REPORT

ON THE

ENGINEER OPERATIONS,

OF THE

CHITRAL RELIEF FORCE,

1895.

CALCUTTA:
OFFICE OF THE SUPERINTENDENT OF GOVERNMENT PRINTING, INDIA.
1896.

REPORT

ON THE

ENGINEER OPERATIONS,

OF THE

CHITRAL RELIEF FORCE,

1895.

CALCUTTA:
OFFICE OF THE SUPERINTENDENT OF GOVERNMENT PRINTING, INDIA.
1896.

CALCUTTA:
GOVERNMENT OF INDIA CENTRAL PRINTING OFFICE,
8, HASTINGS STREET.

No. 657.

FROM

THE COLONEL ON THE STAFF,

ROYAL ENGINEERS,

Chitral Relief Force.

To

THE CHIEF STAFF OFFICER,

CHITRAL RELIEF FORCE.

Dated Malakand, 21st September 1895.

SIR,

As laid down in Field Service Manual, India, Appendix F., paragraph 14, I have the honor to submit herewith the Reports on the Engineer operations by the Commanding Royal Engineers, 1st Division, and Line of Communications, Chitral Relief Force.

2. The following Royal Engineer Officers and Companies of Sappers and Miners have been employed with the Force :—

40 Royal Engineer Officers.
2 Warrant Officers.
No 1 Company, Bengal Sappers and Miners.
No. 4 Company, Bengal Sappers and Miners.
No 6 Company, Bengal Sappers and Miners.
"A" Company, Pontoon Section, Bengal Sappers and Miners.
No. 6 Company, "Q.O.," Madras Sappers and Miners.
One Engineer Field Park.

and in addition the 23rd and 34th Regiments, Punjab Pioneers, have been working continuously under the orders of the Commanding Royal Engineers.

3. A nominal roll of the Royal Engineer Officers is attached.

4. North of Dir much of the road-making was carried out by Infantry working parties, the 25th Punjab Infantry being particularly useful in this capacity.

5. The names of the Officers who have specially distinguished themselves in connection with the Engineer operations of the Force have been previously brought to the notice of the Lieutenant General Commanding in a separate communication.

6. In conclusion, I would add that I am unable to agree with the opinion expressed by Lieutenant-Colonel Shone regarding trestle bridging on pages 6 and 7 of his report, which appears to me to be somewhat too sweeping. My experience with this class of bridge over large rivers on the Eastern Frontier of India goes to prove that they will often stand sudden and heavy floods in a most surprising manner, provided the roadway remains above the water level.

I have the honor to be,

SIR,

Your most obedient Servant,

H. P. LEACH, *Colonel on the Staff,*
Royal Engineers, Chitral Relief Force.

Nominal Roll of Royal Engineer Officers employed on Engineer Operations, Chitral Relief Force.

Rank.	Name.	Appointment.
Colonel	H. P. Leach, D.S.O.	Colonel on the Staff, Commanding Royal Engineer, Chitral Relief Force.
Bt. Lt.-Col.	W. T. Shone, D.S O.	Commanding Royal Engineer, Line of Communications.
Major	M. C. Barton	In charge Royal Engineer Field Park.
Do.	C. C. Ellis	Field Engineer.
Do.	H. E. S Abbott	Ditto.
Captain	J. A. Tanner, D.S.O.	Adjutant, R.E , Chitral Relief Force.
Do.	G. Williams	Field Engineer.
Do.	B. B. Russell	Adjutant, R E., Line of Communications.
Capt. and Bt. Major	F. J. Aylmer, V.C.	Commanding No. 4 Company, Bengal Sappers and Miners.
Do.	G. M. Heath	Commanding "A" Company, Pontoon Section, Bengal Sappers and Miners.
Do.	W. G. R. Cordue	Field Engineer.
Do	J. R. B. Serjeant	Commanding No. 1 Company, Bengal Sappers and Miners.
Do.	F. E. G. Skey	Commanding No. 6 Company, Bengal Sappers and Miners.
Do.	H C. Nanton	Field Engineer.
Do.	A. J. H. Swiney	Ditto.
Do.	G. M. Duff	Ditto.
Lieutenant	J. S. Fowler, D.S.O	Assistant Field Engineer.
Do.	A. Walpole	Ditto.
Do	C. Ainslie	Commanding No. 6 Company, "Queen's Own," Madras Sappers and Miners.
Do.	G. C Kemp	Company Officer, No. 6 Company, Bengal Sappers and Miners.
Do.	E. C. Ogilvie	Assistant Field Engineer.
Do.	F R. F. Boileau	Ditto.
Do.	R. F. G. Bond	Company Officer, No. 6 Company, Bengal Sappers and Miners.
Do.	H. F. Thuillier	Assistant Field Engineer.
Do.	A. R. Winsloe	Company Officer, No. 6 Company, "Queen's Own," Madras Sappers and Miners.
Do	F F. N. Rees	Assistant Field Engineer.
Do.	P. G. Grant	Ditto.
Do.	H. W. Weekes	Company Officer, No. 1 Company, Bengal Sappers and Miners.
Do.	W. G. Hibbert	Company Officer, No. 6 Company, "Queen's Own," Madras Sappers and Miners.
Do.	J. M. C. Colvin	Company Officer, No. 4 Company, Bengal Sappers and Miners
Do.	G. Lubbock	Company Officer, No. 4 Company, Bengal Sappers and Miners.
Do.	S. D'A. Crookshank	Assistant Field Officer.
Do.	E. G. Farquharson	Company Officer, No. 1 Company, Bengal Sappers and Miners.
Do.	C. O. Halliday	Company Officer, No. 6 Company, Bengal Sappers and Miners.
Do.	H. A. L. Hepper	Assistant Field Engineer.
Do.	G. H. Boileau	Ditto.
Do.	H. F. E. Freeland	Company Officer, No. 4 Company, Bengal Sappers an Miners.
Do.	F. G. Howard	Assistant Field Engineer
Do.	E. C. Tylden Pattenson	Company Officer, No 1 Company, Bengal Sappers and Miners.
Do.	W. Robertson	Company Officer, No. 6 Company, "Queen's Own," Madras Sappers and Miners.

H. P. LEACH, *Colonel on the Staff,*

Commanding Royal Engineer, Chitral Relief Force.

MALAKAND,

The 21st September 1895.

REPORT

ON THE

ENGINEER OPERATIONS,

1ST DIVISION,

CHITRAL RELIEF FORCE,

BY THE

COMMANDING ROYAL ENGINEER.

1st Co., Bengal S. & M., under Capt. Serjeant, R.E.
4th Co., Bengal S. & M., under Major Aylmer, V.C., R.E.
6th Co., Bengal S. & M., under Capt. Skey, R.E.
The Fd. Park for one Div. Inf., under Major Barton, R.E.
The Fd. Printing and Photo-Litho. Sections, Bengal S. & M.

1. On the 17th March orders were received at Roorkee for the marginally noted units of the Bengal Sappers and Miners to be held in readiness to join the Chitral Relief Force.

2. The 1st Company with the Photo.-Litho. and Printing Sections left on the evening of 18th March 1895 in one troop train, and 4th and 6th Companies with the Field Park followed on the 26th March 1895 in two troop trains.

3. On the 18th March Colonel Leach, D.S.O., R.E., received orders from Adjutant General in India to proceed at once to Peshawar and take up the appointment of Commanding Royal Engineer, 1st Division, C. R. F. He accordingly left Roorkee the same day, and visiting Rawal Pindi Arsenal *en route*, arrived at Nowshera on 21st March, and thence, under orders of the G. O. C., proceeded at once to Mardan to make the necessary preliminary arrangements.

4. While awaiting the arrival of the troops, the next few days were spent at Mardan in examining the roads which led from there towards the frontier, in making enquiries as to the various routes, nature of rivers, etc., and in ordering up the stores which appeared necessary.

5. Among these stores were steel wire ropes for bridging; these had to be obtained from Bombay, but owing to the congested state of the railway lines, were very late in arriving. This would have been a serious matter had not Mr. Dempster of the Telegraph Department offered to get up some heavy telegraph wire from India, and, upon its arrival at the Base, to convey it to the front with his own transport. This wire came in most opportunely, as will be seen later on, for the suspension bridge over the Panjkora.

6. A large number of mussacks were also collected and boatmen engaged.

7. The native accounts showed that we might expect to be able to ford both the Swat and the Panjkora rivers for some little time to come. This proved to be true as far as the Swat was concerned, which was fordable up to the 14th April, by which time the trestle bridge was in a sufficiently advanced stage to be used; but the Panjkora rose almost directly we got there, and the passage of the troops was delayed until a bridge could be constructed.

8. The Companies arrived at Mardan on the following dates:—

1st Company 23rd March; 4th Company 31st March; 6th Company 31st March; and were pushed on to improve the roads to the front, on which the 23rd Pioneers were already employed.

9. The Field Printing and Photo. Sections remained at Mardan to await the arrival of Head Quarters, which were then at Nowshera.

10 The heavier part of the Field Park at first remained at Nowshera, but a proportion of tools were sent up at once to Mardan and thence on to Jalala.

11. The various Royal Engineer Officers, who had been appointed to the 1st Division as Field and Assistant Field Engineers, had all arrived by the 31st, and others, whose services were considered necessary, had been asked for.

12. On the 1st April the Divisional Head Quarters moved to Jalala. The three Sapper Companies which had been told off to Brigades marched with their Brigades and were collected at or in the neighbourhood of Dargai on the evening of the 2nd.

13. On the morning of the 3rd the three Sapper Companies under the orders of the Commanding Royal Engineer marched with the advanced troops up the nullah leading from Dargai towards the Malakand Pass, improving the path nearly up to where it ascends the hillside to the Kotal. At this point they came under the fire of the enemy and were moved under cover, remaining there until the British regiments advanced to the direct assault of the position. Following in rear of the latter they at once commenced to improve the path up to the Kotal, which was of the roughest description; they worked at this all the afternoon and by night-fall had made it fairly passable for laden mules.

14. That night the 4th Company bivouaced on the Kotal, the 1st and 6th Company in the nullah down below, though many of the men passed the night on the hillside in charge of their equipment mules, it being impossible to get the latter either up or down, owing to the mass of animals on the path. The 23rd Pioneers, had in the meantime, improved the road in rear, and by the morning of the 4th camels had no difficulty in reaching the foot of the pass.

15. Next morning the 4th Company started work from their bivouac down the north side of the pass, and later on in the day took part in the operations of the 1st Brigade in the neighbourhood of Khar, advancing to the support of the 37th Dogras at what appeared to be rather an opportune moment. The 1st and 6th Companies improved the path on the south side and commenced work on an old Buddhist road, traces of which had been discovered the day before. The 23rd Pioneers also started on it from the lower end. The existence of this Buddhist road was most fortunate, as one real hard day's work on the 5th by the above-mentioned troops (for which they were all specially thanked by the General Officer Commanding) made it possible for laden camels to reach the top of the pass by 10 A.M. on the 6th. On the 5th Major Aylmer accompanied a Cavalry reconnaissance to the Swat river to look for fords, and for any sites which might be suitable for bridging.

16. On the 6th April the 4th Company collected material from Khar village for a bridge over the Swat river, at a site which had been selected opposite the village of Chakdara.

17. On the 7th April the fight at the Swat river took place, in which the 4th Company played a prominent part. The 1st and 6th Companies, with the assistance of the 23rd Pioneers, had by noon on the 7th opened the Buddhist road as far as was necessary to enable camels to proceed down the north side of the pass, a really good piece of work and only rendered possible by the united exertions of every man employed.

18. On the 8th April the 4th Company commenced work on the Swat bridge. They were joined in the evening by the two other Companies and by the 23rd Pioneers. Large Infantry working parties were also employed carrying timber to the site of the bridge.

19. On the 9th work on the bridge was continued by all three Companies of Sappers, as the reconnoitring party which had proceeded to the Panjkora on the previous day had reported that this river was fordable. The supply of material was kept up from all sides: some from Khar village, some from dismantled forts on the right bank of the river, and some from the village of Thanna. Infantry working parties, local labour, kahars, etc., being all pressed into this service. The Pioneers were employed on the approaches to the bridge, and demolishing the houses from which the timber was obtained.

20. Troops and supplies were pushed across the river during the day by the ford, and the Attock boatmen gave invaluable assistance here in helping men and animals over.

21. On the 10th April the 4th Company and two Companies of the 23rd Pioneers under Captain Burne marched with the 2nd Brigade for the Panjkora river, improving the road as they went; the other two Companies of Sappers being left to complete the bridge, under the direction of Major Barton, R.E., who had

arrived with the Field Park at the Swat river. The 23rd Pioneers continued improving the approaches and collecting timber from the villages, forts, etc.

22. Work was steadily carried on at the Swat bridge and its approaches by the 1st and 6th Companies Sappers and 23rd Pioneers until the 16th April, when the bridge was opened for traffic.

23. On the evening of the 11th, after working on the road, the 4th Company arrived at the Panjkora. The river was then fordable, but began to rise directly, and the current increased to such an extent that a trestle bridge was not feasible. As there were a lot of logs lying in the river and the telegraph wire (mentioned in paragraph 5) had not yet arrived, the quickest method of crossing the river seemed to be by a floating bridge; the collection of logs was accordingly proceeded with.

24. All the 12th was devoted to the construction of the bridge, which, with the assistance of the two Companies of Pioneers and large Infantry working parties, progressed so rapidly that by the evening the Guides Infantry were able to cross.

25. Unfortunately during the night of the 12th April it rained hard and the river rose suddenly. At about 5 A.M. on the 13th two large logs came down the river and struck one of the rafts of the bridge, completely submerging it. This raft was cast loose from the bridge and was then reconstructed, but every effort to get it into position again proved unavailing, owing to the increased rapidity of the current. During the attempt to do so a 3-inch cable parted and a raft, with half a dozen Sappers and boatmen on it, was carried away down stream at the rate of about ten miles an hour. It eventually brought up against a rock and the occupants were fortunately able to get to land, though with much difficulty.

26. As the force of the current still kept increasing, and as the telegraph wire had reached Gumbat, it was decided to abandon any further attempt to reconstruct the floating bridge. A suspension bridge was then immediately commenced some two miles lower down, where the river enters a narrow gorge.

27. The telegraph wire arrived on the evening of the 13th, and the 4th Company worked all that night in reliefs and all through the day of the 14th at the bridge. By the afternoon of the 15th it was sufficiently advanced to admit of a temporary roadway being put on for Infantry working parties to cross over, and make a road into the Jandoul valley along the impassable hillside on the right bank. This continual crossing of men backwards and forwards delayed the actual construction of the bridge very much, but enabled the road to be completed simultaneously with the bridge and so saved time in the end.

28. During the afternoon of the 15th, Major Aylmer, with the assistance of some of the men of the 4th Company and particularly Lance Naik Sham Singh, succeeded in saving in a most plucky manner the life of a man belonging to the Maxim Gun Detachment of the Devonshire Regiment who was being carried down on a skin raft which had been upset higher up the river.

29. The bridge was completed throughout on the 16th, an exceedingly smart performance, although again the work was much delayed by the frequent passage of working parties.

30. During the night of the 15th it had rained heavily, causing a considerable rise in the river at the gorge by the bridge. Although this rise quickly subsided, it showed that the bridge, which, owing to the limited supply of wire, had of necessity been placed lower down the bank than was desirable, could not be relied upon for any length of time. It was, therefore, decided to commence another as soon as possible at a higher level, and the 1st Company under Captain Serjeant, R.E., was ordered up from the Swat to do this. Half of the 4th Company was also placed at his disposal, while the other half Company accompanied General Gatacre's brigade, the first to cross the bridge.

31. By the 18th the force had advanced to Mundia Khan fort. The right half 4th Company, which was detailed to accompany the 3rd Brigade on its march to Chitral, reached the village of Zerani, 2½ miles on the north side of the Janbatai Kotal, on the 19th April, after a very fatiguing march of 13 miles, making the road passable for the 3rd Brigade baggage the whole way; in this they were assisted by working parties from the Buffs and 2/4th Goorkhas.

32. On the 21st April, when the news came of the relief of Chitral by Colonel Kelly, and all necessity for pushing on rapidly ceased, this half Company

was employed beyond Dir in constructing cantilever bridges over the mountain torrent that runs down to Dir from the Lowarai Pass, and, with the assistance of Infantry working parties, in opening the road up the valley sufficiently to enable laden animals to move over it.

33. Thus far in the report the Engineer operations have been described from day to day in order that it may be seen how they effected the advance of the force, whose object was to relieve Chitral as quickly as possible. The further operations will be dealt with under their several headings. The appendices which accompany the report give a detailed account of everything that was done.

34. On the 8th May it was decided at Dir that in future the executive charge of the Commanding Royal Engineer 1st Division should extend from Dir to Chitral, and that of the Commanding Royal Engineer Line of Communications, from Mardan to Dir.

Road-making :—

35. In addition to the road-making already mentioned during the advance to Dir, the extremely difficult track between that place and Chitral, a distance of 68 miles, was first opened out sufficiently to allow the 3rd Brigade to reach Chitral by the 14th May. The difficulties were great, involving the crossing of the Lowarai Pass, at that time covered with snow, the construction of many bridges, and carrying the road over a succession of bluffs or "paris" which exist between Badulga and Chitral. The photographs attached show what these road-making difficulties were.

36. Meanwhile, following in rear, the road was widened out and improved by the 1st Company, Bengal Sappers and Miners, the 23rd Pioneers, and working parties of the 25th Punjab Infantry All worked hard and well, especially the 1st Company, Bengal Sappers and Miners; the 25th Punjab Infantry took most kindly to the work also.

37. Subsequently the 1st Company, Bengal Sappers and Miners, and the Head Quarters Wing of the 23rd Pioneers were withdrawn for a time for employment on the Line of Communications. From then until the end of July the improvements made to this road were carried out by the 4th Company, Bengal Sappers and Miners, the Left Wing, 23rd Pioneers, under Major Jones, and working parties supplied by the Infantry at the various posts along the line.

Bridging :—

38. The bridging operations have been made the subject of a special report for submission to His Royal Highness the Commander-in-Chief. A copy of this will be found in Appendix C.

Defensive works :—

39. The arrangements for the defence of the various camps along the line were almost entirely left to the Officers in command of them. The defences usually consisted of walls, abattis, and wire entanglements. Small bridge heads were constructed to protect the suspension bridges at the Swat and Panjkora.

40. A depôt at Drosh was required for the storage of Commissariat supplies. Of the two existing forts, the older one, built by the Chitralis, proved the more suitable for this purpose; so it was decided to dismantle the newer one, constructed by Umra Khan, and to utilise the timber obtained from it in the erection of Commissariat godowns inside the other. The 4th Company, Bengal Sappers and Miners, assisted by Infantry working parties and local coolies, soon had the latter ready for the reception of some 30,000 maunds of supplies.

41. The walls of this fort were also repaired, and to secure a good supply of water Lieutenant Freeland made a covered way of ingenious design from the fort to the river flowing below the cliff, on which the Fort is situated. Full details are given in Appendix D. This also contains a description of an ordinary native fort as seen in this part of the country.

Hutting :—

42. The little hutting that was necessary beyond Dir was carried out by the troops themselves.

Royal Engineer Field Park :—

43. This was located at the Panjkora, an advanced section only being sent beyond Dir. There are a few points which it is desired to bring to notice; they will be found in Appendix E.

Photo.-Litho. and Printing Sections :—

44. A very large number of photographs were taken during the operations: the Divisional Orders were printed daily, and other miscellaneous work done. Suggestions for improving these sections are detailed in Appendices F and G.

Chitral :—

45. Some points connected with Chitral which seemed to be of interest, together with the arrangements proposed for the fort there, are described in Appendix H.

Engineer Staff :—

46. The Engineer staff allotted to the force proved to be equal to the duties they were called upon to perform.

Miscellaneous :—

47. Various improvements in matters of detail have suggested themselves during the time the force has been in the field, such as—

(*a*) Service Companies of Sappers, *see* Appendix J.
(*b*) Equipment of 23rd Pioneers, *see* Appendix K.
(*c*) Field Service Manual, Part VIII, *see* Appendix L.

To which, it is hoped His Excellency the Commander-in-Chief in India will give his favourable consideration.

H. P. LEACH, *Colonel,*
Commanding Royal Engineer,
1st Division, Chitral Relief Force.

MALAKAND,
The 6th September 1895.

INDEX.

APPENDIX A.

Report on Preliminary Operations at the Base.

1. Colonel Leach, C.R.E., arrived at Nowshera on the 21st March, 1895, and at once proceeded to Mardan to superintend the preliminary arrangements. This move was necessary because the roads between Mardan and the frontier required immediate attention, but for many reasons, it would have been more convenient had he been able to remain at Nowshera while preparations for the advance were being made.

Arrival of C. R. E.

2. The C.R.E. was joined by his Adjutant, Captain Tanner, at Mardan on 27th March; Major Ellis, Field Engineer, and Lieutenant Duff, Assistant Field Engineer, also arrived on that date; Lieutenant F. R. Boileau, the remaining Assistant Field Engineer, reported himself on the 28th March.

Arrival of Engineer Staff.

3. As stated in the General Report, the roads between Mardan and the frontier had to be repaired and made passable in many bad places; the heavy rain which fell during the end of March added greatly to the difficulty of doing this.

Repairs to Frontier Roads.

4. The 1st Company, B. S. & M., and the 23rd Pioneers were employed on these roads directly they arrived at Mardan; Major Ellis was sent to direct the work being done by the latter; Lieutenants Duff and Weekes, with such local coolies as could be collected, were employed in improving the portion of the road nearest to Mardan, at a safe distance from the frontier.

5. Arrangements were made with the Executive Engineer, Swat River Canal, to open out a road for returning empties along the canal bank parallel to the main road between Mardan and Jalala.

6. Government having sanctioned the metalling of the Mardan-Jalala road preparations were commenced to carry this out; as however the C.R.E., L. of C., arrived almost immediately, this work was left to him.

Metalling Main Road.

7. Lieutenant Boileau was employed in collecting a small advanced Field Park containing stores, which it was thought would be immediately required on the advance taking place. He also collected a number of native boatmen with their mussacks, etc., ready to make rafts for crossing the Swat River if required.

Advanced Field Park.

8. Orders were sent for various stores which would be required in excess of those carried by the Field Park. The most important items were as follows:—

Stores ordered.

500 Mamooties.
1,000 Shovels.
500 Axes, pick.
900 Spare helves, ditto.
2,000 lbs. gun-cotton.
100 Fathoms, 3-inch galvanised iron wire rope.
100 „ 1½ inch ditto.
4,000 Iron spikes, 12 inches long.
2,000 lbs. Dynamite.
1,000 Detonators, ditto.
4 Ropes, 100 fathoms, 3-inch flexible steel wire.
4 Miles, 600 lbs. Telegraph wire.
400 Fathoms, Fuse, safety, No. 2.
100 Solid steel boring bars, 1 inch diameter.

As will be seen in the General Report, it was impossible to get the steel rope up in time for use with the first Panjkora Suspension Bridge.

9. The above completed the preliminary arrangements.

APPENDIX B.

Report on the road from Mardan to Chitral.

This report deals with the road from Mardan to Chitral, describes the state it was found in when the advanced troops began to march over it, and details the work that was done on it by the 1st Division, as far as Dir. After reaching Dir, it was decided on the 8th May that all work up to that place should be carried out under the orders of the C.R.E., L. of C.; the further improvements made up to this point are therefore dealt with in the report of that officer. From Dir to Chitral all the work was executed by the C.R.E., 1st Division, hence the improvements made to this portion of the road are fully described in the following report.

Remarks.

Heading.

2. It will be convenient to divide the road into four sections:—

1st.	Mardan to foot of Malakand	26 miles.
2nd.	Foot of Malakand to Panjkora River	36 ,,
3rd.	Panjkora to Dir	53 ,,
4th.	Dir to Chitral	68 ,,
		183 miles.

Mardan to foot of Malakand—

Mardan to foot of Malakand.

3. This was an ordinary wide *kutcha* road as far as Jalala, soft in places and becoming almost impassable after heavy rain for a few days until the surface dried and hardened again. The 1st Company, Bengal Sappers and Miners, and 23rd Pioneers were sent on in advance to improve the road in bad places with brush-wood, etc., as far as possible, and Lieutenants Duff and Weekes were employed with local coolies in preparing its surface for metalling, and in excavating ditches along the sides. Arrangements were made with local contractors to collect metal, and E.E., Swat River Canal, commenced clearing a *kutcha* road along the bank of that Canal, to be used by empties returning to Mardan.

4. From Jalala to the foot of the Malakand Pass the *kutcha* road gradually disappeared; the track really led for the most part over open fields. Several dry nullahs with steep banks had to be crossed, thus the principal work on this section was in cutting ramps down into and up out of these nullahs. This work was done by the 1st Company, Bengal Sappers and Miners, and 23rd Pioneers, who were sent on ahead as far as the frontier, and afterwards, when the troops advanced, by all three Sapper Companies, the 23rd Pioneers, and Infantry working parties from the 3rd Brigade.

5. As the first Company, Bengal Sappers and Miners, and 23rd Pioneers only arrived at Mardan about 23rd March, and the remaining troops not until 31st idem, while the advance over the Malakand Pass commenced on 3rd April, it was only possible to complete this section of the road for camel traffic; it almost immediately passed under the C.R.E., L. of C., and is dealt with in his report much more fully.

Foot of Malakand to Panjkora—

Foot of Malakand to Panjkora.

6. At first the only track over the Malakand Kotal appeared to be a steep zig-zag, very much broken in places, and it was only ascended by our laden mules with the greatest difficulty and delay, though used by native traders with their camels; but during the action on the 3rd April the line of an old Buddhist road was discovered running up to the Kotal (2,900′), which was on an even gradient of one-eighth to one-tenth throughout; in many places this road had completely broken away, but on the morning of 4th April the 1st and 6th companies, Sappers, and 23rd Pioneers were put on to open it out and make it passable for camels, while the 4th Company improved an existing track down the north side of the range on what at first appeared the best route,

7. The Malakand Range is for the most part formed of hard igneous rock, the hill slopes are steep on both sides, and but scantily covered with scrub jungle. At the Kotal there were a large number of wild olive trees and an occasional chir. Excellent water was found near the summit on the north side, but none was met with on the Buddhist road after leaving Dargai until reaching this place.

8. The camel road up the pass was opened by great exertions on the evening of the 5th April. Meanwhile the old Buddhist road was also found to extend along and down the hill, and as the track improved by the 4th Company was not considered fit for laden camels, as much of this road as was possible at the time was opened out by the 1st and 6th Companies Sappers and 23rd Pioneers; the remaining portion on the north side of the hill was so seriously broken away that it was left to be done later by the L. of C. and a track cleared down a nullah and made passable for laden camels.

9. In this way the track over the Kotal was sufficiently advanced to admit of camels coming into Khar on the 7th April. The old zig-zag routes were then used for the returned empties, both up and down the pass. The opening out of these roads even to this extent entailed very severe and continuous labour from daylight till dark. In some places heavy blasting had to be done, but most of the work consisted in re-cutting the road where it had fallen away in the softer places, and in building up dry stone walls. In this work the 1st Company, Bengal Sappers, especially distinguished themselves.

10. It is curious that such an excellent road, as this must have been originally, should have fallen quite out of repair and use; but the scarcity of water along it may account for this neglect to some extent.

11. From Khar to the Swat River (2,450′) the road was an easy *kutcha* path, suitable for present requirements; and as the bridging of the Swat River now demanded all available labour, it was left to the L. of C. to deal with.

12. The Swat Valley is a pretty one, richly cultivated, but the swampy ground and rice fields near the river render it rather feverish. Fruit trees abound and among them a few planes are seen, while round a graveyard at Batkhela is a grove of olive trees quite fit for trestle bridging. In ordinary years most of the timber used is floated down the Swat River, but none, however, was brought down this year up to the date of the demobilisation of the force.

13. On the 10th April all the labour that could be spared at the Swat, *i.e.*, the 4th Company Sappers and two Companies, 23rd Pioneers, went on towards the Panjkora: no

difficulties were met with over the Katgola Pass (2,700′) the track being easy until two miles from the Panjkora. This bit, down a deep ravine, was opened for camels on the 11th April, and alternative route over the Kamrani Pass (3,300′) to Sado was improved later on by infantry working parties of the 3rd Brigade.

14. The route after leaving the rich Uch Valley runs through dry country with little cultivation, cut up by ravines on the summit of the Katgola Pass, only an occasional chir can be seen, but lower down plane and fruit trees become fairly numerous.

15. While the 4th Company was employed in bridging the Panjkora, *i.e.*, until the evening of the 16th April, the remaining six companies of 23rd Pioneers having finished the approaches to the Swat Bridge moved up and gradually improved the camel road to the Panjkora, so that by the 18th there was a road for laden camels down the valley, and another for empty camels to return by over the Kamrani Pass. The control of this section of the road then passed to the L. of C.

Panjkora to Dir—

Panjkora to Dir.

16. The portion from Panjkora to Kambat calls for no remark, as, except the part immediately opposite the bridge head, it was an easy wide road up a broad open valley. For a mile beyond the bridge two tracks had to be cut in the hillside, one for laden animals and the other for return empties. The first was done by working parties from the 3rd Brigade during the construction of the suspension bridge, and the other by the 6th Company later on, after they could be dispensed with at the Swat River.

17. The Panjkora River always contains a large number of deodar logs floating down in the water or lying temporarily high and dry on the banks or islands in midstream. From these excellent timber can be readily obtained for bridging purposes.

18. From Kambat to the top of Janbatai Kotal (7,400′) the road was in places very steep, in others almost flat; at first it was very narrow and rocky so that laden mules fell constantly. Half the 4th Company Sappers, with General Gatacre's advanced column, could do little or nothing to it. It was first taken in hand by two companies of the 23rd Pioneers on 21st April. The remaining 6 companies joined them on 24th April, and by making diversions, widening and clearing the road, had succeeded in opening a fair mule track over the Kotal by the 29th April. The descent on the far side was steep, but surface fair; in many places pine trees abound, and here and there deodar may be seen. The soil over this pass was much easier than at the Malakand.

19. With a view to avoiding so long and steep an ascent Major Ellis, R.E., made a reconnaissance of the track over the pass east of Janbatai, but the result was not encouraging enough to make any change desirable.

20. The road from Janbatai to Dir (4,800′) was a narrow but tolerable mule track except in places. It passes through a pretty valley studded with fruit trees and fairly well cultivated; the hills on both sides are barren, except for a kind of holly or stunted mountain oak which grows all over them in monotonous abundance. A wing of the 23rd Pioneers was left from the 29th April to the 4th May to improve these places; a tolerable mule track was then open to Dir. From the 8th May all work on the road up to this point passed under the control of the L. of C.

21. In order to avoid the Janbatai Pass and with the object of keeping the main line of communication in friendly territory, Major Barton made a reconnaissance of the route along the left bank of the Panjkora from Sado to Chutiatan. This led afterwards to a camel road being made up this valley in July, and the transfer of the communications to this line in August. The new road was no longer than the old one; by its adoption an ascent and descent of 5,000 feet were avoided, while it was much less exposed to attack from Bajaur.

Dir to Chitral—

Dir to Panakot.

22. Leaving Dir Fort (4,800 M.0) the road runs down to what may be called the Lowari River. This bit of road was very narrow and full of enormous boulders of very hard rock which knocked the mule loads about badly. The river was crossed by a cantilever bridge which had been made by the Khan of Dir; the bridge itself was good, but the approaches to it very steep, narrow, and rocky. From the bridge to the stream opposite the village of Panakot (5,150 M.3) the road, which is of easy gradient in hard soil, was made fairly passable by the 4th Company Sappers and Infantry working parties of General Gatacre's column. It runs up the east side of the valley above the level of the fields, which extend across the flatter ground below. The hills here are bare like those south of Dir, but during the rainy season a coarse kind of grass grows plentifully on them. This portion of the road was eventually widened to 10 feet, and two small wooden bridges made over streams by Infantry parties furnished from Dir, chiefly by the 25th Punjab Infantry, and partly by the Seaforth Highlanders. This work, commenced on the 27th April, was completed on 5th July under Lieutenant Farquharson, R.E.

Panakot to Kashgaria.

23. From the stream opposite Panakot, in order to avoid a rocky cliff, the road to Kashgaria (5,800 M.5) was originally carried up a spur by a very steep and narrow zig-zag, and thence by a narrow path in hard soil to the river opposite Kashgaria, which was crossed by a small wooden cantilever bridge, built on 23rd April 1895 by the 4th Company Sappers. As this was both an unnecessary rise and fall of 600 feet and a very trying bit of road, as soon as the 1st Company Sappers had finished the high level suspension bridge over the Panjkora they were moved to Panakot,

and on the 6th May commenced blasting a road out of the solid rocky cliff between that place and Kashgaria, near the river level. The 1st Company also made a cantilever wooden bridge over the river beyond this cliff. This heavy piece of work was completed on the 11th May.

The road from Panakot to Kashgaria was afterwards widened to 10 feet by the aid of Infantry working parties from the 25th Punjab Infantry, Dir, under Lieutenant Tylden-Patteuson, R.E., working from the 27th May 1895 to 15th June 1895.

Kashgaria to Upper Kolandi.

24. From Kashgaria to Upper Kolandi (6,400 M.7) the road was originally very bad indeed. Half the 4th Company made a cantilever bridge over the stream at Lower Kolandi on 23rd and 24th April, and another beyond Upper Kolandi on 24th April 1895; a track was opened by the Infantry working parties of General Gatacre's column with much difficulty. On the 20th April Lieutenant Colvin with the other half of 4th Company Sappers and 100 men of the Seaforth Highlanders under Lieutenant Featherstonhaugh moved to Kashgaria and worked on this part of the road, much of which lies in rocky soil, improving it until the 4th May. During this time a zig-zag was made through fields up the Kotal from Lower to Upper Kolandi, where previously there had been practically no road at all. On the 5th May the Right Wing, 23rd Pioneers, moved to Kashgaria and worked on this section until 11th May, during which time they much improved the road and made an important diversion on the north side of the Kotal below Upper Kolandi, saving 200 feet rise and fall. On the 26th May Lieutenant Tylden-Patteuson, R.E., with a party of 100 men of 25th Punjab Infantry, was moved to Kashgaria to maintain and widen the road between it and Upper Kolandi; he succeeded in making a 10-feet wide road up to Lower Kolandi by the 5th July. The road has now been made through a narrow gorge in which the river runs, which avoids the Kotal altogether, a heavy piece of work most satisfactorily carried out by the abovenamed officer, and by the 1st Company, Bengal Sappers and Miners.

Upper Kolandi to Mirga.

25. From Upper Kolandi to Mirga (7,200 M. 10) the road was also very bad originally, running for the most part up the rocky bed of the river. The advanced half 4th Company Sappers made a bridge below Mirga over the river on 24th April 1895, and on this date an indifferent track was opened out by General Gatacre's column over which laden mules managed to pass. On the 29th April the Left Wing, 23rd Pioneers, moved to Upper Kolandi and worked on the road to Mirga until 1st May, entirely remaking the lower portion of the road in the khud on the right bank of the river. On the 12th May the Head-quarters Wing, 23rd Pioneers, commenced work on this section of the road and continued on it until 1st June, by which date they had made a 10-feet wide road clear of the river bed and another wooden bridge above Upper Kolandi. This was a capital piece of work mostly in very hard soil and soft rock.

26. The valley narrows and cultivation ends at Mirga; here the vegetation alters and very little grass can be obtained at any time from the hillsides, many of which are covered with dense pine forests mixed with a small proportion of deodars.

Mirga to top of Lowarai Pass.

27. From Mirga to Gujar (8,400 M. 12) a bad path originally ran, chiefly in the river bed and thence up to the Lowarai Pass on snow in the bottom of the valley at an easy gradient. General Gatacre's column on 26th April 1895 had to tramp out a path in the snow. Afterwards when the snow began to melt fast this became dangerous, as it was hollow underneath and gave way in places. On the 1st May the Left Wing of the 23rd Pioneers moved to Gujar and began cutting out a new road from Gujar to the top of the pass on the last side of the valley clear of the snow; this was done in easy soil for 1½ miles and turned into the snow near the top, which was still hard, by the 3rd, when this Wing of Pioneers was required for work on the other side of the pass. On 12th May the 1st Company, Bengal Sappers and Miners, moved to Gujar and improved the road from Mirga to Gujar, and on 14th continued the new road, from where the Pioneers left off on the 3rd, to the top of the Lowarai Pass (10,200 M. 15). This was finished in easy soil on 17th May. On the 4th May Lieutenant Halliday took charge of working parties furnished by 25th Punjab Infantry, Gujar, and commenced widening the road from Gujar to top of pass and removing the snow bridges as the snow melted. A road 8 feet wide had been completed in this way by the 9th June. Lieutenant Duff then relieved Lieutenant Halliday at Gujar and completed the portion between Mirga and Gujar in the same way by the 30th June. By this date a mule road 8 to 10 feet wide on an easy gradient was open from Dir to the top of the Lowarai Pass, *all of which had been done by military labour*. A good deal of this was unskilled, amongst which the 25th Punjab Infantry particularly distinguished themselves. This road was widened to 10 feet throughout during August.

28. The ascent to the Lowarai Pass is, considering its altitude, easy and gradual. During the winter months it is covered with deep snow, but except during bad weather is never closed to foot traffic. The stream is full of large boulders which must either be brought down by avalanches or violent floods. The current is always rapid; the greatest flow occurs during the melting of the snow in June, except when violent thunderstorms cause floods. These come down like walls and subside as rapidly as they rise.

Top of Lowarai Pass to Ziarat.

29. From the top of the Lowarai Pass to Ziarat (7,200 M. 18) the road for the first 1½ miles was a *very* steep path cut in snow, down which laden mules could not travel, and from thence to Ziarat the Infantry working parties of General Gatacre's column on 26th April 1895 made a rough path on the left bank of the stream, which was very steep, rocky, and narrow. On the 5th May the left half 4th Company Sappers began improving the road near Ziarat, where some snow bridges had become impassable. On 4th May the Left Wing, 23rd

Pioneers, commenced cutting a zig-zag down the snow on the north side of the pass, an opening out an old trace on the right side of the valley above the snow. They continued cutting out this road in easy soil down to the stream in the valley a mile above Ziarat till the 18th May when, leaving one company to maintain the road, the remaining companies moved to Mirkandi. On the 18th May the 1st Company, Bengal Sappers and Miners, moved to Ziarat and commenced cutting out a new road from the bridge where the Pioneers had finished, down the right bank opposite Ziarat. This was completed as far as Ziarat on the 24th May. It was a heavy piece of blasting, and nearly all in hard soil. On 26th May Lieutenant Farquharson was put in charge of this section, and maintained and widened it with Infantry working parties from the Mountain Battery and Buffs until 7th June. Lieutenant Duff then succeeded him and worked with these parties till 15th June, when Ziarat was abandoned as a station. By this date an 8-foot road had been made on a gradient of $\frac{1}{6}$ to $\frac{1}{8}$ throughout the section. This was afterwards maintained by the 23rd Pioneers, and widened to 10 feet during August.

30. At Ziarat there is a fine deodar forest, but little or no grass. Down this valley the hillsides are generally steeper than on the south sides of the pass, and the rainfall is much less, though at times very heavy storms occur. During the dry season extensive tree fires are prevalent.

Ziarat to Ashreth.

31. From Ziarat to Ashreth (4,850 M. 24) the road ran mostly down the bed of the stream and was much impeded by fallen trees, big boulders, and narrow steep places, where leaving the nullah it passed over bluffs in the hillside. This was opened out by the advanced half 4th Company and by Infantry working parties of General Gatacre's column, but was a very bad track indeed. The 4th Company made three small wooden bridges on this section on 26th April 1895, working 16 hours, where the road crosses and recrosses the stream. From 5th to 9th May the left half 4th Company Sappers worked on this road near Ziarat. On 25th May 1st Company Sappers commenced making a new road from Ziarat to the gorge, two miles below that place. A road was built up at the bottom of the left bluff passing the gorge, and a rise and fall of 200 feet thereby avoided. This was finished on the 29th May. From 21st May Infantry working parties of the Buffs from Ziarat and Ashreth cleared that portion of the road of stones which ran down the bed of the stream, and from 1st to 13th June a section of the 4th Company Sappers cut through some of the rocky bluffs where the road left the river bed. On 17th June three Companies, 23rd Pioneers, commenced to widen and improve the road in the remaining bad places, and to replace the bridges by others on a higher level; this was finished on 30th June, when a good road 8 feet wide was open all the way to Ashreth.

Ashreth to Mirkandi.

32. From Ashreth to Mirkandi (4,250 M. 27) the road was originally very bad, narrow, steep and rocky in many places, with several rises and falls. General Gatacre's column first opened a path on 27th April 1895. On 20th May three Companies, 23rd Pioneers, commenced working back from Mirkandi on the worst bit of the road in hard rock. They completed a mile back by the 28th May. Again on the 15th June the same three Companies, assisted by Infantry working parties of the Buffs from Ashreth, completed a road 8 feet wide back from this point to Ashreth by the middle of August.

Mirkandi to Galatak.

33. From Mirkandi to Badulga (M. 28) the road first made a very steep and bad descent to the river bank, and then was fairly good. From Badulga to mile 31 it was extremely bad, rising and falling over a series of rocky cliffs, very steep, stony, and narrow. Thence to Galatak (M. 33) it ran for 2 miles over an open down-like plateau, with two or three bad rocky bits. On the 28th, 29th April, and 6th, 7th, 8th May, the right half 4th Company Sappers, assisted by working parties from the Infantry of General Gatacre's column, managed to get a path open for laden mules by means of corkscrew staircases and gallery roads in several places. From the 29th May the Left Wing, 23rd Pioneers, commenced to work on this road, and by the 10th June had made a good road 8 feet wide as far as Galatak. The bad portion at Badulga was replaced by another road on a better gradient by 1st Company, Bengal Sappers and Miners, in August.

34. Opposite Badulga is the picturesque Fort of Kila Naghar. Here in June the villagers erected a twig rope bridge across the Chitral river, but it sagged so much that a sudden rise carried it away before it could be of much use. They then ran a wire across and with the aid of an iron ring managed to pass a large quantity of bhoosa over on it. This would be an excellent site for a suspension bridge.

35. Unlike the rest of the road, there is no water between Badulga and Galatak along side the route. The open downs on the south of the latter place are not unlike the dried up patânas of Ceylon. They support a yellow-looking aromatic grass which is readily eaten by mules.

Galatak to Drosh.

36. From Galatak to Drosh (4,400 M. 37) the road was fairly good originally, but there was a bad descent from Galatak village, and a steep ascent to Drosh. On the 8th May the 4th Company Sappers, made a path up to Drosh, and on 21st May began cutting another approach near the fort. On 25th May seven sections moved to near Galatak and made a good road down from the village, and a high level road for 1½ miles from that village to replace the old path in the river bed. This then became a good mule track 8 feet wide as far as Drosh.

37. The two forts at Drosh were good examples of the native forts in this part of the world. The walls of boulder masonry in clay are thick and strengthened by the use of a large quantity of timber as binders. This renders them very liable to catch fire. Below the cliff on which the forts stood was the remains of a large cantilever bridge over the Chitral River; the

piers built of the same class of masonry as the walls of the forts were still standing with some of the cantilevers, but the connecting beams had been removed.

Drosh to Chitral. *Preliminary Remarks.*

38. From Drosh to Chitral the road was originally almost impassable for laden animals; it was opened out with great labour against time by the 4th Company, Bengal Sappers and Miners, and Infantry working parties of the advanced column under General Gatacre. The 32nd Pioneers from Chitral assisted a little near that place.

Drosh to Shishu Ku River.

39. From Drosh to the Shishu Ku River bridge, 3½ miles, the road runs over an open plateau, and is very fair. A rather steep descent takes one to the cantilever bridge, built by the 4th Company, Bengal Sappers and Miners, on the 9th and 11th May. A steep ascent up the opposite spur was cut out by the Buffs and Goorkhas. This can be avoided and two miles saved by fording the Shishu Ku near its junction with the Chitral River, when the water is low. Before reaching

Khairabad.

Khairabad (M. 42) a rocky pari is passed, with a very steep ascent and descent. This corkscrew and gallery road was made by the 4th Company, Bengal Sappers and Miners. Between Khairabad and Kesu

Kesu.

another smaller pari is passed, and then there is a fair track along the high bank till another pari with a guard-house is reached. After this an easy track runs to Kesu (M. 45). At this village the road leaves the high ground and runs through some low cultivation to the aqueduct over the Chitral River north of Kesu. At all these paris the 4th Company Sappers did a great deal of rapid work to render the road passable. Later in July and August this company improved the road immensely as far as Gairat.

40. The aqueduct is taken across the river in a hollow trunk of large dimensions supported by cantilevers as in the case of the bridges. The water it conveys across the river is used for irrigation, and it is itself an interesting piece of native engineering.

Gairat.

41. Leaving the aqueduct a steep narrow road runs to another rocky pari at mile 45½ with a sharp rise and fall, then along an easy khud at high level, until at mile 47 the track descends at a steep gradient to a low level along bank of river. At mile 48 the ascent begins to Gairat. This is a very steep and narrow bit of road; in one place it is a sheer gallery road along a cliff of rock. This very difficult piece of work was done by the 4th Company, Bengal Sappers and Miners, on 13th May, and greatly improved by the same company in August.

42. Leaving Gairat (M. 49) the road is very narrow, and at mile 50 it descends again into the river bed. It leaves this at mile 51 and ascends by an easy road to Spalasht. Between this and Broz it is a very fair road, except the 54th mile, where it passes along a steep khud of shifting shale which is never permanent. Broz is reached at mile 55½ and the road runs above the line of villages of this name to mile 58½; this is a very fair track, rather narrow, with three bad crossings through streams running down the khud. From mile 58½ a flat sandy bit of road runs to mile 60, when it passes round a rocky pari, most of the road being built up of stone walls. After passing round this, Chamarkhand is reached (M. 61).

43. There are apparently several good defensive positions across the river between Mirkandi and Chamarkand at which a small force could hold a large one in check, such as Badulga, Khairabad, Gairat, etc. But in no case is the position on both sides of the river equally good; further exploration would probably show that many of them could be turned without any great difficulty. A thorough reconnaissance would be necessary before any trustworthy estimate of their value could be made.

Chamarkand.

44. From Chamarkand to Joghur (M. 65) the road runs on the low bank of the river, except where at mile 63 it passes round a rock pari; here there is a very bad steep ascent and descent. Thence along high bank of river a very fair track to mile 65½, when a steep ascent leads to a long steep khud of shifting shale, where the road is constantly being blocked. The 4th Company, Bengal Sappers and Miners, did much to improve this on 17th and 18th May. After leaving this khud at mile 67, a narrow road passes through the village of Dariel and descends across open

Chitral.

fields to the Chitral Bridge (M. 67½); crossing the bridge a narrow path runs along a rocky khud for a quarter of a mile, thence Chitral Bazaar is reached by a good track at mile 68½. This last bit of road was improved on 19th May by the 4th Company, Sappers.

45. The road that has been made is not a permanent one, no *pucca* drainage has been given, nor have breast walls been built to prevent the sides slipping in heavy rain. The retaining walls too are very hastily made of uncoursed dry rubble and brushwood. Where the road has been cut out of solid rock it will doubtless remain intact for a long time, but the other parts will require considerable repairs annually, especially after the melting of the snow on the passes and during the rains.

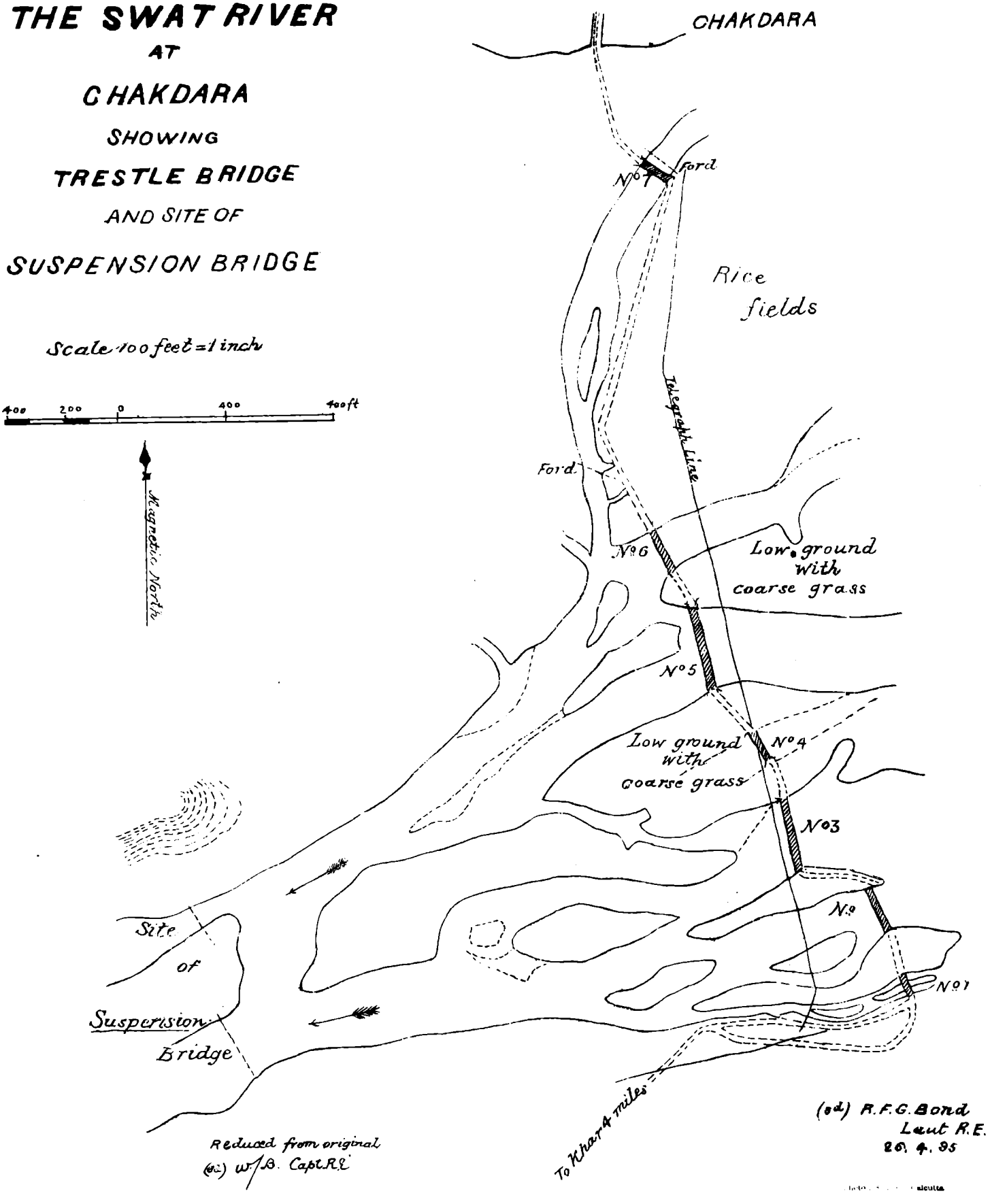
46. There is no timber in the Chitral Valley itself, except fruit trees, but the mountains on both sides have forests of pines and deodars at altitudes of 7,000 to 8,000 feet. Many logs from these are constantly floating down the river. In the main stream the water has a large quantity of sand in suspension and the current is always rapid; in the side streams, except during storms, the water is quite clear. The natives are adept at crossing the river on small mussacks into which they stuff their clothes, and in this fashion they may often be seen floating down for long distances, quite oblivious to any danger there may be from rapids, etc.

47. A plan and section of the road Dir to Chitral will be found at the end of these appendices.

THE SWAT RIVER
AT
CHAKDARA
SHOWING
TRESTLE BRIDGE
AND SITE OF
SUSPENSION BRIDGE

Scale 100 feet = 1 inch

400 200 0 400 400ft



Reduced from original
(sd) W. B. Capt R.E.

(sd) R.F.G. Bond
Lieut R.E.
26. 4. 95

SWAT RIVER

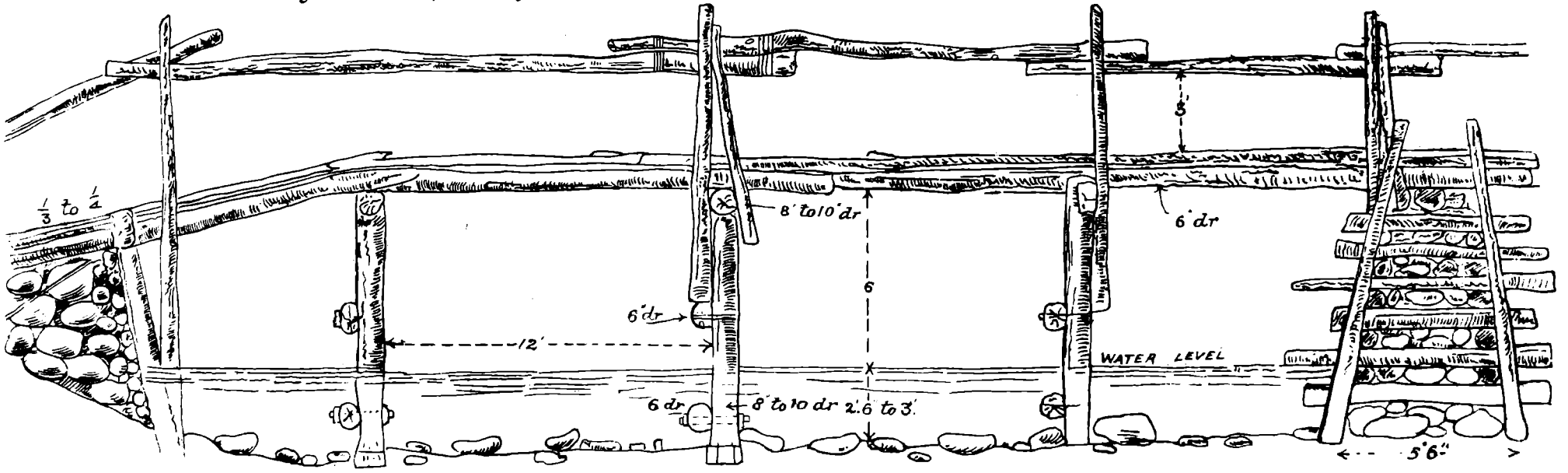
TRESTLE BRIDGE

PLATE II

Side elevation shewing construction of trestles & cribs.

Roadbearers bound with wire or spiked to transoms.

Timbers framed together with spikes dogs or botts.



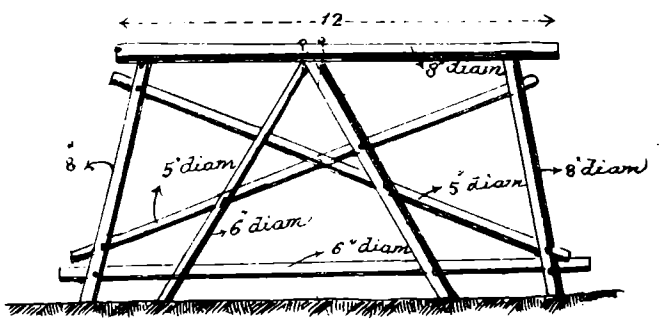
River bottom – Stones & Sand

Scale 4 feet to 1 inch.

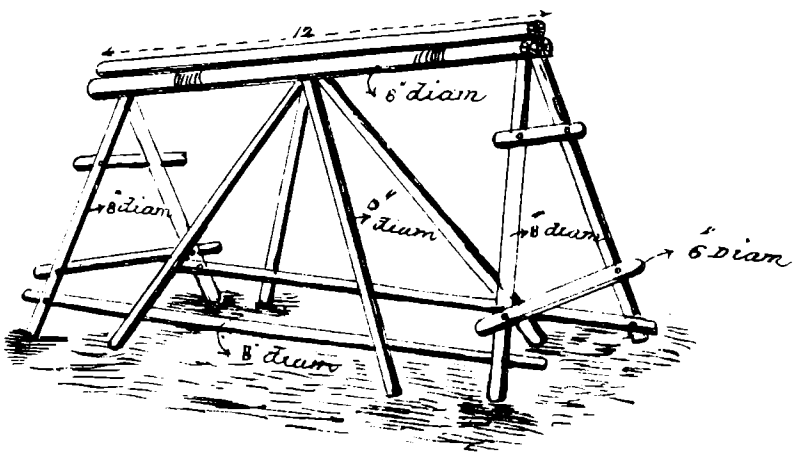
SKETCHES OF TRESTLES

SWAT RIVER BRIDGE

Two Legged Trestle



Four Legged Trestle



Height varies with depth of river

APPENDIX C.

Trestle and Crate Bridge over the Swat River.

Constructed by Major Barton, R.E.

On the arrival of the advanced troops of the Chitral Relief Force at the Swat River, it was found that, although the river was then fordable, it would soon cease to be so, and thus the immediate construction of a bridge was necessary.

2. There was a ford opposite to the village of Chakdara where the river flowed in five separate channels, with low islands between them, and although the distance from bank to bank was some two-thirds of a mile, it was evident that this would be the most suitable site for the proposed Trestle and Crate Bridge, owing to the river being too deep and the stream too rapid in other places with narrower channels.

Description of River.

3. The width and depth of the various channels on 7th April were as follows (counting from the left or south bank of the river):—

No. of Channel.	Width.	Approximate Depth.
1	.....	Dry.
2	216ft.	2 ft. to 2ft. 6in.
3	276ft.	2ft. to 3ft. 3 in.
4	.....	Dry.
5	372ft.	1ft. to 2ft. 6 in.
6	180ft.	2ft. to 3ft.
7	96ft.	2ft. to 3ft.

Nos. 1 and 4 were dry when the bridge was commenced, but shortly afterwards filled. Nos. 2, 5, 6, 7, could be forded fairly easily, while No. 3 was even then difficult and almost dangerous. (See Plate I.)

4. The depth of the river changed considerably from time to time. The rise due to snow water was small and very gradual, whereas that due to storms was sudden and the river subsided with almost equal rapidity. These storms were of frequent occurrence in May and June. During April the maximum rise was about 1 foot 6 inches, in May about 4 feet and in June 5 feet. Rises, however, like these, combined with the rapid current, taxed the stability of the bridge very severely. On the 28th June, the river rose about 7 feet and a portion of the bridge was carried away.

Depth.

5. The current was very rapid and varied a good deal, being greater in some channels than in others, and even in different parts of the same channel; on the 7th April it was estimated as varying from 3 to 6 miles an hour. It increased considerably later on, reaching 8 or 9 miles an hour at times.

Rate of Current.

6. The bed of the river consisted of round boulders, whose tendency to roll away at each rise added to the difficulty of maintaining the bridge.

Nature of Bed.

7. The material for bridging purposes consisted of timber, obtained by demolishing a native fort and some villages in the neighbourhood. It was, however, of inferior quality both in size and soundness, and as it was impossible to pick and choose, a considerable margin of safety had to be given. That suitable for the trestles and roadbearers was about 15 feet long and 6 inches to 8 inches in mean diameter, while the doors of houses supplied material for the roadway.

Material available.

8. The following general plan of the bridge was decided on:—

Method of construction.

Piers.—One crate (or crib) filled with stones to every 3 or 4 trestles to give steadiness to the whole structure.

Trestles.—Two-legged, braced as usual, and strengthened by two props under the transoms (see sketch in Plate III).

Span.—A uniform span of 12 feet was adopted.

Roadway.—The width was limited to 5 feet 6 inches as the doors available for use as chesses did not admit of its being made broader.

Roadbearers.—Four per span were, as a rule, considered sufficient.

The height of the roadway was fixed at 6 feet above the level of the water on the 8th April. This allowed for as much rise in the river as the bridge would stand.

9. The pattern of two-legged trestle adopted proved to be an excellent one of its kind, and it may be noted that, out of 80 trestles of this description, only one failed from structural weakness, and then only because the diagonal braces gave way. Many had to be replaced later on by four-legged trestles on account of the scour undercutting the down stream legs, but none actually broke.

Trestles.

10. The crates (or cribs) proved rather weak and required constant attention, as in some instances they were made without bottoms; in three cases the scour of the water completely emptied them of stones in the course of a few hours.

Crates.

Owing to the short time available, they were rather too roughly put together, but under ordinary circumstances, when properly made, they add immensely to the stability of a bridge.

Four-legged trestles.

11. The four-legged trestles used to replace any of the two-legged ones which had to be taken out owing to undercutting, were of the pattern given in the accompanying sketch (see Plate III). They were made by joining a couple of the two-legged trestles securely together with wire lashings and braces, and then putting an extra transom on the top. If carefully made, and bolted instead of spiked, this forms a very strong trestle, and, given time and material, is preferable, for a river of this description, to the two-legged trestle.

Officers and men employed on the construction.

12. The 4th Company, Bengal Sappers and Miners, under Major Aylmer, V.C., worked on the bridge from the 8th April until the evening of the 9th April, when Major Barton, R. E., was placed in charge of the work. The 1st Company under Captain Serjeant, and 6th Company under Captain Skey, assisted him from the 9th April until 16th April.

13. In addition to building the bridge, a large number of the sappers were employed in demolishing houses, stacking the timber obtained from them, also in making the approaches in the different portions of the bridge and the raised causeways between them. Hospital dhooly bearers and local coolies were utilised in carrying the timber from the villages to the site of the bridge and collecting stones for the causeways.

14. On the 14th April, there was no work on the bridge, as a large convoy of ordnance and other stores had to be taken over by coolies. But by the 15th April, or in eight working days, the bridge was completed. It was opened for traffic the same evening, and a large convoy of pack bullocks crossed over it. The total length of the bridge was 1,350 feet or 450 yards.

Maintenance.

15. This mainly consisted of replacing two-legged trestles by four-legged ones (often a matter of considerable difficulty in the rapid current) whenever this was rendered necessary by scouring, placing camel nets filled with stones on the upstream side of the trestles and crates to break the force of the current and to prevent scouring, raising the transoms of any trestles that had sunk, repairing hand rails, keeping roadway in order with fresh earth, grass, etc.

16. The bridge was never closed for the whole day, it was always open to the regular convoy. Repairs were carried out in the afternoon and only occupied a few hours daily.

17. Major Barton left Chakdara on the 22nd April, and the maintenance was entrusted to Captain Skey from 22nd to 30th with half the 6th Company, Bengal Sappers and Miners. Afterwards Captain Heath, assisted by a small detachment of the 6th Company, Bengal Sappers and Miners, took charge of it.

Traffic.

18. Captain Heath estimates the number of laden animals (mules, ponies, camels, and bullocks) that passed daily at somewhere about 3,000. Major Barton says:—"From my own notes and those of "Captain Heath it will be seen that the bridge was open for traffic from the 14th April to 25th "June, a period of 72 days, and if Captain Heath's estimate be correct, during this period "some 200,000 laden animals crossed it, representing probably a maundage (1 maund=80 lbs.) "of not less than 600,000. A large number of unladen animals also crossed the bridge on "their return journeys."

Destruction of bridge.

19. A flood on the night of the 24th-25th June did so much damage to the bridge that the available labour was not sufficient for its repair, and it was decided to abandon it. It remained standing, however, though a very heavy flood on the night of 25th-26th June; on the night of 27th-28th June thirty or forty yards were carried away.

20. During the construction of the bridge, the troops, followers and baggage animals had to use the ford, which daily became more dangerous, owing to the rise in the river, and to the smaller stones in the bed being displaced by the traffic and then carried downstream by the current, thus making the ford deeper.

Attock boatmen.

21. The Attock boatmen on their mussacks (inflated skins) were invaluable here. They are absolutely fearless of the water, however rapid it may be. They were stationed at intervals across the river; any man crossing who found himself in difficulties had a boatman at his side in a moment, and animals wandering off the ford and floundering in the water were at once seized and brought back.

22. With the exception of two sepoys who endeavoured to cross at an unauthorised place, not a single man or animal was drowned while fording the river.

23. Major Barton, with reference to these boatmen, writes: "Had we not been able to avail "ourselves of their assistance, I am convinced that the loss of life in crossing the river would "have been considerable and that of stores very great."

Panjkora Raft Bridge.

Constructed by Major Aylmer, V.C., R.E.

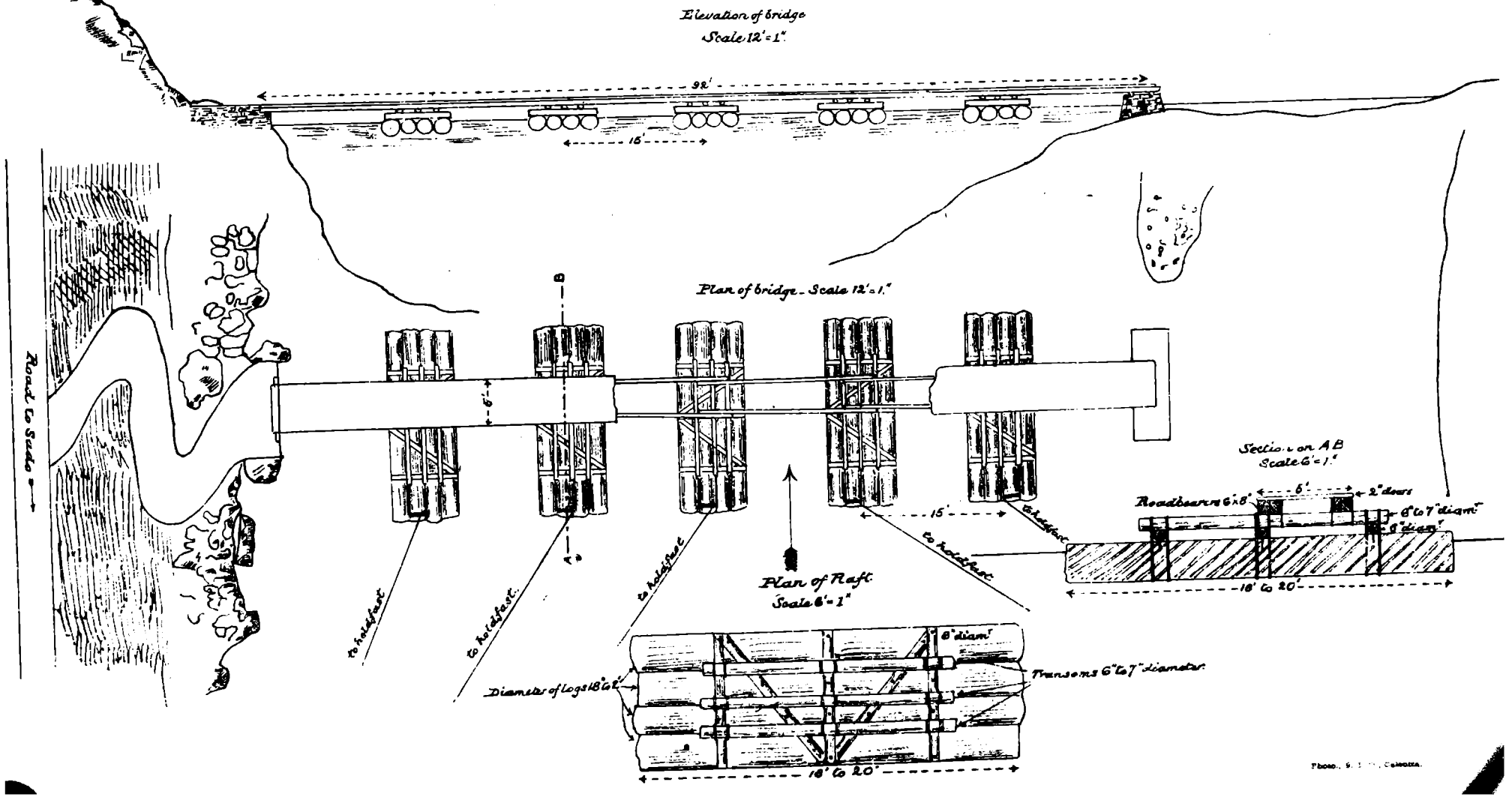
Description of river.

1. The Panjkora river is easily fordable in winter, but unfordable in summer. Its bed is sometimes half a mile broad, the water flowing in several shallow streams over a pebbly bottom; sometimes, as at the site of the suspension bridge, it flows through a narrow rocky gorge, and except during excessive floods, is here barely 100 feet wide.

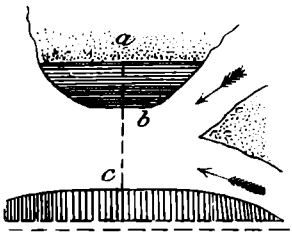
2. When the Cavalry arrived on the 8th April, it was fordable, but, by the afternoon of the 11th April, the water had risen considerably, and the ford was considered unsafe, even for Cavalry.

PLATE V.

Sketch of Raft Bridge, Panjkora.



3. It was quite impossible to make a suspension bridge, which was plainly the best sort of bridge to make, as no materials had arrived in the way of wire. There were, however, a very large number of big logs lying in the river bed; many of these were 2 feet in diameter and 20 feet long.



4. It was determined that a floating bridge should be constructed with log piers.

5. The site chosen was as shown (see marginal sketch), A. B. C. being the position of the bridge. A. B., 40 feet, was only about 6 inches deep; B. C., 92 feet, was very deep indeed. Owing to the set of the stream, the current on the surface was not great, considering the small width. It was probably not over five miles an hour on the 11th.

6. On the evening of the 11th, the Sappers of the 4th Company, Bengal Sappers and Miners, after a long day's work on the road, began to collect timber and float it down to the bridge site.

Construction.

7. Work was begun at 6-30 A.M. on the 12th. Working parties of British and Native Infantry brought roadbearers, chesses, doors of houses and all smaller timbers from Sado, some two miles above the site; two Companies of the 23rd Pioneers assisted in collecting more large logs and in making approaches. The Sappers, some 130 strong, were partly engaged in collecting timbers, and partly in making the bridge.

8. Each raft was composed of four of the biggest logs, 20 feet long and 18 inches to 24 inches in diameter. These were connected together with cross and diagonal pieces of timber as shown, fastened to the big logs by large spikes and wire. On these cross pieces were three transoms well secured by wire. These transoms were so placed that the roadbearers would not rest in the middle of the rafts, but several feet nearer the sterns so as to raise the bows.

9. The rafts were placed at 15 feet intervals and secured to iron jumpers, driven into the rock upstream, by wire and 3-inch manilla cables.

10. By the evening a rough roadway, suitable for Infantry in single file, had been finished from C. to B. There were five piers. Only two roadbearers had been put in and the chesses were only very loosely secured. On the 13th, it was intended to make the roadway thoroughly good, build a causeway from B. to A., and endeavour to raise the bows of the rafts, by a thin wire cable that arrived in the evening.

11. During the night, however, the river unexpectedly rose some 2 feet, and several large logs coming down struck the bridge. One log got over the bows of No. 2 raft and completely submerged it.

Destruction.

12. On the morning of the 13th, an attempt was made to repair the bridge. No. 2 raft was cast off, repaired, and an endeavour made to get it into its place again, but the current was now running at about 10 miles an hour. Finally a 3-inch cable broke and No. 2 raft broke loose and was wrecked half a mile down stream, the six men on it having a wonderful escape.

13. Just after this, No. 3 raft got into a bad way, and it was decided to give up the idea of a floating bridge altogether.

14. Plate V gives necessary details of the bridge. It was intended only for mule transport.

Description of Small Suspension Bridge at Panjkora.

Constructed by Major Aylmer, V.C., R.E.

1. On the morning of the 13th April 1895, the log pier bridge over the Panjkora River was washed away, so it was determined to make a Suspension Bridge some two miles lower down.

2. The site was carefully examined and measured, the river being crossed on a mussack raft.

Material available.

3. The only available material for the cables was telegraph wire. In the evening wood was collected and the construction of the telegraph wire cables and trestles was commenced. Work was carried on all night by reliefs.

Construction.

4. On the morning of the 14th April the trestles were carried down to the bridge site. The first thing done was to establish communication across the river by means of a seat secured to a block travelling along a tightly stretched 3-in. manilla cable. During the day footings were cut for the trestles, the anchors got into position and made secure, as hereafter described, and one trestle was raised.

5. On the 15th April the other trestle was put up, both trestles were stayed and strutted, the wire cables, which had been finished on the 14th, were got into position and secured to anchorages, slings and transoms were attached; by the evening foot passengers could go across, which they did, interfering greatly with the work. It rained for a great part of the day, making the fixing of slings and transoms a dangerous undertaking.

6. On the 16th the roadway was made thoroughly good even for camel transport, railings and side screens of bushes were put up, approaches finished and wind-stays fastened up and down

stream to jumpers driven into the rock. Over 3,000 men crossed the bridge during the day stopping the work for about three hours.

7. Infantry working parties assisted each day in carrying wood and stores, and in making approaches.

Labour employed.

8. The average number of men employed daily for 14th, 15th and 16th was :—120 Sappers (4th Company, Bengal Sappers and Miners), 150 Infantry. Actual work on the bridge was from 7 A.M. to 6 P.M.

9. The bridge could have been finished by the evening of the 15th—

(*a*) if the sappers had been camped at the site, instead of 2½ miles off ;

(*b*) if the weather had been fine. It was bad most of the time, especially on the 15th;

(*c*) if the work had not been constantly interrupted by the passage of troops when the roadway was incomplete.

10. This bridge had a constant and heavy traffic over it for two months It was finally washed away, but not until the water had risen above the roadway.

DETAILS OF CONSTRUCTION.

Cables.

The telegraph wire used was supplied in bundles, suitable for mule transport. The wire had a breaking strain of 2,000 lbs. Each bundle gave about 440 feet of wire.

1. All the wire was properly unrolled, as follows :—Each bundle was taken by two men who attached one end of the wire to a tree, and then rolled the bundle along the ground and away from the tree (see fig. 1, Plate VII) This is necessary, for if the wire is merely pulled off from one face of a bundle, there will be one twist in each length equal to the circumference of the bundle, and, when stretched, kinks and a corresponding weakness are produced.

2. It was settled to make the bridge with a span of 90 feet and dip of $\frac{1}{10}$. Taking the weight of the roadway as 60 lbs. per foot run, and the maximum distributed dead load as 210 lbs. per foot run, which is that for Infantry in single file crowded, we get a maximum stress of 32,000 lbs. or 16,000 lbs. in each cable. It was thought best to have a considerable factor of safety, so 30 wires were put into each cable, giving a strength of 60,000 lbs.

3. After taking a careful section of the site, it was found that each cable would have to be 210 feet, allowing for fastening to anchorages. Instead of cutting the wire and making two cables, a single cable was constructed about 430 feet long. This saved time.

4. To construct the cable, seven of the unrolled wires were attached to a tree A. Another holdfast B. was made at a distance of 430 feet. One of the wires was now taken, and a rope attached to its free end. Ten men having stretched this wire as tight as possible, made it fast to B. holdfast by walking round it a couple of times, keeping the strain (see fig. 2). In a similar way, the six other wires were stretched.

5. Now beginning at A. the 7 wires were bound into a group with twine at every foot (see fig. 3). The wires were not allowed to ride anywhere. Similarly three other 7 strand cables were made.

6. The main cable was then made by stretching the four 7 strand cables and two single wires, and binding them together with string at every 3 feet.

Trestles.

7. For details, see fig. 2, Plate VI. The wood used was common pine, The standards had a minimum diameter of 10 inches. They were tenoned at the thin ends, and morticed crosspieces were then fastened to them by iron straps 2-inch wide and ⅜ inch thick, serving as a resting place for the cables. These trestles were so constructed that the roadway might pass a considerable height above the feet of the standards. They were put together at the site and erected entire, being strutted up and down stream, as well as in shore. They were also tied back to the anchorages, and were given a slight inclination in shore to allow for the tightening of the ties when the strain came on the cables.

Anchorages.

8. Both consisted of 14 feet logs 15 inches in diameter. That on the left bank was placed in a depression in the solid rock. Jumpers were driven down in front of it, and the whole was weighted down by some 4 or 5 feet of stone work above it. That on the right bank was placed behind a convenient shoulder of rock as shown.

Placing cables.

9. One end was fixed fastened to one side 'a.' of the anchorage on the right bank by passing it twice round and binding the free end to itself, as shown in fig. 8. The cable was then placed over the two trestles ' b. c.' and fastened in a similar manner to one side, 'd.', of the anchorage on the left bank, then taken to the other corner, 'e.', of the same anchorage and fastened as before, the free end being then led over the two trestles back to the anchorage on the right bank and secured to the end 'f.' of the log remote from the place where it was first attached (see fig. 7). This was done so as to leave the cable between the trestles hanging on both sides with a dip of $\frac{1}{13}$.

Construction of roadway.

10. The length of the slings by which the transoms were hung from the cables were calculated, *vide* para. 178, Vol. I, Part III., Military Engineering, and an allowance made in their length for a camber of 1 foot 6 inches. To the length so calculated was added a constant of 1 foot 6 inches for depth

Sections of Panjkora Saspension Bridge

PLATE VI

Wire Cable

Section through Roadway

Fig 1

Scale 1/24

Railing

Railing

Railing

Railing

Bushes

Sling

3" diam

5'

Ribband Boots as chesses 1"

Ribband

Road Bearers

Transom

9" diam x 7' long

Stays each of 6 wires with a B.S. of 1000 lbs.

2 Spikes

2 Spikes

6' diameter

Wire Cable 30 strands of telegraph wire each with breaking strain of 2000 lbs.

Fig 2

Section at Main Trestle

Scale 1/12

4" x 6"

Strut 6" diam

Strut

5'

Transom 9" diam 12" diam

Fig 3

Side Elevation looking up stream

Boulder filling

Cable

Back ties

90' dip 1/10

Cable

Back ties

Big log as anchor

Anchorage Big log

Strut

90'

Crib

Small boulder

Small boulder

Scale 1/60

Details of Construction.

PLATE VII.

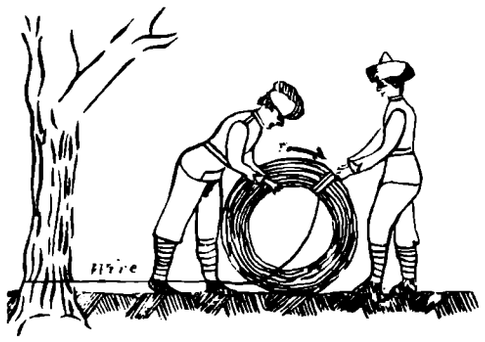
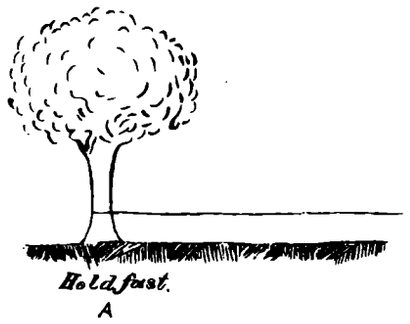


Fig. 1.



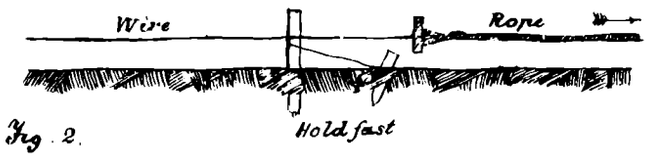


Fig. 2.

Fig. 3

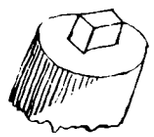


Fig. 4.

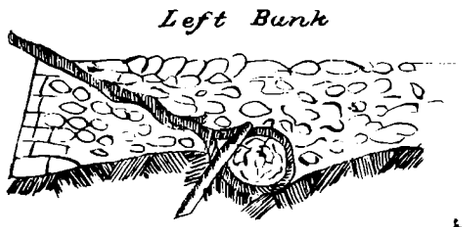


Fig 6.

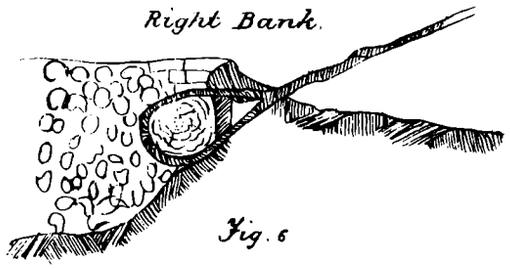
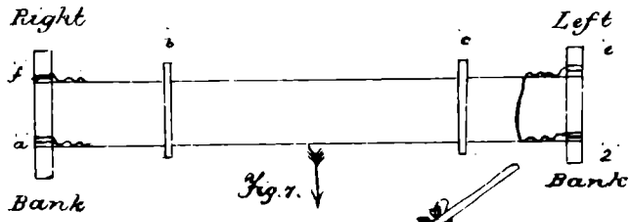


Fig. 6



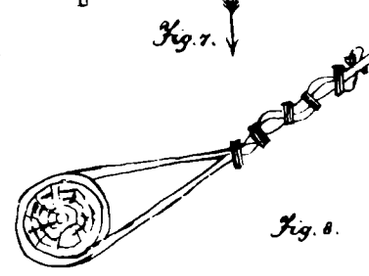


Fig. 8.

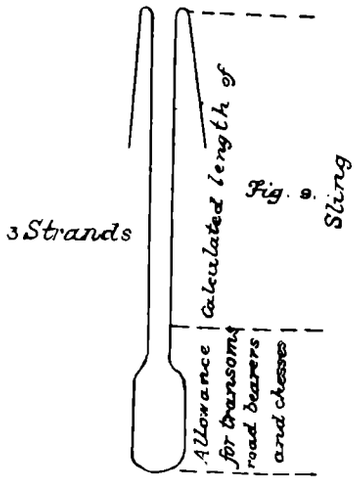


Fig. 9.

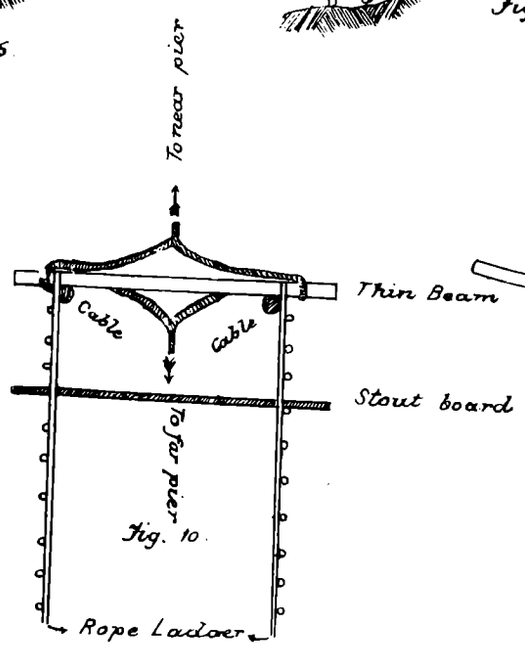


Fig. 10.

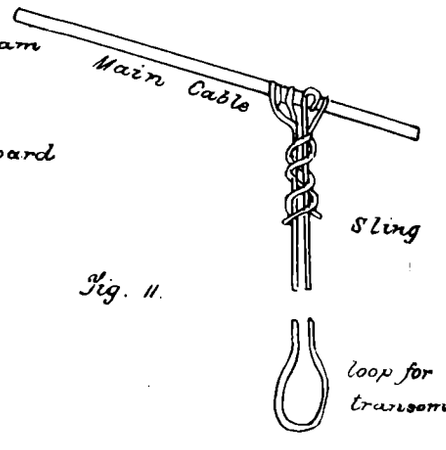


Fig. 11.

Photo. S. I. O. Calcutta

of transom, roadbearers, and chesses. The slings were made by stretching and binding together 3 strands of wire. This was then bent in the shape shown (fig. 9).

11. The slings were fixed as follows :—A thin beam, with rope ladders hanging from either end, was placed on the main cables near the trestles. The bottoms of the ladders were connected by a stout board so that men could stand on it. The beam had also ropes attached so that it could be pulled backwards or forwards (fig. 10). Two of these cradles were used simultaneously, one at either end of the bridge.

12. To fix the slings two Sappers, each taking a sling, stood on the board connecting the rope ladders, and were pulled out some 11 feet. Each Sapper then fixed his sling by turning the ends a couple of times round the main cables, and then three or four times round the slings themselves (fig. 11). The first two slings were tied back to the trestle to prevent them slipping forward.

13. The first pair of slings being fixed, transoms were placed in the loops and secured. A pair of roadbearers were then lashed to the transom, and a rough temporary roadway made with a few chesses (doors).

14. In practically the same way the roadway was made throughout; after being completed in this rough manner, the bridge was carefully inspected and any error in the length of slings corrected.

15. The roadway was then finished off. There were four 6-inch roadbearers, generally covering two bays. The roadbearers were spiked to the transoms. The chesses were made of doors from native huts in the neighbourhood, ribands were well racked down, breaking joint with the roadbearers. Railings were added as shown in the section, and to these were attached branches and bushes, forming a screen so that animals should not be frightened at the rush of water below.

16. The chesses were covered with leaves and earth. Side stays were added up and down stream to prevent lateral motion, being secured to jumpers driven into the rock.

17. On the right bank, in shore from the trestle, the roadway was supported on two small trestles and a small crib pier

18. For other particulars of this bridge, see plates VI and VII.

Report on Panjkora River Suspension Bridge,

ERECTED BY

Captain Serjeant, R.E., and 1st Company, Bengal Sappers and Miners, April 1895.

Collection of materials.

1. The 1st Company, Bengal Sappers and Miners, marched from Chakdara to Panjkora River on the 18th April over Katgola Kotal and through Sado. On the following day a small party went up the river to look for suitable timber for the main frames. The C. R. E. had previously chosen a site for the bridge where the span was approximately 200 feet, rocks on either bank giving footings for the main frames, and allowing about 25 feet for the roadway above the water at the time. The dip of cables was fixed at $\frac{1}{12}$, and allowing for a camber of 2 feet and for the centre transom of the bridge to be not less than 2 feet below the main cable, the main frames had to be about 20 feet high. None of the wood taken out of villages and forts in the neighbourhood was considered of sufficient scantling or sound enough for these, so that logs had to be found and sawn up for the purpose: in fact, with the exception of some of the side struts of the main frames, and a few doors used for chessing, the whole of the wood used in the bridge was sawn from logs taken out of the river. The logs were warped down by Nowshera boatmen to a convenient position about 300 yards above the bridge, where they were landed and sawn up.

Construction.

2. On the 20th April a party was detailed to commence stretching the strands of telegraph wire for the main cables, on the principle described in Major Aylmer's "Notes on Bridging." Each cable was made up of 84 strands of telegraph wire (300 lbs. to the mile, breaking strain of each wire 1,000 lbs.); the several wires being uniformly stretched by a party of 10 men and secured to holdfasts. The wires were then bound up in bundles of seven with twine at intervals of about 9 inches, care being taken to prevent strands overriding. For this purpose a rough gauge of wire twisted in loops was used, and run along as the binding progressed, keeping each wire in its proper relative position. The bundles of seven were subsequently bound up into one cable in a similar way, wire bindings taking the place of twine. Each cable, when complete, weighed about a ton.

3. The excavations for anchorages were commenced the same day. On both banks rock was met with, and considerable blasting had to be done before sufficient depth was obtained. The excavation on the left bank could only be taken back about 42 feet from the main frame as the ground rose very steeply beyond this. The rock met with was very hard, a kind of trap. A depth of 5 feet was excavated below the natural ground and the anchorages, which consisted of logs 18 feet long by 20-inch diameter, were placed in position. Holes were jumped immediately in front of the anchorages, and steel crowbars were placed in these; the whole was then very carefully built in with stones, pieces of wood being placed at intervals to bind the stones together into one mass.

4. The Sapper artificers and all sawyers were meanwhile engaged in making the main frames, and cutting up logs for roadbearers and chesses. The details of main frames are shown in Plate VIII. The transoms were morticed on to the standards, and broad straps of iron were bolted on to take the main cables. A headway of 11 feet was allowed. The main frames were allowed to pivot at their base, and rested on broad bearing plates of wood, into which they were slightly recessed; they were prevented from moving forward by jumpers driven into the rock immediately in front of each standard. The frames were erected on 23rd and 24th April. The tackle for the left bank frame was fixed to a rock on the water's edge about 50 feet in front of the footing of the frame, the rocks on this side being only covered with water when the river is in flood. The tackle for erecting the right bank frame had to be secured on the far side of the river, as rocks fell almost vertically down to the water below the footings. The frames were raised in the usual way, back struts were fixed as shown in the plate, the frames being slightly set back from the vertical. The back guys were then secured to the anchorages. They consisted of 1¼ inches steel wire cable, subsequently supplemented by cables of 14 strands of telegraph wire (300 lbs. to mile).

Main frames.

5. On 26th April the main cables, which had previously been placed in position in prolongation of the line of bridge, were passed over, one at a time. A 3-inch rope was attached to one end of the wire cable, and to a block and tackle on the opposite bank. The cable was then slowly payed out over the top of the main frame, every precaution being taken to prevent it touching the water. The stream was so strong that the cable would have probably become unmanageable if it had once gone into the water, or, at any rate, would have been liable to be damaged against rocks, etc. Accordingly, when about one-third of the cable had been passed over, a preventer block and tackle was fixed on the paying out side to prevent the cable taking charge. The cables were then secured to the anchorages with two round turns, the spare ends being twisted round the standing parts and securely bound with wire at every 9 inches. It was much less difficult than was anticipated to take the two turns round the anchorages. The cables were fixed about 5 feet higher than their permanent position, to allow for subsequent stretching, etc., when the load come on. Late the same evening, two 3-inch steel wire cables arrived. On the following day, these were put up alongside the telegraph wire cables and at the same dip. The roadway was then started, and as each transom was got out and slings fixed, the two cables were securely bound together with wire at intervals of about a foot.

Fixing cables.

6. The slings for transoms consisted of 8 strands of (300 lbs.) telegraph wire The length for each transom was calculated, and the wire bent over into hooks at exact length, measured from top of transom to bend of the hook, as calculated. Each transom was prepared on the banks and slings ready fixed, so that it was only necessary to hook the wires over the main cables, pass the transom out to its right interval, and secure. The return of the hooks was passed twice round the main cable, and the spare ends then twisted round and round their own standing ends, and bound with fine wire. The details of the rest of the roadway are shown in the plates of the bridge. Sloping struts, from the foot of the main standards to the top of the first sling, were added to take the strain off the first two bays and to lessen motion. Wind ties were then fixed at every alternate transom and secured to jumpers driven into rocks on the banks. Diagonal wire braces of 7 strands of wire, as shown in the plate, were added to help to take the strain off the vertical slings. The bridge was completed on May 1st.

Slings and roadway.

7. The actual number of men employed cannot be stated, as all spare men were worked on the approaches to the bridge; a party of about 15 men was employed daily sawing timber, and on an average, from 30 to 40 men on the rest of the bridge.

Men employed.

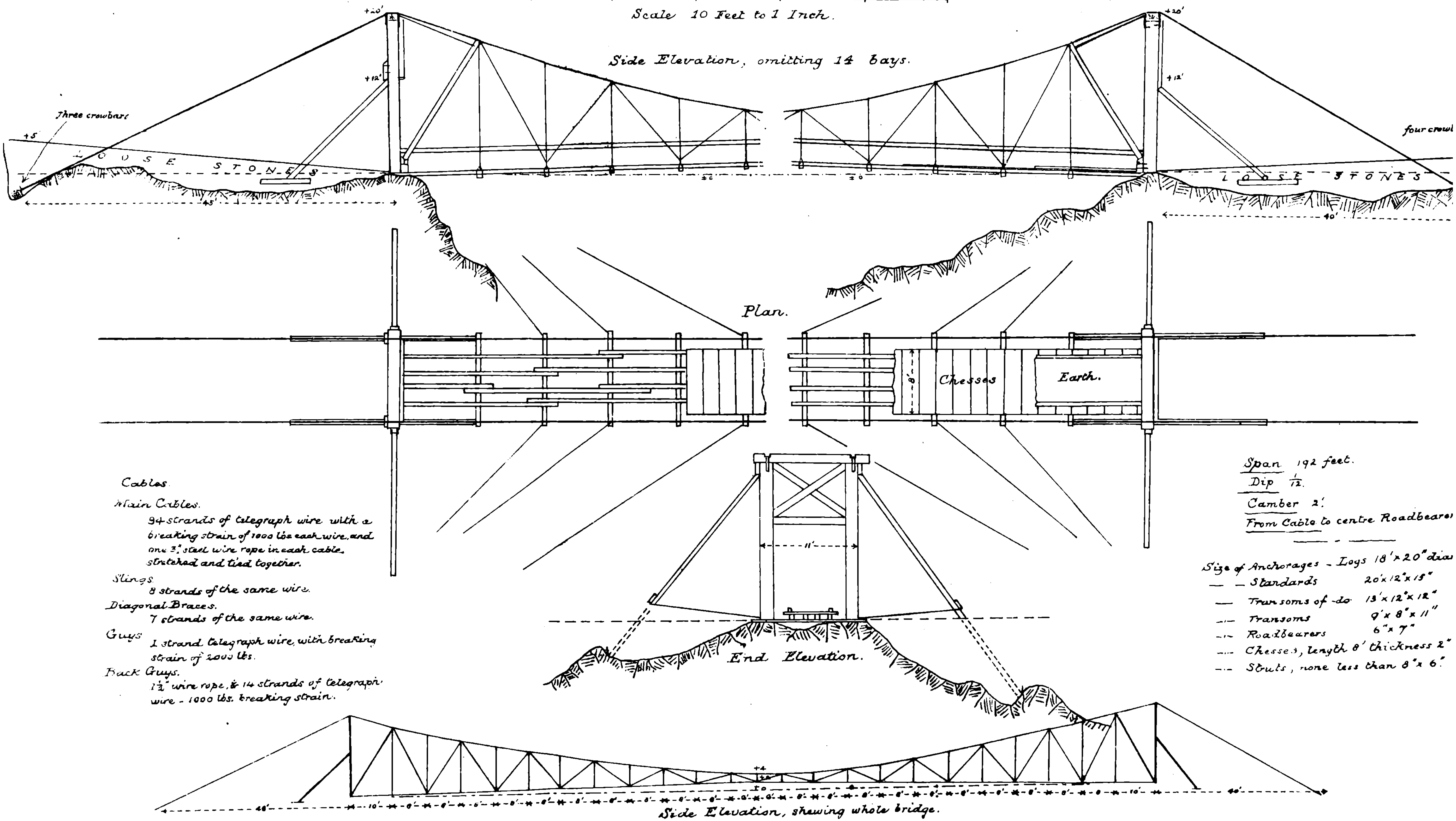
Materials used. The following is a general idea of materials used:—

Main standards	19 ft. × 12 in. × 15 in.	No.	4
„ transoms	13 „ × 12 „ × 14 „	„	2
„ ledgers	11 „ × 8 „ × 5 „	„	2
„ diagonals	15 „ × 8 „ × 4 „	„	4
„ struts	16 „ × 8 „ × 6 „	„	10
„ „	27 „ × 8 „ × 7 „	„	2
Ground plates	15 „ × 15 „ × 5 „	„	2
Transoms	10 „ × 9 „ × 8 „	„	23
Roadbearers	18 „ × 7 „ × 6 „	„	48
Chesses	8 „ × 12 „ × 2 „	„	200
Ribands and handrails	18 „ × 4 „ × 3 „	„	48
Anchorages, logs	18 „ × 20 „ diameter	„	
3" steel wire cables, about 400 ft.		„	
Telegraph wire about	20 miles.		
Wire for binding	150 lbs.		
1¼" steel cable for back guys about 500 ft.			
Screws 4"	6 gross.		
Spikes 12"	200 lbs.		
Twine for binding	40 lbs.		
Crowbars and jumpers for anchorages			20

PANJKORA RIVER BRIDGE.

Plate VIII.

built by
1st Company, Bengal S. & M.
in 11 days.

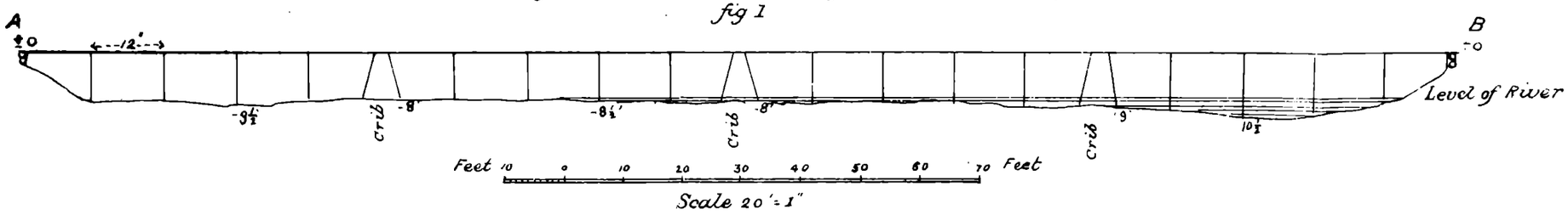


Side Elevation, shewing whole bridge.
(Scale 20 Feet to 1 Inch; Timbers shewn as thick lines.)

Plate X

SKETCH OF JANDUL BRIDGE

Longitudinal Elevation of Jhandul Bridge
fig 1



Scale 20' = 1"

Longitudinal Section of One Bay.

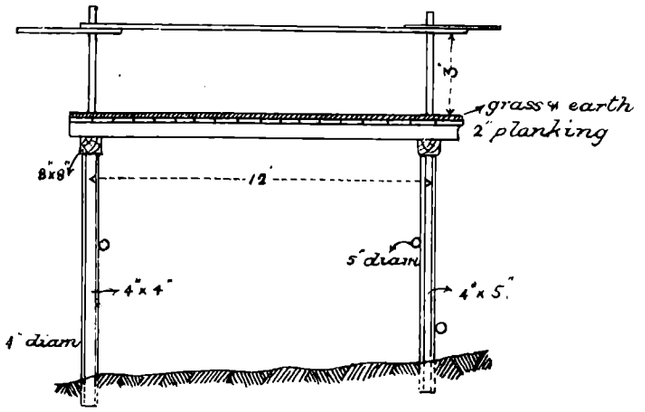


Fig. 3

Elevation of Trestle

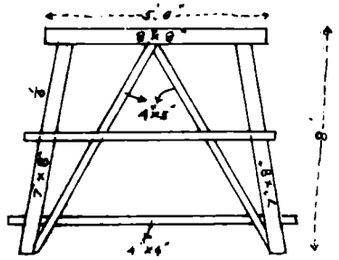


Fig 2

Scale . 5' = 1"

Feet 5 4 3 2 1 0 5 10 Feet

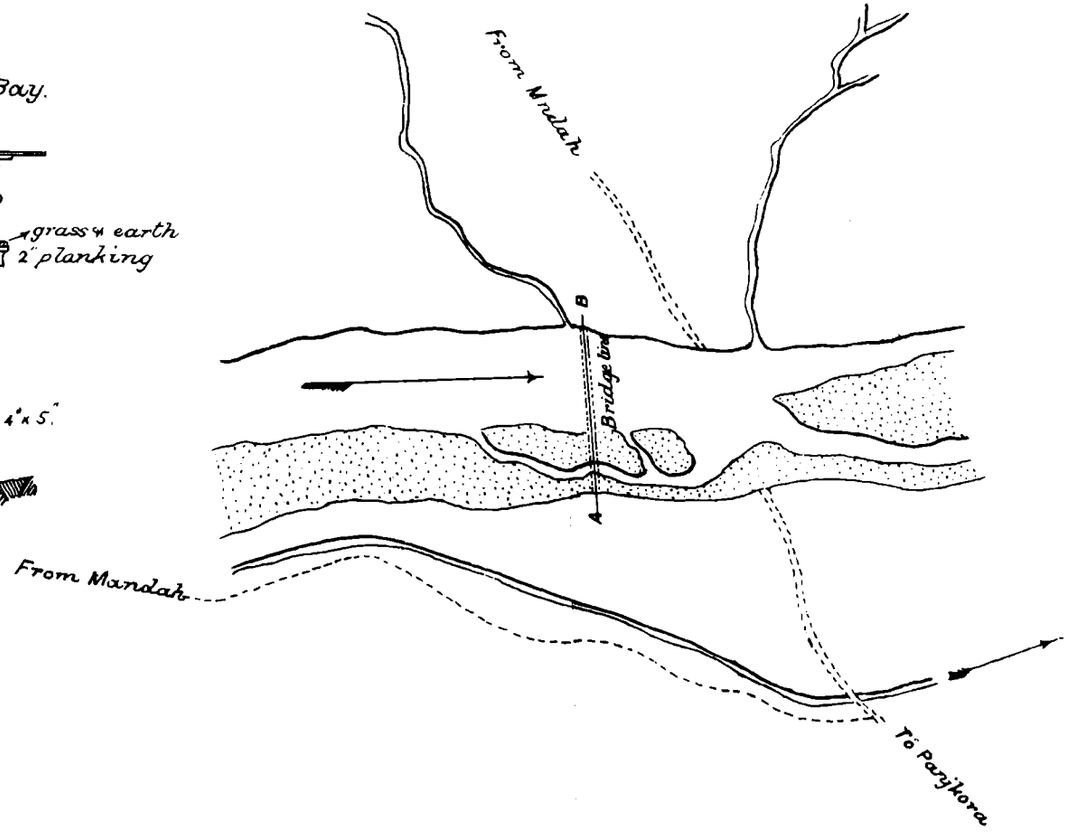


Photo. S. I. O. Calcutta

Report on the Jhandul River Bridge.

Constructed by Lieutenant Kemp, R.E., and the 6th Company, Bengal Sappers and Miners.

1. The trestle and crib bridge over the Jhandul river (at first called the Ushiri) was commenced by the left half of the 6th Company under Lieutenants Kemp and Halliday, on Saturday, 4th May 1895.

Site.

2. The site was that chosen by Major Ellis, R.E., about half a mile above the junction with the Panjkora River, and 50 yards above the present ford.

Nature of river.

3. The water of the Jhandul at the time was about 100 feet broad, its maximum depth 2 feet 6 inches at the point of crossing; the current ran at 4½ to 5 miles an hour over a shingly bed, the boulders being small, not averaging much more than half a cubic foot; where the bed was dry there was a deposit of 6 inches to 12 inches of fine sand on the right bank. Close to the right bank was a small collection of smooth rocks slightly higher than the rest of the bed of the river. The total breadth of the river is about 230 feet, the banks on each side being of loam, 8 feet to 10 feet high, the right sloping ¼ and the left ⅓.

Nature of bridge.

4. The bridge was 240 feet long, divided into 20 spans of 12 feet, one crib between 4 trestles, giving a total of 3 cribs and 16 trestles (fig. 1). The clear waterway allowed was 8 feet to the bottom of the roadbearers, the level being taken from the surface of the water, so that in some places 10 feet 6 inches depth of water was provided for. The width of the roadway was 5 feet 6 inches.

Construction.

5. The building of the bridge for the first three days progressed rapidly, as the timber used was that floated down the river by Lieutenant Fowler, R.E., obtained from dismantling the fort at Mundah; after this the only timber that could be procured was that obtained by sawing up the deodar logs floating down the Panjkora. About half the bridge material was obtained from the scantlings floated down from Mundah, but about 120 feet of roadbearers, 6 trestles, and 140 chesses had to be sawn.

Trestles and Cribs.

6. The trestles were of the same description as those in the Swat trestle bridge, having two ledgers, and the diagonals meeting under the centre of the transom (fig. 2). The scantlings were about 7 inches × 8 inches for uprights, 8 inches × 8 inches for transoms, 5 inches × 4 inches and 4 inches × 4 inches for ledgers and diagonals. The average size of the roadbearers was 6 feet × 7 inches or 8 inches diameter, four being allowed for the roadway. At least half these were of sawn scantlings; the two outer ones were spiked to the transoms, and the inner ones tied with wire, to facilitate the substitution of new ones, if necessary.

7. The chesses were some of old doors, about 5 feet 6 inches long and 2 inches thick, and varying in width from 2 feet to 9 inches; the remainder were sawn 2 inches thick, 5 feet 6 inches long, and 10 inches wide. Over the chesses was a 2-inch layer of grass and rushes, and above this 2 inches of earth and sand.

8. The handrail was formed of thin scantlings, the supports being sloped slightly outwards, to give greater width for mule loads, and strutted, height 3 feet above roadway.

9. The cribs were 6 feet wide at bottom and 3 feet 6 inches at top, formed chiefly of small scantlings floated down the river; as two of them were built on the dry bed, or in only 1 foot of water, they were put together in their places in line with the trestles. Each trestle and the frames of the cribs were let down about 1 foot in the sand or shingle until they found a sound bottom on rock or large shingle, and heavy stones were piled round their feet.

Approaches.

10. The approaches were practically level with the roadway of the bridge, small cuttings and embankments were necessary at the shore ends and the road was curved slightly northwards on both sides to meet the line of the bridge.

Number of Sappers employed.

11. The bridge was begun on 4th May by the left half of the Company, numbering 66 men all told; on the night of the 4th the right half Company arrived at Panjkora, and their carpenters and sawyers were employed, but beyond this no addition was made to the number of men. The average number of Sappers was 60, including carpenters and sawyers, per day, and the total number of days for the work seven, but, if suitable timber could have been found on the spot, the time would probably have been reduced to four days.

Report on the Chitral Bridge.

Constructed by Major F. J. Aylmer, V.C., R.E., and 4th Company, Bengal Sappers and Miners.

General.

1. On the first arrival of the Relief Force at Chitral in May 1895, with a view to the possible future occupation of the country by a British force, the General Officer Commanding and the Commanding Royal Engineer selected a site for a suspension bridge over the Chitral River with a fort on the

right bank to protect it. In order to prevent the fort being commanded, it became necessary to have the site of the suspension bridge where the banks were flat and the span very great.

Site.

2. The site chosen was about 1½ miles below the old Chitral Fort. Plate X gives a section of the river at this point with an elevation of the bridge. The bed of the river up to 10 feet above the ordinary flood level consists of boulders, shingle and sand, and above that level of ordinary alluvial deposit. Every 30 or 40 years extraordinary floods occur. These are caused by an advancing side glacier blocking some main channel above Chitral. A lake is formed which finally carries away the side glacier, causing a sudden rush of water. To provide against such floods the roadway was built 15 feet above ordinary flood level, necessitating a span of 294 feet.

Material.

3. The large frames were entirely constructed of pine wood joined with spikes and wire; all the wood for frames, cribs and roadway had to be brought down from forests some 4 miles off and about 3,000 feet above the bridge site. As many of the timbers were very large, this entailed a great expenditure of labour. The only trees from which the larger timbers could be obtained were of soft wood, probably the pinus excelsa, which made it necessary to employ heavy scantlings, especially for the frames. The only material available for the cables was telegraph wire with a tensile strength of 2,000 lbs.; of this some 20 miles have been used in the Chitral bridge.

Work on bridge.

4. The 4th Company, Bengal Sappers and Miners, arrived at Chitral on the 21st of August 1895. Previous to this Lieutenant Freeland, R.E., had made certain preparations. The hole for the crib on the right bank had been excavated. Five large timbers 75 feet long and of minimum section of 12 inches and 12 inches had been brought down from the forests. Some 300 rough pine spars 15 to 22 feet long and a certain quantity of chesses had been collected at the site. A protecting pier on right bank had been constructed and two wire ropes with travellers, each carrying a single passenger, had been rigged up, and were in working order. From 22nd of August to 13th of September, when the bridge was finished, with exception of small shore trestles, the average daily working parties were: —

4th Company, Bengal Sappers and Miners	110 Rank and file.
Native Infantry	15 „ „ „
Coolies on bridge and cutting wood	200

The Sappers and coolies worked generally from 6 A.M. to 3 P.M., and the Infantry from 6-30 A.M till 12 noon.

Description of bridge. Cribs.

5. The cribs were sunk from 5 to 6 feet in the boulders and shingle, and had a total height of 15 feet. Their length at top was 42 feet interior measurement which allowed of the main props for compound frames being fixed at a good angle. The width of 10 feet at top was considered the minimum for stability. The different faces of the crib were at a slope of $\frac{6}{1}$. Eight unsquared timbers about 9 inches diameter were first set up at the required angles at the corners. The horizontal timbers of the cribwork were built up between and within these 9 inches corner props and fitted into each other at the corners The 9 inches corner props were bound to each other by diagonal lashings of wire at every 3 feet of height. Large flat stones were carefully packed from the inside between the horizontal spars of the cribwork and the whole interior space packed with large stones. (*Vide* Plate X, figs. 1, 2 and 3.)

Frames.

6. On account of the great height of frames (51 feet) it was impossible to get single timbers strong enough to support the great crushing force produced by the cables, so compound legs, V shape, were constructed. Full details are given in Plate X, figs. 2 and 3. The main timbers were 50 feet long and over 12 inches by 12 inches in section. Each pair were fastened together by cross and diagonal bracing secured by 10 inches spikes. This double spar weighed about 2 tons and was raised by a derrick; when it was in position and well guyed it served as a derrick to raise the second double spar. These two double spars rested on carefully levelled footings at the bottoms of the cribs and were 12 feet from centre to centre. Each was fitted at top with a tenon of 1½ inch round iron projecting 6 inches. The top cross piece of 12 inches by 9 feet was then placed on these; iron straps 5 feet 6 inches long, 3 inches wide and ½ inch thick, for cables to pass over, were bolted to the frames and the frame was then braced across and diagonally (fig. 3) by spars 6 inches by 6 inches. When the cribwork had been built up to about 14 feet, three props were added at either side. The whole frame was securely tied back to subsidiary anchorages by two cables of 14 wires each (28,000 lbs. tensile strength).

Cables.

7. Each cable, consisted of 58 telegraph wires and had a tensile strength of 116,000 lbs. Taking weight of roadway at 90 lbs. per foot run, and Infantry crowded in single rank as 210 lbs. per foot run, total 300 lbs. per foot run, span 292 feet, dip $\frac{1}{10}$, this allowed of a factor of safety of 2. To prevent any possibility of accidents, however, only 12 laden mules or 50 men were allowed on the bridge at the same time. The total length of each cable was 600 feet and they were constructed as described in the case of the Panjkora bridge or in Major Aylmer's notes on bridging published in the Royal Engineer Professional papers.

Anchorages.

8. The anchorages consisted of round timbers, 22 feet long and with a minimum diameter of 18 inches. They were placed in trenches 6 feet deep and further strengthened by large stone piers above and in front (*vide* Plate X).

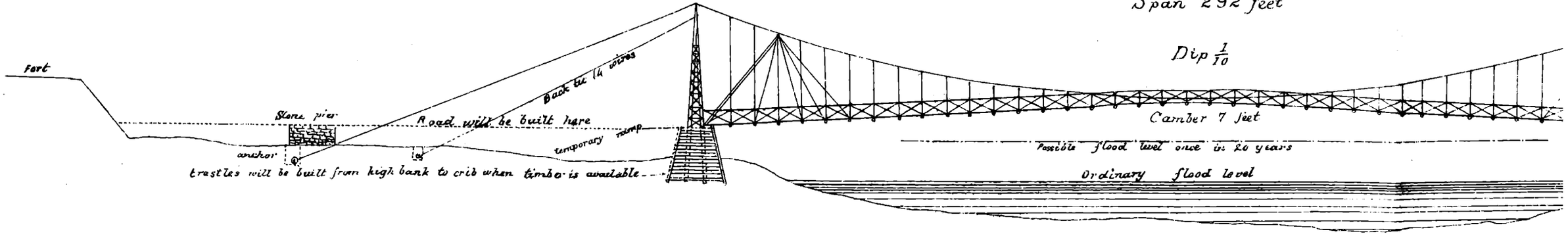
Bridge over Chitral River.

Major Aylmer. V.C. R.E.

Side Elevation of whole bridge

Span 292 feet

Dip $\frac{1}{10}$



Scale 30 ft = 1 inch

Bridge over Chitral River.

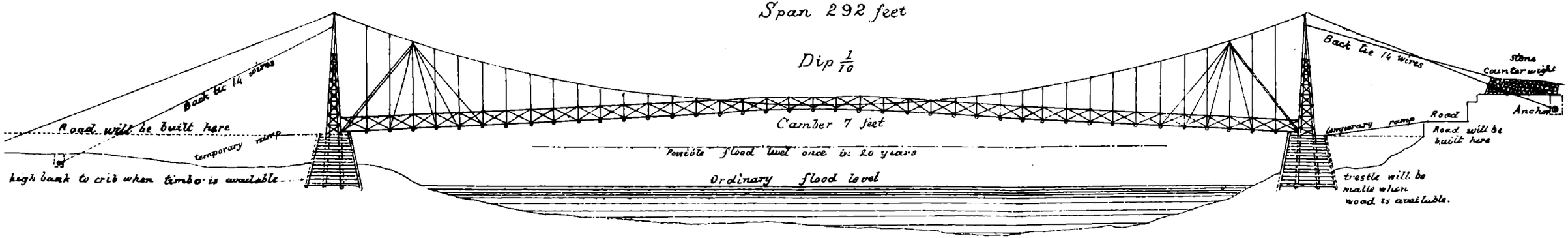
Major Aylmer. V.C. R.E.

Plate X

Side Elevation of whole bridge

Span 292 feet

Dip $\frac{1}{10}$



Scale 30 ft = 1 inch

Photo. S. I. O., Calcutta

9. One end of the cable was fixed to the anchorage by passing it round three times and then fastening the short end to the standing part by opening it up and lashing with numerous thin wire lashings. The long end was then passed over the near frame and pulled across to the other side of the river over the far frame, being finally secured to the far anchorage in the same way as it was to the near one. To prevent the heavy cable dipping into the water when being pulled across, it was supported at intervals by single blocks running on a 3-inch manilla cable, which was tightly stretched between the tops of the frames. The cables were fixed with a dip of a little less than $\frac{1}{12}$ to allow for stretching and tightening at anchorages.

Fixing of cables.

10. The roadway was then built out in the ordinary way. The slings were 7 feet apart and each was of four wires giving a tensile strength of 8,000 lbs. They were attached to the cables simply by their top ends being tightly twisted round the cables three times and then round the slings themselves. The transoms were of 9 inches round timbers lying in the loops of the slings. The roadbearers were four in number, being 6 inches spars. They were placed breaking joint, many passing over as many as four or five transoms. The chesses were of rough split fir timber 6 feet long, 15 inches wide and 2 inches thick. Long ribands and diagonal railings were added. To prevent sinking at the ends of the bridge from concentrated loads, inclined props 34 feet long were got into position, and the bridge was completed by the addition of wind stays from every alternate transom fastened to props up and down stream.

Roadway.

11. The 4th Company, Bengal Sappers and Miners, began work on the 22nd of August. By the 4th September, the cribwork and frames were finished. By the 6th September both cables were secured, and on the 10th the roadway was so far complete that 80 mules passed over safely. On 11th, 12th and 13th railings, wind stays and props, etc., etc., were added. The work was delayed slightly by failure of the local authorities to deliver the big spars in the dates fixed.

Time.

Cantilever Bridges.

1. Throughout Kashmir, Ladak and Chitral, the most common form of bridge, and the only one made by the local people that is suitable for the passage of transport animals, is the Cantilever Bridge. As Military Engineering books take little or no notice of this extremely useful form of bridge, a few words on the subject may not be out of place.

2. From the smallest to the largest span, which may be taken as 120 feet, the method of construction is practically identical. A site is chosen where a large rock or rocks rise out of the stream or a pier is constructed of dry stone work and wooden bindings. On the top of these are laid a number of stout beams aa, áá, a″a″, projecting over

Construction.

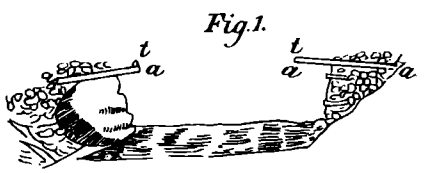


Fig. 1.

Elevation.

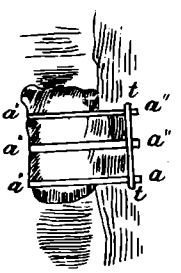
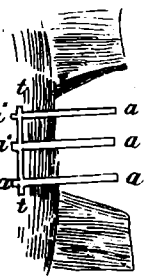


Fig. 2.



Plan.

the stream, with the projecting end somewhat higher than the shore ends. The number of beams, their length and amount of projection, depend on the span. Stones are packed round the shore ends of these cantilevers, and they are then covered up with large bits of rock. Transoms tt, tt, are then placed near the projecting ends (figs. 1 and 2). If after this the span between the transoms is sufficiently small, central roadbearers rr are put into position, the number and size depending on

the span. If the span is small, one or two cantilevers are necessary (figs. 3 and 4).

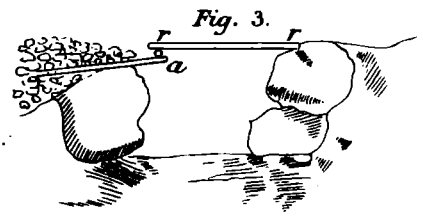


Fig. 3.

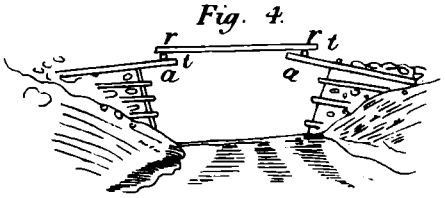


Fig. 4.

Supposing in figure 4, that the central span is too large for available timbers, then a second row of cantilivers bb is placed on the first row aa, two more transoms t't' are placed near the projecting ends and the road bearers rr are placed in position (fig. 5). There are generally more cantilevers in the bottom row than in the row above, and so on.

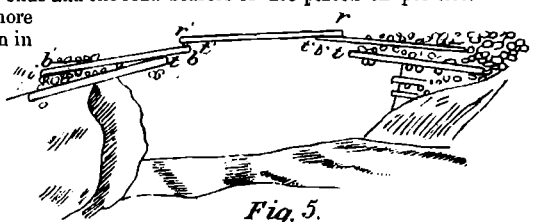
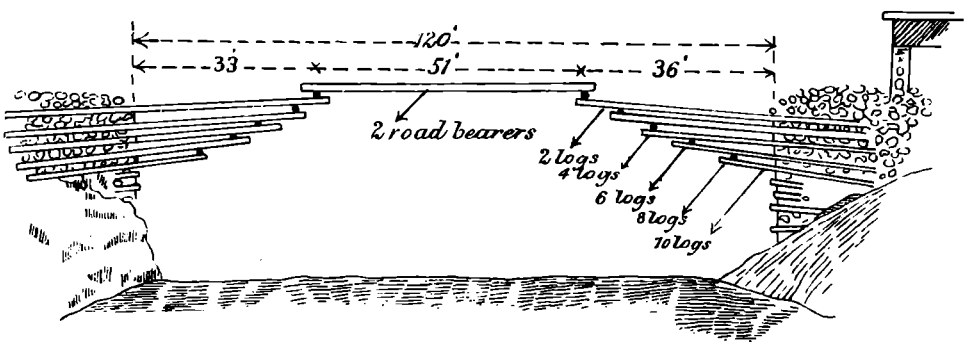


Fig. 5.

Chitral Bridge.

Figure 6 gives the Chitral Bridge, 120 feet span. In this the timbers are very large, being from 15 inches to 18 inches in diameter. There are 10 logs in each of the bottom row of cantilevers, 8 in the next, 6 in the next, 4 in the next, and 2 in the top row. There are only two central roadbearers.



The only chesses used as a rule are roughly split bits of pine wood. These are fastened down to the central roadbearers and the top layers of cantilevers by thin ribands secured by withies. The roadway is about 4 feet wide and there are seldom any railings. The above is a fair description of the cantilever bridge in its primitive state in which it is generally seen.

3. Many improvements can be made provided time and material are available.

(1) The step from top row of cantilevers to top of central road bearers can be avoided.

(a) By lashing the top transom 't' underneath the ends of the top row of cantilevers instead of placing it on the top—wire is best for this (fig. 7).

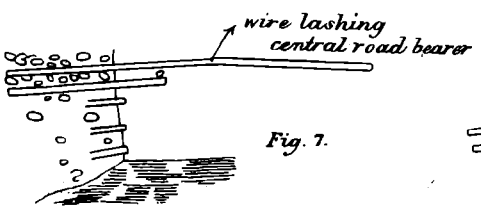


Fig. 7.

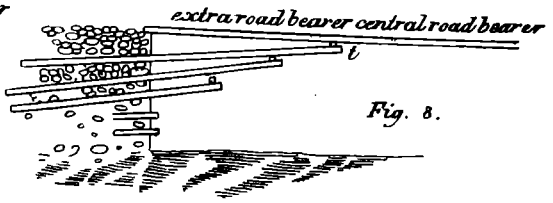


Fig. 8.

(b) An extra row of roadbearers may be added above the top row of cantilevers (fig. 8).

(2) The counter-weighting of the cantilevers may be improved by covering the shore ends of each row with thin bits of wood or rough chesses before covering them up with stones, also by fastening the top layers to the bottom ones by wire (fig. 9).

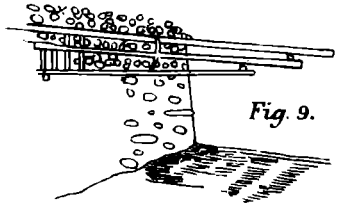


Fig. 9.

(3) A better class of chesses may be used and properly fastened down to the roadbearers with wire nails and ribands. The best chesses can be made out of the doors of houses in the neighbourhood.

(4) Railings should be added, and to prevent beasts getting frightened, these should be made into regular screens by aid of boughs of trees. The railings should be given an outward splay so as not to catch the loads (fig. 10).

Fig. 10.

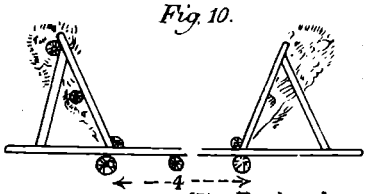
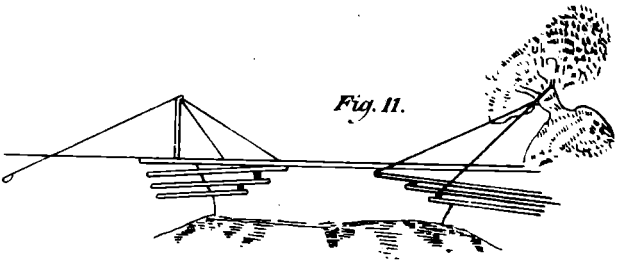


Fig. 11.



(5) Earth and grass should be spread over the roadway to prevent animals being frightened at the noise.

(6) In the case of a long bridge a few wire ties are a great improvement, as they stiffen the bridge greatly (fig. 11).

4. This kind of bridge has the following advantages:—

(1) The construction needs no skilled labour of any kind.

(2) No material except wood and stone is absolutely necessary, though, as has been pointed out, a better bridge can be made if some wire be available.

(3) Very few tools, and those of the simplest kind, such as felling axes, are required.

(4) This bridge can be made when, on account of the shortness of the timber, no other, except a suspension bridge, is possible.

(5) When timber is close at hand, and large working parties are available, it can be very rapidly constructed.

(6) When finished it lasts a very long time without requiring any repairs, except the renewal of chesses.

5. These bridges, though strong, are generally somewhat jumpy, especially when of great span, but, if railed and screened with bushes, the shiest animal will go freely over them. When over 50 or 60 feet in span, traffic must be carefully regulated.

6. Numerous bridges of this type were made at various places on the road, especially between Dir and Chitral.

APPENDIX D. (I)

Panjkora Bridge Head.

1. In order to protect the Suspension Bridges at the Panjkora from being set on fire or otherwise destroyed during a sudden attack by the tribes in the Jhandoul Valley which, from the unsettled state of this part of the country, seemed possible, bridge heads were constructed on the right bank of the river opposite each bridge. They were of similar design.

2. The photograph shows that erected at the second Suspension Bridge, consisting of flanking towers, used also as sentry boxes, connected by stone walls with banquettes in rear.

3. These defences were built by Lieutenant Duff, R.E., with coolie labour.

APPENDIX D. (2)

Report on Commissariat Sheds in Kila Drosh.

By Major Aylmer, V.C., R.E.

1. As explained in paragraph 40 of the General Report, sheds were required in Kila Drosh Fort for about 30,000 maunds of Chitral supplies. This work was begun by the 4th Company, Bengal Sappers and Miners, on 31st May and finished by the 17th June.

Accommodation.

2. The daily average of working parties was :—

Working parties.

75 Sappers.
30 British Infantry.
125 Local Coolies.

The actual expenditure on labour was Rl,381.

3. Previous to the 31st May the interior of the old fort at Drosh had been cleared out and roughly levelled by fatigue parties. Umra Khan's fort some 300 yards away (*vide* Plate XIII) had been partially demolished and a large amount of timber was stacked outside the old fort.

Construction.

4. The British Infantry were employed in carrying timber and getting it out of Umra Khan's fort, which it was necessary to totally demolish in order to obtain sufficient wood.

5. The coolies were used as carriers ; they cut brushwood, put earth on roofs and rammed it carefully in thin layers.

6. The Sappers did all carpentry and erection ; they supervised coolies, levelled floors and posts, made packed stone floors in the sheds, doors, etc.

7. When finished the area of the stores was as follows :—

	Superficial area.	Cubical contents.
Upper half Fort	3,684 s. f.	35,616 c. f.
Lower half Fort	5,182 ,,	46,638 ,,
Total .	8,866 s. f.	82,254 c. f.

This was considered sufficient by the Commissariat for between 30,000 and 40,000 maunds of supplies.

8. Plate XIII, Figure 1, shows the positions of the fort with reference to the river and neighbouring ground. Figure 2 gives an enlarged plan of the fort showing the arrangement of sheds and position of the waterway. Figure 3 gives a section through the lower part of the fort. Figure 4 is a view of the fort from the south.

Plans.

9. Plate XIV gives working drawings of the sheds. All the sheds were not exactly like the elevation and section given, but differed slightly owing to the varied scantlings of timber obtainable. The principal joints such as those above the uprights were spiked.

10. At the same time that the sheds were under construction the communications round the walls were attended to, the necessary step ladders being added ; the parapet walls and loopholes were also repaired and put into a good state of defence.

APPENDIX D. (3)

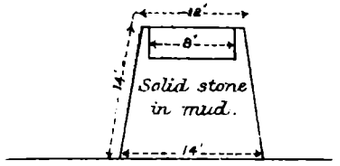
Report on waterway of Drosh Fort.

By Lieutenant Freeland, R.E.

1. The waterway was commenced on 22nd May 1895, by two sections of the 4th Company, Bengal Sappers and Miners The site chosen is west of the fort, and the lower portion runs down a small steep nullah to the face of the cliff. The first thing done was to clear out the brushwood from this nullah, so as to be able to get stones and wood down, and begin the staircase at the bottom. Just above the cliff was a lot of loose earth and stones which had to be removed before the cantilevers were put in, and several small springs were discovered below this, which gave a great deal of trouble during the construction. On 25th May, the Company went to Galatak, leaving one section with stonemasons at Drosh to continue the work. By this time the four cantilevers had been got into position, 19 feet long with 7 feet projecting over the cliff. Stones for building were brought from the site of the demolished fort, a distance of 350 to 400 yards, by working parties of the Buffs to the top of the nullah, and from there were run down to the site of the work by a basket slung on a double wire; subsequently, as the work progressed, they were handed down by coolies. By this means sufficient stones and wood could be got down to keep the work going slowly.

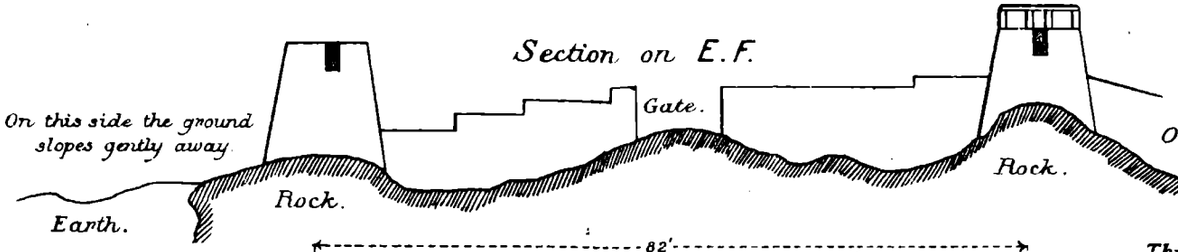
Construction.

PLATE XII.

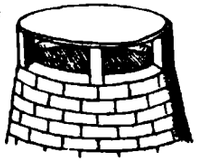


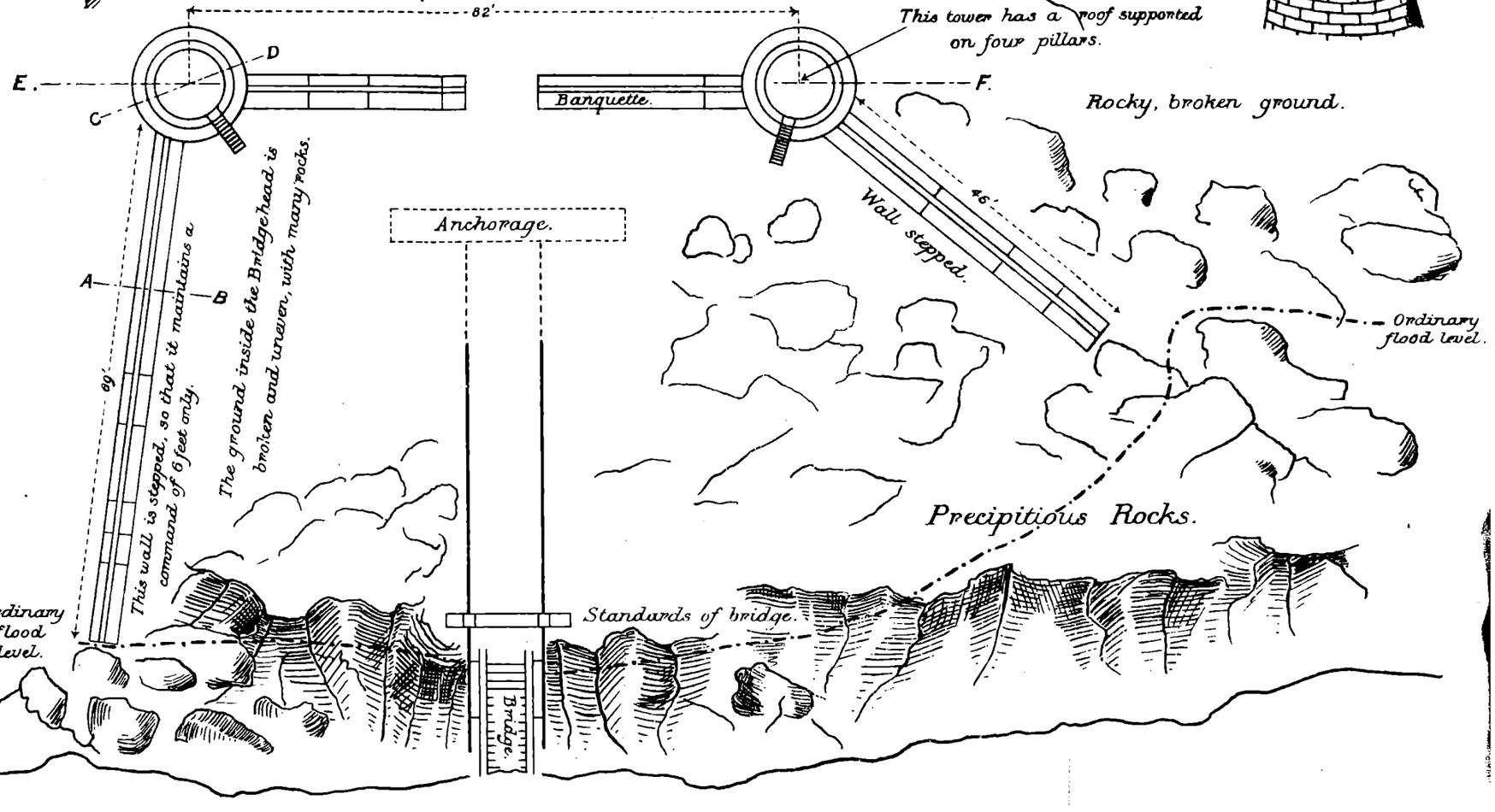
Section thro' tower (C.D.)

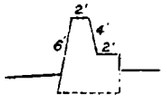
Section on E.F.



Mud roof.







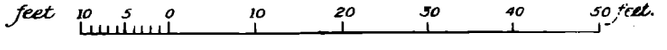
Section on A.B.

Rough sketch of Bridge head at suspension bridge, built by Captain Sergeant, R.E. at Panjkora. The ground is very rocky & irregular; the enclosure wall is generally 6 feet above the ground outside.

NOTE. The bridge head at Major Aylmer's bridge has been in great part destroyed.

PANJKORA RIVER.

Scale: $\frac{1}{16}$" = 1 foot. ($\frac{1}{192}$).



Sd. W. C. Baden Major RE.

Litho School, B.S. & M, Roorkee.

Photo., S.I.O. Calcutta.

2. On 14th June, the staircase, with 6 feet walls on either side, reached the top; in some places, owing to the steep sides of the nullah, it was unnecessary to build side walls at all, but, as a rule, these were essential, with a view to the cross-walls to be built over them. On 15th June, the carpenters were employed in making the framework for the waterhouse, and the stone-masons commenced building the cross defilading walls. The staircase with defilading walls was completed on 22nd June, but the water-house was not finished till 1st July, chiefly owing to the difficulty of getting timber for planking. (See Plate XV.)

Walls of staircase.

3. The walls of the staircase have in all cases a firm foundation either on rock or stiff clay, in most cases 1½ to 2 feet below the steps themselves. The average height of the walls is a clear 6 feet above the steps, and from 2 to 2½ feet thick throughout. They are built of stone and stiffened by longitudinal and transverse pieces of wood, notched into each other. The longitudinal pieces are put in at every 18 inches of wall, but where the latter is only 2 to 3 feet in height, as in the case of the cross defilading walls, longitudinal and transverse binding pieces of wood were considered unnecessary. (*Vide* Sections on A B., C.D., and E F.)

Cross walls for defilading.

4. The cross-walls at the bottom are 4 to 5 feet in height, and are built on every other step of the side walls (*vide* Section), but after building in this way for about a quarter of the way up, it was found better and quicker to build small walls, 1½ to 2 feet high, on each step. (*Vide* Sections on A.B., C.D., and E.F.).

5. The cross-walls are also built in a similar manner over the trench, which joins the top of the staircase to the Sungar round the fort door, and in every case defilade the water-way from all points within 1,500 yards.

The trench.

6. The trench is 6 feet deep, 6 feet broad at the top and 4 feet at the bottom, with an average slope of 1 in 6 from the fort to the top of the stair-case. All excavated earth was thrown out on both sides of the trench, and completely screens it from view and fire from both flanks. (*Vide* Sections on P Q.)

Sungar round fort door.

7. Round the door of the fort is built a Sungar with walls 7½ feet high, completely screening the door from view from all points up to 1,500 yards. The trench is reached from the door by a short flight of steps under the wall of the Sungar. The Sungar walls are loopholed (1 tier) on front and flanks. (*Vide* Section on G.H.)

The tower.

8. At the top of the nullah is a tower, so situated as to command the waterway and its approaches from the north. It is considered that it is not possible to approach the lower portion of the staircase from the south, except by scaling the cliff at that point. The tower is connected with the main trench by a branch trench, which runs under the south wall; the floor level being reached by steps, at the bottom of which is a door. The tower is 15 feet in height and the lower storey serves as a guard-room. The upper storey has four loopholes in each wall and one in each corner, the walls being 7 feet above the floor, and defiladed from all points within 1,500 yards. (*Vide* Section on R S.)

The waterhouse.

9. This house is built out over the cliff on two pairs of cantilevers, strengthened by a trestle 4½ feet from the outer ends. Two struts were added afterwards fitted into the bottom of the trestle, and to the ends of the cantilevers Over the latter is laid a platform and framework to take the walls of shingle and planks, which are 12 inches thick. The flank walls have only 6 inches of shingle between 1½ inch planks, and the front wall 9 inches of shingle; this arrangement was tested by firing several shots at it from the opposite bank of the river with a Martini-Henry rifle, none of which penetrated.

10. Over the side walls, which are 6½ feet high, small defilading walls about 18 inches high are built. There are two loopholes in the front wall, and one in the north wall; large stones have been cut, so as to fit into them, and close them when they are not in use.

11. Water is drawn up from the river through a hole in the floor by means of a wheel bucket and rope. (*Vide* Sections on L.M, and N.O.)

APPENDIX D. (4)

Report on Forts between the Malakand Pass and Chitral.

By Lieutenant Colvin, R.E.

General description.

1. All the forts in Swat, Bajour, Dir and Chitral are built on the same main principles, and are practically fortified houses or villages. The plan is some rectilinear figure, usually four-sided, the sides of which are composed of walls with towers at the angles, which sometimes flank the walls and sometimes do not. (See Plate XVI.)

Walls.

2. The walls are from 20 to 30 feet high and are practically crates filled in with rubble stone in mud. The walls are from 4 to 8 feet thick at the ground line, and are built with a slight batter, on both faces.

3. The top wall often forms the banquette, and the parapet is made either by continuing the main wall upwards for a thickness of about 2 feet or by building out a wall on cantilevers by which latter method vertical fire on the foot of the wall is obtained. Loopholes are invariably used in the parapet and are placed about 6 feet apart, but they are very roughly made and only give a very small field of fire.

Towers.

4. The towers are from 40 to 50 feet high and 15 to 20 feet square in plan. The lower portion is built solid, usually to the height of the banquette on the walls, and then above that they are built hollow, access to them being obtained through doors 3½ feet in height. The walls of the hollow portion are about 2 feet thick and are built in the same way as the main walls of the fort, except that the longitudinal and horizontal timbers are rather closer together—about 18 inches apart. There are either one or two storeys in the towers, and ladders made of a single round timber with notches cut in it for steps, lead from one storey to the other or to the roof through holes in the floor; the various floors being supported sometimes on pillars as in the drawing, or merely by strong joists let into the walls. The floors and roof are made of mud resting on thin cross timbers which again rest on the pillars on joists. The roof forms a terreplein and has a parapet wall, usually cantilevered out on all four sides forming Machicouli galleries. Although the towers are placed at the angles, they project but little, and so give a very small amount of flanking fire to the walls; and often loopholes are omitted in the various storeys. In a few instances, as in one tower at Drosh and at Chitral, Machicouli galleries are made in the lower storey, which however only protect the towers themselves.

Ditch.

5. There is no ditch or other obstacle, beyond the main walls, in any of these forts, with the exception of Fort Ramora on the Swat river. It has a dry ditch about 15 feet deep and 15 feet broad at the top, with sloping sides, the bottom of the ditch being about 6 feet broad. On the inside of the ditch is a 7-foot loopholed wall running right round the fort. The ditch could probably be flooded with ease, as a water channel runs quite close to it on one side.

Water-supply.

6. The forts are invariably placed on the banks of a stream, which provides the water, and in some elaborate arrangements are made for obtaining it, consisting of sometimes a mined gallery between the fort and the stream, made so that the roof covering appears to be merely the surface of the ground, as originally existed at Drosh, or of a walled-in passage, protected by a detached tower as at Chitral.

Doors.

7. As a rule there is only one entrance to the fort, closed by double doors opening inwards; though at Chitral there was a main entrance and a rather smaller one on the opposite side. Similarly at Drosh besides the main gate there was a small one through which access is gained to the new waterway. In Ramora Fort there is only one entrance, through three doorways, one immediately behind the other; the outer doorway being on the outside of the ditch and furnished with sharpened stakes to prevent people climbing over or round it; the inner doorway was in the main wall, and the third was in the low loopholed wall running round the fort. The doors are made of a single plank from 3 to 6 inches thick, and are about 7 feet high; they are fastened by a wooden bar placed behind them across the doorway and let into the wall at each end.

Defilade.

8. In many instances owing to the narrowness of the valleys, it is impossible to defilade the interior of the forts without special arrangements, and sometimes parados are used to protect the men firing on a parapet, but as long as the forts are defiladed from short range fire that is usually considered sufficient.

Accommodation.

9. The interior of the fort is entirely filled up with low huts built of stone with mud roofs in which the inhabitants or garrison live.

APPENDIX E.

Report on the Royal Engineer Field Park, Chitral Relief Force.

By Major M. C. Barton, R.E.

Mobilization.

1. On the 15th March 1895, orders were received for the mobilization of the Field Park—1st Division, which is kept in regimental charge of the Officer Commanding, Bengal Sappers and Miners, at Roorkee.

2. The equipment was complete with the exception of one important item, *viz.*, the proportion of 3¼-inch steel rope, which was allowed in the revised Table G, and for which due allowance had been made in the budget estimate for 1894-95; unfortunately, however, owing to delay in their arrival from England (the Government having refused to allow their local purchase) these ropes were not available though much needed.

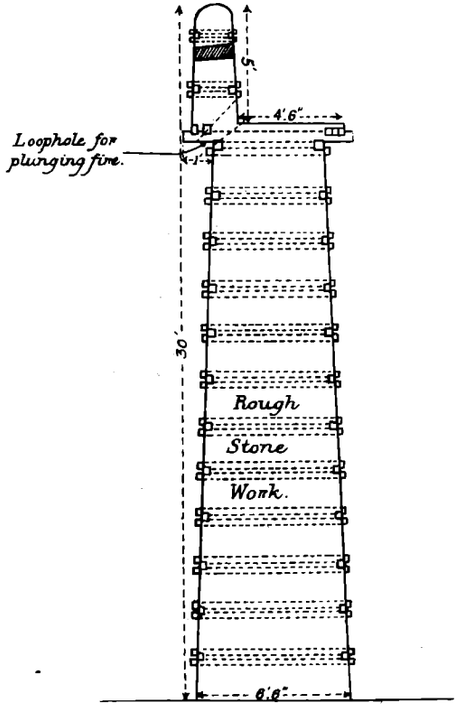
TYPE SECTIONS

of an Ordinary Native Fort
in Swat and Panjkora Valleys.

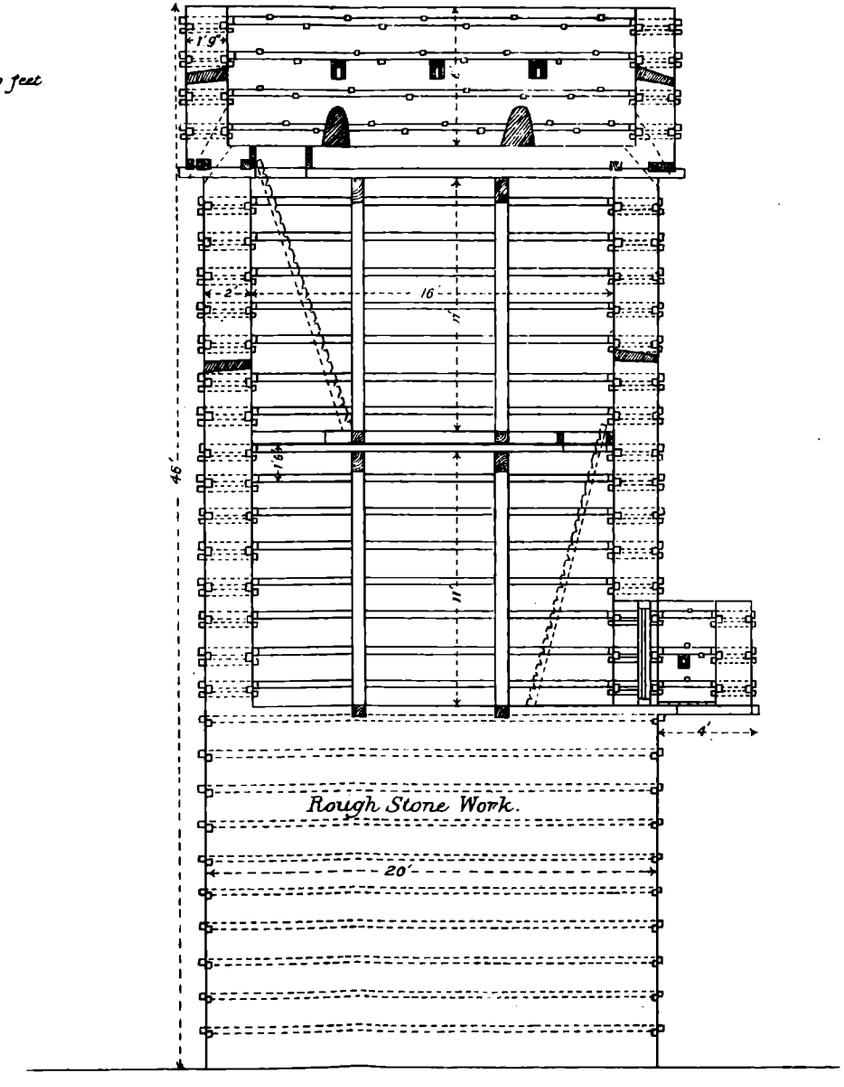
Scale 6' = 1" (1/12).

1 0 5 10 15 20 feet

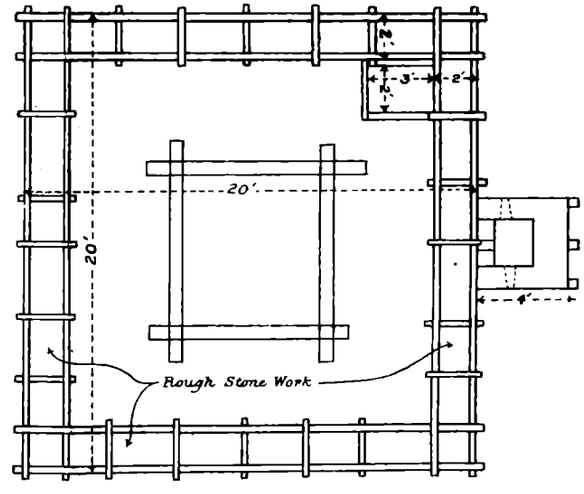
Section of Wall.



Sectional elevation of Tower.



Plan of Upper Story.



Sd J. H. Olver
Lt. R.E.

Litho' School, B.S. & M, Roorkee.

3. The required number of hired Artificers, Khalassis, etc., having been entertained, the establishment was complete by the 20th March, and was as follows :—

Major M. C. Barton, R E. (in charge).
Conductor A. Watt, Bengal Sappers.
Sergeant S. Sellens, Military Works Department.
,, T. Scott, ditto ditto.

with the number of artificers and other followers as laid down by regulation.

4. On the 26th March, the Field Park was entrained and reached Nowshera on the 29th March : it remained there till the 2nd April, when it received carriage and moved towards the front, reaching Chakdara on the 8th April.

5. At Chakdara a large number of tools were made over to Captain Williams, R.E., who was in charge of the Swat River Suspension Bridge : a halt of a fortnight was made here for the purpose of supplying the working parties on the Trestle Bridge. On the 22nd April the Park was moved to Panjkora, where it remained until the end of the operations.

6. Sergeant Scott was detached at Nowshera to forward stores arriving by rail, and Sergeant Sellens was transferred to Captain Williams. Towards the end of May, a section of the Field Park was detached to Dir under Lieutenant Duff, R.E. Sergeant Sellens rejoined for this and accompanied Lieutenant Duff, subsequently taking over entire charge of the advanced section from that officer.

7. I have the honour to offer the following remarks on the organization and working of the Royal Engineer Park.

Personnel : I. Officers.

8. At present only one officer is allowed for a Field Park—now in all expeditions in which a complete division is mobilized the numbers of artificers and the quantities of tools and stores required for the use of the force will be very largely in excess of the quantities and numbers laid down in the equipment tables. The requirements of men and material cannot be accurately foreseen at the beginning of the operations, and it is most desirable that a competent officer should be left at the base to arrange for the supply of tools and materials and for the entertainment of such labour, skilled or otherwise, as may from time to time be indented for from the front ; the officer so detailed should be of some standing, and preferably he should be well acquainted with the resources, in material and labour, of the district in which the base is situated.

9. During the operations of the Chitral Relief Force these duties were carried out by Mr. W. C. Cooper (the Sub-divisional Officer, Military Works Department, Nowshera), whom the courtesy of the Executive Engineer, Peshawar Division, Military Works Department, placed at my disposal for this purpose, and I am obliged to Mr. Cooper for the assistance he afforded me—the work which thus devolved upon him was considerable (as Sergeant Scott, who was originally left at Nowshera, was very shortly moved to Dargai) and was performed in addition to his own normal duties.

10. I would, therefore, strongly recommend that an additional officer be allotted to the Royal Engineer Field Park on mobilization.

II. Warrant Officers and Park Sergeants.

11. One Warrant Officer is sufficient, but in cases like the present where the line of communications is drawn out to a considerable length, the formation of one or more depôts detached from the main Park is certain to be required, and in view to the formation of such I advocate the addition of two Park Sergeants, making a total of four instead of two as at present.

III. Native Soldiers.

12. At present only one Havildar and one Naik are allowed, but the want of more men of this class was much felt. I think there should be 10 men (Sappers, if possible, or Native Infantry) attached to the Park —3 or 4 of these should be Non-Commissioned Officers, and all should be men of good character and able to read and write a little.

IV. Artificers.

13. The number and description of hired artificers must vary for each campaign. I think it would be impossible to lay down any fixed establishment which would satisfy the requirements of all expeditions. The number as at present laid down forms a very good nucleus, but a proviso should be added to the effect that, under the orders of the C. R. E. any extra men may be entertained as required, all such becoming entitled to free rations in the same way as the artificers on the fixed establishment.

V. Khalassis :

14. The Khalassis entertained at Roookee, chiefly Hindus, were found very useless ; it would be better to take men enlisted locally at the base : the increase recommended in the numbers of the Native soldiers would, if given effect, render the Park more independent of Khalassis.

V. Other public followers : cooks.

15. One cook is laid down—presumably this man is intended for the Warrant and British Non-Commissioned Officers, but as these would seldom be together a servant should be allowed for each.

Sweepers.

16. No men of this class are included in the fixed establishment—they are urgently needed, and two at least should be allowed The Field Park Camp is often a very considerable one and is generally more or less stationary—it is impossible to keep it in a sanitary state without sweepers.

17. Should the above recommendations be carried into effect the annexed table shows the increase in establishment which would be involved.

Royal Engineer Field Park for one Division.

Designation.	Authorized establishment.	Proposed establishment.	Increase.
British Officers	1	2	1
Warrant Officers	1	1	...
Park Sergeants	2	4	2
Hospital Assistant	1	1	...
Havaldar, Bengal Sappers and Miners	1	1	...
Naiks ditto ditto	1	2	1
Sappers ditto ditto	...	8	8
Bheesti	1	1	...
Pakhali	1	1	...
Cooks	1	5	4
Clerks, Native	1	1	...
Hired Artificers	12	12	...
Khalassis	12	12	...
Sweepers	...	2	2

Equipment (Revised Table G of Engineer Equipments, India, 1889).

18. The numbers of the different kinds of tools and stores required for a Royal Engineer Park in the field must vary very much with the nature of the country in which the campaign is conducted, and it is probably impossible to lay down any fixed proportion which would be suitable for all expeditions.

Revised Table G (R. E Equipment, India, 1889).

19. The revised Table G with certain modifications, which I shall have the honour to put forward in detail later on, may, I think, be accepted as giving a very fair nucleus of stores generally suitable—and provided a sufficient reserve be maintained in all arsenals I would not advocate any material increase in the numbers and quantities laid down in that table. It seems, however, doubtful whether a sufficiently large reserve is kept up in all arsenals, and this appears the more so from the fact that during the five months the Park was mobilized stores were received from nearly every arsenal in India; the arsenal nearest to the base should hold a sufficient reserve to supply one Field Park for so short a time.

Dynamite.

20. In this connection I would most strongly urge that Government should store in some accessible place or places a good stock of dynamite with a suitable proportion of detonators and fuze. During the operations of the Chitral Relief Force, a very large quantity of this explosive was expended, and, as it had to be brought up from Karachi, great delay and inconvenience were caused: had there been a good store at, say, Attock, this would have been carried out at a cheaper rate than is possible when explosives have to be purchased from a private firm.

Transport.

21. The Field Park was equipped with camel and mule Transport at Nowshera (*See* Table X (D) of Field Service Equipment Tables, Section II, Sappers and Miners), but it was obvious from the first that the scale therein laid down is quite insufficient to provide for modifications which would become necessary at the outset of any expedition, and in the present instance a considerable number of tools and stores had to be left at the base for want of carriage.

22. In the same way that it is impossible to lay down the exact number of tools that will be required for any expedition, so it is also impossible to fix any scale of carriage which shall be universally suitable, and I think it is a mistake to have any scale fixed by regulation. Carriage should be laid down for tentage, baggage and hospital equipment, but the amount of carriage for engineer equipment and stores should be left blank and the nature and amount should be indented for at the base as occasion requires.

23. The Royal Engineer Park being once established in a central position a proportion of carriage, of a nature suitable to the roads, should be permanently allotted to it for the purpose of distributing tools and stores to the various working parties indenting for them; the number of animals so allotted must depend upon the distance to which the tools, etc., have to be sent, and it is not advisable that any fixed number should be laid down as a matter of regulation, especially as the number required depends a good deal upon the facility or otherwise of sending forward the necessary stores by ordinary convoy.

List showing the numbers of the commoner tools which were in use during the operations of the Chitral Relief Force, March to September 1895.

Names of stores.	Number or Quantity.	Remarks.
Axes, pick, helved	10,000	
Shovels, universal	6,500	
Phowrahs	500	
Bars, jumping and boring	2,500	
Hammers, miners, sledge	650	
Wedges, miners	500	
Wheel, barrows	700	
Axes, felling, 6 lb	100	
Hatchets, hand	300	
Hooks, bill	300	
Saws, cross-cut	30	
„ hand 26″	50	
„ pit frame	20	Civilian Sawyers brought their own saws with them.
Helves for axes, pick	5,800	Helves only to replace broken ones.
„ „ shovels	2,500	
„ „ axes, felling	160	
„ „ hatchets	200	

A list giving fuller detail is being compiled and will be available later on.

M. C. BARTON, Major, *R.E.*,
in charge R.E. Field Park, Chitral Relief Force.

List showing quantities of wire expended during the operations of the Chitral Relief Force, March to September 1895.

Names of stores.	Number or Quantity.	Remarks.
Wire, 600 lb per mile . . . miles	34	
„ 300 „ „ . . . „	62·5	
„ 150 „ „ . . . „	5	

M. C. BARTON, Major, *R.E.*,
in charge R.E. Field Park, Chitral Relief Force.

List showing quantities of explosives expended during the operations of the Chitral Relief Force, March to September 1895.

Names of stores.	Numbers or Quantity.	Remarks.
Dynamite . . . . . lb	22,000	
Guncotton, wet, slabs . . . . . „	11,000	
„ dry primers . . . . . „	1,000	
Gunpowder . . . . . „	12,000	
Detonators, dynamite . . . . . No.	75,000	
„ No. 8 . . . . . „	11,000	
Fuze, safety . . . . . fms.	25,000	

M. C. BARTON, Major, *R.E.*,
in charge R.E. Field Park, Chitral Relief Force.

List of rope, timber, iron, and steel and miscellaneous materials expended during the operations of the Chitral Relief Force (exclusive of materials for the Chakdarrah suspension bridge).

Names of stores.	Number or Quantity.	Remarks.
Cordage, manilla, 3″ . . . . fms.	2,500	
„ „ 2″ . . . . „	4,000	
„ „ 1½″ . . . . „	2,800	
„ „ 1″ . . . . „	500	
Spun yarn, tarred . . . . . lb	500	
Timber, deodar . . . . . c'ft.	7,500	
Iron and steel of sorts . . . . lb	5,000	
Spikes, nails, and dogs . . . . „	4,000	
Wire, 11 to 20 gauge . . . . „	3,000	Exclusive of telegraph wire.
„ various gauge . . . . „	2,000	
„ steel, barbed . . . . „	5,000	
Sand bags . . . . . No.	8,000	

M. C. BARTON, Major, *R.E.*,
in charge R.E. Field Park, Chitral Relief Force.

APPENDIX F.

Report on the Photo.-Litho. Section, Bengal Sappers and Miners with the Chitral Relief Force, and suggestion for Improvements.

1. Only one British Non-Commissioned Officer accompanied this section. He was a Photographer and had to be frequently detached, consequently the Litho. Section was very little used. There should be two British Non-Commissioned Officers, one a Photographer, the other a Lithographer, with this section.

Strength.

2. The following alterations and additions are recommended in the Photography Equipment, which should be of larger size as the result of the experience gained during the campaign.

Photo. Equipment.

Deductions.

3. Liquor Ammonia ·880, Bromide Paper, Silver Paper, Soda Acetate, Boxes Plate (tin), all extra bottles, some 30 in number.

Liquor Ammonia is very liable to break; also after a march, when the bottle is opened it is very liable to fly out of the bottle like a fountain; this occurred at Chitral, and it is liable to damage peoples' faces.

Bromide Paper is too delicate to be worked successfully in the Field.

Silver Paper, sensitized, rapidly deteriorates, Printing Out Paper lasting treble the time.

Soda Acetate, being used with Sensitized Silver Paper, would not be required.

The Boxes Plate are useless; any negatives packed in them would be broken on the first march.

Additions.

4. Printing Out Paper two quires, Sulphocynide Ammonium 4 oz., one small rapid filter, one extra piece ground glass for back of Camera, one Canvas Chagul, to hold two gallons, for developing purposes.

Printing Out Paper to replace Sensitized Paper, whose keeping qualities are very bad.

Sulphocynide Ammonium for use with Printing Out Paper.

The filter is for the water required to make up the developer; the water up in the hills is very gritty, causing pinholes in the negative. Two or three negatives were spoilt in Chitral through this cause.

An extra piece of ground glass should be carried as the one in the camera is liable to be broken.

The canvas chagul is to hold the water required to wash the negative after developing. The Bheesti cannot keep the operator supplied with water, each negative requiring at the very least one mussack of water.

Alterations.

5. Twelve dozen dry plates instead of 8 dozen, 8 dozen not being sufficient to take into the Field.

Twenty pounds of Hyposulphate of Soda instead of 12 lbs., the latter quantity not being nearly sufficient for use.

Twelve pounds of candles, stearine, instead of 6 lbs. The latter is not sufficient.

Four pounds of Alum instead of 2 lbs., more being required for use with Printing Out Paper.

Six pounds Soda Carbonate to replace 2 lbs. Ammonia ·880.

6. It is also suggested that some *stationery* be allowed for the purpose of keeping up ledgers, diary, etc. During the expedition this was borrowed from the C. R. E., who might not always have it to spare.

7. *Watertight mule boxes* are necessary; perhaps if made more the shape and size of Mountain Battery Artificer's boxes, it would be an improvement. Very good boxes are also made at the Postal Workshops, Aligarh.

8. *Papier Maché boxes* might be supplied to pack the plates in, as the ordinary cardboard boxes in which they are supplied by the trade rapidly go to pieces.

Litho. Equipment.

9. The following additions and alterations appear to be most desirable in the Litho. Equipment, which should be of larger type.

Deductions.

10. *Gelatinized Paper* as it is absolutely impossible to work the papyrotpye process with any satisfactory results in the Field. Zincography is quite capable of doing all that is required on Field Service.

Bichromate of Potash, Printing Frames, Rollers gelatine, glass measure 40 oz: these will not be required if the Gelatinized paper be discontinued.

Soda common washing: this is not required for Lithographic work.

Ammonia: this should be in the Photo. Equipment.

Alterations.

11. For Paper "Demy" substitute "double foolscap", it being a more convenient size for use in the press.

For leather Tympan substitute brass one.

Iron bands instead of leather at bottom of the bed. Bed slide at present wood, to be lengthened 6 inches, with two supports instead of one to prevent rocking; this should be of iron made in four parts, to allow of easy packing; these alterations would greatly strengthen the press, and last much longer, as the leather and wood are liable to perish and get damaged.

The scraper would be required to be covered by leather, also more play is required between the scraper box and tympan.

Additions.

12. A portable table and chair, with a drawing board required for plans, etc.

A strong lantern is required for night work, one burning candles recommended.

Six pounds of candles for above lantern.

A chagul for holding water for the purpose of cleaning the Zinc plates.

A ferrotype frame 14" by 11½", similar to those used by the Survey Department, and some prepared ferrotype paper.

This process is a very simple one and most useful in reproducing plans, etc.

A zinc plate 18" x 12", No. 10 guage for use as an inking slab; at present nothing is allowed for this.

Tin cases for rollers, as the skins are liable to get damaged on a march.

Tin box containing 6 lbs. of graining sand, 2 lbs. not being sufficient.

One quire of tracing transfer paper: with this a transfer can easily be taken from plans, etc.

Four empty pint bottles are required for the following: Gum, Galls, Phosphoric Acid, Caustic Potash, as these are at present carried in a dry state, and when required for use, no bottles are available for these to be mixed in.

General.

13. *The Photo. and Litho. Sub-sections* should be capable of being separated at any moment; the former is required to go anywhere at short notice to take photographs, while the latter, like the Printing Section, would probably remain chiefly with Divisional Head-quarters.

14. At present no allowance whatever is made for the *carriage* of the British Non-Commissioned Officer's cooking utensils; only the same quantity of baggage is allowed as in the case of a Sergeant of Infantry, whose messing is provided for under regimental arrangements.

APPENDIX G.

Report on Printing Section, Bengal Sappers and Miners.

The following alterations and improvements in the Printing Section, Bengal Sappers and Miners, have suggested themselves during the Chitral Relief Expedition:—

EQUIPMENT.

Changes and improvements.

1. A foolscap folio Press, to replace the quarto size at present in use, would save a great amount of press work when orders are lengthy, and enable any printed reports to be done on proper official paper of foolscap size. The larger press would necessitate the "Wetting boards," "Imposing stone," and "Chases," being twice their present size. This involves considerable increase in weight, but would largely increase the capabilities of the press.

2. The composing frames required strengthening generally.

3. Two "Palette knives" and one "Book-binder's knife" should be changed, and one "Palette knife" and two "Book-binder's knives" substituted.

4. Ink powder and empty bottles would be better than present bottles of ink.

5. A superior class of lantern is required. A folding one like that used by photographers but larger, with thick glass, would be more easily packed and less liable to break.

6. Two reams "Double Foolscap" and two quires "Demy" instead of two quires "Double Foolscap" and two reams "Demy." The press being Foolscap size, Foolscap paper for printing orders, etc., can be far more economically used.

7. Five additional pounds "Quotations" are required; 5 lbs. "Brevier quads" may be struck out.

Additions.

8. A canvas or India-rubber bath of some kind for holding water is required to mix Potash in.

9. Needles and thread (Book-binder's) required.

10. Three composing sticks instead of two. Whilst two men are composing, the third stick is necessary for corrections, etc.

11. Extra calico for tympan; the one tympan is not sufficient.

12. There are 3½ sets of composing cases If the four sets were completed, the type at present carried tied up could be disposed of, making three Long Primer Roman cases—the right portion of the Upper case of one being used for geometrical signs, and superior and inferior figures.

13. Eight ounces alum is required to mix with paste and prevent the latter going bad.

14. Fourteen pounds lead instead of 7 lbs.

15 Four pounds candles instead of 2 lbs.

16. Six pounds "Furniture" instead of 3 lbs.

Deductions.

17. "Eureka" roller composition, mould, glue pot, etc., could be dispensed with, as the two India-rubber rollers are found sufficient. In continual moving about the composition rollers would get damaged and frequent changes of climate affect them.

19. The above changes would necessitate another mule load.

20. The weight allowed for the British Non-Commissioned Officer's baggage is not sufficient, there being no allowance made for cooking utensils, etc. He is at present allowed the same as an Infantry Sergeant, whose cooking arrangements are provided for in his company.

Cooking utensils, baggage, etc.

21. Transport should be allotted to each section separately, and not to the Photo-Litho. Section and Printing Section conjointly. It might be necessary to separate them at any moment.

22. No spare mules are allowed, they should be.

APPENDIX H.

Chitral.

1. The accompanying plans of the environs of Chitral show all that is of interest, both as regards the past, present and immediate future, including the scene of the recent operations there, the sites of the old fort and bridge, and that of those proposed to be constructed.

2. A detailed plan of the old fort is also attached, on which are marked the chief points of interest connected with the siege. If this be studied with the photographs that have been taken, a very good idea of the situation will be obtained.

3. The old bridge, a large cantilever one, was very shaky and unreliable; it was also very inconveniently situated for parties moving to and from Drosh, rendering a detour necessary that caused an extra hour to be spent on the march to that place. It was, therefore, decided to replace this by a suspension bridge lower down the river, opposite the site selected for the new fort. (See Bridging report.)

4. With a view to ensure the safety of the escort to the British Agent, it was considered that a fort capable of holding 200 men and 20,000 maunds of supplies would be necessary. A site was selected near the river by Sir R. Low. The attached report and plans explain the details of the type of fort proposed.—*See Plates* XX—XXIII.

MEMORANDUM.

Explanatory of proposed type for a new Fort at Chitral.

1. The General Officer Commanding the Chitral Relief Force considered that if it should be decided to garrison Chitral, it would be necessary to build a new fort and bridge over the Chitral river; the fort to be a place of refuge for the British Agent and the Chitral garrison in case of need and to accommodate in peace time 200 Native troops and 20,000 maunds of supplies; the bridge to be commanded by the fort.

Object.

2. On 17th May, the General Officer Commanding proceeded with General Blood and Colonel Leach, C.R.E., to select a site for the new fort. A satisfactory site was found on the river bank some 2½ miles below the existing fort opposite the village of Joghur. The river bank here favoured the construction of a suspension bridge. The ground was open all round and no high commanding points existed in the vicinity. The nearest commanding ground is the precipitous cliff on the opposite bank about 1,000 yards distant, and it is too steep to afford good sites for an enemy's sungas.

Site.

3. The proposed site is shown on Plates XVII and XIX. Plate XVII indicates its position in the Chitral Valley, and Plate XIX shows the site in detail with the proposed fort and bridge in outline. It will be seen that walls are carried down to the river from both flanks of the fort; this will give an enclosure for animals, cooking places, etc.

Site plans.

4. It is not proposed to provide quarters for the British Agent inside the fort during peace time, as the Political Officer of necessity has a large and miscellaneous native following, whom it is not desirable should have access to or be accommodated near the fort.

Political Officer.

5. The chief objects then in designing the fort which have to be kept in view are:—

Object affecting design.

(1) To provide the accommodation mentioned in paragraph 1.
(2) To have a clear field of fire all round.
(3) To protect the new bridge over the Chitral river.
(4) To be secure from escalade, from being mined, or being set on fire.
(5) To have a secure and abundant water-supply.
(6) To provide emplacements for two mountain guns and for any machine guns that may be allotted to it.

6. The type proposed follows that of the Native forts in the Chitral Valley generally, *i.e.*, it is a retangular fort with walls some 30 feet high which are flanked by two corner towers and a defensible gateway or blockhouse. The latter enfilades the new bridge and protects the covered way to water. Round the walls in the lower story are arranged all Commissariat godowns and regimental stores with a Guard Room and Prisoners Lock-up at the gateway. In the upper story the officers are quartered over the gateway, the Native Officers in the four corners, and sepoys, followers, etc., in barracks and hospitals round the walls; on the roof there is a parapet wall all round, and at the flanking towers and over the gateway are Machicouli galleries.

Type proposed.

Ditch.

7. No ditch has been given as the nature of the soil makes it unlikely that any enemy would undertake mining operations.

Walls.

8. The walls are to be of stone masonry in mud mortar, pointed on the outside with Portland cement mixed with six parts sand, or with lime if obtainable. Suitable stone can be obtained from the shaly-khud on the opposite bank of the river; but should earthquakes be apprehended, the floors and roofs must be supported on pillars clear of the walls as has been done at the blockhouse and not on the walls as shown on the type plan. The exterior walls are to be 6 feet thick in the lower story, 3 feet in the upper and 2 feet in the parapets. The interior walls to be 3 feet in lower story and 2 feet in the upper story; partition walls to be 2 feet thick.

Floors.

9. The floors are to be of mud throughout. In the godowns the supplies will be stored on wooden platforms raised 18 inches above the floor with a 4 feet passage in front and 2 feet behind. In the barracks the sepoys will be provided with wooden beds as at Buxa Bhutan on which men can stand and fire through the loopholes.

Roofs.

10. The roofs will be of mud of the kind usually constructed in Chitral. The parapet walls will also be roofed according to local custom to keep out rain.

Magazine.

11. The magazine will be in the centre of the land face opposite the gateway. Its roof will be strengthened and made thicker than usual, and no barrack will be placed over it.

Gateway.

12. The entrance gateway will be protected by a defensible blockhouse. The lower story will be loopholed and have an outer gate of iron bars, which will be the ordinary gate of the fort to be opened and shut daily; also a bullet-proof inner gate to be closed on emergency.

Officer's quarters.

13. Over the gateway are quarters and a mess room for two British Officers with an open verandah looking towards the river. The cookhouse and servants' quarters are below.

Guns.

14. The guns are placed in the four corners on the first floor, the ground underneath being filled up solid. Each emplacement contains room for one gun which can fire in two directions through bullet-proof shutters. Ramps lead to each emplacement, which is also provided at the flanking towers with musketry loopholes on the flanking faces. It is proposed that under ordinary circumstances when the mountain battery would probably be located outside the fort, that these emplacements should be utilised as quarters for Native Officers belonging to the infantry garrison.

Parapet wall.

15. On the upper story is a parapet wall giving another tier of musketry fire all round, while Machicouli galleries are provided at the unflanked faces of the towers and gateway blockhouse. Machine guns if available would be placed on this story at the angles and over the gateway as required.

Loopholes.

16. Except at the gateway no loopholes are placed in the walls of the lower story. Owing to the difficulty of making loopholes in such walls, the plan that prevails at Buxa Bhutan is adopted in the upper story, and all the windows of the barracks and hospitals are covered with bullet-proof iron sheeting loopholed. The men stand on their beds and can fire through them easily. *Owing to fire being in a downward direction there is no danger of the flanking corner towers firing into each other.*

Verandahs. Defilade.

17. Inside, a double-storied verandah runs round the buildings. On the outbreak of hostilities measures can be taken to close them by screens, etc., against reverse fire, but these would be most objectionable in peace time, interfering with light and the free circulation of air, etc. The remaining defilading walls, etc., are also left to be erected when the fort is put in a state of defence. It was found during the siege of Chitral that any screen was quite sufficient to stop all firing, as the enemy did not care to expend ammunition unless the object was visible to them.

Drainage.

18. The drainage is arranged so that it all passes outside the fort under the gateway and into the river.

Cooking places.

19. All cooking places for natives and latrines will as is usual be placed outside the fort and will *be strictly temporary buildings.*

Water-supply.

20. Water, will be obtained from the river, the approach being a covered way under the road leading to the bridge; a well might also be sunk inside the fort and another just outside, from which good water may be obtainable.

Bridge head.

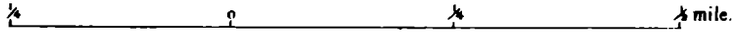
21. There will be a small bridge head on the opposite bank to protect the entrance to the bridge. This might be a tower like the existing one at Chitral bridge.

PLATE XVII.

THE ENVIRONS OF CHITRAL.

to illustrate action of March 3rd 1895.

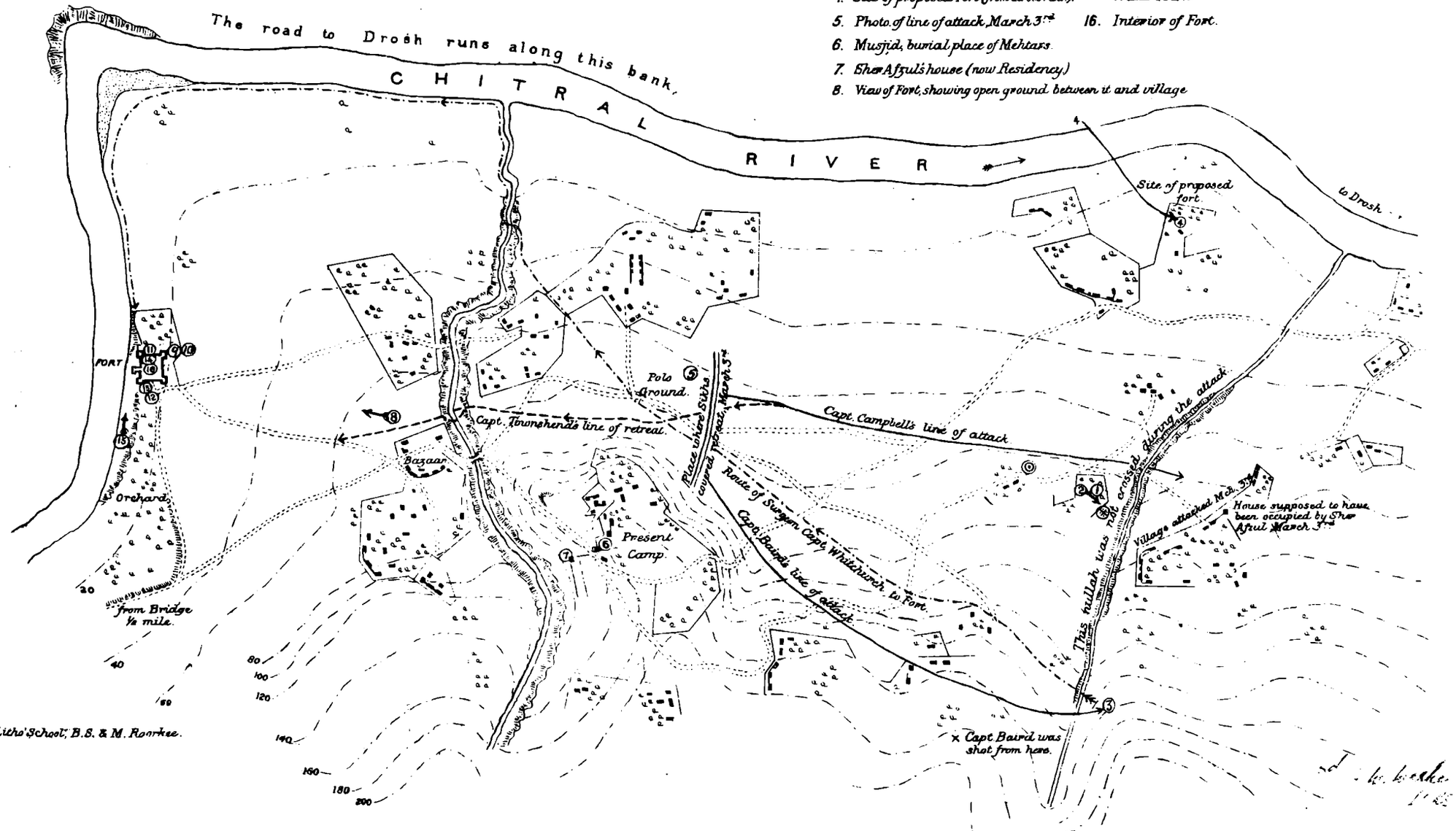
Scale: 6 ins. = 1 mile.



Magnetic.

References.

1. View of objective village, Sortie Mch. 3.
⊙ Place where Capt. Campbell was wounded.
✻ Place where Genl. Baj Singh and Major Bhikram Singh were killed & furthest point reached by our troops.
2. View of above place.
3. Place where Capt. Baird was wounded
4. Site of proposed Fort (from across river).
5. Photo. of line of attack, March 3rd
6. Musjid, burial place of Mehtars.
7. Sher Afzul's house (now Residency)
8. View of Fort, showing open ground between it and village
9. View of Mine from Guntower.
10. " Guntower from head of mine.
11. Gate from which Harley's sortie was made.
12. Main Gate of Fort.
13. Capt. Baird's grave.
14. View of Water Tower from East Tower.
15. " Fort, from Sungar built to fire on Water Tower
16. Interior of Fort.



Litho'd School, B.S. & M. Roorkee.

PLAN OF CHITRAL FORT,

by

Lieut: Freeland, R.E.

PLATE XVIII.

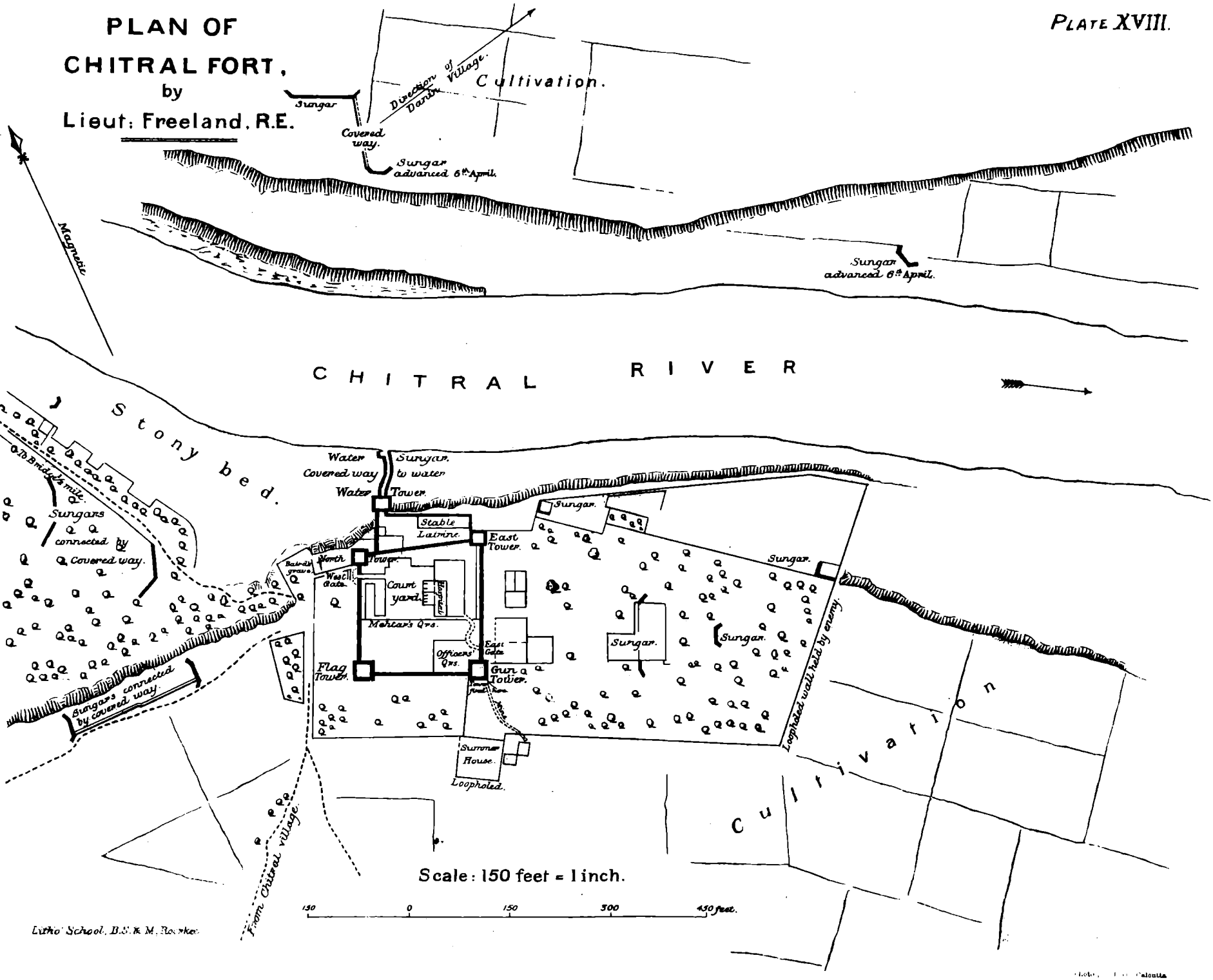
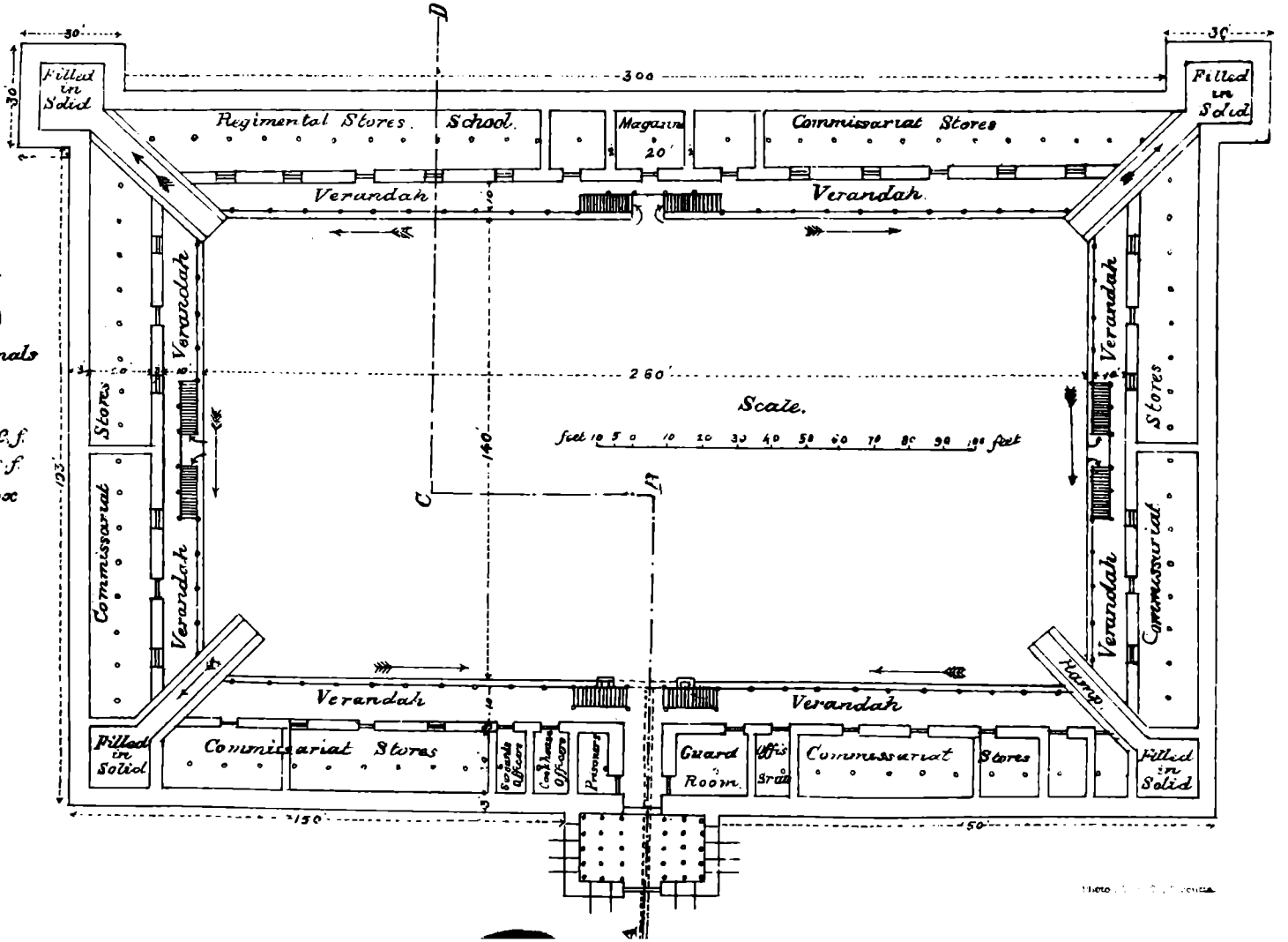


PLATE XX.

Ground Plan of Proposed Fort at Chitral
to accommodate 200 Native Infantry & 20.000 maunds of Commissariat Stores.



Rations for 1 year for

2000 Natives (F.M.)

850 Transport Animals

are

48.352 bags - 1 md. = 2C.f.

1.428 boxes -"- = 3C.f.

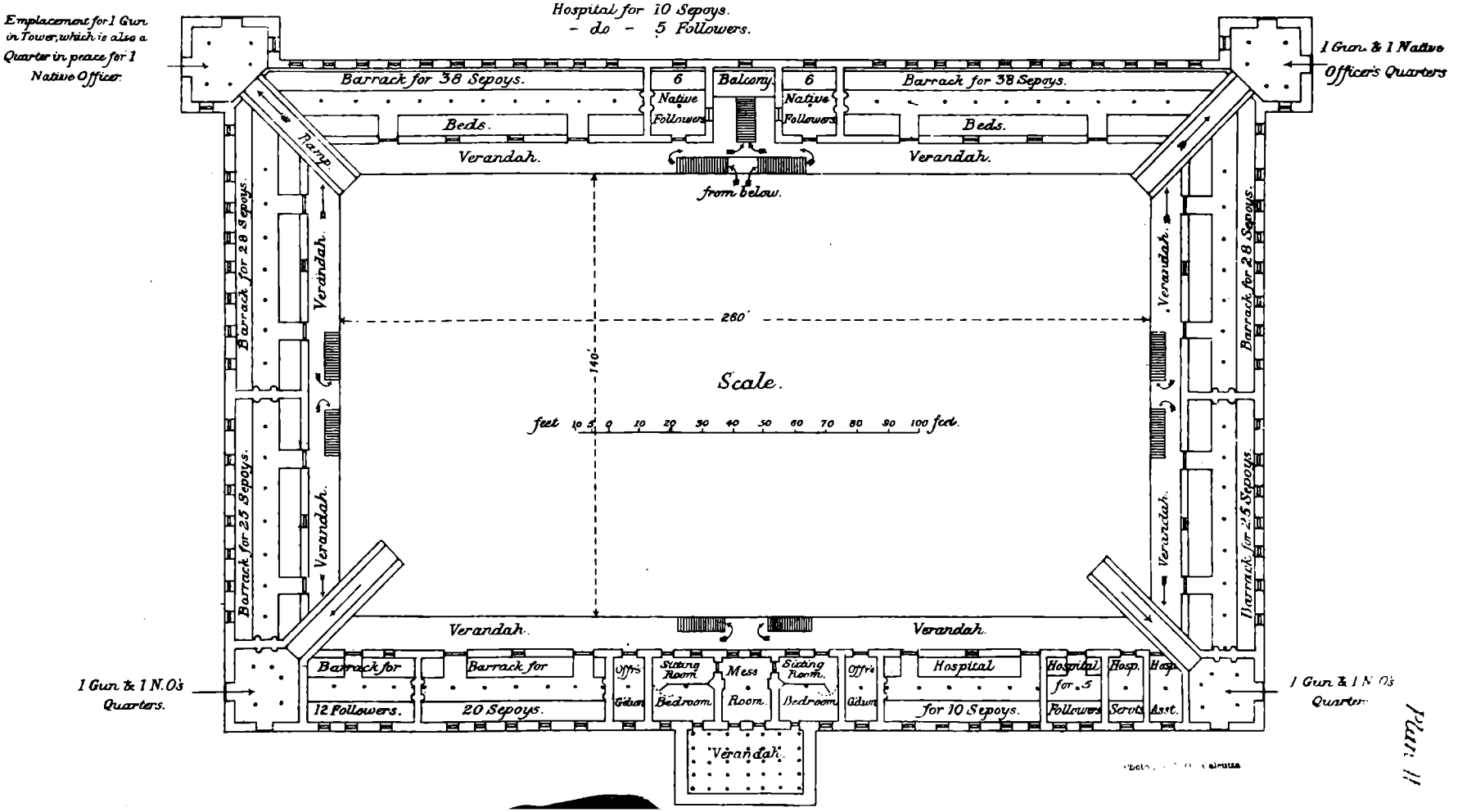
Each bag & each box

weighs 1 maund.

PLATE XXI.

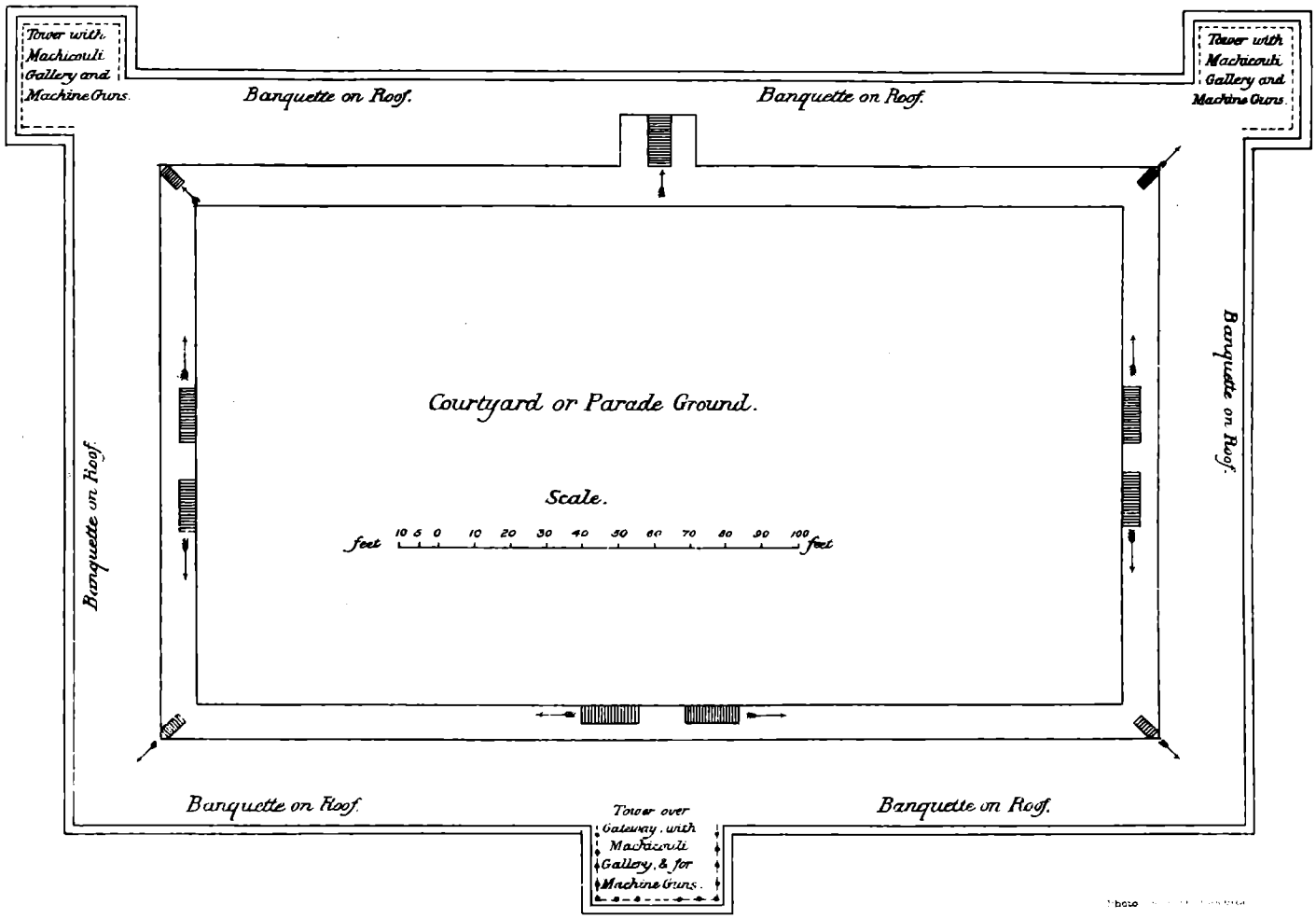
Ground Plan of First Floor of Proposed Fort at Chitral.

showing the following accommodation:-
Quarters for 2 British Officers & Mess.
- do - 4 Native Officers.
Barracks for 200 Sepoys.
- do - 24 Followers.
Hospital for 10 Sepoys.
- do - 5 Followers.



Plan II

Plan of Top Story.



22. The bridge itself is a suspension one, made of telegraph wire cables with wooden frames at each end, and has a span of 300 feet (see Bridging Report).

Bridge.

APPENDIX J.

Service Companies, Sappers and Miners.

The following points are brought to notice:—

Equipment.

AUGERS. Bull nosed Augers are preferable to Augers, common. The former only should be carried.

AXES, PICK. The heads should be of solid steel. Their initial cost is slightly greater, but their durability is very much more so.

BARS, BORING. Should be abolished from all Engineer Equipments and only bars, jumping, octagonal, should be carried. These should be of steel throughout.

BARS, CROW. Should be entirely of steel.

BILL HOOKS. Those at present supplied do not seem to be of the best shape possible. Their quality also leaves something to be desired.

BLOCK WOOD. The galvanised iron pattern is lighter and more durable.

BOTHWAY. Snatch blocks should be substituted in all cases for the single blocks.

GRINDSTONES. A second grindstone is absolutely necessary.

ROPE, STEEL WIRE. A certain proportion of 1¼ inch steel wire rope with a light traveller should take the place of some of the manilla rope carried by companies.

SAWS, CROSS CUT. More are required.

SHOVELS. Those carried are not now of the best pattern. The more modern rolled steel shovel with a pointed nose is preferable.
The proportion of picks to shovels in the equipment should be increased.
It is obviously false economy to take inferior tools requiring constant repair and renewal into the field, and Service Companies should not be called on to accept tools which are inferior to and differ from the authorised patterns on the plea that the existing stock must be used up. These tools should be utilised for coolies.

Officers.

From the experience gained in this and on other expeditions I consider it very advisable that Service Companies should be commanded by Officers of not lower rank than that of Captain.

Artificers.

The value of the artificers in the Bengal Companies has been very clearly shown. It would probably be advantageous to increase the number of carpenters even if this involves a corresponding reduction in the number of smiths.

Ration.

A note should be added to the Field Service Manual that Sappers and Miners and Pioneers should receive a full seer of atta when on active service and employed on work. On all recent expeditions this has been recognised.

Increase in the number of Service Companies.

Recent experience points to the fact that the number of Service Companies in India would be very advantageously increased.

Reserve.

At present Sapper Corps have no reserves.

H. P. LEACH,
Colonel on the Staff, R.E.

APPENDIX K.

23rd Pioneers.

1. This regiment, under the command of Lieutenant-Colonel Gordon, formed, from the first, part of the advanced troops. As a general rule, two or four companies were employed immediately behind the 4th Company, Bengal Sappers and Miners, while the remaining portion of the regiment worked somewhat further in rear.

2. The work done by the Pioneers chiefly consisted in making new roads, in widening and improving existing tracks, and in erecting many of the cantilever bridges required between Dir and Drosh.

3. At this they proved themselves to be efficient; the large number of men in the regiment enables it to make a great show on work; the men are capable of prolonged exertion and can, as shown on the opening of the Malakand Pass road, turn out a large quantity of excellent work, under difficult circumstances, in a very limited space of time.

4. Attached is a copy of a report by Lieutenant-Colonel Gordon, in which he proposes to add to the equipment of his regiment in many ways, which will require, if adopted, an increase

in mules from 32 to 55. These proposals might be carefully considered later on by a committee.

5. There is, however, likely to be no difference of opinion regarding the desirability of all jumpers being octagonal solid steel bars, and of guncotton being carried in place of a portion of the gunpowder. Some of the stores, proposed to be added, might not invariably be required and could perhaps be better obtained, as at present, from the R. E. Field Park.

6. The picks and shovels carried are not of the best quality. This is a great mistake, as it is quite evident that it is economy in the end to take on service none but tools of the very best quality and make. There can be no two opinions on this point.

Explanatory notes accompanying tables showing alterations recommended in the "detail of Pioneer Equipment for Field Service, Table IX, Field Service Equipment Tables, Native Infantry, Section 10, page 10.

(*a*) This is an increase of four crowbars and four jumping bars per company.
The increase is urgently needed owing to the work where hard rock cutting is met with, having on all occasions been much delayed owing to the scanty number of these tools in the present authorised scale.

(*b*) As in Table IX, but half gunpowder and half guncotton recommended in place of all gunpowder as at present.

(*c*) This is an increase of four boxes (two blacksmiths' and two Carpenters') per regiment of artificer's tools. The present scale equips two shops per regiment. This is insufficient for its requirements, over and over again four detached parties have to be furnished, working many miles apart. The increase would furnish equipment for four blacksmiths' and four carpenters' shops per regiment, *i.e.*, one shop of each to two companies, none too many.

(*d*) An increase of two anvils, but necessary for equipment of four blacksmiths' and four carpenters' shops in place of two in present scale.

(*e*) An increase, no cross-cut saw detailed in present scale of equipment. These tools are always wanted and should be included in list of Pioneer Equipment in the Field, most useful, necessary in all kinds of bridging work.

(*f*) Ropes, drag, and 3-inch, not in present scale, much wanted for bridging work, etc.,—have invariably to be indented for, causing delay, etc.

(*g*) Spikes and dogs, an increase, but like rope and cross-cut saws should form part of equipment authorised, being necessary in many kinds of work, more especially bridging.

(*h*) Wire (two coils) a most useful and desirable equipment for Pioneer regiments in the field, very strongly recommended to be added and carried on all occasions, specially necessary for bridging work in the field.

(*i*) The pattern of jumping bars issued to Pioneer regiments has been found, after exhaustive trial at defence works, Rawal Pindi, 1892-93, Khagan Valley and Chilas, 1893-94, and Chitral Relief Field Force, 1895, to be unsatisfactory. They are too light, of defective steel and unfit for the heavy work for which used. These jumping bars should be replaced, in equipment Pioneers, by heavy octagonal steel jumping bars of the pattern in use in the Military Works Department which are infinitely superior in manufacture and material, and used in preference when available.

In forwarding these recommendations, I am of opinion that the present scale of Pioneer Equipment in Table IX, Field Service Tables, is inadequate, and that a considerable increase on the lines suggested, *viz.*, to 55 mule loads, is desirable and would promote general usefulness of these Corps.

The present scale of 32 mule loads was adopted some ten years ago. The scale is not in keeping with present regimental requirements in the Field, and I consider its revision called for in the interests of the regiments.

L. C. GORDON, *Lieut.-Col.*,
Commanding 23rd Pioneers.

CAMP BIBIAR,
The 16th July 1895.

Table showing alterations recommended in Table IX, Field Service Equipment Tables, Native Infantry, Section 10, Page 10—Pioneers.

DETAIL OF EQUIPMENT PIONEERS FOR FIELD SERVICE (RECOMMENDED).

	*		d	b	b	a	a	c	c			f	f	e	g	h	
		Number of mules.	Anvils, ¾ cwt.	Axes, pick head.	Barrels, powder, I. P., half.	Boxes, guncotton.	Guncotton detonators.	Bars, crow.	Bars, jumping.	Bars, tamping.	Chest, tool, No. 4, filled.	Chest, tool, No. 11, filled.	Fuze.	Grindstone, F.S. 18".	Hammers, sledge, 14 lbs.	Handles, tools.	Mamooties, English.	Ropes, drag.	Ropes 3".	Saws, cross-cut.	Scoops and scrapers.	Shovel.	Spikes and dogs.	Wedges, miners, 1".	Wire.	Remarks.
A Company	*	1						4	4												4					
		2						3	3	3											3					
		3						3	3							10					3					* The letters (a), (b), (c), (d), (e), (f) (g) and (h) refers to paragraphs in notes accompanying this table.
		4		10													5					10				
		5													4	20								4		
B Company	*	6						4	4												4					
		7						3	3	3											3					
		8						3	3							10					3					
		9		10													5					10				
		10													4	20								4		
C Company	*	11						4	4												4					
		12						3	3	3											3					
		13						3	3							10					3					
		14		10													5					10				
		15													4	20								4		
D Company	*	16						4	4												4					
		17						3	3	3											3					
		18						3	3							10					3					
		19		10													5					10				
		20													4	20								4		2 Bundles fuze of 400 fathoms. 2 Barrels of gun powder, 50 lbs. each. 2 Boxes guncotton 96 " " 4 Boxes detonators of 100 " "
E Company	*	21						4	4												4					2 Boxes, containing spikes and dogs weighing 85 lbs. each.
		22						3	3	3											3					
		23						3	3							10					3					
		24		10													5					10				2 Coils of wire weighing 85 lbs. each.
		25													4	20								4		Ropes, 3 inches, 150 feet, weighing 85 lbs.
F Company	*	26						4	4												4					
		27						3	3	3											3					
		28						3	3							10					3					
		29		10													5					10				
		30													4	20								4		

G Company	31							4	4											4					
	32							3	3	3										3					
	33							3	3							10				3					
	34		10														5				10				
	35														4	20							4		
H Company	36							4	4											4					
	37							3	3	3										3					
	38							3	3							10				3					
	39		10														5				10				
	40														4	20							4		
Right Wing	41										2														
	42											2													
	43	2												2											
	44																								
	45			1	1	2																			
Left Wing	46										2														
	47											2													
	48	2												2											
	49			1	1	2																			
	50																								
Head-quarters	51												2												
	52																4	1							
	53																		8						
	54																					2			
	55																							2	
TOTAL		4	80	2	2	4	80	80	24	4	4	4	2	32	240	40	4	1	8	80	80	2	32	2	Now proposed.
TOTAL F.S.E. T. IX, *b*.		2	80	8	...	...	48	48	40	2	2	2	2	16	240	40	...	...	...	48	96	...	32	...	

CAMP BIBIAR,
The 16th July 1895.

L. C. GORDON, *Lieut.-Colonel*,
Commanding 23rd Pioneers.

APPENDIX L.

Report on alterations in the Field Service Manual, Part VII, and on the information to be supplied to a Commanding Royal Engineer on taking the Field.

1. The Field Service Manual lays down the duties of the Commanding Royal Engineer plainly enough in the case of an army or army corps, but in the case of one division only with a line of communications it is not expressed with sufficient clearness, and it might be taken that the Commanding Royal Engineer 1st Division, and Commanding Royal Engineer line of communications, are entirely independent of one another.

2. Paragraph 3 of the Manual should lay down that in addition to his executive duties the Royal Engineer Commanding 1st Division, in his position as the Staff Officer of the General Commanding the Force is also charged with the administration of the Engineer arm generally.

3. It would not be advisable or possible that the Commanding Royal Engineer of the Division should interfere with the Commanding Royal Engineer line of communications, regarding the immediate supervision or orders of the Engineer services of the line of communications, but it is essential that he should be kept well posted up in what is going on there, especially as to progress of work, labour employed, and what new work it is proposed to undertake. This is necessary in order that he should be in a position to advise the General Officer Commanding as to the effective distribution of the Engineer arm.

4. To be of use this information must be up to date, so it should be supplied by the Commanding Royal Engineer line of communications, direct to the Commanding Royal Engineer 1st Division.

5. Of course all correspondence connected with Royal Engineer operations generally, reports, etc., should be submitted through the Commanding Royal Engineer 1st Division.

6. As regards Section II no change seems necessary, except that the information supplied to the Commanding Royal Engineer on taking the Field is very meagre at present.

7. *Immediately* the Commanding Royal Engineer is appointed to the Force, the D.A. A.G., R.E., Simla, should send him the following information :—

1. Field Service Manual.
2. Equipment Tables, R. E.
3. A printed statement giving the following information : —
   - (*a*) The places at which Engineer Field and Siege Parks are maintained.
   - (*b*) The places at which R. E. mobilisation stores are kept, and the number of different articles available at each depôt, also the officer in whose charge they are.
   - (*c*) The list of stores actually supplied to the R. E. Field Parks in different expeditions that have taken place, the number expended during the campaign.
   - (*d*) A list of firms at Calcutta, Bombay, Karachi, and Rangoon, who supply engineering stores, with the probable amount of each which they generally keep on stock available at a few hours' notice.
   - (*e*) Any regulations relating to transit of explosives by railway that are likely to be of use such as railways not taking dynamite after 1st April.
   - (*f*) The places where the Office Mobilisation Boxes are kept and where all office requirements are to be obtained.

8. With this information at hand *immediately* he is appointed, the Commanding Royal Engineer with the General in Command of the Force would be able to demand at once, much more accurately than at present, the stores he would be likely to require during the expedition.

9. Part XI, paragraph 64, requires alteration It is obviously wrong to put officers who probably have no special training "in charge of all roads and railways, if any, within their sections." Any such arrangement must lead to friction with the Engineer Officers who are also very properly put in charge, *vide* paragraphs 70, 72 of the same Part XI. To prevent this happening, the following Divisional Order had to be issued : —

Camp Ashreth, 11th May, 1895.

3. "As R.E. Officers on the various Road Sections have their orders from the Commanding "Royal Engineer these orders should not be interfered with by Road Commandants of Sections "without reference to the Commanding Royal Engineer, or in case of necessity, when there is no "time to make a reference, the Commanding Royal Engineer should be immediately informed of "the orders given.

"It is also the duty of the Road Commandant to report to the Commanding Royal Engineer in case anything connected with road-making goes wrong or requires attention."

APPENDIX M.

Report on boatmen employed under the Commanding Royal Engineer during the operations of the Chitral Relief Force, 1895.

BY MAJOR M. C. BARTON, R.E.

During the above operations about 145 boatmen were employed (maximum number); they were supplied as follows :—

From Attock		Indus River,	24 men.
„ Jehangira		Kabul River	13 „
„ Nowshera		„	21 „
„ Hastnagar		„	13 „
„ Hund	Indus River		19 „
„ Kabul	Indus River		17 „
„ Char sudder, Kabul River			24 „
„ Panjkora River			15 „
	TOTAL		146 men.

2. Attock and Jehangira could probably have supplied many more men, but owing to work on the alternative bridge of boats at Nowshera some of those willing to come were not available at the time the force started.

3. Considerable difficulty was experienced in getting good mussacks; apparently owing to men having to take out a license to use them, they either don't keep them or won't own to having them in their possession. A number of very inferior ones were supplied by the Civil authorities and a few good ones were procured from boatmen themselves.

Mussacks.

4. The men were paid at the following rates :—

Rates of pay.

	£
Jemadars (1 only)	60 per mensem.
Duffadars (about 1 to 18 or 20 men)	45 „ „
Boatmen	30 „ „

Free rations were issued in each case in addition to above rates of pay.

I do not think that men will come for less than the above rates.

Blankets were issued in some cases; if possible the free issue of a blanket should always be sanctioned on similar expeditions.

Clothing.

5. The boatmen were extremely useful in helping the troops to ford the Swat river before the bridge was finished. But for their assistance and skill in the water, I am convinced that many lives would have been lost; it is due to their help that out of the two brigades that crossed the Swat river only two lives were lost (due to imprudence on the men's own part), and that the loss of transport animals and baggage and supplies was so small as to be absolutely insignificant. The boatmen have also rendered great assistance in maintaining the trestle and pontoon bridges. I consider that if they had not been present at the trestle bridge it would have been necessary to keep a Sapper Company there permanently. Captain Heath also reports very favourably on the good work done by them: they have also been useful in collecting and floating down deodar logs required for use in the various bridges.

Work done.

G. I. C. P. O.—No. 71 A. G.—30-6-96.—50.

ROAD SURVEY.

FROM

DIR TO CHITRAL.

No. 1.	Dir - Lower Kolandi.	7 Miles.
No. 2.	Lower Kolandi - Lowarie Pass.	8 Miles.
No. 3.	Lowarie Pass - Ziarat.	5 Miles.
No. 4.	Ziarat - Mirkandi.	7 Miles.
No. 5.	Mirkandi - Galatak.	6½ Miles.
No. 6.	Galatak - Shi-Shi-Kuf.	5½ Miles.
No. 7.	Shi-Shi-Kuf - Kesu Aquaduct.	5½ Miles.
No. 8.	Kesu Aquaduct - Gairat.	5½ Miles.
No. 9.	Gairat - Broz.	6 Miles.
No. 10.	Broz Chumarkon.	5 Miles.
No. 11.	Chumarkon - Near Chitral.	5 Miles.
No. 12.	Danil and Chitral.	2 Miles.
	Total.	68 Miles.

Drawn & printed under the direction of Colonel H.P Leach, D.S.O.
at the Litho' School, B.S & M, Roorkee.
by Sergts White & Hunwitz, R.E.

Bhoto, ... Calcutta

REPORT

ON THE

ENGINEERING OPERATIONS,

LINE OF COMMUNICATIONS,

CHITRAL RELIEF FORCE,

BY THE

C.R.E., LINE OF COMMUNICATIONS.

CALCUTTA:
OFFICE OF THE SUPERINTENDENT OF GOVERNMENT PRINTING, INDIA,
1896.

Report on Engineering Operations carried out on the Line of Communications of the Chitral Relief Force.

I.—Roads.

The communications extended ten days after the commencement of operations from Mardan to the Malakhand Kotal, a distance of 32 miles, and a few days later Uch, 50 miles from Mardan, was the limit.

Early in May, the "Line" was from Mardan to Dir *viâ* Mundah and Janbatai Kotal, 116½ miles, and later, the new route, *viâ* the Panjkora valley, added 50½ miles more, giving a total road length on the main lines of 167 miles.

At the commencement of the campaign, a kucha road existed for about seven miles from Mardan, and the remainder of the country was traversed by mere native paths, which, where they crossed the passes, were unfit even for mule transport, until a certain amount of work had been done.

The First Division, during the advance, rapidly improved existing paths so as to make them passable for the troops and mule transport. Subsequently, good convoy roads had to be made throughout under the orders of the General Officer Commanding the Line of Communications.

In some cases three roads had to be constructed: firstly, during the advance, a rough road for mules; secondly, an improved but rapidly made road for camels; and finally, for long ascents, a graded camel road.

The graded camel roads have, as far as possible, been kept on cart road alignments to admit of their being at any time easily widened into cart roads.

Roads traversing level ground were at once made suitable for cart traffic, the drainage ditches being cut 30 feet apart. It is practically as easy on such ground to make a fairly wide road as a narrow one, and, even if carts are not used, the movement of transport is much facilitated by a wide road.

The chief physical difficulties which had to be overcome are presented by the Malakhand, Katgola and Janbatai Passes, the crossings of the Swat and Panjkora rivers, and the rocky cliffs through which the road had to be cut a great part of the way along the Panjkora valley.

Mardan to the foot of the Malakhand Pass.

Leaving Mardan, the road (metalled for 1½ miles) traverses the Northern portion of the Peshawar valley for a distance of 26¼ miles to the foot of the Malakhand, passing Takht-i-bhai hill, and the villages of Jalala, Shergarh, Sakot and Dargai.

The soil is clay, becoming almost impassable in wet weather; it was consequently decided by Government that this portion of the road should be metalled, and contracts were given to Messrs. Spedding and Company for 14¾ miles at an average rate of ₹9,240 per mile, and to five native contractors for 10 miles at an average rate of ₹7,500 per mile. It was stipulated that the work was to be completed by the 30th June. Three of the native contractors had finished by that time, the other two by July 20th; but Messrs. Spedding and Company's work was not all done till the 1st August.

All works on the Mardan-Dargai Section were in charge of Captain Cordue, R.E., until he was invalided in May, when Captain Nanton, R.E., took his place.

Malakhand Pass (2,850 feet).

The roads over this pass were constructed by Major Abbott, R.E., whose report is attached. The new camel road having been aligned on suitable gradients is now being widened into a cart road.

Swat Valley.

After descending the Malakhand Pass, the road turns to the East, up the broad irrigated Swat valley; and in 6½ miles reaches the Swat river Suspension Bridge (see Bridges), Chakdarrah (2,450 feet), being on the right bank of the river.

This 6½ miles of road which, for half its length, passes through rice cultivation, has been constructed 30 feet wide and is bridged, drained and metalled. Metalling, which was essential before the rains owing to the clayey nature of the soil, was commenced in May, and completed on the 24th July; half this work was carried out by Major Abbott, R.E., and half by Captain Williams, R.E., the former portion being completed in the short space of seven weeks.

Chakdarrah, Katgola, Sarai, Panjkora.

This section of the road is above 20 miles in length and, leaving the Suspension Bridge and rising gradually, runs for four miles in a northerly direction towards the Laram range; it then turns to the west, and two miles farther on the ascent of the Katgola is commenced, the crest (3,100 feet) being reached in another four miles.

The road now descends gradually down an open valley, passing Sarai in about two miles, and entering the Shagukas Defile, four miles further on.

A good kucha cart road has been constructed throughout this length. The width is 30 feet, except for the four miles of the eastern ascent to the Katgola, where a limiting grade of 1 in 20 and a width of 20 feet has been adopted.

This graded road was made by Lieutenant Ogilvie, R.E., in three weeks, but prior to its commencement a very passable temporary camel road was made by the 34th Pioneers in the short space of six days.

The last four miles to Panjkora is a camel road which, descending the defile and traversing the left bank of the Panjkora by a cliff road for half a mile, crosses the river by a Suspension Bridge of 197 feet span.

The road over the Kamerani range, which leads by the Panjkora valley to Dir, turns off just before the Shagukas is entered.

Panjkora to Kanbat.

The route here lies first up the right bank of the Panjkora river, and then follows the Jandul valley for a distance of 18 miles, the first five being in a westerly direction, after which the stream turns to the north.

Leaving Panjkora, the road lies up the right bank of the river and traverses a gallery, constructed by the 6th Company, Bengal Sappers and Miners, along the side of a rocky cliff, the Jandul river, which is fordable except during heavy floods, being crossed a little farther on.

Floods in this river are of short duration and run off quickly when the rain ceases, but while they last the volume of water is great and the velocity high.

A strong trestle bridge, constructed by the 6th Company, Bengal Sappers and Miners,—roadway nine feet above water level,—was swept away about a fortnight after completion.

The rest of this route presents no difficulty to animal transport of any description, and it has only been improved where necessary.

Janbatai Pass (7,300 feet).

This is a formidable Pass, the ascent on the South side being 3,600 feet, and the descent to Janbatai 2,000 feet. The road opened up by the troops during the first advance had necessarily to be made rapidly and was far too steep and narrow for continued use by convoys.

The 34th Pioneers and the 6th Company, Bengal Sappers and Miners, were consequently ordered up to make a road 10 feet wide, on a grade of about 1 in 12.

The total distance to Janbatai by this road is about 13 miles, the first seven having been made by the 34th Pioneers in a little over three weeks and the remainder by the Company of Sappers.

This road reflects much credit on all engaged upon it, and was carried through in excellent time. The 6th Company, Bengal Sappers and Miners, also constructed a branch road, nearly a mile long, leading to the Camp at Janbatai west.

Janbatai to Dir.

From Janbatai, the road leads down the picturesque Baraul valley for a distance of 17 miles to Chutyatan where the Panjkora river is again joined; its right bank is then ascended in a northerly direction for half a mile, after which the Dir stream is followed for five miles to the town of that name.

A mule road, made in the first instance, has now been converted into a good camel road throughout the whole of this distance, the troops employed being :—

Janbatai to Bandai	... 5 miles,	6th Company, Bengal Sappers and Miners.
Bandai to Chutyatan	... 12 „	11 miles, 34th Punjab Pioneers. 1 mile, 1st Company, Bengal Sappers and Miners.
Chutyatan to Dir	... 5½ miles,	Wing, 23rd Punjab Pioneers.

Panjkora Valley Road.

It was obvious from the first that, unless the physical difficulties of making a road were very great, the Panjkora valley was the proper route to adopt for a convoy road to Dir; since, although the saving in length was but two miles, the rise was gradual

throughout, and the only height to be crossed was the Kamerani, entailing a rise and fall of some 500 feet, while, by the other routes, the ascent to the crests of the Janbatai or Kargosar passes involved a rise of between 3,500 and 4,000 feet.

The valley was reconnoitred by Major Barton, R.E., and a sketch of the route made by Lieutenant F. R. F. Boileau, R.E., at the end of April; the graded road over the Kamerani was then laid out and started, this being in any case necessary for return traffic from Sado as the Shagukas route was too narrow for up and down convoys to cross. The valley was further examined and reported on by the C. R. E., Line of Communications, in May.

The existing track was so bad that in many places it was difficult even for mules and was almost impassable for baggage ponies. The physical difficulties were also considerable, as about one-half the distance required heavy rock blasting.

A good suspension bridge was built at Chutyatan, the northern end of the route, in substitution of the ricketty and dangerous native cantilever bridge, and road alignments were selected by Captain Swiney, R.E., and Lieutenant F. R. F. Boileau, R.E., in case the route should be adopted later on.

It was not, however, until the end of June, that orders were received for the opening up of a mule road along the Panjkora valley, on which military labour alone was to be used, and the entire road, 43½ miles in length, from Sado to Chutyatan, was to be completed as a good mule road, six feet wide, by 15th July.

To Myabyda, 3½ miles from Sado, the road was already suitable for mules, hence the entire distance requiring work was 40 miles.

In consequence of this order, the following troops were moved into the valley:—

Wing, 23rd Pioneers—Lieutenant-Colonel Gordon, to construct road from Chutyatan to near Darora, 8¼ miles.

1st Company, Bengal Sappers—Captain Serjeant, R.E., to strengthen and re-construct the bridge over the Ushiri at Darora and to make about 2¼ miles of heavy road approaches to the Chutyatan and Darora bridges.

34th Pioneers—Lieutenant-Colonel Wilson, to work from a point about a mile south of Darora to Manki, 11½ miles.

6th Company, Madras Sappers—Lieutenant Ainslie, R.E., from Manki to Toormung, 5½ miles, which was the heaviest portion of the work.

6th Company, Bengal Sappers, less detachment of 25 men employed elsewhere,—Lieutenant Kemp, R.E., Toormung to Myabyda, 12½ miles.

The last two Companies were under the orders of Captain Swiney, R.E., who was in charge of the construction of the southern part of the road.

Work was commenced on 28th June and completed on 14th July: thus 40 miles of good mule road were made in a difficult and rocky country in seventeen days, a feat which, considering the nature of the ground, reflects great credit on all the troops employed.

On 4th July, seven days after this mule road had been started, Government authorised the employment of civil labour on the south end of the Panjkora road. Additional officers were at once sent to the valley, orders being given to widen out the road to ten feet and to re-align those portions not suitable for camels. Civil petty contract labour was employed on the greater part of the southern half, and military labour on the remainder.

A through convoy of 1,200 camels started from Sado on 1st August, reaching Dir on 4th August, thirty-eight days after work had been commenced.

Some idea of what was accomplished in that time may be formed from the fact that Mr. Bennett, a contractor who tendered for 23 miles of the centre portion of the road, required three-and-a-half months to complete a ten-foot camel road, and the price asked was R10,000 per mile.

The whole road is now practically ten feet wide throughout, and the total cost, including a number of bridges, has been:—

	R
Civil labour	67,000
Working pay, troops	8,200
	75,200
Tools and Plant on labour at usual rate, 1½ per cent., say	1,200
Timber for bridges	2,800
Explosives, approximate	10,000
Total	89,200

This, for 43½ miles, gives an average rate of ₹2,050 per mile.

Kamerani Pass Section.

The hill section, 6½ miles long from Sado over the Kamerani range into the Sarai valley, was made on cart road gradients 1 in 20 and under on the south side, and 1 in 15 on the north side; and though it cannot properly be considered a cart road, since the width is only ten feet, still a large number of transport carts and pontoon wagons have recently crossed and re-crossed it. This road was laid out and in great part made by Captain Duff, R.E.; it was completed by Lieutenant Thuillier, R.E., and is fully bridged.

Since the beginning of August, the Panjkora road has been still further improved, a cantilever bridge, 57 feet span, has been built over the Niag or Lo River, and a number of smaller bridges, varying in length from 10 to 40 feet, have been constructed with result that, though still narrow for carts, since only intended for camels, carts could now run from Mardan to Warai and an ekka could travel without difficulty to Dir.

The road from Mardan to Dir has been measured, and mile posts have been erected. The distance to the bridge just beyond Dir is 114½ miles, while, by the Jandul valley, the estimated distance is about two miles more.

From the south foot of the Kamerani, where the routes diverge, to Chutyatan where they again meet, the distance is 50½ miles; a mileage itinerary of the road is attached and also a tracing from the survey map showing the roads.

The following mule roads have also been made :—

Other Roads.

Rabat to Laram Kotal, 8 miles, made by Captain Swiney, R.E., in five days.

Sarai to Bircharai, 6½ miles, a good graded mule road 1 in 7, made by Lieutenant Ogilvie, R.E., up a rocky hillside, in the short space of nine days.

Panjkora to Kamerani Kotal and Panjkora to Sado, 3 miles, Lieutenant Thuillier, R.E.

The road from Biran to Laram, 4 miles, has also been improved and regraded, the Madras Sappers having assisted the Infantry working parties in making the original road.

The rock excavation required on the Shakot Pass, to make that steep and difficult road to some extent passable for transport animals, was also done by the Madras Sappers.

Total Mileage of roads constructed.

The total mileage of roads constructed on the Line of Communications is :—

	Miles.
1. Metalled cart roads—	
Mardan to foot of Malakhand Pass (1½ miles previously metalled)	24¾
Swat Valley. Foot of Malakhand Pass to Chakdarrah . .	6½
Total .	31¼
2. Unmetalled cart roads—	
Chakdarrah to foot of Kamerani Pass	16
3. Camel roads aligned on cart road gradients, and which though narrow are passable by carts—	
Malakhand Pass graded road	9
Panjkora Road from south foot of Kamerani, over the Pass to Warai	30¾
Total .	39¾
4. Camel roads—	
Dargai to Khar, *viâ* Buddhist road over Malakhand Pass . .	9
Panjkora Road, Warai to Dir	25½
From bifurcation of Panjkora route, west of Sarai *viâ* Mundah to Kanbat	23
Janbatai to Chutyatan	17
Total .	74½

5. Mule roads—	Miles.
Janbatai Pass, Kanbat to Janbatai, gradient and width suitable, but ascent too long, for camels	12½
Road to Janbatai West	1
Kamerani Kotal to Panjkora and Panjkora to Sado	3
Rabat to Larum	8
Biran to Larum	4
Sarai to Bircharai	6¼
Total	35

Totals—	
1. Metalled cart roads	31¼
2. Unmetalled cart roads	16
3. Camel roads on cart road gradients	39¾
4. Camel roads	74½
5. Mule roads	35
Total roads constructed on Line of Communications	196¼

II.—Bridges.

A copy of the report on bridges constructed under the orders of the C. R. E., Line of Communications, which has been prepared for transmission to the Horse Guards, is attached and describes the bridging work done.

Kabul River.

Communication over the Kabul River, which has to be crossed immediately on leaving Nowshera, is maintained by means of a bridge of boats with a roadway sufficiently wide for one line of traffic only. When the force was mobilised and very heavy convoys had to be constantly running, serious blocks of traffic would have resulted from this single bridge, and it was decided to provide a second one. The boats and superstructure of the Defence Division, Military Works, were accordingly brought up from Attock, and a second bridge established. This work was commenced by Major Barton, R.E., and completed by the Punjab Public Works Department.

Swat River.

When the force first moved into the Swat valley, the river, which spreads out over a broad bed of boulders and sand, was rising and, in the first instance, a long trestle and crib bridge to carry transport animals of all sorts was commenced under the orders of the C. R. E., First Division, and completed under the C. R. E., Line of Communications.

Major Barton, R.E., was in charge of the work, which was carried out by the 1st and 6th Companies, Bengal Sappers and Miners.

This bridge with constant, and latterly daily, repair and with frequent construction and substitution of new and heavier trestles, successfully withstood two floods, but finally collapsed on 26th June.

This year, the floods in the Swat river have fortunately been unusually low, but it was quite evident from the first that, should heavy floods occur, this temporary trestle bridge could not stand. This has since been abundantly proved by the fact that stronger bridges over the Jandul, Uch and Alladand rivers were completely swept away by floods, notwithstanding that, in the two latter cases, the trestle legs were packed in by floors of heavy dry stone paving.

A permanent bridge being necessary, it was decided to adopt a suspension bridge, this being the only kind of structure it would be possible to erect with reasonable rapidity. As, however, this would be an extensive work involving some time and much labour for construction, it was deemed advisable to order up the Pontoon Train from Rurki, so as to secure this weak link in the Line of Communications, pending the completion of the suspension bridge.

After the pontoon bridge had been established on the 4th May, it was felt that the Swat river crossing was fairly secure and as a matter of fact, the floods this year having been less than usual, this bridge has been practically maintained throughout the last rainy season and is still in daily use.

Swat River Suspension Bridge.

The Swat river was carefully examined by the C. R. E., Line of Communications, for a length of about eleven miles (exploring to a greater distance not being permitted at the time), on the 12th April, with a view to finding the best site for a permanent bridge.

None of the sites were good, as they all entailed masonry piers, for which no rock foundations existed. It thus became necessary to build on boulders and sand, and as a suitable depth of foundations would have necessitated the use of steam pumps, besides delaying the construction for months, the only arrangement possible was shallow foundations, with crates and other protective works, to guard the piers against erosion. It was also necessary to provide a long bridge so as to give a large waterway and thus reduce as much as possible any tendency to scour. The site, which is a little below the village of Chakdarrah, was selected on the same day. Work was fully started on 22nd April ; the bridge was ready for foot traffic on 8th June, seven weeks after commencement, and was available for transport, six days later. Had it not been for the " Id " festival and for delays about transport for cement, timber, etc., work would have been completed some ten days earlier.

Owing to the shallow foundations, necessitated by the short time available for the construction of the bridge, it will be necessary to pump out and fill in deeper masonry foundations around those now existing. It is very desirable that this should be done during the ensuing cold season and, if suitable deep foundations are provided, the main suspension bridge of 500 feet would probably be sufficient to pass all the water. Training works of some extent would have to be built in this case to restrict the channel of the river.

The Pontoon and Suspension bridges are fully described in the attached reports.

Jandul River Bridge.

In addition to the bridges mentioned in the reports, a crib and trestle bridge, similar to that first thrown across the Swat river, but stronger and constructed of heavier timbers, was built over the Jandul river by the 6th Company, Bengal Sappers and Miners. This bridge had 21 spans with a total length of 252 feet. A heavy flood occurred on the 14th June, soon after the bridge was completed, and almost the entire structure was swept away, showing that bridges of this description are not to be relied on in hill rivers running at high velocities. Their obvious defect is that they obstruct far too much of the waterway.

III.—Water Supplies.

Jalala.

Wells, a filter bed, tanks and drinking troughs have been provided.

Dargai.

Wells, masonry drinking troughs and tanks, fitted with taps and pukkal pipes, were first built, but on sanitary grounds and because it was feared that the supply might not be sufficient during the hot season for the enormous number of transport animals constantly collected at this depôt at the foot of the Malakhand Pass, it was decided at the end of April to provide Dargai with a pipe water-supply. A pipe line, 3¼ miles long, was consequently laid and connected with a storage tank in the defensible post, and with stand-posts for the lines, and watering troughs for the animals in a central situation. The pipes are 3 inches diameter at the head, diminishing to 2 inches at Dargai, and the discharge is 1,750 gallons an hour.

In addition to the above, a well has been sunk in the Defensible Post, in order that its water-supply may be self-contained should the pipe line at any time be cut.

Malakhand.

A short pipe line has been installed in order to tap the water-supply above the lower camp, and troughs, taps and pukkal pipes in connection have been built.

A new pipe line with reservoir and distributing taps is now being constructed. This takes off from the highest point of the water-supply, and is designed so as to deliver water as little below the upper camp as the levels will permit.

Laram, Bircharai, Sado.

Water tanks and troughs have been provided at Laram and Bircharai; temporary supply pipes and taps have in addition been erected at Sado.

IV.—Other Works.

Defensible Post at Dargai.

A Defensible Post for a Wing of Infantry and Commissariat stores has been constructed at Dargai.

This post is 625 feet in length and 375 feet in breadth. It consists of a 6 feet parapet strengthened by a V-shaped ditch 12 feet wide at top; there are bastions at the diagonal corners for flank defence and the western face is indented to suit the ground.

A well has been sunk in the centre of the fort to render the garrison independent of outside or pipe water-supply. The greater part of the earth-work was done in two days by a Wing of the 34th Pioneers.

Defensible enclosure at Sarai.

A good defensible walled-in enclosure has been constructed at Sarai by Major R. W. MacLeod, 29th Punjab Infantry, with working parties from that regiment, which at the time supplied the garrison of the post. Considering that there were only two Companies in garrison and that many men were required for guards, convoys, etc., this is a very creditable piece of work.

Hutting.

Huts for 8 Officers and 19 Subordinates have been built at Jalala, and for 22 Officers and 32 Subordinates at Dargai.

Sun shelters for Europeans have been built at Malakhand, as well as for the hospitals and certain other buildings at Panjkora.

Shelters for horses have been provided as under :—

	Horses.
Jalala for	12
Sakot for	12
Dargai for	80
Foot of Malakhand for	8
Total shelters for	112

Incinerators.

Incinerators (Silchar pattern) have been built at the following places: Jalala, Dargai, Malakhand, Khar, Chakdarrah, Sarai, Laram and Dostai (Laram range).

Levy Posts.

Lieutenant P. G. Grant, R.E., has carefully examined ground in the vicinity of the posts at Sarai, Sado, Rabat, Warai and Darora, with a view to selecting sites for the defensible levy posts to be erected at those stages. Reports and sketches showing the sites selected in each case have been forwarded to the Political Officer.

V.—Points brought to notice.

Service Pontoons.

Regarding the Indian pontoons, which have been practically subjected to a severe test on this campaign, it is worthy of notice that expeditions undertaken by the Indian Army are usually in hilly countries, and for this reason it would be better, for purposes of transport, to introduce either some form of collapsible boat or sectional pontoons similar to those now adopted in England, instead of the heavy entire boats weighing about 1,000lb each. The bows of the pontoons, though probably strong enough for a five-mile current, are not sufficiently strong to properly resist a stream running at eight miles an hour, and, since it has now been proved that the pontoons can be kept afloat in the latter current, the bows should be strengthened by thicker copper, or better supports, or by a combination of both.

Mobilisation Tools.

The whole of the tools kept at Peshawar for mobilisation purposes (besides large quantities obtained from the Ordnance and Military Works Department) have been used on this campaign. The tools were new and of good quality, and the desirability of keeping up this reserve for forces in the field may be considered established. Such of the wheel-barrows as are in fair order, on the termination of the campaign, should be repaired, others being replaced; but entirely new sets should be substituted for the remaining tools. The old ones might perhaps be made over without value, or at a low rate, to the Military Works or Public Works Department.

W. T. SHONE, Major, R.E., & Lt.-Col.,

Commanding Royal Engineer, Line of Communications,

Laram, the 10th September 1895. *Chitral Relief Force.*

Itinerary of Road from Mardan to Dir, constructed under the orders of the Commanding Royal Engineer, Line of Communications, Chitral Relief Force.

Miles.	Furlongs.	Descriptive Points.	Class of Road.	Remarks.
0	0	MARDAN . . .		
7	6	West end of Takht-i-bhai .		
11	2	Bridge south of Jalala .		Trestle Bridge, 5 spans of 5 feet.
11	4	JALALA Camp . .		1st Stage.
12	0	Jalala Nullah . . .		200-foot Suspension Bridge for pack transport and foot traffic only.
12	2	Jalala Village . . .		
16	4	Shergarh Village . .		
21	0	Sakot Village . . .	Metalled cart road	
21	4	Bridge		Span 10 feet.
22	6	Sakot Bridge . . .		Framed wooden girders, 2 spans of 50 feet each.
24	0	Bridge		Span 8 feet.
25	0	DARGAI Camp . .		2nd Stage.
25	6	Bridge		Span 8 feet.
26	3	Foot of ascent to Malakand Pass.		
32	3	Crest of Malakand Pass .	Camel road on cart road gradients not exceeding 1 in 20. Now being widened into a cart road.	
34	5	Foot of first descent on north side of Malakand Pass.		
35	4	Crest of Kotal . . .		A low Kotal between Malakand and Khar.
36	0	Foot of Kotal . . .		
36	6	KHAR Camp . . .		3rd Stage. Village lies ½ mile to the north.
37	2	Butkhela Village . .		
37	4	Butkhela Nullah . .		Unbridged.
38	4	Amandarrah Kotal . .	Metalled cart road	
39	4	Alladand Bridge . .		Trestle bridge of 7 spans, length 112 feet.
40	2	Bridge		Trestle bridge of 2 spans, length 10 feet.
40	4	Do.		Trestle bridge of 4 spans, length 27 feet.
41	5	Swat River Suspension Bridge		Total length 948 feet.
42	3	Bridge over Uch Nullah .	Unmetalled cart road.	Trestle bridge of 11 spans, length 162 feet.
43	0	CHAKDARRAH Camp .		4th Stage. Village lies ½ a mile to the east.
46	5	Bridge opposite Uch Village		Length 17 feet. Village lies 1½ miles to the north.

Itinerary of Road from Mardan to Dir, constructed under the orders of the Commanding Royal Engineer, Line of Communications, Chitral Relief Force—*continued.*

Miles.	Furlongs.	Descriptive Points.	Class of Road.	Remarks.
47	0	Bridge	Unmetalled cart road.	15 feet.
49	0	Foot of Katgola Pass Bridge		
50	1	Bridge		15 feet.
51	1	Manjour Village . .		50 yards to north.
52	0	Crest of Katgola Pass .		
52	4	Bridge		1 span of 15 feet.
54	0	SARAI Camp . . .		5th Stage.
55	0	Road crosses Main Talash Nullah.		Unbridged.
56	7	Road re-crosses Main Talash Nullah.		Ditto.
58	1	Road to Sado *viâ* Kamerani leaves the road to Panjkora Bridge and the Jandul Valley.		
58	1½	Bridge	Graded camel road, could be widened into a cart road.	3 spans of 15 feet each.
58	2	Do.		2 spans of 15 feet and 1 span of 6 feet.
58	6	Do.		1 span of 15 feet and 1 span of 6 feet.
58	7½	Chunar trees below road .		Water.
59	0	Bridge		1 span of 15 feet.
59	1	Commencement of ascent, grade 1 in 20.		
59	4	Bridge		1 span of 12 feet.
59	6	Do.		1 span of 8 feet.
61	4	Crest of Kamerani Pass .		Descent commences at gradient of 1 in 15.
62	6	Bridge		1 span of 15 feet. End of 1 in 15 gradient. The remainder of the descent is on easy gradients.
62	7	Do.		2 spans of 15 feet.
63	4	Do.		2 spans of 15 feet. Bottom of the descent.
65	2	SADO Camp . . .		6th Stage. The Camp is at the village of Khongai.
65	3	Bridge over Khongai Nullah		Trestle bridge, 2 spans of 11 feet each.
67	2	Landai Nullah, Fort and Village.		
68	6	Bridge		1 span of 8 feet.

Itinerary of Road from Mardan to Dir, constructed under the orders of the Commanding Royal Engineer, Line of Communications, Chitral Relief Force—*continued.*

Miles.	Furlongs.	Descriptive Points.	Class of Road.	Remarks.
		Myabyda Village		On the west of the road.
68	7	Kalaban Village		On the east of the road.
		Bridge		1 span of 12 feet.
69	1½	Do.		1 span of 12 feet.
69	7	Do.		Trestle bridge, 2 spans of 12 and 1 of 15 feet.
71	4	Corner of spur opposite Shazadgai.		
72	2	Bridge		Trestle bridge, 2 spans of 12 feet.
73	7	Rani Nullah		Unbridged.
74	0	Rani Fort on north and Village on south.		
74	5	Bridge		1 span of 12 feet.
75	4	Do.		1 span of 12 feet.
75	7	Rabat Nullah		Unbridged.
76	0	Rabat Fort		
76	6	Bridge	Graded camel road, could be widened into a cart road.	1 span of 12 feet.
77	1	Do.		Do.
77	4	RABAT Camp		7th stage. Bridge, 1 span of 8 feet.
77	7	Bridge		Trestle bridge, 2 spans of 12 feet.
78	5	Do.		1 span of 12 feet.
79	4	Do.		Do.
80	0	Do.		1 span of 16 feet.
80	4	Graveyard and Ziarat		
80	5	Bridge		1 span of 12 feet.
81	3	Toormung Nullah		Unbridged.
82	1	Bridge		Wood lattice girder, 1 span of 23 feet.
83	5	Kharo Nullah		Unbridged.
84	5	Bridge		Cantilever, 1 span of 20 feet.
85	1	Do.		Do. Do.
86	0	Nullah		Unbridged.
86	7	Manki Camping Ground		
88	6	WARAI Camp	Camel road.	8th Stage.
89	7	Niag River and Bridge		Cantilever, 1 span of 57 feet.

Itinerary of Road from Mardan to Dir, constructed under the orders of the Commanding Royal Engineer, Line of Communications, Chitral Relief Force—*concluded.*

Miles.	Furlongs.	Descriptive Points.	Class of Road.	Remarks.
91	1	Bridge		1 span of 6 feet.
91	6	Nullah		Unbridged.
95	2	Jughabanj Village . .		
95	3	Graveyard . . .		
95	5	Jughabanj Camping Ground		
97	3	Bridge		1 span of 6 feet.
97	6	Do.		Do.
98	6	Do.		1 span of 4 feet.
99	3	Darora Village . . .		
99	4	Bridge over Ushiri River .		Old cantilever bridge strengthened by trestles and suspension cables.
101	0	Bridge		1 span of 6 feet.
101	1	DARORA Camp . .	Camel road.	9th Stage.
103	2	Seri Village . . .		
104	0	Bibior Village and Fort .		
104	4	Bridge		1 span of 6 feet.
105	0	Do.		Do.
106	0	Do.		Do.
107	0	Do.		Do.
108	3½	Chutyatan Suspension Bridge		Over the Panjkora River, 1 span 78 feet.
108	6	Chutyatan Camping Ground .		Fort just below Camping Ground.
112	3	Large Nullah . . .		Unbridged.
113	4	Dir Fort		
114	0	DIR Camp . . .		10th Stage.
114	2½	Bridge beyond Camp . .		Cantilever bridge over Dir stream.

Note.—From Cantilever Bridge (miles 114-2½) to CHITRAL the distance is 68 miles.

LARAM;
The 9th September 1895.

W. T. SHONE, *Major, R.E., and Lt.-Col.,*
Comdg. Royal Engr., Line of Communications,
Chitral Relief Force.

List of Bridges carried out under the orders of the Commanding Royal Engineer, Line of Communications.

1.—Suspension Bridge for pack transport and foot passengers over the Kalapani at Jalala, constructed by Captain H. C. Nanton, R.E., with civil labour.

2.—Bridge over the Sakot Nullah, on the Mardan-Dargai road, designed and constructed by Captain H. C. Nanton, R.E., with civil labour.

3.—Pontoon Bridge over the Swat River, carried out by Captain G. M. Heath, R.E., and the Pontoon Section of "A" Company, Bengal Sappers and Miners.

4.—Swat River Suspension Bridge, built by Captain G. Williams, R.E., with No. 6 Company, "Queen's Own" Madras Sappers and Miners. (Lieutenant C. Ainslie, R.E., Commanding), assisted by some 200 civil artificers and by detachments of the Bengal Sappers Pontoon Section, when available.

5.—Bridge over the Ushiri River at Darora, stengthened and improved by Captain J. R. B. Serjeant, R.E., with No. 1 Company, Bengal Sappers and Miners.

6.—Suspension Bridge over the Panjkora River at Chutyatan, built by Captain J. R. B. Serjeant, R.E., with No. 1 Company, Bengal Sappers and Miners.

Photographs of the above bridges except 1 are attached; also of the following minor bridges :—

(*a*) Alladand Nullah Bridge—Captains G. Williams and G. M. Heath, R.E.
(*b*) Uch River Bridge—Captains G. Williams and G. M. Heath, R.E.
(*c*) Khongai Bridge—Lieutenant H. F. Thuillier, R.E.
(*d*) Niag River Cantilever Bridge, 57 feet span—Lieutenant F. R. F. Boileau, R.E., with working parties of the 34th Punjab Pioneers.
(*e*) Cantilever Bridge at Dir, constructed by the 25th Punjab Infantry, under Colonel E. W. Smyth, Commanding that regiment.

A number of smaller bridges have also been built, among which may be mentioned a wooden lattice girder bridge of 23 feet span and two cantilever bridges of 20 feet span, all built by Lieutenant H. F. Thuillier, R.E.

The reports and photographs fully explain the work that has been done.

Report on Suspension Bridge over the Kalapani River at Jalala.

The new metalled Mardan-Dargai road crosses the Kalapani river, north of Jalala, at mile 12. The river here flows between sandstone cliffs, about 250 feet apart and 50 feet high.

The metalled road crosses the nullah by long graded approaches, but there is no bridge, because, when the road was constructed, the rains were approaching and foundation works would have been liable to damage by floods.

The Kalapani is usually a petty stream, not more than one foot deep, and is easily crossed, but rain in the adjoining hills or surrounding country causes a considerable rise of water, and three-and-a-half feet depth renders the nullah impassable on account of the rapidity of flow. Recently, three times during one week, the river rose so as to stop all traffic, each time for half a day; and the river has been known to rise 25 feet and to remain impassable for two days. It was undesirable that the risk of communication being completely stopped should be incurred, and it was evident that sudden rain, with a consequent rise of water, might delay troops returning from the front in the wet on the banks of the Kalapani for some hours.

The Field Engineer, Dargai, represented these facts, and reported that there was sufficient timber on stock at Jalala, and steel cable and telegraph wire at Dargai, to construct a light suspension bridge which could be erected in a comparatively short time.

The proposal was approved, and the Commanding Royal Engineer, Line of Communications, directed the bridge to be built.

Some delay was caused by the telegraph wire on stock at Dargai being suddenly required for the construction of the Chitral Bridge; work was, however, commenced on the 22nd August, and the bridge was open for traffic on the evening of the 7th September.

A site, north of Jalala Camp, was chosen, and considerable excavation was necessary to obtain level platforms on which to erect the towers.

The clear span of the bridge is 200 feet, the width of roadway being 6 feet. The towers are 24 feet high and the dip of the cables 20 feet, while the roadway is 45 feet above the river bed.

The towers are constructed of deodar timbers, 8 inches square, and take the form of four-legged trestles which had to be built in two tiers, since no wood longer than 13 feet was obtainable.

The anchors are trunks of large trees, buried 8 feet deep in the sandstone. Each suspension cable consists of two flexible steel wire ropes, $3\frac{1}{4}$ inches circumference.

The roadway has three $6'' \times 4''$ road-bearers covered by $1\frac{1}{8}$ inch planking, and resting on $6'' \times 4''$ transoms, 6 feet apart from centre to centre. The transoms are hung from the cables by tension rods made of telegraph wire, 300lbs. to the mile, with three wires in each tension rod. The rods are fastened to the cables by stopper hitches formed of the tension rod wires.

Four side-stays are provided at each end of the bridge to check the swaying.

The bridge is constructed to carry infantry in single file, or four horses at one time.

H. C. NANTON, *Captain, R. E.*,
Field Engineer.

JALALA;
The 7th September 1895.

Report on bridge near Sakot on the Mardan-Dargai Road.

Between the 22nd and 23rd miles from Mardan the cart road crosses a tributary of the Kalapani River. This tributary, which is in ordinary occasions dry, runs in floods, say, from 3 to 10 feet, after every heavy fall of rain in the Swat Hills. To prevent seriously stopping the traffic and continual repairs to any temporary road which might be constructed across the bed of the stream the Commanding Royal Engineer, Line of Communications, decided to erect a bridge.

A wooden trussed bridge consisting of two spans of 50 feet clear, each resting on each bank on masonry abutments and in the centre on a stout braced double trestle, itself standing on a masonry foundation, was designed by Captain Nanton, R.E., and approved.

A wooden trussed bridge was chosen, as wood could be quickly obtained, and, if not required, in long pieces could be carted over the then kutcha road from Mardan. Much delay would have been caused had an iron bridge been decided on, both in carting the heavy pieces and in erecting at site.

Each wooden truss of the bridge consists of an upper compression boom, a lower tension boom, braces, counter-braces and vertical tie-rods.

The truss is 9 feet high, and is divided into nine panels.

The upper boom consists of three longitudinal strips measuring 7″ × 6″ each, and the lower boom of three longitudinal strips measuring each 10″ × 6″.

These strips in each boom are placed horizontally beside each other, and kept 1½ inches apart by means of filling pieces.

The braces are in pairs butting against the outer strips of the upper and lower booms. The counter-braces are single, and pass between the braces.

The braces and counter-braces butt against hard wood blocks, triangular in sections, which rest against the top of the lower and the bottom of the upper booms. The joints at the heads and feet of the braces and counter-braces are butt joints.

The vertical tie-rods are in pairs, and pass through the 1½″ intervals left between the strips of the booms. The pairs of tie-rods pass through the hard wood blocks at the heads and feet of the braces and counter-braces. The head and nut of each tie-rod catches on heavy washers at the top and bottom of the upper and lower boom, respectively.

By tightening up the tie-rods the upper and lower booms are brought to bear on the heads and feet of the braces and counter-braces, and the whole truss is set up.

The braces and counter-braces measure 5″ × 6″, and the tie-rods are 1½ inches in diameter.

Two trusses per span are used, and the roadway is carried on the lower boom.

The roadway consists of buckle-plates, obtained from Rawal Pindi Defences, resting on 7″ × 10″ road-bearers, which themselves rest on the lower booms of the trusses.

The roadway is 12′ wide. The bridge will carry any traffic, including crowded men. The road-bearers are not designed to carry elephants.

The foundations of the masonry are on clay, 10 feet below the bed of the stream.

Any piece of wood in the bridge can be renewed from time to time when required. The time occupied in construction from the laying of the first basket of concrete in the foundations to the opening of the bridge for traffic was two months.

The work was delayed slightly by the Utman Khel tribe killing some of the workmen at the bridge site.

A photograph of the bridge is attached.

H. C. NANTON, *Captain, R.E.,*
Field Engineer.

DARGAI ;
The 24th July 1895.

Report on work done by the Pontoon Section, Bengal Sappers and Miners, during the Chitral Relief Expedition, 1895.

Mobilisation. April 11th.

Orders for the mobilisation of the Pontoon Section of A Company, Bengal Sappers and Miners, were received at Roorkee, on the morning of April 11th. The pontoons were then in Bridge at Hardwar on the Ganges.

Establishment.

The Section detailed for the expedition consisted of: one Captain, one Subaltern (Lieutenant G. Boileau, R.E.), three British Non-Commissioned Officers, two Native Officers, 61 rank and file—with 26 pontoons and equipment carried on 38 wagons and 4 carts.

The above were despatched in two trains, which left Roorkee on the evenings of the 13th and 14th of April, and arrived at Nowshera on the mornings of the 16th and 17th.

Transport by rail. April 13th to 17th.

The trucks supplied by the Oudh and Rohilkhand Railway were *end loading*, which much facilitated the entraining operations. The trains were marshalled in a continuous line of trucks in front of an end loading ramp, built by the Royal Artillery of gun skids and platform planks, and the pontoons loaded on their wagons were run intact from the ramp to their relative positions in the train. It was supposed that owing to the length of a pontoon it would be necessary to interpose a store wagon or an empty truck between every two pontoons, but this was not found to be the case; the trucks supplied gave about one foot of air space between the ends of two adjacent pontoons, which space was considered to be sufficient by the Traffic Inspector and proved a safe allowance.

April 17th to 22nd. Malakand Pass.

The road over the Malakand Pass was reconnoitred by the Officer Commanding the Section on April 17th, and it was considered that with a little labour at certain bad places, it was passable for the pontoons, but with difficulty. A report to this effect was made to the Commanding Royal Engineer, Line of Communications, and on April 21st orders were issued for two pontoons and stores to be got over if possible. The whole of the pontoons had, however, been stopped at Nowshera by order; it was not therefore until the 22nd that the experiment could be made. On that day one pontoon and wagon were manhauled half way up the Pass.

April 25th.

By the evening of the 25th, with the help of working parties from the 29th and 30th Punjab Infantry, six pontoons and their equipment had been got to the top of the Pass. The work was difficult, as in many places owing to the narrowness of the road (track of wagons 5′ 10″) and the weakness of the outer retaining walls, the pontoons had to be shouldered and the wagons got over afterwards, while, in order to get round the bends in the road, the wagons had frequently to be bodily lifted, and the time available for work was restricted to from one to three hours daily, as the road was required for convoys.

April 26th.

On the 26th, with the help of a working party of 100 men from the East Lancashire Regiment, four pontoons were taken down the ziz-zag to the northern foot of the Pass. The road was extremely bad, the pontoons had to be shouldered and carried the whole way down, while the wagons had to be sent down in two pieces.

April 27th. Arrival at Swat River Flying Bridge.

Four pontoons, with equipment, reached the Swat River at Chakdarrah on the evening of the 27th, and on the morning of the 28th a flying bridge, working by a traveller on a steel wire cable, was established near the site of the suspension bridge.

Strength of current.

The current at this place averaged 9 miles an hour in the swiftest part of the stream, and with a little care, such as keeping all loads towards the stern of the pontoons, the flying bridge worked well and safely and was in continual use, working daily from 6 A.M to 5 P.M. until June 8th (42 days), when it was no longer required, as communication had been established across the suspension bridge. Two accidents occurred, one from the breaking of a rope, and the other from mismanagement, but the raft was only temporarily stopped.

April 28th. On the evening of the 28th orders were issued for the whole of the pontoons to be brought to the Swat River. Lieutenant Boileau went back to Malakand for this purpose, and by the 3rd of May, sufficient pontoons had arrived to form a bridge over the larger stream. On that day a bridge was formed of 13 pontoons, about 50 yards below the site of the suspension bridge.

First Bridge. May 4th to 7th. On the 4th, more pontoons having arrived, the small stream was bridged with five pontoons, and on the 5th Lieutenant Boileau arrived with the remainder of the Section.

Second Bridge. On the 6th the current increased, and it was considered advisable to shift the bridge lower down stream. A cable was stretched and an attempt made on the 7th to bridge where the current was slightly slacker, but while constructing the bridge, two pontoons were swamped in the rough water, and the attempt was given up; the pontoons were recovered, but were badly damaged.

May 13th. Present Bridge. A fresh site was selected about half a mile below the suspension bridge and was bridged by the evening of the 13th.

Strength of current. This bridge consists of 22 pontoons (345 feet) and 150 feet of trestle and crib work, joining up two islands to the main banks (*vide* sketch): the current here, when snow water was coming down, ran to eight miles an hour, but has probably run ten miles an hour in times of flood; these, however, usually last only from three to five hours at a time.

Behaviour of Bridge. This bridge, on the whole, has stood well, and, from the day it was established until the date of this report, has taken daily convoys running to 3,000 animals in one convoy, with one exception, June 26th, when a heavy flood swamped two pontoons and cut off the approaches. On two other occasions pontoons were swamped, once by flood and once by crowded camels, but the damage was only temporary.

Suitability of Pontoons. The pontoons, however, are ill adapted to stand the strain of strong currents, the copper of the bows, from the continued bulging in and out, occasioned by the varying pressure of the water, eventually cracks and the pontoons in the swiftest part of the current

Defects. have one or other been almost continually under repair, so much so, that, had there been no spare (one was spare), the pontoon bridge would have had to be constantly closed while

Cracks in copper of bows. a pontoon was being taken out, mended and replaced, an operation of some hours. Pontoons taken out of bridge have been found with six, seven or eight cracks, varying from one to

Ribbing. three inches long. It was found best to double plate the whole of the bows, if possible, but even this is not effective, as in several instances cracks have appeared through both plates. The only remedy appears to be a better system of ribbing, or a better form of bow (the instructional pontoons with raised bows have suffered very little, but they are not in the strongest part of the current).

Defective balance of pontoons. The balance of the pontoons appears bad; in strong currents they are so "down by the bows" that in addition to a heavy weighting of stones on the stern, most uneconomical of floatation, it has been found necessary for the sake of safety to lash the up stream ribands to the second baulk from the outside so as to keep the loads towards the stern of the bridge—this, of course, has the disadvantage of reducing the roadway. The square stern of the pontoons is believed to be partly responsible for this defect.

Camel net breakwaters. Camel nets loaded with stones and slung from a wire rope so as to hang three feet in front of each pontoon, were found to be of good effect as breakwaters and as protection from logs. On one occasion a cask bridge, some yards in length, was swept on to the pontoons and it was probably greatly owing to these nets that the bridge was saved from severe damage. These nets were, however, rapidly washed to pieces in a flood, and have since been replaced by nettings of wire.

The experience gained, first on the march up-country and, secondly, with the pontoons in bridge, suggests the following remarks :—

Remarks.

(1) That some sort of portable pontoon should be adopted, either the pattern existing at home, or a form of collapsible boat—(the German Army is, I believe, equipped with a large size of Berthon boat to carry loads up to siege guns).

Portable pontoons.

(2) If the copper pontoon is adhered to, its shape should be adapted to fast currents and the bows should be considerably strengthened.

Bows of pontoons.

(3) The combings of pontoons should be heightened.

Combings.

(4) In rapid water the pontoon drill for forming up is in one respect unsuitable—on the word "baulks" only the two outer baulks should at first be placed and the others got out gradually; this prevents crowding on the last pontoon.

Drill.

(5) The remainder of the equipment can hardly be improved—the wagons especially have stood the rough work admirably.

Equipment.

Besides the work noted above, the Pontoon Section have built three trestle bridges, 70′, 130′ and 160′, respectively, in length, and have assisted when required at work on the suspension bridge.

Photographs of the pontoon bridge and of two trestle bridges are attached.

G. M. HEATH, *Captain, R.E.,*
Comdg. A. Coy., Bengal Sappers and Miners.

CHAKDARRAH,
The 15th July 1895.

Report on Suspension Bridge over Swat River.

General description of river and necessity for bridge.—The Swat River between the villages of Thana and Khar flows in a broad flat valley some 1½ to 2½ miles wide, and is divided in some parts into as many as five separate branches or beds, while in others it is confined to one or two. Very little was known regarding the course and nature of the river above the point where it enters British territory at Abazai before the Chitral Relief Expedition started. Observations at the head works of the Swat River Canal showed that, as soon as the hot weather set in, snow water came down in considerable quantities, while later on, in July and August, floods rising to 9 feet at Abazai occurred after heavy rain. It was also known that a large quantity of timber (deodar) was floated down the river, and this was believed to come chiefly from the Upper Swat Valley. As a matter of fact, however, it seems probable that the greater part of the timber and a considerable portion of the snow and flood water comes down the Panjkora River, which joins the Swat River above Abazai, but below the point where it was crossed by the Chitral Relief Force.

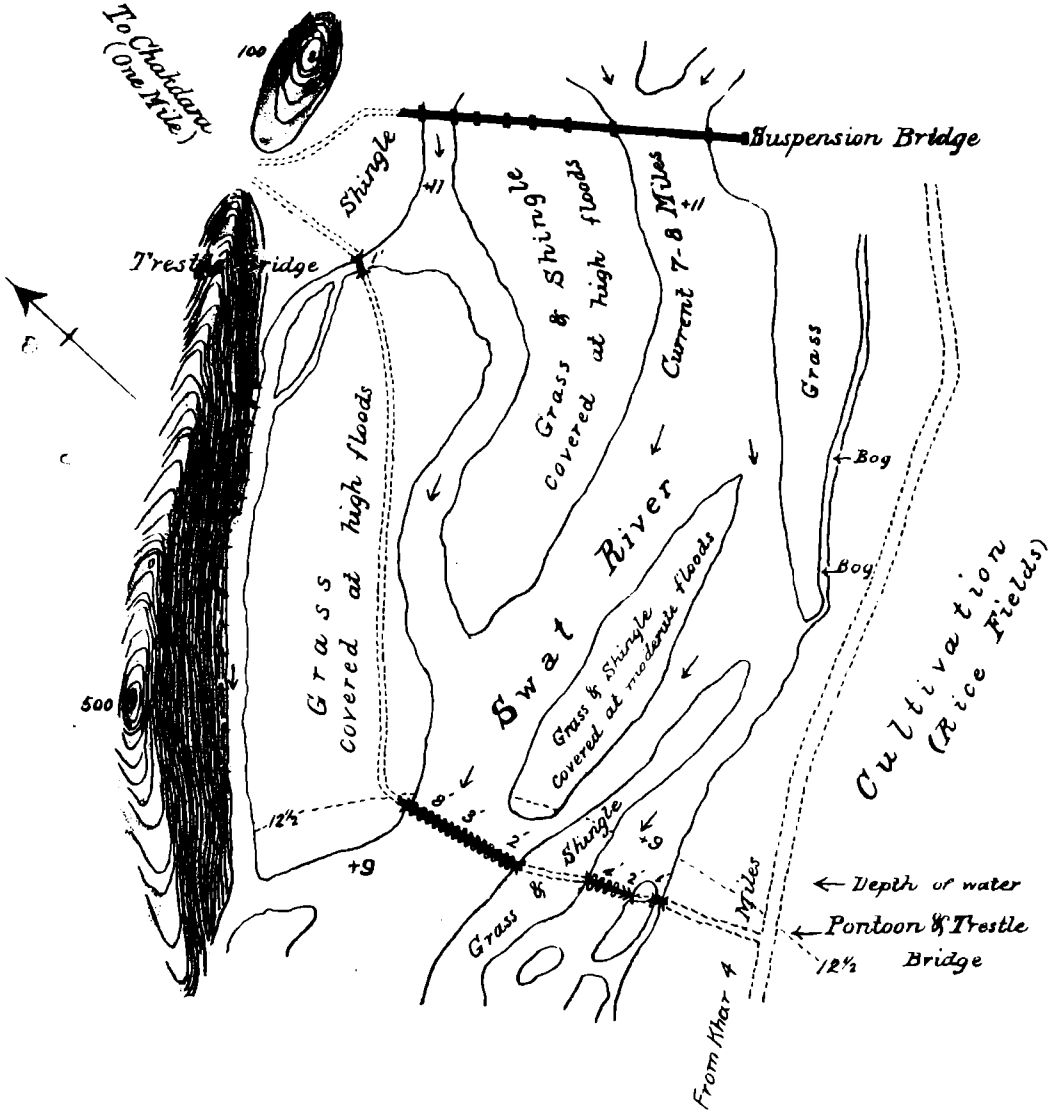
After forcing the Malakand and advancing up the valley to Alladand and Thana, the Relief Force forded the river above the village of Chakdarrah, and the 1st and 6th Companies of Bengal Sappers and Miners, assisted by Attock boatmen, at once proceeded to construct a trestle and crib bridge opposite Chakdarrah itself. At this point the river flows in five separate beds, with islands between, and the current is normally about seven miles an hour.

The trestle bridge, a very substantial piece of work, was completed on April 17th, but it was felt that it would not be safe to rely on this one bridge as the sole means of communication across the river, especially as it was not known how soon it would be before the river rose to such a height as to imperil the bridge, or it became damaged by the logs which it was thought would soon be floating down in large numbers. It was accordingly decided to construct a permanent bridge raised to a safe height above flood level as quickly as possible.

Style of bridge necessary.—As substantial piers could not be erected in the running water in the time available, the only alternative for bridging the wide branches of the river was to have one or more suspension bridges. After careful search a site was selected for the new bridge about half a mile below the trestle bridge. At this point the five branches crossed by the trestle bridge are united into two main branches, that on the left side being considerably the wider. Measurements were made of the widths of the waterway, and it was found that at that time—the middle of April—the left branch could be spanned by 250 and the right by about 100 or 110 feet. It was, however, obvious that a very small rise in the water level would very considerably increase the width of waterway, and that the island between the two branches, which was some 350 feet across, was completely submerged in flood time, and would have to be crossed at a high level with arrangements for a considerable waterway underneath.

These considerations led to the adoption for the bridge of two suspension spans, one of 250 feet for the left, and the other of 100 or 110 feet for the right, branch. In order partially to cross the island and to provide for the increase in the width of the waterway in flood time it was decided to form back half spans for each of the suspension bridges; by this means the effective length of each suspension bridge was doubled, and the width to be crossed on the island about halved. The remaining intermediate space of 160 or 170 feet could easily be bridged with trussed beams resting on trestles, with one or two stone piers to give stability.

Materials for piers.—For the 250-feet span it was obvious that there would be a difficulty in obtaining, locally, suitable timber for the piers. With a dip of $\frac{1}{12}$ and a camber of 3 or 4 feet, a height of 24 or 25 feet is required for the piers. It was known by this time that no deodar could be obtained from the river, and the only wood available in any quantity consisted of chir bullies up to 8 inches which had to be carried several miles from the Laram Pass. There are a few mulberry and shishum trees near the villages, but all the fine specimens grow in graveyards, from which the Political Officers would not allow them to be taken, and the few logs required for anchorages, etc., were only



Scale 12 Inches = 1 Mile.

Yards 100 50 0 100 200 300 +00 Yards

Contours 12½ Feet V. I.

(Sd.) G. M. HEATH, *Capt., R. E.,*
Chaukdarrah,
15th July 1895.

I. B., Topo Dy. No. 1,349.
Exd. C. J. A., August 1895.

No. 882-

obtained with the greatest difficulty. It was therefore decided that the uprights of the 250-feet span should be of angle-irons suitably braced together.

Length of iron piers.—It was at first intended that the ironwork should be 40 feet high, of which 14 feet was to be built into the masonry and 26 feet to rise above the roadway. Each pier was to consist of two pillars joined at the top by cross-bracing. Each pillar was made up of four angle-irons $3\frac{1}{2}'' \times 3\frac{1}{2}'' \times \frac{1}{2}''$ forming a square with an 8-foot side at the bottom, where they were connected by horizontal angle-pieces. These angle-pieces sloped inwards at a slope of 1 in 12 making the dimensions 1′ 4″ square at the top, and the width between the two pillars at the roadway level, *i.e.*, 14 feet from the bottom, was fixed at 7 feet. It was also decided that the cables should consist of 3-inch flexible steel wire ropes, and it was roughly worked out that six of these would be required for each cable in the large span, and two each in the small span. The cables were to be laid flat, *i.e.*, side by side, with clips at every 10 feet, the clips being provided with rings in the centre to which the $\frac{1}{4}$-inch round iron suspending rods could be hooked.

These preliminaries having been settled by the Commanding Royal Engineer, Line of Communications, Lieutenant Rees, R.E., was on April 15th despatched to Rawal Pindi to arrange for the preparation of the ironwork, and meanwhile Lieutenants Duff and Walpole, R.E., who were temporarily in charge of the work, commenced the collection and dressing of stone for the piers.

On April 18th, Captain G. Williams, R.E., who had been put in charge of the construction of the bridge, arrived at Chakdarrah and took over from Lieutenant Duff, R.E., who at once left for Panjkora, Lieutenant Walpole remaining with Captain Williams.

Length of spans.—On laying out and measuring accurately the length of the bridge, it was considered advisable to make the smaller or right suspension span 110 feet so as to keep the piers well out of the permanent stream, as the banks were sandy and liable to scour.

Loads to be carried.—The orders for the bridge were to the effect that it was to be capable of carrying,—

(1) Infantry in single rank, crowded.
(2) Camels and other pack transport.
(3) Fields guns.

Of these loads the maximum stress is brought on the cables by the loaded camels, for the infantry load amounts to 140lbs. (live) per foot run, while the camels give 15 cwt.=1,680lbs. over a length of 10 feet (Instruction in Military Engineering, Part III, page 6) or 168lbs. per foot.

Taking the probable weight of the bridge at 130* feet per foot run, the total dead loads work out to—

For large span—

$$250 \times (130 + \tfrac{168 \times 3}{2})$$
$$= 250 \times 382 = 42{\cdot}6 \text{ tons.}$$

For small span—

$$110 \times 382 = 18{\cdot}8 \text{ tons,}$$

and, taking the dip at $\frac{1}{12}$ in each case, the maximum tension in the cables is†—

For 250′ span—

$$42{\cdot}6 \times 1{\cdot}58 = 67{\cdot}3 \text{ tons.}$$

For 110′ span—

$$18{\cdot}8 \times 1{\cdot}58 = 29{\cdot}7 \text{ tons.}$$

With 6 and 2 wire ropes in each cable, respectively, this gives a strain of—

5·6 tons per 3-inch rope in the large span, and
7·4 tons per 3-inch rope in the small span.

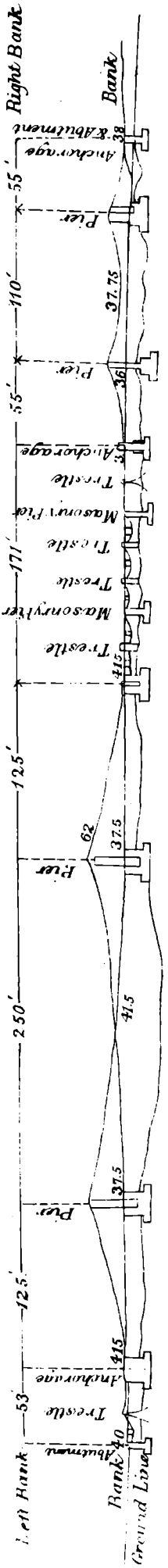
Taking the breaking weight of a 3-inch flexible wire cable at 18 tons‡ this gives factors of safety of 3·2 and 2·4, respectively.

---

* Instruction in Military Engineering, Vol. I, Part III, paragraph 176, gives 45lbs. for a 100-foot span and 90lbs. for 200-foot span. This is very misleading, as each bridge is designed to take the same load (infantry two deep) and the weight of roadway per foot would be nearly the same in the two cases.

† Instruction in Military Engineering, Part III, paragraph 175.

‡ Instruction in Military Engineering, Part III, paragraph 22, gives 24·5 tons, but this is believed to be too high.



Elevation of Bridge

The extra strength in the large span was found of considerable value in preventing unsteadiness in the bridge. The calculations for the suspending bars and for the transoms and road-bearers are not given, as they are perfectly simple. The bars are of $\frac{1}{2}$-inch round iron, the transoms are of deodar 6″ × 8″ or of chir 7″ diameter, and the road-bearers, six in number, are of chir and about 6″ diameter. The transoms are 10 feet apart and 8 feet long between the suspending bars.

Level of floor of bridge.—It was proposed to put the road level of the bridge about 5 or 6 feet above the highest flood level of the water in the river. At the time the bridge was commenced, the water level in the river was not more than some 3 or 4 feet below the flood level, for, owing to its being able to spread out, the river does not rise very much in time of flood. As already explained, the idea was to embed in masonry the lower 14 feet of the 40-foot long iron piers. But, as the road level, as shown, would only be some 8 or 9 feet above the water level in the river when work commenced, it was obvious that the lower end of the ironwork would have to be 5 or 6 feet below water level. This might no doubt have been very desirable, had steam pumps been available for emptying the excavation; but, as nothing better than grass baskets was obtainable for clearing the foundations of water, and the latter percolated through the gravelly river bed very rapidly, it at once became clear that the excavations could not be taken very deep, and that the embedded portion of the ironwork would have to be reduced in length.

Reasons for reducing length of iron piers.—The Executive Engineer, Rawal Pindi Division, Military Works, was accordingly asked to reduce the piers from 40 to 34 feet in height, it being the intention to embed 9 feet of the 34, leaving 25 projected, instead of embedding 14 feet out of 40.

Elevation of bridge.—In the margin is given a longitudinal elevation of the bridge showing the various spans as well as the reduced levels finally adopted for the roadway and the tops of the piers.

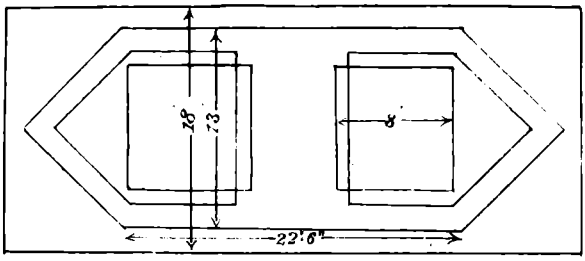
It will be noticed that in the 110-foot bridge there is a camber of 1 foot 9 inches, or 1 in 31, and in the 250-foot bridge, one of 4 feet, also 1 in 31, and that the back half-spans have a similar rise from the piers. It was thought advisable that the half-spans and the full spans should be symmetrical, so that the strain on the piers with equal loads should be vertical. As the form of anchorage adopted has a beam right across, the roadway had to rise, and passes over the beam, the top of which is protected with iron.

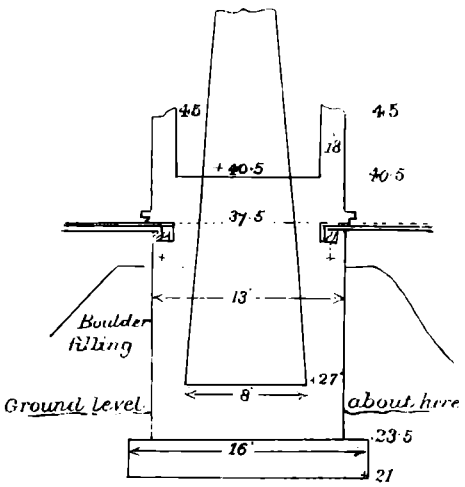
The water level is not shown on the section; it varies considerably in the two channels and even in different parts of the same channel. In the channel near the left bank, that is, in the main channel, the water level is some two feet lower than in the smaller channel near the right bank.

The level of highest flood is extremely difficult to fix, as the testimony of the inhabitants is most conflicting and untrustworthy. As far as can be judged from the indications, the highest flood level is about R.L. 31·5 on the right bank and about R.L. 29·5 on the left bank. This gives a clear height of about 6 feet* at the centre of the small span, and of 12 feet at the centre of the large span. The greater height above floods over the main stream is necessary as it is in the main stream that floating trees, with projecting branches, will come down in flood time.

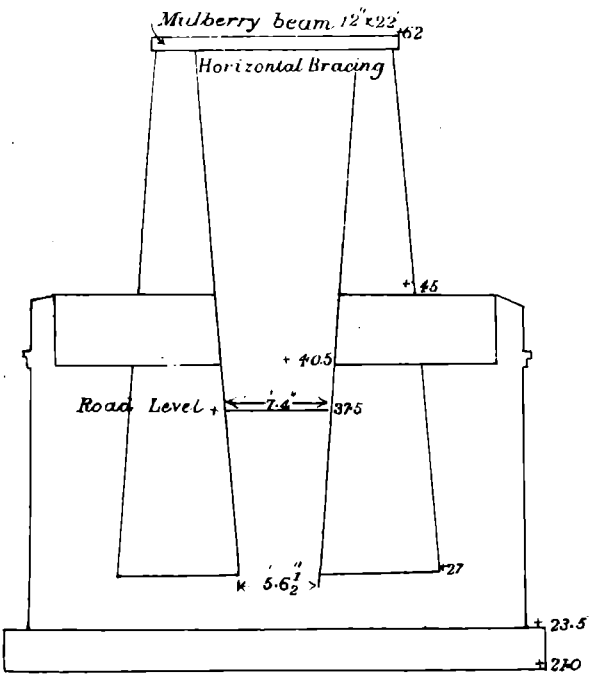
Details of 250-feet span.—It will now be convenient to describe the different portions of the bridge in detail, beginning with the suspension bridge of 250-feet central span.

* As a matter of fact the small span for various reasons sank a good deal more than the large span, and finally had a camber of about 9 inches only, making the level of roadway at the centre about R.L. 36·75.





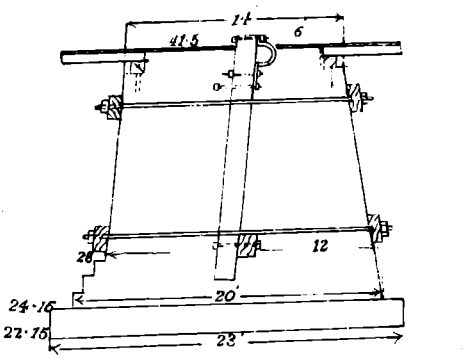
Scale 10 to 1 inch.

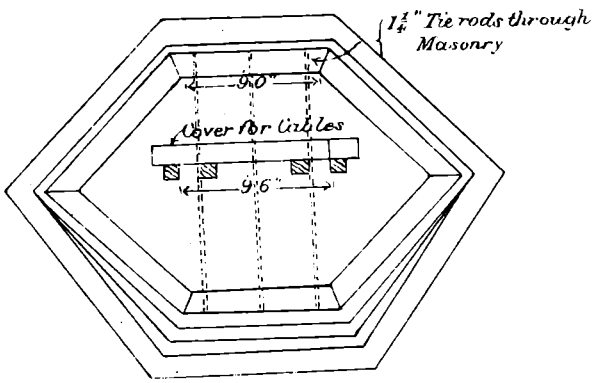


In a bridge with back half-spans, in which the weight of roadway, etc., is considerably less than that of the occasional load, it was obviously necessary to fasten the cables on the tops of the pier, as otherwise they would slip over when one part of the bridge was loaded and the other parts were empty. At such a time there is a considerable overturning moment acting on the pier, and it was necessary to make the iron pillars themselves, and the masonry base strong enough to resist this.

In the margin is given a plan and section of the piers of the 250-foot span.

It will be seen that the ends of the piers were built up 2 feet 6 inches above the roadway level, in order to give greater stability, and an 18-inches parapet was built round them for defensive purposes.



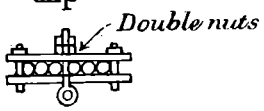


In the margin are given a plan and section of the 250-foot span anchorages. The anchor beams consisted of mulberry logs, about 15-inches diameter, strongly bolted and strapped to a framework of mulberry or shishum wood 16 feet high and of timbers about 10 inches square, the whole being built into the masonry, and the roadway passing over the top of the anchor beam which was faced with iron.

To strengthen the anchor piers in the case of the 250-foot span six 1¼-inch round iron tie-rods, bolted to mulberry timbers at each end, were built into the masonry, as shown in the drawings.

Suspending arrangements.—As already stated, each cable of the 250-foot span consisted of six 3-inch steel wire ropes. They were laid flat, side by side, and were clipped at 10-foot intervals by clips consisting of two ½-inch iron plates bolted together. These clips also formed the point of attachment for the ½-inch round iron suspension rods, a bolt with an eye passing through the centre of the clip having three wire ropes on each side,—*vide* margin. The holes in the ½-inch plates, through which the central suspending eyebolt passed, were slotted so as to give the suspending bar play in case it did not hang vertically.

Sketch of suspending clip



These clips were found to answer very well, and did not slip when tightened up even on the more sloping parts of the cables near the piers.

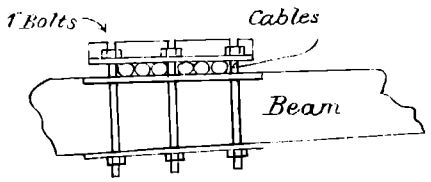
Suspension rods.—As stated, the suspension rods were of ½-inch round iron; and, as everything had to be brought up on camels, the longer rods were made with welded eye-joints, so that they could be folded together.

Each suspension rod was screwed for two feet at the lower end, and had a couple of nuts. The end of the rod passed through a hole in the transom; a strong washer was then put on and the nuts screwed up to the required point. This is by no means a convenient arrangement, as it is a troublesome matter to raise or lower a transom as frequently as has to be done. It was found that the

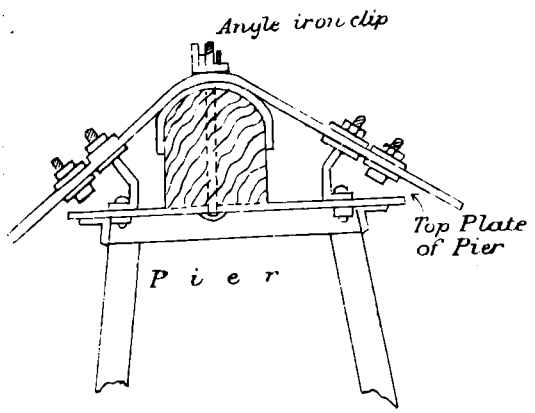
nuts could not be screwed up so as to lift the transom without first taking off the weight with ropes or wire slings. A better arrangement would be to have the suspension rods, in two parts, screwed with male and female screws, and connected by a coupling placed at a convenient height. With this arrangement the transom can be raised or lowered without taking the weight off the suspension rod.

The upper ends of the rods were provided with a hook to engage with the eyebolt of the clip. The idea was that it would be convenient to hook the suspension rod in when constructing the roadway. As a matter of fact, the men at work on the cables found it very difficult to manipulate the long rods so as to get the hooks in, and found it easier to take out the eyebolt, hook it on to the rod, and then pass it through the clips and nut it up. The hooks were all strongly moused with wire, but proved a source of weakness when a number of camels fell down on the bridge, and subsequently the rods were attached to the eyebolts with welded eyes.

Cross-bracing (vertical).—The spaces between the suspension rods, except at the centre, where the rods are short, were cross-braced with double 600lbs. telegraph wire, or four strands of 300lbs. wire, twisted up tight. This undoubtedly steadied the bridge vertically, but it was troublesome to keep the bracing tight in the varying temperatures.



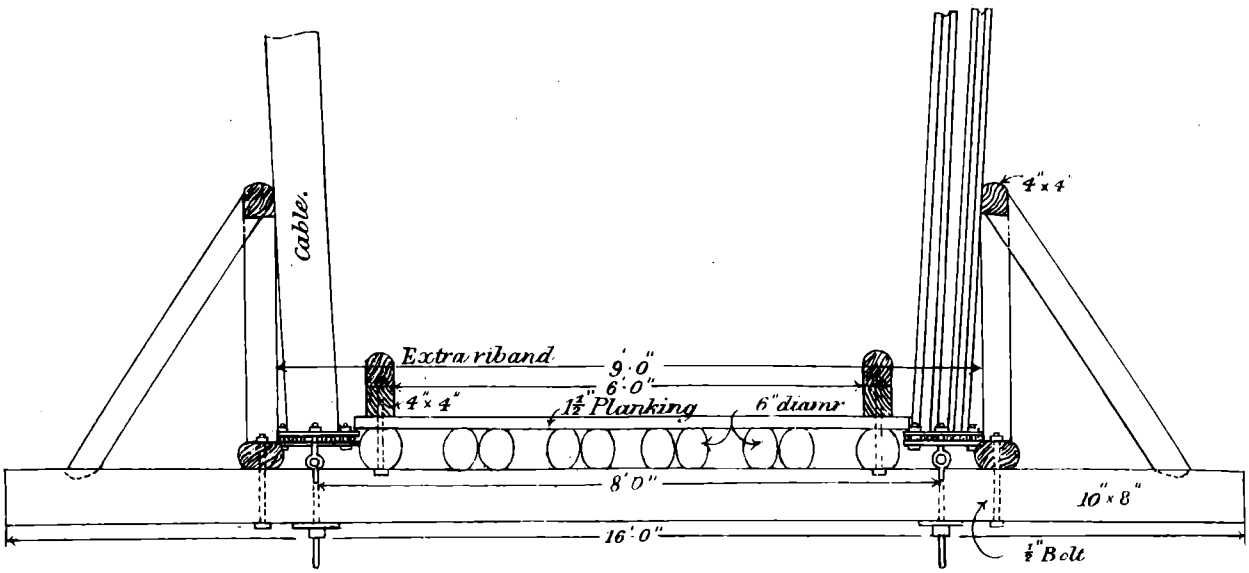
FASTENING ARRANGEMENT



Clipping arrangement at top of piers.—As already explained, it was necessary to clip the cables at the top of the piers to prevent their slipping under partial loads. For this purpose three 1-inch bolts were provided, passing through the centre of the wooden beam over which the cables passed, and a strong angle-iron clip was screwed down on to the cables, so as to grip them to the iron plate on top of the beam. Between the clip and the cables a lead-washer was used. This arrangement was, however, found insufficient to prevent the cables from slipping, and the arrangement shown in the margin was adopted and found to act successfully.

Fastening arrangement.—The ends of each wire rope forming the cables were fastened off separately by taking a round turn round the anchor beam and clipping the running to the standing part with a modified form of the clip shown in Instruction Military Engineering, Volume I, Part III, plate XXI, figs. 5 to 9. The modification of the clip chiefly consisted in omitting the small bolt passing between the cables as shown in the text-book. It is obvious that this bolt must

prevent the cup and wedges being tightened up and gripping the wire ropes. The modified form of clip was found to answer very well, three being used on each wire rope.



Roadway.—Attached is a section of the roadway of the bridge taken at the centre of the 250-foot span. Except at the centre the transoms are only ten feet long, the railing being fastened with wire to the ½-inch suspension rods.

The outer road-bearers are laid in a continuous line, the ends being halved over the transoms, so that the ribands which are bolted through to these road-bearers with ½-inch bolts might also be in a straight line. The remaining road-bearers are laid overlapping on the transoms to which they are spiked.

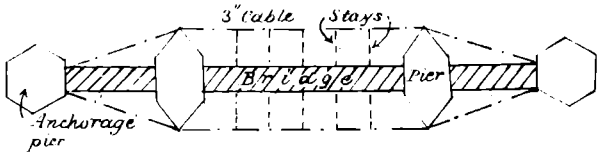
In every six road-bearers one long one reaching over two spans, so as to give the bridge stiffness, was included, but, as hardly any bullies over 20 feet long could be obtained, fished road-bearers had to be used for this purpose.

Railings.—The 3 feet 6 inches railing shown in the section has uprights 3 feet 3 inches apart, the spaces between being filled with cross-bracing of 300lbs. wire twisted up tight. This forms a girder which stiffens the bridge considerably under light loads, but is of course far too weak to do so when the bridge is fully loaded.

Movable ends in 250-foot span.—An important point in a long bridge with a considerable camber is that the ends of the road should be allowed free play to move backwards and forwards as the curve of the bridge gets pressed down under the load. If this is not allowed for, *i.e.*, if the end road-bearers are spiked to the wall plates, the bridge comes into compression longitudinally under a heavy load, and this causes it to vibrate horizontally to an excessive extent. In the 250-foot span the ends of the end road-bearers pass through loops of 3" × ½" iron fastened to the wall plates with coach screws.

Horizontal swinging.—A great difficulty in the 250-foot span was to prevent horizontal swinging under heavy loads. Camels especially caused very considerable swinging, and they are very apt to fall if the movement is not checked. As will be seen from the plan of the bridge site, there were no suitable positions in which the usual up and down stream stays could be fixed, as in flood time the piers are surrounded with water. An endeavour was made to provide anchorages by using large crates of wood filled with stones, but in heavy floods these showed signs of scouring and moving, and it was considered unsafe to stay the bridge to them. Accordingly, the bridge was steadied with wire stays, tightened by couplings, which were hooked on to 3-inch wire cables

stretched tightly, on either side of the bridge, round the points of the masonry piers, the cables being fixed about the height of the centre of the bridge, when unloaded, and being anchored back to the anchorage piers. This undoubtedly has a good effect, although it does not altogether stop the swinging under a load of camels.



Protection of foundation from scour.—As already explained, it was not possible to take out the foundations of the masonry piers to a greater depth than two feet below the level of the water at the time of commencing work. As the main channel was at this time about ten feet deep and running at about seven miles an hour, it was obviously necessary to take steps to prevent the foundations becoming undermined by scouring. As will be seen from the plan, the pier in the most dangerous position is the right main pier, as in flood time it is exposed to the full force of two large branches of the river which meet just above it. In this case the pier was entirely surrounded by wooden crates, each 10 feet long by 5 feet by 5 feet. These were made of chirbullies (shishum, mulberry, or other hard wood not being available in sufficient quantities), and were fastened together and to one another with telegraph wire. The crates and the space inside them were then filled with boulders, forming an island 190 feet long and 44 feet broad round the pier.

This protected the pier satisfactorily for a time; but, when heavy floods (which rose to the top of the crates) came down, the river bed was scoured out right up to the crates, and the boulders began to run out of them. To prevent this, long rolls of wire-netting filled with stones—the rolls being 3½ feet diameter—were placed along the front of the crates and were held in by pieces of wire cables carried back and fastened under the boulders forming the island. This had the desired effect, as the roll of stones could not be moved by the flood, and, when scouring along it occurred, the roll dropped into the hole formed. Of course such an arrangement can only be considered temporary, and, if the bridge is maintained, the foundations should be protected in some more substantial way.

In the case of the other piers it was found sufficient to pitch well round the base, and between the piers with stones.

On the left bank, which is very low and flooded at times, two long protective bunds were built to protect the bank forming the left approach to the bridge. The bunds are 6 feet wide at the top—have side slopes of 1 in 1, and are formed of alternate layers of boulders and brushwood mixed with earth and grass roots. This forms a good protective bank.

110-foot suspension span.—The details of the small suspension span are similar in most respects to those of the large span. The clips and suspending arrangements are the same, except that the former take only two cables instead of six.

The masonry of the piers and anchorages are very similar to those of the large span, the piers being 8 feet and the anchorages 12 feet wide at the top.

For the uprights of the piers no ironwork was ordered, as it was hoped sound wood would be obtainable. Unfortunately, owing to the prohibitions placed on the cutting of trees, shishum or mulberry scantlings of sufficient size could not be obtained, and it was found necessary to use chirbullies. These could only be obtained up to 8 inches in diameter, and were of inferior quality; and accordingly five were used dogged and framed together to form each side of the frame, the two sides being connected at the top by a mulberry beam over which the cables passed. Owing to the difficulty of getting wood the piers are made as low as possible, and give a clear headway of 11 feet only, while 5½ feet of the frame is embedded in the masonry.

Intermediate span.—The two intermediate masonry piers are four feet wide at the top. The wooden trestles are four-legged, of the usual design, and the spans, which are 22 feet long, are crossed by four trussed beams. The latter consist of two deodar beams, 6′ × 6″, fished together with two planks, 7″ × 2.″ There are two struts two feet long, and the tie-rod is of 1 inch round iron.

Carrying out work.—The only points to notice are—The 34-foot iron piers of the 250-foot span were put together *in situ* with the assistance of a derrick. The piers were made at Rawal Pindi, one pier consisting of two pillars, and the cross-bracing being made in the workshops of the Executive Engineer, Military Works, and the other in the North-Western Railway shops. The different shops of origin caused slight differences in the two piers and very considerable differences in marking the various parts. The ironwork was brought up by train to Nowshera, from thence to Dargai in carts, and from Dargai to Chakdarrah partly on camels and partly by coolies Consequently, although every endeavour was made to forward the four pillars complete, parts of one arrived mixed up with parts of another, and there was some delay in sorting out the different members. In such cases the marking of the pieces should be very complete, as, though it may seem simple to fit the parts together in the shop, it may probably be difficult to do so at the site of the work. For instance, the base pieces of one of the pillars arrived and erection could have commenced, but there was nothing to show which side of the base faced the river, or which of the pillars was the up-stream and which the down-stream one; erection had, consequently, to be delayed until the remainder of the pier arrived and the relative positions could be traced by the numbering.

Cables.—The six 3-inch wire ropes forming each cable of the 250-foot span were strained separately and clipped together before being placed in position. Lach cable weighed about 2 tons, and was hauled into position over the tops of the piers with tackles, attached to a 6-inch hemp hawser. A point to bear in mind is that precautions should be taken to prevent the twisting of the cable, owing to the tendency of the hemp hawser to untwist when the strain comes on it.

Materials.—The concrete in the foundations was mixed as follows at first:—

Mortar . {	1 part Portland cement.
	4 parts sand.
Concrete . {	100 parts gravel.
	35 „ mortar mixed, as above.

The cement came chiefly from the old stock of the Attock Military Works Division. It was not quite of the best quality, and did not set very fast; and, as the bailing which had to be carried on in the foundations to keep the water down drew out a good deal of cement, the proportions in the mortar were increased to 1 of cement to $3\frac{1}{5}$ of sand.

As the bridge would have to be used directly the work was complete, *i.e.*, while the masonry was still green, the mortar in the masonry of the piers and anchorages was composed of 1 cement to $2\frac{2}{3}$ sand.

For ballast pebbles of different sizes collected on the banks were used. Broken stone would have been more satisfactory, but there was no time to get up hammers, etc.

It may be useful to note that, when cement has to be carried on camels, it should be packed in tarred or water-proof bags, each holding half a cask. At first the cement was despatched to Dargai in casks by cart, and some delay was caused, as a cask of cement cannot be loaded on a camel.

The sand was sharp and of excellent quality.

The masonry was coursed rubble, the courses being from 5 to 7 inches deep. The outer face and the joints for 6 inches were chisel-dressed; and the outer 18 inches of the piers were carefully built of roughly-squared stone, the interior being filled in with rough rubble and boulders.

The timber used was shishum and mulberry for the anchorages and tops of piers—chir for the road-bearers, hand-rails, ribands and piers of the small span, and for the transoms deodar brought from Nowshera. All but the latter was quite green and was obtained, specially the hard wood, with great difficulty, some of the trees having to be brought three or four miles across an irrigated country intersected with nullahs and without roads or paths.

Date of commencement and progress of work.—The work was commenced on 19th April.

On 4th May the cement ran out and the concrete and masonry work was stopped till the 8th May, when a convoy bringing cement arrived.

The masonry was completed to the level of the bottom of the ironwork in the right main pier on 1st May and in the left main pier on May 3rd.

The ironwork of one pier began to arrive on May 3rd, but, owing to two of the angles of the base having been dropped by the camelmen in the Malakhand Pass, the erection of the ironwork could not be commenced until the 12th May, when the missing pieces were found and forwarded.

The ironwork of the second main pier did not arrive till 17th May.

The erection of the ironwork of the right pier was completed on the 18th May and of the left pier on 22nd May.

The small span bridge was completed on 30th May.

Communication for foot traffic across the whole bridge was established by 8th June, and by the 14th June animals could cross. The railings, &c., were completed by 25th June, on which date the up (loaded) traffic crossed the bridge.

It may be noted that the work was much impeded by the difficulty of communication across the river. All the building stone for the left bank had to be carried across the river. At first the only means of communication was by rafts of inflated skins and by cradles slung on a wire stretched across either branch of the river. On 28th April a cask pier bridge was completed across the small branch of the river, and on 3rd May a pontoon bridge was established across the main branch. On 7th May, however, the pontoon bridge had to be moved quarter mile down stream to a part of the river where the current was weaker, and communication at the bridge site was carried on by means of a flying bridge consisting of two pontoons with superstructure. On Saturday, 8th June, a heavy flood came down which carried away the cask bridge, swamped the approaches to the flying bridge, and sank two pontoons in the pontoon bridge.

Agency by which work was carried out.—The work was carried out partly by civil and partly by military labour.

The following officers and subordinates were employed on the work :—

Captain G. Williams, R.E., from commencement to completion

Lieutenant A. Walpole, R.E., from commencement to 3rd May.

Lieutenant F. F. N. Rees, R.E., from commencement to 16th May on preparation of and forwarding the ironwork, and from 16th May to 12th July at Chakdarrah.

Lieutenant C. Ainslie. } "Queen's Own" Madras Sappers and
Second-Lieutenant W. Robertson, } Miners.
from 21st April to 26th June.

Sub-Conductor P. Hay, Military Works Department, from 24th April to 18th June.

Sergeant Sellens, Military Works Department, from commencement to 29th June.

The 6th Company "Queen's Own" Madras Sappers and Miners, Lieutenant C. Ainslie, R.E., Commanding, with the exception of small detachments at the Shahkot Pass, and at Laram, were employed on the work from 21st April to 26th June.

The pontoon section of A Company, Bengal Sappers and Miners, under Captain G. M. Heath, R.E., assisted in completing the bridge, especially as regards wiring.

The civil labour employed included at one time 148 masons, 34 carpenters, and 12 blacksmiths.

Two photographs are attached.

G. WILLIAMS, *Captain, R.E.,*
Field Engineer.

CHAKDARRAH ; }
The 1st August 1895. }

Report on bridge over Ushiri River at Darora.

I received orders on the 26th June 1895 to proceed to Darora and improve the existing bridge, making the approaches fairly easy for mules; also to work on the road to the south.

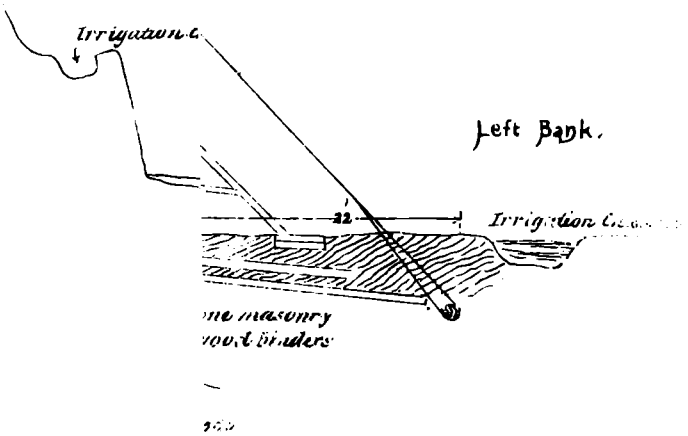
The 1st Company, Bengal Sappers and Miners, marched to Darora on the 27th June. The approaches to the bridge were very bad on either side, and the bridge itself was very shaky, several mules falling into the river. The 34th Pioneers, who were marching immediately behind the 1st Company, were only able to get one wing over by dark.

Owing to transport being passed over, no work could be done on the bridge or its approaches the following day. The bridge was of the ordinary native cantilever type—span 66 feet, height of roadway above water 15 feet, depth of water in deepest channel 5 feet. The piers on either side were built of rough stone with wooden binders, that on the left bank being built up on an overhanging rock; both were much out of repair. The centre span consisted of two 45-foot timbers about 12-inch diameter and $3\frac{3}{4}$ feet apart. They were supported on three timbers about 32 feet long, projecting 12 feet beyond the piers, these being in their turn supported by four similar timbers projecting about 6 feet, the shore ends being well weighted with stones. The flooring of the bridge was of the roughest hewn planking, with a plaited willow-twig riband. There were irrigation channels about 5 feet wide and 30 feet from either pier, the water from which was constantly cutting way the piers, and making the approaches to the bridge quagmires. The channel of the river towards the right bank was comparatively shallow and protected by rocks up stream, the main force of water being towards the left bank. There was a large rock almost in the centre of the river (see sketch) and immediately above the bridge.

As my first orders were to have the bridge ready for mule traffic in fifteen days I started making a crate of square timbers (5′ × 10′ at top inside dimensions, 7′ × 11′ at bottom), each piece being spiked to the uprights (7″ × 6″), and all being firmly bound together with telegraph wire. The crate was placed in position on 3rd July as nearly as possible in the centre of the river, and immediately below the rock above referred to. It was securely anchored to this rock with jumpers, one about water level and another 3 feet higher up.

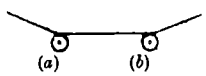
The crate is shown square in the sketch, but owing to the bed of the river being uneven, it did not settle down quite straight, but had a list towards the deeper part. The footings of the crate were excavated till shingle was reached and the whole was filled in with large boulders. A frame was next made 10′ high (standards 10″ × 8″) and braced in the usual way. This was erected on the top of the crate, and forced up, till it took the whole of the sag off the centre road-bearers, and practically stopped all motion in crossing the bridge. Two transoms, 8″ × 7″, were then lashed to these road-bearers, half-way between the centre frame and the piers, and sloping struts were placed as shown in the sketch, butting against the transoms. These struts were subsequently connected by ledgers and transoms and were braced in the usual way: wire ties were taken from the centres of the struts butting against the centre frame over the top of the centre frame. A rough frame was made on the right bank to take the feet of the struts; this was anchored back with wire to the original masonry pier, and the foot was further protected with a small crate of stones, all securely bound together with wire. The old flooring of the bridge was removed, and new chesses, $6\frac{1}{2}$′ × 2″ × 12″, were put down. Owing to the massiveness of the existing road-bearers a third road-bearer was not considered necessary. Three subsidiary road-bearers were placed from shore transom on either bank, butting against the centre road-bearers, so as to make one continuous roadway and to eliminate the step on to the centre span which existed in the old bridge. The bridge was completed in this way with hand-rails, etc., by 15th July.

Owing to reports of the natives that in high floods logs came floating down, I started on 16th July to collect timber for the main frames shown in the sketch, the idea being to take the weight of the main road-bearers by wire ties passed over these frames and anchored back on shore. The frames were made as shown in the sketch, and erected on wooden foot-plates about 4 feet from the



Sd.) J. R. B Sergeant Capt R.E

edge of the pier on either side. Owing to the irrigation channels, it was impossible to get the anchorages as far back as was desirable. Logs about 13 feet long and 12 inches diameter were used for anchors and were sunk 5 feet in the ground. The frames were strutted as shown in the sketch and tied back to the anchors with seven strands of (300lb to mile) telegraph wire. Two transoms, 9′ × 10″ × 8″, shown as *a* and *b* in the sketch, were roughly lashed to the road-bearers, dividing the length of road-bearers into three parts of 15 feet each. The ties, which consisted of twenty-one telegraph wires bound up together in bundles of seven, were then passed over the main frames and round the two transoms as shown in the margin. A round turn was taken round each anchor, and each tie was hauled taut by a tackle fixed at both ends. Hand-rails were subsequently fixed.



The object of the above arrangement of ties was that in case the centre crate got shifted in a flood, the centre span would still remain supported at *a* and *b* by the ties, even if the whole substructure got washed away. There was no connection between the substructure and the rest of the bridge, so that its collapse would not affect the bridge itself.

The bridge was finally completed on 26th July. There was some difficulty in obtaining wood near at hand. All had to be taken from the Panjkora River, as there was none in the Ushiri itself.

A photograph of the bridge is attached.

The following is a rough list of materials used in the bridge:—

Main standards	17½′ × 12″ × 10″	No.	4
„ transoms	12′ × 12″ × 10″	„	2
„ ledgers	9′ × 10″ × 5″	„	2
„ diagonals	13′ × 10″ × 5″	„	4
Ground plates	15′ × 12″ × 6″	„	2
Main struts	16′ × 8″ × 6″	„	4
Crate standards	10′ × 7″ × 6″	„	4
„ webbing	13′ × 4″ × 4″	„	20
„ „	8′ × 4″ × 4″	„	30
Centre frame standards	10′ × 12″ × 8″	„	2
„ transoms	8′ × 12″ × 8″	„	1
„ ledger	8′ × 10″ × 5″	„	1
„ diagonals	13′ × 8″ × 5″	„	2
Sloping struts	18′ × 8″ × 7″	„	8
Ledgers and transoms for do.	8′ × 7″ × 4″	„	8
Bracing for do.	15′ × 5″ × 4″	„	8
Horizontal ties	16′ × 6″ × 4″	„	8
Subsidiary road-bearers	15′ × 7″ × 6″	„	6
Chesses	6½′ × 12″ × 2″	„	70
Ribands and hand-rails	16′ × 4″ × 3″	„	22
Anchors	13′ × 12″ × 12″	„	2
Wire (300lbs. to mile)		about	800lbs.
„ (75lbs. „)		„	100 „
Spikes, 7″		„	150 „
Screws, 4″		grs.	¼
Twine, country		lbs.	15

J. R. B. SERJEANT, *Captain, R.E.,*
Comdg. 1st Company, Bengal Sappers and Miners.

DAROḤA;
The 27th July 1895.

Report on bridge at CHUTYATAN built by the 1st Company, Bengal Sappers and Miners, June 1895.

The company marched to Chutyatan on 6th June, about five miles from Dir, with orders to repair the existing bridge and make the approaches to it on either side. The old bridge was of the ordinary cantilever pattern, but was in such a state that it was scarcely fit for single foot-passengers: one side had sunk down over a foot owing to one of the only two road-bearers having half snapped across, and the planking was prevented from sliding off sideways by stones laid along above the sound road-bearer. It was at once evident that this could not be repaired. At the same time it was necessary to keep it up till the new bridge was made, as this formed the only communication from bank to bank.

The company meanwhile worked on the right approach from the Bandai-Dir Road, making a road 10 feet wide at average gradient of $\frac{1}{12}$, waiting for further orders about the bridge.

On Monday, 10th June, I received orders from Commanding Royal Engineer, Line of Communications, to erect a suspension bridge, as I had suggested, and I at once started all available sawyers, collecting logs from the river and warping them down near site of bridge. It was a little difficult getting the wood from the river, as it had been jammed up among rocks and there were only places here and there where logs could be landed and sawn up.

On 11th June I started the anchorages: 40 feet back from the foot of the standards the right bank was in loam and easy work; the left anchorage was all in rock, and took considerable blasting. I found there was just room to erect the bridge alongside (below) the existing one: there was a width of only just 10′ on the left bank, measured from the timbers of the old bridge to the edge of the rock, so that it was a little trouble erecting the main frame this side, and ties had to be used up and down-stream in place of side struts to steady the main frame when raised.

The main cables were pieces of 3 inches steel cable, about 35 fathoms each, which had been cut off as surplus from the cables used in the Panjkora bridge. One of these pieces seems of a very much better quality than the other, for no reason that I can see.

On 13th June the company started working on the left bank approaches, about 16 men being employed daily sawing, and carpenters making the frames, and 6 or 8 men on the left bank anchorage.

On 17th June the right bank frame was erected and backguys and struts fixed, and the following day the left bank frame which, as already stated, gave a little trouble owing to the site being so cramped, the men having to stand on the very edge of the rock 20 feet above the water, while raising the frame.

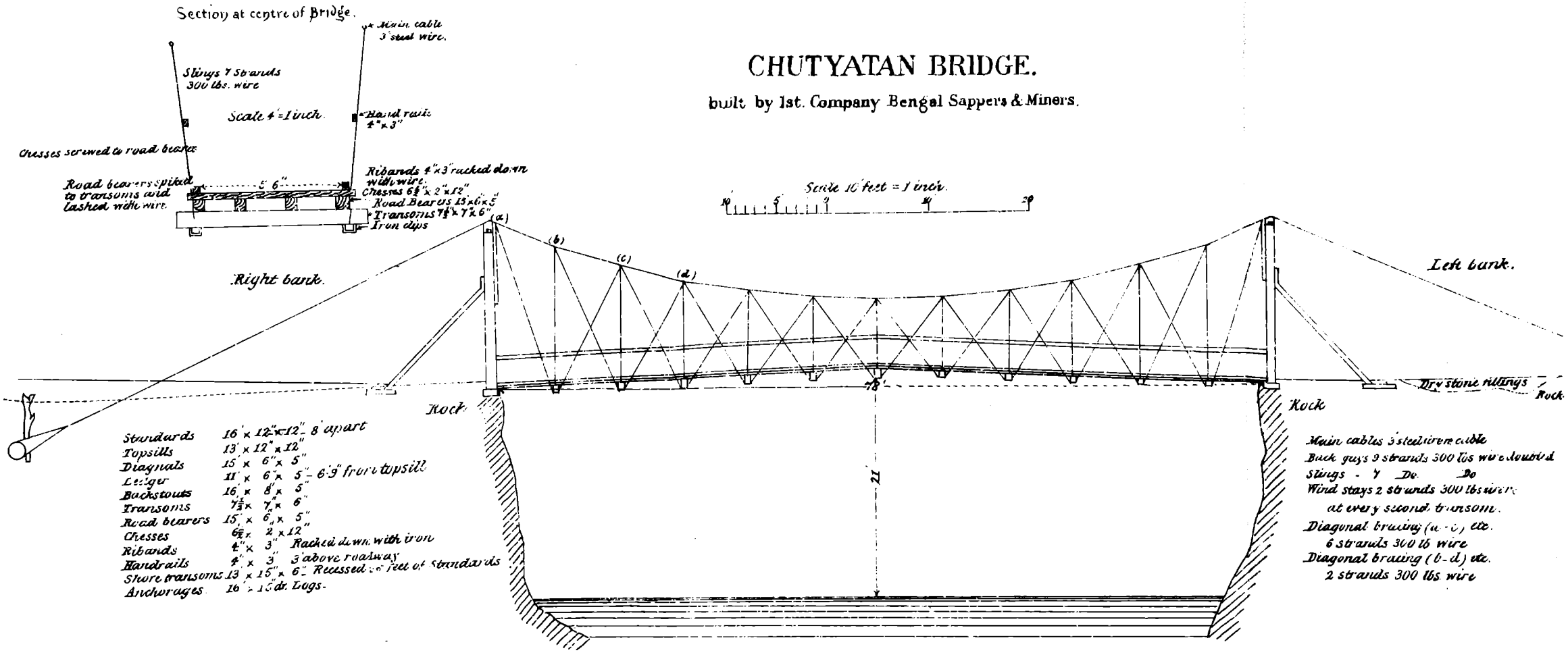
On 20th June the transoms were all got out, and communication effected from bank to bank. I fixed all the vertical slings to the transoms *before launching them out*, passing them through iron clips underneath the transoms, and measured the slings accurately (from previous calculation) on the bank and bent the spare ends over in form of hooks, so that it was only necessary to hook these over the main cables and pass the transoms out to their proper interval—in this case 6½ feet. I found in this way it was scarcely necessary to adjust the length of any sling after getting out all the transoms. Diagonal bracing to assist the vertical slings was added, the braces passing under the transoms through the iron clips. Wind ties were subsequently fixed to every second transom, and fastened to jumpers let into the rock on either bank up and down-stream. These were tightened with Spanish windlass so as to reduce lateral motion as far as possible.

The following is a list of all the principal materials employed:—

4	Standards	16′ × 12″ × 12″.
2	Topsills	13′ × 12″ × 12″.
4	Diagonals	15′ × 6″ × 5″ for bracing main frames.
2	Ledgers	11′ × 6″ × 5″ allowing headway of 9′6″.
4	Backstruts	16′ × 8″ × 5″.
2	Shore transoms	13′ × 15″ × 6″ for feet of standards.

CHUTYATAN BRIDGE.

built by 1st. Company Bengal Sappers & Miners.



Span of Bridge 78'- dip 8'- total height of Standards 16'9" fitted with iron shoes to carry the main cables - Camber 18". Height above water 21'. footings on each side in rock with Jumpers let in to prevent shore transom moving forward. On left bank there was no room for side Struts so main frame was guyed with wire (6 strands of 300 lb wire doubled) up and down stream, anchorage on left bank was in rock with three Jumpers let in in front of it: on right bank in loam, with holly oak uprights in front of anchor; and whole heaped up with dry stones. Every second transom was guyed up and down stream to Jumpers let into the rock to prevent lateral motion and each guy was tightened up with a windlass. Started collecting timber June 10th. Bridge open for traffic 22nd. June. Average number of men employed on bridge daily about 30.

(Sd.) J. R. F. Serjeant Capt R. E.
O. C. 1st Comp B. S & M.

2	Anchorages	logs 16′ × 15″ diameter.
11	Transoms	7½′ × 7″ × 6″.
24	Road-bearers	15′ × 6″ × 5″.
80	Chesses	6′6″ × 2″ × 12″.
12	Ribands	15′ × 4″ × 3″.
12	Hand-rails	15′ × 4″ × 3″.

2 Cables 3-inch steel wire, about 35 fathoms each.
20 Bundles of telegraph wire (say, 2½ miles), 300lbs.
100lbs. fine wire for binding.
6 Jumpers for anchorages, footings, and windguys.
2 Gross 4-inch screws for fixing chesses.
150 Spikes, 10 inches.

Average number of men, say, thirty, daily working at bridge.—The number of men actually employed on the bridge cannot be stated, as all spare men were working on the approaches. Two sections (about forty men) were employed raising the frames, and one section laying the roadway, half working from each bank, and a party of 12 to 15 men were sawing each day. The bridge was open for traffic on 22nd June, and the old bridge was dismantled, as it had become quite unsafe and was a source of danger to the new bridge.

Three photographs of bridge are attached.

J. R. B. SERJEANT, *Captain, R.E.,*
Comdg. 1st Company, Bengal Sappers and Miners.

Report on the graded road over the Malakand Pass.

The Malakand is one of the three main passes by which our troops could have crossed from Hoti-Mardan in the Peshawar Valley, over the Ilam range of mountains, into the valley of the Swat River: and this pass was the one selected over which to perfect our communications.

The rise from Dargai—the camp near the foot of the hills on the south side—to the crest of the pass is about 1,100 feet. The original road, or track rather, went as far as possible along the open plains into an angle formed by two spurs from the main range, and then ascended steeply by ziz-zags up the mountain side. A very rough track only practicable for pedestrians, or mules very lightly laden. The mules of the advanced brigades were got up the hill by this path after it had been, to some extent, hastily improved by the sappers. Supplies were delayed at the foot of the pass on account of the difficulties of the ascent, and until some new road could be made up—a task which appeared truly formidable. However, energetic and wide exploring led to the discovery of an old alignment of Buddhist times. The re-opening of this route was decided on: at once taken in hand, and in three or four days laden camels could be taken up it. Grade 1 in 12. Distance 2½ miles of hill road.

The northern descent into the Swat Valley was similarly negotiated. The fall is 500 feet on this side. A steep ziz-zag mule track was first made, and the existing country tracks improved. The Buddhist alignment was found to run down conveniently on this side too, and it was converted into a good camel road in five days by the 34th Punjab Pioneers and some few coolies. Distance 1¼ miles.

Thus the Buddhist road over the pass became the main route for convoys to the front. Average width 8 feet and grade very uniformly 1 in 12. Convoys returning from the front—generally convoys of unladen animals—used the first-made steep paths.

It was found, however, that, although camels at first passed over by the Buddhist road with apparently little difficulty, when it came to continuous passing of convoys over this high ascent in very hot weather, the 1 in 12 grade was too severe for them and they began to break down and die on the road. Orders were received for the speedy construction of a new road: and it was considered best to make it on a *cart road* alignment—that is, a grade of 1 in 20, and the width was ordered to be 16 feet.

Orders were received on the 1st May to commence this cart road, as it was called, and to use every possible kind of labour to get it speedily completed.

Lieutenant (now Captain) A. J. H. Swiney, R.E., aligned the road. Lieutenants S. D'A. Crookshank and G. H. Boileau had charge of the work on the north and south slopes, respectively.

After the work had proceeded for a few days, orders were received from Government that only camel roads were to be made over the pass; and the width of the new road was consequently reduced to 10 feet.

Thus, the road has been made minimum width 10 feet. Ruling gradient 1 in 20. Where hillside slopes are easy, 10 feet cutting has given more than 10 feet width of road, if the insecure portion on "made ground" be reckoned in. And the necessity of grading evenly between certain obligatory points has made the *average* grade somewhat less than 1 in 20. This grade, however, has been worked to wherever possible. In one or two places, for very short lengths, the 1 in 20 grade has had to be abandoned for one slightly steeper.

A well-known firm of contractors, Messrs. Spedding and Company, offered to undertake this work. Their price was R20,000 per mile, and four months to complete. The figures to include only hillside cutting, all masonry work, such as retaining walls, bridges, culverts, etc., extra.

The Commanding Royal Engineer, however, decided to proceed with the work with his own officers, engaging civil labour (petty contractors chiefly) and utilizing what military labour could be got. Practically none of the latter was available.

The work was finished in two and-a-half months, by 15th July. Had it not been for the 'Id festival intervening, during which time all civil labour insisted on going away, a reduction of ten days in the time would have resulted.

The cost has been about R15,000 per mile. This includes cost of explosives used, and, had it not been that during the last month the work was rushed, and large quantities of explosives had to be used, the cost per mile would have been appreciably less.

The length of the road is six miles on the Dargai (or south) side of the pass, and three miles on the Khar (or north) side. Total nine miles.

Practically, the whole work consisted of heavy rock-blasting: the explosive used being chiefly dynamite. But about 1,000lbs. of gun-cotton and some gunpowder were also used.

LARAM,
The 8th August 1895.

H. E. S. ABBOTT, *Major, R.E.,*
Field Engineer.

G. I. C. P. O.—No. 71 A. G. (D)—12-7-96.—50.