



Army and Navy Flyover ECC Bridge No. 1000

Interim Measures

28th August, 2019

Document Control Sheet

Document prepared by: [REDACTED]

Structures

T [REDACTED]

Floor 2, Seax House,

E [REDACTED]@essexhighways.org

Victoria Road South,

W www.essex.gov.uk/highways

www.essex.gov.uk/enquiries

Chelmsford,

Essex

CM1 1QH

| Issue | Status | Author | Date | Check | Date | Review | Date |
|-------|--------|------------|---------|------------|---------|------------|---------|
| 01 | Final | [REDACTED] | 20/8/19 | [REDACTED] | 21/8/19 | [REDACTED] | 22/8/19 |
| | | | | | | | |

Table of revisions

| | | | |
|---------------------------|---------|--|---------|
| Original Version Produced | 20/8/19 | | Issue 1 |
| Reviewed | 27/8/19 | | Issue 2 |
| Published | 28/8/19 | | Issue 3 |

Distribution

| Organisation | Contact | Number of Copies |
|----------------|-------------|------------------|
| Essex Highways | Simon Butt | Electronic |
| Essex Highways | Andrew Cook | Electronic |

Contents

| | |
|--|---------------|
| 1. Executive Summary | 3 |
| 2. Introduction..... | 4 |
| 3. What has happened? | 5 |
| 3.1 September to October 2018 - Thermal..... | 5 |
| 3.2 July 2019 - Thermal..... | 5 |
| 3.3 Historic issues | 6 |
| 4. What next? | 7 |
| 4.1 Option 1 – Flyover remains closed until such time as the wider Chelmsford transport strategy determines the future solution for the junction. | 7 |
| 4.2 Option 2 – Immediate fixing of thermal related defects to enable reopening of the flyover | 9 |
| 4.3 Option 3 – Replacement of bearings and deck ends to address root cause of issue plus major maintenance | 13 |
| 4.4 Option 4 – 2018 Option Study, Deck replacement..... | 16 |
| 4.5 Wider Chelmsford Strategy for the Army and Navy Junction..... | 18 |
| 5. Discussion | 20 |
| Appendix A – Record Drawing | 23 |

1. Executive Summary

Over the last 12 months the Army and Navy Flyover has exhibited movement within its supporting columns. This has been caused by lengthening of the structure during the high temperatures of July/August in 2018 and more recently in July 2019. The flyover was closed due to these movements on 25 July this year and currently remains closed.

As in 2018, the recent damage caused by the lengthening of the structure is limited to the columns within the roundabout. Small upward movement of the northern columns has been noted at supports six and seven and shearing of the holding down bolts to the northern column at eight has led to it moving approximately 30mm south, measured at the base plate.

The flyover cannot be reopened until the movement issues are addressed, however such a limited repair will not deal with the underlying root cause.

This report has been prepared to outline potential options in the short and longer term. The following options have been considered;

- ◆ Option 1A Flyover remains closed until such time as the wider Chelmsford transport strategy determine the need for a flyover or other solution
- ◆ Option 1B Flyover remains closed. Flyover removed.
- ◆ Option 2A Initial fixing of defects to enable reopening of flyover
- ◆ Option 2B Initial fixing of defects to enable reopening of flyover with HD replacement.
- ◆ Option 3 Replacement of bearings and deck ends to address root cause of issue, plus major maintenance.
- ◆ Option 4 2018 Option Study, Deck replacement

The report discusses the costs, programme and traffic management requirements of the options and in the discussion section outlines the pros and cons that have been considered. Options that fall short of major refurbishment (option 3) or the deck replacement of option four leave no confidence that use of the structure can continue uninterrupted during seasonal high temperatures.

Ongoing work on the wider Chelmsford Strategy for the Army and Navy Junction may lead to a decision to take down the flyover. The strategic outline business case is expected to be issued to the DfT in January 2020 at which point the future of the Army and Junction will be clearer.

2. Introduction

The Army and Navy Flyover is 15 span steel concrete composite structure on steel supporting trestles located on the approach and above the Army and Navy roundabout in Chelmsford. The structure, which was a new construction in 1978 has in recent years exhibited large movements related to thermal effects which required intervention in 2018 and most recently in July 2019.

The structure remains closed following the issues identified in July which are outlined in the following paragraphs.

The paragraphs below in italics provide a more detailed description of the structure.

The Army and Navy Flyover carries a single 3.10 metre wide carriageway over the Army and Navy roundabout at the junction of the A414 and A138. It operates on a tidal basis under traffic signal control with traffic running from east to west in the mornings and from west to east in the afternoons. The speed limit on the bridge is 20 miles per hour. Traffic over the bridge is restricted to light traffic and maintenance vehicles. The structure is curved in both horizontal and vertical planes.

The flyover comprises fifteen spans which are simply supported and vary from 11.03 metres to 20.46 metres in length. Each span consists of a reinforced concrete deck slab supported by regularly spaced steel cross beams and two longitudinal steel beams. The reinforced concrete deck slab acts compositely with the steel beams which are supported by cast iron bearings with a downstand plate at the beam ends sitting in a groove in the bearing.

The deck is supported by steel portal frame trestles consisting of a cross beam and two columns. Lateral stability of the structure is provided at each trestle by the cross beam with stiffened haunches that ensure portal frame action. Longitudinal stability of the structure is provided by additional framing that links four columns beneath spans D5 and D11 (see Appendix A).

The flyover was originally designed in 1977 for a loading of 20% HA load or a 9.9 tonne gritting lorry with a 1.5 tonne trailer. The structure was built in 1978 and was originally intended as a temporary solution to improve the traffic situation at this busy junction.

For the purposes of this report, the bridge spans are numbered D1 to D15 from west to east as shown in Appendix A. Trestles are numbered T1 to T14, T1 being the first trestle in from the western abutment.

3. What has happened?

The structure is in a poor condition with a history of maintenance work to steel and concrete elements. However there have been two confirmed temperature related issues with the structure in recent years.

3.1 September to October 2018 - Thermal

In September 2018 movement of the northern column at trestle seven was brought to our attention on social media. This was confirmed to be the case by engineers and movement was also identified at the northern column to trestle six. The flyover was closed to traffic at this point and measures were put in place to support the structure whilst an investigation took place to understand the root cause. Various on site investigations complemented by desk based analysis determined that the cause of the movement was from thermal effects during high summer temperatures which peaked at 34.1°C.

The issues were exacerbated by deterioration of the structures bearings which had become fixed longitudinally due to corrosion and hidden defects. The holding down bolts to the trestles six and seven had deteriorated due to water ingress and corrosion within the grout plinths beneath the base plates to the point that at failure (northern column to trestle seven) there was little section remaining to resist shear from lateral movement of the sub structure.

The defects were addressed during an emergency intervention, during which the trestles to six and seven were propped and base upstands broken out and reconstructed complete with new holding down bolts. Existing reinforcement was maintained. Elsewhere corrosion severed holding down bolts to the southern column of trestle two and to the northern columns of trestle nine and 12 were also replaced. No work was undertaken to address the problems at the bearings.

3.2 July 2019 - Thermal

Following the issues outlined above temperature and location remote monitoring equipment was introduced onto the structure in March 2019. Over the course of the months, the monitoring equipment indicated gradually increasing movement of the structure as ambient temperatures increased. The movement, which is in a southerly direction caused by the gradual lengthening of the deck of the structure as the material temperature increase. During a particularly hot spell in July temperatures peaked at 37.9°C on the 25 July 2019. Following review of the forecast and the monitoring readings a decision was taken to complement the remote monitoring by visits to the structure to inspect the areas susceptible to defects from the lengthening of the deck. During the second of these visits on 25 July 2019, upward movement of the baseplate *and* supporting grout was identified at the northern columns of trestles six and seven. The structure was closed immediately to traffic at this point through Essex Highways changing the signing to closed on both approaches, however as the inspection progressed a loud metallic noise was heard and movement of the northern column at trestle eight was identified. Movement on site was measured to be 35mm. Upward movement of the northern columns to trestle six and seven was found to be up to 3mm. Since 25 July it has become apparent that the position vertically fluctuates depending on

the temperature. In addition, cracks measuring 0.15mm were found to have opened within the concrete upstands constructed in 2018.

3.3 Historic issues

Besides the thermal movement issue of 2018, an intervention took place in 2016 to address the movement of the bearings to the western abutment. The work required at that time was the temporary support of the main beams above the bearings and replacement of the bearings. It was not confirmed at the time but it is considered likely that this was an issue with thermal movement.

Elsewhere the structure has a history of corrosion defects to the bearings and downstand beam elements which sit within the bearings and metal elements elsewhere. Thrust pads to the beam ends and deck ends to the abutments are also in a poor condition with evident over compression.

The concrete deck is in a poor condition to the deck edges, where there is a long history of concrete repair. The deck was originally intended to be unsurfaced, presumably as it was intended for temporary use only.

4. What next?

The following options are provided as potential next steps and seek to provide options for keeping the flyover closed, providing an initial non permanent fix, a permanent refurbishment fix and a re-decking which was the preferred option from an option study completed in 2018 prior to the movement issues becoming apparent in September 2018.

4.1 Option 1 – Flyover remains closed until such time as the wider Chelmsford transport strategy determines the future solution for the junction.

Option 1A

Work should be undertaken to understand the cost of the closure of the flyover on the economy of Chelmsford and wider Essex. The cost of maintaining the closure of the flyover is minimal, cost of traffic management only with weekly visits by engineers to inspect the existing movement related defects at trestles six, seven and eight. During this period the remote monitoring (temperature and location) will continue along with an enhanced inspection regime. It is likely that there may be a need for periodic maintenance during the period. This option does not consider the removal of the flyover.

Requirement for Traffic management

Continuation of current traffic management arrangements with no further impact on surrounding network.

Programme

Immediate

Cost

Negligible

Option 1B

In addition to the items under 1A, design work should be undertaken to demolish the flyover and remove for recycling. A means of undertaking this work will need to be considered in detail during the design phase, the work lending itself to an Early Contractor Involvement approach to delivery. The following measures are considered necessary:

- a) Set up off network compound and working area near site
- b) Instigate night time lane closures alongside flyover
- c) Remove parapet and rails for recycling
- d) Instigate night time full closure to remove spans

- e) Remove end span (one or 15) in night one to compound for demolition and eventual recycling off site.
- f) Continuing from starting point, remove individual spans every few days thereafter – depending on progress with demolition
- g) Remove trestles to compound for cutting up and eventual recycling off site
- h) Remove gantries and terminate electrical supply
- i) Demolish approach ramps and construct island in their place, consider use of lining in place of island.
- j) Demobilise and clear site

Requirement for Traffic management

Initially night time lane closures would be required alongside the flyover for the removal of the parapets. Following removal the bridge spans would need to be lifted out and transported to the compound area, this would require full night time closure of the roads alongside the working area. It is considered that traffic lanes could be opened without restriction during the days.

Programme

This option requires a moderate amount of design work to consider the best means of demolishing the asset and identifying areas for the compound. It is considered the best approach to take the spans down in one complete section to avoid noisy and dusty operations within the structure area. Removal of these sections would constitute an abnormal load movement by virtue of their length, weight and width. The process would be subject to abnormal load notification and there may be a need to review the route to the compound and the structures that exist along it.

The following outline programme is anticipated;

| Activity | Duration | Detail |
|----------------------------------|----------|--|
| a) Design and ECI Contract Stage | 6 weeks | Procurement of ECI contract Preparation of demolition sequence and contractor documents and drawings. Identification of compound areas and land licencing, if required. Stakeholder liaison, agreement of timing of work. |
| b) Tender and tender review | 4 weeks | Tenders may not be required due to ECI approach. |

| Activity | Duration | Detail |
|---|----------|---|
| c) Mobilisation | 4 Weeks | |
| d) Set up compound | 1 Week | Constructing access, setting up welfare, breaking area of decks and material storage areas. |
| e) Remove parapets | 1 Week | Night time lane closures |
| f) Remove consecutive spans | 7 Weeks | Assume two per week, with concurrent removal of trestles |
| g) Remove gantries and above ground level foundations | 1 Week | |
| h) Construct islands | 2 weeks | Night time lane closures |
| i) Clear site and demobilise compound | 1 Week | |
| Option A Total Duration | 27 Weeks | |

Given the advantages of ECI, certain durations may be reduced, mobilisation for instance. Assuming a decision were taken to continue this option by the 30 August 2019, work could begin during December and would be complete by the end of February.

Cost

Cost estimates have not been prepared for the demolition of the structure. It is anticipated that the demolition work would take 13 weeks and cost in the region of 380k.

4.2 Option 2 – Immediate fixing of thermal related defects to enable reopening of the flyover

Option 2A

In order to reopen the flyover the defects related to the July movement should be corrected. However this is acknowledged to be a temporary fix as the root cause will not be addressed. When temperatures rise in the future i.e. summer 2020, the structure will once again be expected to lengthen and behaviour of the bases will again be uncertain leading to unpredicted closures.

The following measures are considered necessary

- a) Introduce propping to trestles six, seven and eight
- b) Release bolts and break out upstands to north plinths to trestles six, seven and eight.

- c) Design and reconstruct new upstands, including new reinforcement.
- d) Bolt down columns in at rest locations
- e) Repeat steps b – d above for southern columns
- f) Remove propping
- g) Reopen flyover.
- h) Backfill
- i) Clear site

Option 2B

Investigation work undertaken in 2018 determined a condition rating for the majority of holding down bolts. Whilst seven bolts were replaced, some were not exposed and did not therefore receive rating due to obstruction by street furniture, cable trays or in the case of bases where there were four holding down bolts just two received investigation. In total 53 bolts received a rating, the following ratings were awarded;

| Rating | Description | Count | % |
|--------|--------------------------|-------|----|
| 0 | Unclassified | 0 | 0 |
| 1 | Clean | 7 | 13 |
| 2 | Slight surface corrosion | 14 | 23 |
| 3 | Severe surface corrosion | 34 | 53 |
| 4 | Fractured | 6 | 11 |

Replacing the bolts that were awarded the rating of three would offer greater confidence of the structure resisting movement at the bases, however, ignoring the rated three bolts at the northern column to trestle eight which have failed, those affected are not currently exhibiting any visible defect and replacement may well be unnecessary. Replacement of these would add a considerable increase to the programme with associated costs. Considered below as an Option 2.A.

The following measures would be required to replace the 32 bolts rated three;

- a) Core out base plate to enable smaller diameter core to remove existing holding down bolt
- b) Core out holding down bolt
- c) Drill down through foundation slab to depth (approx. 900mm from surface)

- d) Resin fix replacement holding down bolt
- e) Pull test
- f) Tighten down and grout up base plate
- g) Final tighten

Requirement for Traffic management

The majority of this work can be undertaken without carriageway incursion. Erection of temporary propping to trestle six would however require inner ring closure on the Army and Navy roundabout with restrictions on approaching lanes. This would be a night time activity.

Programme

Work could start within a matter of weeks, although this assumes availability of sub-contract resource. It would be intended to go direct to specific suppliers; Mabey Hire for the propping and Topbond PLC for remaining work. The use of these suppliers is based on their use during the intervention in September 2018 and the experience that was gained then.

The following outline programme is anticipated;

| Activity | Duration | Detail |
|--|----------------------------|--|
| a) Mobilisation, Base design and analysis of superstructure. | 8 Weeks | |
| b) Propping | 1 Week | |
| c) Works to northern upstands | 1 Week 1 Week 1 Week | break out upstands fix steel and shutters and pour concrete cure and remove shutters and bolt down columns and pour grout to underside of column base plates |
| d) Works to southern upstands | 1 Week 1 Week 1 Week | break out upstands fix steel and shutters and pour concrete cure and remove shutters and bolt down columns and pour grout to underside of column base plates |
| e) Remove propping | 2 Days | |
| f) Reopen Flyover | 1 Day | |

Interim Measures

| Activity | Duration | Detail |
|----------------------------------|----------|--|
| g) Backfill | 2 Days | |
| h) Clear site | 1 Week | |
| Option A Total Duration | 17 Weeks | |
| Option B | | |
| i) Holding down bolt replacement | 4 Weeks | Assume two crews working, 1 bolt per day. With pull testing done in final week. 4 weeks. |
| Option A and B Total Duration | 21 Weeks | |

During the course of this programme it is likely that other work will be undertaken as had been planned during the later summer this year, maintenance work to the flyover in the form of steel repairs, some minor concrete repairs and bearing investigation. In addition, the flyover will be given a General Inspection (one is currently due) and any work required to the top in order to reopen it will also be done (removal of leaves and any debris that has gathered during the closure.).

Assuming a decision were taken to continue this option by the 30 August 2019, work could begin by November and would then be complete by mid-January 2020 for option A and mid-February for option B. The mobilisation and design period would be used to prepare specifications and designs for the repair work, including new reinforcement design for the bases at trestles six, seven and eight. In addition, analysis of the deck would be undertaken to determine the effect of the corrosion at the bearings and inability to accommodate movement on other structural elements. Due to the short timescales leading into the work, quotations for the work by the contractor would follow as the work progresses.

Cost

The prices below have been built from a mixture of 'order of cost' estimates from supply chain partners and from known costs for the work from September to October 2018, which is similar in scope to that outlined above.

| Activity | Estimated Cost |
|-----------------------|---|
| a) Preliminaries | 25,000 |
| b) Traffic Management | 5,000 (assumes 3 nights of lane 2 roundabout closure) |
| c) Propping | 55,000 |

| Activity | Estimated Cost |
|--|----------------|
| d) Breaking out and reconstruction of upstands | 37,500 |
| e) Pull testing of holding down bolts | 2,000 |
| f) Backfill | 1,000 |
| g) Misc (sweeping of flyover, etc.) | 1,000 |
| Sub-Total | 126,500 |
| Contingency and Staff costs 20% | 25,300 |
| Option A Total | 151,800 |
| | |
| Option A Sub Total | 126,500 |
| h) Holding down bolt replacement | 113,763 |
| Option A and B Sub-Total | 240,263 |
| Contingency and Staff costs 20% | 48,052 |
| Option A and B Total | 288,315 |

4.3 Option 3 – Replacement of bearings and deck ends to address root cause of issue plus major maintenance

Option

Should options in 3.1 or 3.2 above not meet client requirement the option of refurbishment should be considered. The refurbishment option in the paragraphs below would solve the movement issue and prevent this issue arising again. However it would not prevent other issues within the structure from causing the need for unplanned closure. ECC have previously indicated that 10 years should be considered when arriving at maintenance options for the flyover, the maintenance work within Additional Work below is required to meet that target.

The options above do not tackle the root cause of the movement issues that are affecting the flyover, these stem from the structures' inability to accommodate elongation caused by peak temperatures. To address these issues it is believed that the bearing arrangement will need to be refurbished and possibly replaced/ to accommodate

these movements. In addition, thrust pads which are present at the beam ends and abutments which are in poor condition should be renewed.

The means of undertaking this work has not been established, however it is likely to require the lifting in place of each span in position in order to remove the bearings and undertake steel repairs to the end plates which sit within the bearing. On a worst case scenario basis it may prove necessary to cut the deteriorated sections of these plate from the beams and weld new in place. Depending on the temperature at the time of the work, there may be a need to brace trestles to prevent movement once the spans are jacked up or perhaps loosen their bolts in order to provide some flexibility to drop the deck back into position. A means of undertaking this work will need to be considered in detail during the design phase, the work lending itself to an Early Contractor Involvement approach to delivery.

This year it had been intended to investigate the bearings and determine the possibility of clearing out the corrosion product with the beams in place. It is considered unlikely that this would be possible but should be ruled out.

Additional Work

The structure has significant issues to other elements of the bridge which should be addressed during this intervention to prevent need for unplanned closure of the structure in the future. The prime areas of concern are:

| Element | Condition and Work required |
|-------------------------|---|
| Beams | Currently superficial corrosion defects to primary deck elements (beams) (not downstand elements, which are in poor condition and included in above Option section) – Maintenance painting required |
| Deck | Poor condition to deck edges, otherwise in good condition. Extensive concrete repairs required. In addition, sacrificial anode cathodic protection system should be considered to prevent future deterioration due to high percentage chloride content. |
| Columns | Holding down arrangement should be improved, grout plinths beneath should be replaced. (This was scored under element 14 Bearing shelf within the recent independent PI). |
| Crosshead | Currently superficial corrosion defects to areas surrounding bearings. Maintenance painting required. |
| Superstructure drainage | Drainage system should be renewed. |
| Waterproofing | No waterproofing system in place. Timber kerbs should be lifted and deck edges at least should receive waterproofing. |
| Movement joints | Movement joints are all compressed and allow water to leak onto the bearings. Joints should be replaced throughout the structure. |

| Element | Condition and Work required |
|----------|--|
| Parapets | Parapets exhibit severe corrosion. Maintenance painting should be undertaken to every parapet post. Repair of posts or perhaps replacement should be expected. |
| Kerbs | Sleeper kerbs should be replaced with concrete kerbs. |

Requirement for Traffic management

The work would likely require 24/7 closure of the lanes either side of the flyover for a protracted period, if not the entire construction programme. Scaffold access would need to be installed complete with debris netting and shielding to protect members of the public and work force alike. Issues with getting access to the elevations and bearing areas would preclude maintaining running lanes adjacent to the flyover.

Programme

This option requires a large amount of design work to consider the best means of delivering the end result. Structures like the Army and Navy are becoming fairly unusual with little experience to hand in their major refurbishment. Design for this work could start fairly soon, however the programme for the design is likely to run into months before an ECI contract could be prepared following which the work pack would be developed collaboratively.

The following outline programme can be expected;

| Activity | Duration | Detail |
|---|---------------|---|
| a) Initial Design | 8 – 12 weeks | Preparation of design brief to determine what success looks like and agree order of cost of option for consideration. Preparation of tender information for ECI contract. Testing work as required to inform design. |
| b) ECI Contract Tender Period and Award | 6 weeks | |
| c) Design Period | 12 - 16 weeks | This period will be used to progress the design and method of the refurbishment. Any further investigations that may be necessary will be undertaken. Suppliers of special components such as bearings, thrust pads and fabricators of steel products (non standard parapets) if required will be contacted and arrangements begun. Period also used to get specialist sub-contractors on board for welding and installation of bearings and thrust pads etc. |

| Activity | Duration | Detail |
|-------------------|--|---|
| | | Booking of road space and stakeholder engagement would also take place. |
| d) Mobilisation | 16 weeks | Purchase of long lead in items. Construction of bespoke lifting/jacking frames for the deck. |
| e) Works | 39 weeks | Assumes 7 weeks to reconstruct the bases at 6, 7 and 8 and 30 weeks for the remainder, working on one spans at any one point with each span taking two weeks to undertake steel repairs, concrete repairs. Cathodic protection to lag behind the refurbishment aiming to finish one week after the final span has been refurbished. |
| f) Reopen Flyover | Work continues with at night lane closures if required | |
| Total Duration | 89 Weeks | |

Cost

Efforts have not been made to consider the cost of implementing this option. However a refurbishment option was considered during the 2018 option study which was completed prior to the movement issues becoming apparent. This option was similar to the option above, however did not address the downstand elements of the end plates of the main beams which would be refurbished in the option above.

The cost of the option from the option study was £665k with a programme of 14 weeks. It is considered that by adding the requirement of refurbishment of the beam ends which is required to solve the issue of the thermal movement and improving the holding down arrangement at the bases which was also not included, the overall cost of this option would be in excess of 1 million pounds with a range of 1.5 to 1.8 million considered at this stage.

4.4 Option 4 – 2018 Option Study, Deck replacement

Option

The 2018 option study recommended the complete replacement of the existing deck on a like for like basis. The report concluded that this would maintain the existing horizontal alignment/footprint of the asset which proved difficult to do with other replacement options.

The option concluded that the new deck units could be constructed off site and lifted in to the existing bearings one at a time. Parapets would be removed from the existing structure, refurbished and installed on the new structure. This method of construction, apparently identical to that when the flyover was introduced, was considered to offer the shortest time frame for construction, estimated at 10 weeks.

The capital cost of undertaking this work was estimated £999,000 and the study felt that the option would be relatively maintenance free over the target 25 year period which had been set for the study.

Requirement for Traffic management

The option report considered that there would be a need for night time full closure of the road and roundabout to deliver this option. Lanes would be re-opened during day light hours.

Programme

The option study did not discuss the length of time required to design this option, considering construction duration of 10 weeks only. On balance the 10 week considered is not adequate to remove the old deck, prepare the bearing arrangement, refurbish substructure and lift in the new spans. In addition it did not consider defects which have recently come to light at trestles six, seven and eight. It is considered that similar to option 3.2 above an ECI contract approach may offer best certainty of delivery. The following table considers the different stages that would be required and their duration.

It is considered the best approach to take the spans down in one complete section to avoid noisy and dusty operations within the structure area. Removal of these sections would constitute an abnormal load movement by virtue of their length, weight and width. The process would be subject to abnormal load notification and there may be a need to review the route to the compound and the structures that exist along it.

| Activity | Duration | Detail |
|---|---------------|--|
| g) Initial Design | 8 – 12 weeks | Preparation of design brief to determine what success looks like and agree order of cost of option for consideration. Preparation of tender information for ECI contract. |
| h) ECI Contract Tender Period and Award | 6 weeks | |
| i) Design Period | 16 - 20 weeks | This period will be used to progress the design and method of construction. Any further investigations that may be necessary will be undertaken. Suppliers of special components such as bearings, thrust |

| Activity | Duration | Detail |
|---|----------|--|
| | | pads will be contacted and arrangements begun. Period also used to get specialist sub-contractors on board for welding, steel work repair and refurbishment to parapets and installation of bearings and thrust pads etc. Booking of road space and stakeholder engagement would also take place. |
| j) Mobilisation – suggest this will be longer | 16 weeks | Purchase of long lead in items. Construction of bespoke lifting/jacking frames for the deck. |
| k) Works – this will be longer, night time working. Noisy work, consideration of the needs of adjacent residents and businesses (hotel) | 38 weeks | Assumes seven weeks to reconstruct the bases at six, seven and eight. Assumes working on one at a time with each span taking two weeks to lift out the old span, prepare the bearing arrangement and lift the new into position. Parapets would be installed once all spans in place, this would take one week. Breaking up of the old deck spans would continue off site in compound area. |
| l) Reopen Flyover | | |
| Total Duration | 92 Weeks | |

Cost

The option study estimated that the basic re decking option would cost 999k. However this did not address defects that have since come to light. It is considered that the additional cost of repairing the bases at six, seven and eight and addressing holding down bolts with severity three rating elsewhere, the cost would increase to a range of £1.3 to £1.6 million range.

4.5 Wider Chelmsford Strategy for the Army and Navy Junction

Essex Highways' Transport Planning team are leading on options to address congestion at the Army and Navy junction and wider Chelmsford area. Conclusions drawn thus far include the need for a modal shift from single

occupancy car journeys and options under consideration include upgrade of junction (hamburger), replacement flyover and complete removal of the flyover amongst others.

The following paragraph has been provided by the team leading the project;

“Alongside the structural issues with the flyover, the Army and Navy junction is subjected to high levels of congestion given that it sees 60,000 vehicles per day using the interchange and with 10,000 of these vehicles using the tidal flyover. As a result of these significant issues and given the importance of the interchange in serving the City of Chelmsford with infrastructure required to be able to cope with future levels of growth at the Army and Navy, a special Taskforce Panel has been established which has a vision for ‘a long-term solution for the Army and Navy Roundabout which leads to improved traffic and increased people throughput in the area in the future’. The project looking at long term options for the flyover is currently working through the DfT appraisal process for a Strategic Outline Business Case (SOBC). Following identification of the problems, a long list of options was developed, which has been sifted to a shorter list of 8 broad options which are being assessed in more detail. It is expected that a SOBC will be submitted to DfT in January 2020 with an Outline Business Case following in Spring 2021. Subject to funding, land, utilities and planning it is then expected that a Final Business Case and construction could commence in 2023.”

5. Discussion

This report has been prepared to aid decision making at the junction for both short and medium term scenarios.

It is difficult to choose between the options with the work under ref 3.5 being relatively early in its programme. Given the likelihood of a recurrence of the movement issues in future hot weather option 2A or 2B can only be considered a temporary fix and Essex Highways would perhaps find itself in the position of having to instigate precautionary closures of the flyover once temperatures rise, June to August 2020^{*1}. The defects that have become apparent during September 2018 and July 2019 have occurred following local temperatures of approximately 34°C and 38°C. On this basis, closing the flyover and undertaking close inspections should be instigated once temperatures exceed 32°C. This would mean an opening period of perhaps 5 months if the durations within this report prove accurate.

Given the length of closure of options three and four and their high cost, a decision to adopt either with an opening date perhaps being within of 2021, is difficult to take should the work under option five lead to a decision to take the flyover down within a year or two.

It is considered that should option three or four be progressed the flyover will remain closed until such time as either 2A or 2B have been completed. Both three and four rely on at least the work in 2A being complete.

Options 2A, 2B, three and four are compromised by re-use of the existing structure supports and foundations. Even with the installation of new holding down bolts, the life of the asset must be considered limited.

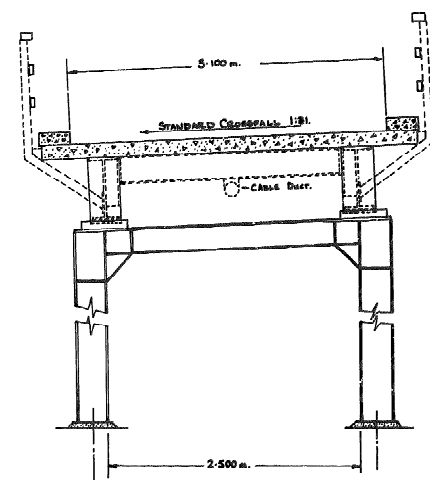
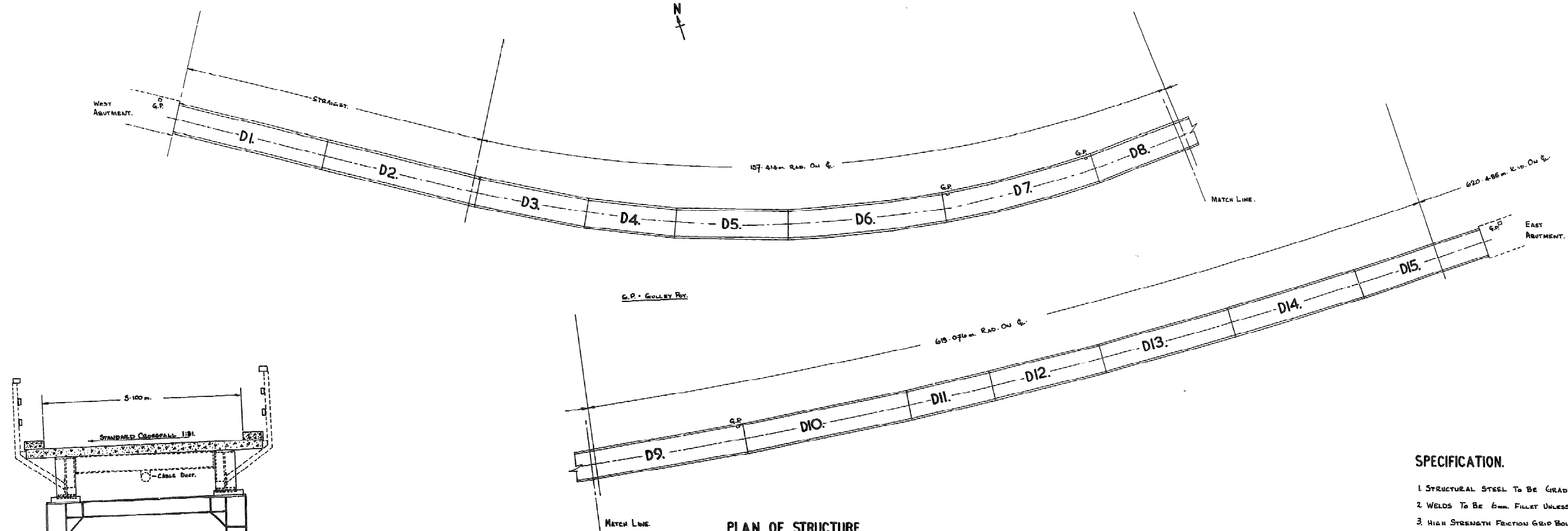
The table below considers durations, cost and the pros and cons of the options included within this report.

^{*1} A review of temperatures at Chelmer Village weather station (<http://www.chelmer-village-weather.co.uk/wxtempdetail.php>) reveals that peak year temperatures have occurred during June, July and August since 2013.

| Option No. | Description | Programme (in weeks) | | Estimated Cost | Pros | Cons |
|------------|---|----------------------|---------------------|----------------|--|--|
| | | Construction | Total (Inc. Design) | | | |
| 1A | Flyover remains closed until such time as the wider Chelmsford transport strategy determine the future solution | Immediate | | Negligible | <ul style="list-style-type: none"> Limited cost Keeps fresh in people's mind to ensure funding | <ul style="list-style-type: none"> Disruption to travelling public Constant reminder to public of flyover being out of use Remains a maintenance and inspection liability Remains an unstable structure Does not solve congestion at junction Requires temporary traffic management to keep public away from structure supports within roundabout |
| 1B | Flyover remains closed. Flyover removed. | 13 | 27 | £380,000 | <ul style="list-style-type: none"> Limited costs, although more than 1A Removes maintenance and inspection liability Relatively short construction period Removal of the flyover will assist in future junction work May enhance vehicle movements in the area (remove uncertainty over exit/joining) Opportunity to increase capacity at junction. Would require design work Not a constant reminder so could lead to public accepting situation | <ul style="list-style-type: none"> Cannot be repaired once it is taken down Disruption whilst it comes down Does not solve congestion at junction Whilst this is costly to do, it is inevitable that it will need to be taken down in the years to come. |
| 2a | Initial fixing of defects to enable reopening of flyover | 9 | 17 | £151,800 | <ul style="list-style-type: none"> Quickest route to reopening the structure Relatively cheap measure | <ul style="list-style-type: none"> Very limited life, due to likely recurrence of issues leading to closure in summer 2020 Ongoing enhanced inspection costs Lack of confidence in structural resilience during high temperatures will lead to unplanned closures. Need for six to eight weeks of analysis to determine the effect of inability to accommodate movement on other structural elements. Does not solve congestion at junction |
| 2b | Initial fixing of defects to enable reopening of flyover with HD replacement. | 13 | 21 | £288,315 | <ul style="list-style-type: none"> Fairly quick route to reopening the structure Relatively cheap measure Offers greater confidence of structural resilience | <ul style="list-style-type: none"> Limited life, due to likely recurrence of issues leading to closure in summer 2020 Ongoing enhanced inspection costs Lack of confidence in structural resilience during high temperatures will lead to unplanned closures. Need for six to eight weeks of analysis to determine the effect on other structural elements. |

| Option No. | Description | Programme (in weeks) | | Estimated Cost | Pros | Cons |
|------------|---|----------------------|---------------------|----------------------|---|--|
| | | Construction | Total (Inc. Design) | | | |
| | | | | | | ♦ Does not solve congestion at junction |
| 3 | Replacement of bearings and deck ends to address root cause of issue, plus major maintenance. | 39 | 79 | £1.5 to £1.8 million | ♦ Offers 10 years plus of normal use without expectation of unplanned closure | ♦ Costly ♦ Long design programme ♦ Long site programme with extensive disruption requiring round clock lane closures ♦ Decision may be made to remove structure in near future years ♦ Does not solve congestion at junction ♦ Makes use of existing supports and the majority of the bridge deck |
| 4 | Deck replacement | 38 | 92 | £1.3 to £1.6 million | ♦ Offers 25 years plus of normal use without expectation of unplanned closure ♦ Reduced impact to the network over option 3 due to shop fabrication of bridge decks ♦ Does not require daytime impact on network | ♦ Costly ♦ Long design programme ♦ Long site programme with extensive night time disruption ♦ Decision may be made to remove structure in near future years ♦ Makes use of existing sub-structure |
| 5 | Wider Chelmsford Strategy for the Army and Navy Junction | | | | The pros and cons in this table should be evaluated against the programme and potential redundancy of the flyover once the wider strategy programme has been concluded. Construction from this is not likely before 2023. | |

Appendix A – Record Drawing

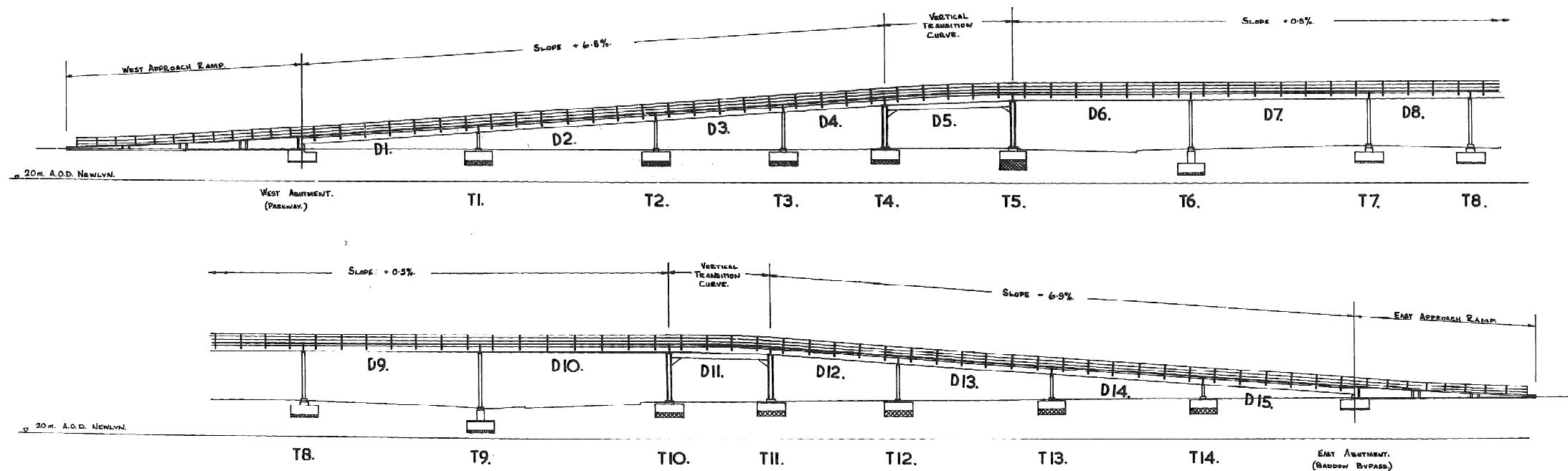


TYPICAL CROSS SECTION.

PLAN OF STRUCTURE.

SPECIFICATION.

- STRUCTURAL STEEL TO BE GRADE 43A. TO B.S. 4360 UNLESS NOTED.
- WELDS TO BE 6mm. FILLET UNLESS NOTED.
- HIGH STRENGTH FRICTION GRIP BOLTS TO BE GENERAL GRADE TO B.S. 4395 PREV.
- ALL BOLTS TO BE SHERALISED.
- PAINT SYSTEM.
SURFACE PREPARATION: BLAST CLEAN 1st QUALITY TO B.S. 4232.
SURFACE TREATMENT TYPE A:
1ST COAT: ZINC CHROMATE/RED OXIDE BLAST PRIMER. APPLIED AT WORKS.
2ND COAT: ZINC PHOSPHATE EPOXY ESTER UNDERCOAT. APPLIED AT WORKS.
3RD COAT: ZINC PHOSPHATE EPOXY ESTER UNDERCOAT. APPLIED AT WORKS.
SURFACE TREATMENT TYPE B:
4TH COAT: ZINC PHOSPHATE EPOXY ESTER TOUCH UP COAT APPLIED AT SITE.
5TH COAT: M10 UNDERCOAT NATURAL GREY APPLIED AT SITE.
6TH COAT: M10 FINISH DARK GREY. APPLIED AT SITE.
MINIMUM TOTAL DRY FILM THICKNESS: 200µm.
FAYING INTERFACES BETWEEN TRANSVERSE DECK BEAMS AND MAIN BEAMS, BETWEEN BEAMS AND COLUMNS IN LONGITUDINAL BRACED BAYS, AND ALL SURFACES IN CONTACT WITH CONCRETE TO BE LEFT UNPAINTED. ADJACENT SHOP PAINTING SHALL CONTINUE ON INTO SUCH AREAS HOWEVER BY 25mm. AROUND ALL EDGES.
- CONCRETE FOR DECK TO BE GRADE 30/20.
CEMENT - ORDINARY PORTLAND CEMENT.
MAXIMUM TOTAL WATER CEMENT RATIO TO BE 0.45.
MINIMUM CEMENT CONTENT TO BE 370 kg/m³.
WIRE BRUSH FINISH IN ACCORDANCE WITH CLAUSE 1618 OF THE SPECIFICATION.
- CONCRETE FOR FLYOVER PRECAST CONCRETE KEYS TO BE GRADE 30/10.
- REINFORCEMENT TO BE HOT ROLLED MILD STEEL TO B.S. 4449. BENDING TO BE IN ACCORDANCE WITH B.S. 4446.
- DECK UNITS ARE DESIGNED FOR DEAD LOADS TO BE CARRIED BY COMPOSITE ACTION. STALLAGES ON WHICH DECK STEELWORK IS ASSEMBLED TO BE APPROVED BY THE ENGINEER PRIOR TO CONCRETING.
- DECK UNITS SHALL BE CHECKED FOR DIMENSIONAL ACCURACY AFTER ASSEMBLY AND PRIOR TO CONCRETING. TOLERANCE ON DIAGONAL DIMENSIONS ON PLAN TO BE ±5mm. FROM THEORETICAL.
- FOR THE LIFTING OF ANY DECK UNIT THE CONCRETE IN ITS DECK SLAB MUST BE 14 DAYS OLD AND HAVE ACHIEVED ITS DESIGN STRENGTH OF 30N/mm².
- PERMITTED VARIATION IN WIDTH GAP BETWEEN END ANGLES AT ANY TRANSVERSE DECK JOINTS AFTER ERECTION 5mm. LIMITS ON SPECIFIED NOMINAL GAP WIDTH AT ANY POINT ±5mm.
- FITTING AND LAYING OF TRANSVERSE JOINT SEALS TO BE UNDERTAKEN BY SPECIALIST APPLICATORS.
- ERECTION OF DECK UNITS TO BE COMMENCED AT EITHER BRACED BAY, AND PROCEED TO ABUTMENTS.



SOUTH ELEVATION.

ESSEX COUNTY COUNCIL
HIGHWAYS DEPARTMENT

G. CARPENTER, C.Eng., F.I.C.E., F.I.Mun.E., F.Inst.H.E.,
COUNTY SURVEYOR,
GLOBE HQ. SE. NEW STREET, CHELMSFORD.
Telephone: Chelmsford 67131

SCALES:
1:200. 1:25.

| | INITIALS | DATE | REVISIONS |
|----------|----------|---------|-----------|
| SURVEYED | | | |
| LEVELLED | | | |
| DESIGNED | J.B. | 20/7/77 | |
| DRAWN | J.B. | 20/7/77 | |
| TRACED | | | |
| CHECKED | A.B. | 20/7/77 | |

| REVISION | DATE |
|----------|------|
| SUFFIX | |

DESCRIPTION OF DRAWING
GENERAL ARRANGEMENT.
(FLYOVER STRUCTURE)



SCHEME TITLE
A.130. ARMY & NAVY TEMPORARY FLYOVER.

DRAWING No. B1000/11.

SHEET
NUMBER