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High Speed Two (HS2)

Infrastructure Design and Construction

Volume 4 Architecture, Digital Engineering, Environment and Heritage

Introduction

Britain's new high-speed railway is being built from the South East to the North West, with HS2 trains connecting the biggest cities in Scotland with Manchester, Birmingham and London. Europe's biggest infrastructure project will transform Britain with high speed trains running across new lines and upgrades to deliver fast, reliable, high capacity travel to major towns and cities. The project is being built to the latest engineering and environmental standards using world-class engineering and is already supporting nearly 30,000 jobs across the UK.

This is the fourth in a series of books capturing the technical excellence and learning from across the HS2 programme. It is published as part of HS2's Learning Legacy commitment to share lessons, good practice and innovation and help raise the bar throughout the UK infrastructure industry to improve productivity.

The technical papers provided in volume 4 were submitted as part of the HS2 Technical Papers Competition (2022) and include papers categorised as Architecture, Digital Engineering, Environment and Heritage. Papers categorised as Design and Engineering are published in volume 3.

This book provides a brief history of the original London and Birmingham Railway, which opened in full in 1838. It describes how HS2 came about and the phased design and construction of the route between London, the West Midlands and the North. The route as it stands today and the organisational framework, including HS2 Ltd as the client and the delivery partners, are described to provide context for the technical papers.

We hope you enjoy reading about this fascinating programme to construct a high-speed railway fit for the 21st century and built to last into the 22nd century.

We would like to thank all our authors across 22 organisations in the HS2 family and the supply chain as well as more than 50 reviewers who have helped to produce the papers and this book.

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Case study 2

Figure 20. Calcareous grasslands on the HS2 Western Slopes, The Chilterns.

The HS2 Western Slopes project in the Colne Valley demonstrates how a landscape–led design approach is being successfully achieved. Ninety hectares of calcareous grasslands which once thrived on the valley slopes are being recreated using chalk excavated from tunnelling in the Chilterns. The chalk will be sculpted to replicate the area's dry valleys and deliver a range of microclimates. Concrete and limestone aggregate used in HS2's construction will be recycled to add to the calcareous grassland to reduce the removal by truck to help minimise HS2's carbon footprint. The proposals will deliver multi-functional habitats which provide wider project benefits and efficiencies including water management, soil protection, and the delivery of lower maintenance landscapes which maximise biodiversity and habitat value in a contextually appropriate manner.

HS2 Green Corridor and the River Cole

HS2 are committed to minimising and compensating the environmental impacts of its proposed infrastructure, including the minimising the loss of habitat from constructing an operating the railway and, where possible, are committed to enhancing landscapes affected by the route. HS2's Green Corridor *"is the largest single environmental project in the UK. We will leave behind more than 33 square kilometres of new woodland, wildlife and river habitats alongside the line from the West Midlands to London, the equivalent of 23 new Hyde Parks lining the spine of the country"*[1] Along this Green Corridor lie a number of important Sites, not least the River Cole and its floodplain. The River Cole is located within the southernmost section of the Delta Junction, within North Warwickshire Borough Council. The Delta Junction is a triangular section of railway, covering a distance of approximately 4.6km, where the HS2 route divides, curving westward to Birmingham and running northward to Crewe. The eastern section of the Main Line runs north and crosses the River Cole via the Coleshill viaduct with the western part, the Birmingham Spur, crossing the River Cole via a pair of single-track viaducts (the East and West Viaducts).

Figure 2. HS2 Route to Birmingham (Including the Delta Junction)

The proposed East and West Viaducts are each 158m long and include 4 spans. The Viaducts are large, engineered structures of concrete and steel intersecting the landscape, inclusive of the River Cole and its floodplain. Despite the railway being raised above most of this landscape on viaduct a significant amount of work is involved to ensure these structures are not only intersecting the landscape but are integrated into the landscape fabric. This landscape integration includes a number of elements, not least the displacement of the River Cole itself. This paper will seek to dissect the HS2 design principles, governing the way in which DJV/BBV design landscapes around HS2 and vice versa, with a particular focus on the displacement of the River Cole and HS2 as a catalyst for green recovery and climate resilience, to determine if these methods are indeed best practice and easily translated to good design beyond HS2.
The River Cole sits within Arden National Character Area (NCA) 97, as defined by Natural England. The key landscape characteristics of this area are as follows:

- Well-wooded farmland landscape with rolling landform.
- Mature oaks, mostly found within hedgerows, together with ancient woodlands and plantation woodlands that often date from the time of enclosure. Woodlands include historic coppice bounded by woodlands.

Figure 14. Design Ideology

The River Cole, a sensitive ecological receptor in itself, passes through a diverse landscape all of which has been incorporated into the design for the river displacement and site. The land required for the construction of the River Cole Viaducts consists primarily of agricultural land, species rich grassland, lowland meadows and broadleaved deciduous woodland. Although no Local Wildlife Sites (LWS) are within the land required or directly adjacent to the construction area, wildlife conservation does exist in the wider study area most notably at Coleshill Farm LWS, Wheeley Moor Farm Meadow LWS and Coleshill Park Belt LWS.

The ecology of the site is highly influenced by the River Cole, which supports a wide variety of protected species and priority habitats. The grassland along the banks of the River Cole consists of five large cattle-grazed pasture fields containing the perennial rye grass community Lolium perenne - Alopecurus pratensis grassland. The river itself is to be realigned, as stated in the ES. Realignment works on the River Cole will result in the permanent loss of approximately 660m of existing channel, however any impact on watercourse habitat and function is considered likely to be offset by the increase in channel length within the realigned section.

Due to the presence of valuable ecological assets and the significant change that will be caused to them due to the diversion works, sensitive design must be underpinned by clear objectives with the aim of mitigating any impacts to these valuable receptors and enhancing them where possible. The objectives for the River Cole diversion are as follows:

- During construction and operational phases, losses of vegetation and habitats along the viaduct footprint will be minimised.
- Reduce environmental impacts.
- Achieve the target of ‘no net loss’ in biodiversity for replaceable habitats.

To achieve these goals the design has included a range of important ecological mitigation features, with habitat creation at the forefront of this.

Habitat creation in the River Cole area plays a key role. The realignment of the river provides an important opportunity for swathes of wet grassland and riparian planting along its banks. This grassland planting will help to provide continuation of grassland habitat surrounding the River Cole.

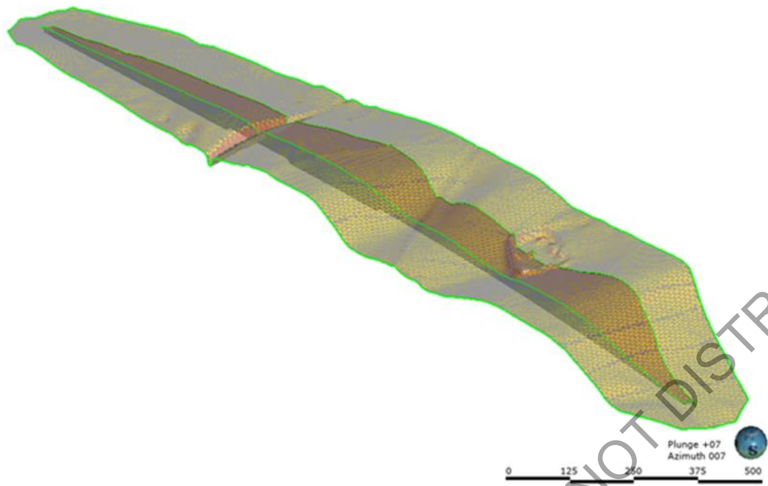

Figure 3. Topographical surface, and extent of excavation, combined to create the proposed excavation volume

Ground model

Prior to creating the geological model (by stratigraphic zoning), the model Level of Detail (LoD) was determined. This is dependent on:

- the complexity of the geology;
- the extent of the available data;
- ability to identify and separate different stratum during excavation; and
- the value in using a greater resolution of stratigraphic zoning (greater resolution may not always suit the purpose of the model).

For example, Offchurch Cutting consists of a series of glacial sequences (glaciofluvial, glacial till and glaciolucustrine) overlying Mercia Mudstone that are all readily identified on site and are likely to vary in material reuse properties (i.e., zoned based on material reuse characteristics). As a result, individual geological units were modelled. In contrast, shallow superficial deposits at Glasshouse Wood Cutting are unlikely to be able to be separated from the weathered Kenilworth Sandstone and therefore a lower resolution was adopted where only soil and rock was modelled (i.e., combining the superficial deposits and weathered Kenilworth Sandstone Grade D/E material).

Another important step in producing a 3D geological model is considering the extent of data to create a model as implicit realism can produce misplaced trust[7]. The initial extent of the 3D stratigraphically zoned geological model was set to 200m beyond the boundary of the asset to incorporate surrounding data within the analysis to reduce boundary 'edge' effects. This was reviewed on a case-by-case basis and the distance amended as deemed appropriate.

The ground models created represent a 'best estimate' based on the available data using implicit software modelling which uses algorithms to interpolate and extrapolate between data. Engineering judgement was applied during the creation of the ground model and particularly at the boundaries between the modelled strata to ensure they aligned with the

Figure 6. Existing landmarks showing potential landmarking along route

Virtual reality application

Creative and imaginative proposals – the virtual train (environment)

The purpose of Stage 2 of the project was to explore more widely the opportunities that exist in enhancing the passenger experience and to provide further information on how passenger experience can be improved through innovative tools such as technology, art and landscape architecture. The brief was to include as many of the railway features as possible (tunnels, noise barriers, cuttings and embankments etc.) but excluded the experience passengers will have when being in or around stations and depots.

To fulfil the brief, Arup collaborated with the University of Sheffield using their broad and scientific approach and particular expertise in landscape architecture, landscape history, social sciences, digital technologies, and land art.

A 10 km section of route between the Wendover and Chiltern tunnels was modelled in detail. This was built upon the hybrid design model developed for the photomontages and animations. For the context, a high resolution lidar [4] scan was commissioned and was the basis for the detailed context in the distant views. The lidar survey was undertaken by a special Aerial Capture Company (Bluesky) who used a small aircraft with one IXU camera and an Optech Galaxy LiDAR system.