Derby Road Bridge

Beam Design & BIM Integration

25th February 2025

national highways

Amey

Speakers

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Part 1: Introduction & Challenges

Impact Damage

- Impact occurred on 5th of June 2018.
- It involves an excavator on the back of the trailer
- Caused severe damage to the northern precast pre-tensioned beam, and 2no. Precast concrete cladding panels.
- Severed, damaged and split tendons with the surrounding reinforcement stirrups deformed.
- Secondary shock waves running through the beam have caused the web to become hollow and spall.

Split tendon in the bottom flange of the main beam

Design Overview

The main elements of the project were:

- Demolition of the damage edge beam and existing parapet
- Construction of a new edge beam, and parapet
- Waterproofing of the deck
- Reinstate the bridge to its original state

Before the impact

After the impact

Key Challenges

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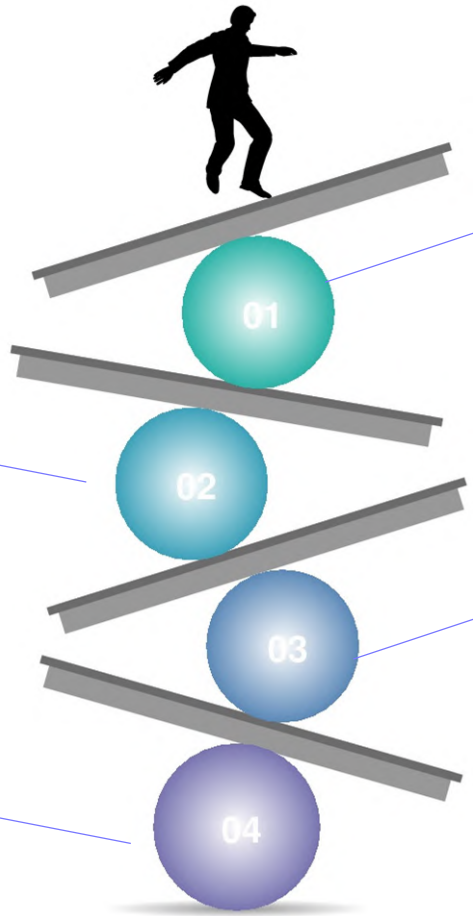
The project faced many challenges, some of the most notable include:

Stakeholders



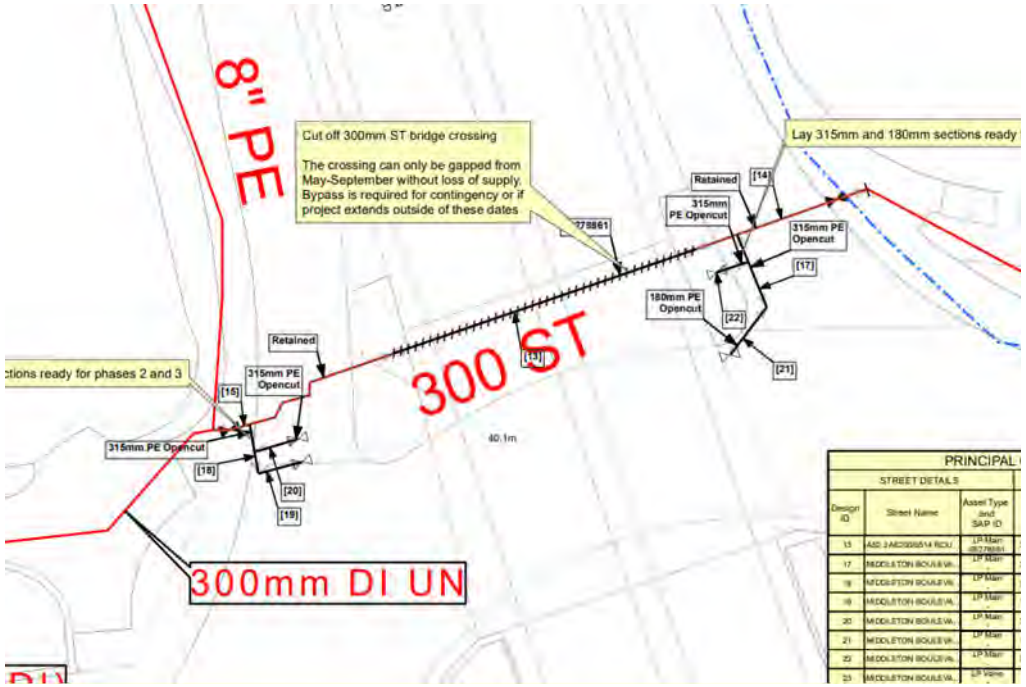
Provisions for Statutory Undertakers Equipment

Technical Challenges

Suppliers

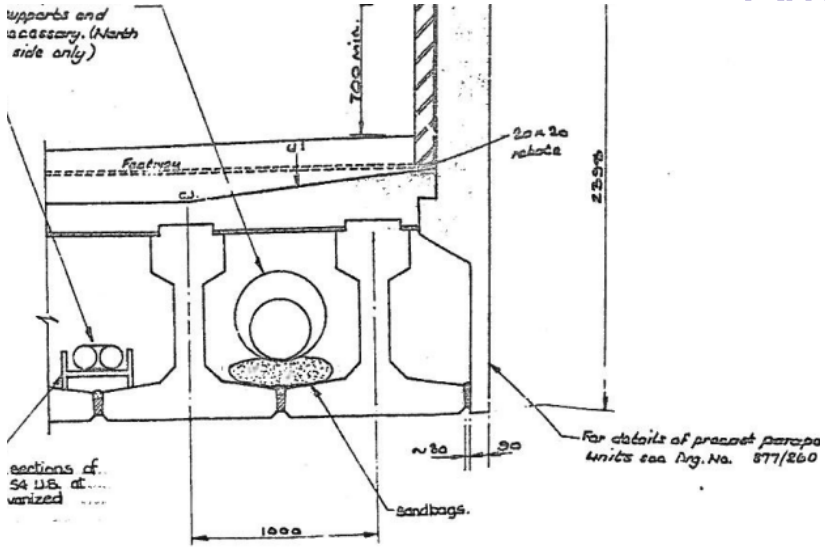
Key Challenges – Services

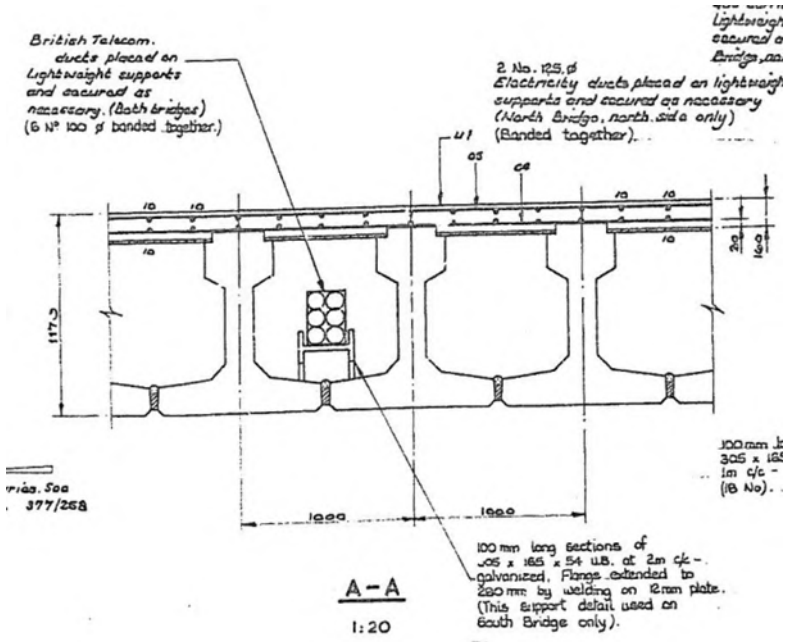
- The bridge carried wide ranging service provision
- The affected services from the proposed work are:
  - The GAS MAIN
  - The electricity cables



Estimate of Cost for the Diversion of Cadent Plant

Price	£142,587.22	Inclusive of £23,764.54 VAT charged at 20%





Key Challenges – Stakeholders

Events:

- Nottingham University Open Day – June
- Nottingham University Open Day – Sep
- Splendour Music Festival – Wolaton Park
- Nottingham Half Marathon

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Part 2: Assessment & Design

Interim Measures

- Footway has been diverted 1.7m away from the inside parapet face to minimise risk of overloading.
- Temporary Barrier Guard 800 steel barrier vehicle restrain system (VRS) 600mm from the front face of the kerb.
- Inspection regime in place to be carried out every six months.

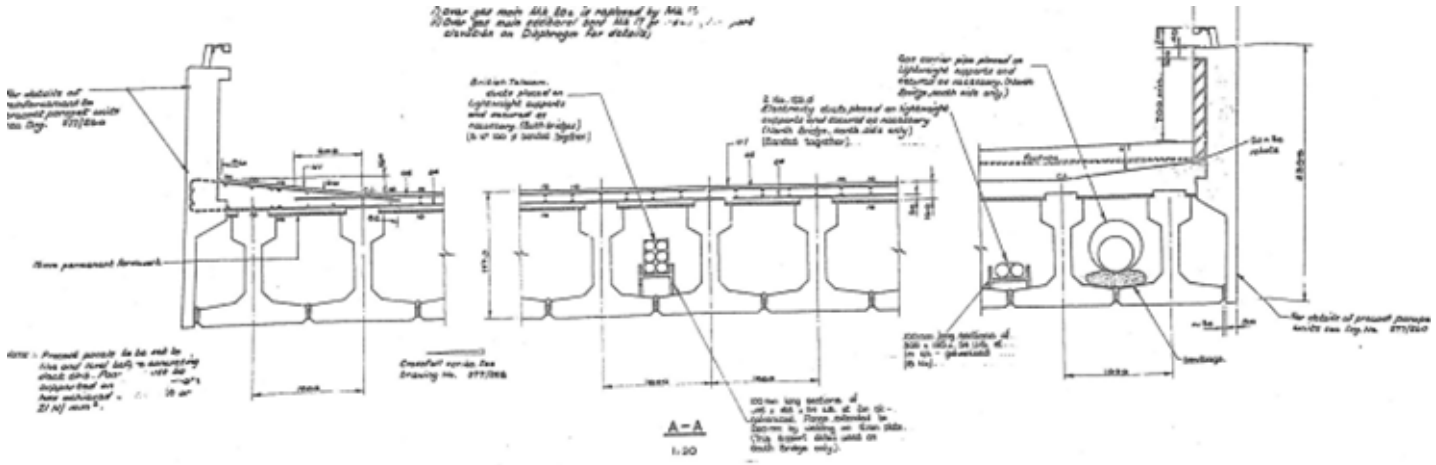
- Special Inspection Report dated 5th December 2018.
- Special Inspection Report dated 27th July 2019.
- Special Inspection Report dated 29th June 2018
- Special Inspection Report dated 15th June 2018.
- Special Inspection Report dated 5th June 2018.
- Latest Principal Inspection Report dated 8th November 2012.

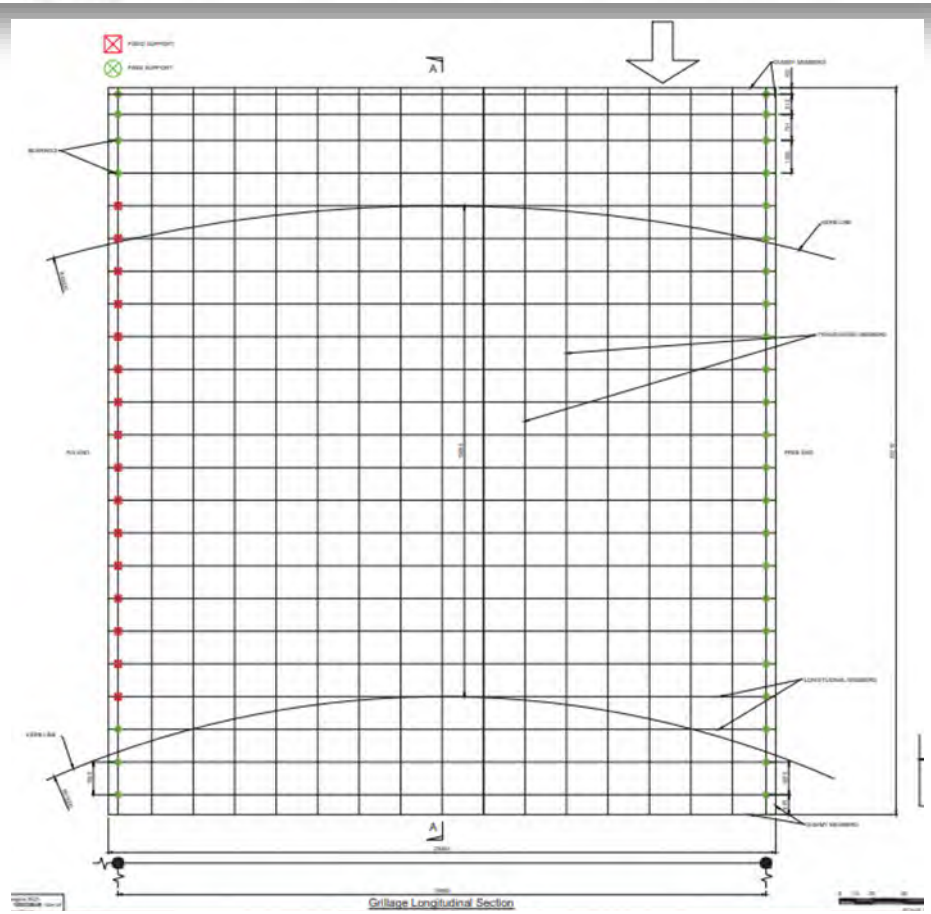
Assessment Method

- A simple strip analysis to determine the applied dead load.
- A grillage model to analyse the deck for superimposed dead & live loads.
- Longitudinal members to represent the twenty-one undamaged prestressed beams.
- For the damage beam, only the upper flange and deck properties were used.
- Transverse members were used to represent the deck slab & diaphragms at each support.

The impact damage to the prestressed edge beam is severe, exposing nearly all the bottom flange tendons. At the point of impact, the tendons are severed, deformed and split with surrounding reinforcement stirrups deformed. The web has spalled at the point of impact and a longitudinal crack of undetermined length exists at the lower flange / web interface. A second 1.3 m long crack exists above the point of impact, at the upper flange / web interface.

Considering the above damage the section properties of the damaged beam were only considered to consist of the upper flange and deck.





Assessment Results

- Damage Edge Beam
  - ➢ Fail in bending under permanent Dead Load
  - ➢ Failure does not result in collapse of the edge beam. The transverse slab provides support

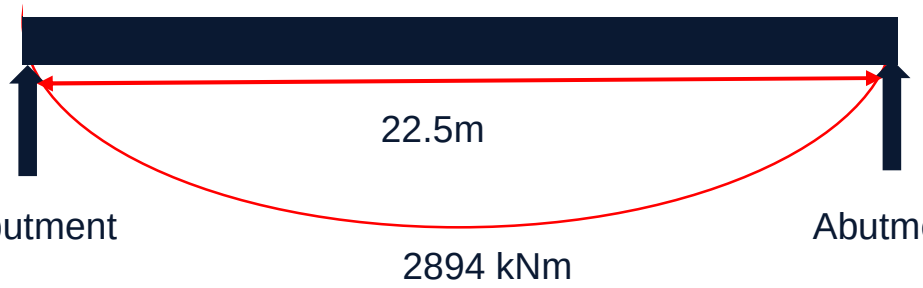
- Transverse deck slab
  - ➢Fail in bending under permanent Dead Load (unrestricted footway loading)
  - ➢Pass under permeant and ALL loadings (restricted Footway loading).
- Undamaged First Inner Beam
  - ➢Pass under permeant loading

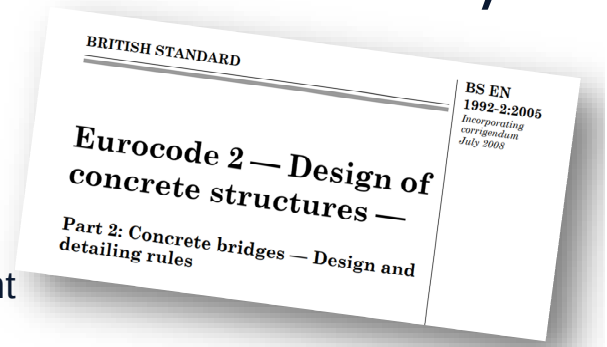
Loading	Load Combination	Total Live Load (kN)	DL+ SDL (kN)	Results (kN)	Capacity (kN)	Utilisation	Pass/Fail
SHEAR (kN)	HA (Full Ped)	124	582	706	1021	69%	Pass
	HA (Restric. Ped)	34	582	616	1021	60%	Pass
	HA AWL	450	582	1032	1021	101%	Fail
	HB+ HA (Full Ped)	150	582	732	1021	72%	Pass
	HB+ HA (Restric. Ped)	50	582	632	1021	62%	Pass
	SV+ HA (Full Ped)	148	582	730	1021	71%	Pass
	SV+HA (Restric. Ped)	73	582	655	1021	64%	Pass
BENDING (kNm)	**Load Combination**	**Total Live Load (kNm)**	**DL+ SDL (kNm)**	**Results (kNm)**	**Capacity (kNm)**	**Utilisation**	**Pass/Fail**
	HA (Full Ped)	745	2203	2948	4142	71%	Pass
	HA (Restric. Ped)	355	2203	2558	4147	62%	Pass
	HA AWL	1501	2203	3704	4135	90%	Pass
	HB+ HA (Full Ped)	992	2203	3195	4145	77%	Pass
	HB+ HA (Restric. Ped)	601	2203	2804	4151	68%	Pass
	SV+ HA (Full Ped)	951	2203	3154	4149	76%	Pass
	SV+HA (Restric. Ped)	560	2203	2763	4153	67%	Pass

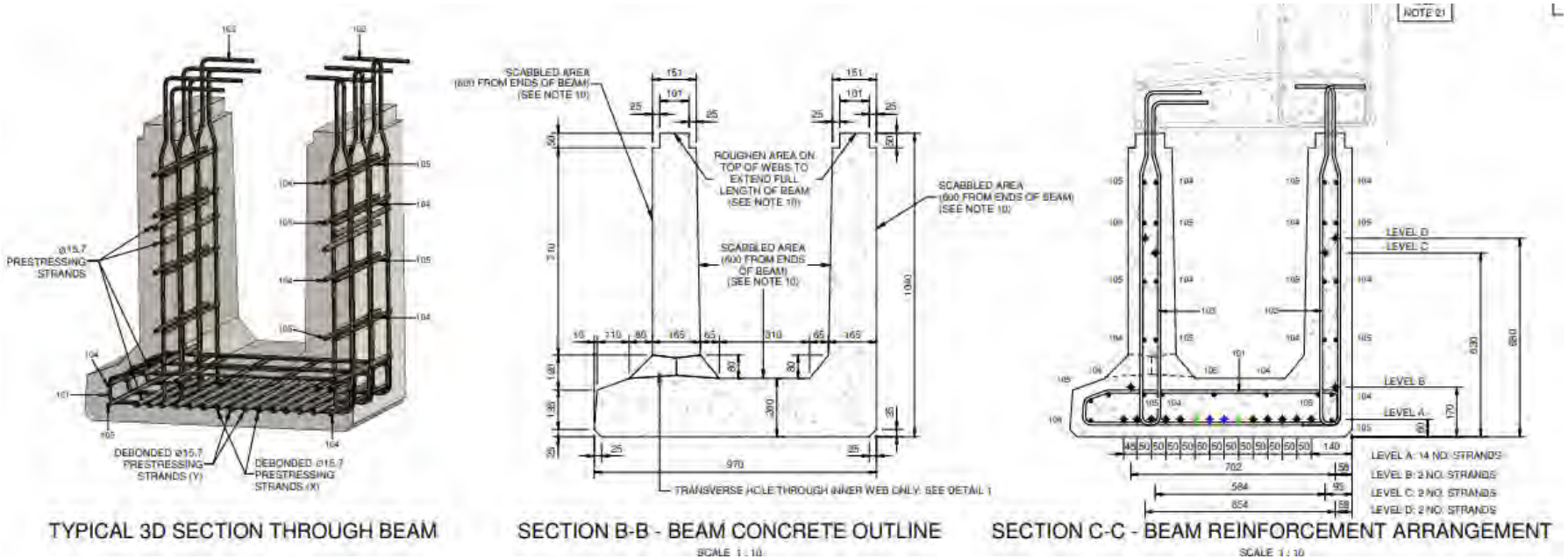
Loading	Load Combination	Total Live Load (kN)	DL+ SDL (kN)	Results (kN)	Capacity (kN)	Utilisation	Pass/Fail
SHEAR (kN)	HA (Full Ped)	7	47	54	136	40%	Pass
	HA (Restric. Ped)	0	47	47	136	35%	Pass
	HA AWL	120	47	167	136	123%	Fail
	HB+ HA (Full Ped)	7	47	54	136	40%	Pass
	HB+ HA (Restric. Ped)	0	47	47	136	35%	Pass
	SV+ HA (Full Ped)	7	47	54	136	40%	Pass
	SV+HA (Restric. Ped)	0	47	47	136	35%	Pass
BENDING (kNm)	**Load Combination**	**Total Live Load (kNm)**	**DL+ SDL (kNm)**	**Results (kNm)**	**Capacity (kNm)**	**Utilisation**	**Pass/Fail**
	HA (Full Ped)	13	53	66	54	122%	Fail
	HA (Restric. Ped)	0	53	53	54	98%	Pass
	HA AWL	175	53	228	54	422%	Fail
	HB+ HA (Full Ped)	13	53	66	54	122%	Fail
	HB+ HA (Restric. Ped)	0	53	53	54	98%	Pass
	SV+ HA (Full Ped)	13	53	66	54	122%	Fail
	SV+HA (Restric. Ped)	0	53	53	54	98%	Pass

Beam Design

- One span prestressed beam – 22.5m span.
  - ➢ Simply supported on elastomeric bearings.
  - ➢ Sagging bending moment at mid-span.





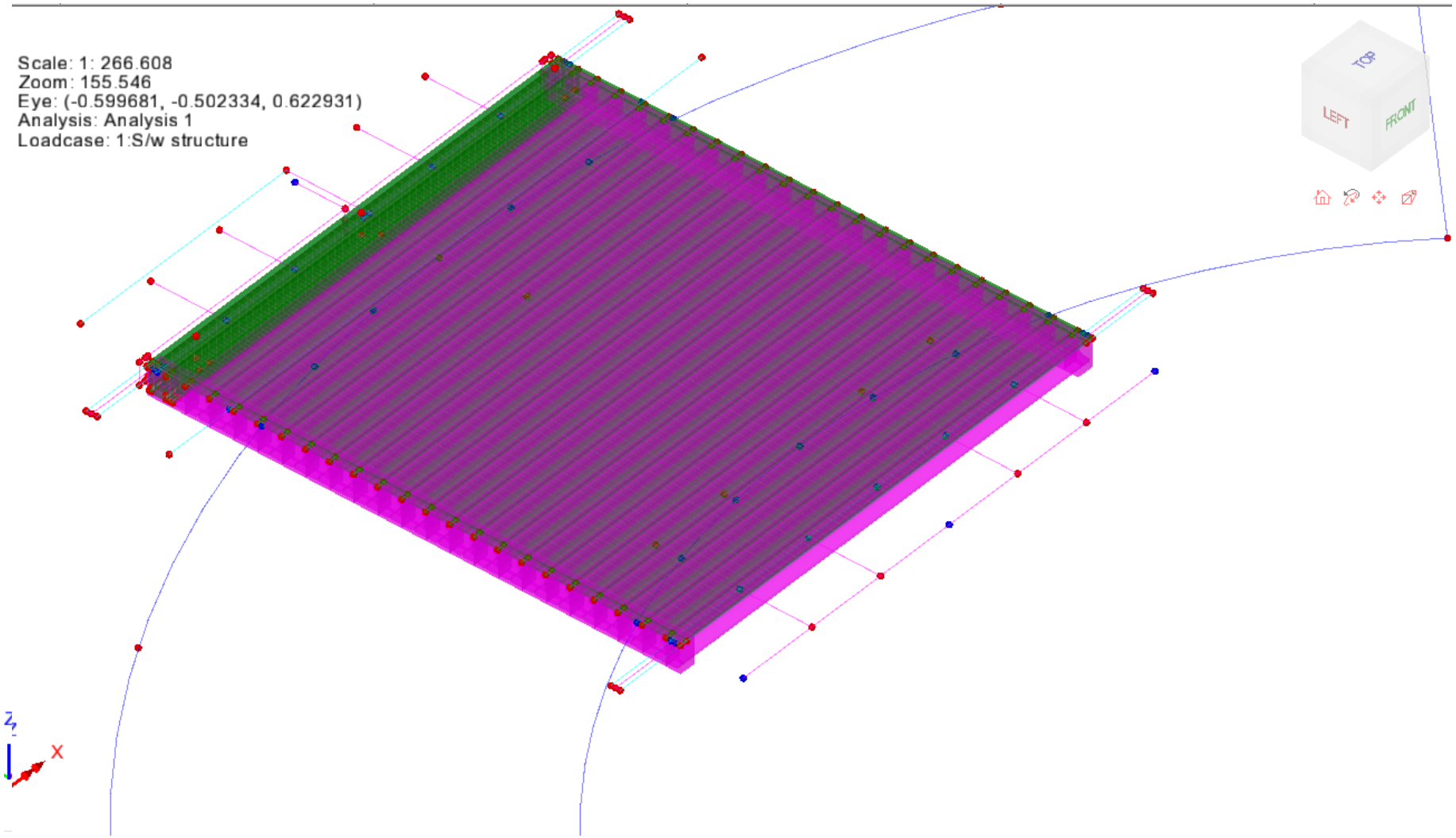


TYPICAL 3D SECTION THROUGH BEAM

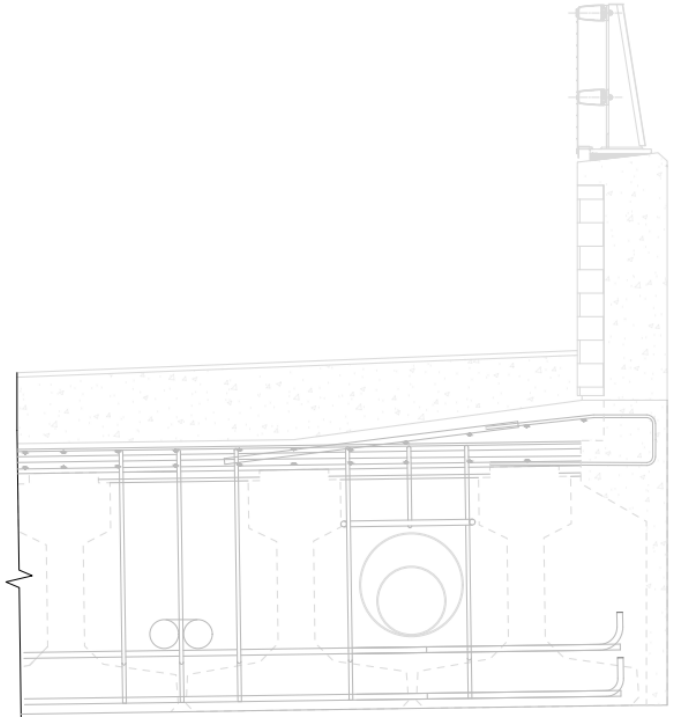
SECTION B-B - BEAM CONCRETE OUTLINE

SECTION C-C - BEAM REINFORCEMENT ARRANGEMENT

Analysis Modelling

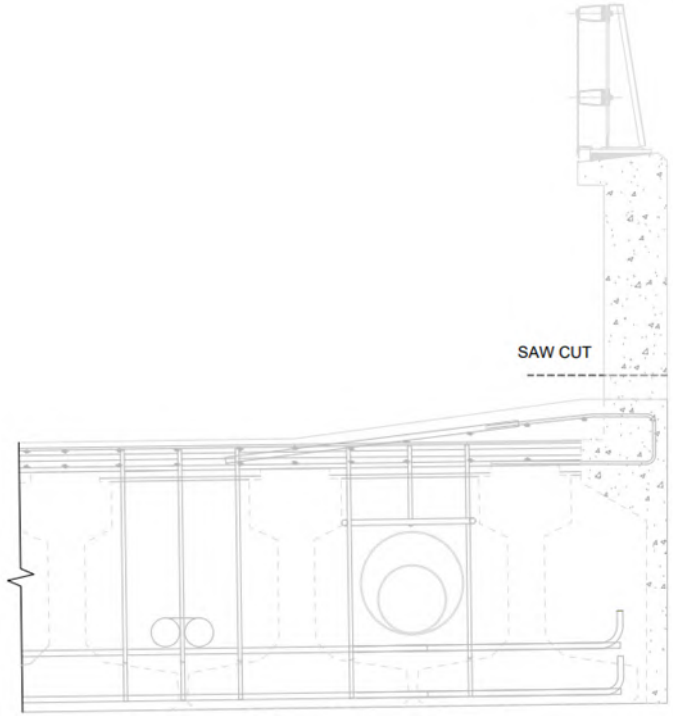


Construction Sequences



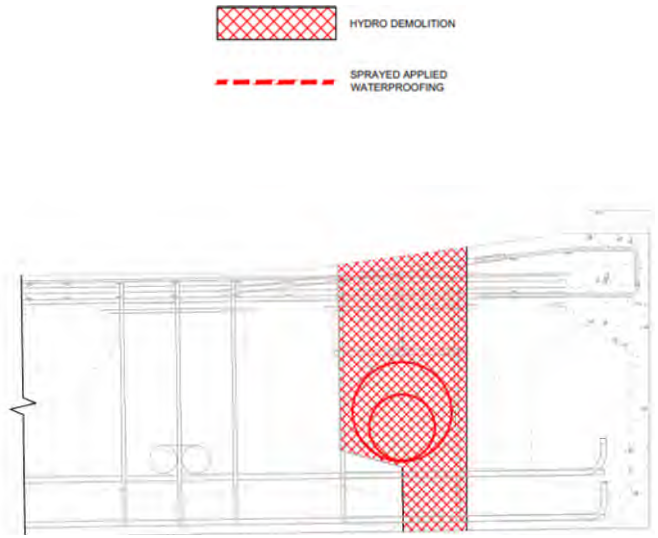
Phase 1

- Disconnect the gas main
- Install traffic management
- Temporary protection and diversion of the electricity cable ducts
- Removal of the surfacing, lean concrete deck, masonry brick.



Phase 2

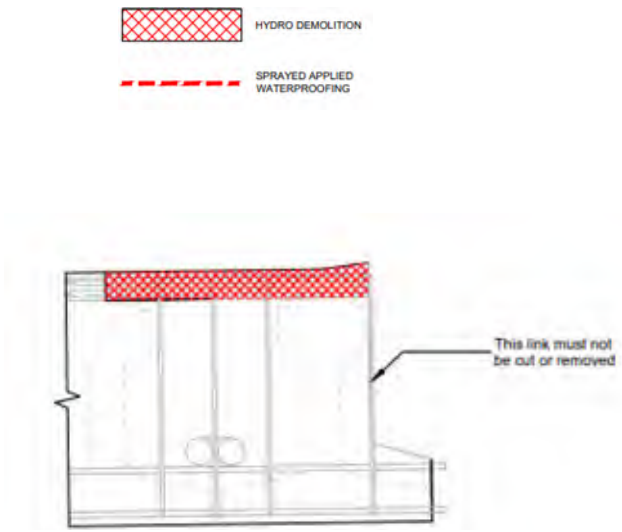
- Saw cut and remove the precast parapet unit



Phase 3

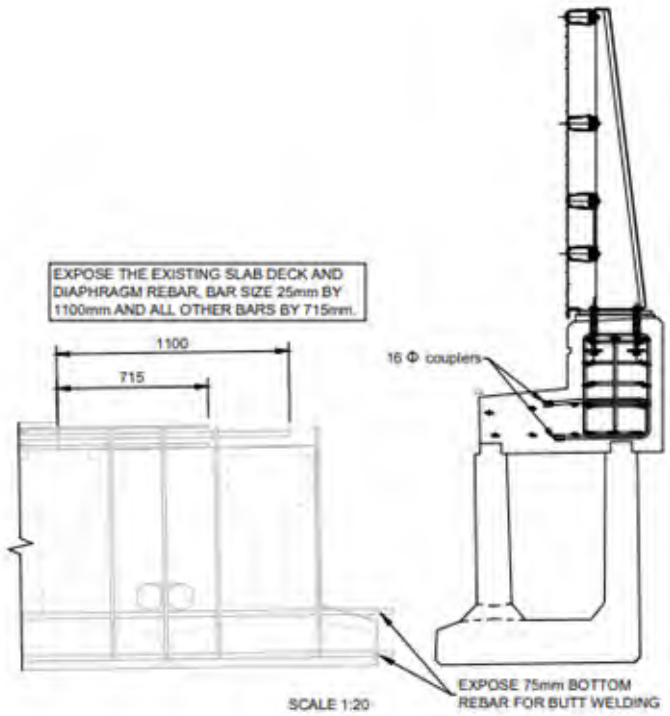
- Hydro demolition above and around the Gas Main.
- Remove the Gas Main
- Remove the damage precast beam.

Construction Sequences



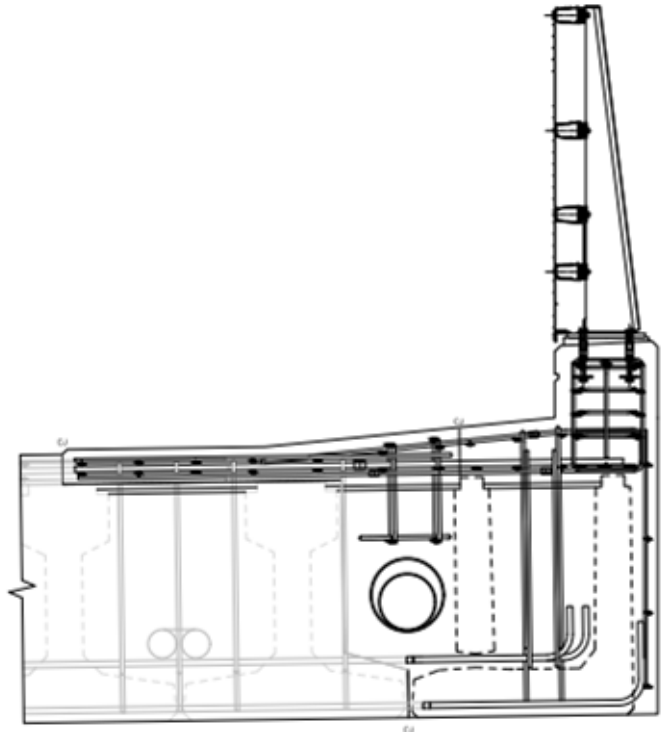
Phase 4

- Hydro demolition of top deck slab.
- Replace expose bearing



Phase 5

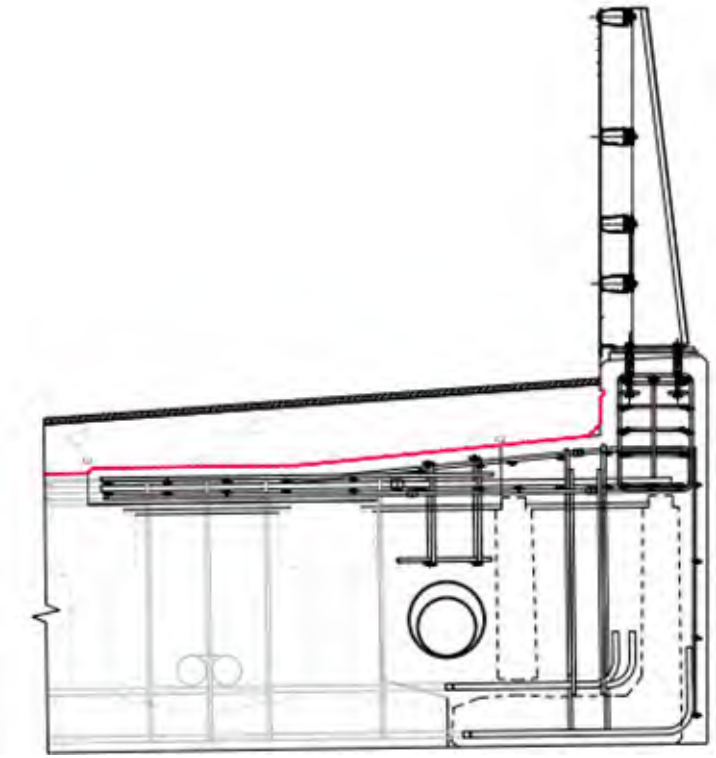
- Expose the reinforcement to achieve the required length.
- Couplers to be installed



Phase 6

- Install the replacement precast beam
- Reinstate gas main duct, gas main
- Connect back the electricity and test it.
- New bars to be coupled or lapped with existing.
- Bottom diaphragm reinforcement be welded.

Construction Sequences



Phase 7

- Replace waterproofing
- Replace the expansion joints
- Reinstate lean concrete and surfacing

Construction Programme

- Programme started last July and finish July 2025.
- 11 Full weekend closures to support the damage beam prior lifting, remove the damaged beam, and install the new beam.
- Full lane closure to one of the roundabout lane during the programme.