PAPER No. 84.

TEMPORARY QUARTERS, No. 1 DIVISION, KHYBER RAILWAY.

MAJOR E. P. ANDERSON, R. E.

At the commencement of the construction of the Khyber Railway the building of quarters for the staff was a matter of more than usual urgency. Apart from the extreme variations of temperature the westerly gales which for several months each year perpetually roar through the Ali Masjid gorge made the use of tents, even with angle iron pegs 3 feet long, terribly expensive owing to the need for constant replacement of those blown away, and rendered life a misery to their occupants. For materials there were available: (*a*) limestone which owing to its hardness and numerous veins of calcite is hardly fit to dress but makes good ballast and a pure fat lime when burnt in a kiln, (*b*) shale rocks of all sorts which break easily along their planes of lamination often into " pencils " of a characteristic rhomboidal section, and (*c*) small pockets of good clay which had to be brought in from a distance of a mile or more for use. Had water been available and these pockets of clay more extensive good bricks could have been made. Neither of these essentials exists; the whole of the water used on the first ten miles of the line has to be distributed by pumping and gravity pipe lines to all the works. Timber or corrugated iron is almost prohibitive in cost owing to transport difficulties.

Labour of a sort was plentiful, but political considerations precluded the giving of contracts to any one but local Afridis, and strictly limited the importation of down country labour of any sort. The ideas of the Afridi on "masonry " are so primitive that work of the class he does in his own village could not be accepted, and indeed proved actually dangerous on one occasion.

The use of some sort of pisé work or mud concrete was therefore decided on. Experiments had just been started when Mr. D. Macfarlane's paper read at the last congress, appeared, to which the author desires to express his indebtedness for many valuable ideas.

The mixture ultimately decided on for the mud concrete was based on one given in Marryatt's Specifications and called " economic concrete" by M. Coignet, the French expert in reinforced concrete. As used in the Khyber it consisted of—

1 part unslaked lime,
3 parts clay,
7 parts shale bajri in pieces not larger than 2 inches.

A very slight slaking action takes place when the water is added in mixing which is done as for ordinary concrete, and if mixed fairly dry this mixture sets hard enough to remove the forms from a wall in 24 hours.

Owing to the expense of carrying the clay the smallest practicable quantity of it was used. This results in the walls having a rough surface which is no disadvantage if they are to be plastered (see below). No special virtue is claimed for these ingredients ; they were used because they happened to be obtainable and there are doubtless many others which would do just as well.

Fortunately there was available among the plant brought out from England for the Khyber Railway a supply of self-climbing steel shuttering in various lengths. By designing the units of menials and similar quarters to such dimensions as to work in these lengths construction was much simplified. The shuttering consists of very light frames completely encased in galvanised steel sheeting. The long edges are rounded, and provided with small holes at intervals of 12 inches.

When a wall is to be built these shutters are set up in pairs on the foundation, and wired together by 20 gauge wires passed through each opposite pair of holes and twisted tight. The shutters are held at the correct distance apart by wooden gauges—see fig. 1. The form thus made is filled with concrete in the ordinary way and left to set. With the mud concrete the period was generally 48 hours but in hot dry weather it could be reduced to 24 hours. If using cement concrete for which this patent shuttering is really intended, the period could be reduced probably to 3 or 4 hours if a dry mixture were used. When the concrete has set, the bottom row of wires are cut on the outside of the form, and the shutters turned upward and outwards, and again wired together to gauge at a level one course higher. The depth of a course is 17 inches with the shutters employed ; but other depths would be equally possible with specially made ones. At the corners of the buildings and at the joints between exterior and partition walls, timber frames were set up as shown in fig. 1, in accordance with the method recommended by the makers of the shuttering, see photo. These can be taken down and used again and again.

In concreting it was found that with Afridi labour a gang of 6 coolies with a carpenter to adjust forms and a mistry in charge could easily mix and lay 60 cubic feet in a day. This is a very poor output and with reasonably efficient labour I should hope to double it. The walls were first made 1 foot 6 inches thick, but it was subsequently found possible to reduce this to 1 foot in the case of partition walls.

Wide eaves are necessary to protect the walls from moisture and in order to make doubly sure it was decided to seal the tops

of the walls against moisture by making the last six inches of lime concrete (lime stone ballast, white lime and surkhi). Various methods were also tried for protecting the outside surfaces from disintegration. Owing to the small rainfall in the Khyber (some 2 or 3 inches in all since these quarters were built) it is impossible to give a final opinion on their efficacy ; but so far there has been no necessity for any such covering. The following methods have been tried :—

(*a*) Lime plastering (white lime and surkhi).
(*b*) Mud plastering.
(*c*) Whitewashing.
(*d*) Silicate of soda both as a wash and also mixed with the water used for the concrete.
(*e*) Cement grout applied very thin with a Wells whitewash sprayer.

Of these (*a*), (*b*) and (*c*) call for no further remarks, (*d*) was done as directed in Mr. Macfarlane's paper and certainly produces an appreciably harder surface than the plain mud concrete, (*e*) was a mixture of cement 3 parts and sand 5 parts with water to a consistency as for whitewash. 1 cubic foot of cement covered 200 square feet and the cost including labour was Rs. 3-9-0 per 100 square feet.

Two types of roof covering were used—curved corrugated sheets supporting a layer of mud, and a mud roof supported on closely spaced ballies with ordinary matting above them. Of these the former is the more satisfactory but the latter is cheaper in the Khyber. The sheets used are 26 S. W. G., curved to a circle of 10 feet diameter. Two such sheets rivetted end to end form a section of roof whose length is the width of the sheet less two corrugations for overlap. They are quickly set up water-tight and will have considerable value when dismantled on completion of the work. To reduce the effect of changes of temperature they are covered with a layer of earth 4 to 6 inches thick as shown in fig. 2.

Where used for buildings such as those described it is advisable to fit 2 or 3 tie bars in the end bays and to thicken the end walls as some outward thrust due to arch action undoubtedly occurs. This type of roof, devised by Col. G. R. Hearn, D. S. O., R. E., when Engineer-in-Chief of the Khyber Railway, has proved extraordinarily useful for many other purposes where temporary shelter is required on works. A minor disadvantage of its use with concrete walls is that a special form is required for the inside of the semi-circular "gable ends" of a building. This slows the work and for this reason these gable ends were usually built of rough stone in mud mortar on top of the mud concrete walls already described.

The approximate costs of the different classes of work described were as follows. The rates are based on the very high cost of the inefficient labour available in the Khyber and the prices of materials include a very heavy item for transport to site.

(*a*) Mud concrete walls, including timber and supervision, all labour and material Rs. 29 per 100 cubic feet.

For comparison it may be noted that the poorest class of stone in mud walling costs Rs. 43 per 100 cubic feet.

(*b*) Curved corrugated iron roof with mud covering Re. 1-7-0 per s. ft. of floor area.

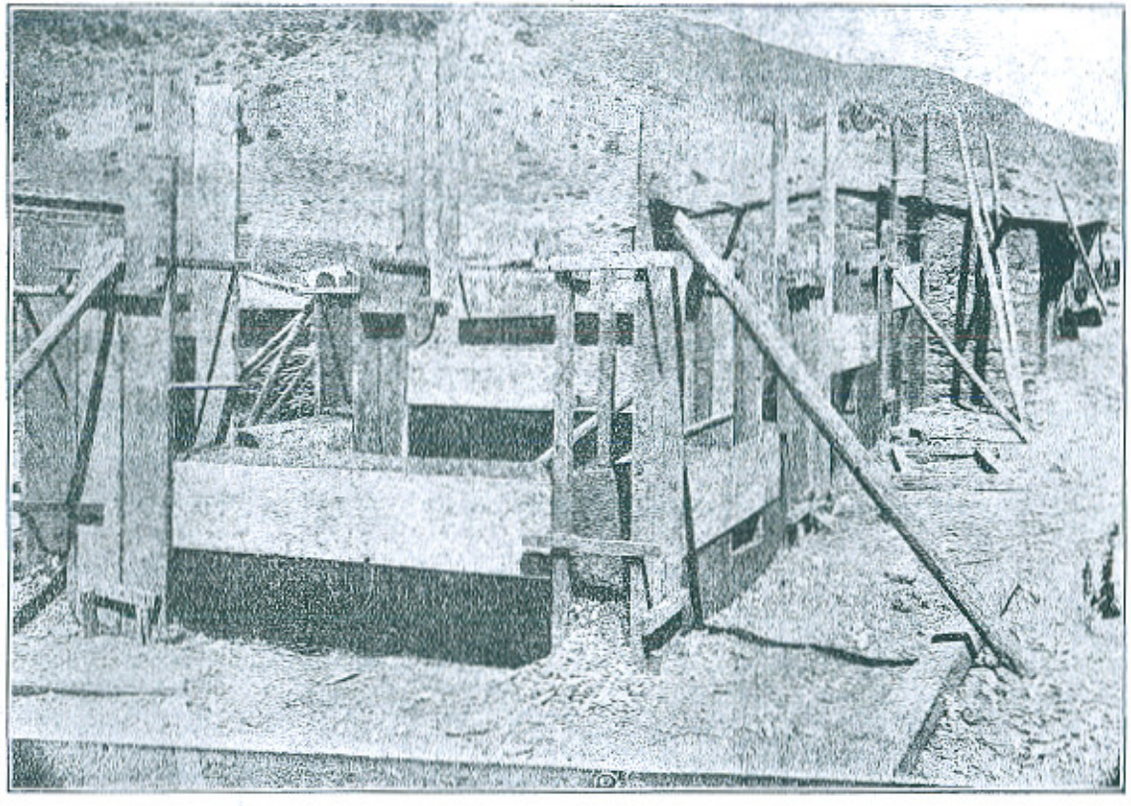
(*c*) Total cost of a block of 15 menials quarters each 10′×9′ with mud concrete walls and curved corrugated iron roofs Rs. 1,932.

Cost per unit Rs. 538.

Cost per s. foot of plinth area Rs. 4·07.

This makes no allowance for credits on recovery of corrugated sheets on completion of the railway.

The method of mud concrete construction described can be confidently recommended for use in dry climates, such as Sind and many parts of the North-West Frontier, and will prove economical where labour and materials are less expensive. Its cost should compare favourably with that of sun-dried brick in mud under such conditions. But the degree of its resistance to monsoon rainfall needs further experiment. The quarters described have recently been tested by unusually heavy winter and spring rains, and the only trouble experienced has been in two places where owing to imperfectly fitted eaves or a gap in the lime concrete seal, water found its way into the wall and brought down a few feet which had to be rebuilt. This trial, though not so severe as prolonged steady rainfall, has considerably increased confidence in their usefulness.



KHYBER RAILWAY CONSTRUCTION SHAHGAI CAMP.

TEMPORARY QUARTERS UNDER CONSTRUCTION. MUD CONCRETE WITH CLIMBING STEEL SHUTTERING.

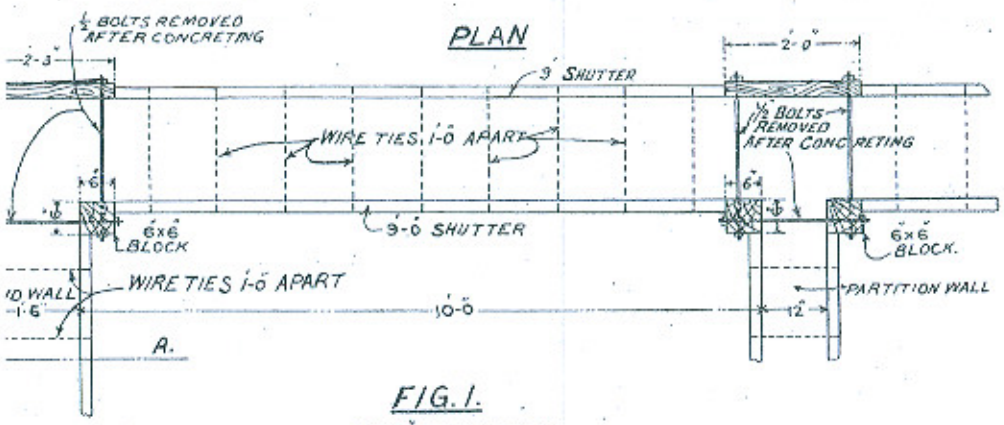
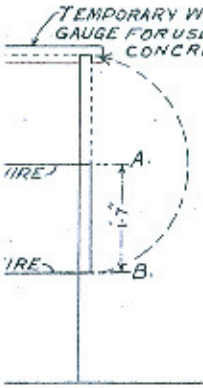


FIG. 1.

SCALE. ½ INCH TO 1 FOOT



TION ON A.A

THOD OF WORKING CLIMBING SHUTTERING)

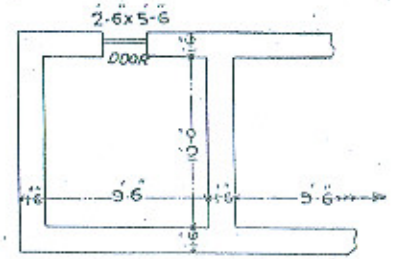
THE TIMBER MUST BE SET UP STIFFLY TO PRESERVE LINE OF THE WALL & KEEP ITS FACES VERTICAL

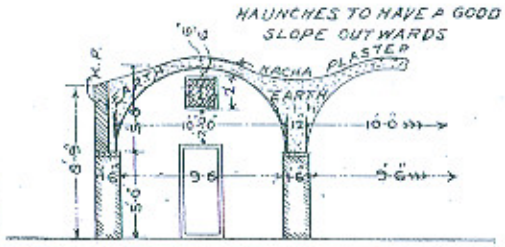
NOTE:— WHEN CONCRETE REACHES LEVEL A. CUT WIRES B. & FOLD SHUTTERS UP & OUT FOR NEXT COURSE

FIG. 2.

TYPE ROOF FOR LIGHT SHELTER

SCALE. ⅛ INCE TO 1 FOOT





SECTION ON A.B.

E.P. ANDERSON
MAJOR R.E.

DISCUSSION.

The AUTHOR introducing his paper said that the paper described work done early in 1922. It was originally intended to submit it to the 1923 Congress, but the delay caused by waiting to see the effect of heavy rain on these buildings resulted in it being crowded out. As a result, another year's experience could be added to the test and it was now possible to say that no further damage beyond that described in the last para. of the paper had occurred, and as far as he knew nothing more had been spent in maintenance. The costs given were not comparable with any other situation. They included heavy transport charges, absurdly high rates for terribly inefficient labour and their due proportion of those expenses which were necessarily incurred when one built a line in the country of someone else who did not particularly want us there. Under normal conditions the method should prove useful and economical elsewhere.

For the benefit of those who had not had time to read the paper, it described the use of mud concrete made of 1 part unslaked lime, 3 parts clay and 7 parts shale bajri for the construction of walls with climbing steel shuttering. Various methods of surface protection such as mud plaster, silicate of soda, and cement grout were tried ; and all had proved equally effective up to date. The climbing steel shuttering had also proved useful for cement concrete work, but needed great care to prevent bulging, if used in heavy walls.

MR. B. M. SULLIVAN said he would have liked to know the maximum height to which the walls of the buildings were constructed. In fig. 2 the height was 8′ 9″ but possibly in other cases the height might have been more. This was an interesting point. With regard to the use of imported shuttering described in the paper, could not cheaper shuttering equally suitable for the work, have been made locally? No doubt the method of construction described was most suitable for use in the Khyber ; it possessed the advantages that all materials required were on the spot and this meant that heavy transportation charges were eliminated. He was very interested to learn that the structures had lasted so well but he was a little doubtful if the materials employed in the construction would be suitable for larger buildings.

THE PRESIDENT said that at the last Delhi Darbar he built coolie houses with walls and roofs of galvanised corrugated iron, well fitted together and the cost worked out at about Rs. 100 per house. He asked what objections there were to building the walls of galvanised corrugated iron, in the Khyber also, especially as that might work out cheaper. He would also like to get fuller details of the rainfall which had taken place since the erection of the quarters and thought that this information would be very helpful in shewing the durability of the work.

MR. F. H. BURKITT said he did not know how long the Author had been on the Frontier and perhaps he had been lucky with his buildings in experiencing only very light rainfall.

The speaker had a long experience of the Frontier and did not agree with the Author's description of the North-West Frontier as having a dry climate.

He remembered one year, there was rain nearly every alternate day for three months and a host of houses fell down. Mr. E. R. Foy was compelled to prop up the roof of his pakka house and the pakka house of the Political Agent at Malakand collapsed.

MR. E. R. FOY wanted to know whether the use of unslaked lime with clay as described in the paper did not cause eventual disintegration.

Replying to the discussion the AUTHOR acknowledged his indebtedness to Mr. MacFarlane's paper, and said that as he had the climbing steel shuttering available, Mr. MacFarlane's method was not tried. Walls up to 10′ high could be built without difficulty, and he thought higher ones provided they were thick enough. The method could beused to advantage for filling in panels between "pukka" pillars carrying roof trusses or beams. No beams were used in these roofs as they were made of curved corrugated iron sheets covered with mud. To use the corrugated iron for walls, or without the mud covering in roofs would make the buildings uninhabitable owing to extremes of temperature. The rainfall in the Khyber was about 15 inches per annum, usually received in a few storms each giving 2 or 3 inches at a time. The Malakand seemed to him to be more in the track of the storms than the Khyber, as they apparently passed over Kohat or down the Kabul River valley following the outer Himalayas, and so missed the Khyber. The effect of the unslaked lime appeared to be to make the mixture expand slightly and therefore to consolidate it in the forms. The local method of building adopted in Afridi villages consisted of boulders rather widely spaced in mud mortar. Many of these walls fell down when it rained, and it was the fact that some railway quarters built on those lines had collapsed just before he took over charge which forced him to seek for improved methods of construction.