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6 DIVISION APPENDICES

AUSTRALIAN WAR MEMORIAL
AWM2020.71.1471

APPENDIX II

AUSTRALIAN IMPERIAL FORCE.

Ref 43/44/8.

H.Q. N.A.B.
6 Aust Div.
5 Sep 43.

REPORT ON TEST TO DESTRUCTION OF AN 128 FT SPAN STIFFENED SUSPENSION BRIDGE CONSTRUCTED BY 2/15 AUST FIELD COY 6 AUST DIVISION NORTHCOTE.

C.E.
2 Aust Corps.

1. GENERAL.

In accordance with the E in C's instructions, the 128 ft span stiffened suspension bridge, erected during training by 2/15 Aust Field Coy, was tested to destruction during week ending 5 Aug 43.

2. DESIGN.

(a) The bridge was designed to carry a 3½ ton tractor and, with minor modifications, was built to the attached plan (Appendix I).

(b) It will be noted that the design provides for a minimum of engineering materials as under:-

(i) The towers and trusses were built of round timber cut adjacent to the job.
(ii) The cross girders were squared from locally cut timber.
(iii) The road bearers were of round timber cut locally.
(iv) The decking was sawn and hewn 9" x 2" timber.
(v) The hangers were made of twisted 10 gauge fencing wire attached to the main cables by square wire lashings.
(vi) The main cables were of S.W.R.
(vii) The stiffening truss diagonals were made of twitched 10 gauge wire secured to the chords as shown in photos 6,7 and 8 (see Appendix II). The connection shown in photo 8 is more positive than the spike connection shown in photos 6 and 7.
The twitched fencing wire diagonals were duplicated and tested in the testing machine. As a result of tests it was found necessary to leave the twitching bar held in position in order to develop the full strength of the diagonal, see photos 7 and 8.

(c) All engineering materials, other than timber, used in the construction of this bridge could be carried by pack transport or be dropped from a plane.

3. CONSTRUCTION.

(a) The appearance of the bridge after erection is shown by photos 1,2,3,4, and 5. Constructional details are shown in photos 6,7,8,9 and 10.

(b) Construction was carried out by three platoons of 2/15 Aust Field Coy, 3200 manhours being required for the job. Construction was not continuous due to 2/15 Aust Field Coy being required for Brigade and Divisional exercises.

(c) Two new 3" ordinary lay cables were used on the upstream side of the bridge and two old 3" long lay cables on the downstream side. As the new cables were not prestressed they stretched more than the old cables with the result that the deck had a small tilt in the upstream direction. A symmetrical arrangement of old and new cables would have resulted in the same stretch on up and downstream cables.

/over.

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5. METHOD OF TESTING.

(a) In a stiffened suspension bridge the maximum stresses under live load occur as under:-

(i) The maximum stresses in the cable occur with the live load in the centre of the bridge.
(ii) The maximum chord stresses (maximum bending moment in stiffening truss) are given by placing the live load at the ¼ point.
(iii) The maximum stresses in the diagonal and vertical truss members occur when the live load is at the end of the bridge.

(b) As the main object of the test was to determine the value of the stiffening truss, it was decided to carry out the test by using a 3 ton winch truck and 11 ton transporter winch to drag a sled loaded with galvanised iron from the end of the bridge up to the ¼ point of the bridge until failure took place. By this means the capacity of the truss to resist bending moment and shear was determined without damaging valuable S.W.R.

(c) The deflections of the trusses at the ¼, ½ and ¾ point of the bridge were measured after each load reached the ¼ point.

6. RESULTS OF TEST.

(a) Photographic results of the tests are shown by photos 11 to 45, inclusive, of Appendix II.

(b) A table of deflections under load is shown in Appendix III. Appendix IV shows a graph of deflections plotted against load.

(c) The bridge collapsed under a load of 23.4 tons due to the hangers between the 1/8 and ¼ point of the bridge breaking.

(d) As the test load increased from 16.2 tons to 22.4 tons the distortion in the stiffening truss increased, with the result that the truss became increasingly inefficient, as a means of distributing the concentrated test load to the cables. At 23.4 tons the concentration became so great as to break the hangers. In effect, as the loads increased, distortion at the joints etc. caused a stiffened suspension bridge to gradually change to an unstiffened suspension bridge.

(e) When the 18.4 ton load was removed (it was not entirely removed, see photo No.27) the bridge resumed its original shape and did not deflect unduly when loaded with a jeep. This will be seen from photos 27,28,29,30,31 and 32. See also serial 8 Appendix III.

7. DEDUCTIONS FROM TEST.

(a) Considering the very improvised type of connection used and rough nature of the construction, the stiffening trusses carried out their function of distributing the live load surprisingly well.

(b) The test showed a factor of safety against ultimate failure of 6.7 but the stiffening truss showed first signs of damage at 12.2 tons when one of the joints started to open (see serial 5 Appendix III). At 10.4 tons there was no apparent damage to the stiffening truss which suggests that this truss had a factor of safety against partial failure of between 3 and 3.5 which checks very well with the design calculations.

(c) The bridge is capable of taking a heavy overload (say 250%) and returning to its original shape when the load is removed. It is capable of carrying a class 9 load as an occasional overload. The tests did not indicate the effect that heavy continuous overloading would have on the joints. Before the test was carried out a loaded 3 ton truck (gross load 6.3 ton approx) was driven over the bridge a number of times and no permanent deformation resulted.

8. CONCLUSION.

(a) Considerable improvement in the structure would result if the web members could be made more rigid. For work in the field, under operational conditions, the web members and joints would need to be simple in design and to be constructed of materials easily transported and readily available in the field.

(b) The answer to this desirable web and joint connection is given by the ring connector and it is strongly recommended that quantities of 2½" and 4" ring connectors with grooving tools be made available to Divisional and Corps Engineer Field Parks engaged in operations in the tropics where timber is plentiful.

(c) As ring connectors were not available in this area, 2/22 Aust Field Park Coy improvised 3" and 4" ring connectors and groove cutters, for use with the compressor, out of 3" and 4" water pipe. Photos 46,47 and 48 show these improvisations.

(d) A drawing of an 128 ft span stiffened suspension bridge using improvised 3" and 4" connectors was hastily prepared and 2/22 Aust Field Park Coy commenced making the ring connected trusses but the time available will not allow this bridge to be completed. It is proposed, however, to test the trusses to destruction and the results of this test will be submitted later. Photo Number 49 shows ring connector trusses built by 2/22 Aust Field Park Coy to the drawing shown in Appendix V attached. This drawing, was hastily prepared and does not purport to be a finished design of a connector bridge.

(e) Two men, with a jig, can build one 16 ft truss in 4 hours and 2/22 Aust Field Park Coy with compressor and carpenter assistance are capable of turning out 8 to 12 trusses per day.

(f) The stiffened suspension bridge is the only long span improvised bridge capable of being erected by Field Engineers in reasonable time.

(g) A good set up for the erection of a bridge of this type would be for Field Park to mill the sawn timber necessary for the job, if it were not available from engineer dumps, and fabricate the trusses from jigs, leaving the Field Coys to do the field erection. If milling were necessary a 42" breaking down saw would be required. The provision of a 42" breaking down saw complete with engine has been the subject of previous correspondence with you but its use in this connection has not be mentioned before.

G E Baird
.....Lt. Col.
C.R.E. 6 Aust Div.

LIST OF APPENDICES.

APPENDIX I Plan of 128 ft stiffened suspension bridge.
APPENDIX II Photos.
APPENDIX III Table of deflections under test load.
APPENDIX IV Graph showing deflection against load.
APPENDIX V Plan of 128 ft stiffened suspension bridge using ring connectors.

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APPENDIX III

H.Q. [illegible]
6 Aust Div.
4 Sep 41.

LOADING TEST RESULTS 128 FT STIFFENED SUSPENSION BRIDGE.

SERIAL	TEST LOAD TONS	DEFLECTION (INCHES) AT ¼ POINT UPSTREAM	AT ¼ POINT D'STREAM	AT ½ POINT UPSTREAM	AT ½ POINT D'STREAM	AT ¾ POINT UPSTREAM	AT ¾ POINT D'STREAM	REMARKS.
1.	6.8	4"	5"	¾"	½"	- 1¾"	- 2"	See photo No.13.
2.	7.75	4½"	5¼"	7/8"	¾"	- 1"	- 1"	See photo No.14.
3.	8.8	4-5/8"	7"	7/8"	¾"	- 1-7/8"	- 3"	See photo No.15.
4	10.2	4-7/8"	8¼"	1½"	¾"	- 3"	- 4-5/8"	See photo No.16. End cross bearers, (marked in red on plan appendix I) started to split at the ends due to longitudinal shear. The ends were bound with wire and the loading continued.
5.	12.2	10½"	8-1/8"	1½"	¼"	- 3-5/8"	- 4¾"	(a) See photos 17 and 18. (b) The 4th, 5th, 6th and 7th hangers on the upstream side slipped down the cable (see photo No.19). After the load was removed the hangers were replaced and secured with bull dog clips. (c) The second joint in the bottom chord on the downstream side opened 1". This joint did not open any further until failure occurred. (d) The twitched diagonal web members in the end panels showed a tendency to untwist. Some of the twitching bars started to bend, see photo 20.
6	14.2	11½"	10"	1"	½"	- 5¼"	- 5-5/8"	(a) See photo 21 (b) The diagonal tension member in the second panel on the downstream side became untwisted due to the twitching bar flying out, see photo 22.

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SUB-LET	TEST LOAD TONS	DEFLECTION (INCHES) AT ¼ POINT UPSTREAM	AT ¼ POINT DOWNSTREAM	AT ½ POINT UPSTREAM	AT ½ POINT DOWNSTREAM	AT ¾ POINT UPSTREAM	AT ¾ POINT DOWNSTREAM	REMARKS.
6.								(c) A bottom pin connecting a diagonal to the bottom chord started to bend, see photos 23 and 24. This is partly due to the diagonal being connected too far down the pin. Where this connection was well made the pins did not bend, see top joint, photo 24.
7.	16.2	15"	13¾"	8"	3½"	- 5/8"	- 5¼"	The diagonals in the end panels, subject to heavy shear, showed a marked tendency to untwist, due to the twitch bars bending. These diagonals are now taking approx. 450# their design load.
8.	18.4	16½"	14-3/8"	5½"	-1/8"	- 6-1/8"	- 5¾"	(a) See photos 25 and 26. (b) The fish plates in the first bottom chord joint on the upstream side started to split. (c) The second joint in the bottom chord, upstream side, opened up 2". (d) At this stage the load was almost completely removed from the bridge. It was not completely removed owing to the difficulty of getting the loaded sled back on to the bridge. Photos 27,28 and 29 show the bridge with the test load almost completely removed. (e) Photos 30,31 and 32 show the bridge loaded with a jeep at the ⅛, ¼ and ½ point. The deflection in the bridge at the 1/16 point due to a portion of the test load (18.4 tons) still being on the bridge, is shown clearly in photo 32. It will be noted that when the test load was almost completely removed the bridge resumed its original shape.

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SERIAL	TEST LOAD TONS	DEFLECTION (INCHES) AT ¼ POINT UPSTREAM	AT ¼ POINT D'STREAM	AT ½ POINT UPSTREAM	AT ½ POINT D'STREAM	AT ¾ POINT UPSTREAM	AT ¾ POINT D'STREAM	REMARKS.
8.								(f) Photo 33 shows the uplift at the far end of the bridge with the 18.4 ton load at the ¼ point.
9.	20.4	18½"	17¼"	5¾"	5½"	- 7"	-6¼"	(a) See photos 34,35, 36 and 37. (b) Short twitch pins (6" long) still prevent diagonal web members from untwisting. All long twitch pins (12" and over) in members subject to heavy shear have bent and allowed tension members to partially untwist. (c) All hangers, up to the 4th hanger from the far end, are taking load and helping to distribute the test load throughout the bridge. The stiffening truss, therefore is still carrying out its function although with reduced efficiency. The main cables are still parabolic in shape. (d) The bridge has lifted off far bed log 18" on downstream side and 8" on upstream side, see photo 33.
10.	22.4	21"	19¾"	6"	5¾"	- 7¼"	- 7"	Apart from the extra deflection there is no apparent change in the structure.
11.	23.4	Bridge Failed						(a) The 4th hanger on the downstream side snapped. The load slipped to the downstream side of the bridge and cut hangers 5 and 6. All other hangers on the downstream side broke immediately and the bridge collapsed. See photos 38,39,40,41, 42,43 and 44. (b) Two joints in the tension chord failed due to tension and torsion as the bridge collapsed. No other joints failed completely. There are two good photos illustrating these 2 joint failures.

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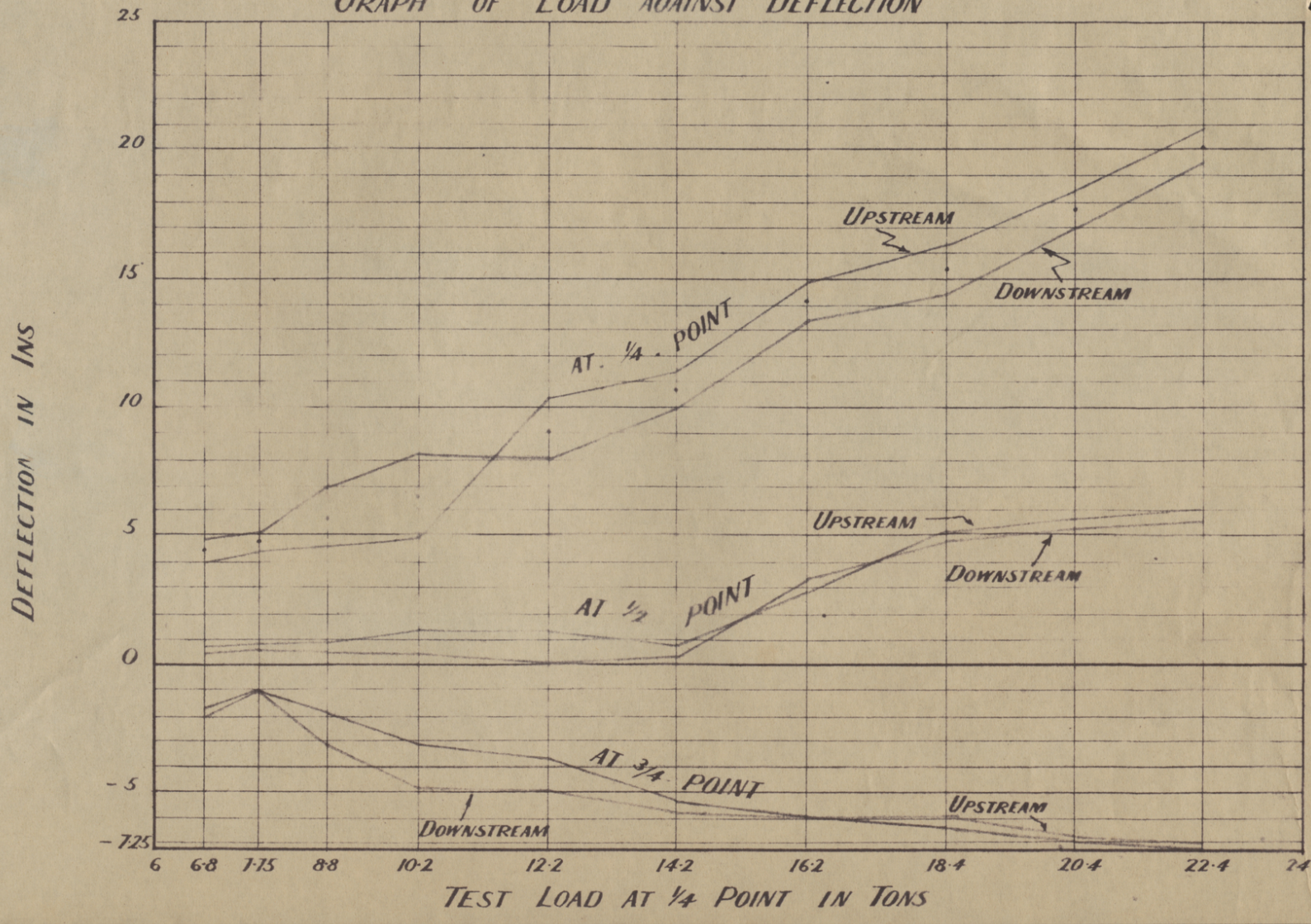
APPENDIX IV

LOAD TEST OF 128' SPAN STIFFENED SUSPENSION BRIDGE

GRAPH OF LOAD AGAINST DEFLECTION



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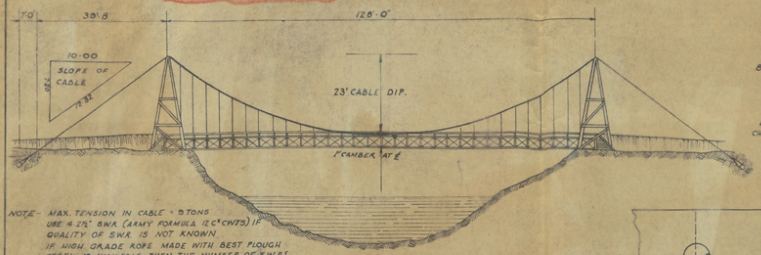
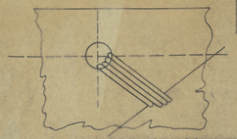
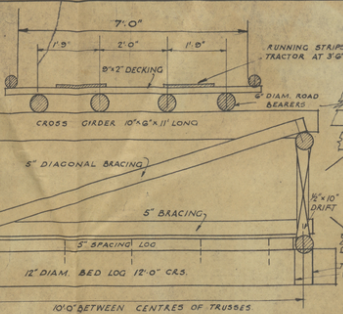
APPENDIX I

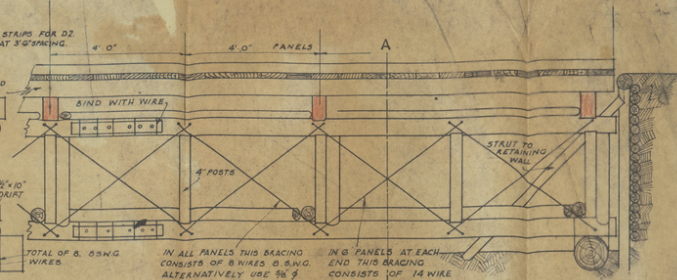


NOTE - MAX. TENSION IN CABLE = 8 TONS USE 4 2½" S.W.R. (ARMY FORMULA 12 C.WTS) IF QUALITY OF S.W.R. IS NOT KNOWN. IF HIGH GRADE ROPE MADE WITH BEST PLOUGH STEEL IS AVAILABLE, THEN THE NUMBER OF S.W.R.'S MAKING UP THE CABLE, MAY BE REDUCED.



DIAGONAL BRACING CONNECTION

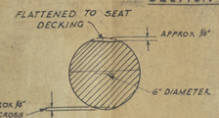




IN ALL PANELS THIS BRACING CONSISTS OF 8 WIRES 8 S.W.G. ALTERNATIVELY USE ⅝" ϕ BOLT AND SUITABLE WASHERS.

IN 6 PANELS AT EACH END THIS BRACING CONSISTS OF 14 WIRE 8 S.W.G. ALTERNATIVELY USE ⅝" ϕ BOLT AND SUITABLE WASHERS.

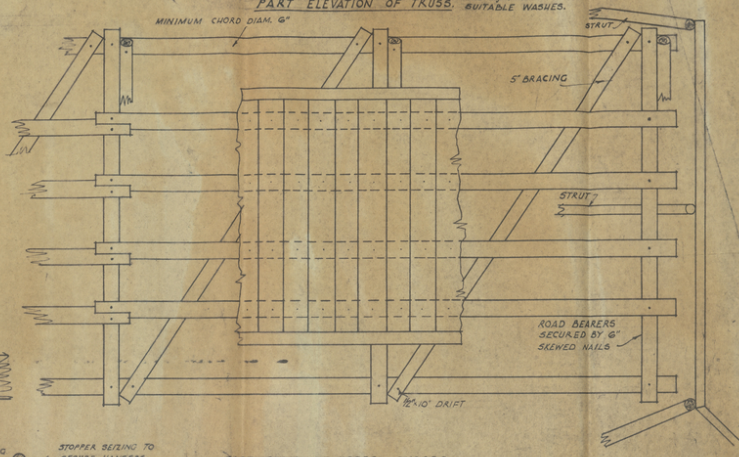
SECTION AT A·A.



SECTION OF ROAD BEARERS

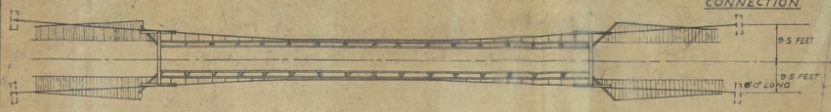


PART ELEVATION OF TRUSS.



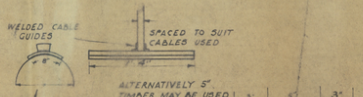
ELEVATION

SCALE 1" = 20 FT.



PLAN

SCALE 1" = 20 FT.



SECTION AT LAP IN BEARERS

BIND WITH FENCING WIRE TWITCHES

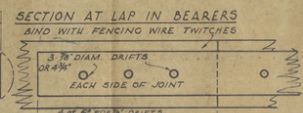
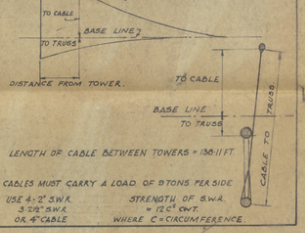


TABLE OF ORDINATES

DISTANCE FROM TOWERS	DISTANCE ALONG CABLE	TO CABLE	TO TRUSS	TRUSS TO TRUSS
0	0	23·00	1·00	27·10
4	4·03	20·20	0·88	24·18
8	8·05	17·60	0·77	21·68
12	14·24	15·20	0·68	18·54
16	16·02	12·95	0·56	16·58
20	23·32	10·89	0·49	14·41
24	27·74	9·00	0·38	13·45
28	32·05	7·26	0·32	11·65
32	36·36	5·75	0·25	9·04
36	40·59	4·40	0·10	8·62
40	44·75	3·14	0·14	6·31
44	48·87	2·25	0·10	5·37
48	52·85	1·44	0·06	4·52
52	57·00	0·81	0·04	3·87
56	61·03	0·36	0·02	3·38
60	65·04	0·09	0·00	3·10
64	69·05	0·00	0·00	3·01

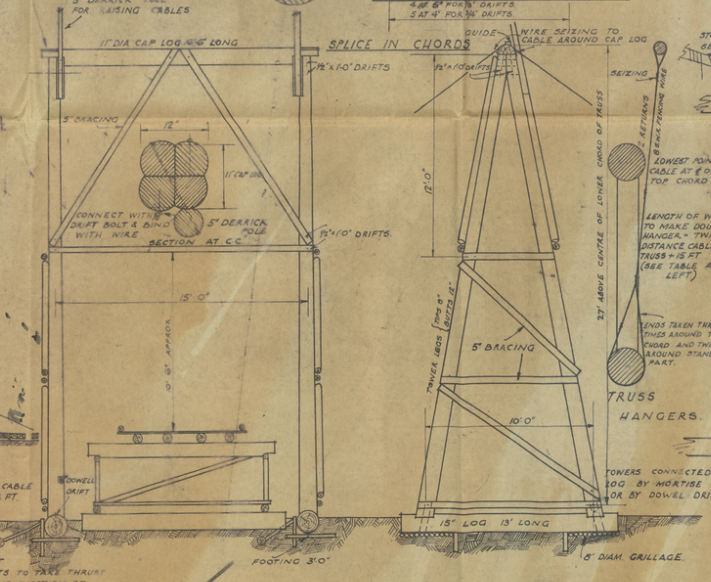


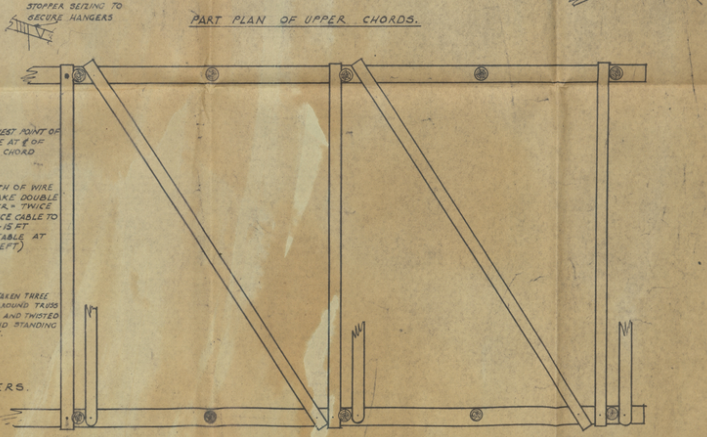
LENGTH OF CABLE BETWEEN TOWERS = 130·11 FT.

CABLES MUST CARRY A LOAD OF 8 TONS PER SIDE

USE 4·2" S.W.R. 3·2½" S.W.R. OR 4" CABLE

STRENGTH OF S.W.R. = 12 C·WT. WHERE C = CIRCUMFERENCE.





PART PLAN OF UPPER CHORDS.

PART PLAN OF LOWER CHORDS

SCALE 1 IN. = 4 FT.

ERECTION PROCEDURE



1. ERECT TOWERS. CONNECT HANGERS TO CABLES. ASSEMBLE TRUSS IN SECTIONS ON BANKS WITHOUT DECKING OR ROAD JOISTS. DRILL AT HOLES FOR DRIFTS AT SPLICES & BRACES.

2. PASS CABLE ACROSS GAP & RAISE ONTO TOWERS. ERECT CABLE FOR CABLEWAY.



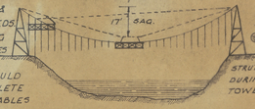
3. RAISE CENTRE SECTIONS ONTO CABLEWAY RUN OUT TO POSITION, ATTACH HANGERS & LOWER UNTIL SUPPORTED BY HANGERS. PROCEDURE REPEATED WITH ALTERNATE SECTIONS FROM EACH SIDE.

CONNECTING SPLICES, LATERAL BRACING & WIRE DIAGONAL BRACING AS ERECTION PROCEEDS

NOTE. TO ALLOW FOR CABLE STRETCH & TAKING UP OF SLACK AT ANCHORAGES, MAIN CABLES WHEN FIRST SLUNG SHOULD HAVE DIP OF 22 FT. & ONE JOINT AT CENTRE SHOULD BE LEFT UNCONNECTED. AFTER COMPLETE TRUSS IS IN POSITION BLACKEN OFF, CABLES AT ANCHORAGE UNTIL CORRECT DIP IS OBTAINED, AND THEN CLOSE CENTRE JOINT. ADJUSTMENT SHOULD BE MADE AFTER PLACING DECKING.

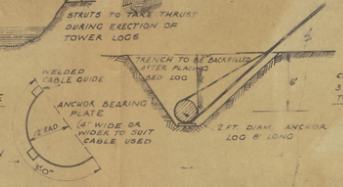
4. TRUSSES COMPLETED, INSTAL ROADBEARERS & DECKING DISMANTLE CABLEWAY.

LENGTH OF ERECTION CABLE BETWEEN TOWERS 132·4 FT.



WEIGHT OF 20 FT. SECTION INCLUDING WORKING PARTY 15·25 CWT.

MAXIMUM TENSION IN ERECTION CABLE 15 48 CWT.



TOWER

SCALE 1 IN. = 4 FT.

CABLE SECURED BY TAKING 3 TURNS AROUND LOG & SEIZING TO STANDING END OF CABLE.

LOADING

BRIDGE IS DESIGNED TO CARRY D2 TRACTOR WITH GROSS WT. OF 35 TONS OR 2 JEEPS OR A BODY OF 50 MEN MARCHING IN THREES

PERMISSABLE STRESS IN TIMBER 1500 LBS/SQ IN.

TOWERS CONNECTED TO BASE LOG BY MORTISE & TENON OR BY DOWEL DRIFT.

130 FT. SUSPENSION BRIDGE WITH TIMBER STIFFENING PLAN	
DESIGNED	C.E. Bond Lt. Col
DRAWN	CHECKED & APPROVED

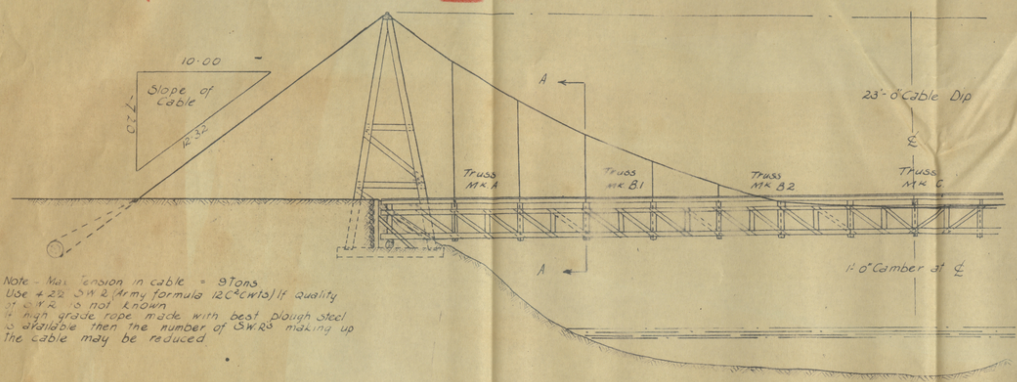
Traced by Spr. C.D. Johnson 12 Aust. C.R.E. (works)

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX I

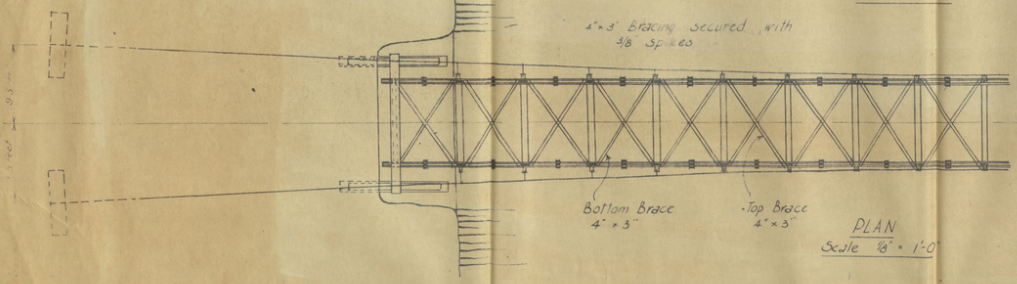
AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX V

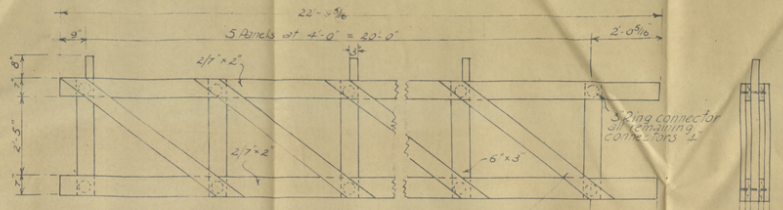


Note - Max tension in cable = 9 Tons
Use 4.28 SW & (Army formula $12C^2(wl)^3/f$ Quality of SWR is not known
If high grade rope made with best plough steel is available then the number of SWRS making up the cable may be reduced

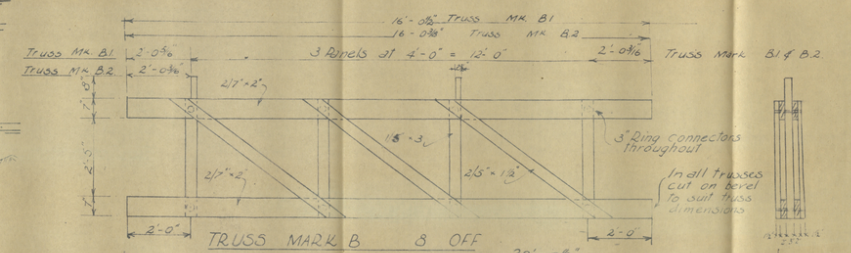
ELEVATION
Scale 1/8" = 1'-0"



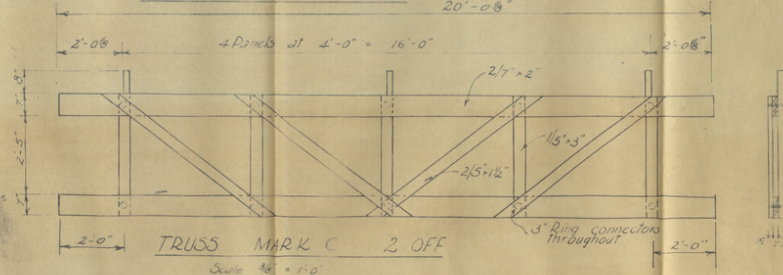
PLAN
Scale 1/8" = 1'-0"



TRUSS MARK A 4 OFF



TRUSS MARK B 8 OFF



TRUSS MARK C 2 OFF
Scale 3/8" = 1'-0"

HANGER DETAILS

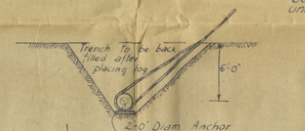
Distance from Tower FT.	Distance from centre FT	Ordinate Cable FT	Ordinate Truss	Length of Hanger FT	Length of hanger corrected for Slope
0	64	23·00	1·00	27·29	27'-4 5/16
8	56	17·61	·73	21·63	21'-8 1/16
16	48	12·94	·49	16·72	16'-9 1/16
24	40	8·98	·31	12·58	12'-7 1/16
32	32	5·75	·17	9·21	9'-2 5/16
40	24	3·23	·07	6·59	6'-7 1/16
48	16	1·44	·01	4·74	4'-9"
56	8	·36	0	3·55	3'-7 1/16
64	0	0	0	3·29	3'-3 5/8

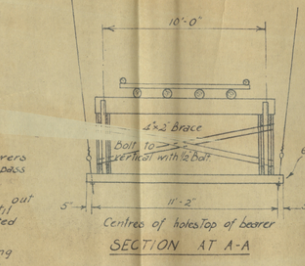
ERECTION PROCEDURE

1. Erect Tower
Connect hangers to cables & transomes to hangers
2. Pass cable across gap & raise onto towers
Erect cable for cableway (if necessary pass cables across gap on traveller)
3. Raise centre sections onto cableway run out to position, ~~temporarily support~~ lower until supported on hangers procedure repeated with alternate sections from each side

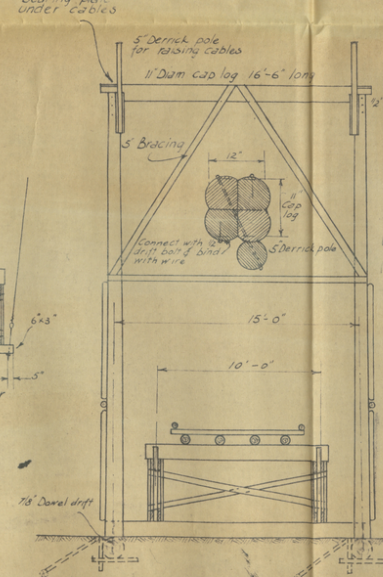
Note - To allow for cable stretch & taking up of slack at anchorages. Main cables when first slung should have dip of 22 ft. & one joint at centre should be left unconnected After truss is in position slacken off cables at anchorages until correct dip is obtained & then close centre joint adjustment should be made after placing decking

4. Trusses completed install road bearers & decking
Dismantle cableway

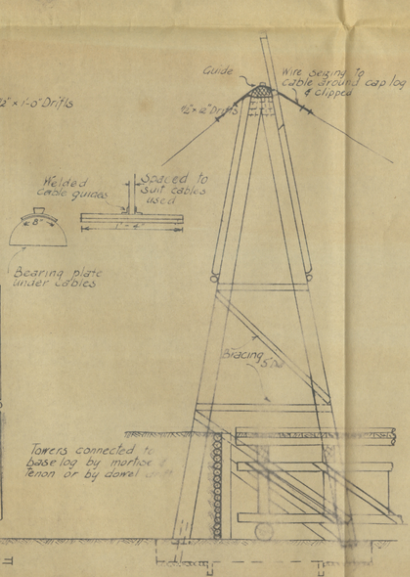




SECTION AT A-A

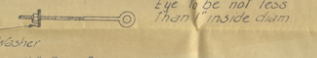


TOWER
Scale 1" = 4'-0"

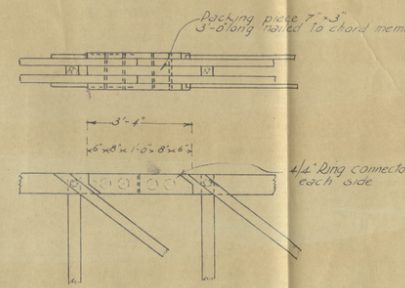


SECTION on ℄

Loading
Bridge is designed to carry Detachment with ground of 3·5 tons or 4 troops or a load of 80 men marching in threes
Permissible stress in timber 1500 lbs/sq. in



1/2" Eye Bolts 30'-0"



Splice plates 2/7"×2"×3'-4" selected timbers cut as shown

DETAIL OF CHORD SPLICE
Scale 1/2" = 1'-0"

130 FT. SUSPENSION BRIDGE TRUSS TYPE

Designed
Drawn C Young.
Checked & Approved
Traced C Young 1/52nd Div
HQ R[illegible] Div

APPENDIX V

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



PHOTO No.1.



PHOTO No.2.



PHOTO No.3.



PHOTO No.4.

Note slight tilt upstream in bridge deck due to stretch of new cables in upstream side.

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PHOTO No.5.



PHOTO No.6.

Showing one method of connecting diagonals to chords.



PHOTO No.7

Showing a second method of connecting diagonals to chords. Note long twitching bars in diagonals. Short bars were better as they did not bend under heavy load and allow the diagonals,to untwist.



PHOTO No.8.

Showing a third method of connecting diagonals to chord (the best method). No bolts were used in joints.

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PHOTO No.9.



PHOTO No.10.

Showing log anchorage connection.



PHOTO No.11.

Loading sled with a test load of galvanised iron.



PHOTO No.12.

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PHOTO No.13.

6.9. ton load on bridge.



PHOTO No.14.

7.75 ton test load on bridge.



PHOTO No.15.

8.8 ton test load on bridge.



PHOTO No.16.

10.2 ton test load on bridge.

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PHOTO No.17.

12.2 ton test load on bridge.



PHOTO No.18.

12.2 ton test load on bridge.



PHOTO No.19.

12.2 ton test load on bridge - note hangers have slipped down main cable.



PHOTO No.20.

Note tension in one diagonal and short twitching bars.

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PHOTO No.21.

14.2 ton test load on bridge.



PHOTO No.22.

14.2 ton load on bridge, long twitching bar broke and diagonal untwisted under load.



PHOTO No.23.

14.4 tons test load on bridge. A badly made connection and pin bending under load.



PHOTO No.24.

14.4 tons test load on bridge. Note better pin connection on top chord.

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PHOTO No.25.

18.2 tons test load on bridge.



PHOTO No. 26.

18.2 tons test load on bridge.



PHOTO No.27.

18.2 ton load removed from bridge (a small part of the load still remains on bridge), Note bridge has almost returned to its original shape.



PHOTO No.28.

18.2 ton load removed from bridge.

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PHOTO No.29.

18.2 ton load removed from bridge.



PHOTO No.30.

18.2 ton load removed from bridge, jeep at 1/4 point.



PHOTO No.31.

18.2 ton load removed from bridge, jeep at $\frac{1}{2}$ point.



PHOTO No. 32.

18.2 ton load removed from bridge, jeep at $\frac{3}{4}$ point.

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PHOTO No.33.

18.2 ton load at ¼ point, showing uplift at far end of bridge.



PHOTO No.34

20.4 ton test load on bridge.



PHOTO No.35.

20.4 ton test load on bridge.



PHOTO No.36.

20.4 ton test load on bridge.

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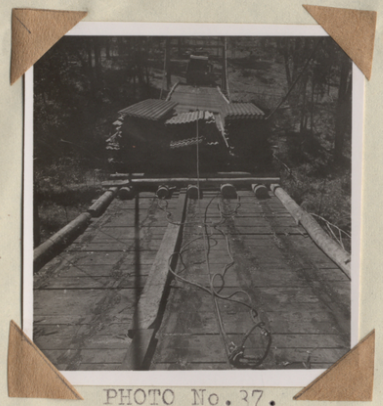

PHOTO No.37.

20.4 ton test load on bridge.



PHOTO No.39.



PHOTO No.38

Bridge after failure at 23.4 tons.



PHOTO No.40.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



PHOTO No.41.



PHOTO No.42.



PHOTO No.43.



PHOTO No.44.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



PHOTO No.45.



PHOTO No.46.

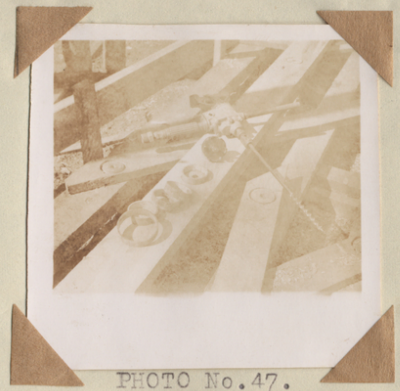

PHOTO No.47.

Showing 3" & 4" ring connectors and grooving machine.
All were improvised by water pipe by 2/22 Aust Fd Pk Coy.



PHOTO No.49.



PHOTO No.49A.

Showing 36 feet ring connected trusses being prepared
for testing by 2/22 Aust Fd Pk Coy.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

War Diary AUSTRALIAN IMPERIAL FORCE. APPENDIX 12

H.Q. R.A.E.
6 Aust Div.
9 Sep 43.

Ref 43/47/18.

REPORT ON CRATER DEMOLITIONS IN HARD CLAY.

C.E.
2 Aust Corps.

1. GENERAL.

A report on experiments carried out by 2/15 Aust Field Coy on crater demolitions in hard clay is attached.

2. NEW GUINEA EXPERIENCE.

Drilling difficulties were experienced when widening sections of the Rouna Pass Road, (Port Moresby) due to the drills becoming stuck when drilling through a mixture of clay and conglomerate boulders. The boulders were easy to drill but on entering clay the drills frequently became stuck. The difficulty was only partially overcome by using bits with side air holes as, due to rains, the clay was wet and sticky.

3. FURTHER EXPERIMENTS.

Further experiments are being carried out by 2/15 Aust Field Coy in the jungle to develop a technique for drilling with air compressor and tools in soft clay. So far some success has attended the experiments as it has been found that a hole can be rapidly drilled in soft clay by removing the bit and drilling with a drill steel only. A report on drilling and cratering in soft clay will be submitted at a later date.

C E Bavin
.....Lt. Col.
C.R.E. 6 Aust Div.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

AUSTRALIAN IMPERIAL FORCE.

2/15 Aust Fd Coy.
R.A.E. 6 Aust Div.

REPORT ON DEMOLITION CRATERS IN HARD CLAY.

Report by:- Maj W.T. GRAHAM. 2/15 Aust Fd Coy.
Date:- 1 Sep 43.

C.R.E.
6 Aust Div.

1. GENERAL.

Experiments were carried out at Newcastle Waters, (N.T.) and Mondecla, (Atherton Tablelands) on demolition craters in clay using a compressor and tools for the drilling of holes. (See Appendix A for the test data).

2. RESULTS.

(a) A compressor with jack hammer and jack bits readily drilled holes 12 feet deep in clay. Side air holes, see Appendix E, were necessary in the jack bits.

(b) The rate of drilling varied from 1" to 6" per minute.

(c) A crater 32 feet in diameter, 8 feet deep, was blown with 300 lbs of A.N gelignite 60 by one N.C.O. and two sappers in 2 hours, using a 9 feet drill hole and a 4½ lb camouflet charge.

(d) See appendix B for an analysis of the test results.

3. CONCLUSIONS.

(a) The tests indicate that craters 40 feet to 50 feet in diameter, 10 feet to 12 feet deep are possible in clay.

(b) Under average conditions in hard clay one section working continuously should produce a crater every one to two hours.

(c) The crater formula ($C = \frac{D^3}{100} \times$ factor) is satisfactory for hasty work. The Mining Formula (M.E. Vol.IV, Chap.IV) may be necessary for plastic clays or for craters greater than 32 feet in diameter and in deliberate work may give economy in explosives.

(d) The camouflet charge required is $\frac{C}{80}$ lbs or $\frac{C}{5}$ ozs, (see Appendix B para 7).

(e) The method is applicable to rock, see separate report.

4. RECOMMENDATIONS.

It is recommended that:-

(a) Sappers receive training in the use of a compressor and tools for drilling clay.

(b) Engineer Coys be issued with 8 ft, 10 ft and 12 ft drills and jackbits with side air holes.

(c) Further tests be carried out to confirm deductions for craters over 32 feet in diameter and to obtain for different clays data on:-

/over.

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4. RECOMMENDATIONS (Cont'd).

(i) Drilling rates.
(ii) Soil factors.
(iii) Explosive factors for Australian explosives.
(iv) The maximum safe camouflet for any depth.
(v) The camouflet charge required for any required volume of chamber.

.....Major.
O.C. 2/15 Aust Fd Coy R.A.E. 6 Aust Div.

LIST OF APPENDICES.

APPENDIX A. Test Data.
APPENDIX B. Analysis of test results.
APPENDIX C. Example of method.
APPENDIX D. Civil and military experiences of this method.
APPENDIX E. Sketches of drills.

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APPENDIX A.

CRATER DEMOLITIONS IN CLAY - TABLE OF TEST DATA.

SERIAL	DEPTH OF DRILL HOLE	TIME TAKEN (Mins)	CANNUFLET G&S 1st	CANNUFLET G&S 2nd	VOLUME (cubic ins.)	DEPTH AFTER CANOU-FLET	CRATER MAIN CHARGE (lbs)	CRATER AVER. DEPTH	CRATER DIAM.	TIME TO LOAD MAIN CHARGE (Mins)	TOTAL TIME TAKEN hrsmin	AVERAGE RATE OF DRILLING (Inches per min)	CANOU-FLET Cub Ins per cm.	RATE OF LOADING CHARGE (lbs per min)	n INDEX OF MINE	s SOIL FACTOR
1.	-	-	-	-	-	5'6"	40	12'3"	3'6"	-	-	-	-	-	1.22	5.56
2.	-	-	-	-	-	6'6"	50	12'3"	2'9"	-	-	-	-	-	1.02	6.16
3.	-	-	-	-	-	5'9"	40	12'3"	2'6"	-	-	-	-	-	1.17	5.50
4.	6'0"	60	3	-	460	6'2"	-	-	-	-	-	1.2	153	-	-	-
5.	5'4"	60	-	-	-	-	-	-	-	-	-	1.1	-	-	-	-
6.	6'0"	70	12	-	1460	6'3"	-	-	-	-	-	1.0	122	-	-	-
7.	8'0"	90	2	96	6550	8'9"	-	-	-	-	-	1.1	68	-	-	-
8.	10'3"	105	2	108	17700	11'3"	-	-	-	-	-	1.2	164	-	-	-
9.	12'0"	125	2	160	21000	13'4"	-	-	-	-	-	1.1	131	-	-	-
10.	6'0"	65	2	24	-	6'6"	-	-	-	-	-	1.1	-	-	-	-
11.	6'0"	45	6	-	-	-	-	-	-	-	-	1.6	-	-	-	-
12.	6'0"	30	9	-	800	-	-	-	-	-	-	-	89	-	-	-
13.	6'0"	30	2	18	3560	-	-	-	-	-	-	2.4	198	-	-	-
14.	6'0"	21	2	18	-	6'6"	80	19'3"	3'0"	27	1 - 32	3.4	-	3.0	1.58	3.32
15.	6'0"	15	2	24	3630	6'9"	120	21'3"	4'6"	42	2 - 0	4.8	151	2.9	1.73	3.75
16.	6'0"	14	-	18	3350	6'5"	80	20'0"	5'0"	36	1 - 30	5.1	186	2.2	1.67	2.86
17.	9'0"	16	2	70	14500	10'6"	300	32'0"	8'0"	80	2 - 0	6.8	207	3.7	1.66	2.72
18.	8'0"	14	6	-	910	8'4"	-	-	-	-	-	6.8	152	-	-	-

1. For symbols used see M.E.(Vol.IV) Demolitions and Mining 1934 Index of mine n = $\frac{\text{Radius of crater}}{\text{L.L.R.}}$
2. Explosive used A.N. Gelignite 60.
3. Tests at NEWCASTLE WATERS probably show false results due to the small charges being placed too deep.
4. Reference Pamphlets (a) E in C Technical Instruction No.3 (Australian Explosive)
   (b) M.E. Vol.IV Demolitions and Mining 1934.
   (c) M.E. Vol IV Part 1, Demolitions 1942.
5. All depths are in feet and inches.
6. Serials 1 to 3 are for black soil at NEWCASTLE WATERS.
   Serials 4 to 13 are for red hard clay at WONDECLA, ATHERTON TABLELANDS.
   Serials 14 to 18 are for red hard clay and clayey gravel at WONDECLA.

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APPENDIX B.

ANALYSIS OF TESTS WITH A.N. GELIGNITE 60.

1. RATE OF DRILLING.

(a) The rate of drilling varied from 1.0 inches to 6.8 inches per minute. These times include time taken in changing drills. (See Appendix A for details).

(b) The drilling rate is NOT appreciably decreased by depth.

(c) The average rate of drilling for all tests was 1.7 inches per minute.

2. RATE OF CHARGING HOLES.

(a) The rate of charging holes varied from 2.2 to 3.7 lbs per minute. (See Appendix A).

(b) The average rate of charging for all tests was 3.1 lbs per minute.

3. DIAMETER OF CRATER AND DEPTH OF CHARGE.

(a) Excluding Newcastle Water tests the depth of charge to diameter of crater varied from $\frac{1}{3}$ to $\frac{1}{3.5}$

(b) If the mining formula $C = \frac{s}{10e} L^3 (V 1 + n^2 - 0.41)^3$ (M.M. Vol IV, Chap XIV) is used then with the charge placed at a depth $\frac{D}{4}$ the crater will be as deep as the charge.

4. SOIL FACTOR (S).

(a) The figure quoted for blue clay in M.M. Vol IV is 1.5 and for hard rock is 2.5 to 4.0.

(b) From test results, appendix A, the value of S may be calculated from the formula in para 3(b) above with the following results:-

Newcastle Waters	S = 5.50 to 6.16
Wondecla	S = 2.72 to 3.75

(c) Further tests are necessary to check these results. Some of the discrepancy, with the figures shown in para 4(b) above, may be due to the explosive factor, see para 5 below.

5. EXPLOSIVE FACTOR. (e)

(a) In the mining formula, M.M. Vol IV, the ratio of ammonal to dynamite for e is $\frac{1.0}{2.8}$

(b) In the E in C's Technical Instruction No.3 the ratio of ammonal to A.N. Gelignite 60 for the crater factor is $\frac{1.0}{1.25}$

(c) The figures in para 5(a) are in the denominator of the mining formula; and in 5(b) the figures are used in the numerator of the crater formula.

Therefore for Australian A.N. Gelignite 60.

$$e = 3.0 \times \frac{1.0}{1.25} = 2.4 \text{ and NOT } 2.8.$$

(d) If 2.4 is used instead of 2.8 the values of the soil factor as calculated in para 4 above would be decreased by 14%.

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6. CALCULATION OF MAIN CHARGE.

(a) The soil factor S has been calculated from Appendix A. Neglecting the Newcastle Waters tests, where the charges were probably too small and gave false results, the average soil factor for Mondecla is 3.28.

(b) On comparing the crater formula $C = 1.25 \frac{D^3}{100}$ and the mining formula $C = \frac{SL^3(1+n^2-0.4)^3}{100-0.4}$ it will be found that the two formulae give similar charges when S = 3.5 to 3.7 with the charge at a depth $\frac{D}{3}$ to $\frac{D}{4}$. Hence the crater formula is satisfactory for hard clay.

(c) When economy in the use of explosives for a deliberate scheme is desired or the clay hardness is uncertain a charge of 80 to 100 lbs can be placed at a depth of 6 ft say, fired, the crater diameter measured and the soil factor calculated from the mining formula, para 3(b).

7. CAMOUFLET CHARGE.

(a) The average of all tests in appendix A shows that a 1 oz camouflet charge gives a chamber of 129 cub ins volume. Only two tests, serial 7 and 12, give figures much below this.

(b) Precise figures are not available for weight per cub foot of gelignite but from measurements of the gelignite used, and allowing 25 to 30% air space, 2/3 oz of gelignite requires 1 cub inch of volume.

(c) For calculated main charges in hard clay placed at a depth between D/3 and D/4, the camouflet charge (b) is $\frac{C}{5}$ ozs or $\frac{C}{80}$ lbs.

(d) For camouflet charges over 16 ozs a preliminary camouflet of 2 ozs will normally be required. For large camouflet charges the preliminary charge may be calculated from the above formulae.

(e) For holes less than 6 feet deep camouflet charges greater than 24 ozs may shatter the hole and cause minor cratering and loss of the hole.

(f) Camouflet charges (calculated from the formula $\frac{C}{5}$ oz) above 24 oz may be used in holes over 8 feet or 9 feet deep.

(g) In some camouflet tests the mouth of the hole suffered from minor cratering but when the lumps of clay were removed the hole was seen to be in good order.

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APPENDIX C.

WORKED EXAMPLES.

PROBLEM. Require a 40 feet crater in clay using A.N. Gelignite 60.

1. HASTY CALCULATION.

(a) Charge C = $1.25 \frac{D^3}{100}$ = 800 lbs.

(b) Camouflet = $\frac{800}{80}$ lbs = 10 lbs.

(c) Preliminary Camouflet = $\frac{10}{5}$ oz = 2 oz.

(d) Depth of drill hole $\frac{D}{3}$ to $\frac{D}{4}$ i.e. 13 ft 4" to 10 ft 0", adopt a depth of 10 feet.

(e) Time required.

Drilling 2" per minute - $\frac{10 \times 12}{2}$ = 60 mins.

Loading at 3 lbs per minute $\frac{800}{5}$ = 270 mins.

Camouflet, setting up, firing etc.= 30 mins.
Total. 160 mins.

(f) Labour.

(i) For 1 crater, 1 N.C.O. and 2 men.
(ii) For a number of craters, 1 Section.

2. DELIBERATE CALCULATION.

(a) Firstly drill a 6 feet hole in nearly similar soil and blow a crater using an 80 lb charge with a 16 oz camouflet charge. Assume a crater of 20 feet diameter, results.

(b) From the mining formula by transposition

$$S = \frac{10Ce}{L^4(\sqrt{1+n^2} - 0.41)^3} = 2.86.$$

Assuming n = 2 and e = 2.8

(c) Hence with a soil factor S = 2.86 and n = 2 (that is, the charge is placed at a depth D/4) the main charge C is given by

$$C = \frac{2.86}{10 \times 2.8} 10^3 (\sqrt{1+2^2} - 0.41)^3$$

= 625 lbs.

(d) The calculations are then continued as from para 1(b) onwards.

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AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX B.

CIVIL AND MILITARY EXPERIENCES OF THE METHOD.

1. GENERAL.

The method was used with success on several works over a number of years for loosening hard clays prior to excavation.

2. JUMPER BAR.

These bars (see Appendix A fig 2) were operated by raising and dropping by hand. Water was used to produce a sludge and scraper bars to clean out the drilled clay. Camouflets were blown and the main charge was placed at depths up to 10 feet or 12 feet.

3. DRILL STEEL WITHOUT JACKBITS. (see Appendix A fig 3)

Instead of the normal hand sharpened sharp chisel bit, the chisel was given a broad end.

The actual width was varied by trial and error, the softer the clay the wider the "point".

The drills were used up to 7 feet depth. Camouflets and main charges were then blown.

4. JACKBITS.

When jackbits with central hole only are available they can be converted to side holes. (see Appendix A fig 1).

Side air holes are necessary as the central hole quickly becomes plugged with clay.

5. During the last 12 months sappers of 2/15 Aust Fd Coy have successfully employed the method for drilling in hard clays, soft, and hard rocks and for various excavations etc.

A camouflet approximately double suggested formula ($b = \frac{c}{5}$ ozs) placed in a hole, drilled at the bottom of a soakage pit in clay loosens the clay and assists soakage.

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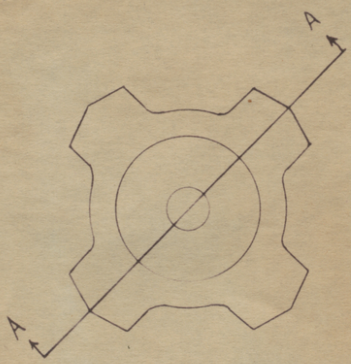
APPENDIX-E



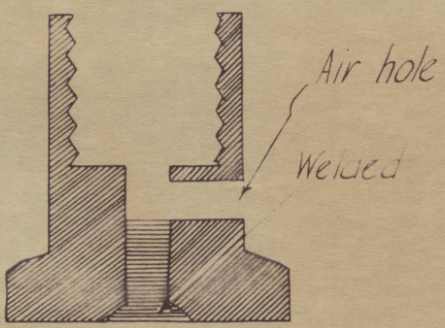


FIG 1.
Plan of Jack Bit with side air hole

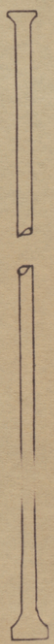
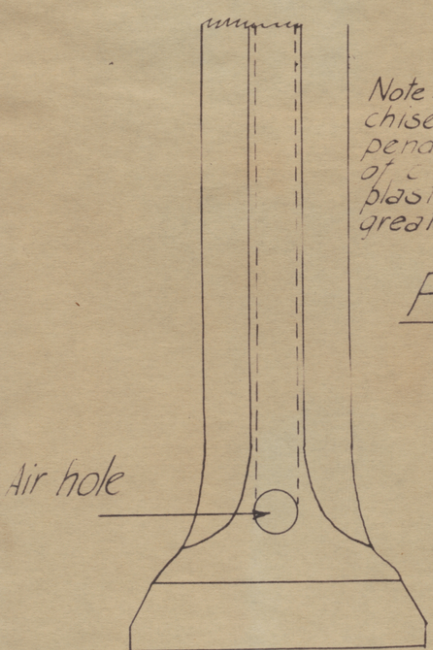
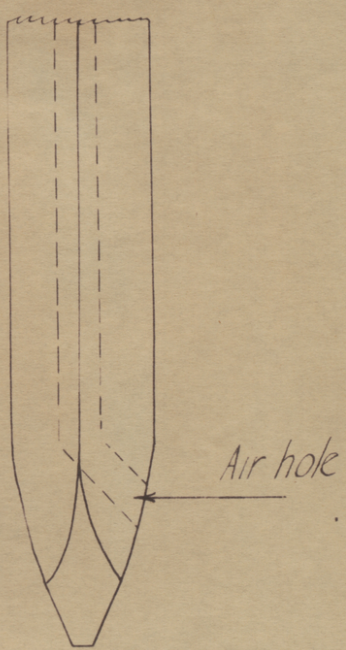


FIG. 2.
Jumper bar



Note = Width of chisel point depends on type of clay - more plastic the clay greater the width

FIG. 3.



Broad Chisel Point for drilling clay

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

AUSTRALIAN IMPERIAL FORCE.

APPENDIX 13

War Diary

Ref 43/57/18.

H.Q. R.A.E.
6 Aust Div.
24 Sep 43.

REPORT ON CRATER DEMOLITIONS IN SOFT CLAY.

C.E.
2 Aust Corps.

1. Referring to para 2 of our 43/47/18 of 9 Sep 43. A further report on crater demolitions in soft clay by Maj W.T. Graham is attached.

2. From Maj Graham's report it will be noted that soft clay, such as is found frequently in tropical rain forests, can be rapidly drilled with a compressor using drill steels only, see Appendix A for diagram showing drilling technique.

3. Experiments are being carried out on drilling and cratering in rock.

C E Baird
.....Lt. Col.
(C.E. BAIRD)
C.R.E. 6 Aust Div.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

AUSTRALIAN IMPERIAL FORCE.

2/15 Aust Fd Coy.
R.A.E. 6 Aust Div.

REPORT ON 48' DIAMETER CRATER IN SOFT CLAY.

Ref Map.- ATHERTON TABLELANDS - 1 inch to 1 mile.

Report by:- Maj W.T.GRAHAM. 2/15 AUST FD COY.
Date:- 3 Sep 43.

C.R.E.
6 Aust Div.

1. GENERAL.

(a) This report should be read in conjunction with:- REPORT ON CRATERS IN HARD CLAY dated 3 Sep 43.

(b) In general the method, calculations, etc, will be similar, but due to the characteristics of hard and soft damp clay being different, quantities of explosives required, etc, will also be different.

(c) Further tests will be undertaken to obtain further data on drilling rates etc.

2. METHOD.

The diagrams in APPENDIX "A", show the method.

3. RESULT.

(a) A 1350 lb. charge of AN gelignite 60 gave a crater 48' in diameter x 14' deep. APPENDIX "A".

(b) Times Taken.

(I)	Drilling or "punching" holes.	5 minutes.
(II)	Removing drill.	3 "
(III)	Increasing hole diameter.	2 "
(IV)	Blowing 2 Camouflets.	5 "
(V)	Safety precaution, blowing in air.	5 "
(VI)	Loading main charge 1350lbs.	45 "
(VII)	Placing, tamping & firing charge.	45 "
	Total time taken.-	110 "

(c) The above work was done by 1 NCO and 5 men (including a driver) with a truck, compressor and tools.

(d) The relatively long time taken to place the earth tamping was due to the camouflet charge being calculated as for hard clay, and the camouflet being at least twice, possibly three times the required size.

4. CONCLUSIONS.

(a) The method requires further testing.

(b) The times taken suggest that a Platoon (or 3 Sections) well organised & familiar with the method could within 1 to 2 hours of commencing work produce a large crater, and from then on, if craters were less than 1/2 mile apart produce one each 1/2 to 1 hour.

(c) With drills greater than 12' in length larger craters are possible.

(d) Only experienced NCO's and men can be expected to carry out the method rapidly.

5. APPENDICES.

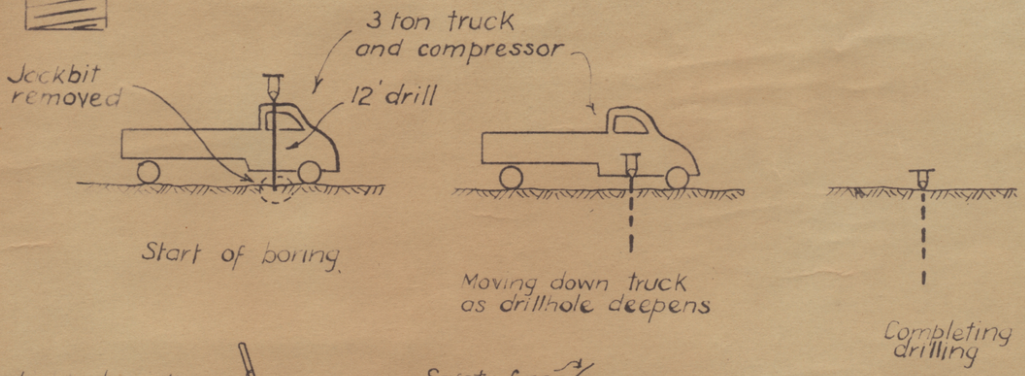
A. Diagrams of Methods & Results.
B. Check tests of drilling method.
C. Photographs of the crater.

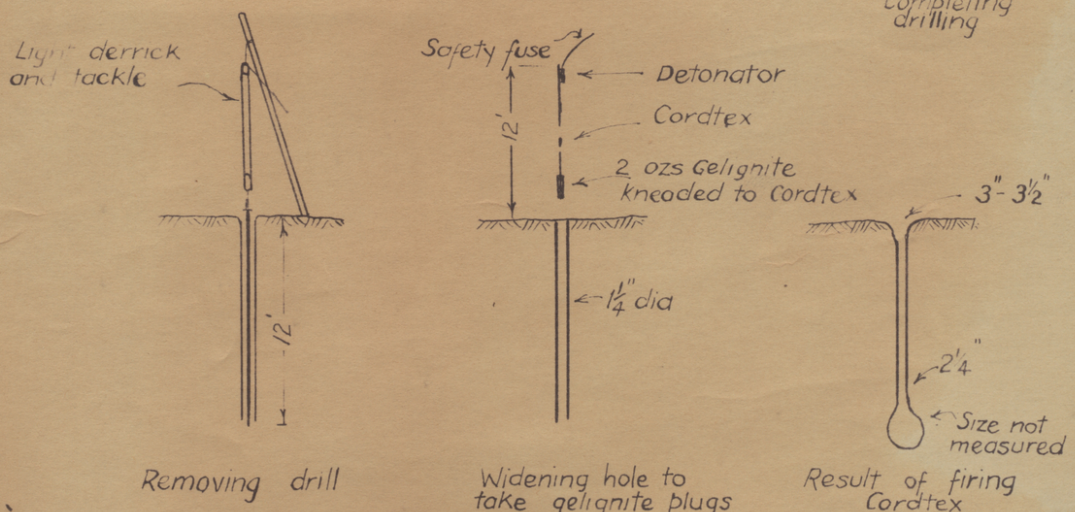
W.T.Graham Major
O.C. 2/15 Aust FdCoy. R.A.E.

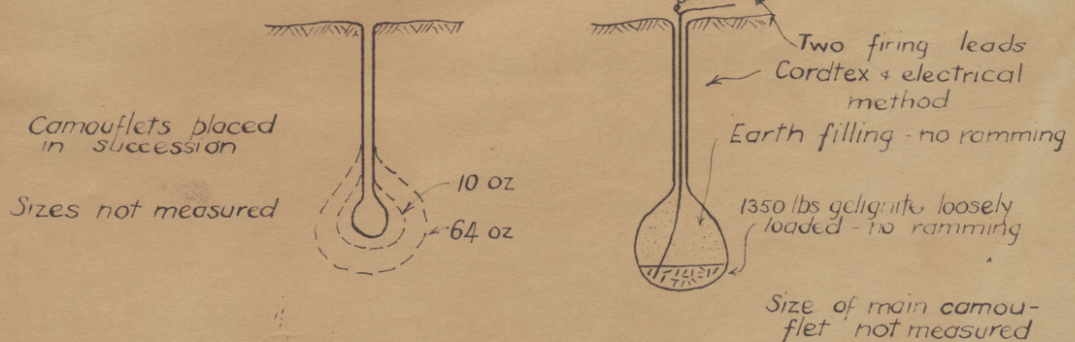
AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

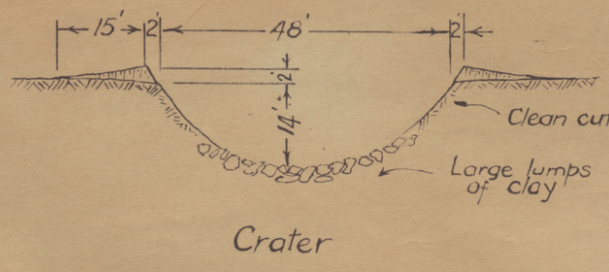
APPENDIX A











R.A.E 6 AUST DIV.

DEMOLITION CRATERS IN SOFT DAMP CLAY	
Plan No. FF 36	Sheet No 1
Designed by A/S/Sgt Hill	
Drawn by Lieut J.M. Barrett	
Checked by Capt Maj 9 Sep 43 OC 2/15 Aust Fd Coy R.A.E	

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX B.

CHECK TESTS OF DRILLING IN SOFT CLAY.

1. Table of Time & Labour.

(a) First day's experiments.

Serial No.	Task.	Men.	Time (Mins)	Remarks.
1.	Drilling	2	10	Depth 11'. All times
2.	Preparing derrick.	2	10	are the average of two
3.	Erecting "	4	40	tests.
4.	Withdrawing steel.	4	10	

(b) Second day's experiments.

1.	Drilling	2	3	Depth 11'. The times
2.	Preparing derrick.	2	3	are the average of 12
3.	Erecting "	4	(27)	tests carried out dur-
4.	Withdrawing Steel.	4	6	ing one morning between 0830 & 1130 hours.

2. On the second day's tests:-
   (a) The derrick was prepared and erected, prior to commencing drilling, for all holes except the first.
   (b) With 4 men the average time for 11 tests for drilling and withdrawing the drill steel was 9 minutes.

3. All the above tests were carried out using 12' drill steel without jackbits, in soft damp clay.

4. In very damp or sticky clays it may be preferable to only drill 4' to 6' in depth, withdraw the drill, widen the hole diameter with cordtex, continue drilling another 4' to 6' and repeat the above process until the required depth is reached.

.....

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX C.



1. View looking across the crater.



2. View looking down into the crater.

48 FEET DIAMETER CRATER IN SOFT CLAY.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

AUSTRALIAN IMPERIAL FORCE.

APPENDIX 14

War Diary

Ref 43/45/18

H.Q. R.A.E.
6 Aust Div.
7 Sep 43.

REPORT ON END ON PILE DRIVING.

C.E., 2 Aust Corps.

1. END ON PILE DRIVING.

(a) General. End on pile driving, using an industrial crane with false leaders and a single or double acting steam hammer, has proved to be one of the fastest methods of driving piles in railway bridge construction.

(b) Experimental Work. During the last few weeks 2/22 Aust Field Park Coy and 2/15 Aust Field Coy, working independently, have been carrying out experiments to determine whether methods of end on pile driving suitable for use in forward areas can be developed. The following methods have been developed:-

(i) 2/22 Aust Field Park Coy, have developed single and double headed piling frames, cantilevered from a 3 ton winch truck. (See Appendices C and D).

(ii) 2/15 Aust Field Coy have developed a cantilevered timber traveller. (See Appendix E).

2. SINGLE HEADED PILING FRAME MOUNTED ON A 3 TON TRUCK.

(a) General. Details of the frame, mounting and method of driving are shown in Appendix C. It will be noted that this arrangement allows pile sets to be driven at 10 feet centres which would be quite suitable for light jetty construction.

(b) Tests. Details of pile driving tests carried out with this arrangement are shown in Appendix A.

(c) Rate of Driving. The winch gear of a 3 ton winch truck is capable of delivering 2½ blows per minute with a drop varying from 7 feet to 15 feet. (See Appendix A).

3. DOUBLE HEADED PILING FRAME MOUNTED ON A 3 TON TRUCK.

(a) General. Details of the frame and method of mounting are shown in Appendix D. This frame is cantilevered to enable pile sets to be driven at 16 feet centres. The frame has been built, see photo Appendix B, but not yet mounted on a truck and tested.

(b) Method of Working. With this machine two monkeys can be operated by the winch of a 3 ton winch truck at the same time which should enable the time of driving a set to be appreciably increased and offset, to some extent, the slow rate of driving with the winch gear of a 3 ton truck.

(c) Placing of beams. With the above frames after a set of piles has been driven, pile driving has to stop until the superstructure for the bay ahead has been put down and then pile driving may be continued. The above frames may be used for placing the beams in position.

/over.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

4. PILE DRIVING TRAVELLER.

(a) General. Details of construction and the method of working the traveller are shown in Appendix E. After driving the pile set is capped, temporary struts are placed between the sets and by means of the winch gear pulling on the newly driven pile set, the traveller is dragged forward ready for driving the next set. With this arrangement pile driving can proceed continuously whilst another party follows behind installing the superstructure.

(b) Experimental Work. A traveller similar to the one shown in Appendix E has been built and tested. In this model there was too much deflection and whip at the ends of the beams. In spite of these difficulties three sets were driven by 2/15 and 2/2 Aust Field Coys and sufficient experience obtained to show that the idea is sound and likely to be of considerable value for piled jetties or bridges.

The drawing, Appendix C, incorporates improvements found necessary as a result of the experience gained in the construction of the first traveller. These improvements are:-

(i) Packing pieces on the ends of the cantilevered beams to allow the tie wires to be placed further forward and so reduce end deflection.
(ii) The diagonal struts are carried further forward to reduce "whip" when driving.
(iii) Plain wire or S.W.R. ties are used instead of barbed wire which was found difficult to tension.
(iv) Rollers, now under construction by 2/2 Aust Field Park Coy, to assist in pulling the frame forward. Rollers are not essential if the beams are well greased.

(c) Winch. The winch gear of a 3 ton truck is only a makeshift for pile driving work. Best results would be given by a light petrol or diesel winch with a lifting capacity of, say, 25 cwt direct off a drum operated by a friction clutch. Natives using block and tackle could be used in lieu of a winch truck for operating the hammer and pulling the traveller forward.

(d) Batter Piles. Batter piles may be driven from the traveller by turning the piling frame through 90° and placing on a ramp of the required batter. A device for driving batter piles and rakers is being developed.

(e) Long Spans. By using light through trusses in place of the two twitched beams a traveller could be built for driving at say 40 feet centres.

5. COMPARISON OF METHODS.

(a) Small bridge or Jetty. It takes about 1½ to 2 days to build the traveller whereas the truck piling frames can be assembled in about ½ a day. For a small job therefore the piling frame cantilevered from a 3 ton truck may be more suitable.

(b) Large bridge or Jetty. For a long jetty the traveller would be more suitable since pile driving can continue without interruption and after the pile driving has got ahead by by two bays, the party erecting the superstructure may also work without interruption.

/over.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

5. COMPARISON OF METHODS.

(c) Long versus short spans. Experience is necessary before it can be laid down whether, say, 40 feet spans are more economical in labour and time than 30 feet, 20 feet or 10 feet spans. A traveller for driving 40 feet spans could easily be built and a piled bridge with sets at 40 feet and a trussed beam superstructure might be a very suitable answer to a river subject to heavy floods.

E. E. Bavin
.....Lt. Col.
C.R.E. 6 Aust Div.

LIST OF APPENDICES.

APPENDIX A. Table of Test Results.
APPENDIX B. Photo of double headed piling frame.
APPENDIX C. Drawing of single headed frame.
APPENDIX D. Drawing of double headed frame.
APPENDIX E. Drawing of traveller.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX "A".

TABLE OF TEST RESULTS FROM SINGLE HEADED PILING FRAME MOUNTED ON A 3 TON TRUCK. (SEE APPENDIX C).

Dia of Pile.	Height drop.	Set	Pene-tration.	Average blows per Min.	Safe Load. $P=\frac{3wH}{S+1}$	Time taken to drive pile.
6"	7' - 17'	Max set $\frac{15}{16}$". Final set $\frac{1}{2}$"	11'6"	2½ blows p/m Power winch driven.	5 tons	1 hour.
8"	5'-15'6"	Max set $\frac{7}{8}$" Final set $\frac{1}{2}$"	8'	1 blow p.m Hand winch driven.	5 tons	2 hours.
10"	7'-15'	Max set $\frac{9}{16}$" Final set $\frac{7}{32}$"	9'5"	2½ blows p/m Power winch driven.	6 tons	1¾ hrs.
12"	7'-11'6"	Max set $\frac{5}{16}$" Final set $\frac{3}{16}$"	6'2"	2½ blows p/m Power winch driven.	4.5 tons	2 hours.

REMARKS.

COMPOSITION OF SOIL.

1' Clay (Soft)
1' Gravel (Light)
10' Wet compact Clay & Gravel.

After two (2') feet the driving was hard.

DETAILS OF MONKEY.

A 350 lb. Wooden Monkey was used.

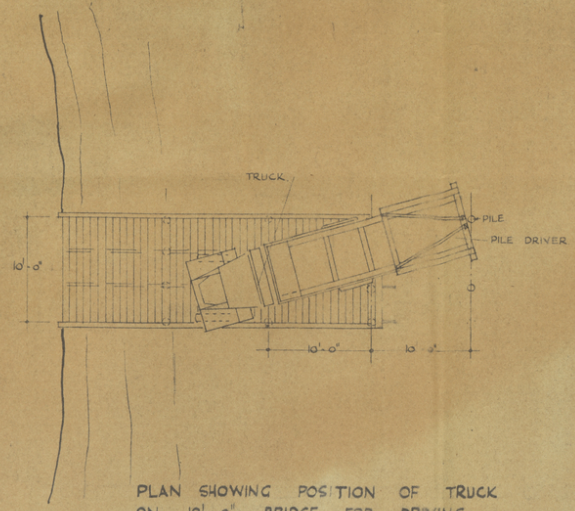
AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX B.



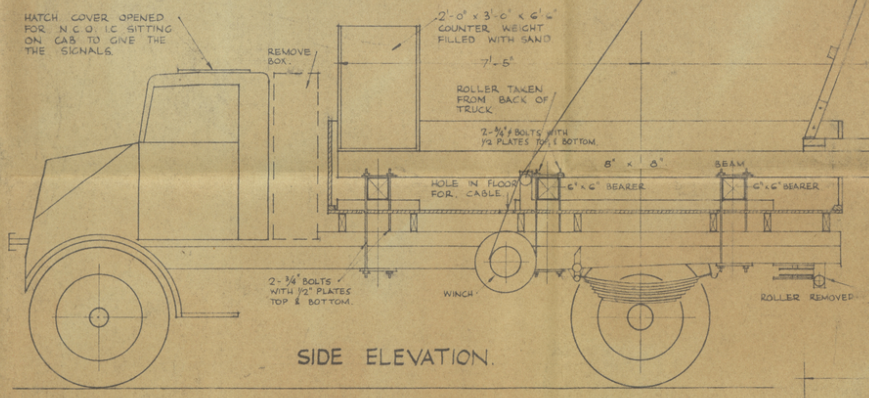
Double headed piling frame, built by 2/22 Aust Field Park Coy, ready for erection on a 3 ton winch truck. (See appendix D for details).

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

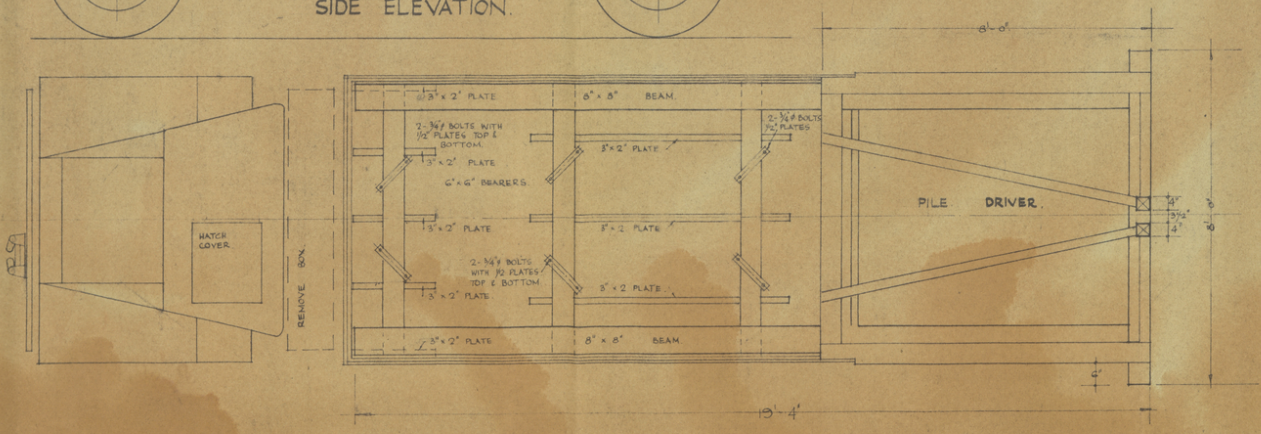


PLAN SHOWING POSITION OF TRUCK ON 10'-0" BRIDGE FOR DRIVING SIDE PILE 10'-0 OUT.

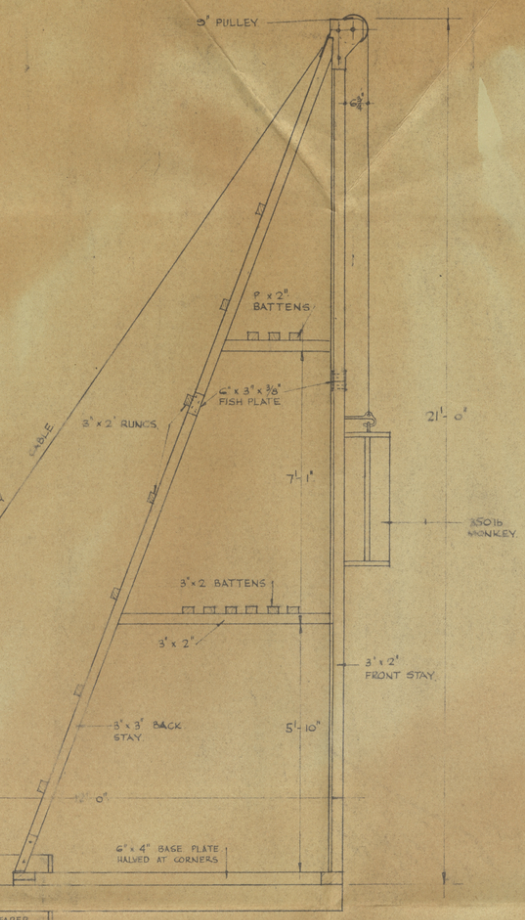
SCALE 1/8" = 1 FOOT

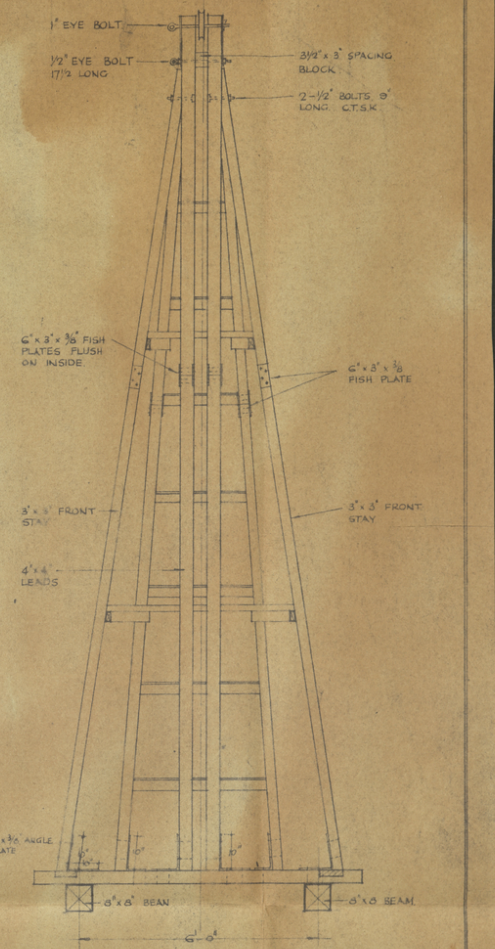


SIDE ELEVATION.



PLAN





FRONT ELEVATION.

PLAN OF LIGHT FIELD PILE DRIVER MOUNTED ON 3 TON WINCH TRUCK

AS CONSTRUCTED BY 2/22 AUST FIELD PARK COY R.A.E. 6TH AUST DIVISION

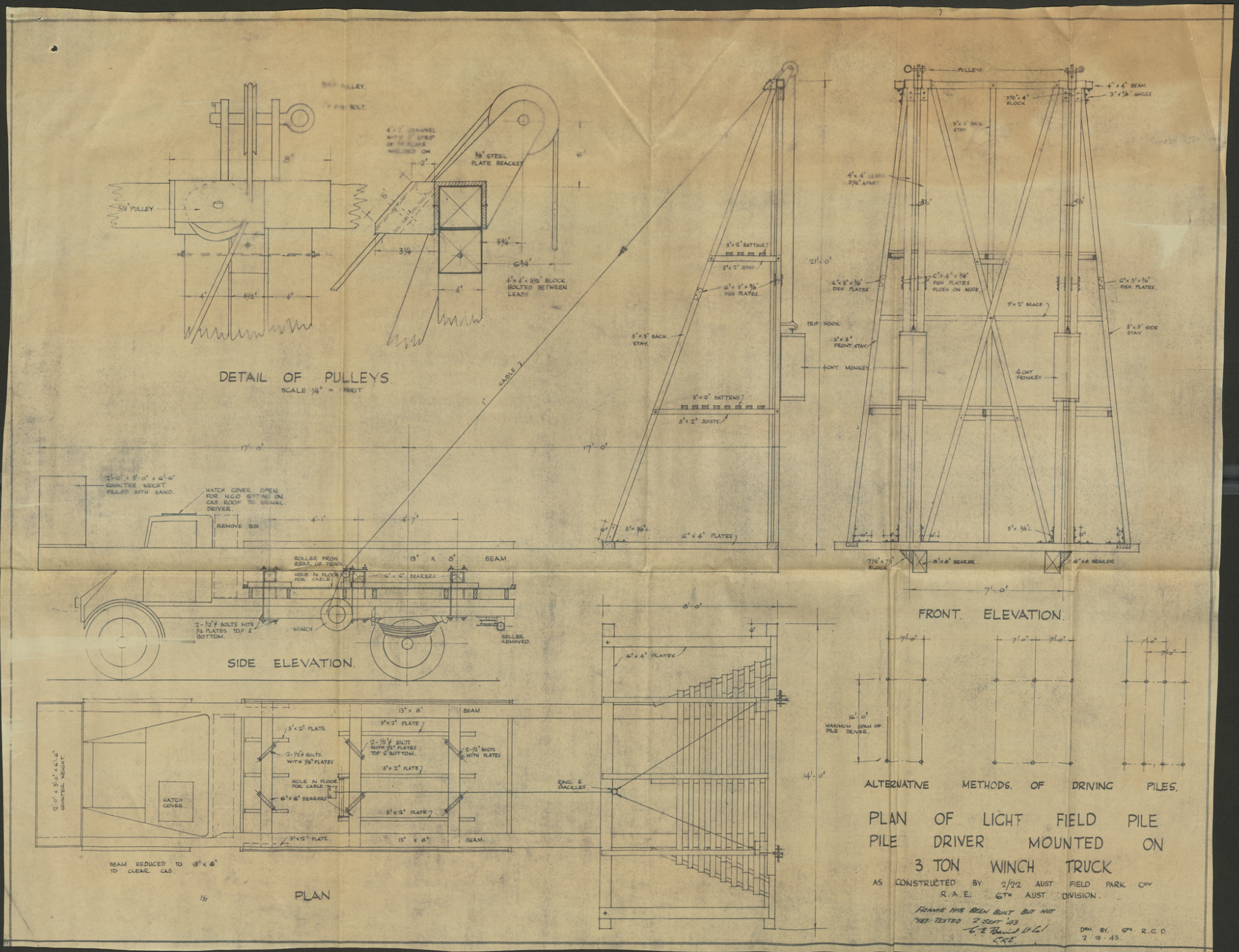
SCALE. 1/2" = 1 FOOT

NOTE :- FOR DETAILS OF PILE DRIVER REFER MILITARY ENGINEERING VOL III PART I REF Nº SEC 78.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX C

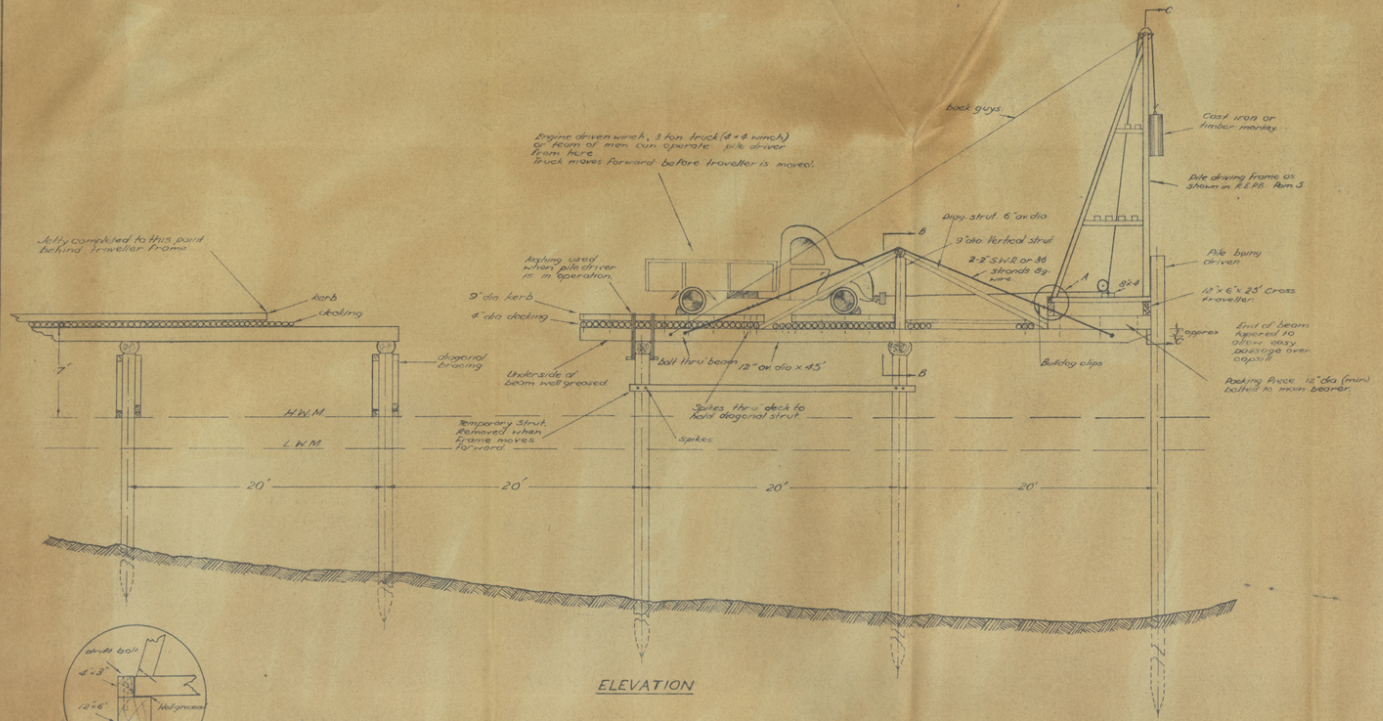
AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX D

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



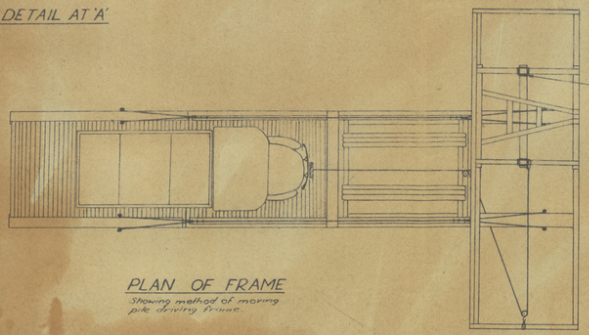
ELEVATION

DESIGN DATA

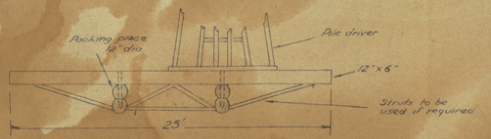
WEIGHTS.
a. 3 ton truck (4x4 winch) – 4 ton 10 cwt
b. Cast iron monkey – 10 cwt
c. Pile frame – 10 cwt
d. Pile 30' × 12" dia. – 25 cwt
Timber – Group B
S.W.R. or Plain wire – Safe load half normal safe load i.e. 90°

TRAVELLER FRAME	SPAN 10'	15'	20'	25'	30'
Top Diameter (twin) inches			10		
T or T Strut Diam – inches			9		
Diag. Tension member S.W.R.			3		
REMARKS.					

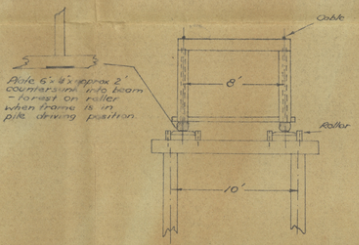
DETAIL AT 'A'



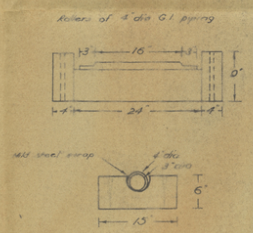
PLAN OF FRAME
Showing method of moving pile driving frame.



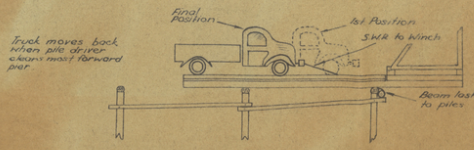
SECTION 'CC'



SECTION 'BB'
This view shows rollers as alternative method for moving frame forward. Rolling not shown on main elevation.



DETAIL OF ROLLERS



METHOD OF MOVING FRAME FORWARD
(diagrammatic only)

STANDARD.
R.A.E. 6. AUST. DIV.
E.E. Baird Lt-col.
C.R.E.

TRAVELLER FOR PILE DRIVING FOR BRIDGE OR JETTY.

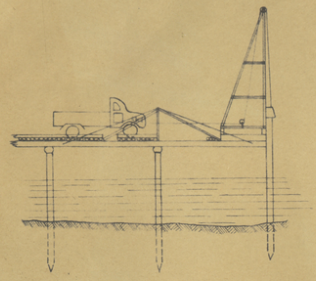
PLAN No F.F. 2	SHEET No 1
Designed by Major W.T. Graham.	
Drawn by Lieut. A.J. Bryant.	
Checked by Capt. J.L. Daly.	
W.T. Graham Major	
O.C. 2/15 Aust. Fd. Coy. 3 Sep 43	

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

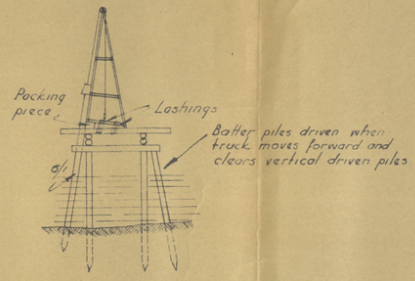
APPENDIX E

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

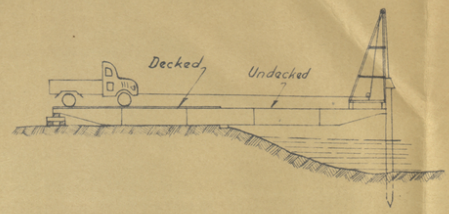
APPENDIX F



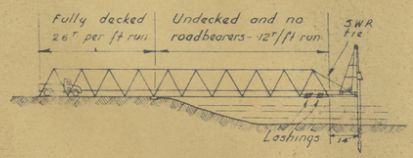
TIMBER GIRDERS
(See Drg. N° FF 2)



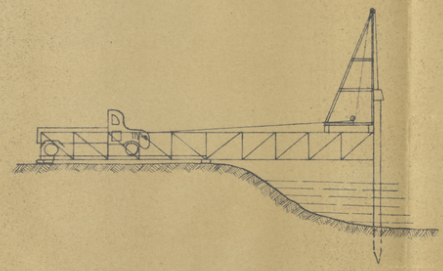
DRIVING BATTER PILES



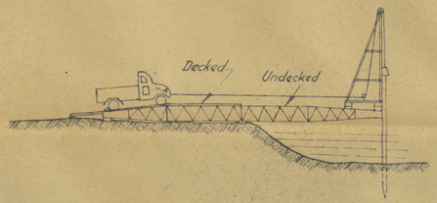
COMMERCIAL BOX GIRDER



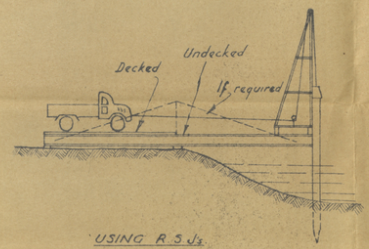
STEELE BRIDGE



IMPROVISED TIMBER RING CONNECTOR TRUSS FOR LONG SPANS



S. B. G.



USING R.S.J.s

NOTES:

1. Suggested methods of cantilever end on pile driving using improvised and equipment bridging. Detail calculations will be required for each case, depending on:-
   a) Weight of monkey, pile frame, etc.
   b) Max. length of cantilever.
   c) Weight of Counterweight

2. The diagrams show the use of a 3-ton winch truck. A normal power driven pile driving winch would be preferable for speedier construction.

RAE - 6 AUST DIV.
G E Baird Lt-col.
CRE.

CANTILEVER METHODS OF PILE DRIVING	
PLAN N° FF 44	SHEET N° 1
DESIGNED BY:	2/15 Aust Fd Coy
DRAWN BY:	Lieut K Wegg
CHECKED BY:	Bal Capt
W L Graham Major	
21 Sep 43	OC 2/15 Aust Fd Coy

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

AUSTRALIAN IMPERIAL FORCE.

APPENDIX 15

H.Q. R.A.E.
6 Aust Div.
24 Sep 43.

Ref 43/55/18.

War Diary

REPORT ON END ON PILE DRIVING.

E.E.
2 Aust Corps.

1. Ref our report 43/45/18 of 7 Sep 43. Will you please add the attached drawing as Appendix F to the above report.

2. The piling diagrams of Appendix F are not worked out in detail but indicate further applications of end on pile driving methods for use with standard equipment bridges.

C E Baird
.....Lt. Col.
(C.E. BAIRD)
C.R.E. 6 Aust Div.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

War Diary

APPENDIX 16

AUSTRALIAN IMPERIAL FORCE.

H.Q. R.A.E.
6 Aust Div.
10 Sep 43.

Ref 43/68/17.

BRIDGING TRAINING R.A.E. 6 AUST DIV.

C.E.
2 Aust Corps.

1. GENERAL.

Photos of bridges erected by R.A.E. 6 Aust Div during training are attached (Appendix A).

2. 148 FEET STIFFENED SUSPENSION BRIDGE.

(a) General. This bridge, with modification, was built to the drawing shown in Appendix A, Engineer Intelligence Summary, No.13. The general arrangement of the bridge is shown in photos 1 to 8 and photos 9 to 13 show details of construction. The principal modifications to the original design, were:-

(i) The hangers, at 8 feet spacing, were attached to transomes instead of to the bottom chords, see photo No.12.

(ii) Longitudinal decking instead of transverse decking.

(iii) A different method of connecting the diagonal truss members to the top and bottom chords was used, see photos 12 and 13. This method of connection is good if S.W.R. is available for the diagonals but is not as good as the connection shown in Appendix A of E.I.S. No.13. If plain wire is used to develop the full strength of the diagonals it is necessary to leave the twitching bars in the diagonals and to secure them so as to prevent the wires from untwisting under heavy loads.

(iv) A clip connection was used to attach the hangers to the cables.

(b) Man hour data. All the decking was sawn by 2/22 Aust Field Park Coy on their 28" saw bench, the round timber being cut locally. Construction was interrupted due to works, 2564 man hours being required for the erection of this bridge. Man hour details are given in Appendix B.

3. TWITCHED BEAM BRIDGE.

(a) General. A 60 feet class 9 bridge was constructed by 2/2 Aust Field Coy to the drawing shown in Appendix C, E.I.S. No.14. Old mining cables and plain wire were used for twitching the beams. Photos 14 and 15 show details of construction.

(b) Man hour data. 1297 man hours were required for the erection of this bridge. This figure includes the time and labour required to cut and transport the 60 feet beams from the jungle, about 6 miles away, to the site of the bridge.

4. UNSTIFFENED SUSPENSION BRIDGE.

(a) General. An 100 feet span, class 9, unstiffened suspension bridge was built by 2/2 Aust Field Coy to the design shown in Appendix B, E.I.S. No.14. Photo No.16 shows the main cables being secured to the anchorages.

(b) Man hour data. 1300 man hours were required for the erection of this bridge.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

5. BEAM AND TRESTLE BRIDGES ETC.

The following bridges were built by 2/22 Aust Field Park Coy during training:-

(a) Class 9, Beam and trestle bridge.

Overall. 124 feet, 7 girder spans and 1/37 feet truss span.
Man hours. 2873. See Appendix B.
Design. See photos, Appendix A.

(b) Class 5, Beam and trestle bridge.

Overall. 64 feet, 2/21 feet and 1/32 feet girder span.
Man hours. 831. See Appendix B for detail.
Design. See photos, Appendix A.

(c) Truss bridge, class 5.

Overall. 75 feet, one 50 feet truss.
Man hours. 1855.
Design. See photos, Appendix A.

L E Barnard
.....Lt. Col.
C.R.E. 6 Aust Div.

LIST OF APPENDICES.

APPENDIX A. PHOTOS.
APPENDIX B. MAN HOUR DATA.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471





PHOTO No.1.

PHOTO No.2.

128 feet stiffened suspension bridge, class 4, erected by 2/22 Aust Fd Pk Coy.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



PHOTO No.3.



PHOTO No.4.

128 feet stiffened suspension bridge, class 4, erected by 2/22 Aust Fd Pk Coy.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



PHOTO No.5.



PHOTO No.6.

128 feet stiffened suspension bridge, class4, erected by 2/22 Aust Fd Pk Coy.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471





PHOTO No.7. PHOTO No.8.

128 feet stiffened suspension bridge, class 4, erected by 2/22 Aust Fd Pk Coy.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



PHOTO No.9.



PHOTO No.10.

128 feet stiffened suspension bridge erected by 2/22 Aust Fd Pk Coy, showing details of towers.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471





PHOTO No.11

PHOTO No.12.

128 feet stiffened suspension bridge erected by 2/22 Aust Fd Pk Coy, showing details of construction.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



PHOTO No.13.

128 feet suspension bridge, showing details of bracing.



PHOTO No.14.

60 feet twitched beam bridge, class 9, erected by 2/2 Aust Fd Coy.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



PHOTO No.15.

60 feet twitched beam bridge, details of construction



PHOTO No.16.

100 feet unstiffened suspension bridge, class 9, built by 2/2 Aust Fd Coy, showing cables and anchorage.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



PHOTO No.17.



PHOTO No.18.

Beam and trestle bridge, class 9, erected by 2/22 Aust Field Pk Coy. Seven girder spans and one truss span, overall length 133 feet 7".



PHOTO No.19.



PHOTO No.20.

Beam and trestle bridge class 6, erected by 2/22 Aust Field Pk Coy. Overall length 64 feet, 3 bays, 21 feet, 32 feet and 21 feet.

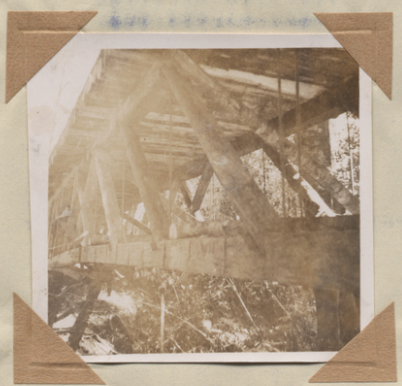


PHOTO No.21.

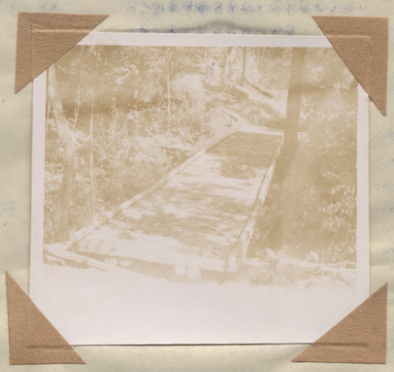


PHOTO No.22.

Truss bridge, class 5, erected by 2/22 Aust Field Park Coy. Span 75 feet (one 50 feet truss).

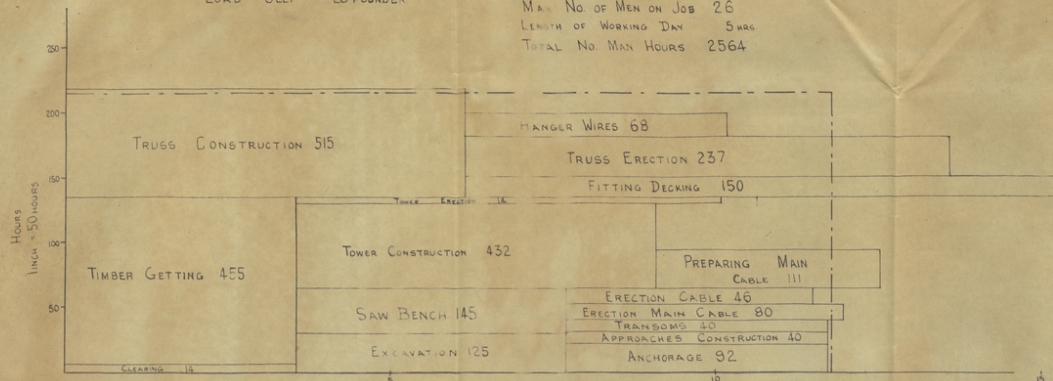
AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

Suspension Bridge

Span - 148' x 7' Roadway

Load Jeep + 25 pounder

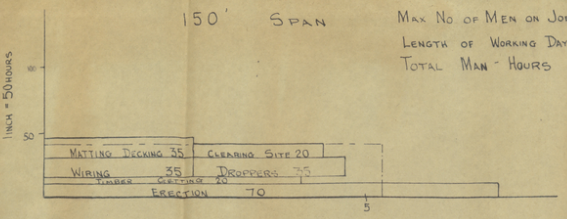
Max. No. of Men on Job 26
Length of Working Day 5 hrs.
Total No. Man Hours 2564



Foot Bridge

150' Span

Max. No. of Men on Job 7
Length of Working Day 5 hours
Total Man-Hours 210

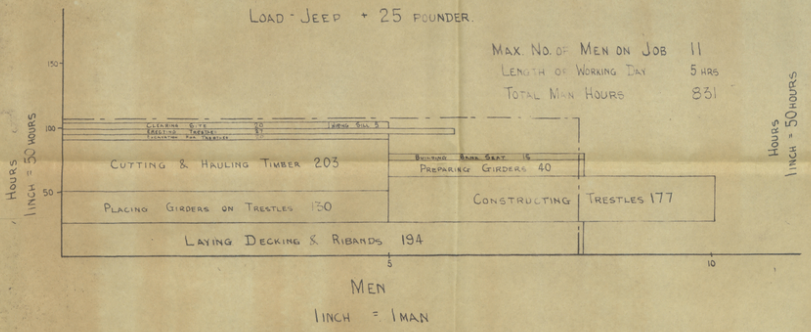


Trestle Bridge

3 bays 21' - 32' - 21' 64' Span

Load - Jeep + 25 pounder.

Max. No. of Men on Job 11
Length of Working Day 5 hrs
Total Man Hours 831

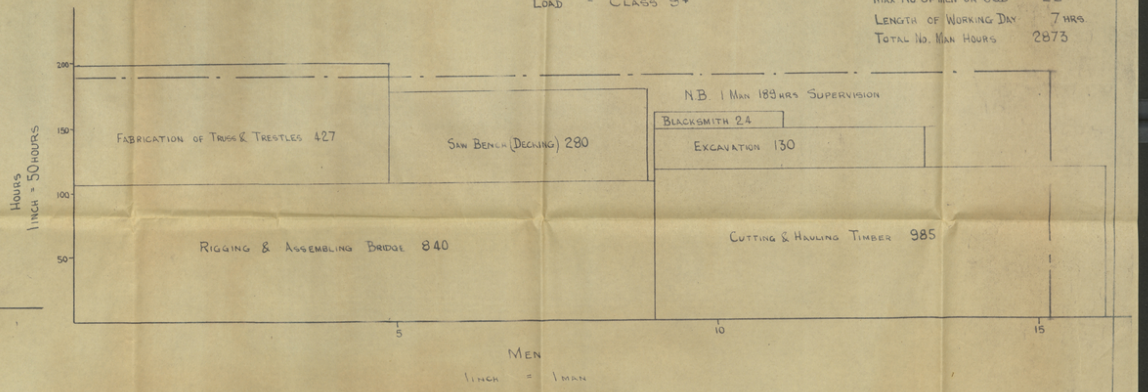


Timber Trestle Bridge 7 Timber Girder Spans 1 Timber Truss Span

Span 123'7" (37' Truss)

Load - Class 9+

Max No of Men on Job 22
Length of Working Day 7 hrs.
Total No. Man Hours 2873

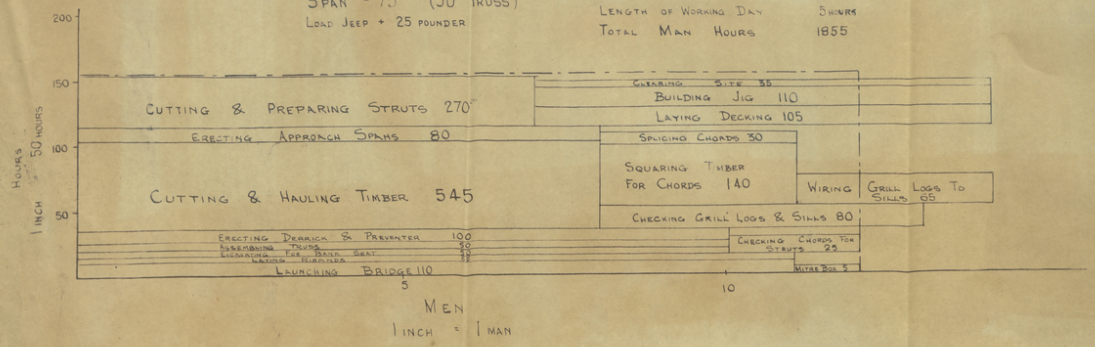


Truss Bridge

Span - 75' (50' Truss)

Load Jeep + 25 pounder

Max. No of Men on Job 20
Length of Working Day 5 hours
Total Man Hours 1855



Bridges Constructed by 2/22 Aust. Fd. Pk. Coy. R.A.E. 6 Aust Div.

Comparative Man-Hour Chart.

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APPENDIX B

AUSTRALIAN WAR MEMORIAL
AWM2020.71.1471

AUSTRALIAN IMPERIAL FORCE.

APPENDIX 17

H.Q. R.A.E.
6 Aust Div.
24 Sep 43.

Ref 43/56/18.

War Diary

REPORT ON HASTY CUTTING CHARGES FOR TREES.

C.E.
2 Aust Corps.

1. A report on experimental work carried out by 2/15 Aust Field Coy on hasty cutting charges for felling trees is attached. The method has proved to be fast and economical of explosives.

C E Baird
.....Lt. Col.
(C.E. BAIRD)
C.R.E. 6 Aust Div.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

AUSTRALIAN IMPERIAL FORCE.

2/15 Aust Fd Coy.
R.A.E. 6 Aust Div.

REPORT ON HASTY CUTTING CHARGES FOR TREES.

Ref Map. ATHERTON TABLELANDS - 4 Miles to 1 inch.

Report by:- Maj W.T.GRAHAM. 2/15 AUST FD COY.
Date:- 16 Sep 43.

C.R.E.
6 Aust Div.

1. METHOD.

(a) The method is shown in the sketches in Appendix C.

(b) AN Gelignite 60 was used for all tests, but other cutting explosives should give similar results.

2. RESULTS.

Test results to date are shown in Appendix A.

3. CONCLUSIONS.

(a) For cutting trees, a scarf cut to a depth of D/6 and loaded with AN Gelignite 60 will cut trees when.-
(1) Untamped charge = C = 2 D lbs.
(2) Tamped charge = C = $\frac{3\ D}{2}$ "

(b) The method is rapid & gives a greater economy in explosives than the normal hasty method of cutting charges, Appendices A & B.

(c) For diameters over 3 feet there is less than 1 lb saving in explosives when compared with the auger hole method, Appendix B.

(d) The method appears to be worthy of further tests in other localities.

4. APPENDICES.

A. Test results.
B. Comparison of tree cutting formulae.
C. Sketches of method.

W T Graham
.....Major.
O.C. 2/15 Aust Fd Coy. RAE.
6 Aust Div.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX "A".

TABLE OF TEST RESULTS.

Serial No.	Tree Diam Ft-ins.	Type of Timber.	Formula Used.	Charge. lbs-ozs.	Tamped or Untamped.	Total time taken. Mins.	REMARKS.
1	0- 6	Hardwood	2D	1 - 0	Untamped	--	Completely cut log on ground.
2	0- 8	"	2D	1 - 6	"	--	" " " " "
3	0- 10	"	2D	1 - 11	"	--	" " " " "
4	1- 3	"	2D	2 - 8	"	--	" " " " "
5	1- 6	"	2D	3 - 0	"	--	" " " " "
6	1- 6	"	3D/2	2 - 4	"	5	Tree approx 75% cut, but fell over.
7	1- 8	"	2D	3 - 6	"	-	Log on ground approx 75% cut.
8	2- 0	"	3D/2	3 - 0	"	7	Tree approx 75% cut, but fell over.
9	2- 9	"	2D	4 - 0	"	-	Log on ground approx 75% cut.
10	2- 6	"	3D/2	3 - 12	"	9	" " " " " "
11	3- 0	"	2D	6 - 0	"	11	Tree completely cut.
12	3- 6	"	2D	7 - 0	"	15	" " "
13	1- 0	"	3D/2	4 - 8	Tamped	4	" " "
14	1- 6	"	"	2 - 4	"	5	" " "
15	2- 0	"	"	3 - 0	"	7	" " "
16	2- 6	"	"	3 - 12	"	9	" " "
17	3- 0	"	"	4 - 8	"	12	" " "
18	3- 3	"	"	4 - 14	"	10	" " "
19	3- 6	"	"	5 - 4	"	15	" " "
20	4- 6	"	"	6 - 12	"	18	(Tree with large fins at base. Only cut centre.
21	3- 6	"	"	6 - 8	"	18	(Tree held in place by fins. Tree completely cut. The main charge by the formula is 5lbs 4ozs. An additional 1-lb 2ozs (3/6oz plugs) was placed on the fins. (See Appendix C).

APPENDIX B

1. TABLE SHOWING COMPARISON OF QUANTITIES REQUIRED:

DIAMETER.	NEW METHOD. TAMPED 3D/2		NEW METHOD. UNTAMPED. 2D	NORMAL CUTTING CHARGE. HARDWOOD 3 x 3D's		NORMAL CUTTING CHARGE. SOFTWOOD 3 x 3D's/2		AUGER HOLE CHARGE. 6 D2	
	lbs.	ozs.	lbs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.
6"		12	1	1	2		9		2
1' 0"	1	8	2	9	0	4	8		6
1' 6"	2	4	3	30	6	15	3		14
2' 0"	3	0	4	72	0	36	0	1	8
2' 6"	3	12	5	140	10	70	5	2	6
3' 0"	4	8	6	243	0	121	8	3	6
3' 6"	5	4	7	385	14	192	15	4	10
4' 0"	6	0	8	576	0	288	0	6	0

2. CALCULATIONS ARE BASED ON :- (i) Using AN Gelignite 60.
(2) Factor for gelignite as per E in C Instructions No.3

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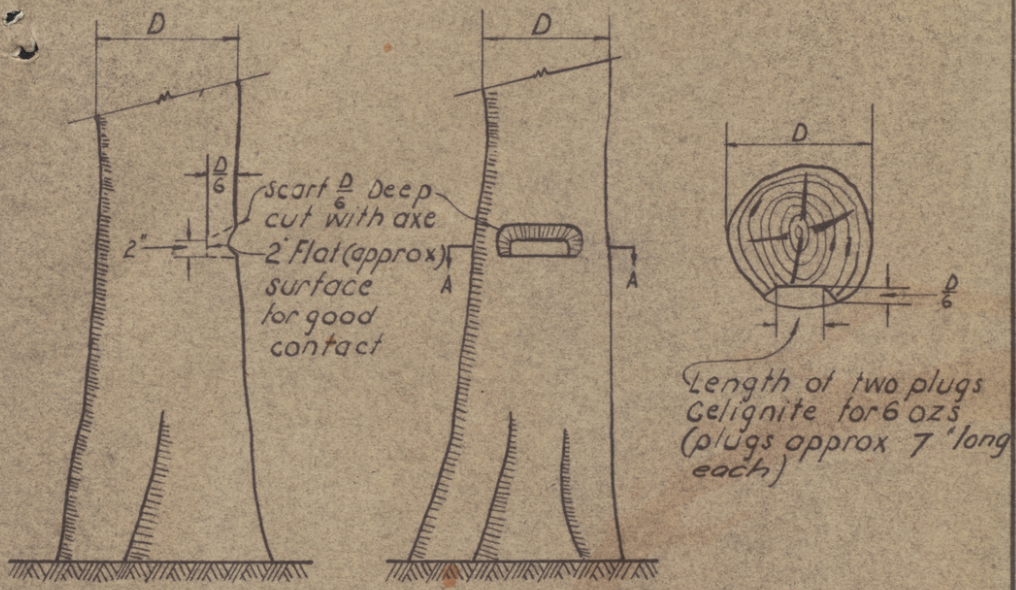
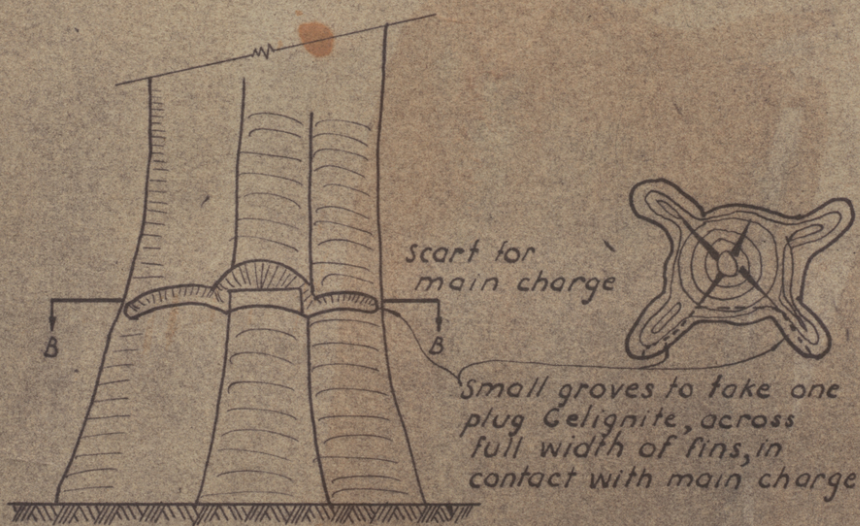


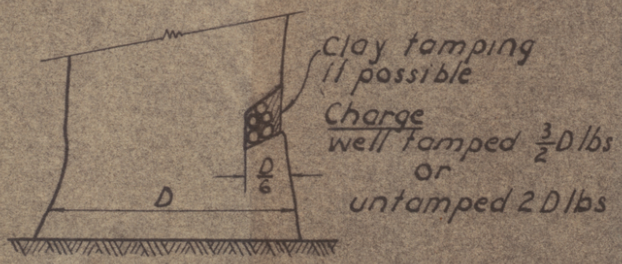
SIDE VIEW FRONT VIEW SECTION A-A

SHOWING METHOD OF SCARFING TREE FOR CHARGE



FRONT VIEW SECTION B-B

SHOWING METHOD OF SCARFING JUNGLE TIMBER WITH HEAVY FIN FORMS



PLACING OF CHARGE

RAE 6 AUST DIV
C. E. Bauer Lt. col
CRE

TIMBER FELLING HASTY METHOD	
Plan No FF 39	Sheet No 1
Designed by A/S/Sjt Hill S.	
Drawn by Spr James E.	
Checked by Baly Capt.	
W. Graham Major OC 2/15 Aust Fd Coy RAE	

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

AUSTRALIAN IMPERIAL FORCE. APPENDIX 18

Ref 43/46/18. War Diary

H.Q. R.A.E.
6 Aust Div.
8 Sep 43.

SUSPENSION FOOT, JEEP AND PACK TRANSPORT BRIDGES.

C.E.,
2 Aust Corps.

1. GENERAL.

Experimental work has been carried out by 2/2 Aust Field Coy, 2/15 Aust Field Coy and 2/22 Aust Field Park Coy on unstiffened suspension bridges to determine the most suitable types for easy erection in operational areas.

2. TWIN CABLE UNSTIFFENED SUSPENSION FOOTBRIDGE.

(a) General. The above bridge was first constructed to the drawing shown in Appendix C on Engineer Intelligence Summary No.14. The decking of the original drawing (E.I.S. No.14) is rather too heavy and less speedy in erection than the matting deck shown in appendices C, D and E to this report. It is recommended that Appendix C (E.I.S. No.14) be replaced by Appendix C to this report.

(b) Details of Design. See Appendix C and photos 1, and 8 of Appendix A for details of construction.

(c) Construction Data. Man hour data on this bridge is shown in detail in Appendix B. It is estimated that, with standing timber available within ½ a mile of the site, an 150 feet span bridge, built to Appendix C attached, can be erected by 1 platoon in 12 hours.

3. SINGLE CABLE UNSTIFFENED SUSPENSION FOOTBRIDGE.

(a) General. This footbridge developed by 2/15 Aust Field Coy, has been found most satisfactory. See Appendix D and photos 2,3,4,5, 6 & 8 Appendix A for details of construction. The single cable bridge has the following advantages over the twin cable bridge:-

(i) Only one cable to erect and two anchorages to build with consequent saving in labour.
(ii) The towers are shear legs and easier to erect.
(iii) The spreader in the single cable bridge enables easy adjustments to be made to the length of hangers after the bridge is erected.
(iv) There is less sway in the single cable bridge due to the live load being directly under the cable.

(b) Construction data. Man hour data on this bridge is shown in detail in appendix B. It is estimated that with standing timber available within ½ mile of the site an 150 feet span bridge, built to Appendix D attached can be erected by 2 sections of a Field Coy in 8 hours.

4. SINGLE CABLE UNSTIFFENED JEEP OR PACK TRANSPORT BRIDGE.

(a) General. See Appendix D for design details. This bridge has not yet been erected and tests are necessary to determine whether it is suitable for jeep loading. The distortion of the cable under a jeep may be too great, in which case it may be possible to distribute the concentrated jeep load over at least 20 feet of the cable, instead of 10 feet, by using wire diagonals in addition to the vertical hangers.

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4. (Cont'd).

(b) Construction data. For man hour data on this bridge see Appendix B.

5. FLAT CABLE SUSPENSION BRIDGE.

(a) General. With improvised holdfasts this footbridge can be more rapidly erected than the footbridges described in paras (2) and (3) above, but it is not as steady under load as the above bridges. The decking is laid directly on top of the cables. For details see Appendix A, photo No.9, and Appendix F.

(b) Construction data. Man hour data for this bridge is shown in Appendix B. Using buried anchorages 3 sections could build an 130 feet bridge in 10 hours, but with improvised holdfasts the time could be halved.

6. LAWYER VINE FOOTBRIDGES.

See report on the structural value of lawyer vine for details.

7. MATERIALS OF CONSTRUCTION.

(a) Main cables. The main cables may be of S.W.R. plain fencing wire, 12½ barbed wire or lawyer vine (for light loads). S.W.R. cables are desirable and owing to difficulties in handling barbed wire should not be used if either S.W.R. or plain fencing wire is available.

(b) Hangers. The hangers may be of plain or barbed wire. Plain wire hangers are easier to handle and less liable to twist than barbed wire. Lawyer vine hangers may be used in a light bridge using the split cane and wedge connection, see report on lawyer vine tests.

T E Baird
.....Lt. Col.
C.R.E. 6 Aust Div.

LIST OF APPENDICES.

APPENDIX A. Photos of bridges.
APPENDIX B. Man hour data.
APPENDIX C. Drawing of twin cable suspension footbridge.
APPENDIX D. Drawing of single cable suspension footbridge.
APPENDIX E. Drawing of single cable pack transport bridge.
APPENDIX F. Drawing of flat cable suspension bridge.

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APPENDIX B.

TIME AND LABOUR DATA ON TWIN AND SINGLE CABLE CONSTRUCTED BY R.A.E. 6 AUST DIV ENGINEER TRAINING.

SER-IAL	WORK.	UNIT	ACTUAL MAN HOURS.	ESTIMATE FOR FUTURE WORK. MAN HOURS			REMARKS.
				MAN HOURS			
1.	Twin cable suspension bridge 150 feet span - 2 S.W.R. cables.	2/15 Aust Fd Coy.	680	600	1.Fl	12	Built to design appendix C S.I.S. No.14.
2.	Twin cable suspension bridge 150 feet span - 2 S.W.R. cables.	"	308	480	1.Fl	10	The anchorages used in serial No.1. A mat deck in lieu of longitudinal decking (see appendix C, S.I.S. No.14) was used.
3.	Twin cable suspension bridge 150 feet span - 2 barbed wire cables of 26 strands each were used for main cables.	2/M Aust Fd Coy	812				Constructed to plan appendix C to this report. Anchorages constructed for serial (1) were used.
4.	Turn cable suspension bridge 150 feet span - 2 barbed wire cables as above.	2/15 Aust Fd Coy	560	800	1.Fl	18	As for serial 3.
5.	Single cable susp.bridge 150 feet span - S.W.R. cable.	"	230	200*	2 Sec.	8	Constructed to drawing Appendix D attached First time constructed.
6.	Single cable suspension bridge 150 feet span - S.W.R. cable.	2/2 Aust Fd Coy	812				Constructed to drawing Appendix D attached First time constructed by 2/2 Aust Fd Coy.
7.	Single cable suspension bridge 150 feet span - S.W.R. cable.	2/22 Aust Fd Pk Coy	210				Constructed to drawing Appendix D attached First Time constructed.
8.	Single cable susp$ bridge 250 feet span - main cable of 54 strands of 16g gauge barbed wire and barbed wire hangers.	2/15 Aust Fd Coy	1255	1000	1.Fl	24	Constructed to drawing Appendix D attached but instead of log anchorages baulk holdfasts and tree stumps were used.

* Estimate based on the use of improvised holdfasts and not buried log anchorages. Add 120 man hours for buried log anchorages.

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SERIAL	WORK	UNIT	ACTUAL MAN HOURS.	ESTIMATE FOR FUTURE WORK. MAN HOURS	MEN	HOURS	REMARKS.
9.	Single cable susp. pack or jeep transport bridge.	2/15 Aust Fd Coy	510	480	1.Pl	10	Bridge 80% constructed to drawing Appendix E attached S.W.R. main cable and plain wire hangers.
10.	Single cable susp. pack or jeep transport bridge.	"	2290	1620	1.Pl	32	Bridge 90% completed. A.R.C. fabric used for decking.
11.	130 feet span flat cable footbridge.	2/15 Aust Fd Coy.	132				The holdfasts excavated for serial No.1. were used.
12.	130 feet span flat cable footbridge.	"	115				The mat decking for serial No.11 was used.
				180	3 Sec	5	Using improvised holdfasts such as trees, posts etc instead of log anchorage.
				360	"	10	Using buried anchorages.
13.	Mat deck for foot bridges. See details of mat foot walk Appendices C and D.						

Rate of making 10 feet coils of matting.

(i) Twisting Wires 2 men
(ii) Placing timbers 1 man
(iii) Twitching plain wire 1 man (twitching not required with barbed wire).

TOTAL. 4 men 20 minutes for 1 10 feet length of matting.

Rate of placing matting and longitudianl bearers in a bridge. 150' span.

Working from both ends a party of 16 men can lay the foot walk in 1 hour.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

SERIAL.	WORK	UNIT	ACTUAL MAN HOURS	ESTIMATE FOR FUTURE WORK MAN HOURS		REMARKS.
14.	Barbed wire straight cable construction - see report on structural value of barbed wire.	24 strand straight cable 300 feet long 56 strand straight cable 300 feet long 92 strand straight cable 300 feet long		-	50 man hours. 120 man hours. 150 man hours.	

NOTE.

(a) ACTUAL MAN HOURS. (Col.4.) The actual man hours required for some of the jobs are high due to:-

(i) Interruptions in the jobs due to other work.
(ii) Some of the phases being experimental.

(b) ESTIMATED MAN HOUR FIGURES. (Cols 5,6 and 7)

The estimate is based on:-

(i) Labour and engineering materials on the site.
(ii) Standing timber being available within ½ a mile of the site.
(iii) Log anchorages (buried) being used except where noted.



PHOTO No.1.

Twin cable unstiffened suspension footbridge 150 feet span erected by 2/2 Aust Fd Coy. Main cables consist of 26 strands of 12½ gauge barbed wire.



PHOTO No.2.

Single cable unstiffened suspension bridge 150 feet span, erected by 2/2 Aust Fd Coy. Main cable S.W.R., barbed wire hangers.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



PHOTO No.1.

Single cable unstiffened suspension foot bridge of 250 feet span erected by 2/15 Aust Fd Coy. Note barbed wire hangers and matting deck.



PHOTO No.4.

Single cable bridge 250 span during erection. The main cable consists of 54 returns of 12g gauge barbed wire.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



PHOTO No 5.

Single cable,250ft Span Suspension Footbridge built by 2/2 Aust Fd Coy.



PHOTO No 6.

Single cable(barbed wire,56 strands) Suspension foot bridge of 250' span. Photo shows placing of cattle

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471



PHOTO No 7

250ft Span Suspension Footbridge showing laying of bearers and Mat decking.



PHOTO No 8.

Twin Cable(24 strands barbed wire) 190ft span footbridge erected by 2/2 Aust Fd Coy.

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PHOTO No 9.

Flat cable suspension bridge, 130ft Span, erected by 2/15 Aust Fd Coy.

Matting deck on 2, 2" S.W.R. Cables.

Trees and picket holdfasts were used for anchorages.

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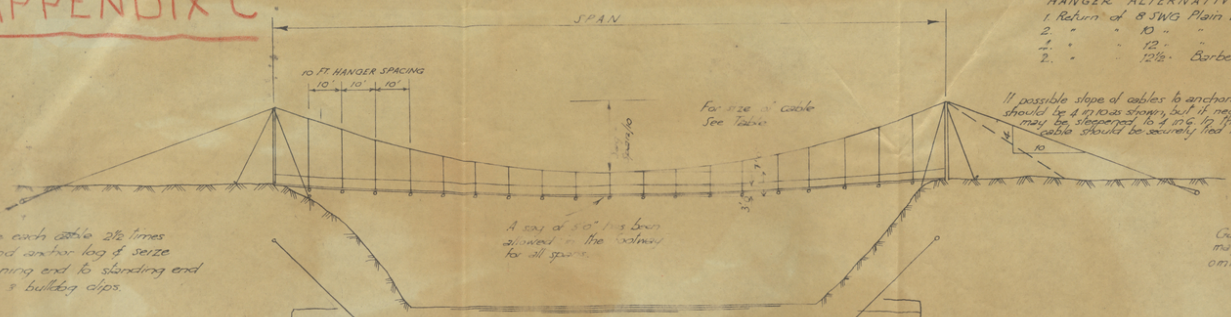
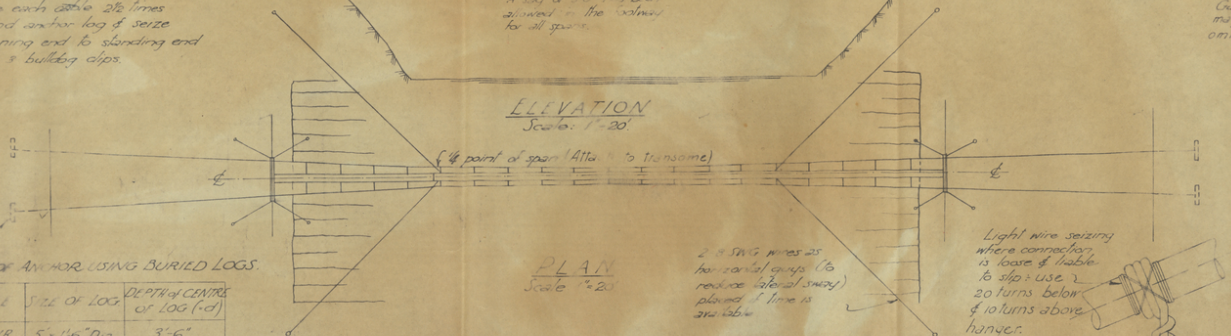
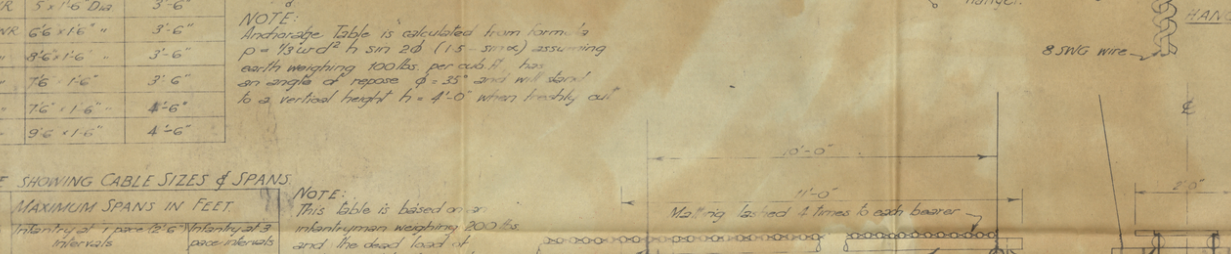
APPENDIX C

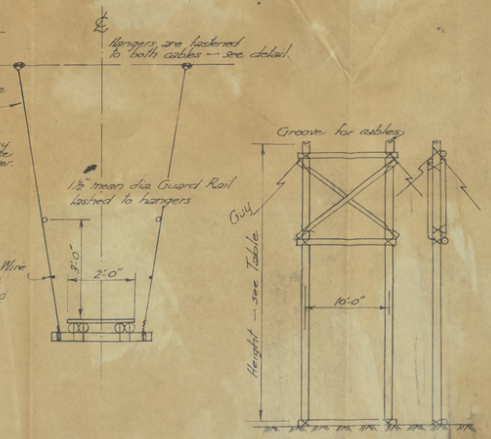






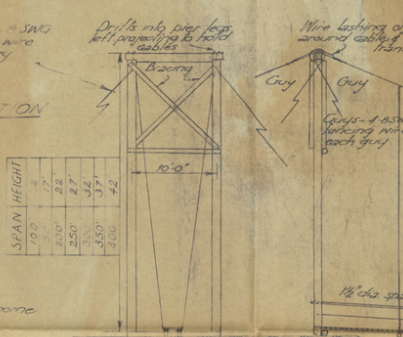
HANGER ALTERNATIVES:-
1. Return of 8 SWG Plain wire.
2. " " 10 " " "
1. " " 12 " " "
2. " " 12½ " Barbed wire

If possible slope of cables to anchorage should be 4 in 10 as shown, but if necessary may be steepened to 1 in 6 in this case cable should be securely tied to tower.



HANGER CONNECTION

PIER WITH LASHED JOINTS



PIER WITH DRIFT CONNECTIONS
Scale ½"=1'-0"

NOTE:
In emergency the main cables may be made up from plain or barbed fencing wire. It is advisable to plait plain wire into a cable but with barbed wire the strands should be laid parallel and held together with trapping turns. The working strengths for plain and barbed standard fencing wire after making deductions for twisting and allowing a factor of safety of 3 are given below.

Type of wire	Safe load per strand in lbs. 8 G	10 G	12 G
Black wire bright as for nails	485	350	260
Black wire soft as drawn	395	250	165
Galvanised	560	390	20-
Galvanised soft as drawn	395	250	15-
Barbed wire 12½ Gau		310 lbs	

SIZE OF ANCHOR USING BURIED LOGS.

CABLE	SIZE OF LOG	DEPTH of CENTRE of LOG (-d)
½" SWR	5' x 1'-6" Dia	3'-6"
1/2⅝ SWR	6'-6" x 1'-6" "	3'-6"
¾" "	8'-6" x 1'-6" "	3'-6"
⅞" "	7'-6" " 1'-6" "	3'-6"
2/2½ "	7'-6" x 1'-6" "	4'-6"
2/3" "	9'-6" x 1'-6" "	4'-6"

NOTE:
Anchorage Table is calculated from formula $p = \frac{1}{3} w r d^2 h \sin 2\phi$ (1.5 - sin α) assuming earth weighing 100 lbs. per cub. ft. has an angle of repose $\phi = 35°$ and will stand to a vertical height $h = 4'-0"$ when freshly cut.

TABLE SHOWING CABLE SIZES & SPANS

Circumference of SWR in ins = C	Maximum Spans in Feet: Infantry 3" pace (2'6") intervals — Two SWR per side	Infantry 3" pace (2'6") intervals — One SWR per side	Infantry at 3 pace intervals — One SWR per side
1"	26'	51'	52'
1⅛"	57'	115'	117'
2"	102'	205'	208'
2½"	160'	320'	325'
3"	230'	460'	468'

NOTE:
This table is based on a infantryman weighing 200 lbs. and the dead load of decking, cable etc. weighing 20 lbs. per foot run. Adopting the safe load for SWR as $16C^2$ then the max. spans for various sized cables are given by the following formulae:-
Infantry at 1 pace interval $L_{max} = 256C^2$
" " 3 " " $= 52C^2$

Ordinates & measurements along cable are calculated from formulae:
$y = \frac{4x^2}{L}$ & $S = x + \frac{8y^2}{3L}$
Origin ⅓ or ⅔ centre D of parabola.

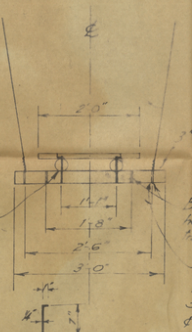


SPAN 150 FT	H	0	10-0	20-0	30-0	40-0	50-0	60-0	70-0	75-0														
	L	0	10'-7"	21'-0"	31'-3"	41'-8"	51'-10"																	
	D	-	33'-11"	19'-2"	8'-1"	7'-3"	7'-0"																	
SPAN 150 FT	H	0	10-0	20-0	30-0	40-0	50-0	60-0	70-0	75-0														
	L	0	10'-8"	21'-2"	31'-6"	41'-10"	52'-1"	62'-6"	73'-0"	77'-6"														
	D	-	35'-4"	20'-10"	11'-0"	8'-4"	8'-3"	7'-5"	7'-0"	-														
SPAN 200 FT	H	0	10-0	20-0	30-0	40-0	50-0	60-0	70-0	80-0	90-0	100-0												
	L	0	10'-9"	21'-6"	32'-1"	42'-9"	53'-6"	64'-4"	75'-2"	86'-0"	96'-10"	107'-8"												
	D	-	36'-9"	22'-6"	12'-9"	9'-4"	9'-0"	8'-4"	7'-10"	7'-7"	7'-6"	-												
SPAN 250 FT	H	0	10-0	20-0	30-0	40-0	50-0	60-0	70-0	80-0	90-0	100-0	110-0	120-0	125-0									
	L	0	10'-10"	21'-8"	32'-6"	43'-4"	54'-2"	65'-0"	75'-10"	86'-8"	97'-6"	108'-4"	119'-2"	130'-0"	135'-5"									
	D	-	38'-6"	24'-6"	14'-7"	10'-11"	10'-6"	9'-10"	9'-3"	8'-11"	8'-8"	8'-7"	8'-6"	8'-7"	8'-8"									
SPAN 300 FT	H	0	10-0	20-0	30-0	40-0	50-0	60-0	70-0	80-0	90-0	100-0	110-0	120-0	130-0	140-0	150-0							
	L	0	10'-9"	21'-8"	32'-6"	43'-5"	54'-3"	65'-1"	76'-0"	86'-10"	97'-8"	108'-6"	119'-4"	130'-3"	141'-1"	152'-0"	157'-5"							
	D	-	39'-7"	26'-6"	16'-8"	12'-10"	12'-5"	11'-8"	11'-0"	10'-6"	10'-3"	10'-1"	10'-0"	10'-0"	10'-1"	10'-2"	10'-3"							
SPAN 350 FT	H	0	10-0	20-0	30-0	40-0	50-0	60-0	70-0	80-0	90-0	100-0	110-0	120-0	130-0	140-0	150-0	160-0	170-0	175-0				
	L	0	10'-9"	21'-8"	32'-7"	43'-5"	54'-4"	65'-3"	76'-2"	87'-0"	97'-11"	108'-10"	119'-9"	130'-8"	141'-7"	152'-6"	163'-5"	174'-4"	180'-0"					
	D	-	41'-6"	28'-11"	18'-4"	14'-6"	14'-1"	13'-4"	12'-8"	12'-2"	11'-9"	11'-6"	11'-4"	11'-3"	11'-3"	11'-4"	11'-5"	11'-6"	11'-7"					
SPAN 400 FT	H	0	10-0	20-0	30-0	40-0	50-0	60-0	70-0	80-0	90-0	100-0	110-0	120-0	130-0	140-0	150-0	160-0	170-0	180-0	190-0	200-0		
	L	0	10'-9"	21'-8"	32'-7"	43'-6"	54'-5"	65'-4"	76'-3"	87'-2"	98'-1"	109'-0"	119'-11"	130'-10"	141'-9"	152'-8"	163'-7"	174'-6"	185'-5"	196'-4"	201'-10"			
	D	-	43'-6"	30'-2"	20'-0"	16'-2"	15'-9"	15'-0"	14'-4"	13'-10"	13'-6"	13'-3"	13'-1"	13'-0"	13'-0"	13'-0"	13'-1"	13'-2"	13'-3"	13'-4"	13'-5"			





DETAIL of DECKING
Scale: 3¼"=1'-0"



CONSTRUCTION PROCEDURE

1. Erect towers, prepare anchorages & deck matting, drill bearers & transomes and attach transomes to hangers and hangers to cables.
2. Pass cables across each pier on to towers & secure to anchors.
3. Pull hanger cables one as far as possible towards bank & hook bearers over transome using 4" nails in end of bearers. Allow hanger to swing back into position & secure near end of bearers to transome by ½" dowels (or wire lashing). Roll out deck matting, dowel (or lash) far end of bearer to transome & secure deck matting to each bearer by four light wire lashings.
4. Place handrails & connect cables to top of towers as shown in drawings.

SUSPENSION FOOTBRIDGE
FOR SPANS UP TO 400 FT.

ORIGINAL DESIGN (by Spr. Middlehurst)
AMENDED FOLLOWING EXPERIMENTS
BY 2/5 AUST. FD. COY.
TRACED BY [illegible] SPR.
APPROVED BY C.E. BAIRD LT-COL

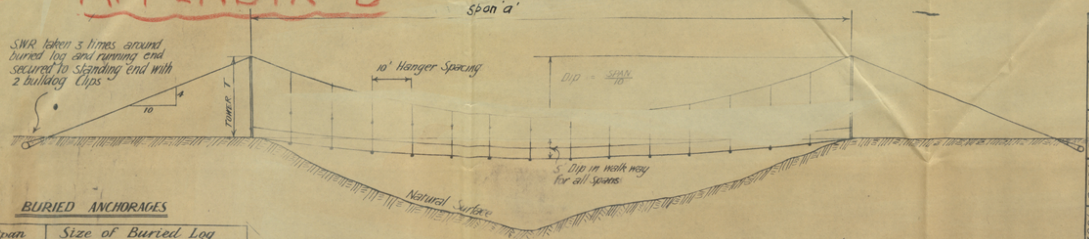
RAE 6 AUST. DIV. STANDARD.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX C

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX D



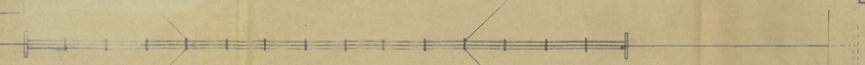
ELEVATION

BURIED ANCHORAGES

Span in Feet	Size of Buried Log	
	Inf. at 1 Place	Inf. at 3 Places
100'	15" x 6"	12" x 5"
150'	15" x 8"	12" x 6"
200'	18" x 9"	12" x 7"
250'	18" x 11"	12" x 8"
300'	18" x 13"	15" x 8"
350'	24" x 12"	15" x 9"
400'	24" x 15"	15" x 10"

Depth to ℄ log = 4·0"

Above table based on formula
$p = \frac{1}{2} w a^2 / h \cdot \sin 2\phi (1 \cdot 5 - \sin \alpha)$
w = 100 lb/cu.ft.
ϕ = 35°
h = 4 ft.
d = 4 ft.
Then p = 1·0 tons/sq.ft.



PLAN

Guys of 2 double strand barbed wire galvd wire Attached to bridge at approx. ¼ point

POSITION & LENGTH OF HANGERS

Length of Cable between Towers = 2 × L at ℄

D is slope length see hanger detail

		℄																				
100'	H	10·0	20·0	30·0	40·0	50·0																
	L	10·65	21·04	31·24	41·54	51·33																
	D	6·33	4·96	4·00	3·43	3·00																
		℄																				
150'	H	10·0	20·0	30·0	40·0	50·0	60·0	70·0	75·0													
	L	10·71	21·21	31·67	41·80	51·93	61·98	71·99	77·00													
	D	10·58	8·46	6·71	5·33	4·29	3·59	3·29	—													
		℄																				
200'	H	10·0	20·0	30·0	40·0	50·0	60·0	70·0	80·0	90·0	100·0											
	L	10·73	21·30	31·75	42·09	52·33	62·50	72·60	82·65	92·67	102·67											
	D	15·15	12·60	10·35	8·40	6·75	5·40	4·35	3·60	3·15	3·00											
		℄																				
250'	H	10·0	20·0	30·0	40·0	50·0	60·0	70·0	80·0	90·0	100·0	110·0	120·0	125·0								
	L	10·73	21·36	31·87	42·28	52·61	62·86	73·05	83·17	93·26	103·30	113·33	123·33	128·35								
	D	20·02	17·12	14·57	12·34	10·20	8·41	6·87	5·60	4·57	3·80	3·29	3·03	—								
		℄																				
300'	H	10·0	20·0	30·0	40·0	50·0	60·0	70·0	80·0	90·0	100·0	110·0	120·0	130·0	140·0	150·0						
	L	10·76	21·39	31·94	42·42	52·81	63·14	73·39	83·53	93·74	103·85	113·92	123·97	133·99	144·0	154·0						
	D	24·80	21·81	19·05	16·49	14·20	12·10	10·18	8·53	7·12	5·91	5·00	4·20	3·65	3·35	3·00						
		℄																				
350'	H	10·0	20·0	30·0	40·0	50·0	60·0	70·0	80·0	90·0	100·0	110·0	120·0	130·0	140·0	150·0	160·0	170·0	175·0			
	L	10·76	21·44	32·00	42·53	52·97	63·33	73·66	83·93	94·14	104·30	114·43	124·52	134·57	144·63	154·66	164·67	174·67	179·67			
	D	29·80	26·58	23·72	20·95	18·38	16·05	13·88	11·90	10·18	8·60	7·25	6·10	5·14	4·58	3·82	3·48	3·28	—			
		℄																				
400'	H	10·0	20·0	30·0	40·0	50·0	60·0	70·0	80·0	90·0	100·0	110·0	120·0	130·0	140·0	150·0	160·0	170·0	180·0	190·0	200·0	
	L	10·77	21·48	32·05	42·62	53·06	63·50	73·87	84·18	94·45	104·67	114·84	125·00	135·10	145·19	155·25	165·29	175·31	185·33	195·35	205·35	
	D	34·61	31·58	28·83	26·47	22·75	20·30	18·05	15·67	13·64	11·82	10·16	8·70	7·39	6·27	5·34	4·55	3·96	3·58	3·33	3·00	

Note: Total hanger length = "D" as above + 11·0"

Parabola

Origin

$y = \frac{4d}{a^2} x^2$

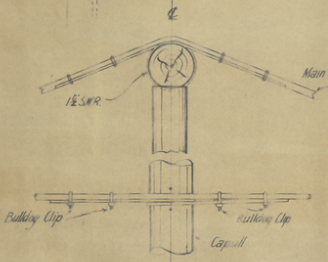
$L = l + \frac{8d^2}{3a}$

TOWER DETAILS

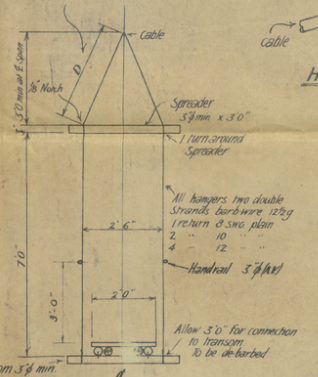
SPAN IN FEET	TOWER LEGS HEIGHT	Av. Diam. in Ins. 1 pace	Av. Diam. in Ins. 3 paces
100	15'·3"	6"	5"
150	20'·3"	7"	6
200	25'·3"	8"	7"
250	30'·3"	9"	8"
300	35'·3"	10"	9"
350	40'·3"	11"	10"
400	45'·3"	12"	11"

MAX. SPANS OF S.W.R. CABLES

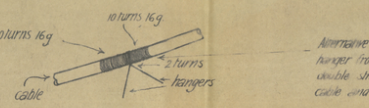
CARRYING S.W.R.	Inf. at 1 pace intervals 1 S.W.R.	2 S.W.R.	3 S.W.R.	4 S.W.R.	Inf. at 3 pace intervals 1 S.W.R.	2 S.W.R.	3 S.W.R.
1"	12'	25'	37'	50'	25'	51'	76'
1½"	28'	57'	85'	114'	57'	115'	172'
2"	50'	101'	152'	202'	102'	204'	306'
2½"	79'	158'	238'	317'	160'	320'	480'
3"	114'	228'	342'	456'	230'	460'	690'
3½"	155'	310	465'	620'	314	628	942



CABLE TO TOWER
SCALE = 1" = 1·0"

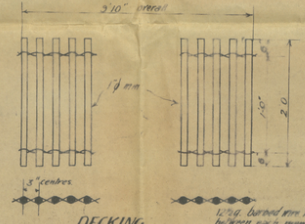


HANGER DETAIL
SCALE = ½" = 1·0"

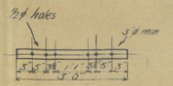


HANGER TO CABLE

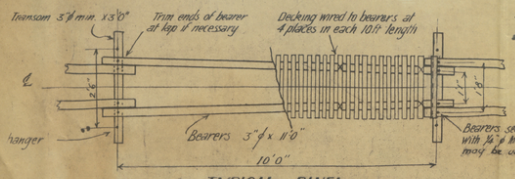
Alternative method of preventing hanger from slipping is one double Strand barbed wire along cable and twisted to each hanger



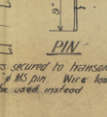
DECKING
SCALE = 1" = 1·0"

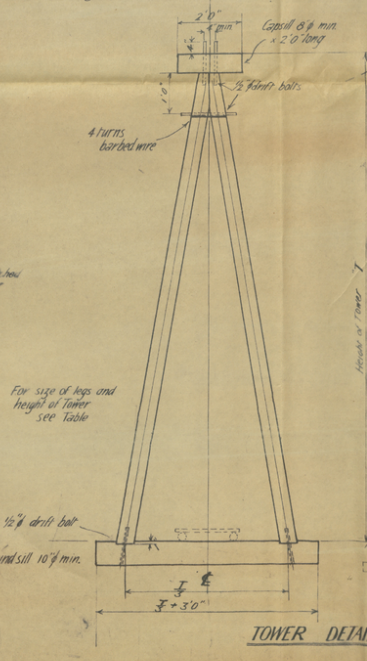


TRANSOM
SCALE = ½" = 1·0"



TYPICAL PANEL
SCALE = ½" = 1·0"





For size of legs and height of Tower see Table

TOWER DETAIL

DESIGN DATA

LIVE LOAD: Infantryman assumed as 200 lb.

DEAD LOAD: 25 lb/ft run

Safe Load on S.W.R. = 16 C² cwt

CABLE:

1 pace intervals.
LL + DL = 80 + 25
= 105 lb/ft.
$16C^2 \times 112 = 1{\cdot}346 \times 105 \times SPAN$
MAX. Span = $12{\cdot}7C^2$

3 pace intervals
LL + DL = 27 + 25
= 52 lb/ft.
$16C^2 \times 112 = 1{\cdot}346 \times 52 \times SPAN$
Max. Span = $25{\cdot}6C^2$

TOWER

Based on formula safe stress $p = \frac{1}{3} f \left(\frac{3r}{10} - \frac{1}{4}\right) \times \frac{3}{4}$
Group "B" timber.
f = 1500 lb/in² + 25% = 1875 lb/in²
A factor of ¾ is taken to cover a condition between trestle legs and Derrick Pole

STANDARD DRAWING BY
R.A.E. - 6 AUST DIV

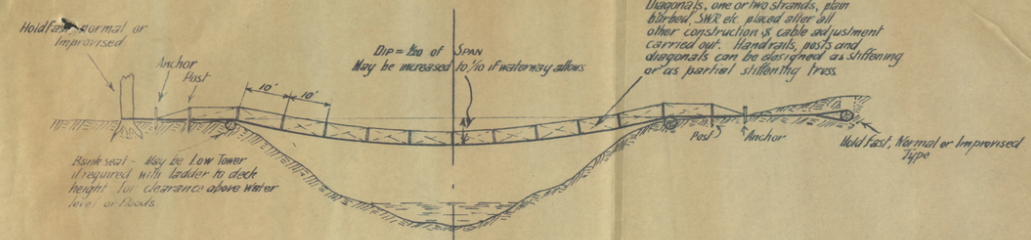
[illegible] Lt Col CRE

FOOT SUSPENSION BRIDGE SINGLE CABLE	
PLAN N°IT 1	SHEET N° 1
Designed by 2/15 Aust. Fd. Coy.	
Drawn by Capt. Daly J.	
Traced by Spr. Furze F.L.	
Checked by Major Draham W.T.	
[illegible] Major 24-8-43	
O.C. 2/15 Aust. Fd. Coy.	

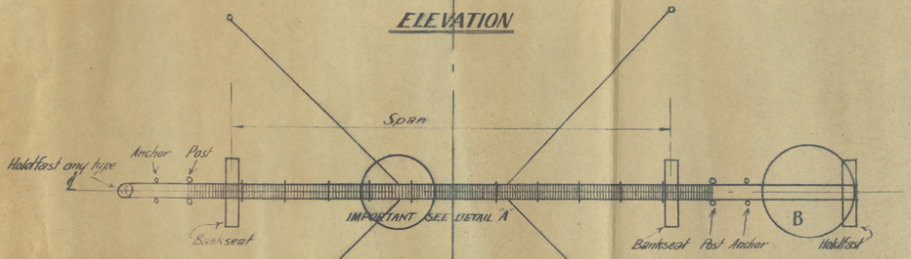
AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX D

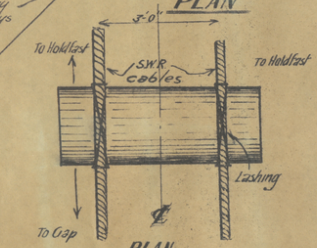
AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

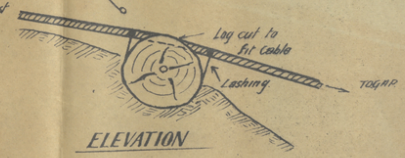


ELEVATION



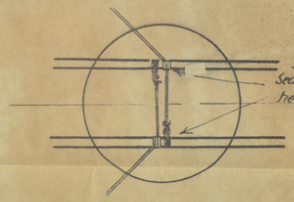
PLAN





ELEVATION

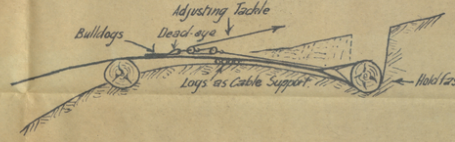
BANK SEAT DETAIL



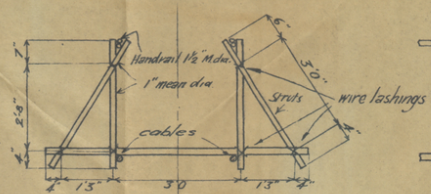
DETAIL AT 'A'

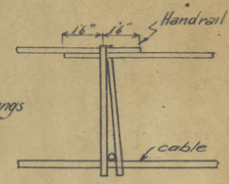
SIDE GUY ATTACHMENT

DETAIL AT "B"

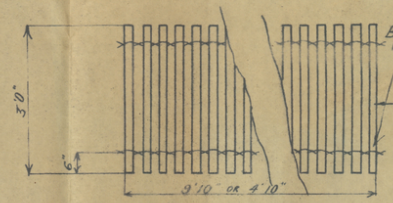


TACKLE FOR ADJUSTING DIP





HAND RAIL FRAME



DETAIL OF MAT DECKING



ELEVATION

CABLE DETAILS

MAX. SPAN IN FT. 2 CABLES						
SWR. INS.	INF. AT 3 PACES DIP			INF. AT 1 PACE DIP		
	1/10	1/15	1/20	1/10	1/15	1/20
1	56	39	30	—	—	—
1½	126	88	67	60	40	32
2	244	156	120	104	72	56
2½	350	224	188	163	112	88
3	504	351	270	234	162	126
3½	686	478	368	340	220	172

DESIGN DATA

1. LIVE LOAD (LL) Inf. 200 lbs
   At 3 pace Interval = 271 lbs/ft run
   At 1 " " = 80 " "
2. DEAD LOAD (DL)
   Approx. 20 lbs/ft run
3. CABLE TENSION
   W = LL + DL (lbs/ft run)
   a = Span in ft. T = tension in cables (lbs)
   For Dip 1/10 T = 1·346 × W × a lbs.
   " " 1/15 T = 1·94 " " "
   " " 1/20 T = 2·54 " " "
4. SAFE LOAD in Cable 16 C² cwts
5. TO GAP Gp. B.

INF. FOOTBRIDGE 100'	
PLAN N° FF 4	SHEET N° 1
Designed by	Maj. Graham W.T.
Drawn by	Spr Furze F.L.
Checked by	Maj. Graham W.T.

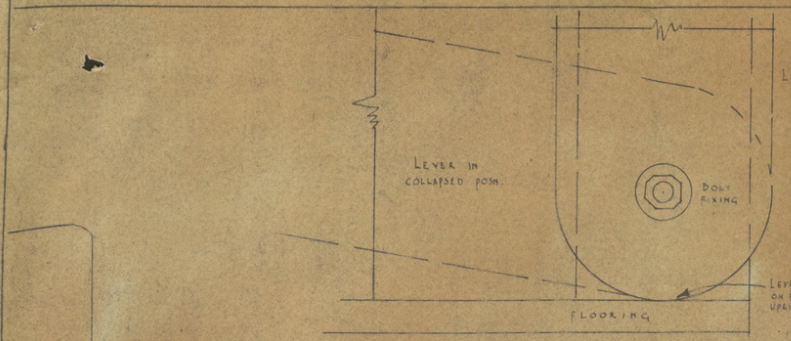
RAE 6 AUST DIV.
G. E. Baird Lt-col
C.R.E.

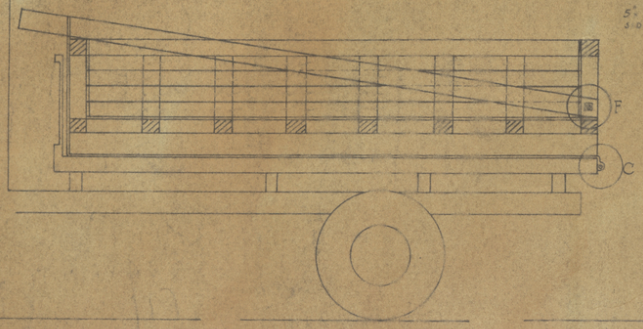
MAJOR
OC. 2/15 AUST. FD COY.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

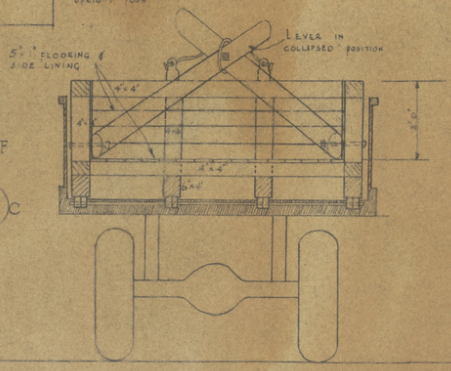
APPENDIX F

AUSTRALIAN WAR MEMORIAL
AWM2020.71.1471

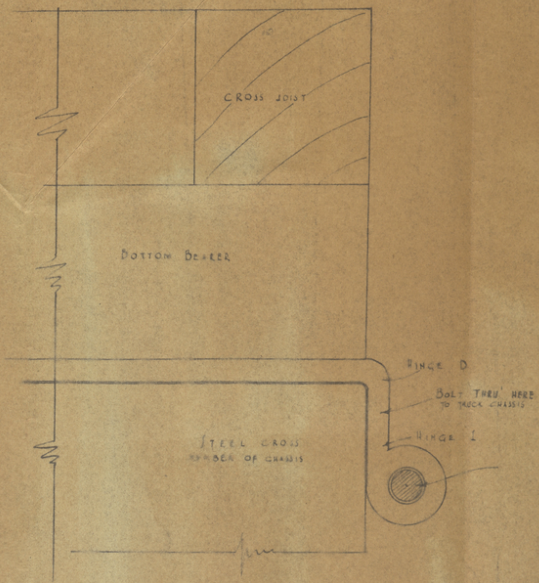




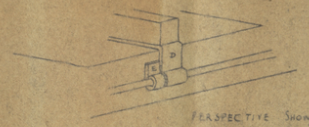
SECTION B-B



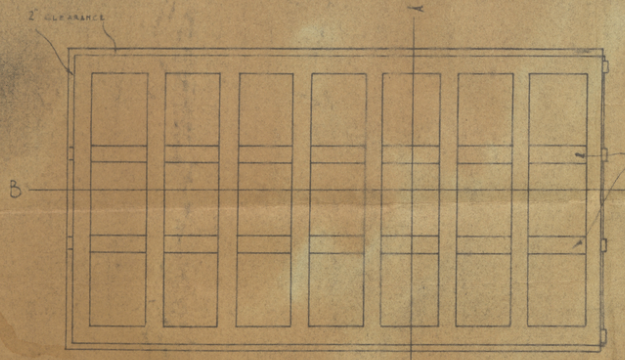
SECTION 'A-A'



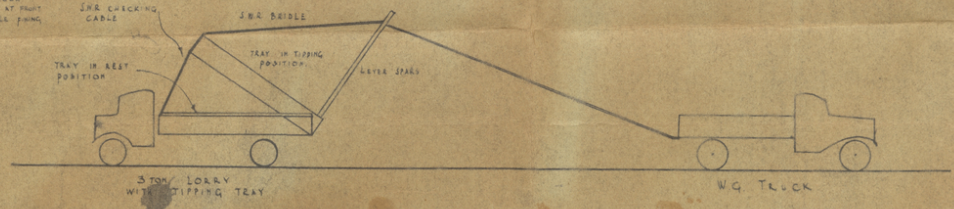
DETAIL AT 'C'
HALF FULL SIZE



PERSPECTIVE SHOWING FIXING OF HINGES 'D & I'



PLAN



IMPROVISED TIPPING TRUCK
DESIGNED & USED BY 2/2 AUST FD COY R.A.E.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

AUSTRALIAN IMPERIAL FORCE.

APPENDIX 19

H.Q. R.A.E.
6 Aust Div.
4 Sep 43.

Ref 43/41/11.

War Diary

IMPROVISED TIPPING TRUCKS.

C.E.
2 Aust Corps.

1. Two prints of an improvisation to enable a 3 ton steel bodied truck to be used as a tipping truck are attached. This arrangement was designed and successfully used by the 2/2 Aust Field Coy on road work in the N.T. and was the means of saving considerable labour and time.

C E Brown

.....Lt. Col.
C.R.E. 6 Aust Div.

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471

APPENDIX 20

War Diary

TELEPHONE—

Australian Military Forces.

Please quote this Number when replying.

43	63	18

Address H.Q. R.A.E.
6 Aust Div.
Date 29 Sep 43.

Subject : TREE CLIMBING APPLIANCE.

To : C.E.
2 Aust Corps.

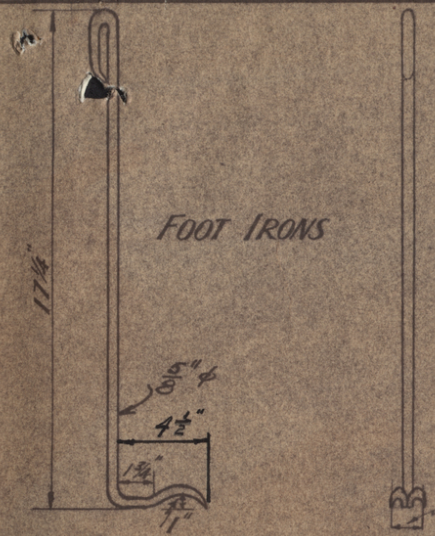
1. The attached drawing (F.F.12) shows tree climbing irons made up and tested by 2/15 Aust Fd Coy.

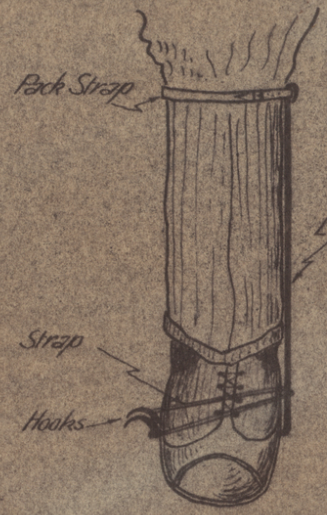
2. Trees of small or large diameter may be climbed with these irons.

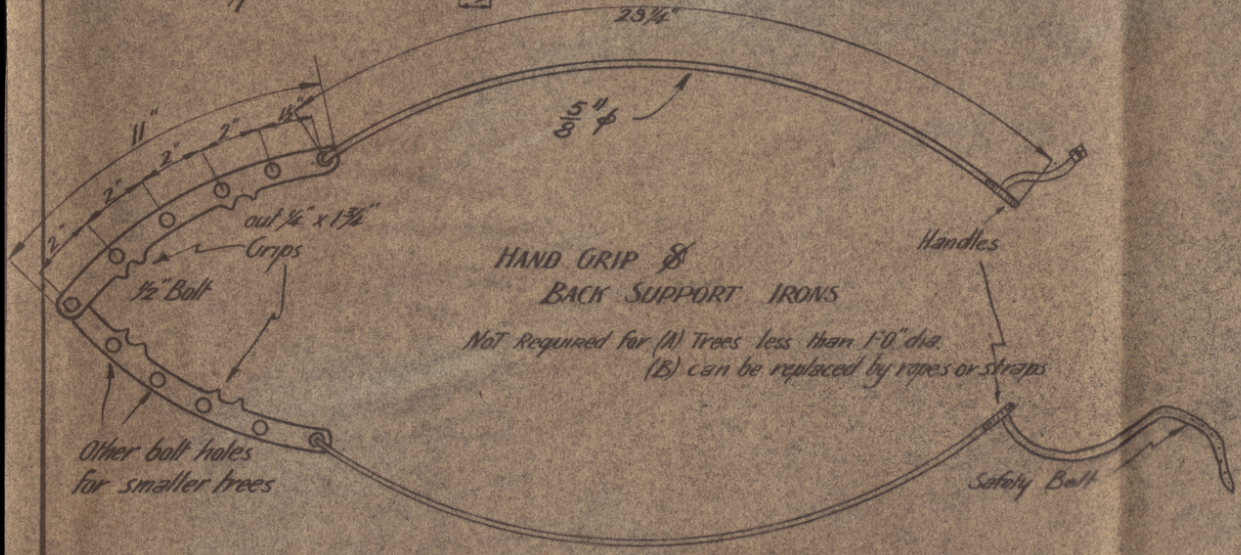
C E Baird

.....Lt. Col.
(C.E. BAIRD)
C.R.E. 6 Aust Div.;

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471







HAND GRIP & BACK SUPPORT IRONS

NOT Required for (A) Trees less than 1'0" dia.
(B) can be replaced by ropes or straps



RAE 6 AUST DIV
G E Baur Lt-Col
CRE

TREE CLIMBING APPLIANCE

PLAN N°FF 12	SHEET N° 1
Designed by	Sor Stormer H.H.
Drawn by	Sor Furze F.L.
Checked by	Capt.
W L Graham MAJOR	
OC 2/15 Aust. Fd. Coy.	

AUSTRALIAN WAR MEMORIAL AWM2020.71.1471