COLNE VALLEY VIADUCT

SUSTAINABILITY AND REGENERATIVE DESIGN CASE STUDY

Location: Colne Valley, UK
Completion: 2024 (Preliminary Construction)
Client: HS2 / ALIGN JV
Contractor: ALIGN JV (Bouygues, Sir Robert McAlpine, and Volker Fitzpatrick)

Partner / Project Leads: Ewan Jones / Chris Patience
Project Team: Grimshaw (Architect), LDA Design (Landscape Architect), Ingerop / Rendel (Structural Engineers), Jacobs (Engineers)

The Colne Valley Viaduct is a landmark structure on the High Speed Two (HS2) rail line. The design for the 3.4km-long viaduct celebrates the architecture of engineering with a structure that is expressive of power, speed and function. The viaduct has been designed to meet demanding technical, environmental, and operational requirements.

Grand Union Canal view ↑

HS2 is a new high speed railway linking London, the midlands and the north. The Colne Valley Viaduct will be a landmark structure within HS2 Phase 1 which connects London and Birmingham. It is located in Buckinghamshire and the London Borough of Hillingdon, crossing the Colne Valley Regional Park between tunnels under London and the Chilterns. Preliminary construction of the viaduct is due to be completed by 2024 and it is planned to be operational from 2029.

The design of the viaduct is highly responsive to the character of the Colne Valley. Structural spans and pier forms vary as the viaduct passes through a mosaic of lakes and woodland. Over water, extended structural spans of 80m open up the space below the structure, enabling panoramic long-distance views to the landscape beyond. The viaduct requires fixed buttresses to transfer train braking loads into the ground and portals to allow thermal expansion at regular intervals. These have been strategically located where the railway crosses key features in the valley landscape. Great care has been taken to express these essential buttresses and portals as visibly special structures, unique to their function and locations.

Structural efficiency:

High speed trains travelling at up to 320kmh generate substantial structural loads. A core challenge for the viaduct design has been to accommodate onerous engineering requirements while minimising the scale of the structure and reducing impact on the local environment. Optimised structural efficiency, within a common design language of faceted forms, has reduced the volumes of concrete and steel required within the viaduct and its foundations. As a result, the carbon footprint will be at least 28% lower than the earlier Hybrid Bill design, saving 63,300 tonnes CO_2e.

Optimised construction:

The Colne Valley is a sensitive landscape which has significant environmental considerations including Ancient Woodland, SSSIs, and multiple water-bodies. A variety of sustainable design strategies have ensured impacts on local communities and the environment are minimised. The design reduced the width of the structure and its construction corridor as far as possible in order to minimise land take for construction and the permanent works.

This has limited impacts on the local environment, substantially reducing tree loss including avoidance of adjacent Ancient Woodland. The construction methodology for the viaduct was developed in parallel with the design, optimising buildability whilst impacts on the local environment are minimised. Concrete deck segments are cast in a compound near the M25, then transported and installed from north to south along the viaduct as it is built, avoiding construction traffic on local roads. A cantilevered construction method allows the deck to be installed at high level between each pier, reducing disruption at ground level and to waterbodies that the structure crosses.

Improving local accessibility:

The landscape design responds positively to the character of the area, enhancing this and contributing the distinctive local environment. A key design strategy is to increase accessibility to the Colne Valley Regional Park, promoted through enhanced recreational routes and the introduction of new footpaths. The landscape and ecology proposals conserve as much of the most sensitive habitats close to the viaduct as possible. The design establishes new landscape and wetland features, reintroducing habitats previously lost in the Colne Valley.

Designing for resilience:

Large areas of the Colne Valley are within flood risk zones. The viaduct design respects existing watercourses, providing a railway that is resilient with no increased risk of flooding in surrounding locations. Significant flood attenuation areas have been incorporated within the landscape by creating substantial wetland areas that contain numerous ephemeral waterbodies, wet grassland, and larger balancing ponds. The structure has been designed to achieve a 120 year design life: to achieve this, all materials are self-finished to maximise robustness and durability, avoiding requirements for long term maintenance or replacement.

Effective stakeholder engagement:

Throughout the design process the design team worked closely with local stakeholders to understand opinions and seek ideas to inform the design of the viaduct and landscape. Align, the JV contractors, held a programme of public events which engaged with local communities from early in the design process right up to submission of Schedule 17 requests for planning consent.

Faceted form and family of components ↑
All components have been designed within a common design language to ensure the viaduct is recognisable as a single, coherent structure wherever it is experienced in the Colne Valley. Curvature is only used in the haunched deck profile, all other structural components are faceted forms with strongly defined edges. These folded planes and straight edges characterise the structure, alongside textured concrete selectively applied in locations where the structures meet ground or water.

Key Sustainability Facts

PROJECT SITE
> Colne Valley Regional Park, Multiple SSSIs and Nature Reserves

EMBODIED CARBON
> Overall construction carbon reduction of project = 28.4%
> Overall embodied carbon reduction = 63,000 tCO_2e
The Scheme Design reduction is in comparison against the Hybrid Bill design used for Parliamentary consent.

CERTIFICATION
> BREEAM Excellent for Infrastructure

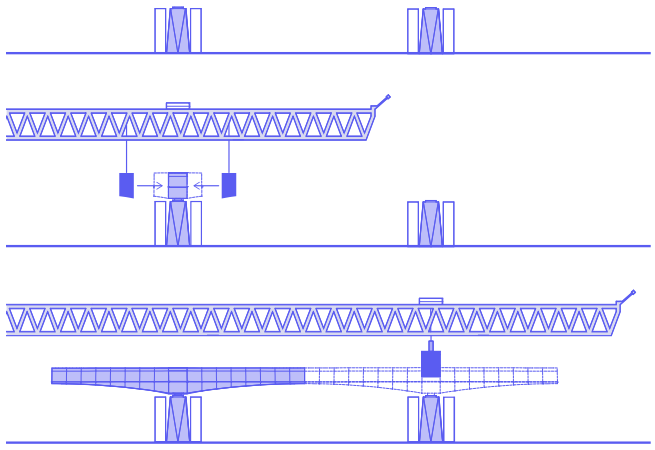
Alignment with UN Sustainable Development Goals

SDG 3 GOOD HEALTH AND WELLBEING
The landscape design delivers distinctive and accessible green spaces that encourage pedestrian access.

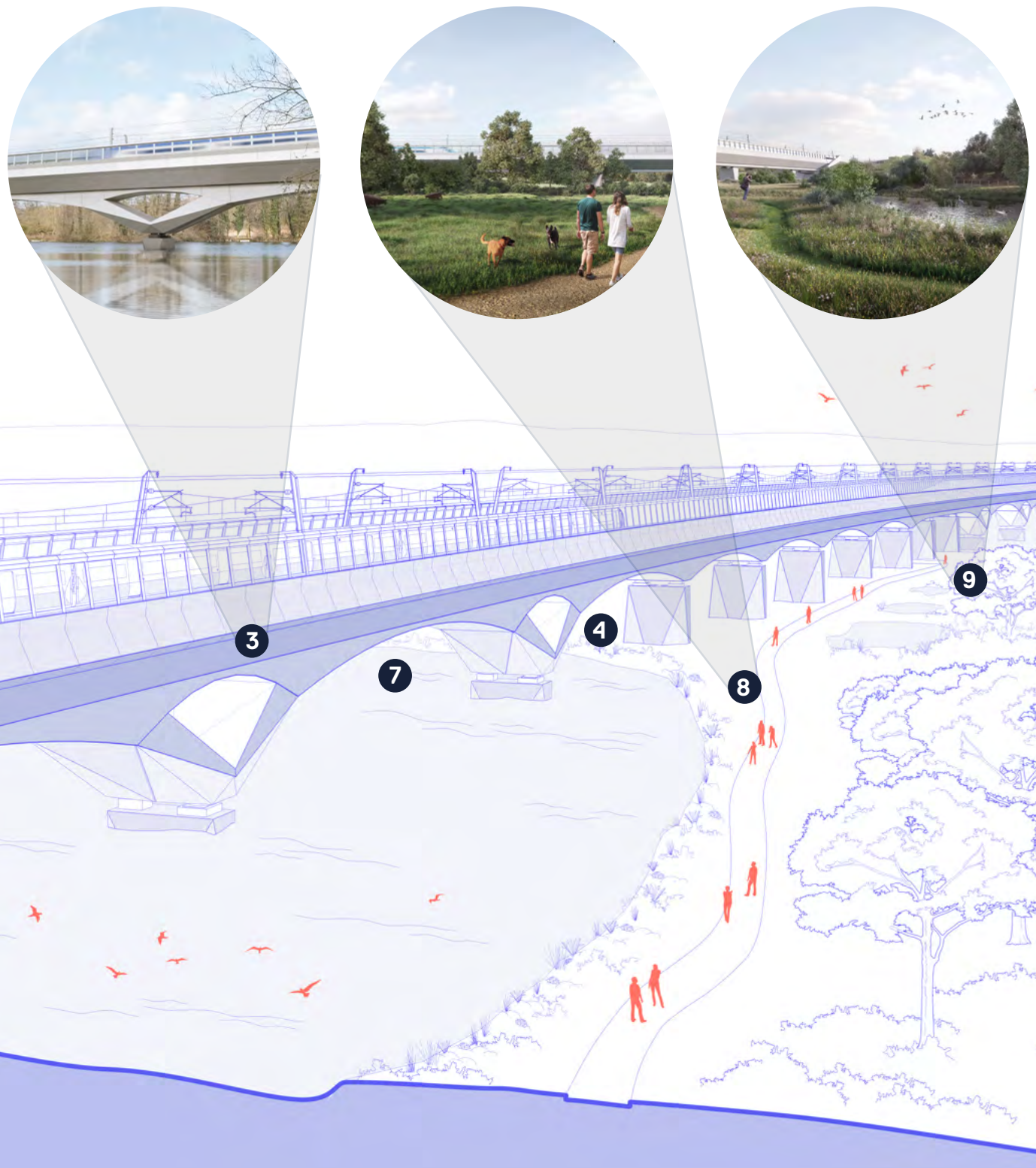
SDG 9 RESILIENT INFRASTRUCTURE
The Colne Valley Viaduct has been designed to last at least 120 years and to withstand future climate change.

SDG 13 CLIMATE ACTION
Carbon footprint has been reduced through structural efficiency, reduced massing and cement replacement.

SDG 15 SUSTAINABLE ECOSYSTEMS
An integrated landscape and ecological design optimises biodiversity through nature conservation, recovery and habitat creation.



6 ↑ Precast deck cantilever construction method



1. **Optimised structural efficiency –** A fundamental design principle for the viaduct has been to reduce the volume of concrete required by maximising structural efficiency. The variable depth box girder deck locates the primary structure directly below the track, resulting in a more direct transfer of load to the columns below. By optimising structural efficiency, less concrete is required within the viaduct deck, resulting in a structure with less visual mass at deck level and a minimised deck width.

2. **Alternative materials –** The weight of the deck has been further reduced by using lightweight ultra high performance concrete (UHPC) parapets and a noise barrier system comprised of aluminium acoustic cassettes and transparent acrylic panels.

3. **Faceted form –** Concrete forms have been carefully crafted and faceted to reduce visual bulk and to achieve a refined and elegant profile. This common language has minimised the volume of concrete required to support the deck above.

4. **Re-use –** The pier geometry has been designed to enable the re-use of formwork, minimising material usage and wastage. Construction access routes will be re-purposed (including retention of base course materials) to provide multi-functional maintenance and recreational paths along the viaduct route.

5. **Comfort / natural daylight –** Much of the HS2 route between London and Birmingham is in tunnels annd cuttings, limiting opportunities for natural daylight and long distance views for passengers. Therefore, wherever possible, transparent acrylic panels have been incorporated within the 4m high noise barriers to allow passenger views over the landscape. To enable the use of transparent panels, the noise mitigation performance of the barrier is tuned the precise needs of each location. To mitigate the risk of bird collision with trains, the noise barriers provide effective enclosure whilst the transparent panels incorporate black lines to ensure they remain visible to flying birds.

6. **Construction methodology –** In order to minimise the impact of construction traffic on local communities and the environment, the precast deck segments are cast on site and transported via a launching girder from the north of the site. They will be constructed piece by piece from high level using a cantilever construction method. The impact on local roads is also reduced with the equivalent of approx. 4000 lorries diverted from local roads via a designated construction corridor including four jetties and a haul road. This construction method also enables the structure to be built over rivers and roads without major impact.

7. **Sustainable construction materials –** The design team have reduced the carbon footprint of the Colne Valley Viaduct through the replacement of cement with ground granulated blast furnace slag (GGBS). Where possible, the aggregate used in the concrete mix is locally sourced to minimise carbon impact associated with transporting materials.

8. **Accessibility –** The project will include provision of 3.5km of new footpaths and cycle routes which are fully connected to the surrounding rights-of-way network, as well as opportunities to interact with nature within a range of environments. The network of new recreational routes will open up previously inaccessible areas of the Colne Valley Regional Park to the local community.

9. **Enhanced landscape and ecology –** The ecological design optimises habitat creation to help deliver local nature conservation objectives. All site soils and substrates have been re-used with profiles matched to the target habitat types. The ecological baseline before starting work has been enhanced through localised changes from species-poor agricultural pasture to a more varied mix of wetland, rich grassland, scrub and woodland.