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.

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 320km/h 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 CO₂e.

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.
1. Organised 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 4m high noise barriers. 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 re-used (including retention of base course materials) to provide multi-functional maintenance and recreational routes along the viaduct route.

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 reuse of formwork, minimising material usage and wastage. Construction access routes will be repurposed (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 and 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 to 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 by using lightweight ultra high performance concrete (UHPC) parapets and a noise barrier system comprised of 4m high noise barriers.

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.