PAPER No. 206.

QUETTA RECONSTRUCTION PROGRESS. 1935-36.

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When the author originally agreed to write this Paper, very little was known as to the amount of work which would be done in the present year. Certain types of construction were approved for the initial contracts, but it is hoped that new ideas and improvements will be discovered as work progresses. This Paper will, therefore, deal only with the following points which, in the main, consist of preparations for the re-building of Quetta Cantonment, and may be sub-divided into the following heads :—

(1) Clearance of sites and salvage.

(2) Labour camps, sidings, and stores inspectorate arrangements.

(3) Sanitary and medical arrangements.

(4) Temporary earthquake-proof accommodation for personnel.

(5) Laboratory work, and experimental work.

(6) A short note on permanent buildings already erected or in the process of construction.

Various factors affecting individual items will be dealt with under the item chiefly concerned, but some general considerations must first be commented upon. The first point of importance is the necessity for keeping the garrison as near normal as possible during the reconstruction period ; transfer of troops to other stations would necessitate accommodation there.

Secondly, the building season in Quetta only lasts from April to November, due to frost and bad weather in the other months.

Finally, it was decided that all designs and specifications of construction and calling for tenders should be made at Army Headquarters, only the purely executive work being carried out at Quetta.

Owing to the lack of time it was found impossible to produce B. of Q. for all buildings.

Big contractors were permitted to tender for groups of buildings on a lump sum basis, definite lump sums being given for certain buildings; other buildings of the same type being calculated on an equivalent lump sum basis from a schedule of individual rates which forms part of the tender.

It was originally decided to start work on the following groups on April 1st 1936:—

Group I.—3 Indian Infantry Lines.

Group II.—1 British Infantry Line.

Group III.—British and Indian Military Hospital.

Group IV.—Bungalows for 58 Officers, married.

Group VI.—Staff College Bungalows for 43 Officers.

Group VII.—Posts and Telegraph Buildings.

But modifications of strengths of units, changes in accommodation and design, etc., in addition to the delay in completing the contracts in the short time available, led to the groups being started on the dates shown:—

Group I—4-5-36.—No building commenced yet. Only collection of materials and machinery.

Grou . II—8-5-36
Group III—8-5-36
Group IV—9-6-36
Group VI—8-7-36
} Remainder collection of materials in dates stated, and building followed in due course.

Other groups will be started only when the documents are ready.

Lay-out.

Quetta having grown rather like a man's house which consisted of one room for his use as a bachelor, and to which additions were made as he married and had a family, was not ideally laid out; the medical authorities discovered that the incidence of malaria was very much greater to the north and west of Lytton Road (Plate No. I) and it was therefore decided that the lay-out should be, as far as practicable, east of this line. The attainment of this ideal was in practice impossible; the railway lay-out and installation, the use of existing roads and water, and electric light mains, allowed little latitude.

Staff.

The staff approved for this work was as follows:—

1 Lieutenant Colonel, C. R. E. in Charge.

2 Asst. C. R. E's (Works and Personnel), (Electrical and Mechanical Stores).

3 Garrison Engineers (equivalent of X.E.N.) one of which was for Civil Works which are executed in Baluchistan by the M.E.S.

8 Asst. G. E's., equivalent of S.D.O's. in P.W.D. of which one was Electrical-Mechanical and one for Stores inspectorate.

1 Civilian Engineer Advisor chiefly for Drainage and Sewage.

Subordinates for the first year have been:—

15 S. D. O's.

27 Overseers.

4 Superintendents E. and M.

4 Surveyors (Assistants.)

6 Supervisors (Stores.)

Clerical and Drawings Establishments consisted of 36 clerks and 18 Draftsmen.

This staff will obviously need considerable increasing as the volume of work becomes greater. For the present year the establishment charges amount to Rs. 4,84,000, out of a total of Rs. 32,88,000 expended (estimated in both cases but reasonably correct). This is only 17·3 per cent.

Clearance.

This was the first item to arrange if building work was to start in April, 1936. The existence of insanitary debris and valuable salvable items was a further argument for expediting this work.

The chief factor affecting this item was the distribution of the debris over a very large area: entirely dissimilar to Quetta City where the debris was approximately 6 to 8 feet deep over the whole area of about a mile square.

In December, 1935, therefore, a survey of debris and, in fact, all buildings was made and the estimated tonnage found to be 1,250,000. This was spread over an area of 17·8 sq. miles.

This estimate was based on plinth areas and the number of 3-ton lorry loads required to move buildings of various classes. The accuracy of this was tested in August, 1936, when a total of 402,000 tons had been moved as counted by lorry and tip trucks as against 388,000 in the original list of buildings and estimated weights.

In general, it was found that the weight of a building was 1·12 tons per sq. ft. plinth area. Referring only to single storied buildings it will be seen that an average room, say 200 sq. ft. weighs 25·30 tons, and the walls would, therefore, take a load of about 1/2 ton sq. ft.: a generally accepted figure.

An important decision to be made was where the spoil was to be dumped. It was originally intended to dump in special areas on the outskirts of Cantonment, but it was soon found that not only was this expensive, but undesirable as the spoil could profitably be dumped in hollows and low areas in the centre of Cantonments, thereby reducing cost and improving the amenities of the station.

The immediate necessity in November and December 1935 was to carry out the clearance of areas in which building work was to be started in April, 1936. For this plant and tools were essential, and the following were ordered:—

(*a*) 50 Karrier lorries from Chaklala no longer suitable for Military Service.

These arrived on about December 12 and were put to work at once. Later, 9 more old Albions were received from local units; all lorries were free of cost but spares have been purchased as required.

(*b*) 2 Bucyruses, 1-yard excavators, were sent from Disposals Officer, Sukkur. These were erected in Quetta and started working on 13.-2-1936 and 1-4-1936.

(*c*) 7½ miles of 2 ft. gauge track.
250 Nos. 1 yd. tip wagons,
6 Steam locos,
4 Fordson locos

were ordered on 29th November 1935 through the I. S. D. This supply arrived in a most unsatisfactory manner. Crossings first, then track and no sleepers, then tip trucks and no locos, etc.



CATERPILLAR ELEVATING GRADER.

It was not till 15th March 1936 that the track could be worked and as further delays in delivery of locos and track, etc., were expected, a large part of the order was cancelled and other arrangements made for tracks; the order for the locos was cancelled, except the 3 Fordson and 1 Steam loco which arrived in February 1936. Six Mountania Diesel Locomotives were ordered on 5th December 1935, arrived in February and were put to work in March 1936.

These have been very satisfactory, though dust has caused heavy cylinder wear.

It will be seen, therefore, that all the loading of debris for the 1936 building programme had to be done by hand. The graph (Plate No. 2) shows the progress made and the cost. The high cost is not only due to the method employed but to the inclement weather which hindered work and output considerably. It was also partly due to the inevitable difficulties at the beginning of a job with new personnel, etc.

From May onwards, however, costs began to come down appreciably as may be seen from the graph.

After the first few months' work, the need for more and different plant was realized and the following were indented for:—

2 " 40 " Caterpillar tractors.

1 " R. D. 6 " Caterpillar tractor.

These were intended to assist in the pulling down of buildings, work which had previously been done by the R.T.C. machines. These arrived and were at work in March and May 1936 respectively. The latter machine, which had a trail builder attachment proved so useful in pushing demolished buildings into nearby hollows that a similar attachment for one of the 40's was ordered in August and arrived on 26th October 1936, and put to work on odd jobs in November, 1936.

Two Road Graders and attachments were ordered for road work and levelling after clearance and these were put to work in March, 1936.

A point of interest in the above is the fact that almost all the plant took 3 months from the time of ordering to the time of setting to work.

The labour employed in clearance in March reached the large total of 3,000. This was undesirable on account of the difficulties of housing, sanitation, etc., and, as anticipated, the adoption of machines was essential. These, as shown, began to arrive in March and their effect was such that, without any reduction in output, the labour was reduced by 50 per cent. by the middle of May. A further large decrease in the labour employed was brought about by the arrival of an elevating grader, a machine not before used in India; a special photo has been included, as this machine might assist many irrigation officers in their " Silt clearing " difficulties. It should also prove a very suitable machine for the construction of distributaries; its cost and that of other machinery is shown in Table A.

TABLE A.

			Rs.
20 lb. Truck 7½ miles	..	Second-hand	37,000
Sleepers	..	12250 ,,	12,320
Turn outs ..	..	40 ,,	2,900
Turn Tables	..	12 ,,	1,850
Tipping wagons ..	..	250 ,,	16,400
Platform wagons ..	..	6 ,,	430
Fordson Rail tractors ..	..	3 ,,	
Steam locos ..	..	1 ,,	
Fishplates and fish bolts ..	..	New	400
Rail Hacksaw and Jib screw	..	,,	70
Mountainia Diesel Motor Locomotive ..	..	6 ,,	28,500
Dy. 10 Rollers complete	..	2 ,,	30,300
4 R. D. Diesel Engines and Road Rollers ..	..	1 ,,	8,526
Road Builders ..	..	2 ,,	14,000
Caterpillar R. D. 6 (Tractor)	..	1 ,,	12,400
R. D. 7 Diesel Tractor and elevating grader ..	..	1 ,,	28,600
Caterpillars 44 Graders with scarifiner etc. ..	..	2 ,,	17,550
Caterpillars Diesel 40 Tractors 40 ..	..	2 ,,	27,520
Rotary Scrappers ..	..	2 ,,	2,800
Trailors ..	..	2 Second-hand	1,160
LeToureaneau Two Wheel crane	..	1 New	9,000
10-ton Scotch Derric crane	..	1 Second-hand	2,000
Compression Tester	..	1 New	3,800
Bucyrus Excavators ..	..	2 Second-hand	39,000

Elevating Grader.

This machine was definitely not designed for removing buildings, but the author having seen it working in the United States, had considerable belief in its possibilities. Its progress has exceeded

expectations ; it has turned out over 600 tons in an eight-hour day, at an all-in cost of -/11/6 per ton load 1 mile, working with 18 lorries.

This progress cannot always be made in such work as removing buildings, owing to a great diversity of factors that have to be considered, but there is little doubt that the machine in favourable ground, such as canal work, could do 60,000 c. ft. or 2, 500 tons a day, at a cost of less than 2/8 per 100 c. ft. allowing for all charges.

The chief trouble associated with the machine in Quetta has been belt wear ; a belt only lasts for 6,000 tons ; as however the material carried up the belt varies from dirt through kucha bricks, pucca bricks and brickbats, wire netting, holding down bolts, verandah post bases to concrete lintels weighing 300 lb. each, the wear is not surprising. In ordinary soil a belt which costs Rs. 600 should last a month, and with special belts for certain work, considerably longer.

In Quetta belt costs have worked out at 1½ annas a ton, and even with this high charge, the total cost of clearance with this machine and lorries is now being at 20/- per 100 c. ft. with a lead of 1 mile.

The lorries used had flat bottoms but these were considerably damaged by the Bucyruses ; as they were also difficult to unload, a sloping bottom type was evolved, and all bodies in for major repairs were modified to this form.

The elevating grader does not damage the lorries, but the drivers require skill to keep the correct pace, particularly in the dust of Quetta.

It is not claimed that machines always reduce costs very appreciably in comparison with labour, but they do reduce the number and work of supervising staff.

The progress to date will be reported at the February session. It will probably be in the region of about 625,000 or half the total. The remaining half must await the provision of new accommodation as no more can be demolished until the new buildings are provided in lieu.

Table B on next page shows a comparison between various methods of removing debris in Cantonments ; in analyzing costs the scattered distribution of debris must be borne in mind. These are facts from which the reader must draw his own conclusions.

TABLE B.

Summary of costs of the several methods of clearance adopted.

	Output tons per day.	Cost in Annas per ton per day.
1. Railway tip wagons, loaded and unloaded by hand	400—450	8·1
2. Lorries loaded by Elevating grader and unloaded by hand ..	450—525	11·5
3. Railway tip wagons loaded by Elevating grader and unloaded by hand..	150—200	12·8
4. Lorries loaded by Bucyrus and unloaded by hand ..	250—350	12·6
5. Lorries loaded and unloaded by hand	200—250	13·1
6. Railway tip wagons loaded by Bucyrus and unloaded by hand ..	250—300	14·5

Salvage.

The above has dealt entirely with the removal of debris. At the time salvage had to be carried on. The recovery of this has progressed by three stages.

Firstly, immediately after the 'quake, accommodation had to be provided and buildings both fallen and dangerous were ransacked in order to obtain the materials required. Materials were collected in various dumps round the Cantonment. This occurred before the formation of the Reconstruction Circle.

Secondly, as Reconstruction Circle took over, increased staff and better organization made it possible to reduce all the dumps to one—to dispose off all unserviceable salvage by auction—to open registers, to account for all materials issued from the dump; there was still at this time no possibility of correlating the materials salved with that originally in the buildings, as the majority of buildings being salvaged had already been ransacked in the first stage.

The final stage now being reached (Nov.) but not likely to be in complete working order till April 1937 (when only complete buildings will be standing) will be the accounting of salvage against the material in the original structures. Some idea of the materials salved may be formed from the Table C attached which shows the figures in the second stage from 24th February 1936 to 3rd November 1936.

TABLE C.

Serial No.	Material.	Issued from 24-2-36 to 3-11-36.	Unit.
1	Almirah, wooden	150	Nos.
2	Arm Racks	54	,,
3	Bricks	6450650	,,
4	C. S. Windows	368	,,
5	Chimney pipe	438	R.ft.
6	C. G. I. Sheets 6′ or over ..	26726	Nos.
7	Ceiling planks	75383	R.ft.
8	Channel iron of sizes	111	R.ft.
9	C. G. I. Sheets under 6 ..	3661	Nos.
10	Cooking Ranges	12	,,
11	Doors of sizes	2269	,,
12	,, Garage CI small ..	39	,,
13	,, ,, ,, large ..	30	,,
14	,, ,, ,, wooden ..	50	,,
15	Eaves Boards	1140	R.ft.
16	X. P. Metal of sizes ..	8273	S.ft.
17	Flat iron of sizes	3966	R.ft.
18	Fire grates, iron	48	Nos.
19	Doors, handles for	99	,,
20	Trellis, wooden	9928	R.ft.
21	Angle iron of sizes	48392	,,
22	M. S. Round of sizes ..	3190	,,
23	Meat Safes	41	Nos.
24	Paving stones	53566	,,
25	Planks, wooden of sizes ..	20883	R.ft.
26	P. G. I. Sheets 6′ and over ..	32212	Nos.
27	Posts concrete	1122	,,
28	P. G. I. Sheets 6′ and below ..	2588	,,
29	R. S. Joists of sizes	16679	R.ft.
30	Roofing golas	18689	Nos.
31	Rails, steel, of sizes	2238	,,
32	Scantling of sizes	347502	R.ft.
33	Shelves, wooden	155	Nos.
34	Stanchions, T iron of sizes ..	250	,,
35	Beams, wooden of sizes ..	31908	R.ft.
36	Trusses wooden of sizes ..	215	Nos.
37	Trusses iron of sizes	77	,,
38	Tee, Iron of sizes	10899	R.ft.
39	W. G. frames for windows ..	543	Nos.
40	Wire gauge	6186	S.ft.
41	Windows of sizes	1425	Nos.

The system now found to be satisfactory for salvage is for each building to be checked over and the materials seen to be entered in a register. A party then dismantles as much as is economically possible and sends the salvage to the dump the same evening in order to avoid theft at night. This is entered on the other side of the register. After the building is demolished and during the removal of the debris, any further materials obtained are sent in and a further per contra entry made. The register can then be checked with the original drawings of the buildings and the deficiencies discovered, due allowance being made for unserviceable materials, etc.

Labour Camps.

Early consideration for provision of accommodation to contractor's labour was necessary; the majority of the labour had of necessity to be imported owing to the unsuitability of local labour for the works involved.

It was undesirable to build a labour camp piecemeal and taking into consideration that at that time, December 1935, there was no accommodation in the city, it was decided to arrange accommodation for 20,000 labourers ; Government provided the site, roads, latrines, and sewage, lighting to roads, and water points to each area from which the contractor to whom the area was allotted could take a metered supply. Police posts and Hospitals were provided by Government. The cost at Quetta for all the above was approximately Rs. 2,71,647. A lay-out of the area is shown. (Plate No : 3).

This work being of an urgent nature was started in January. The first areas were available for occupation by 1st May, 1936.

Discussion with regard to the desirability or otherwise of a water-borne sewage system caused some delay but water-borne system was finally approved and completed by 21st July, 1936. The details of the Septic Tank are shown in Plate No : 4. These have been in use now for six months, and the result is eminently satisfactory. The effluent is innocuous and is now being used for irrigating waste stony land on which maize and other green, rather than root crops, are flourishing. Further experiments with this measure are in hand but there is a little doubt that the effluent will be satisfactory if used in such an arid area as Baluchistan.

The population of the camp has not exceeded 1,000 this year, and this would appear to be, at first sight, unsatisfactory as contractors are employing over 3,500 men. Certain restrictions are, however, being removed, such as the prohibition of females in the camp, and contractors are being made to improve the accommodation (suitable living and bathing accommodation to be provided by the contractor being in their contract) and with the additional work to be carried out next year the

population is soon bound to go up to 2,000—3,000 persons; once this number is accommodated, shops, etc., will spring up and attract more labour. The present position is considered as being more due to conservatism than other causes.

The water consumption of the latrines is perhaps of interest, a 10-seated block using 400 gallons per day and being used by approximately 10 persons at, say 4 gallons per head per day. This amount is increased in the Septic Tank by the addition of all bathing water which is led into the sewers, giving a total effluent of about 20 gallons per head per day, out of a total consumption of 23 gallons per head per day. With larger numbers in the camp this consumption per head will probably decrease.

Railway Facilities : Stores, etc.

As the majority of the works are over 2 miles from the main Railway Station a separate railway siding area was arranged with 1,000 yards of unloading track at a cost of Rs. 1,21,218 (with a rebate of approximately Rs. 36,404 when it is removed). This area was divided into eight smaller areas one of which was allotted to each contractor. This saves a considerable amount of delay and trouble to contractors, besides giving them an area for stores handy to the siding, an arrangement not possible at the main station.

In addition, since all stores for use on works have to go through the contractor's siding stores, it enables a thorough check, of all materials for use on the work to be made before the materials get on the work, but it does not do away with the necessity for check of materials going in. Inspection is carried out by the Stores branch inspectorate in close co-operation with the E.I.C. of groups in order to ensure that the stores going into work are the same as those passed in the siding.

Medical and Sanitary Arrangements.

The general sanitary arrangements of the Labour Camp are discussed elsewhere, but it was essential to provide hospital accommodation. This was situated as shown in Plate 1. The accommodation allowed for was 100 beds : these are in 12 Wana huts : with Wana hut accommodation for Doctors and Medical Staff. If necessary, the number of beds could be increased very rapidly. Two C.G.I. huts were provided for offices and inspection rooms, and in addition, a large disinfection centre, fitted up to enable imported coolies to be inspected, and allowing for the disinfection of their clothes, etc., to be carried out while the inspection was going on.

Arrangements were made for the incineration of hospital sewage, as this is essential in the case of certain epidemic diseases.

Disposal of Rubbish.

Both in the Labour Camp and on site of work rubbish is disposed off by small incinerators of which there is at least one in every group. A dust cart removes the ashes from these incinerators daily.

Sanitation on the site of work is not water-borne but 3 per cent. latrine accommodation has been allowed, and this sewage is disposed off by incineration with the rubbish.

Conservancy for quarters occupied by superior personnel not living in the Labour Camp is carried out in the normal way by the Cantonment authorities.

The following is a list showing the approximate quantities of material required per thousand men for dealing with sewage, and rubbish other than that of the water-borne system in the Labour Camp—

Bhoosa	..	.. 10,000 lb. per month.
Creosote	..	.. 36 gallons ,, ,,
Lime	..	.. 11 cwt. ,, ,,
Crude Oil	..	.. 50 gallons ,, ,,

In order to ensure that careful supervision is maintained for all Conservancy, there is, on the staff of the Reconstruction Department, one whole time Medical Officer who assists also at periodical inspections of all labour.

The incidence of disease has, to date, been extremely small.

Temporary Accommodation for Officers and Indian Superior Personnel.

At present both officers and I. S. P. are living in Wana Huts. There is an E. P. tent roof on 6 feet brick walls in place of kanats. In many cases bungalows which were only slightly damaged by the earthquake are being used for day accommodation. No pucca bungalows are, however, allowed to be used for sleeping purposes. A certain number of temporary corrugated iron huts have been put up for married families, but as bungalows will gradually become available for the normal garrison, it was not considered that the provision of a large number of temporary made huts should be made. This, however, did not apply to the Reconstruction Staff, which will not be entitled to any of the permanent accommodation which will become available year by year as constructed. It was, therefore, decided to build a certain number of temporary huts

for married officers and I.S.P. These were constructed on earthquake-proof lines from salvaged material of which the following were the main items available :—

Wooden trusses.
Steel stanchions, 6″×3″ and 7″×4″.

Doors, windows, cupboards, stoves, bricks, stone slabs, and timber of various sizes. A considerable quantity of the latter was in short lengths.

Plate No. 5 shows the type of building that was approved for officers and Plate No. 6 dated 4th November 1936 the type for I. S. P. The chief points to note in this construction are :—

(*a*) The roof is fixed to steel stanchions structurally independent of the walls.

(*b*) Brickwork in the walls is carried up to a height of 3 ft. approximately, *i.e.*, cill level, so that even if bricks dropped out no damage to human life could occur. This brickwork is tied in all round the building by a thin reinforced concrete course. Above this a wooden frame fits in to the steel stanchions in such a way that it cannot shake out. This frame consists of panels in which the windows and doors fit.

Wire netting is then fixed to both sides of the timber framing and wired together in such a way that it does not bulge when filled with broken brick filling ; any tendency for the wire netting on one side to fall out is immediately transferred to both the timber framing and the wire netting on the opposite side. Nails are not used for holding the wire netting to the timber framing, as this may very easily tear out or break the wire.

On completion of the brick filling, the outside is plastered up with cement plaster and rough cast, the inside with lime plaster, leaving approximately a 4″ gap filled with broken brick. This is an excellent insulating material as shown in Table E on the next page.

TABLE E.—THERMAL RESISTANCES.

Type of Wall.	Outside Surface (Convection).	Brick K=4·00.	Cement Mortar K=8·00.	Concrete K=8·30.	Heraklith K=0·04.	Rough Cast Plaster K=3 70.	Filler Space.	Lime Plaster, K=3.30.	Inside Surface.	Total.	Thermal conductivity of wall BTU/sq. ft. M./O.
9″ Brick Plastered ½″ Cement plaster inside ..	0·230	2·250	0·063	..	..	..	..	..	1·075	3·618	0·280
13½″ Brick plastered ½″ Cement plaster inside ..	0·230	3·375	0·063	..	..	..	..	..	1·075	4·743	0·210
4½″ Concrete Heraklith plastered ½″ Cement plastered inside	0·261	..	0·063	0·484	2·500	..	..	..	1·075	4·283	0·233
½″ Rough cast 4″ space filled with ¼″ broken brick 1½″ lime plaster inside ..	0·667	..	..	..	..	·405	1·170*	·455	1·075	3·772	0·263

* Assumed to be 50% better than an unfilled space, as convection currents are prevented, and full advantage taken of the cellular structure of the brick.

Other advantages of this type of construction are that the roof can be fixed before the walls are put up, and therefore in cold weather work can be continued in spite of weather conditions. Protection from the sun and the reinforcement effect of the wire netting help to prevent the plaster cracking.

The calculations for this building are shown below :—

TABLE F.

Data given.

Distance between Stanchions = 9′—0″

Roof Span =20′—0″

Loads.

Brick work = 100 lb. per s.ft.

Hollow panel with filler. = 40 lb. ,, ,,

Roof = 20 lb. ,, ,,

Weight of Roof on one stanchion =10×9×20=1800 lb.

Seismic load at the top $= \frac{1800}{8} = 225$ lb.

Max. B. M. due to Seismic loads :—

$$\text{B. M.} = \frac{6\,W\,L}{8} + \frac{6\,W\,L}{8} = 12\,W.\,L.$$

$$= \frac{6\times3\times60\times9}{8} \times3 + \frac{6\times11\times40\times9}{8} \times 11 + 12\times225\times11$$

$$= 3645 + 32670 + 29700$$

$$= 66015 \text{ in. lb.}$$

Taking maximum steel stress allowable for Seismic loads as 20,000 lb./□″.

B. M.=f.Z.

or $Z = \frac{66015}{20{,}000} = 3{\cdot}3007$

R. S. J. of Section 4″×3″ gives Z=3·76.

B. M. due to wind :

$$= 6WL+12WL$$
$$= 6\times220\times11+12\times120\times11$$
$$= 1320\times11+1440\times11$$
$$= 2760\times11 = 30360 \text{ inch lb.}$$

B. M. of 66015 is equivalent to a force of X lb. at the top.

$$\therefore X L'' = 66015$$
$$\text{or } X = \frac{66015}{11\times12} = 507 \text{ lb.}$$

Overturning :

Dead load carried by a stanchion :—

Brickwork	=4×9×100	=3600 lb.
Hollow panel	= 8×9×40	=2880 ,,
Roof	=10×9×20	=1800 ,,
	Total	=8280 lb.

Taking moments of forces acting upon stanchion :

$$500\times14\times12=8280\times X''$$
$$\text{or } X'' = \frac{500\times14\times12}{8280} = \frac{7000}{8280}\times12 = \frac{84000}{8280} = 10''\times14$$

$\therefore$ Block Size=1′—8¼″.

The actual design was to a very large extent dictated by the materials available. In order to make the best use of these, it was decided to make up steel stanchions, adjustment of trusses, and preparations of wooden framework by Departmental labour in the dump where all salvaged material was collected ; for this purpose a circular saw was obtained and run off a steam-roller which happened to be available. The first bungalow frame work took about 10 days to prepare in the dump. After that all the materials were prepared in about 4 days per bungalow. The work was put out to contract for fixing, and the first bungalow was completed and occupied in under six weeks from the date of giving the contractor the order to start work.

Other bungalows followed at 4—5 day intervals, the total of 9 being completed in about 2 months. This, of course, includes the electrification and water supply.

The I. S. P. quarters will be constructed in a similar way, but the stanchions, instead of being R. S. J.'s will be angle irons of which a large amount of 4×4 inch size is available. The type is similar except that *sarkanda* mud plaster is used above brickwork and no brick filling is allowed for.

Further information on this type of temporary quarter will be given at the Session.

Permanent Works.

As has been pointed out in the early part of this paper, every effort was made to start work as quickly as possible in order to avoid hardship to those persons stationed in Quetta. It was, however, impossible in the early stages to decide finally on the most suitable form of construction in Quetta. The following were considered:

Double 2" R. C. walls with $2\frac{1}{2}$" air space.

Double reinforced brick wall with 4" air space.

Hollow block concrete construction suitably reinforced.

Single R. C. wall about 4" thick, with some form of patent insulating lining, the concrete to be either singly or doubly reinforced.

The roofs discussed were pent, flat or domed.

The design adopted in the first series of three years' contracts starting in 1936 was as follows:—

4" single centrally reinforced concrete walls with Heraklith heat insulating lining.

Pent roofs for the important buildings and flat roofs for the less important.

These were slightly modified in the case of one contractor who used domed roofs for the more important buildings such as barrack-blocks; feather-crete in place of Heraklith; the former is rice husks impregnated with weak cement mortar while the latter is wood shavings compressed with a patent cementing material. All the main walls of this contractor's contract are doubly reinforced.

Strength against earthquake shocks is obtained by two different methods.

(*i*) The Box Type which is used where flat roofs are part of the building. This type relies on rigidity from the main walls and roofs which are designed to form a reinforced box.

(*ii*) The Framed Type consists of bents of columns and beams constructed as a continuous frame, the walls themselves being panels taking no load other than their own weight.

This latter type, though less economical, is necessary for larger buildings; it also gives far more scope for design and for treatment of the walls for heat insulation.

This latter is important as the temperatures in Quetta have, almost all through the year, a range of 40 degrees between day and night temperatures while in winter the temperature is often below 10 degrees and in summer frequently up to 110 degrees.

The original calculations were based on taking the worst case for any particular type of member and using that loading for all similar members, but it was very soon found that this was uneconomical and that by calculating all members independently very considerable economies would be made. This has since been done and the designs modified.

The two methods of calculations used were:

(*a*) Cantilever Method,

(*b*) Hardy Cross Moment Distribution Method.

The maximum moments by these two methods though being in close agreement occur at different points.

(*a*) Gives the maximum moments in the centre space of the bent.

(*b*) Gives the maximum moments in the penultimate space.

The former method was used first as being the simpler and quicker of the two; the latter has since been worked out and the results of both methods sent home to the Building Research Station in London for a report. This, as yet, has not been received.

The following points with regard to the design may be of interest.

(*a*) The foundation of any one building should be on the same level throughout. This is necessary to produce, as far as possible, equality of stress in all parts, and to provide a line of cleavage between the building and the ground.

(*b*) The buildings should be designed as nearly square as practicable and in no case should the length exceed three times the breadth.

(*c*) The building itself being quake-proof, the floor, which is not an integral part of the structure, is not reinforced. To this there is one exception of British Troops Barracks, of 60 men, which, as an experiment, is being built to the design of the Truss Concrete Company, London. (Patent Diagrid Design). The progress and cost of this building is being watched with interest.

(*d*) *Stresses.*

The following are some of the more important factors in the calculation :—

Seismic $\frac{G}{8}$.

Wind pressure 20-lb. per sq. ft.

Working stress in concrete 750-lb. per sq. in.

Working stress in steel 16,000 lb. per sq. in.

Stress in steel and concrete is allowed to be increased by 25 per cent. when dealing with peak stresses caused by seismic forces alone.

An outline of the stress calculations for a block of six Followers' quarters is attached.

Progress of Work.

Little work has been done during the present year. Of approximately Rs. 140 lakhs worth of work, which has been let out and which has to be completed by the end of 1938, only Rs. 14 lakhs worth of work will be finished this year. The reason for this is twofold.

Firstly, delay in settling the final details of the contracts.

Secondly, all contractors started on small buildings, with inexperienced labour in order that they might gain experience and train their men. There should be little doubt that the progress of work next year will be very considerable provided the contractors have the same labour; it certainly must be if contractors intend to finish their work in the time allowed. They have all now gained experience and in one point alone, it is very noticeable that all now use steel shuttering after many unsuccessful and costly experiments with timber.

Concrete.

Since the majority of the work is Concrete, a word on this subject will not be out of place. Machine mixing alone is used, and the majority of the contractors rely on small Quarter Yard Mixers as the buildings are scattered. One firm has, however, put in a Crushing and Mixing Plant of a modern type. The materials used are limestone crushed by various types of crushers for both coarse and fine aggregate; shingle, which is to be carefully washed in order to remove fine layers of clay and local river sand. This latter is both extremely fine (seldom any coarser than a No. 20 sieve and very dirty), needing careful washing and it has recently been decided that only mechanical washing is of any use. Rigid supervision of concreting has been maintained and concrete cubes taken daily at unspecified hours are tested at 28 days in the Works Laboratory, all concrete under 2250 lb. per sq. in. being rejected and the work cut out. The nominal mix is 1 : 2 : 4 with the grading carefully inspected. The contractor is at liberty to add such cement or water as he wishes provided always that the strength of his concrete is at 28 days, as tested in the Laboratory, 2250 lb. per sq. in. In this the contractor is governed by the workability of the mix necessary in order to place the concrete.

In walls with rodding a slump of 4" has been found suitable. This is sufficient to prevent honey-combing and to give a good surface. With slabs, roofs and beams slightly less is possible.

Only one case has occurred in which work has had to be rejected, but as this case extended over about ten days and three weeks work was put on the top of it, the amount of cutting out was considerable. The principal reason for this unsatisfactory work was that too much water had been added owing to the use of excessive amounts of fine sand.

As far as can be foreseen, the changes in next year's contracts will be that for unimportant buildings, with walls not over 12 ft. in height, reinforced brickwork may be used. For some other buildings a frame construction of reinforced concrete or steel work, with panels consisting of some form of expanded metal, filled with a 1 :12 brick concrete and plastered internally with lime and externally with cement ; a rather similar construction to that of the temporary buildings discussed earlier.

TABLE "G."

Calculation of B. Ms. for *longitudinal* section through main rooms of Class 'D' Quarters-Block of 6.

Fixation.

Bottom of walls taken as pinned B. M. $\frac{WL}{8}$

Roof slabs taken fixed at sides B. M. $\frac{WL}{12}$

Loading.

End walls 20 lb. /ft^2. Windward (See Note).
10 ,, ,, Leeward.

Partition walls 10 lb. /ft^2.

Roofs	4" Concrete slab	53 lb. -ft.^{2}.	
	3" Mud	25 ,,	,,
	Occasional load	25 ,,	,,
	Total	118 ,,	,,

Roof : $10^1 \times 12^1$, fixed on 4 sides.
Load reduction factors (French Government Formula) are
·51 for short span,
·19 for long span.

∴ Loading =60·2 lbs. ft.^{2}. short span.
22·4 ,, ,, long span.

Note. The 20 lb. /ft.^{2}. wind-ward and 10 lb./ft.^{2} leeward load is the seismic load of g/8.
Hence this load is taken in this case for the walls.

Stiffness of members.

The following reinforcement is assumed :

End walls $\frac{1}{4}$" bars at 6" spacing
(Central reinforcement in 4" wall).

Partition walls 1/4" bars at 8" spacing.
Main roof 1/4" ,, ,, 12" ,, (Intermediate spans)
Main roof 1/4" ,, ,, 8" ,, (end spans) 1" cover.

$I = \frac{bn^3}{3} + mA_t - (d.n)^2$ where b=breadth =12"

n=depth of N. A.
m=Modular ratio (=15+1)
A_t=Area of tensile reinforcement
d=Effective depth (=2" for wall and $2\frac{7}{8}$" for roofs).

Hence :—

	I/I
End walls	0·0322
Partition walls	0·025
Intermediate roof spans	0·032
End roof spans	0·046

Proportions for distributing moments :

$\frac{\text{End walls}}{\text{End roof span}} = \frac{\cdot0322}{\cdot0457}$

End walls $\frac{\cdot0322}{\cdot0799} = \cdot414$

End roof span $\frac{\cdot046}{\cdot0779} = \cdot586$

Check = 1·000

Similarly for remaining members—

End roof span	..	·446
Partition wall ..	..	·243
Intermediate roof span	..	·311
Check	..	1·000
Intermediate roof span	..	·36
Partition wall	..	·28
Intermediate roof span	..	·36
Check	..	1·000

The following table gives the working out of the Moments by the normal Moment Distribution Method. The moments are then shown plotted (Plate No. 7) and from this B. M. diagram the reinforcement required in the walls, roofs and junctions are worked out. (See Table H.)

TABLE H.

A. W=20 lb. l=10′ S=·0322 WL/8 ½″ bars at 6″ centres.			B. W=22·5 lb. l=12′ S=·0457 WL/8 ½ bars at 8″ centres.		D. W=10 lb. L=10′ S=·025 ½ Φ at 8″ C.		C. W=22·5 lb. l=12′ S=.032 WL/12 ½″ Φ at 12″ C.			E as for CE. F.		G as for EG. H.		K as for GK. L.		M as for EC. N.		W=15 lb. O·l=10′ S=·0322 WL/8	P.
I. O.	+250·00	−270·00	+270	+125	−270	+270	−125	−270	+270	+125	−270	+270	+125	−270	+270	+125	−270	−270	+187·5
	+ 8·28	+ 11·72	− 55·75	− 30·38	− 38·87	− 45	− 35	− 45	− 45	− 35	− 45	− 45	− 35	− 45	−38·87	− 30·38	− 55·75	−268·09	−189·41
	..	− 27·88	+ 5·86	..	− 22·5	− 19·44	..	− 22·5	− 22·5	..	− 22·5	− 22·5	..	−19·44	− 22·5	..	−134·05	− 27·88	..
II.	+258·28	−286·16	+220·11	+ 94·62	−331·37	+205·56	+ 90	−337·5	+202·5	+ 90	−337·5	+202·5	+ 90	−334·44	+208·63	+ 94·62	−429·80	−25·97	− 1·91
	+ 11·54	+ 16·34	+ 7·42	+ 4·05	− 5·17	+ 15·10	+ 11·74	+ 15·10	+ 16·2	+ 12·6	− 16·2	+ 15·10	+ 11·74	+ 15·10	+ 48·69	+ 38·04	+ 69·82	+16·34	+ 11·51
	..	+ 3·71	+ 8·17	..	− 7·55	+ 2·59	..	+ 8·1	+ 7·55	..	− 7·65	+ 8·1	..	+ 24·35	+ 7·55	..	+ 8·17	+ 34·91	..
III.	+269·82	−266·11	+235·70	+ 98·67	−318·65	+223·25	+101·74	−314·3	+220·25	+102·60	−313·75	+225·7	+101·74	−294·99	+264·87	+132·66	−381·81	+ 25·28	+ 9·63
	− 1·54	− 2·17	− 7·01	− 3·82	− 4·89	− 3·85	− 2·99	− 3·85	− 5·44	− 4·22	− 5·44	− 11·68	− 9·09	− 11·68	− 4·89	− 3·82	− 7·01	− 20·46	− 14·45
	..	− 3·51	− 1·09	..	− 1·93	− 2·45	..	− 2·7	− 1·93	..	−5·84	− 2·72	..	− 2·45	− 3·84	..	− 16·25	− 3·51	..
IV.	+268·28	−271·79	+227·6	+ 94·85	−325·47	+216·05	+ 98·75	−320·87	+218·88	− 98·38	−325·03	+211·3	+ 92·65	−300·12	+254·14	+128·84	−389·05	+ 1·31	− 4·82
	− 1·45	+ 2·06	+ 1·35	+ ·73	− ·94	+ 1·86	+ 1·45	+ 1·86	+ 2·80	+ 2·17	+ 2·80	+ 1·86	+ 1·45	+ 1·86	+ 5·00	+ 3·90	+ 7·17	+ 2·06	+ 1·45
	..	+ 0·68	+ 1·03	..	− ·93	+ ·47	..	+ 1·40	− ·93	..	− ·93	+ 1·40	..	+ 2·50	+ ·93	..	+ 1·03	+ 3·69	..
V.	+269·73	−269·05	+229·98	+ 95·58	−323·60	+219·28	+100·20	−317·61	+222·61	+100·5	−321·30	+214·56	+ 94·10	−304·76	+260·07	+132·74	−390·85	+ 6·96	− 3·37
	− ·28	− ·40	− ·87	− ·48	− ·61	− ·67	− ·33	− ·67	− ·67	− ·52	− ·67	− 1·40	− 1·10	− 1·40	− ·61	− ·61	− ·87	− 2·09	− 1·48
	..	− ·44	− ·29	..	− ·31	− ·31	..	·34	− ·34	..	− ·38	− ·34	..	− ·31	− 0·70	..	− 1·05	− ·44	..
VI.	+269·41	−269·89	+228·91	+ 95·10	−324·25	+218·30	+ 99·67	−318·62	+221·61	+100·03	−322·35	+212·82	+ 93·00	−306·47	+258·76	+132·26	−392·77	+ 4·42	− 4·85
	269·65	324·28	..	..	..	..	318·30	..	..	322	..	..	..	306·15	..	..	391·90	4·64	..
	270	324	..	..	..	..	318	..	..	322	..	..	..	306	..	..	392	5	..

Laboratory.

The principal work of the Laboratory has been to test all cement and concrete. In addition, however, many other items of building materials have been tested from the point of their practical application, for instance, hume pipes and Asbestos pipes for flues, Hyrib and Rib met, and similar materials, for their strength when used with plaster and concrete. Asbestos, Wood, Tretex, Tentest, Celotex, etc., have also been tested from the point of view of their reliability in damp situations, and many other items. Certain materials, such as paint, bricks, etc., have been sent away to Government Test House, Alipore, as facilities for their test were not available.

The attached Table J shows the machines and other instruments, etc., required for carrying out the tests. Some of them have been made up locally and have proved extremely useful.

All cement going into works is tested for strength in accordance with B. S. S. Concrete is tested with 6" cubes. The following experiment was carried out in order to ascertain the difference in strength which could be obtained by using poorly graded and graded aggregates with different quantities of water. The results are interesting as showing how essential it is, not only to control the water but also the grading of materials used in concrete.

Lump.	Schedule D.		Strictly Graded.			Gravel.		
	Stone.	Gravel.	Stone.			Cube.	Cylinder.	
			Cube.	Cylinder.				
1" W./C. ratio.	1866 (1.15)	1804 (1.68)	2200	(1.2)	1565	2628	(1.04)	2610
4" W./C. ratio.	1617 (1.23)	1617 (1.13)	1803	(1.28)	1286	2426	(1.12)	1660
6" W./C. ratio.	1244 (1.28)	1368 (1.17)	1648	(1.31)	1424	2083	(1.135)	2180

It will be seen from this table that the strength obtained by the use of cylinders is about 20—30 per cent. less than that obtained by using 6" cubes. The fact that gravel gives a higher result than crushed stone is due to the fact that it requires a lower water cement ratio to obtain the same slump.

The use of Electric Vibrators was also tested. In this case a 4" wall, 8' high and 10' long was cast using vibrators to shake the concrete down. In the first case Expanded Metal was used as reinforcement

This was found by to be useless as it was almost impossible to keep the reinforcement in the position required. When, however, roads were used no difficulty was encountered, and the surface obtained although having a few pin-head air holes, was excellent.

The saving in time when shuttering can be fixed to this height or even higher and the whole concrete poured in one operation instead of in 2 ft. lifts as is more normal, is obvious. In addition, the use of vibrators permits a far lower water content, and therefore a higher strength, for the same materials used, or to obtain the same strength, less cement.

One essential, however, is that the shuttering must be first class, and proper fixtures allowed for attaching vibrator.

The wall, 10′×8′×4″ thick was poured in half an hour, during which time the vibrator was working about 10 minutes: the power used being very small.

One other very important experiment is being carried out, and this is an actual test of the small building under conditions approximating to that of an earthquake. For this a tank, 12′×12′×4′ deep is being fixed on R. S. Js. which are on ball bearings. The whole of the tank and its platform above the ball bearings are being held in place by 32 Railway buffer springs. The tank being filled with earth and properly rammed, is having a small building about 8′×8′ erected upon it. Arrangements are being made to give the tank platform a blow in order to set up an oscillation with a period in amplitude similar to that of an earthquake. This oscillation will be recorded as also will the oscillation at various points on the building. The effect of the strength of the building will be seen and various types of construction will be tried out over the next 12 months.

It must be realized, however, that to obtain a proper test it is essential to give the building at least one month to set and therefore only one test can be carried out every 2 or 3 months.

It is hoped, by the time of the February Session, to obtain charts showing the strength of concrete at 7—28 days, and in addition, some data with regard to the effect of cold weather on the setting of concrete in the actual work as compared with the Laboratory test when the samples are cured at an even temperature. The climate in Quetta is ideal for this, but sufficient results are not yet available.

Another experiment of interest carried out was in order to find the difference in strengths which would be obtained with good sand, fine sand and very fine sand. These are tabled below. It will be seen that the use of very fine sand is definitely bad when compared with the standard Harro Sand.

Comparative Statement of Tensile Strengths 1: 3 *Mortar with the use of Different Grades of Sand.*

36 Days' Test.

Average of 3 *Briquettes.*

(lb. per sq. Inch).

Neat Cement.	1 : 3 with Harro sand. (Standard sand.)	1 : 3 with Baleli sand Pass through No. 100.	1 : 3 with Baleli sand screened through No. 14.	1 : 3 with washed Baleli sand.	1 : 3 with Bostan sand pass through No. 100.	1 : 3 with Bostan screened through No. 14.	1 : 3 with Bostan sand washed.
647 lb	447 lb.	150 lb.	247 lb.	291 lb.	184 lb.	410 lb.	317 lb.

7 Days' Test.

725 lb.	559 lb.	222 lb.	363 lb.	413 lb.	303 lb.	450 lb.	488 lb.

Remarks.

(1) Anything below No. 100 reduces the strength compared with the ordinary sand obtained from the nullahs.

(2) Washed sands bring the strengths up.

(3) Bostan sand is better than Baleli sand.

(4) The result of washed Bostan sand is *doubtful*.

(This doubt was justified by the result of the 7 days' test.

PLATE No 1
PAPER NO 206



SCALE OF YARDS

1000 500 0 1000 YDS.

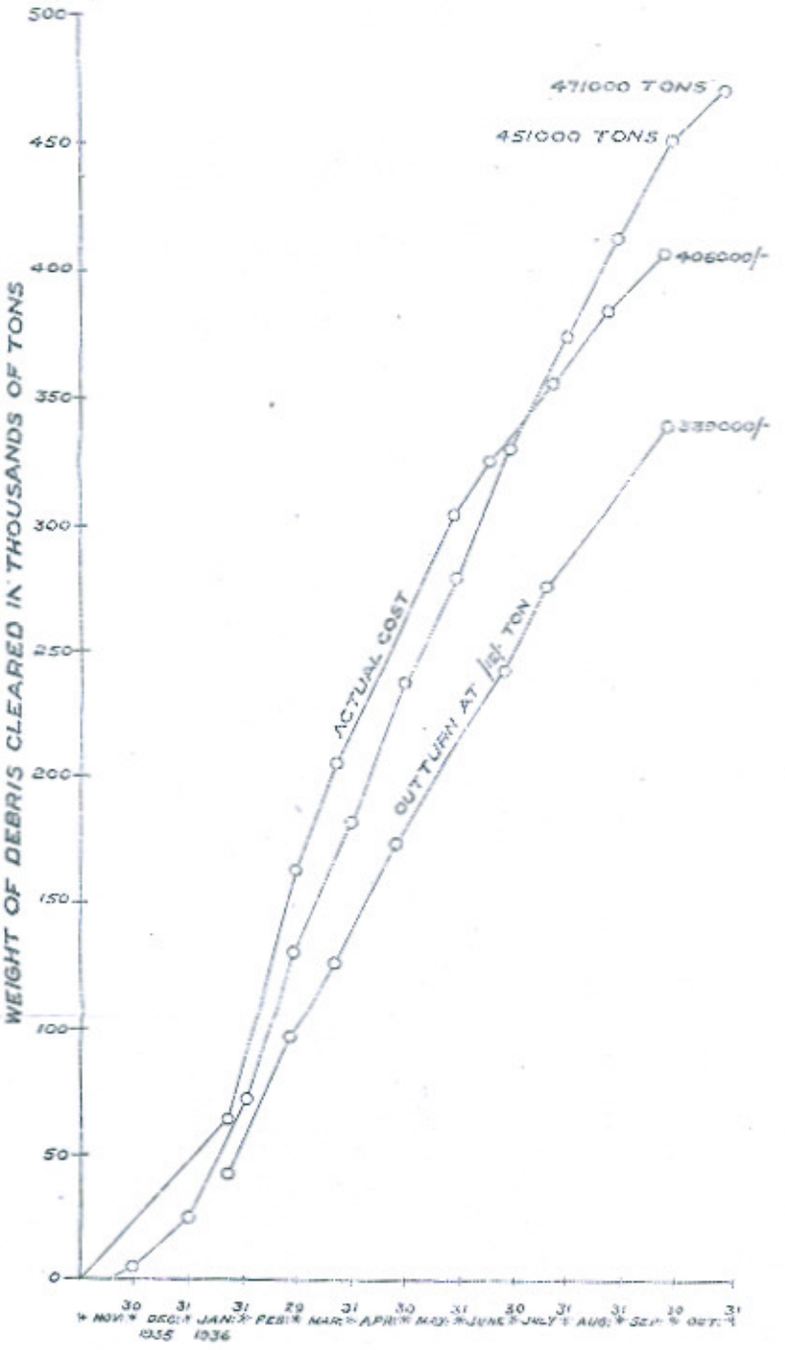
PAPER NO 206

CLEARANCE OF SITES

PROGRESS GRAPH

SCALE: VERTICAL 1" = 40000 TONS

PLATE No. 2
PAPER NO 206



QUETTA RECONSTRUCTION

PLATE No 3
PAPER No 206

LABOUR CAMP

SCALE 8" = 1 MILE

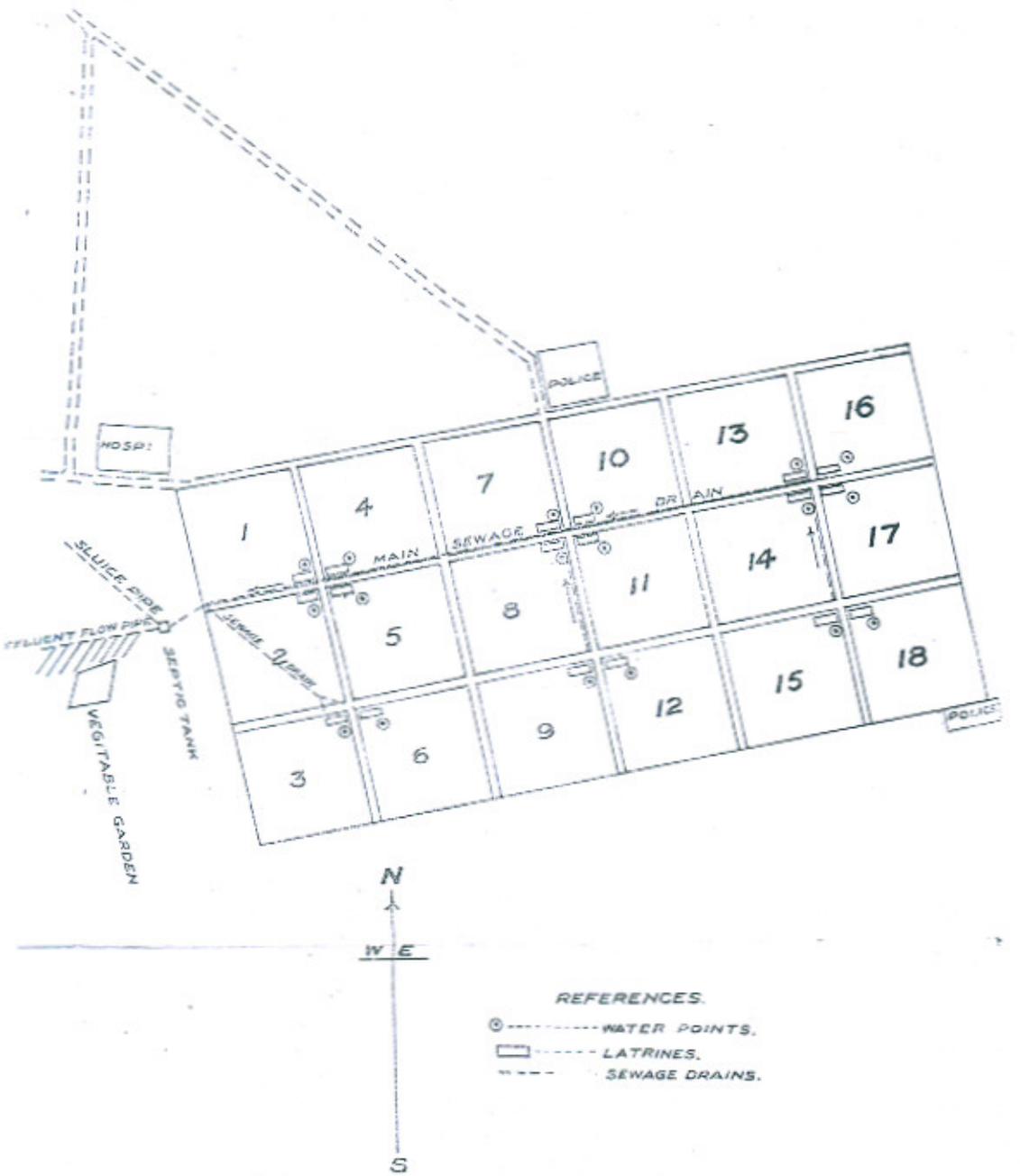
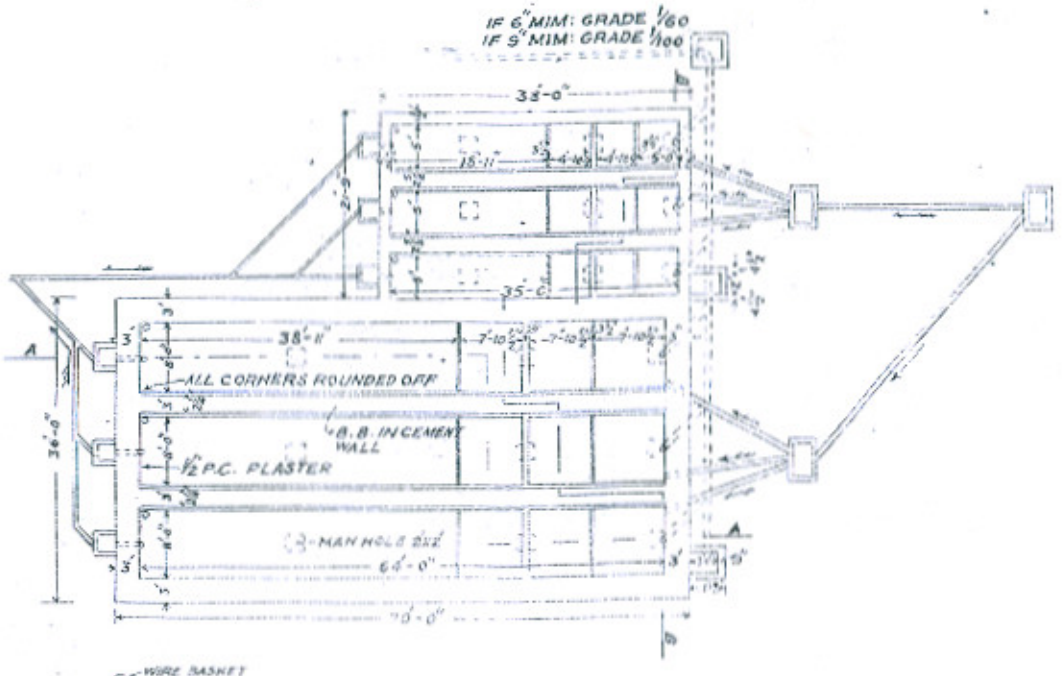
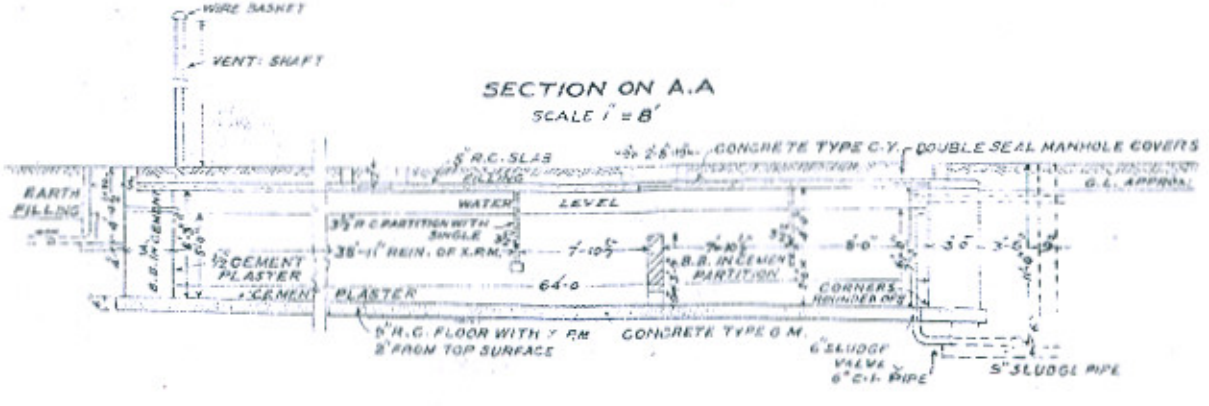


PLATE NO: 4
PAPER NO 206

QUETTA RECONSTRUCTION
COOLY CAMP SEPTIC TANKS
SCALE 1" = 16'





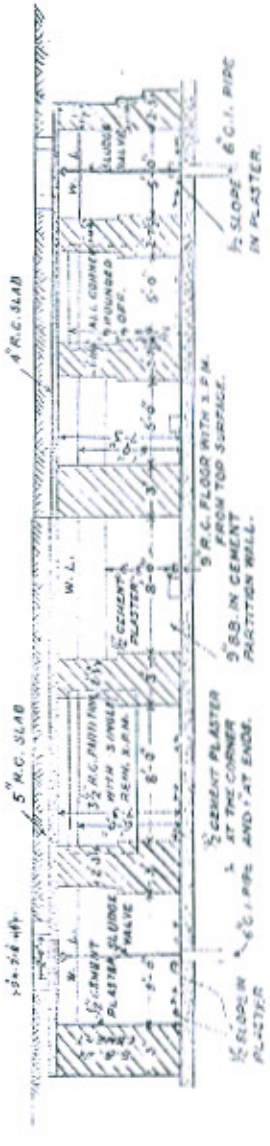
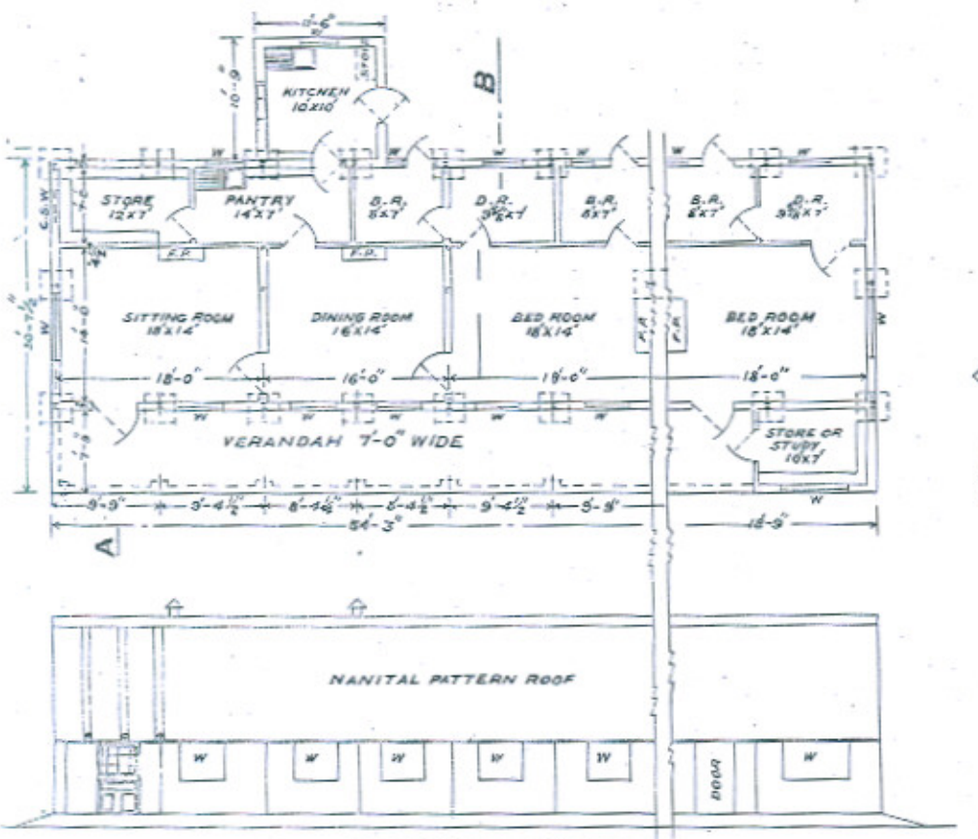


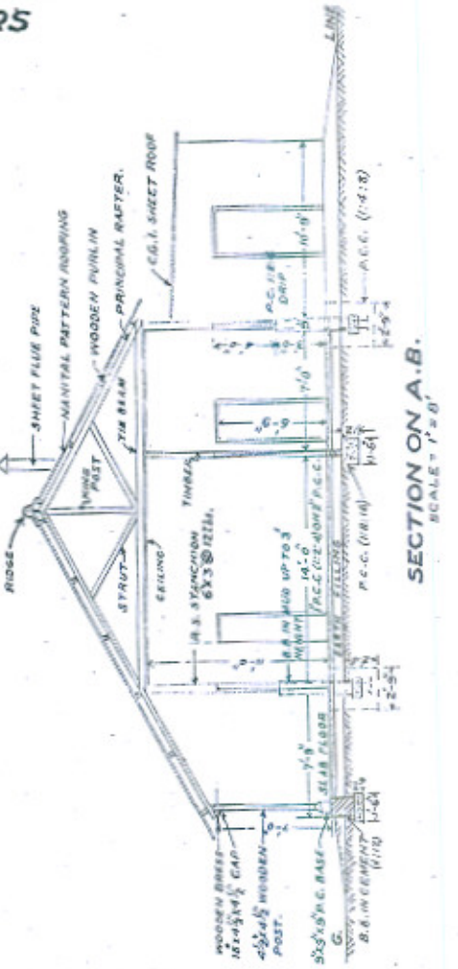
PLATE V
PAPER NO 206

PLAN OF TEMY: ACCO: OFFICERS

SCALE 1" = 12'



FRONT ELEVATION



SECTION ON A.B.

SCALE = 1" = 0"

SPECIFICATION OF FLOORS.

SITTING ROOM. WOODEN.
DINING ROOM. B. ON EDGE OR SLABS.
BED ROOM. WOODEN ON CONCRETE.
VERANDAH. SLABS.
BATH & DRESSING ROOMS. CONCRETE.

NOTE.

WINDOWS TO BE FIXED WITH HORIZONTAL & VERTICAL FRAMES FOR FIXING RABBIT WIRE OUT SIDE TO TAKE ½" THICK CEMENT PLASTER (1:5) TO VER: & CELOTEX TO BE FIXED INSIDE ALL ROOMS.

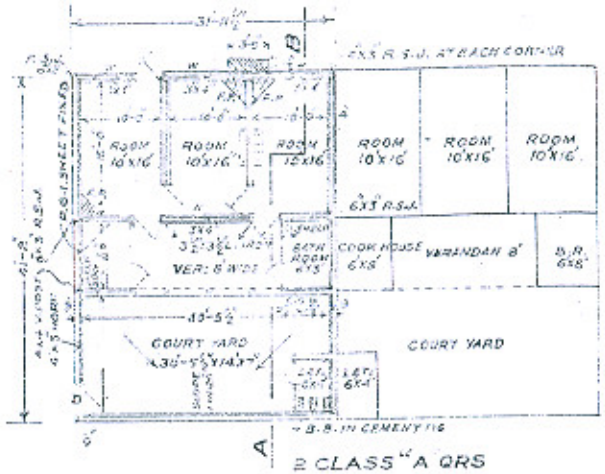
PLATE NO: 6

PAPER NO 206

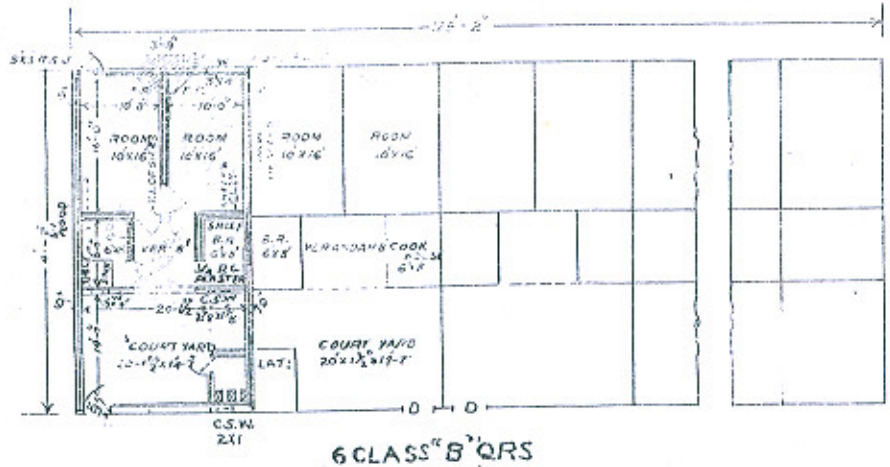
QUETTA RECONSTRUCTION

I.S.P's QRS

SCALE 1" = 16'



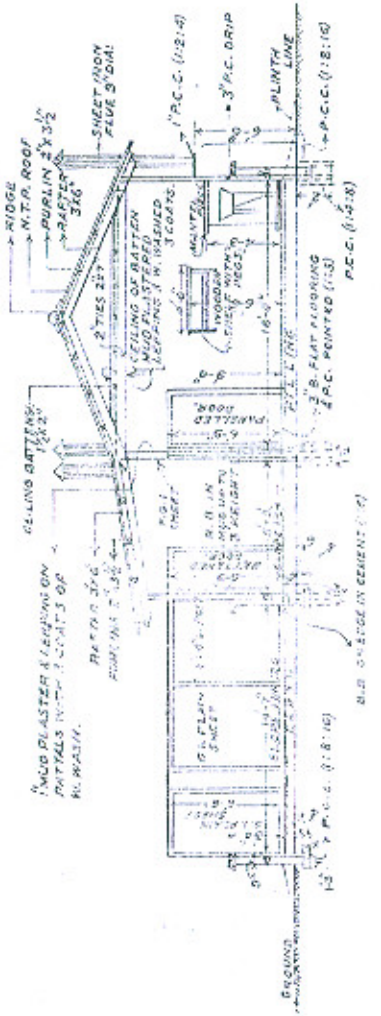
2 CLASS "A" QRS



6 CLASS "B" QRS

SECTION ON A.B.

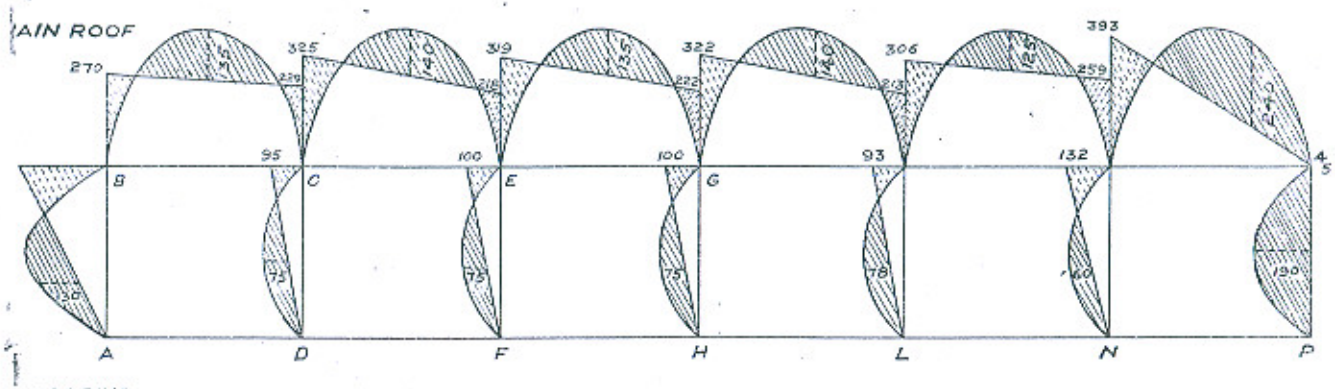
SCALE 1" = 8'



CLASS "D" TYPE QUARTERS
B. M. DIAGRAM

PLATE No. 7
PAPER NO. 206

LONGITUDINAL SECTION BLOCK OF 6 QUARTERS.
SCALE LINEAR 1" TO 8 FEET
MOMENTS 1" TO 400 LBS FT



MAIN SIDE WALL (WINDWARD) A.B. FULL WIND LOAD 20 Lbs/FT²
" " (LEE WARD) " SEISMIC + SUCTION 15 Lbs/FT²
PARTITION WALL " 10 Lbs/FT²

DISCUSSION.

Captain N. Boddington sent an apology for his inability to open the discussion. He had intended to be present but owing to illness on the part of other officers in the Reconstruction District he had been unable to obtain leave, and he wished to bring up the following points :—

Since the Paper was originally written, Group I—1 Indian Infantry and 2 Gurkha Lines—had been started. This work, which was being carried out by Messrs. Gammon Ltd., was of considerable interest as it was proposed to do all the work by vibrating concrete. At present it was still experimental, only three buildings having been concreted but various methods were being employed to improve the result obtained on the first building. The buildings concerned were Indian Officers' Quarters having about 600 square feet plinth area and consisting of 3 rooms, 2 verandahs, a bathroom and a kitchen. All the shuttering, made of steel, was erected complete with the reinforcement, doors, windows, etc., on a previously poured cheap concrete foundation. In the first building the concrete took 2 days ; in all it amounted to about 700 or 800 cubic feet. In the third building, however, it was all completed in 8 hours, and the result was a considerable improvement. The concrete itself was excellent. The chief difficulties were that in dropping the concrete from the top (about 10 feet) it was apt to get clogged up on the reinforcement and occasional gaps appeared in the final result. By scattering the concrete with a shovel instead of pouring it in straight out of the skips, this had been very considerably improved. By this method it was hoped to take about four days to erect the shuttering, etc., one day to concrete, two days to allow the concrete to obtain reasonable strength and two more days to remove the shuttering ; approximately one week per quarter. This method, although costly as regards the original shuttering, when each building had to be repeated about 50 times, was likely to become extremely economical.

Staff.

Owing to the increased work, staff had to be increased now to about 25 officers, including surveyors. These had not arrived at the time of the General Meeting but should do in the course of the next two or three months. Military and civil work to the extent of about one crore of rupees was expected to be carried out in 1937-38.

Clearance.

The total amount of materials so far removed was about 550,000 tons. Work had been slowed down to some extent in order that the labour employed might be carried right through the winter. This was better economically for the individuals concerned. Preliminary work

had been started on the new aerodrome and in this a very interesting use was made of the elevating grader, referred to in the Paper, as a nullah ran down the middle of the new site, and this had to be diverted to the sides of the aerodrome, necessitating a channel of about 25 square feet sectional area with about 10 feet turns and then small bunds made of the excavated material. This was very similar to the type of distributary in Punjab canals and the Elevating Grader did its work extremely well. It completed about 200 yards run per day. This was only about 15,000 cubic feet but as the total cost per day was Rs. 30 including depreciation, etc., it was considered that the rate of Rs. 2 per thousand cubic feet was economical, and the use of this machine might therefore be of interest to Canal Engineers present. The machine was quite capable of making canals up to 4 or 5 feet deep or even more, but it was preferable that the canal should be at least 8 feet wide in order that the whole machine could get down into the work. An ordinary grader was used in conjunction with the Elevating grader in order to make the work simpler and to give a better finish. The grader blade, being set on a skew, forced all the earth to the sides of the canal which made it easier for the elevating grader to pick up the earth.

Temporary Accommodation.

The following temporary accommodation, the Author said, had been completed :—

13 Officers' huts.

9 3-room I. S. P. huts with 4 still under construction.

43 2-room I. S. P. huts with 18 under construction.

These latter were all likely to be finished before March 15th.

Results obtained from some thousands of cubes tested at this work had shown that the increase in the strength between 7-28 days varied between 33 and 40 p. c. for all types of concrete used, and practically irrespective of temperature, provided the temperature remained at about 45° F. Further results were being collected and it was hoped at a later date, to obtain some information from a large number of experiments with regard to the effect on the increase in strength due to low temperatures.

Mr. **S. L. Kumar** remarked that the Author, on page 171, under sub-para. (*d*), mentioned that the working stress allowed in concrete was 750 lb. per square inch. The revised British Code of Reinforced Concrete permitted the same stress in flexure but it required concrete having a minimum compressive strength after 28 days of 2,700 lb. per

square inch. From the statement in paragraph 2, it was obvious that if the concreting done by the contractor gave, as tested in the laboratory, a breaking compressive strength of 2250 lb. per square inch, his work was accepted. Thus, while the working stresses in the concrete for design were the same as recommended by the British Code, the strength of the concrete demanded was at least one sixth less than that required by the British Code. Could the Author explain why this was so?

On page 171, it was mentioned that both in steel and concrete additional stress up to 25 p.c. of normal working stress was allowed when considering the effect of seismic forces. The Earthquake Sub-Committee which represented all Government departments at Quetta and which was presided over by Col. Kidner recommended 50 p.c. additional stress for steel and 25 p. c. for Reinforced Concrete Construction. The Railway Department adopted these stresses. It was not understood why the Military Department did not accept an enhancement of 50 p.c. in the case of steel structures. It would have effected considerable economies.

The speaker said that early in 1936, he had gone though the specifications for earthquake-proof buildings issued by the Military Department. The specifications were so conservative and the various assumptions were so drastic that he could say confidently that the Railway Department would be able to build their earthquake-proof houses about 20 to 25 p.c. cheaper after allowing for a reasonable margin of safety against seismic forces. He did not know whether these specifications had since been altered.

On page 173, there was a note which stated that 20 lb. per square feet windward and 10 lb. per square foot leeward was the seismic load of g/8. There appeared to be some misprint here.

It would have been very interesting if a detailed drawing had been given in the Paper of a class D type quarter, as it would have enabled others to check the strength by different methods and to compare results with those obtained by the Author.

On page 175, some figures were given in the table in brackets What did they indicate?

Captain N. Boddington, the Author of the Paper, in answer to various points which were raised during the discussion said the following points were of interest:—

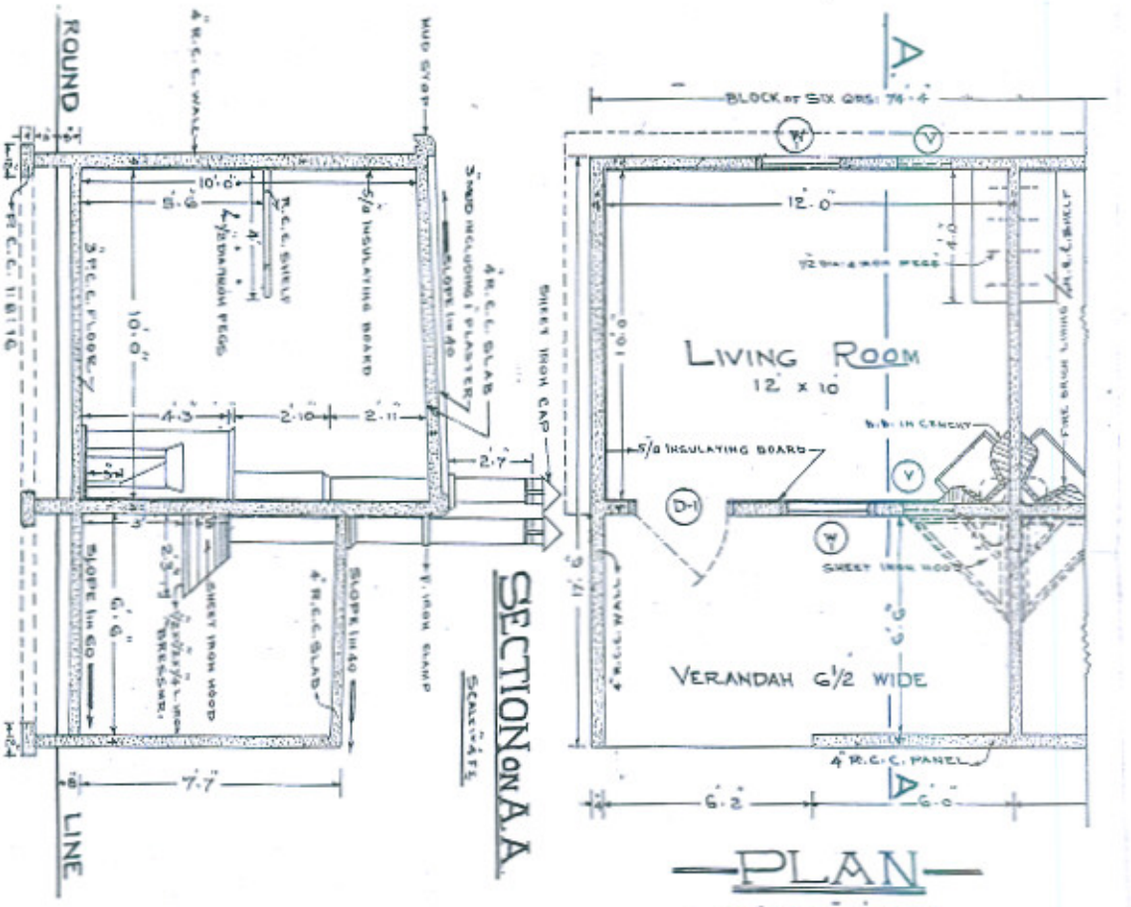
It was stated that the specification was conservative. This was admittedly so, but in view of the tragedy which occurred at Quetta there could be very little doubt that it was quite justified.

It was stated that Railway structures were cheaper. Experiments were being carried out with regard to the use of brick structures, but the strength of concrete was already known for certainty, whereas the real strength of brick structures in an earthquake area was a matter of some conjecture, and therefore in order to start work quickly—an extremely important point—it was essential that concrete should be used until such time as sufficient data as regards brick could be obtained.

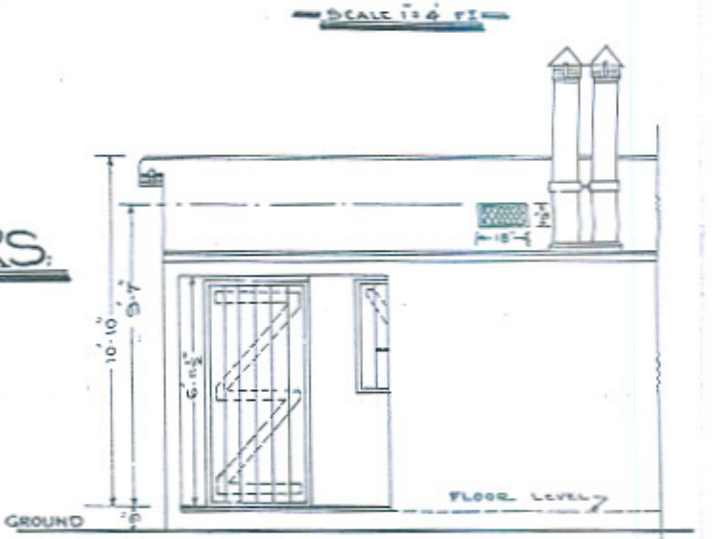
As regards the allowance of 750 lb. per square inch in the design of concrete works the minimum allowable crushing strength accepted for specimens was 2250. This meant a factor of safety of 3. For earthquakes which were of comparatively rare occurrence, an allowance of 25 p.c. more than 750, *i.e.*, just under 1,000, was made as the factor of safety would still be over 2, and in view of the fact that concrete went on becoming stronger for a considerable period after 28 days it was quite obvious that when an actual earthquake occurred, the strength would probably be over 3000, and therefore the original factor of safety would be obtained. The factor of safety 3 at 750 lb. was essential as final stresses, except from seismic forces, came on to the building immediately the shuttering was removed. In fact, in most cases, particularly in roofs and walls, the heaviest loads in single storey buildings occurred during construction.

A Line drawing and other drawings of class D quarters were now enclosed. It was hoped that this would make the calculations for these quarters clearer.

PLATE 8
PAPER No. 206



CLASS "D" QRS.



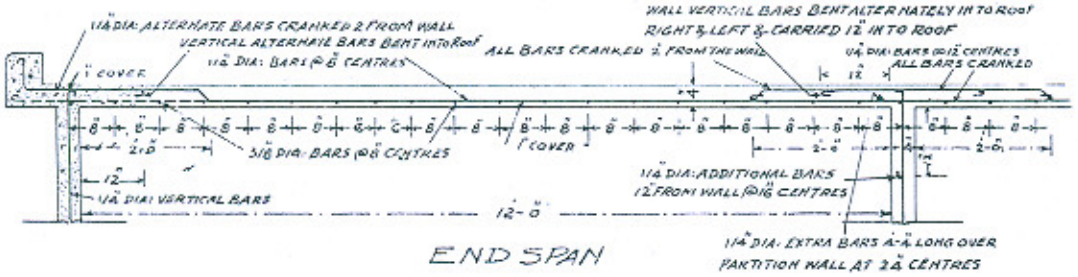
FRONT ELEVATION

PLATE: 9

PAPER No 206

QUETTA RECONSTRUCTION

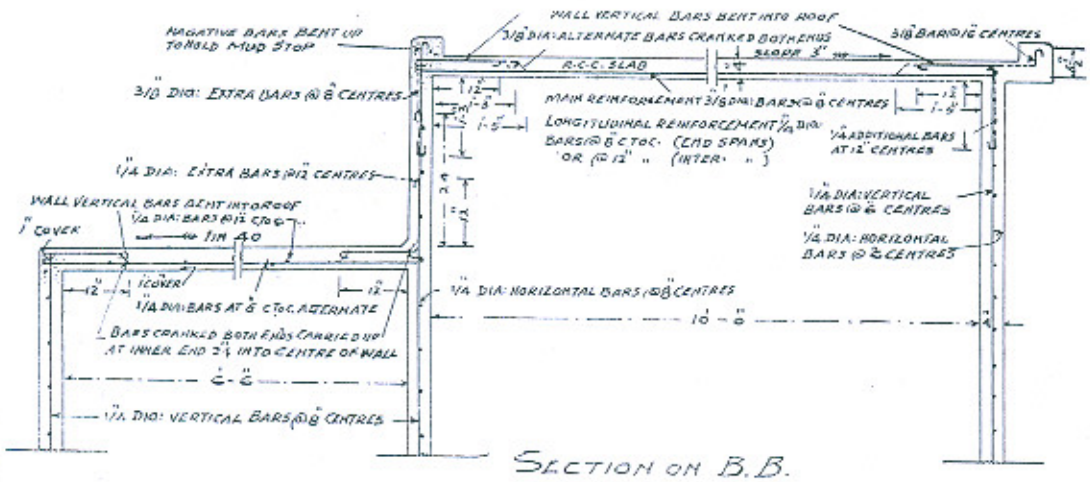
CLASS "D" QRS:



END SPAN

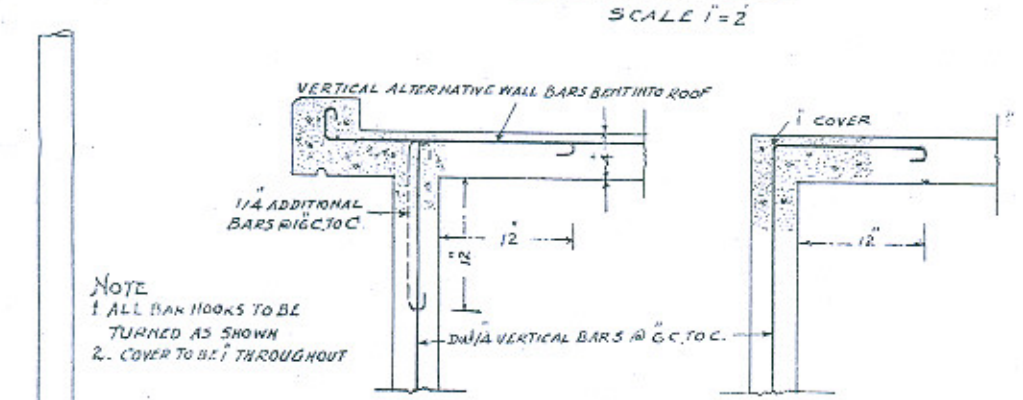
SECTION OF MAIN ROOF on A.A.

SCALE 1" = 2'



SECTION on B.B.

SCALE 1" = 2'

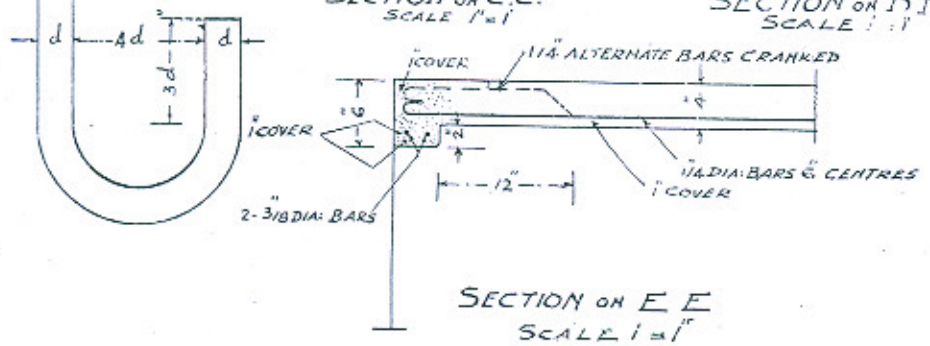


SECTION on C.C.

SCALE 1" = 1'

SECTION on D.D

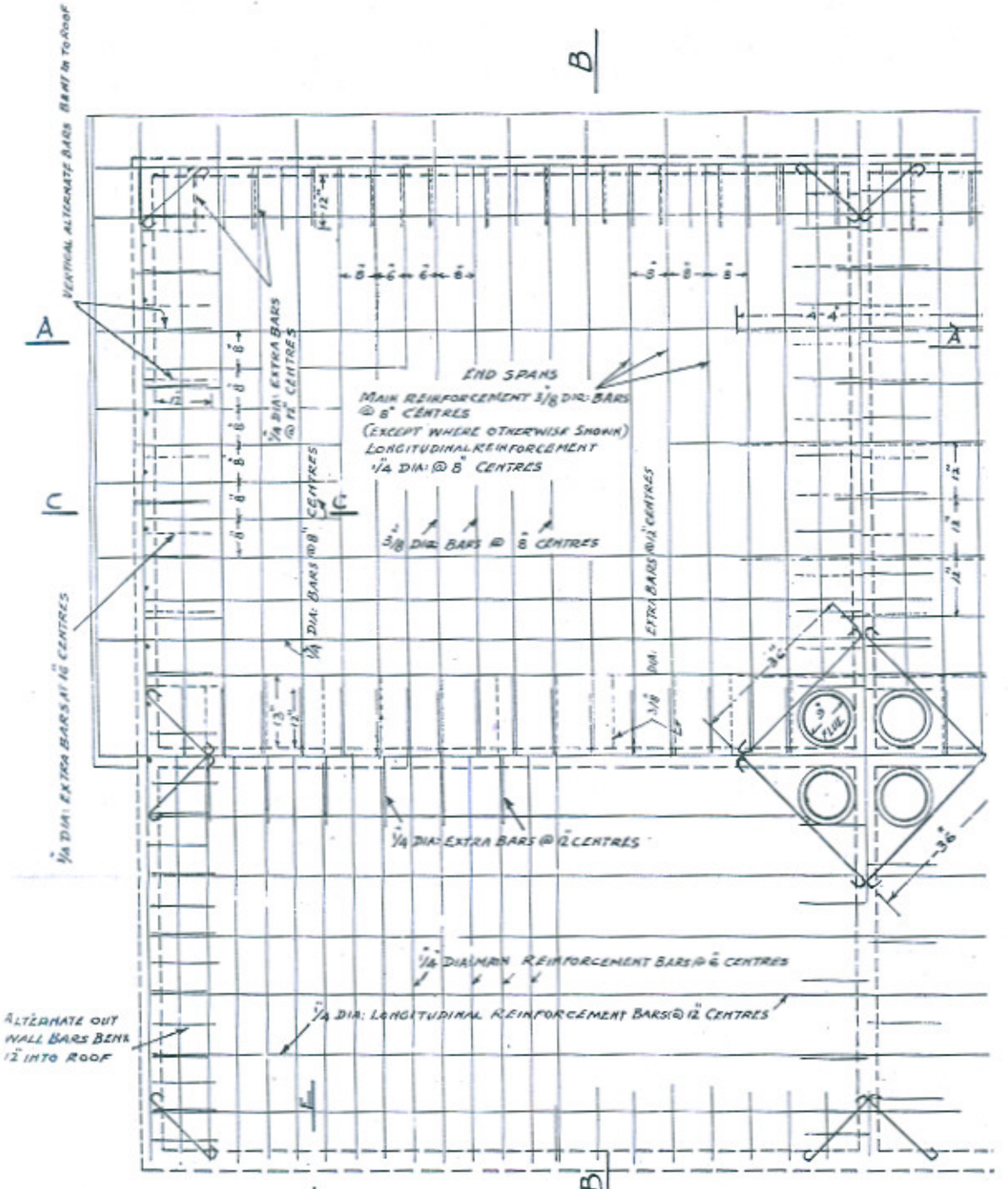
SCALE 1" = 1'



SECTION on E.E

SCALE 1" = 1"

PLATE 10
PAPER No. 206



QUETTA RECONSTRUCTION
CLASS "D" QRS:
ROOF PLAN
SCALE 1" = 2'