M3 J12 Improvements

Preliminary Assessment Report for Pitmore Bridge and Hocombe Bridge for proposed Carriageway Widening

Eastleigh Borough Council

29 May 2019

Notice

This document and its contents have been prepared and are intended solely as information for Eastleigh Borough Council and use in relation to the widening of carriageway over Pitmore and Hocombe Bridges.

Atkins Limited assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

Document history

Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 1.0	For review and comments	SG/CF	MB	AR	CB	15-05-2019
Rev 2.0	For review and comments	SG	AR	AR	CB	29-05-2019

Client signoff

Client	Eastleigh Borough Council
Project	M3 J12 Improvements
Job number	5163169
Client signature / date	

Contents

Tables

Figures

Executive Summary

The Eastleigh Borough Council Emerging Local Plan outlines the proposed amount of development required within the Borough between 2016 and 2036, potential development sites and infrastructure to support this development. The Local Plan supporting evidence includes a transport modelling study, undertaken by SYSTRA, which identifies locations where highway improvements will be required to provide additional network capacity. One of the areas identified as requiring improvement is the road network connecting to Junction 12 of the M3 motorway.

Atkins has been commissioned by Eastleigh Borough Council, to assess the highway network capacity around Junction 12 of the M3 and to ascertain what improvements are required to mitigate the impact of additional traffic resulting from the proposed Local Plan development. This report considers two existing highway bridges crossing the M3 motorway providing direct access to the junction. These bridges are Pitmore Copse Bridge and Hocombe Road Bridge. To accommodate the forecast increase in traffic volume it is proposed to widen the carriageway of these existing bridges.

The purpose of this initial assessment is to review the strength and suitability of the structure to support 40 tonne Assessment Live Load (ALL) for the proposed additional lane. The assessment determines the reserve capacity of the elements of the structure. The results of this initial assessment shall also be used to evaluate implications on future concrete repairs works and strengthening.

Pitmore Bridge:

Pitmore bridge was constructed in 1991 which carries A335 over the M3 motorway. The carriageway of the bridge is 10.0 m. The structure is approximately 40.52 m long and consist of two spans which are square in alignment. The superstructure comprises precast pre-stressed concrete beams with in-situ reinforced concrete slab and a transverse post tensioned diaphragm at the intermediate support. The deck is fully fixed at central pier and is supported on bearings at abutments. The inputs for assessment are taken from as-built drawings and design AIP dated 23rd Jan 1986

The carriage way of the existing bridge will be increased from 2 lane to 3 lanes. The bridge has been assessed for increased carriageway width and loads are applies as per BD21. The structure has been analysed using LUSAS software version 17.0. As per the assessment finding, the structure has sufficient capacity to accommodate additional lane.

Hocombe Road Bridge:

Hocombe bridge was constructed in 1992 and carries C358 over the M3 motorway. The carriageway of the bridge is 11.0 m. The structure is a two-span overbridge at a 26.7-degree skew. The overall length of the skew bridge is 63.2 m. The superstructure comprises precast pre-stressed concrete beams with in-situ reinforced concrete slab and a transverse post tensioned diaphragm at the intermediate support. The deck is fully fixed at central pier and is supported on bearings at abutments. The inputs for assessment are taken from as-built drawings and design AIP dated 23rd Jan 1986.

The carriage way of the existing bridge will be increased from 3 lane to 4 lanes. The bridge has been assessed for increased carriageway width and loads are applies as per BD21.The structure has been analysed using LUSAS software version 17.0. From the assessment findings the service trough cover slabs at north verge are inadequate, and the possible strengthening would be to replace the cover slab with in-situ reinforced concrete by means of stitching the existing deck with the new deck.

It is recognised that strengthening of this bridge will be a costly and complex undertaking. Consequently, options to enhance the assessment findings have also been considered. On this basis it is recommended to the confirm the strength of the reinforcement present by site tests, from which it may be possible to increase the assessed capacity. Further refined analysis utilising cracked section properties or by considering departures from standards, should also be considered.

It is also considered highly likely that diversion of utilities would be required depending on the proposal and approval with associated stakeholders.

1. Introduction

1.1. Project Background

The Eastleigh Borough Council Emerging Local Plan outlines the proposed amount of development required within the Borough between 2016 and 2036, potential development sites and infrastructure to support this development. The Local Plan supporting evidence includes a transport modelling study, undertaken by SYSTRA, which identifies locations where highway improvements will be required to provide additional network capacity. One of the areas identified as requiring improvement is the road network connecting to Junction 12 of the M3 motorway.

Atkins has been commissioned by Eastleigh Borough Council, to assess the highway network capacity around Junction 12 of the M3 and to ascertain what improvements are required to mitigate the impact of additional traffic resulting from the proposed Local Plan development. This report considers two existing highway bridges crossing the M3 motorway providing direct access to the junction. These bridges are Pitmore Copse Bridge and Hocombe Road Bridge. To accommodate the forecast, increase in traffic volume it is proposed to widen the carriageway of these existing bridges.

The M3 is a heavily used motorway connecting London to Southampton and the south coast. Junction 12 of the M3 motorway is situated near Chandlers Ford, Hampshire and consists of a dumbbell type junction with a connecting overbridge (Pitmore Copse Bridge), An urban distributor connector road links the junction to the northern extents of Chandlers Ford via Hocombe Bridge.

For the purposes of this study, the road network in the vicinity of the motorway junction has been subdivided in to four minor junction areas, as follows:

- J1 – Hocombe Road / Winchester Road
- J2 – Otterbourne Hill / Winchester Road
- J3 – M3 Junction 12 East (All brook Way / Winchester Road / M3)
- J4 – M3 Junction 12 West

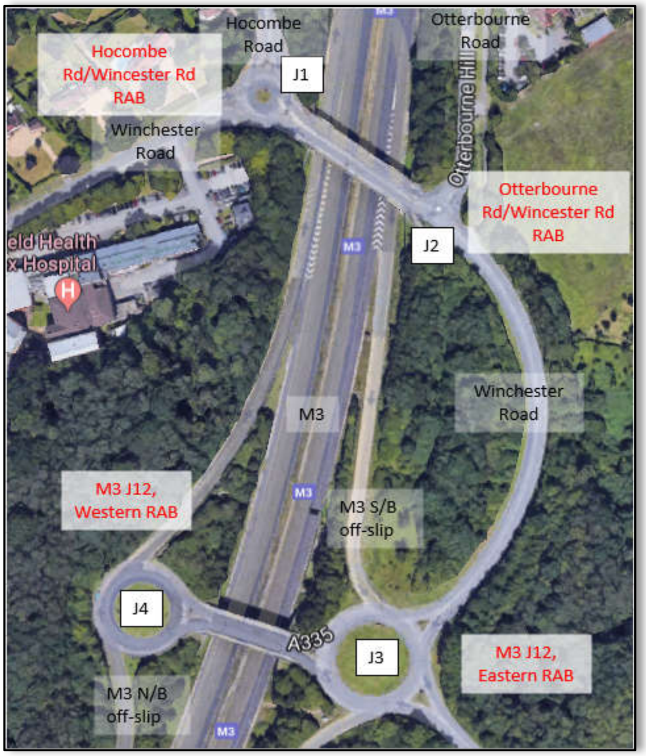


Figure 1 - M3 Junction Overview

To meet the increased traffic demand around Junction 12 of M3, due to the developments envisaged in the Local Plan, it is proposed to increase the number of lanes over both Pitmore Copse Bridge and Hocombe Road Bridge. This review considers the load implications of undertaking this without increasing the overall width of the structures.

This report describes the assessment carried out to determine the adequacy of these two existing bridges to carry additional carriageway lanes. The report further outlines the modifications required to the bridges to carry the additional lanes as well based on the findings of the assessments.

1.2. Scope of the Report

The scope of the report is assessment is as follows:

- Assessment of Hocombe bridge considering the proposed 4 lane configuration and footpaths with reduced widths.
- Assessment of Pitmore bridge considering proposed 3 lane configuration and footpaths with reduced widths.
- Determine load carrying capacity of the bridges for 40t Assessment Live Loads.
- Outline discussion of strengthening the existing bridges to enable the proposed widening, if required.
- Initial, high level cost consideration.
- Recommendations for the development of the scheme.

2. Site and Structure Description

2.1. Site Description

This review considers two bridges over the motorway M3, (Hocombe Road Bridge and Pitmore Copse Bridge) providing access to Junction 12 of the M3 motorway. To meet the increase in traffic volume predicted due to future developments in the area, it is proposed to widen the carriageway of the existing bridges.

Hocombe Road Bridge at present carries three lanes of traffic (one westbound lane and two eastbound lanes) and is proposed the carriageway alignment is modified to accommodate four traffic lanes. The aspiration is that this would be achieved by reducing the width of footpaths on either side of the carriageway.

Pitmore Copse Bridge currently carries two traffic lanes and is proposed to realign the carriageway to accommodate three lanes. The overall width of the superstructure is proposed not to be altered, and the additional lane is accommodated by reducing the widths of existing lanes and footpath.

2.1.1. Pitmore Copse Bridge

Pitmore Copse Bridge is located on the M3 near Chandlers Ford in Hampshire, OS grid reference: 445140 E, 121950 N. The bridge carries the single carriageway A335 over the three-lane dual M3 motorway. The bridge is square to the motorway. Year of construction 1991. The permitted traffic speed under the bridge is 112kph (70 mph). The permitted traffic speed over the bridge is 96kph (60 mph).

2.1.2. Hocombe Road Bridge

Hocombe Road Bridge is located near Chandlers Ford in Hampshire and carries C358 Hocombe road over the M3 motorway. The bridge is skewed at 26° 7 with respect to the abutments and is located at OS grid reference: 445200 E, 122200 N.

This bridge is a replacement for the original structure, which was demolished as part of the upgrading of the A33 to M3 and construction was completed in 1992. The permitted traffic speed under and over the bridge is 112 kph (70 mph) and 64 kph (40 mph) respectively.

2.2. Structure Description

2.2.1. Pitmore Copse Bridge

The bridge is a two-span structure square to the substructures, with spans of 20.31m and 20.21m. The superstructure is formed with 13 precast prestressed concrete M6 beams, supporting a cast in-situ reinforced concrete slab. A reinforced concrete cantilevered diaphragm is provided at the intermediate support to connect the precast beams at the intermediate support. At this location the cast in-situ top slab deck runs continuous over the central support.

The superstructure is supported via bearings and is longitudinally unrestrained at the abutments. The deck of the superstructure has varying thickness, with a minimum thickness of 150 mm. The deck articulation is restrained laterally at both abutments.

The intermediate support diaphragm also incorporates a transverse post-tensioning system. The top tendons of the post tensioning system are in the top slab and the lower tendons are threaded through holes in the beam web.

On either side of the superstructure P2 type parapet supported over edge beams are provided as shown in the Figure 4.

The typical cross sections of Pitmore Bridge at the abutments and intermediate support are as shown in Figure 2 and Figure 3.

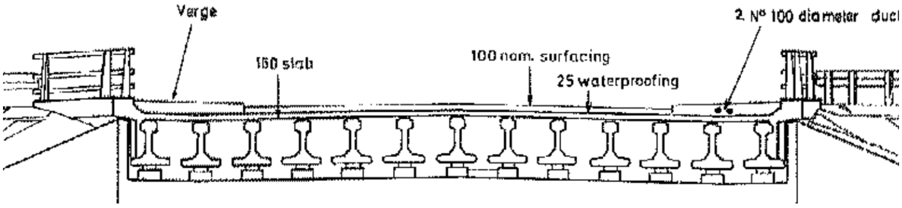


Figure 2 – Typical Cross Section at Abutment

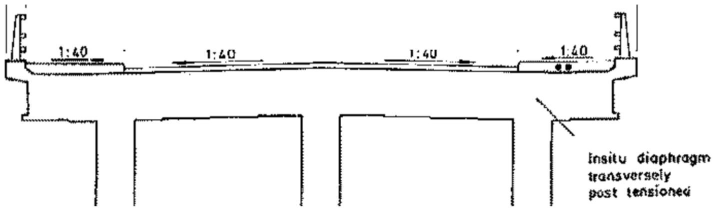


Figure 3 – Typical Cross Section at Pier

2.2.1.1. Existing Carriageway of Pitmore Copse Bridge

The existing cross section of the bridge is shown in Figure 4. The bridge carries two traffic lanes and footpaths on either side of the carriageway. The total width of the superstructure is 16.1m, consisting of 10m wide carriageway (two lanes of 5m width each), 2.5 m verges on either side and a 0.55 m wide parapet beam on each side.

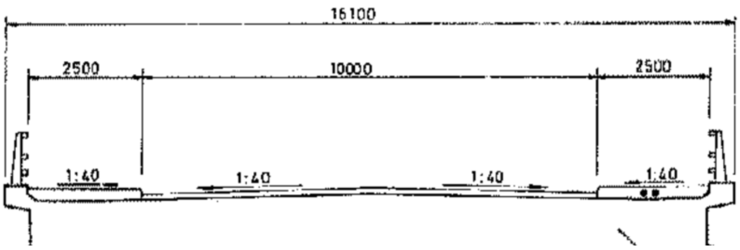


Figure 4 - Existing Carriageway of Pitmore Copse Bridge

2.2.1.2. Proposed Carriageway of Pitmore Copse Bridge

The proposed cross section of the Pitmore Copse Bridge is as shown in Figure 5. It is intended to accommodate the additional lane by widening the carriageway, with widening of 0.5m on either side, reducing the current verge width. Therefore, the carriageway width is increased from 10m to 11m with proposed width of each lane being 3.65m. It is proposed to reduce the width of the footpaths on either side of the carriageway from 2.5 m to 2m.

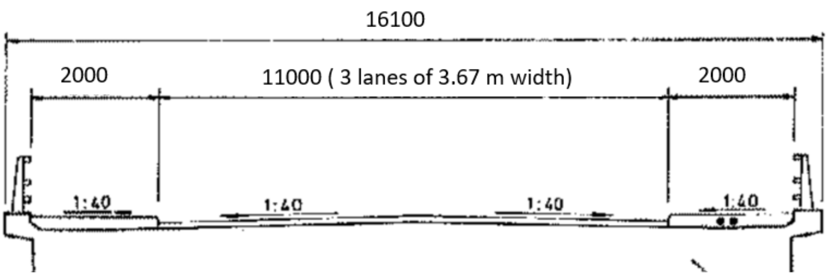


Figure 5 - Proposed Lane Configuration of Pitmore Copse Bridge

2.2.2. Hocombe Road Bridge

The bridge is a two-span skewed bridge, with a skew angle of 26.7o.The superstructure is formed by precast prestressed concrete M-10 beams with in-situ RC slab and a transverse diaphragm at the intermediate support.

The thickness of the deck slab varies, with a minimum thickness of 160 mm. The deck slab is continuous over the precast beams over the southern verge, whereas under the north verge the precast deck slab is discourteous at the north edge of the bridge, with simply supported slabs typically present over the outer three beams as shown in Figure 6. These slabs provide access to services located between the bridge beams.

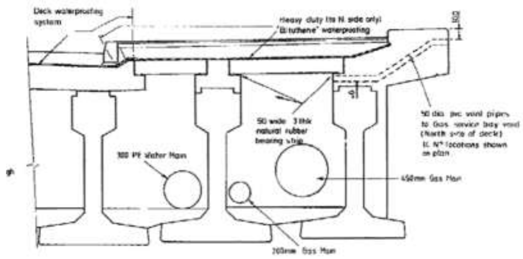


Figure 6 - Existing Service Trough Slabs

The structure is simply supported at each abutment and is continuous over the intermediate support with a transverse post tensioned diaphragm. The transverse post-tensioning with two tendons on the both sides of the transverse diaphragm. The top tendons are in the top slab with the lower tendons threaded through holes in the beam web.

Three 1.0 m diameter piers from intermediate support with piers built into the deck. All the foundations are spread footings. The end supports are cantilevered reinforced concrete abutments.

The existing parapet is considered to be a superseded P2 type parapet and the load characteristics of this system is considered for assessment.

The typical cross sections of Hocombe bridge at the abutments and intermediate support are as shown in Figure 7 and Figure 8.

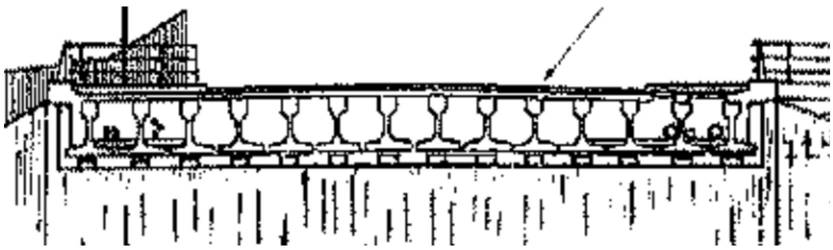


Figure 7 – Typical Cross Section at Abutment

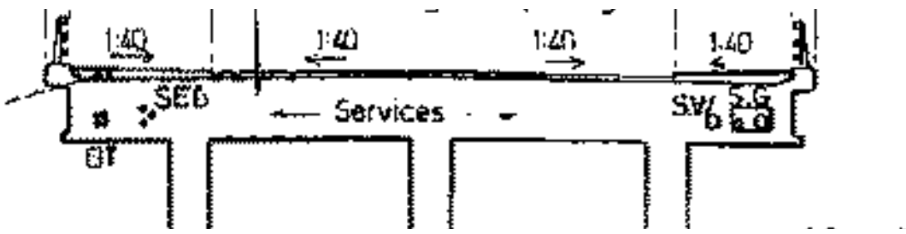


Figure 8 – Typical Cross Section at Pier

2.2.2.1. Existing Carriageway of Hocombe Road Bridge

The existing cross section of the bridge is as shown in the Figure 9. The total width of the bridge is 16.60m comprising of a 10.0m wide carriageway, 2.5m and 3.0m wide footways and a 0.55m wide parapet beam on each side. The skew spans are 31.0 m and 32.20m and the bridge is 26.7 degrees skew to the motorway.

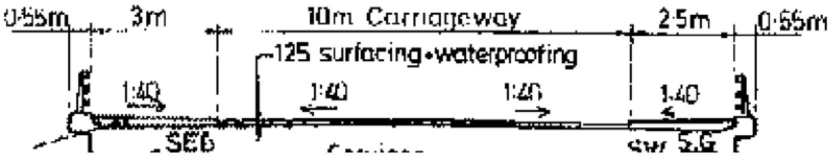


Figure 9 - Existing Carriageway of Hocombe Bridge

2.2.2.2. Proposed Carriageway of Hocombe Road Bridge

The widening proposed will extend the carriageway onto the northern side, reducing the verge width from 2.5 m to 1.0 m. This would achieve a carriageway width of 11.5m. The proposed width of each lane is 2.875 m. The 3.0m wide footpath/cycleway on the southern side will remain functional as it is. The proposed cross section is as shown in Figure 10.

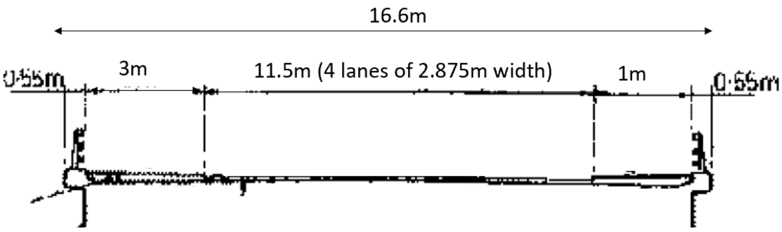


Figure 10 - Proposed Lane Configuration of Hocombe Bridge

2.3. Inspections of the Bridges

2.3.1. Pitmore Copse Bridge

The last Principal Inspection (PI) was carried out in February 2016. The findings of the previous inspections and the PI undertaken in February 2016 did not identify any significant defects that would affect the structural capacity of the bridge and hence, no defects or reduced condition factor are considered in the current assessment.

The defects observed were minor shrinkage cracking, leachate, spot rust staining and water staining at the abutments. No section loss or delamination to the structural elements were observed. Based on the review of the PI report, it was concluded that the overall condition factor should be taken as 1.0.

2.3.2. Hocombe Road Bridge

The last Principal Inspection was carried out in February 2016. The findings of the previous inspections and the last Principal Inspection undertaken in February 2016 did not identify any defects that would affect the capacity of the structure and hence, no defects or reduced condition factors are considered in the current assessment.

Similar to the Pitmore Bridge, the defects observed were minor shrinkage cracking, leachate, spot rust staining and water staining at the abutments. No section loss or delamination to the structural elements were observed. Inferring from the report, it was concluded that the overall condition factor should be taken as 1.0.

3. Assessment of the Bridges

3.1. Scope of Assessment

Assessment is carried out for both Pitmore Copse and Hocombe Road Bridges to determine the adequacy of the structure to carry proposed lane configuration, when subjected to 40t ALL as per BD 21/01. As both bridges do not carry heavy load routes, assessment for abnormal loads as per BD 86/11 has not been undertaken.

As per BD 21/01, structures built after 1965 shall be assessed for Serviceability Limit State (SLS) as well as Ultimate Limit State (ULS). Hence, in the current assessment, the bridges are assessed for ULS and SLS. As the carriageway configuration on the M3 shall not be altered and the effects and risk on to the substructure from impact of vehicles remains unchanged, pier impact assessment on intermediate piers has not been undertaken.

Grillage models of the bridges have been developed using the analysis software LUSAS to determine the load effects. The section capacities of the structural elements have been determined using the software Autodesk Structural Bridge Design and in accordance with BD 44/15. The inputs considered for the assessment are described in the subsequent sections.

For the current assessment, High (H) traffic flow and the Road Surface Category as "Poor" as defined in BD 21/01 is considered. The Road surface category of 'Poor' is assumed to account for the surface quality in the service time of the proposed cross section of bridge with additional lanes.

3.2. Geometry

The geometry as well existing and proposed cross sections of Pitmore Copse Bridge and Hocombe Road Bridge are described in Section 2.2.1 and 2.2.2 respectively. The structural dimensions and reinforcement details considered for the assessment of both the bridges are based on information from as-built drawings provided in Appendix A.

3.3. Material Properties

3.3.1. Pitmore Copse Bridge

The material properties adopted for the assessment have been referenced from BD 21/01, available AiPs and as-built drawings. The properties adopted for this analysis are listed in Table 1.

Table 1 - Pitmore Copse Bridge Material Properties

Sl. No.	Component	Material properties
1	Prestressed precast concrete beams (M6) and edge beams	Grade of concrete - 50/20 Short term Young's Modulus = 33.5 kN/mm^2
2	Reinforced concrete cast in-situ deck, diaphragms	Grade of concrete - 40/20 Short term Young's Modulus = 30.8 kN/mm^2
3	Intermediate Pier	Grade of concrete - 40/20 Short term Young's Modulus = 30.8 kN/mm^2
4	Reinforcement*	Allowable Yield stress of mild steel = 230 MPa Short term Young's Modulus = 200 kN/mm^2 Allowable Yield stress of HYSD= 460 MPa

5	Prestress Tendons	15.2 mm nominal diameter low relaxation to BS 5896 - 1980 with minimum characteristic breaking load of 227kN Initial force per strand -170 kN Loss of pretension (%) – 26.5 (Intermediate beam) Loss of pretension (%) – 25.4 (End beam) Short term Young's Modulus = 205 kN/mm²
6	Post-tensioning Tendons	4 number of ducts each containing 2 no. of 15.2mm nominal diameter strands of low relaxation to BS5896 -1980 Minimum characteristic breaking load of 234kN Initial force per strand – 140kN Loss of post-tensioning (%) – 14.2% Short term Young's Modulus = 205 kN/mm²

*In the absence of definite information on the grade of reinforcement steel, characteristic yield stress has initially been conservatively considered to be 230 MPa, as per Cl.4.4 of BD21/01. However, considering the time of construction the reinforcement type is highly likely to be high yield, therefore calculations are also carried out for higher yield strengths.

3.3.2. Hocombe Road Bridge

Similar to Pitmore Copse Bridge, material properties used for the assessment are referenced from the available design AiP and as built drawings, and are listed in Table 4:

Table 2 - Hocombe Bridge Material Properties

Sl. No.	Element	Material Properties
1	Prestressed precast concrete beams (M10) and edge beams	Grade of concrete - 50/20 Short term Young's Modulus = 33.5 kN/mm²
2	Reinforced concrete cast in-situ deck, diaphragms	Grade of concrete - 40/20 Short term Young's Modulus = 30.8 kN/mm²
3	Intermediate Pier	Grade of concrete - 50/20 Short term Young's Modulus = 33.5 kN/mm²
4	Reinforcement*	Allowable Yield stress of mild steel = 230 MPa Short term Young's Modulus = 200 kN/mm² Allowable Yield stress of HYSD= 460 MPa
5	Prestress Tendons	15.2 mm nominal diameter low relaxation to BS 5896 - 1980 with minimum characteristic breaking load of 232 kN Initial force per strand -174 kN Loss of pretension (%) – 29.3 (Intermediate beam) Loss of pretension (%) – 28.9 (End beam) Short term Young's Modulus = 205 kN/mm²
6	Post-tensioning Tendons	4 number of ducts each containing 2 no. of 15.2mm nominal diameter strands of low relaxation to BS5896 - 1980 Minimum characteristic breaking load of 234kN Initial force per strand – 140kN Loss of post-tensioning (%) – 14.4% Short term Young's Modulus = 205 kN/mm²

*As in the case of Pitmore Copse Bridge, the section capacities of critical elements are determined adopting high yield reinforcement strength.

3.4. Loads, Load Factors and Assessment Standards

The loads and partial load factors for the analysis are based on the recommendations in BD 21/01 and BD 37/01. The partial factors for loads (Y_{fL}) will be in accordance to the Cl 3.7 table 3.1 in BD 21/01. The partial factors for the load effects (Y_{f3}) shall also be in accordance to the BD21/01. The considered for the assessment of the bridges are:

Permanent Load effects considering

- Self-weight of the superstructure
- Superimposed dead (125 mm thickness of surface considered for both bridges)
- Services (Self weight of Water main, Gas main, and ducts are accounted)
    - For gas and water services- 4.4 kN/m
    - Ducts for services – 1kN/m
- Parapet (0.8 kN/m is used as SIDL)

Live Loads

The structure will be assessed for 40 t ALL, as per BD 21/01. For the current assessment the traffic flow has been taken as High (H) and the Road Surface Category as “Poor”. The corresponding reduction factor (K) has been obtained from Figure 5.2 in BD 21/01

The critical loads to be considered are as follows,

- HA UDL + KEL for global longitudinal effects of spans - Cl. 5.18 to 5.27, BD21/01
- Single axle and single wheel loads for local effects - Cl. 5.30 of BD21/01
- Annex D loading for transverse effects - Annex D, BD21/01
- Accidental wheel loading over the cantilevered verges - Cl.5.34 of BD21/01
- Footway loading of 5kN/m² on the footpaths - Cl.5.36 of BD21/01
- Braking load due to vehicular live loads applied over a single lane over carriageway - Cl. 6.10 of BD37/01

Temperature Loads

Differential temperature loads are considered as per cl. 5.4, BD37/01. As the superstructure is supported over bearing at abutments, the decks are unrestrained in the longitudinal direction. Therefore, uniform temperature effects do not induce any stresses and are not considered.

Differential settlement

Differential settlement of 20mm between supports are considered as per section 6.1.3 of the design AiP (dated on 23rd Jan 1986). Scenarios of intermediate support settling 20mm with respect to end supports as well as end supports settling 20 mm with respect to intermediate support are considered.

3.5. Analysis Methodology

3.5.1. Pitmore Copse Bridge

Pitmore Copse Bridge is square bridge, hence the modelling of the bridge has been carried out as a simple grillage in LUSAS, where in the longitudinal lines would represent the precast prestressed M beams and the orthogonal vertical lines represent the deck stiffness.

As the piers forming the intermediate support are casted monolithically to the deck and the ends are supported on cantilever abutments, the structures will be modelled as continuous over the intermediate support. Differential settlement of 20mm between abutment and pier is considered. The articulations will be modelled as per the conditions listed:

- Abutments/End Supports: Pinned condition (laterally and vertically restrained)
- Intermediate supports: Full fixity is considered at the lower end of the piers at mid-level of spread footing.

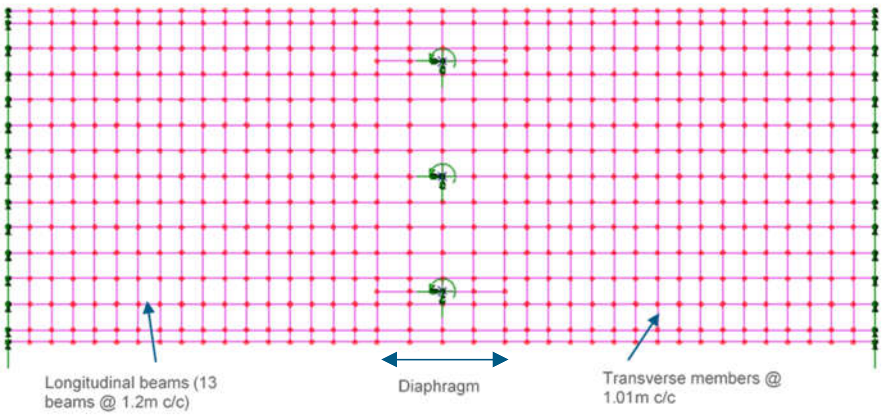


Figure 11 - Pitmore Bridge Idealisation – Plan view

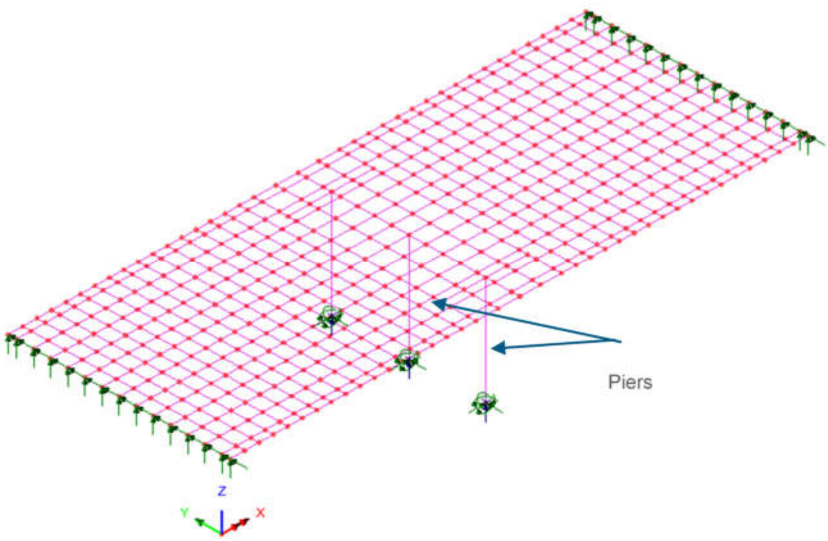


Figure 12 - Pitmore Bridge Idealisation – Isometric view

3.5.2. Hocombe Road Bridge

Since the skew of the deck of Hocombe bridge is greater than 20 degrees (26.7 degrees) and the deck is continuous over the intermediate supports, the grillage model has been developed in accordance with 'Bridge Deck Behaviour' by Hambly. Longitudinal members are modelled parallel to the free edge and are oriented along the physical beams in the superstructure. Orthogonal mesh is considered for the deck to model the transverse members of the grillage.

As the skew angle exceeds 20^{o}, adopting non-orthogonal grillage will lead to more accurate load distribution from the transverse members to the diaphragms and the acute corners of the structure. Hence orthogonal grillage mesh is adopted with aspect ratio between 1 and 2.

The structures is modelled as continuous over the intermediate support. Differential settlement of 20mm between abutment and pier is also considered.

The articulations will be modelled as per the conditions listed:

- Abutments/End Supports: Pinned condition (laterally and vertically restrained)
- Intermediate supports: Full fixity at the bottom of the piers.

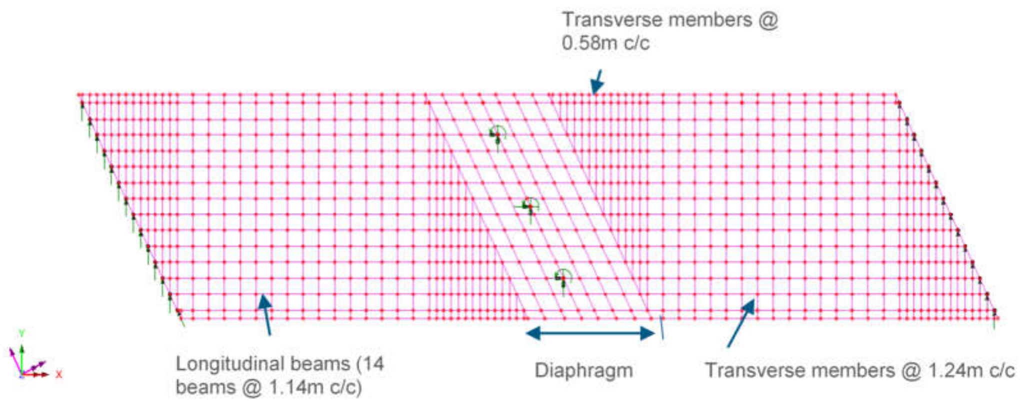


Figure 13 - Hocombe Bridge Structure Idealisation – Plan view

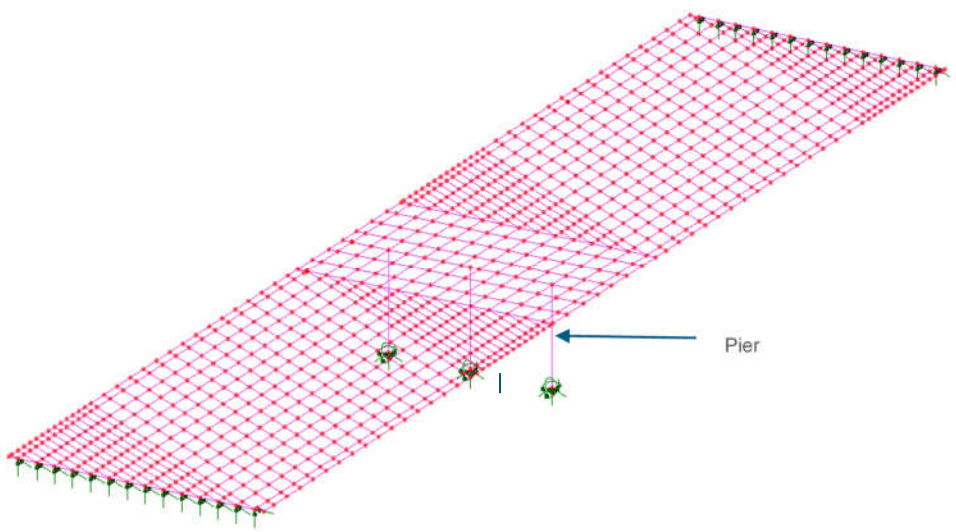


Figure 14 - Hocombe Bridge Structure Idealisation – Isometric view

3.6. Assessment Results

All structural adequacy checks were carried out in accordance with BD21/01, BD44/15 and BD37/01 using structural design software and in-house developed spreadsheets.

The permanent loads, superimposed, live loads, differential thermal loads are considered along with the loads induced by the differential settlement of a foundation. The intermediate support settling by 20 mm with respect to end supports is found to induce critical loads effects in the superstructure and the results summarised correspond to this case. It is unclear whether this level of settlement has actually occurred, and it is recommended this is surveyed on site.

3.6.1. Pitmore Copse Bridge

Summary of results for Pitmore Copse Bridge are as follows.

Table 3 - Table 7 and Table 9 show the results for structural elements considering yield strength of mild steel (230MPa). The reinforced concrete diaphragm was found to be inadequate under flexure and shear checks when reinforcement was considered as mild steel. Considering the year of construction and the high likelihood of high yield reinforcement being used for construction, the structural checks were carried out adopting an allowable yield stress value of 460 MPa.

3.6.1.1. Prestress Precast M-6 - Intermediate Longitudinal Beam Results

The analysis found the inner longitudinal beams have sufficient capacity for bending and shear under 40 tonnes ALL. ULS and SLS checks has been carried out and the results are tabulated in Table 3. Figure 15 illustrates the debonding details for M6 longitudinal beams.

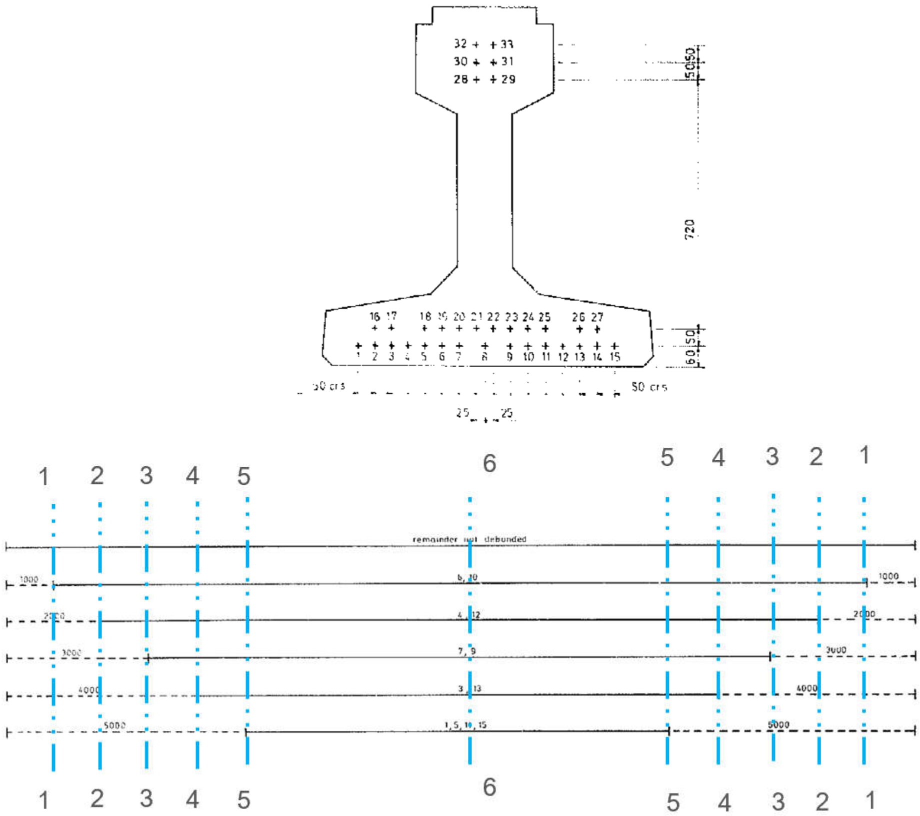


Figure 15 – M-6 Beam Strand Layout and Debonding Details

Table 3 - Prestressed Intermediate Beams Results

Location	Description of Effect	Limit State	Load Effects	Capacity / Limit	Adequacy
Section 1-1	Flexure - sagging (kNm)	ULS	1712	3469	2.03
	Flexure - hogging (kNm)	ULS	691	1485	2.15
	Shear(kN)	ULS	1007	2494	2.48
	Slab top stress (MPa)	SLS -Comp.	0.0	13.3	Pass
		SLS -Tension	3.6	2.4	**Fail**
	Beam top stress (MPa)	SLS -Comp.	0.0	16.6	Pass
		SLS -Tension	4.4	2.6	**Fail**
	Beam bottom stress (MPa)	SLS -Comp.	16.5	16.6	Pass
		SLS -Tension	0.0	2.6	Pass
Section 2-2	Flexure - sagging (kNm)	ULS	1115	3851	3.45
	Flexure - hogging (kNm)	ULS	258	1475	5.72
	Shear(kN)	ULS	765	1703	2.23
	Slab top stress (MPa)	SLS -Comp.	0.0	13.3	Pass
		SLS -Tension	2.6	2.4	**Fail**
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	2.9	2.6	**Fail**
	Beam bottom stress (MPa)	SLS -Comp.	15.9	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
Section 3-3	Flexure - sagging (kNm)	ULS	1210	4097	3.39
	Flexure - hogging (kNm)	ULS	-	1462	-
	Shear(kN)	ULS	458	1743	3.80
	Slab top stress (MPa)	SLS -Comp.	2.8	13.3	Pass
	Slab top stress (MPa)	SLS -Tension	0.0	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	1.5	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	12.2	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
Section 4-4	Flexure - sagging (kNm)	ULS	1493	4302	2.88
	Flexure - hogging (kNm)	ULS	-	1454	-
	Shear(kN)	ULS	353	1794	5.08
	Slab top stress (MPa)	SLS -Comp.	3.5	13.3	Pass
		SLS -Tension	0.0	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	2.6	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	12.9	16.7	Pass

		SLS -Tension	0.0	2.6	Pass
Section 5-5	Flexure - sagging (kNm)	ULS	1714	4496	2.62
	Flexure - hogging (kNm)	ULS	-	1440	-
	Shear(kN)	ULS	308	1851	6.01
	Slab top stress (MPa)	SLS -Comp.	0.0	13.3	Pass
		SLS -Tension	1.3	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	1.3	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	17.1	16.7	**Fail**
		SLS -Tension	0.0	2.6	Pass
Section 6-6	Flexure - sagging (kNm)	ULS	2142	4850	2.26
	Flexure - hogging (kNm)	ULS	-	1423	-
	Shear(kN)	ULS	298	797	2.67
	Slab top stress (MPa)	SLS -Comp.	0.7	13.3	Pass
		SLS -Tension	0.0	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	1.4	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	19.1	16.7	**Fail**
		SLS -Tension	0.0	2.6	Pass

3.6.1.2. Prestress Precast M-6 -Outer Longitudinal Beams Results

The analysis found the outer longitudinal beams have sufficient capacity for bending and shear under 40 tonnes ALL. ULS and SLS checks has been carried out and the results are tabulated in Table 4.

Table 4 - Prestressed Outer End Beams Results

Element	Description of Effect	Limit state	Load Effects	Capacity / Limit	Adequacy
Section 1-1	Flexure - sagging (kNm)	ULS	613	3180	5.18
	Flexure - hogging (kNm)	ULS	789	1396	1.77
	Shear(kN)	ULS	884	7936	8.97
	Slab top stress (MPa)	SLS -Comp.	0.0	13.3	Pass
		SLS -Tension	4.6	2.4	**Fail**
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	4.3	2.6	**Fail**
	Beam bottom stress (MPa)	SLS -Comp.	16.5	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
Section 2-2	Flexure - sagging (kNm)	ULS	636	3404	5.35
	Flexure - hogging (kNm)	ULS	297	1386	4.67
	Shear(kN)	ULS	624	4729	7.59
	Slab top stress (MPa)	SLS -Comp.	0.0	13.3	Pass
		SLS -Tension	2.6	2.4	**Fail**
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	2.9	2.6	**Fail**
	Beam bottom stress (MPa)	SLS -Comp.	15.8	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
Section 3-3	Flexure - sagging (kNm)	ULS	1000	3613	3.61
	Flexure - hogging (kNm)	ULS	0	1376	-
	Shear(kN)	ULS	424	1865	4.40
	Slab top stress (MPa)	SLS -Comp.	1.8	13.3	Pass
		SLS -Tension	0.0	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	1.8	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	12.4	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
Section 4-4	Flexure - sagging (kNm)	ULS	1152	3809	3.31
	Flexure - hogging (kNm)	ULS	-	1367	-
	Shear(kN)	ULS	288	1180	4.10
	Slab top stress (MPa)	SLS -Comp.	2.9	13.3	Pass
		SLS -Tension	0.0	2.4	Pass

	Beam top stress (MPa)	SLS -Comp.	2.8	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	12.4	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
Section 5-5	Flexure - sagging (kNm)	ULS	1274	3987	3.13
	Flexure - hogging (kNm)	ULS	-	1356	-
	Shear(kN)	ULS	424	799	1.88
	Slab top stress (MPa)	SLS -Comp.	0.0	13.3	Pass
		SLS -Tension	0.9	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	0.6	16.7	Pass
		SLS -Tension	1.2	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	17.4	16.7	**Fail**
		SLS -Tension	0.0	2.6	Pass
Section 6-6	Flexure - sagging (kNm)	ULS	1548	4288	2.77
	Flexure - hogging (kNm)	ULS	-	1335	-
	Shear(kN)	ULS	229	853	3.73
	Slab top stress (MPa)	SLS -Comp.	0.0	13.3	Pass
		SLS -Tension	1.0	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	0.6	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	18.6	16.7	**Fail**
		SLS -Tension	0.0	2.6	Pass

3.6.1.3. Transverse Deck Slab Results (Reinforcement f_y = 230 MPa)

Using the grillage model and a localised wheel load, the deck slab was checked in the transverse direction over the beams (flexural shear and hogging) and between the beams (sagging). The results are summarised in Table 5. Combined load effects from local and global analysis are considered. The local load effects on the transverse deck are analysed using Pucher charts.

Table 5 - Transverse Slab Results

Element	Description of effect	Load Effect	Capacity	Adequacy factor
Transverse Deck Slab	Sagging Moment (kNm)	17	19	1.137
	Hogging Moment (kNm)	15	23	1.50
	Shear Force (kN)	92	93	1.01

3.6.1.4. Parapet Upstand (Reinforcement f_y = 230 MPa)

The structural checks are carried out to determine the adequacy of the deck to parapet upstand connection considering the maximum possible load which will be transferred to the upstand from parapet. It is assumed that maximum load that is transferred to upstand is limited by the ultimate capacities of parapet in flexure and shear, obtained from 'design AiP' for Pitmore bridge. The results of checks are summarised in Table 6.

Table 6 – Parapet Upstand Results for ULS

Location	Description of effect	Load Effect	Capacity	Adequacy factor
Connection of edge beam to deck	Shear Force (kN)	94	124	1.32
	Moment (kNm)	42	45	1.06

3.6.1.5. Diaphragm (Reinforcement f_y = 230 MPa)

The diaphragm has been assessed in both longitudinal and transverse direction. Figure 16 shows the idealisation of diaphragm. Section 2 and Section 3 incorporates a post tensioning system and Section 1 and Section 4 corresponds to cast in-situ RC sections. The results are summarised in Table 7

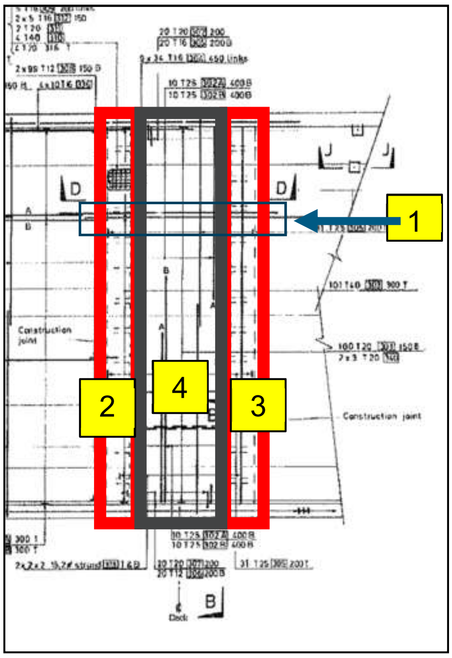


Figure 16 - Typical elements of diaphragm

Table 7 –Diaphragm Results (Reinforcement f_y =230 MPa)

Location	Description of effect	Limit state	Load Effects	Capacity/Limit	Adequacy factor
Section 1 (longitudinal)	Moment (kN)	ULS	2358	1895	**0.80**
	Shear (kN)	ULS	1133	930	**0.82**
	Stress Check -concrete (MPa)	SLS	0.6	13.3	Pass
	Stress Check -rebar (MPa)	SLS	13	230	Pass
Section 4 (transverse)	Moment (kN)	ULS	723	529	**0.73**
	Shear (kN)	ULS	798	737	**0.92**
	Stress Check -concrete (MPa)	SLS	0.1	13.3	Pass
	Stress Check -rebar (MPa)	SLS	4.3	230	Pass
Section 2 & 3 (post tension)	Moment (kN)	ULS	384	1875	4.88
	Shear (kN)	ULS	322	27166	84.47

3.6.1.6. Diaphragm Results (f_y = 460 MPa)

The reinforced concrete diaphragm was found to be inadequate under flexure and shear checks when reinforcement was considered as mild steel. Considering the year of construction and the high likelihood of high yield reinforcement being used for construction, the structural checks were carried out adopting an allowable yield stress value of 460 MPa.

However, the yield strength of steel used in the construction should be confirmed by intrusive investigation of the diaphragm and the acceptance of results in Table 8 will be subject to confirmation of HYSD reinforcement.

Table 8 – Diaphragm Results (f_y =460 MPa)

Element	Description of effect	Limit state	Load Effects	Capacity / Limit	Adequacy factor
Section 1 (longitudinal)	Moment (kN)	ULS	2358	4274	1.81
	Shear (kN)	ULS	1133	1303	1.15
	Stress Check -concrete (MPa)	SLS	0.6	13.3	Pass
	Stress Check -rebar (MPa)	SLS	13	460	Pass
Section 4 (transverse)	Moment (kN)	ULS	723	1058	1.46
	Shear (kN)	ULS	798	1110	1.39
	Stress Check -concrete (MPa)	SLS	0.1	13.3	Pass
	Stress Check -rebar (MPa)	SLS	4.3	460	Pass

3.6.1.7. Pier Results

The results are tabulated in Table 9.

Table 9 –Intermediate Pier Results

Element	Description of effect	Limit state	Load Effects	Capacity / Limit	Adequacy factor
Pier	Shear (kN)	ULS	262	598	2.28
	Moment (kNm)	ULS	1070	1800	1.68

3.6.2. Hocombe Road Bridge

Summary of results for Hocombe road bridge are as follows.

Table 10 - Table 15 and Table 17 show the results for structural elements considering yield strength of mild steel (230MPa). The reinforced concrete diaphragm was found to be inadequate under flexure and shear checks when reinforcement was considered as mild steel. Considering the year of construction and the high likelihood of high yield reinforcement being used for construction, the structural checks were carried out adopting an allowable yield stress value of 460 MPa.

3.6.2.1. Prestress Precast M-10 - Intermediate Longitudinal Beam Results

The analysis found the inner longitudinal beams have sufficient capacity for bending and shear under 40 tonnes ALL. ULS and SLS checks has been carried out and the results are tabulated in Table 10.Figure 17 illustrates the debonding details for M10 longitudinal beams.

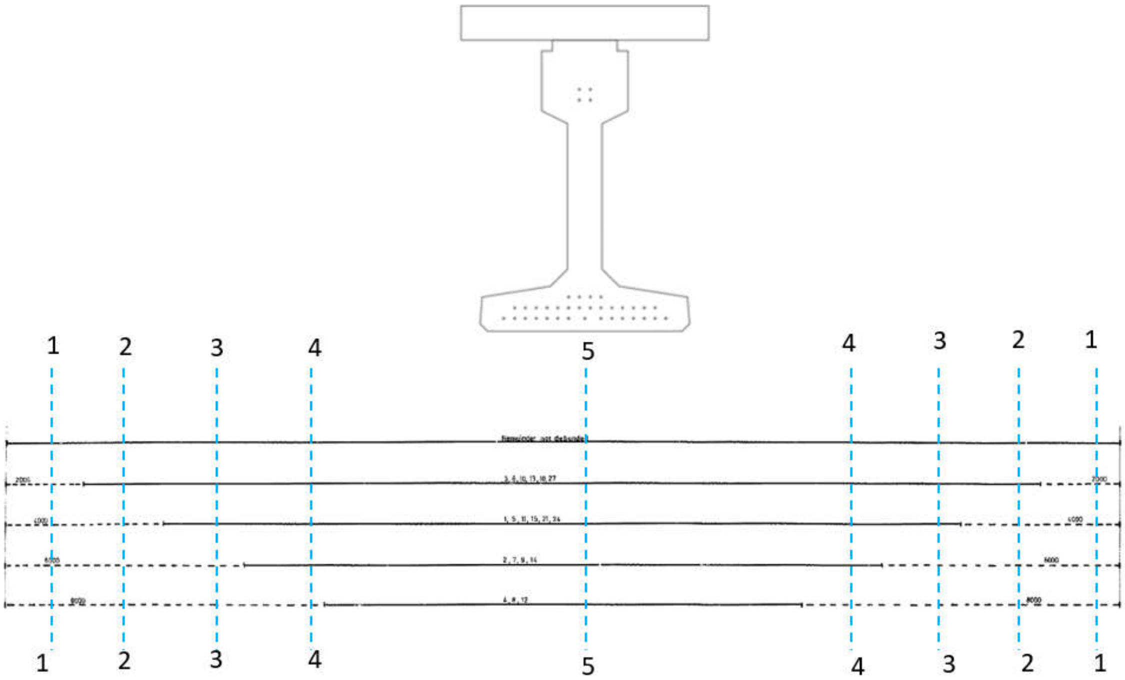


Figure 17 - M-10 Beam Strand Layout and Debonding Details

Table 10 – Prestressed Intermediate Beam Results

Location	Description of effect	Limit state	Load Effects	Capacity / Limit	Adequacy
Section 1-1	Flexure - sagging (kNm)	ULS	1204	3958	3.29
	Flexure - hogging (kNm)	ULS	1388	1434	1.03
	Shear(kN)	ULS	623	796	1.28
	Slab top stress (MPa)	SLS -Comp.	0.0	13.3	Pass
		SLS -Tension	1.4	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	4.7	2.6	**Fail**
	Beam bottom stress (MPa)	SLS -Comp.	11.9	16.7	Pass
		SLS -Tension	0.0	2.6	Pass

Section 2-2	Flexure - sagging (kNm)	ULS	2097	4712	2.25
	Flexure - hogging (kNm)	ULS	1053	1419	1.35
	Shear(kN)	ULS	508	1441	2.84
	Slab top stress (MPa)	SLS -Comp.	0.0	13.3	Pass
		SLS -Tension	1.0	2.3	Pass
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	4.0	2.6	**Fail**
	Beam bottom stress (MPa)	SLS -Comp.	14.1	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
Section 3-3	Flexure - sagging (kNm)	ULS	2729	5656	2.07
	Flexure - hogging (kNm)	ULS	813	1399	1.72
	Shear(kN)	ULS	440	1461	3.32
	Slab top stress (MPa)	SLS -Comp.	0.0	13.3	Pass
		SLS -Tension	0.8	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	3.9	2.6	**Fail**
	Beam bottom stress (MPa)	SLS -Comp.	16.8	16.7	**Fail**
		SLS -Tension	0.0	2.6	Pass
Section 4-4	Flexure - sagging (kNm)	ULS	3353	6796	2.03
	Flexure - hogging (kNm)	ULS	519	1373	2.65
	Shear(kN)	ULS	353	937	2.65
	Slab top stress (MPa)	SLS -Comp.	0.0	13.3	Pass
		SLS -Tension	0.5	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	3.5	2.6	**Fail**
	Beam bottom stress (MPa)	SLS -Comp.	18.4	16.7	**Fail**
		SLS -Tension	0.0	2.6	Pass
Section 5-5	Flexure - sagging (kNm)	ULS	3917	7574	1.93
	Flexure - hogging (kNm)	ULS	370	1349	3.65
	Shear(kN)	ULS	197	751	3.82
	Slab top stress (MPa)	SLS -Comp.	0.4	13.3	Pass
		SLS -Tension	0.0	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	0.4	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	17.5	16.7	**Fail**
		SLS -Tension	0.0	2.6	Pass

3.6.2.2. Prestress Precast M-10 -Outer Longitudinal Beams Results

The analysis found the outer longitudinal beams have sufficient capacity for bending and shear under 40 tonnes ALL. ULS and SLS checks has been carried out and the results are tabulated in Table 11.

Table 11 – Prestressed Outer Edge Beam Results

Location	Description of effect	Limit state	Load Effects	Capacity / Limit	Adequacy
Section 1-1	Flexure - sagging (kNm)	ULS	1123	4185	3.73
	Flexure - hogging (kNm)	ULS	502	1327	2.64
	Shear(kN)	ULS	428	1355	3.17
	Slab top stress (MPa)	SLS -Comp.	0.0	13.3	Pass
		SLS -Tension	0.1	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	0.8	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	9.0	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
Section 2-2	Flexure - sagging (kNm)	ULS	1569	4979	3.17
	Flexure - hogging (kNm)	ULS	309	1313	4.25
	Shear(kN)	ULS	353	1237	3.51
	Slab top stress (MPa)	SLS -Comp.	0.2	13.3	Pass
		SLS -Tension	0.0	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	0.7	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	11.7	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
Section 3-3	Flexure - sagging (kNm)	ULS	1987	5985	3.01
	Flexure - hogging (kNm)	ULS	184	1294	7.02
	Shear(kN)	ULS	296	535	1.81
	Slab top stress (MPa)	SLS -Comp.	0.0	13.3	Pass
		SLS -Tension	0.6	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	1.7	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	15.6	16.7	Pass
		SLS -Tension	0.0	2.6	Pass
Section 4-4	Flexure - sagging (kNm)	ULS	2625	7201	2.74
	Flexure - hogging (kNm)	ULS	134	1269	9.47
	Shear(kN)	ULS	243	9532	39.28
	Slab top stress (MPa)	SLS -Comp.	0.5	13.3	Pass
		SLS -Tension	0.1	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass

		SLS -Tension	1.6	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	17.1	16.7	**Fail**
		SLS -Tension	0.0	2.6	Pass
Section 5-5	Flexure - sagging (kNm)	ULS	3163	8072	2.55
	Flexure - hogging (kNm)	ULS	61.9	1243	20.10
	Shear(kN)	ULS	102	5911	58.06
	Slab top stress (MPa)	SLS -Comp.	0.8	13.3	Pass
		SLS -Tension	0.0	2.4	Pass
	Beam top stress (MPa)	SLS -Comp.	0.0	16.7	Pass
		SLS -Tension	0.6	2.6	Pass
	Beam bottom stress (MPa)	SLS -Comp.	17.3	16.7	**Fail**
		SLS -Tension	0.0	2.6	Pass

3.6.2.3. Transverse Deck Slab Results (Reinforcement f_y = 230 MPa)

As the thickness of slab is varying across the cross section from 160mm to 250mm, assessment has been carried out for both the sections. The depth of slab supporting the carriageway is 160mm and has been assessed for vehicular live load effects together with other permanent loads. The deck slab between the end beam and penultimate beam supporting the north verge is 250mm thick and has been checked for flexural and shear adequacies for accidental live loads. The precast slabs (Type A, as mentioned in the as-built drawings) at those locations where the deck slab is discontinuous at the north verge, were locally checked for accidental live load effects.

Using the grillage model and a localised wheel load, the deck slab was checked in the transverse direction over the beams (flexural shear and hogging) and between the beams (sagging). The results are summarised in Table 5. Combined load effects from local and global analysis are considered. The local load effects on the transverse deck are analysed using Pucher charts.

Table 12 – Transverse Slab Results (230 MPa)

Element	Description of effect	Limit state	Load Effects	Capacity / Limit	Adequacy
Deck (160mm)	Flexure - sagging (kNm)	ULS	13.80	31.56	2,29
	Flexure - hogging (kNm)	ULS	20.93	31.56	1.51
	Shear(kN)	ULS	47.22	128.19	2.72
Deck (250mm)	Flexure - sagging (kNm)	ULS	106	129	1.22
	Flexure - hogging (kNm)	ULS	108	129	1.20
	Shear(kN)	ULS	147	222	1.51
Precast slab - Type A	Flexure - sagging (kNm)	ULS	36	19	**0.53**
	Shear(kN)	ULS	87	79	**0.91**

Table 13 – Transverse Slab Results (460MPa)

Element	Description of effect	Limit state	Load Effects	Capacity / Limit	Adequacy
Precast slab - Type A	Flexure - sagging (kNm)	ULS	36	32	**0.91**
	Shear(kN)	ULS	87	79	**0.91**

3.6.2.4. Parapet Upstand (Reinforcement f_y = 230 MPa)

The structural checks are carried out to determine the adequacy of deck to parapet upstand connection considering the maximum possible load which will be transferred to the upstand from parapet. Similar to Pitmore bridge, it is assumed that maximum load that is transferred to upstand is limited by the ultimate capacities of parapet in flexure and shear, obtained from ‘design AiP’ for Hocombe road bridge. The results of checks are summarised in Table 14.

The connection between the end beam and the penultimate beam are different along the span of the structure, as the deck slab is intermittently discontinuous and hence, the edge beam connection with the rest of the structure is also different in both these cases. Therefore, capacity checks have been carried out for the above-mentioned loads on both these edge beam connection types. Figure 18 and Figure 19 show the two types of connection arrangements of edge beams.

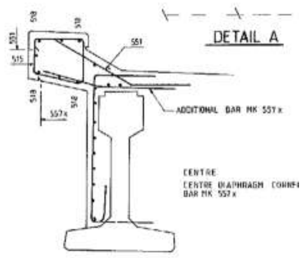


Figure 18 - Edge beam connection where deck slab is continuous (Edge beam Type-1)

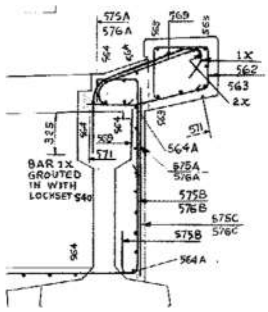


Figure 19 - Edge beam connection where deck slab is discontinuous (Edge beam type-2)

Table 14 – Parapet Upstand Results

Element	Description of effect	Limit state	Load Effects	Capacity / Limit	Adequacy
Edge beam Type-1	Shear (kN)	ULS	94	139	1.48
	Torsion (kNm)	ULS	43	45	1.04
Edge beam Type-2	Shear (kN)	ULS	94	139	1.48
	Torsion (kNm)	ULS	43	45	1.06

3.6.2.5. Diaphragm (Reinforcement f_y = 230 MPa)

The flexure and shear checks under ULS and stress checks under SLS carried on various section of diaphragm are summarised in Table 15. Section 2 and Section 3 incorporates a post tensioning and Section 1 and Section 4 corresponds to cast in-situ RC sections as shown in Figure 20.

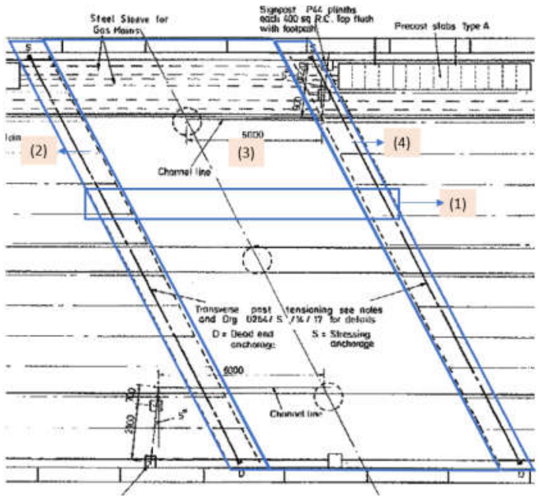


Figure 20 - Typical Elements of Diaphragm

Table 15 – Diaphragm Results (Reinforcement f_y =230 MPa)

Location	Description of effect	Limit state	Load Effects	Capacity / Limit	Adequacy
Section 1 (longitudinal)	Moment (kN)	ULS	3194	2800	**0.88**
	Shear (kN)	ULS	1151	5162	4.48
	Stress Check - concrete (MPa)	SLS	0.2	13.3	Pass
	Stress Check -rebar (MPa)	SLS	7.2	460	Pass
Section 3 (transverse)	Moment (kN)	ULS	1166	3090	2.65
	Shear (kN)	ULS	1528	1548	1.01
	Stress Check - concrete (MPa)	SLS	0.1	13.3	Pass
	Stress Check -rebar (MPa)	SLS	1.8	460	Pass
Section 2 & 4 (post tension)	Moment (kN)	ULS	1166	1469	1.26

3.6.2.6. Diaphragm Results (f_y = 460 MPa)

The results of Hocombe Road bridge are similar to those of Pitmore Bridge. The RC sections of diaphragm were found to be inadequate when reinforcement bars were considered as mild steel. Therefore, structural checks were carried out adopting an allowable yield stress value of 460 MPa, corresponding to HYSD bars. This assumption has been made considering the year of construction and the high likelihood of HYSD bar been used for construction of diaphragm and transverse slabs. However, the grade of steel used in construction shall be confirmed by intrusive investigation of the diaphragm and the acceptance of results in Table 16 will be subject to confirmation of high yield reinforcement.

Table 16 – Diaphragm results (460 MPa yield strength)

Element	Description of effect	Limit state	Load Effects	Capacity / Limit	Adequacy
Diaphragm (longitudinal)	Moment (kN)	ULS	3194	6700	2.10
	Shear (kN)	ULS	1151	9687	8.41
	Stress Check -concrete (MPa)	SLS	0.2	13.3	Pass
	Stress Check -rebar (MPa)	SLS	7.2	460	Pass

3.6.2.7. Pier Results

The results are tabulated in Table 17

Table 17 – Intermediate Pier Results

Element	Description of effect	Limit state	Load Effects	Capacity / Limit	Adequacy
Piers	Shear (kN)	ULS	262	598	2.28
	Moment (kNm)	ULS	1585	2280	1.68

4. Assessment Results and Discussions

4.1.1. Pitmore Copse Bridge

The assessment findings are as follows

- Longitudinal prestressed beams are adequate in ULS bending and shear but fail in SLS stress checks.
- The transverse deck slab has sufficient load carrying capacity for all applicable load effects under 40t ALL
- Parapet upstand and pier have sufficient capacity for all load effects under 40t ALL
- The RC sections of diaphragm were found to be inadequate when reinforcement bars were considered as mild steel (230 MPa)
- With yield strength of 460 MPa, the ratings will improve for diaphragm.
- It may be possible to increase the assessed capacity by means of further refined analysis or by considering departures from standards.
- The consideration of differential settlement 20mm as per section 6.1.3 of design AIP dated on 23rd Jan 1986 seems to be onerous. This should be further evaluated.

4.1.2. Hocombe Road Bridge

The assessment findings are as follows:

- Longitudinal prestressed beams are adequate in ULS bending and shear but fails in SLS stress checks.
- Carriage way deck slab is found to be adequate for all load effects under 40 tonnes ALL
- The precast service cover slabs are inadequate for 40 tonnes ALL
- Diaphragm, parapet upstand and pier have sufficient capacity for all 40t load effects.
- The RC sections of diaphragm were found to be inadequate when reinforcement bars were considered as mild steel (230 MPa)
- With yield strength of 460 MPa, the ratings will improve for diaphragm
- It may be possible to increase the assessed capacity by means of further refined analysis or by considering departures from standards.
- The consideration of differential settlement 20mm as per section 6.1.3 of design AIP dated on 23rd Jan 1986 seems to be onerous. This should be further evaluated.

Results presented above have not been independently verified through a numerical check.

5. Strengthening Recommendations

5.1. Key Constraints

The following constraints are considered key for the development of any strengthening proposals

- Traffic management
- Shifting existing gas mains
- Hydro-demolition and concrete breakout
- Connection of new slab with the existing slab
- Connection of new end diaphragm with the existing diaphragm

5.2. Proposed Strengthening and Modification to the Structure

5.2.1. Pitmore Copse Bridge

None considered applicable

5.2.2. Hocombe Road Bridge

The analysis has confirmed that the service trough cover slabs located at north verge are inadequate to carry 40 tonnes ALL. Diversion of utilities is likely to be required to facilitate strengthening or reconstruction, including approval with the associated stakeholders.

The proposed strengthening options for precast reinforced concrete cover slabs are as follows:

Option – 1 is to replace the existing cover slab and parapet upstand beam and stitch with the existing slab as shown in Figure 21 and Figure 23. This shall incorporate the following steps:

- Install traffic management to create working area
- Erect temporary edge protection
- Divert gas mains
- Remove existing parapet.
- Remove the concrete cover slab, footway deck slab and parapet upstand
- Install permanent formwork
- Clean the existing steel bars.
- Lap the new bars with the existing bars.
- Pour concrete to stitch the existing and new deck

Key

- Existing deck concrete (C40/20)
- New deck concrete (C40/50)
- Surfacing, paved areas etc
- Existing permanent formwork
- New permanent formwork
- Existing reinforcement (230 MPa)
- New reinforcement (500 MPa)

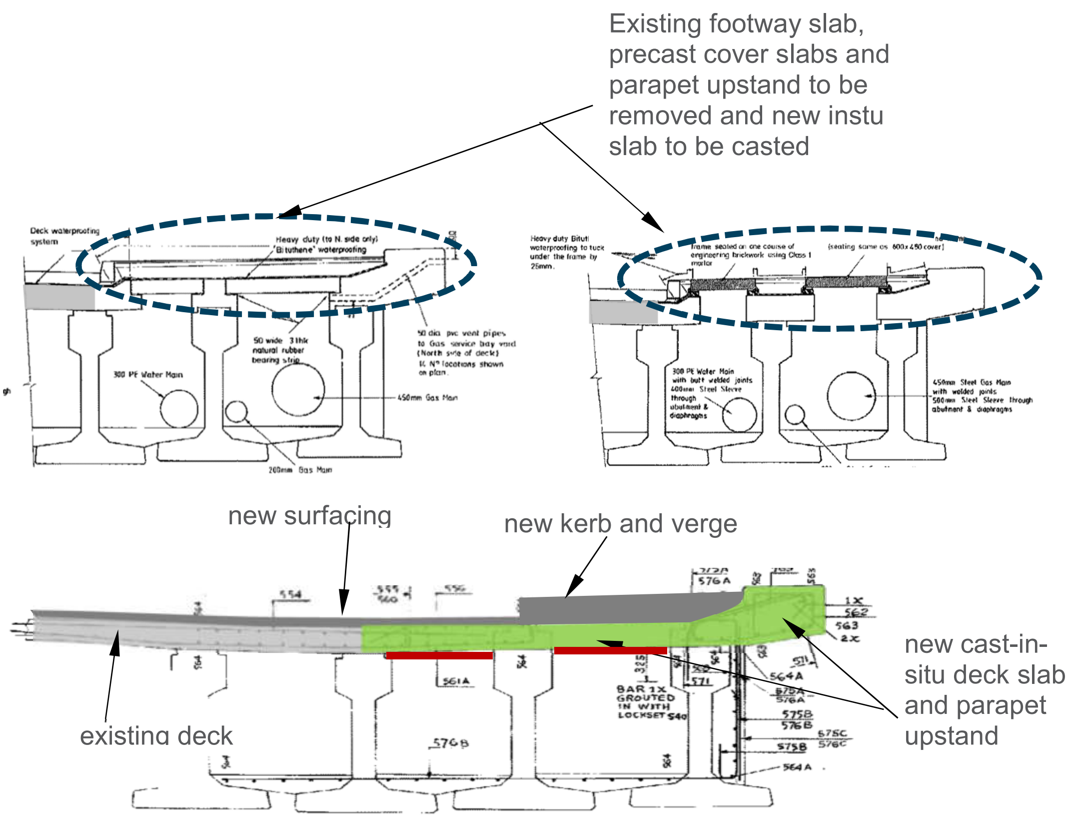


Figure 21 – Proposed deck stitching using cast-in-situ concrete (Option 1)

Option – 2 is to replace the existing cover slab and parapet upstand beam using precast concrete units and form in-situ stitches with the existing slab. as shown in Figure 21 17 and Figure 23

The below steps shall be followed to strengthen the slab

- Install traffic management to create working area
- Erect temporary edge protection
- Divert gas mains
- Remove existing parapet.
- Remove the concrete cover slab, footway deck slab and parapet upstand
- Clean the existing steel bars.
- Install the precast units
- Lap the new bars with the existing bars.
- Pour concrete to stitch the existing and new deck

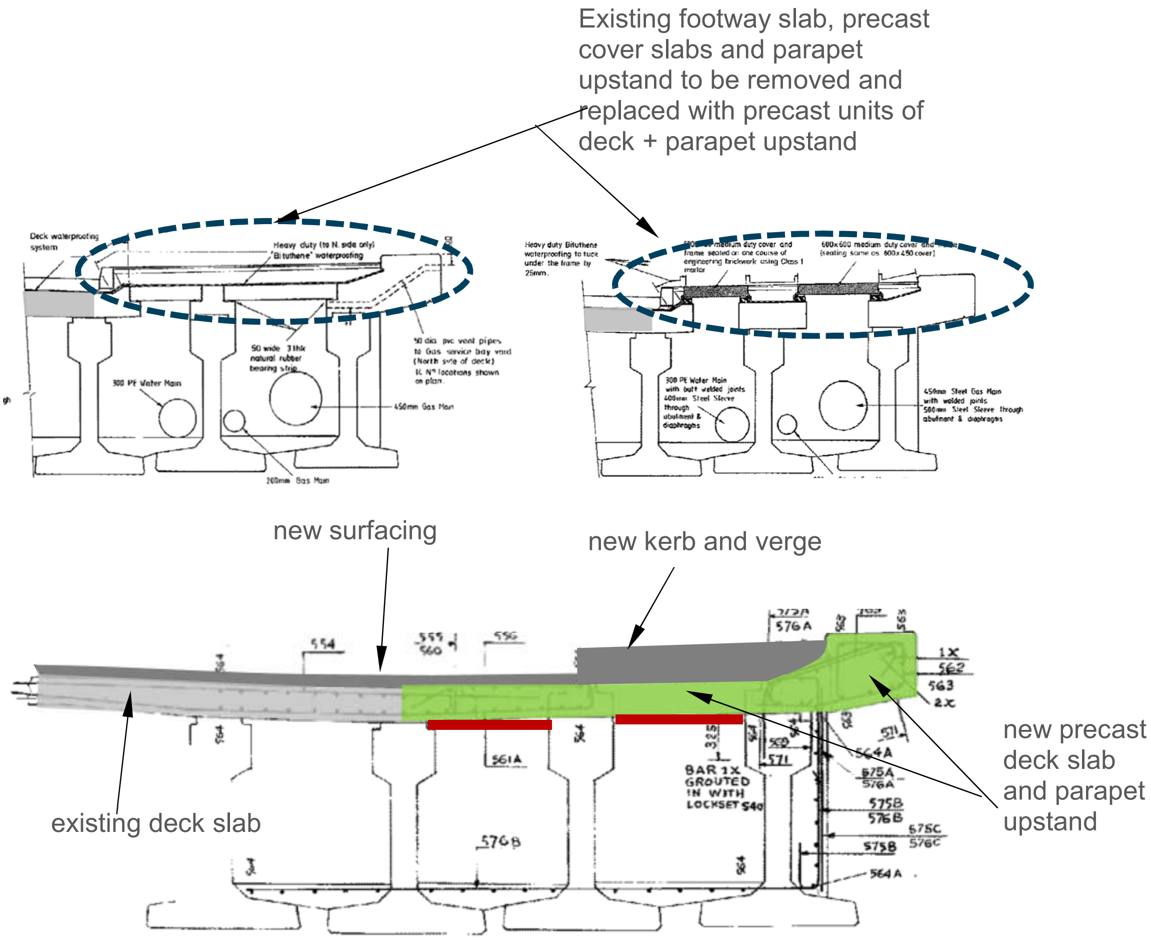


Figure 22 – Proposed deck stitching using precast units of deck + parapet upstand (Option 2)

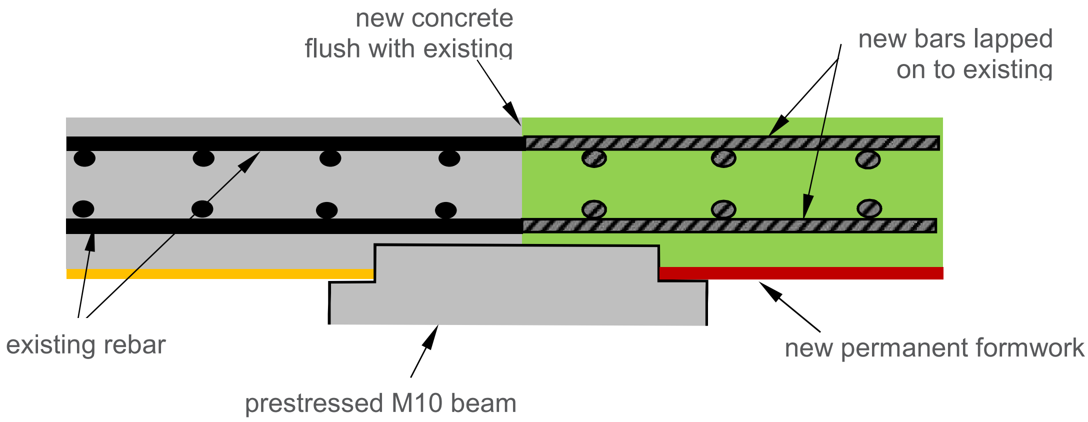


Figure 23 - Proposed deck stitching details (Option 1 and Option 2)

6. Cost Review

The analysis undertaken has identified the need for intrusive strengthening works to accommodate widening of the carriageway. Consequently, structural works are required beyond minor civils works. This will require traffic management and temporary access requirements from the M3 motorway, which will attract significant costs. As such overall scheme costs are likely to be driven by these aspects rather than predominantly structural works.

Consequently, it is extremely difficult to accurate develop an itemised cost estimate at this time. It is recommended that a detailed option development exercise is undertaken to quantify the works, traffic management, access and utility diversion requirements needed to facilitate this strengthening at the next stage of design.

However, at this early design stage and consistent with the local plan feasibility design work, it is anticipated the removal of the service troughs and subsequent strengthening of the deck to have an associated cost in the region of £500,000 to £1,000,000, excluding service diversions. It is recommended that the design proposal be developed to allow a more accurate cost review at the next stage of design.

7. Conclusions

Very similar findings have been noticed from this assessment in both the bridges and the conclusions of the assessment are summarised as follows.

7.1. Hocombe Bridge

With mild steel reinforcement (yield strength of 230MPa)

- The carriageway transverse slab, pier and parapet upstand – Pass both at ULS and SLS for all assessment loads.

- The prestressed beams pass at ULS and fail in SLS stress check. Would need further investigation on the allowance of live load for serviceability criteria.

- Diaphragm fails for the 40 tonnes ALL.

With high yield reinforcement (yield strength of 460MPa)

- Diaphragm passes for the 40 tonnes ALL

- The precast service cover slabs fail for 40 tonnes ALL

7.2. Pitmore Bridge

With mild steel reinforcement (yield strength of 230MPa)

- The carriageway transverse slab, pier and parapet upstand – Pass both at ULS and SLS for all assessment loads.

- The prestressed beams pass at ULS and fail in SLS stress check. Would need further investigation on the allowance of live load for serviceability criteria.

- Diaphragm fails for the 40 tonnes ALL.

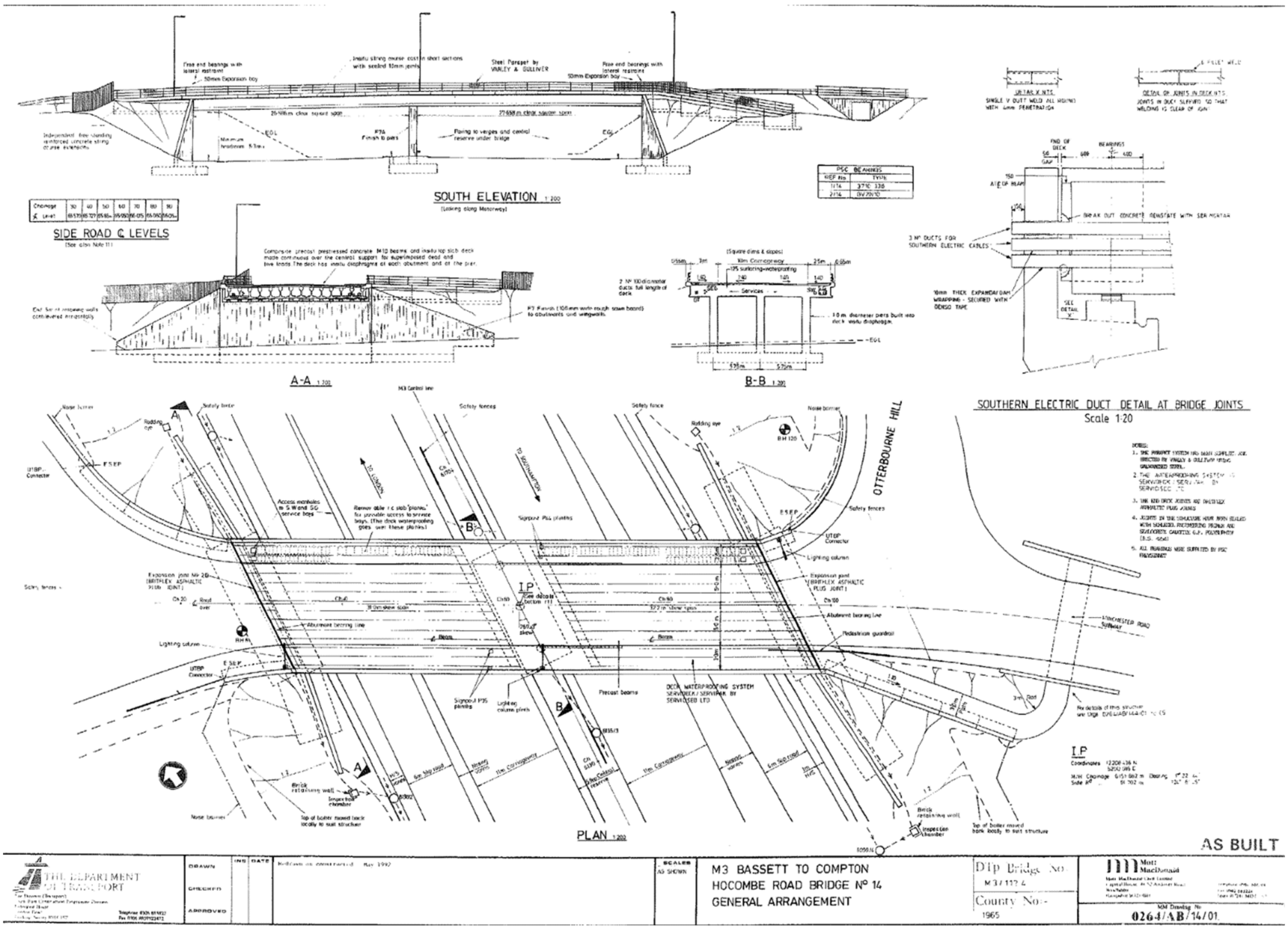
With high yield reinforcement (yield strength of 460MPa)

- Diaphragm passes for the 40 tonnes ALL

Appendices

Appendix A. General Arrangement Drawings

A.1. Hocombe Road Bridge



A.2. Pitmore Copse Bridge