Foundations for Big Carl

Abstract

The foundations for the world's biggest crane challenged the Tony Gee design team to think expansively to meet the contractor's requirements. The crane, chosen to provide massive programme benefits for the construction of Hinkely Point C, needs a huge reinforced concrete foundation which was completely modelled in 3D. Significant time was taken to detail each bar in the heavily reinforced sections to spread the forces from the crane. This paper describes the method of designing the foundation, provides insight into the use of BIM on this project and recounts how the reinforcement cages were assembled as well as outlining the raison d'être for the crane.

1. Preamble - Introducing Big Carl

Having learned from experience constructing the first EPR reactors, EDF Energy and its contractor proposed an ambitious new way of reducing the construction programme for Britain's first new nuclear power station for 20 years. The idea would not only save time but improve quality and safety. During the construction at Flamanville, the Sarens SGC-120 was used. The planners for the Hinkley Point C power station had the idea for an even bigger crane - the world's largest, otherwise known as "Big Carl".

The mechanics of Big Carl are captivating in itself but the forces exerted by this unrivalled crane require big foundations, and their design is the focus of this paper.

Figure 1 - A model of the crane and the foundation

2. Background - Why a Heavy Lift Crane?

High quality welding and concrete completion on previous EPR construction sites proved difficult because work was exposed to the elements. EDF Energy and their Tier 1 contractor at Hinkley Point C, BYLOR, a joint venture between Bouygues TP and Laing O'Rourke, developed the concept of prefabricating the key elements of the two reactor buildings in factory conditions. This would increase the reliability of the fabrication work, reduce exposure to working at height and the effects of weather.

The challenge is that many of the reactor building elements are huge. No standard crane could lift the elements at the required radius. The project partners approached Sarens who developed and perfected the SGC-250 which has been named Big Carl after their technical director.

By prefabricating large sections of the reactor building, the project programme could be significantly reduced and the robustness of the timeline could be enhanced. Many of the reactor building elements require testing with radiation. If the testing was carried out insitu, other critical work could not continue at the same time. By prefabricating the elements in grand temporary bunkers, BYLOR could safely continue working on site during the radiation testing.

As every engineer appreciates, however, a big crane requires a big working platform to spread the huge temporary forces exerted on the ground.

3. Brief - What the contractor wanted

There will be two reactors at Hinkley Point C; a foundation was required that would enable Big Carl to move between the two. BYLOR wanted a reinforced concrete foundation 500m long to support the four rails that the crane sits on with enormous slewing rings at the ends and centre and they approached Tony Gee to design it.

In addition to the structural and geotechnical design, there were two further key requirements Tony Gee had to meet. First; BYLOR wanted the BIM models to enable them to order through their advanced procurement system they developed.

Second; BYLOR planned to prefabricate as much of the reinforcement cages as possible.

4. Solution - The Engineering

4.1. Sizing

Told to develop a reinforced concrete foundation for the world's biggest crane, Tony Gee suggested an interlude for a period of development for a concept design to be reviewed and approved by BYLOR before launching into the detailed design. Using forces provided by Sarens, a finite element model of the foundation was created in Lusas to analyse the structural effects. Springs were used to model the influence of the ground on the foundation underside. The spring stiffnesses were derived from a 2D finite element geotechnical model of the foundation using Plaxis.

Tony Gee verified that the foundation would not deflect beyond the limits specified by Sarens and designed the tremendous reinforcement quantities to enable the concrete to spread the forces. The straight foundations between the slewing rings are formed of two strips 6m wide by 1.5m deep each supporting two rails. The slewing rings are 1.8m deep and consist of a circular strip 8m wide.

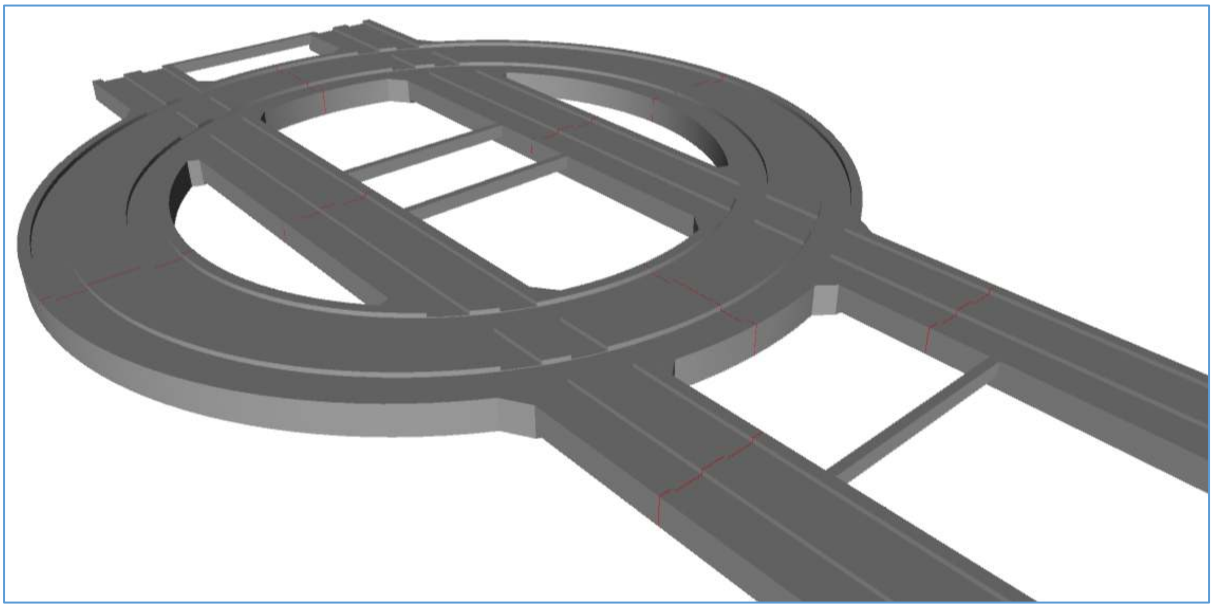

Figure 2 - A model view of the reinforced concrete crane foundation

4.2. Drawing

The foundation was 3D-modelled in Revit and the reinforcement was detailed in 3D using DfMA software. Both the foundation general arrangement model and the reinforcement models were issued in IFC format with specific data embedded in the model according to BYLOR’s strict requirements to provide material specifications and dimensions.

It was a significant task for Tony Gee’s BIM designers to upskill and program the metadata to the contractor’s specification. Indeed, the developers of DfMA software had to get involved to re-write parts of the program to allow the metadata to contain exactly the right information in the correct order.

One of the main advantages of modelling the general arrangement and the reinforcement in 3D is the ability to use Navisworks to view the model and check the deliverables. The geospatial location can be easily checked, clashes with the site-wide co-ordination model can be reviewed, and reinforcement checking is made significantly easier by being able to view the actual bars within the concrete outline.

4.3. Building

The reinforcement was designed to be built in prefabricated subsections which were connected with loose bars threaded through the cages. As an example, the 22m long sections of the straight foundation were divided halfway along the length so that each end was a mirror of the other. Then each half was made up of ten individual prefabricated reinforcement cages. Tony Gee designed the cages to be structurally safe when lifted to avoid the bars deforming too far.

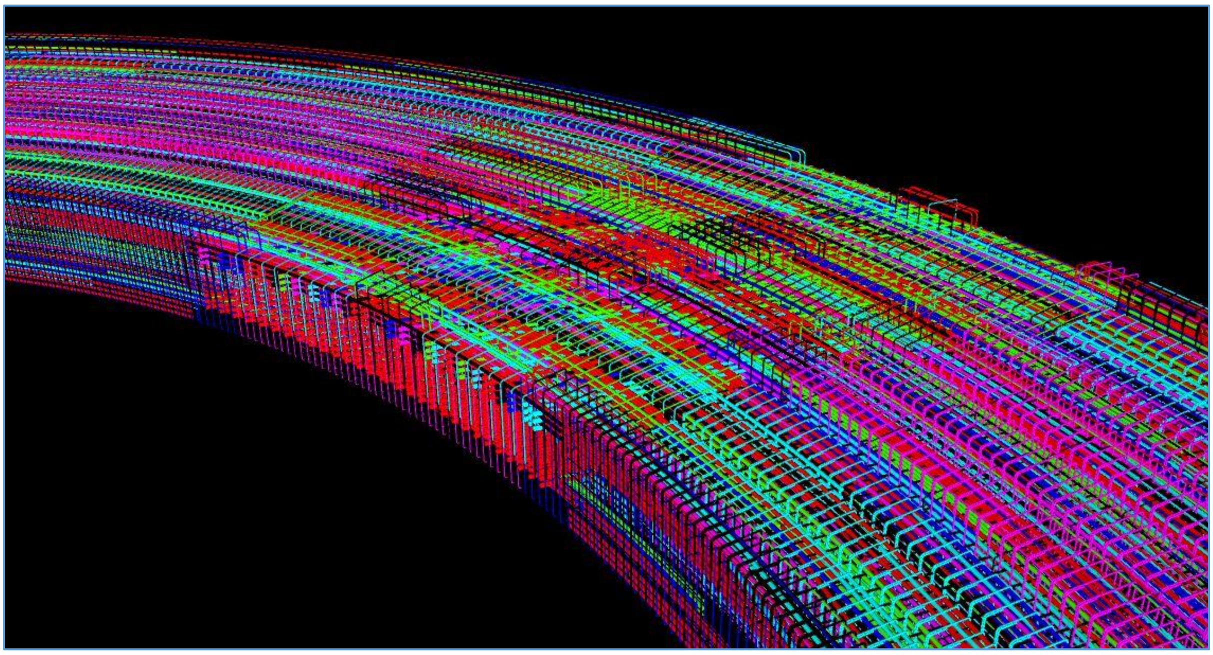

Figure 3 – A model of the reinforcement cages for part of the slewing rings.

For the slewing ring, large curved prefabricated cages were designed to sit side-by-side. At the intersection of the ring and the straight foundations, the cages were fixed completely insitu as the detailing was too complex and congested to prefabricate. Couplers were extensively used to remove laps and try to minimise the congestion.

5. Evaluation - Could it be better?

Naturally, as with all complex reinforcement, bars were missed in the design and bars were missed on site (all addressed through the field change request and non-conformance procedures). Modelling the bars in 3D saved many errors and it also allowed the corrections to be made more quickly. Despite the significantly increased time taken to detail the bars - as each bar needs to be individually placed, the saving is made in construction time which is much reduced through being able to view the 3D model, resulting in an overall project saving.

The overall programme savings coming from the use of the world's biggest crane will reduce the total construction time at Hinkley and help ensure the project can reach the completion of Unit 1 in 2025.

EDF Energy are planning two further EPR's at Sizewell C in Suffolk, making use of experience and repeatability to reduce costs and programme, undoubtedly refined even more based on the experiences with Big Carl. Potentially, the crane foundation could have been constructed out of steel spliced together to create a gigantic crane mat to support the rails. Whilst far more costly initially to fabricate the sections, weld and bolt and guarantee quality, a steel foundation could be re-used not only at Sizewell but at other sites that the SGC-250 is used.

1283 words