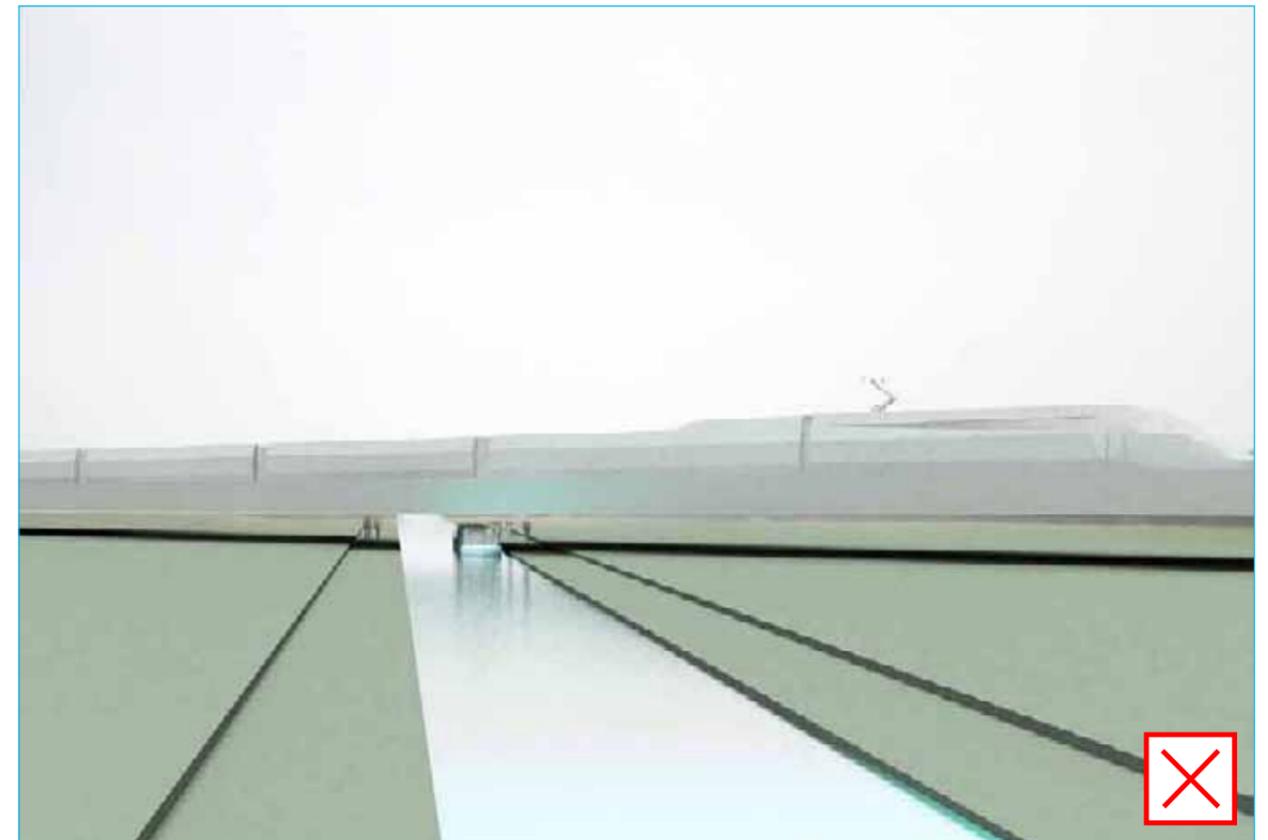


Fig.A3.1 - Crossing obscures views of the horizon

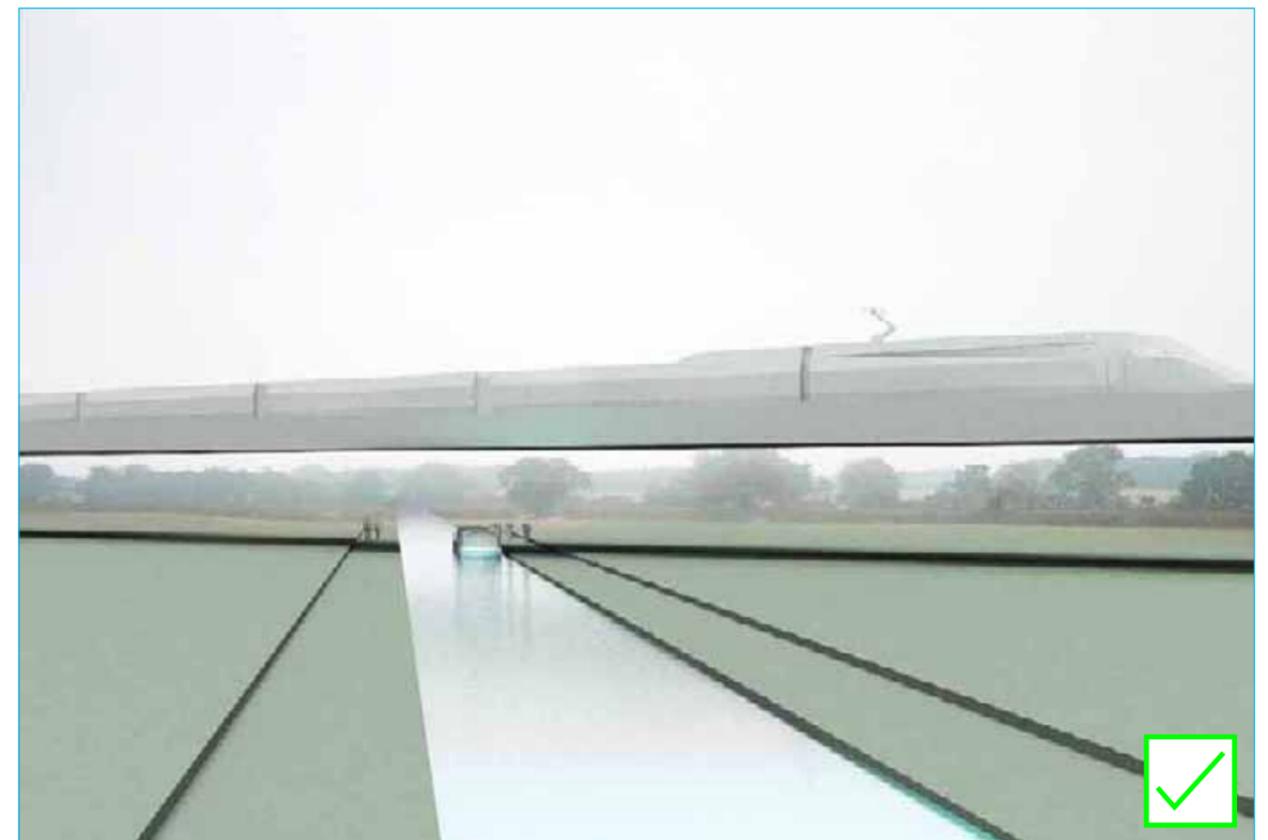


Fig.A3.2 - Crossing permits views of the horizon

# A4 Character

## A4.01 Sense of Place

It is essential that the railway infrastructure of HS2 should respect the urban and rural fabric of the canals and rivers it crosses so that in time it may become an integral part of them. Whilst a consistency of HS2 structures is desirable in order to achieve a uniform quality of materials, detailing, and a clear 'route aesthetic', the bridges will be crossing unique places of great character. Through the creative and elegant use of elevations, piers, soffits, decks, surfacing and lighting, HS2 crossings can be created that are appropriate for their setting.

For example, the characteristics of urban and rural waterway corridors are often different. This distinction needs to be considered and recognised in the HS2 structures with a design philosophy that embraces the distinctiveness of their locale, within the frame of HS2 design.

In order to emphasise this, public realm, landscaping improvements, and opportunities for public art may be carefully and selectively employed. This would need to be carried out with the involvement of local community groups, residents, the Canal and River Trust, and key stakeholders, to ensure that the improvements to the area reflect the aspirations of those who will use it the most.

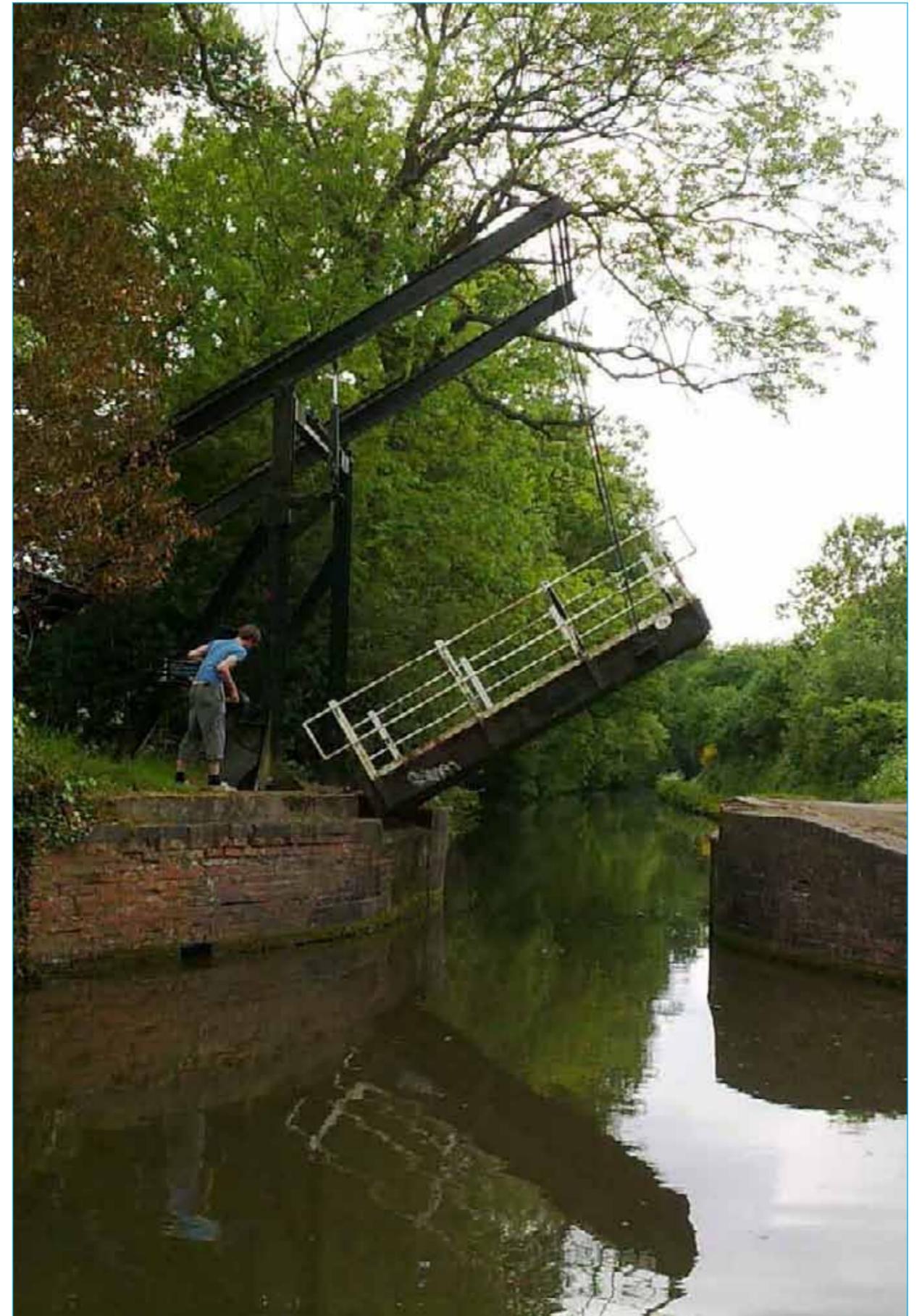


Fig.A4.1 - Bridges potentially add to the character of the waterways

## A5 Scale

The waterways have a specific scale; a scale of size, speed and detail. Physically the canals are detailed at a 'human' scale - towpaths widths, furniture, signage, boats and materials all address the users, and as such the environment is welcoming.

The speed of the waterways is also hospitable. Boats, cyclists and pedestrians all broadly share a common speed, which permits a comfortable environment for all. Where HS2 encroaches upon the canal environment, there will be a stark and severe contrast of speeds. This will have an obvious acoustic impact that must be minimised as outlined in section B14.03. In addition to the acoustic effects of contrasting scales, the visual discontinuity must also be addressed. HS2 is detailed for high-speed trains, and as such will likely feel inhospitable to users of the waterways. Structures, material quality, finishes, and detailing that are appropriate for a high-speed rail environment will almost certainly not be appropriate when viewed from a boat or a towpath at 4mph (Fig.A5.1).

Wherever HS2 structures impose upon the visual envelope of the waterways, they must be detailed so as to read as part of the waterway environment. Furthermore, care will need to be taken to ensure the proportions of the structures are considered in the context of the waterway corridor, therefore consideration needs to be given to the aesthetics derived from the relationship between span, deck depth, and pier size.

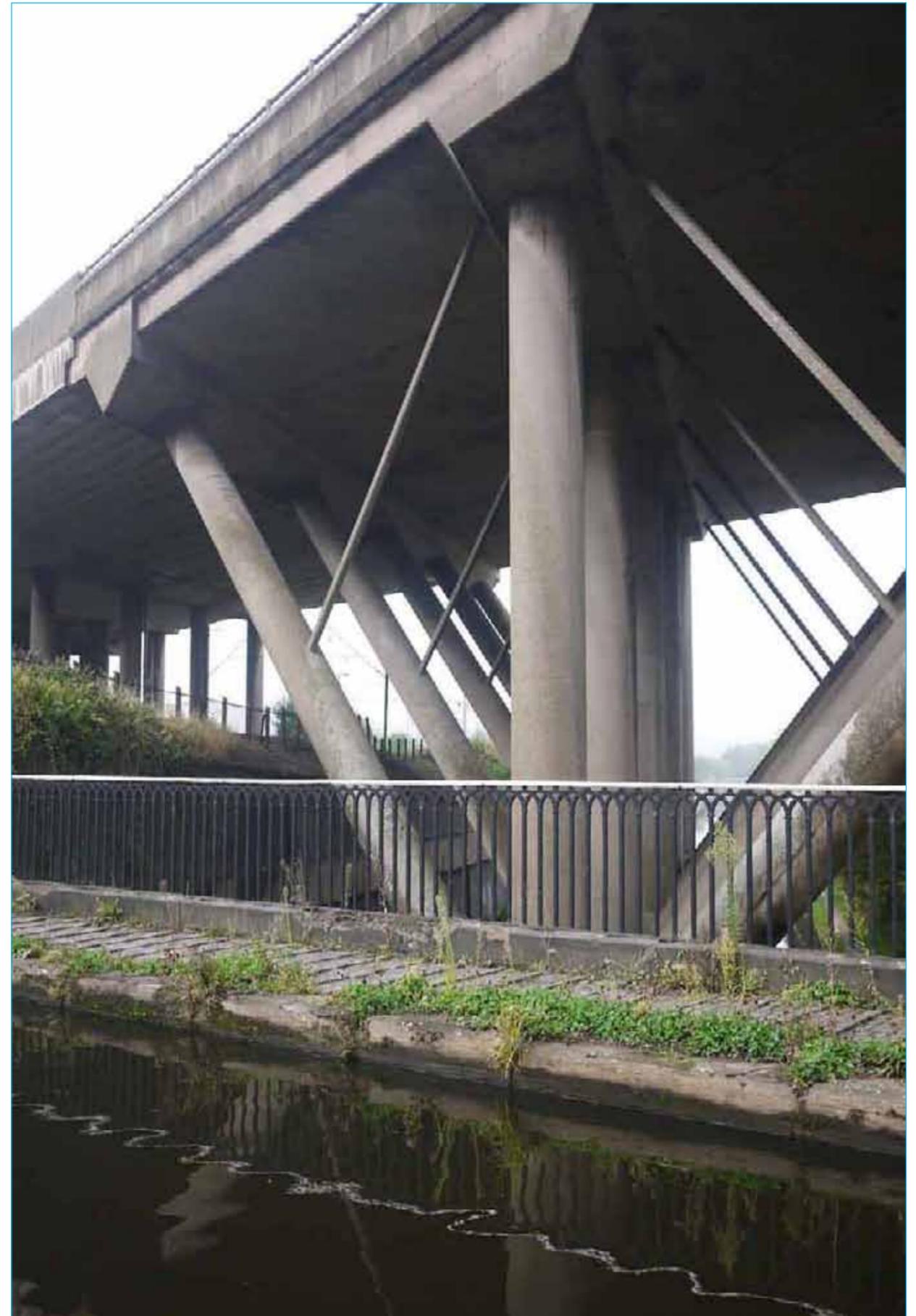


Fig.A5.1 - Modern infrastructure is often at a much larger scale than that of the waterways

## A6 Tranquillity

The waterways are a peaceful environment. The tranquillity of the canals in rural areas is one of their primary attractions, and HS2 must be designed to ensure that its impact on the aural envelope of the canal is minimised.

Planting will do very little to minimise the noise of a train passing by, and so other measures must be used to reduce this impact. Even in areas that have -for example- a close proximity to a road, HS2 will bring sudden and sharp sounds that rise above the comparatively consistent background acoustics of a road.

Details of how acoustic screening may be implemented are outlined in section B14.03.

In addition to the acoustics of HS2 whilst in use, construction noise should be kept to an absolute minimum. At locations with moorings, working hours should be restricted in the same way as when in close proximity to a residential area.

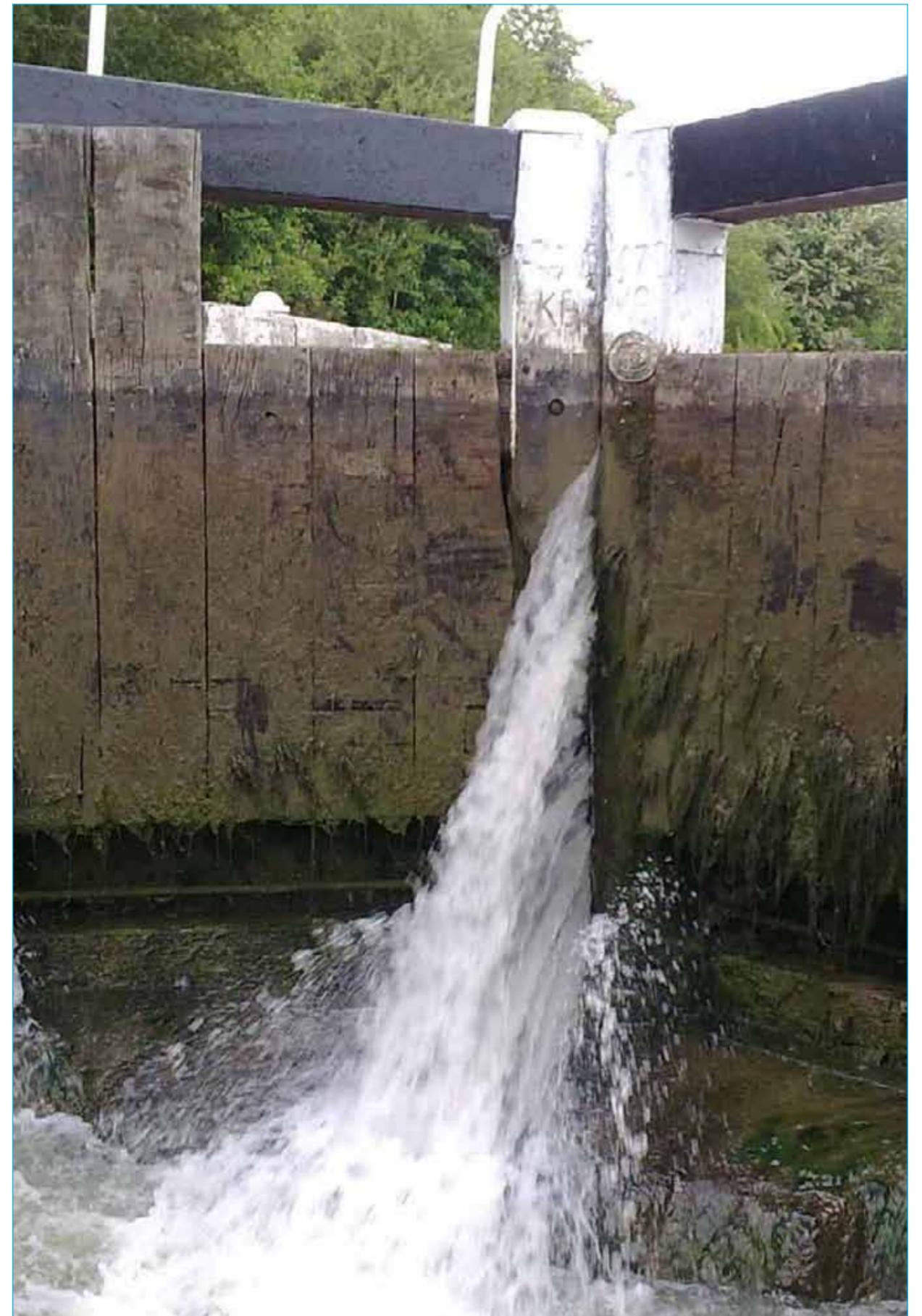


Fig.A6.1 - Tranquillity and characteristic noises add to the appeal of the waterways





# B1 Quality

## Issue

Good design can be difficult to define and this can be particularly true for utilitarian infrastructure such as roads and bridges, however it is very important to consider visual and build quality for these structures because of the very long life span they enjoy. As described in this chapter, it is paramount that consideration is given to aesthetic quality and character in order to avoid poor design that can become an unwelcome addition to the waterway environment.

## Response

HS2 should aim to achieve a consistent visual quality that enhances either the urban or rural environment and provides a clear waterway identity. To this end the many diverse elements of the design will be standardised, controlled and coordinated from end to end of the Project so as to ensure a high quality visual appearance. This section will describe the approach to appearance for the many elements that will contribute a unifying aesthetic design to the Project. Individual elements will be guided by applicable design standards. However, they will also be considered in relation to one another and to viewers, whether stationary or moving, so as to ensure the overarching aesthetic objective of an integrated and harmonious visual environment is met.

A consistent design approach should be taken to all waterway works associated with the project in order to ensure visual coherence.

Within the “standardised designs” approach proposed in HS2’s Draft Planning Memorandum, appropriate designs for open and focused waterway crossings should be developed.



Fig.B1.1 - High quality elements stand the test of time

# B2 Relationship

## Issue

HS2 will introduce a relationship between the high speed rail and the waterways, and careful consideration must be taken to ensure that it is a positive one.

The waterways were once a functional and vital piece of infrastructure. As new modes of transport emerged, these were overlaid on the canal and river network, in a manner that was frequently unsympathetic to the waterways. As the logistical usage of the waterways declined, their recreational usage increased. Today, the waterways are a place of relaxation; people choose their characteristic slow-pace and tranquillity as one of retreat from that of an increasingly speedy world.

## Response

Slow is a quality that must be protected, and the need to do so has never been more apparent than with the addition of HS2. The relationship between these two layers of infrastructure must allow both to function as positively as possible. With careful consideration, the relationship between the two layers of infrastructures can be harmonious as seen in Fig.B2.2. Yet where a new layer of infrastructure is built without due deference to the last, an uncomfortable and unsightly relationship results, as seen in Fig.B2.1. Structures that recognise and address the canal corridor will become a successful part of its environment.



Fig.B2.1 - Bridge with a poor relationship with the canal below



Fig.B2.2 - Bridge with a positive relationship with the canal below

# B3 Horizontal Alignment

## Issue

One of the design characteristics which will potentially have the largest detrimental impact on the waterways is that of horizontal alignment. Notwithstanding the pre-existing structural and functional constraints that largely dictate the alignment, it must be considered a matter of primary importance. Simply put, heavily skewed crossings will have a significantly greater impact on the waterway environment than perpendicular crossings, and as such will require a higher degree of consideration in order to achieve an acceptable result.

## Response

As shown in Fig.B3.1 and Fig.B3.2 the degree to which HS2 is 'skewed' across the water significantly alters the amount of the waterway environment that is beneath the bridge. A perpendicular arrangement is preferable for the following reasons:

- 1 It reduces the area underneath the bridge
- 2 It minimises the footprint of the bridge in the canal corridor
- 3 It reduces the amount of soffit seen
- 4 It reduces the overshadowing of the waterway environment
- 5 It appears to be a more 'considered' and formal arrangement
- 6 The span is reduced, which in turn reduces the structural depth
- 7 Unsightly 'left over' spaces are eliminated
- 8 More vegetation can remain undisturbed

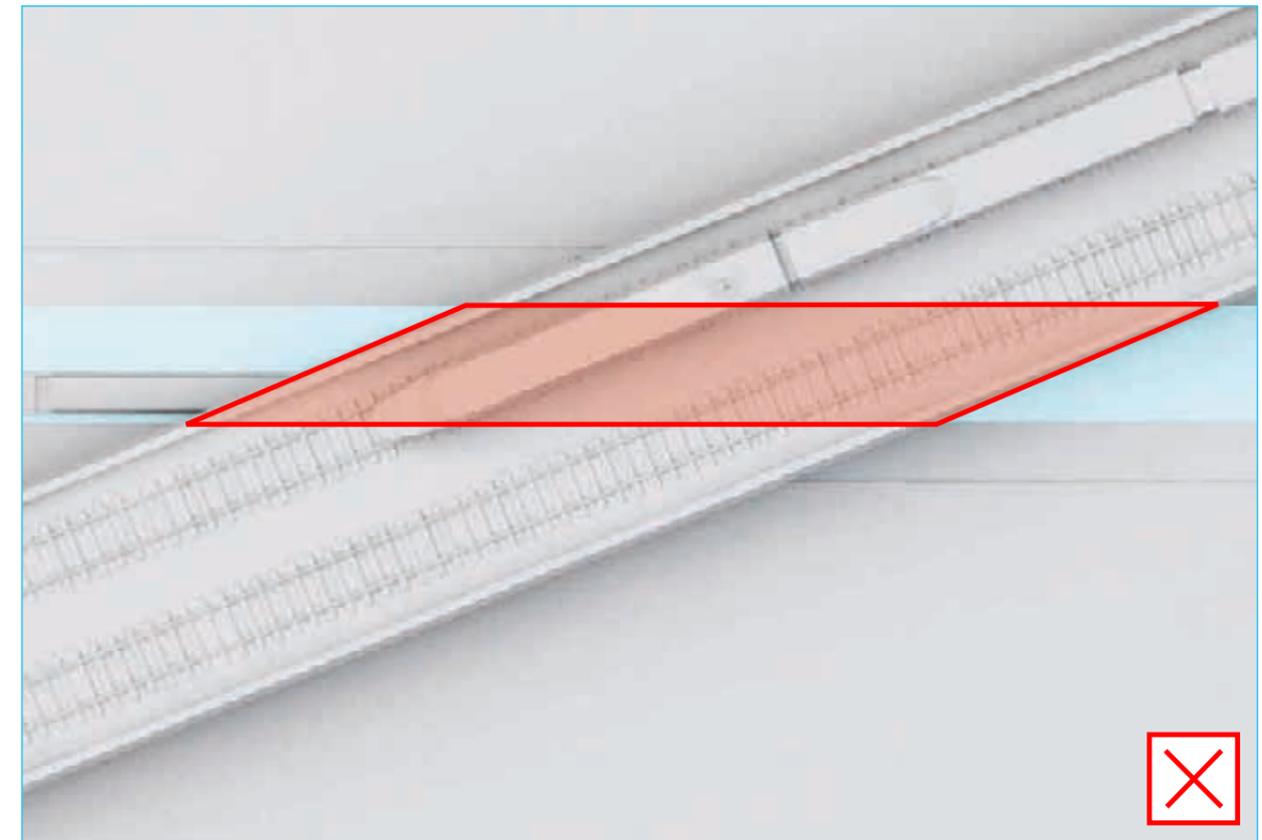


Fig.B3.1 - Heavily skewed crossing increases the 'footprint' of the bridge

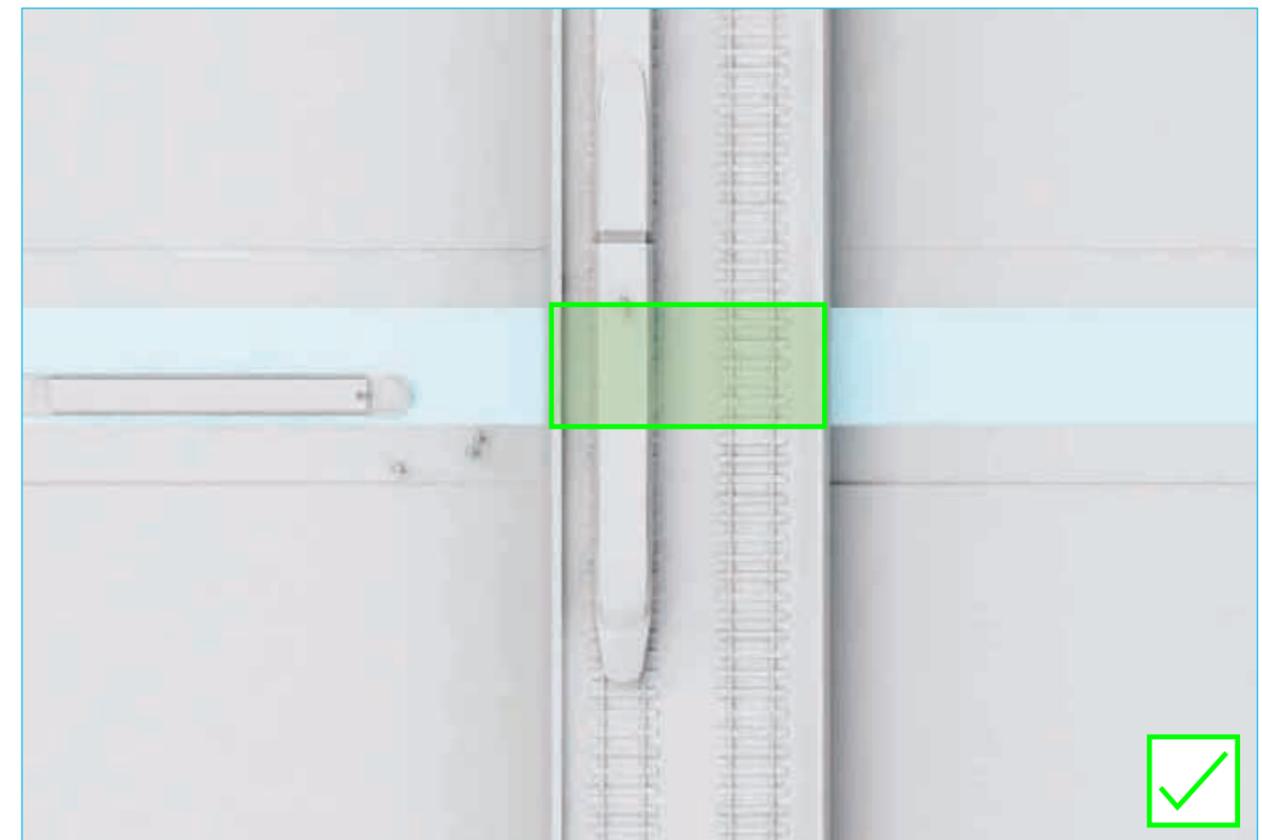


Fig.B3.2 - Perpendicular crossing minimises the 'footprint' of the bridge

# B4 Vertical Alignment

## Issue

Of equal importance to the horizontal alignment is that of the vertical. In addition to the practical considerations of vertical alignment is the aesthetic impact of height. Views along the canal will be greatly impacted by the vertical alignment of HS2 crossings.

## Response

### B4.01 Clearances

Both the towpaths and the waterways have minimum vertical clearances that are required for the sustainable use of the waterway corridor. Both the canal and the towpath have minimum clearances that must be maintained as defined by the Trust for each individual waterway.

### B4.02 Height

Each structure must be considered in its own right, as the vertical alignment of narrower, perpendicular crossings will not have as significant an impact on the waterway environment as wide, skewed ones. Generally speaking, however, lower crossings block views and light, and as such will require great attention to reduce their visual impact (Fig.B4.1). Conversely, crossings with a higher vertical alignment will permit more light to penetrate beneath them, and natural vegetation to encroach further underneath the structure (Fig.B4.2). Higher structures also serve to ease the disharmony of scales as discussed in (x.x).

Furthermore, whilst the vertical alignment of the tracks will be largely fixed, there may be instances in which reducing the span (and consequently the structural depth of the deck) would have a significant benefit on views through the crossing. In addition, where a vertical alignment introduces a clear view of the bridge soffit on approach along the towpath, its design must be carefully considered so as to ensure that the soffit appears as a high-quality, well thought out element of the waterway environment.

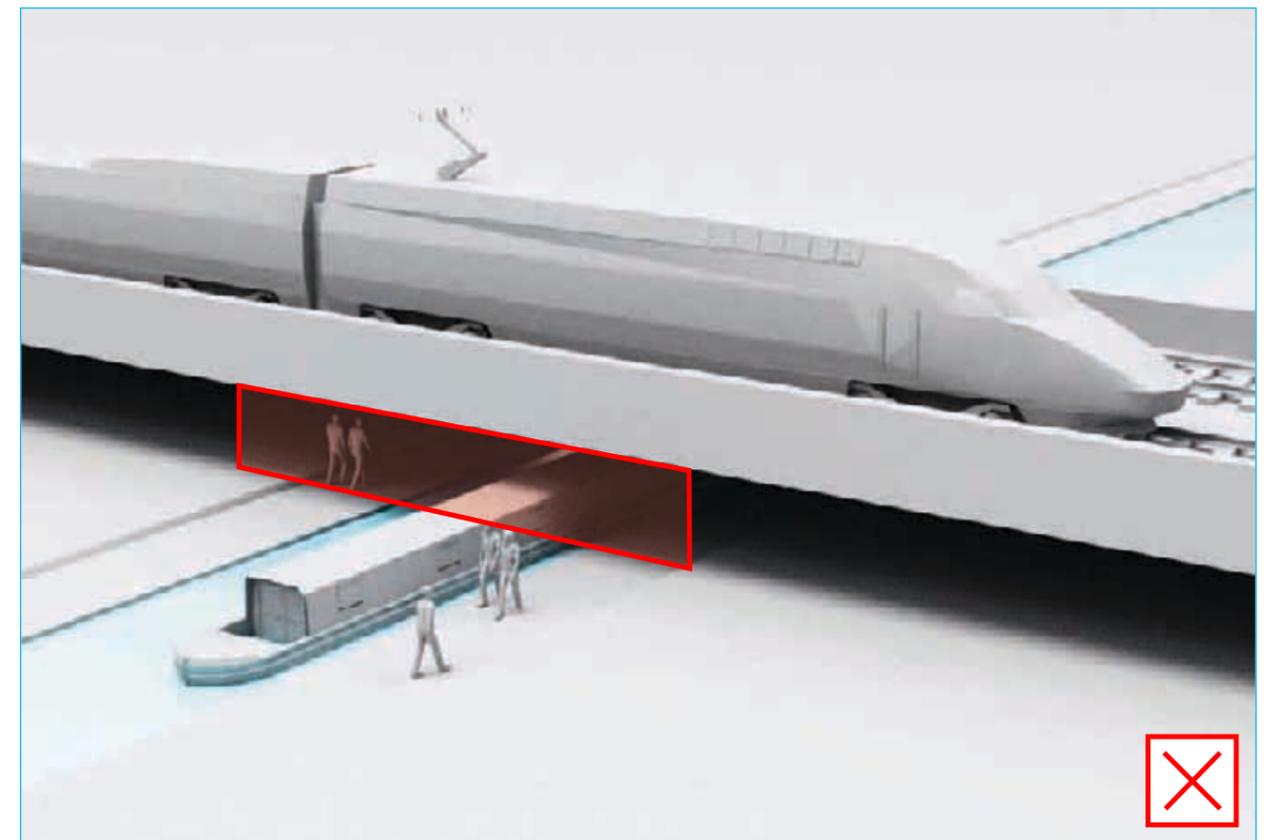


Fig.B4.1 - Low vertical alignment creates dark spaces and a disharmony of scales

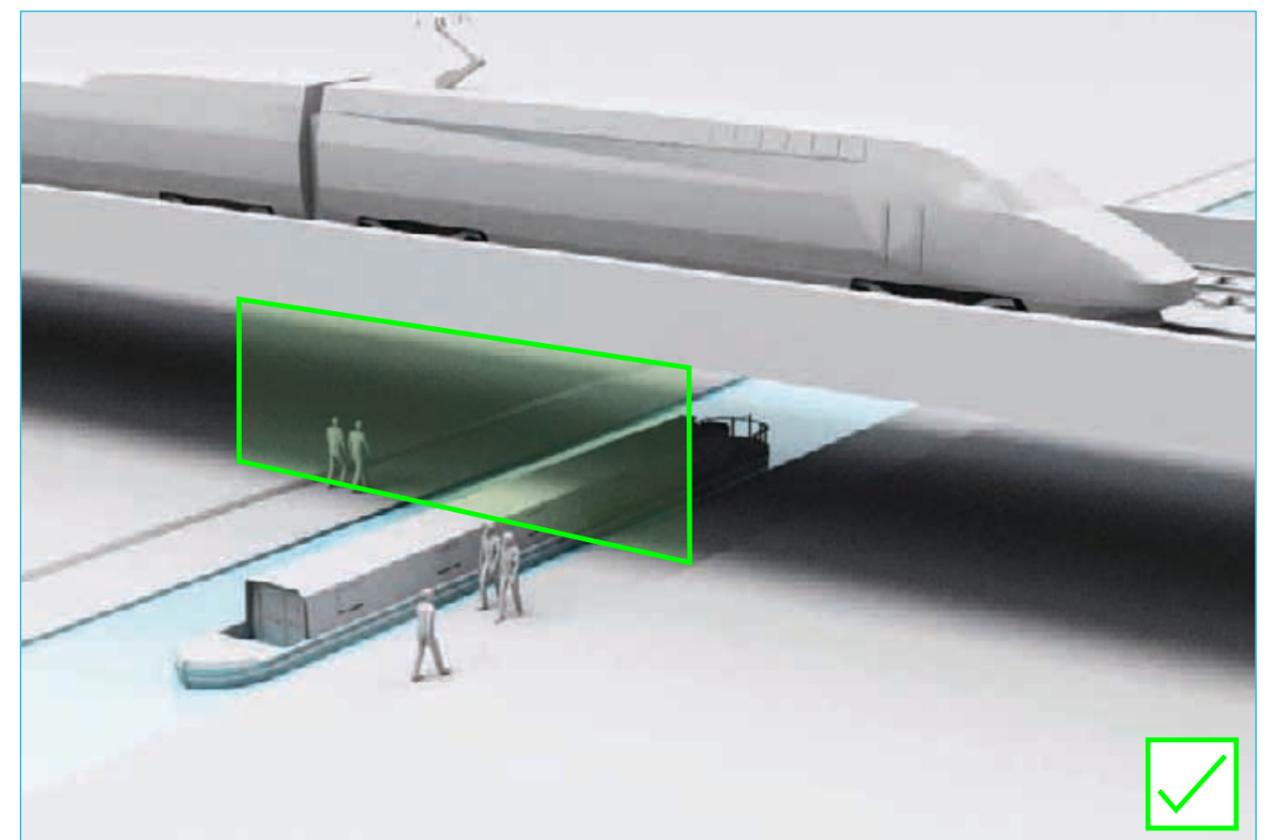


Fig.B4.2 - Higher vertical alignment permits light to enter

# B5 Visual Scenarios

## Issue

Each crossing will present a different structural challenge, in terms of alignment, span and constraints. The supporting structures to HS2 will impact greatly on the visual environment and quality of the waterway environment and as such their careful selection and implementation is essential.

## Response

The following pages look at the various options for supporting the waterway spans, which can broadly be categorised as “open scenarios” with wide views across the landscape (where either a viaduct or embankment is used) and “focused scenarios” with narrow, linear views of the canal. Whilst each crossing must be assessed individually, we can identify some broad preferences for each scenario, as highlighted opposite.

## “Open” Scenarios: Viaducts



**Uniform Viaduct:** Standard piers do not address the water and do not suit its requirements.

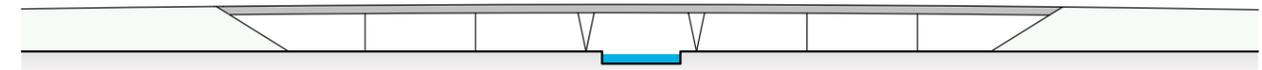


**Waterside Piers:** Special piers for the canal crossing identify the span, and address the requirements of the waterways.

## “Open” Scenarios: Embankments



**Abutment and Piers:** Single backspan and vertical abutment walls curtail open views



**Embankment:** Maintaining multiple backspans behind canal span ensures views remain open

## “Focused” Scenarios



**Abutment and Piers:** Piers and vertical abutment walls create enclosed, dead spaces



**Embankment:** Close, vertical abutments create a ‘picture frame’ span across the canal.



Fig.B5.1 - Typical 'focused' scenario with no lateral views

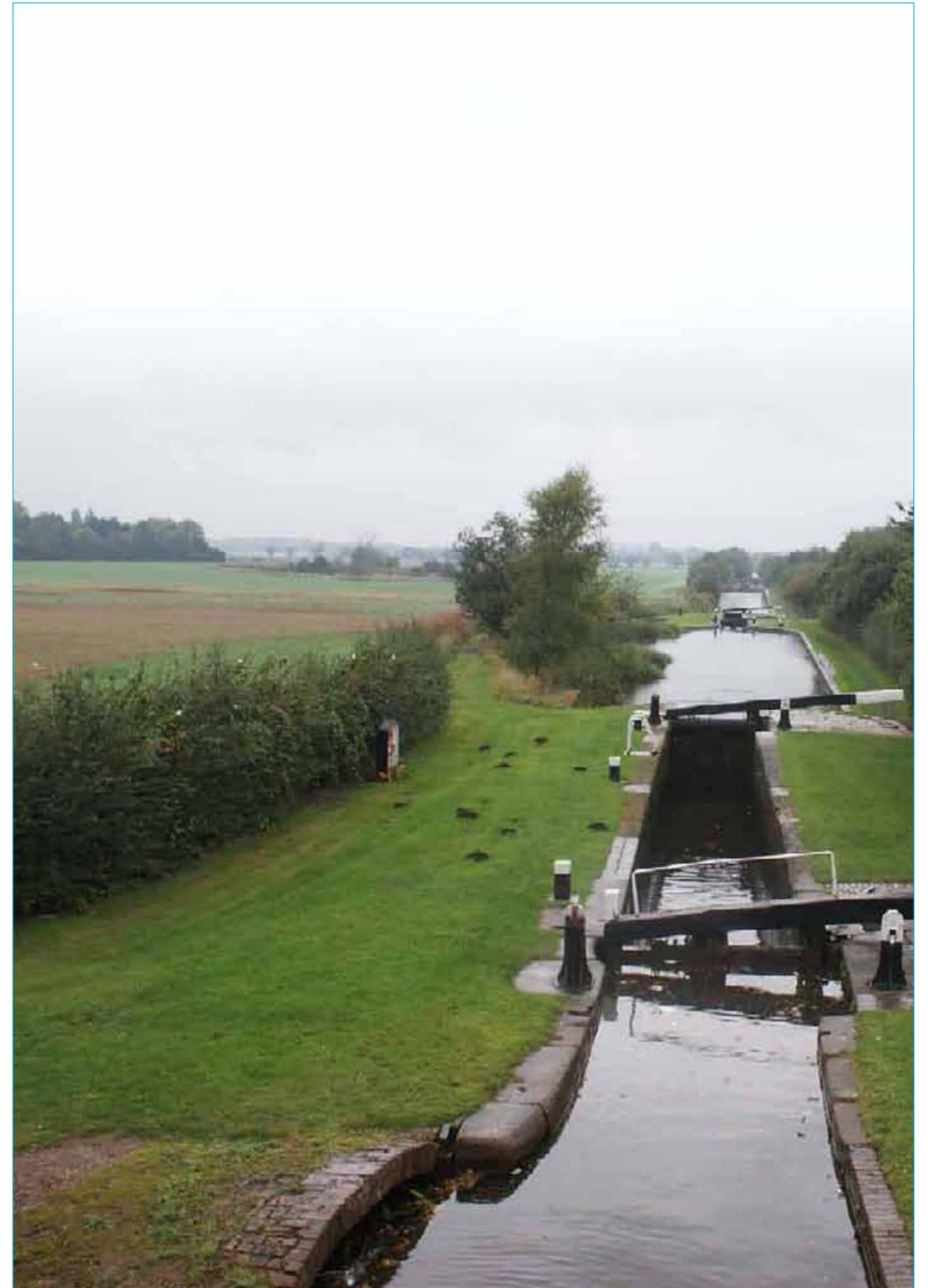


Fig.B5.2 - Typical 'open' scenario with lateral views

# B5.1 “Focused” Scenarios

## Issue

Focused, narrow views are a common characteristic of the waterway environment, and HS2 crossings need to engage with this aesthetic in a positive way. Standard pier arrangements are more suited to open views, and potentially appear cluttered and unresponsive in these ‘closed’ scenarios.

As described previously, analysis of individual crossings needs to be undertaken to determine the most appropriate solution for the landscape. However, generally speaking, where an embankment meets the waterway environment in a ‘focused’ scenario, sloped abutments with intermediate piers (Fig.B5.3) tend to create ‘negative’ spaces between the piers and the abutments. These zones are unusable for planting due to the overshadowing, and worse, can appear as dark and dangerous spaces, that detract from the welcoming waterway environment.

## Response

In situations where there is a closed, narrow visual envelope along the canal (usually created by hedgerow and trees) a beam and vertical abutment solution (Fig.B5.4) may be beneficial. Continuing the embankment up to vertical abutment walls creates a ‘frame’, which complements the linear, narrow views at that location, and appears as a comfortable and appropriate component of the waterway environment.



Fig.B5.3 - Pier and back-span arrangement unsuitable for ‘focused’ scenarios

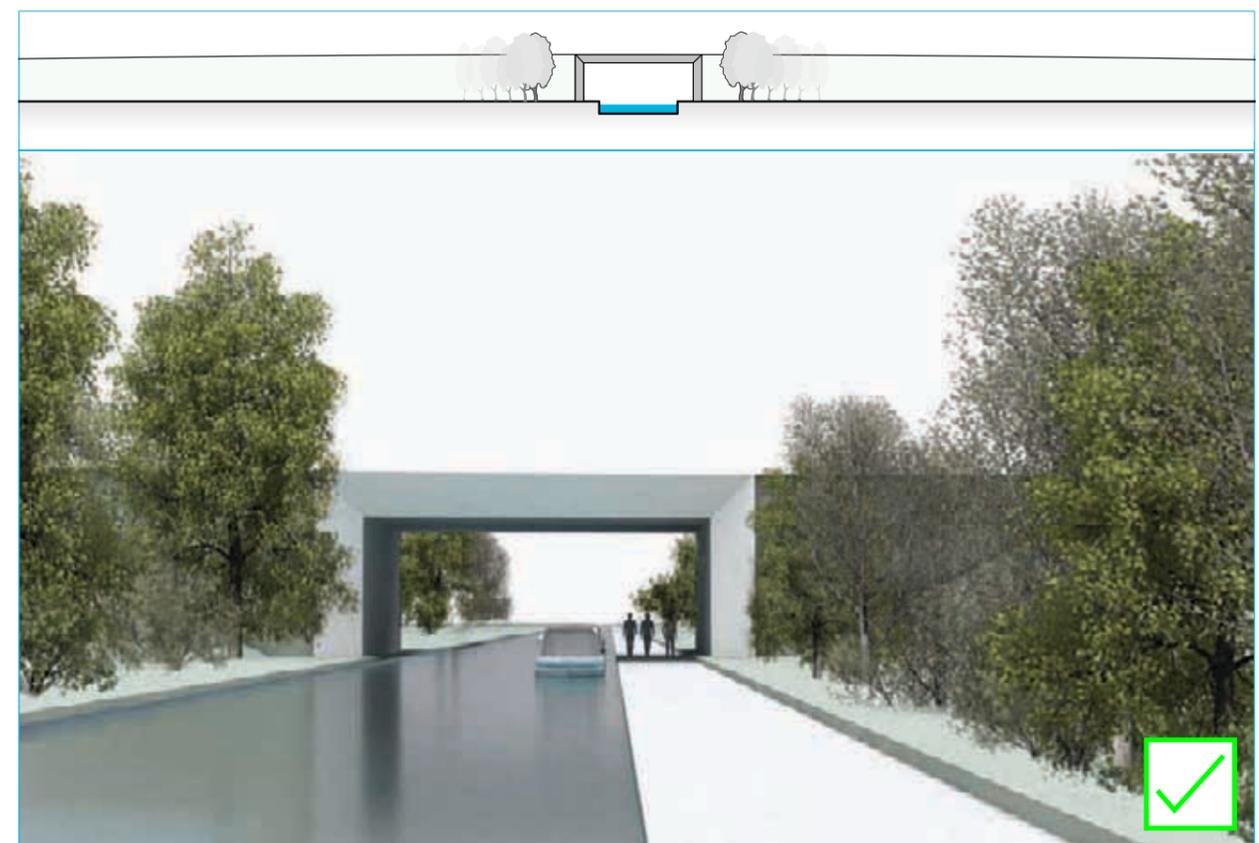


Fig.B5.4 - Framed structure suitable for ‘focused’ scenarios



Fig.B5.5 - Framed structure suits the focused scenario