Manor Farm

Vehicle Bridge

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Unique Engineering

2,276. That’s the total number of unique steel elements it took to fabricate the ninety-one individual panels forming the exoskeleton. The ribs, which integrate as part of the parapets, wrap around the belly of the bridge showcasing a delicate balance between precision engineering and architectural intent. Owing to road possession restrictions, the exoskeleton had to be installed prior to the lift. It marked a memorable day on site, as contractor records were broken during the single lift!

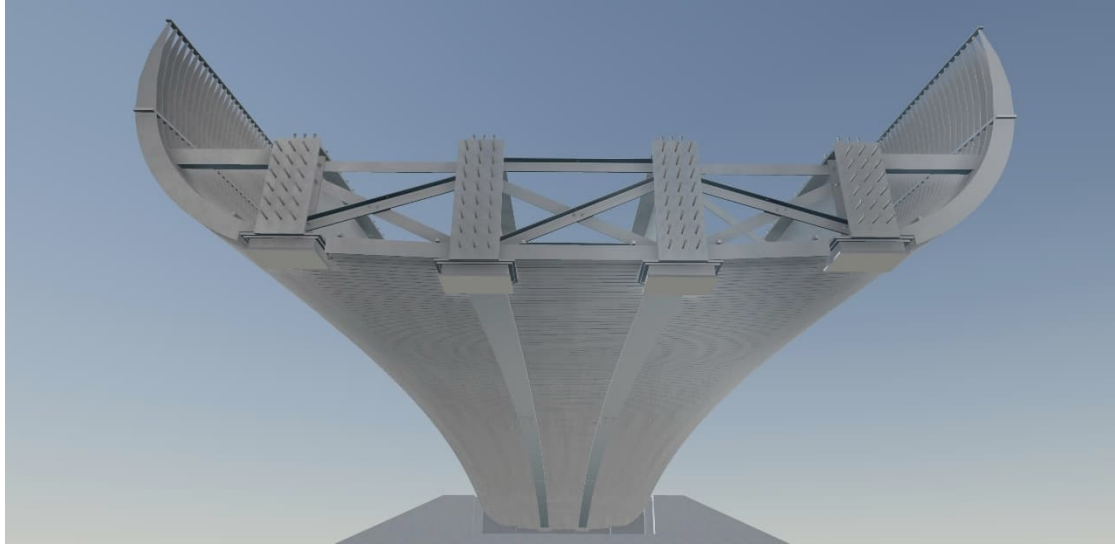
Connectivity

The Newt in Somerset is a world-class luxury country estate and working farm near Bruton, England, set within the historic grounds of Hadspen House. Once a private Georgian estate, it was transformed into an acclaimed rural retreat by South African entrepreneur's Koos Bekker and Karen Roos, opening to the public in 2019. The estate is often celebrated in British travel media as one of the most beautiful and innovative rural destinations in the UK, combining heritage architecture with modern design.

Manor Farm provides a vital link within the estate, connecting the agricultural and horticultural operations of the northern land parcel with the hospitality core of The Newt in Somerset to the south. Designed to accommodate single-lane traffic, including farm vehicles, ATVs, and livestock, the crossing plays an essential role in maintaining the day-to-day rhythm of estate life. By offering a dedicated traffic route, it alleviates congestion on the nearby A359 at Galhampton Hill, improving both operational efficiency and road safety.

The Viper

Inspiration for Manor Farm came from The Viper, an elevated woodland walkway in The Newt in Somerset that won the 2021 IStructE ‘Small Projects’ Award. The structure evokes prolonged immersion as visitors meander through the treetops, achieved through the elegant interaction between the parapet ribs and the central box spine beam. This experience was deemed important to capture on approach to the estate via Galhampton Hill, thus the architectural form of Manor Farm was born.



Adaptation

The exoskeleton at Manor Farm was conceived primarily as an architectural feature; however, design development revealed buildability challenges arising from the in situ concrete deck pour to the cantilever ends. Implementing the ribs as a global structural system eliminated the need for temporary works. The horizontal beam performs dual functions: acting as a flexural spanning member to support the self-weight of the wet concrete during the temporary state and serving as a tie to the cantilever parapet, providing global stability in the permanent condition.

A maintenance strategy was developed in accordance with DMRB requirements leading to the need for a panelised rib system. Access hatches integrated into selected panels enables tactile inspection of critical elements without panel removal. Maintaining the sleek and seamless appearance of the structural ribs was achieved through cleverly hidden bars and joints, virtually invisible to those viewing the bridge from the road.

The Design

Procurement for this scheme was unconventional, as DYSE was engaged only after the conceptual design was complete. Our scope comprised the design of a semi-integral bridge formed using a composite girder deck that spans 32.4m over a highway. The superstructure sits on reinforced concrete abutments that were designed by others. Linear elastic analysis was undertaken using a 2D flat grillage model for global effects and a 3D finite element shell model for determining stresses in the deck slab due to both local and global effects. A separate 3D model was also used to verify the steelwork under temporary conditions for lateral torsional buckling (LTB).

The client opted for an exposed concrete finish that was both waterproof and durable. Although graphene concrete was considered, costs were unjustifiable for the project's scale. An exposed aggregate concrete surfacing with anti-cracking mesh was ultimately adopted, with the concrete dyed to match finishes used across their global estates.

A Tertu vehicle restraint system (VRS) was adopted. Combining the strength of its steel frame with the attractive appearance of timber cladding, the VRS provides a robust and aesthetically pleasing solution, complementing the finish of the deck and bridge approaches.

Challenges

The pursuit of a fully encapsulating ribbed shell demanded careful consideration and balance of performance, buildability, serviceability and cost. Even after optimising the client's architectural vision, the solution still required a substantial increase in steelwork. Fine tuning this steelwork design came down to the thickness of the fin members, governed by its axial buckling capacity under the two load conditions mentioned previously. This steelwork proved both costly and time-consuming due to the large number of laser cuts and welds required. Heat distortion and warping of the thin platework during welding were minimised using low heat processes. Achieving perfect alignment and a seamless flow of the fins between panels was crucial and accomplished using precision engineering techniques. In addition, serviceability of the structural ribs under thermal effects was considered to mitigate against unwanted visual distortion.

Temporary stability of the steel girders from LTB during the lift and concrete pour was achieved, though not without difficulty. Constraints from road clearance and exoskeleton curvature limited the depths of the inner girder and edge girder to 1.25m and 1m, respectively. A span-to-depth ratio of circa 1 to 30 would typically sit on the upper limit of slenderness for standard highway bridge applications, however, this limit was further stretched by the inclusion of additional steel. Introducing plan bracing, in conjunction with torsional bracing, to the footway/cycleway girder bay was most effective at restraining the girders from buckling.

Reflections

Like most steel bridges, Manor Farm demanded significant effort in resolving numerous details during both design and fabrication. Working closely with Beaver Bridges, the design-and-build contractor and fabricator, I was able to streamline many of the complex construction aspects using sketches and 3D modelling. Several reflections have been made along the way.

The project was ultimately driven by the ribbed shell design and its need to perform during the temporary state. Adopting precast deck planks with in situ stitching could have allowed for a lighter exoskeleton system thus providing savings in overall steel. The principal contractor, responsible for the substructure and wider site works, unsurprisingly remained firm on the use of in situ concrete.

Deviation from the recommended maximum horizontal gap between the fins was explored; it was demonstrated that even a small increase to 125mm would save circa 15% in material. This suggestion was ultimately abandoned, as the private bridge was intended for use by estate visitors and therefore carried potential liability concerns.

Additional costs associated with enlarging the approach earthworks to raise the bridge level worked in my favour. What began as a design constraint evolved into a defining feature – the exposed bottom flanges now accentuate the bridge's graceful arch. This experience taught me that a limitation can be a catalyst for innovation.

I feel fortunate to have been presented an opportunity to create something really unique and to take ownership of every aspect of the design, not only as the structural engineer but also as a contributor to its architectural vision and flair. Manor Farm is a great example of how bridge elegance and precision engineering can be one and the same. The bridge was completed in March 2024, on its estimated budget of £1m, and successfully handed over to a delighted client. Visiting the completed structure and seeing how gracefully it sits within its setting has been deeply rewarding.

Project Team

Client: The Newt in Somerset
Design & Build Contractor: Beaver Bridges
Fabricator: Beaver Bridges
Structural Engineer: DYSE
Principal Contractor: ECSL