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Field trials of new construction techniques used for dispensary extension

J. S. Sharma, G. C. Sofat and Lathika Jaisingh

Field trials of certain new construction techniques developed by the Central Building Research Institute, Roorkee are described. These include stone masonry blocks placed with a lime-based mortar, and grouted brick masonry, for walls; and bamboo reinforced concrete, brick arch slab with gypsum mortar, and 600-mm wide channel units, for roofing. The paper describes the experiences gained during construction, the performance and the economics of the different techniques.

An opportunity was presented in the extension to the Shantinagar dispensary to try out some new construction techniques developed at the Central Building Research Institute, Roorkee and for which laboratory tests had showed satisfactory results.

The problem

The extension consisted of a three-bed ward, a small laboratory room and verandah. The existing toilet facilities were not to be changed. The architect wanted the extension to be so planned that the elevation of the existing building be maintained and that in due course the dispensary should look as if there has been no extension and that the whole building is one. The extension was, therefore, planned in such a way that the elevation matched with the existing building and the types of windows, ventilators, doors and the roof projection were all kept the same as in the existing building, *Fig* 1.

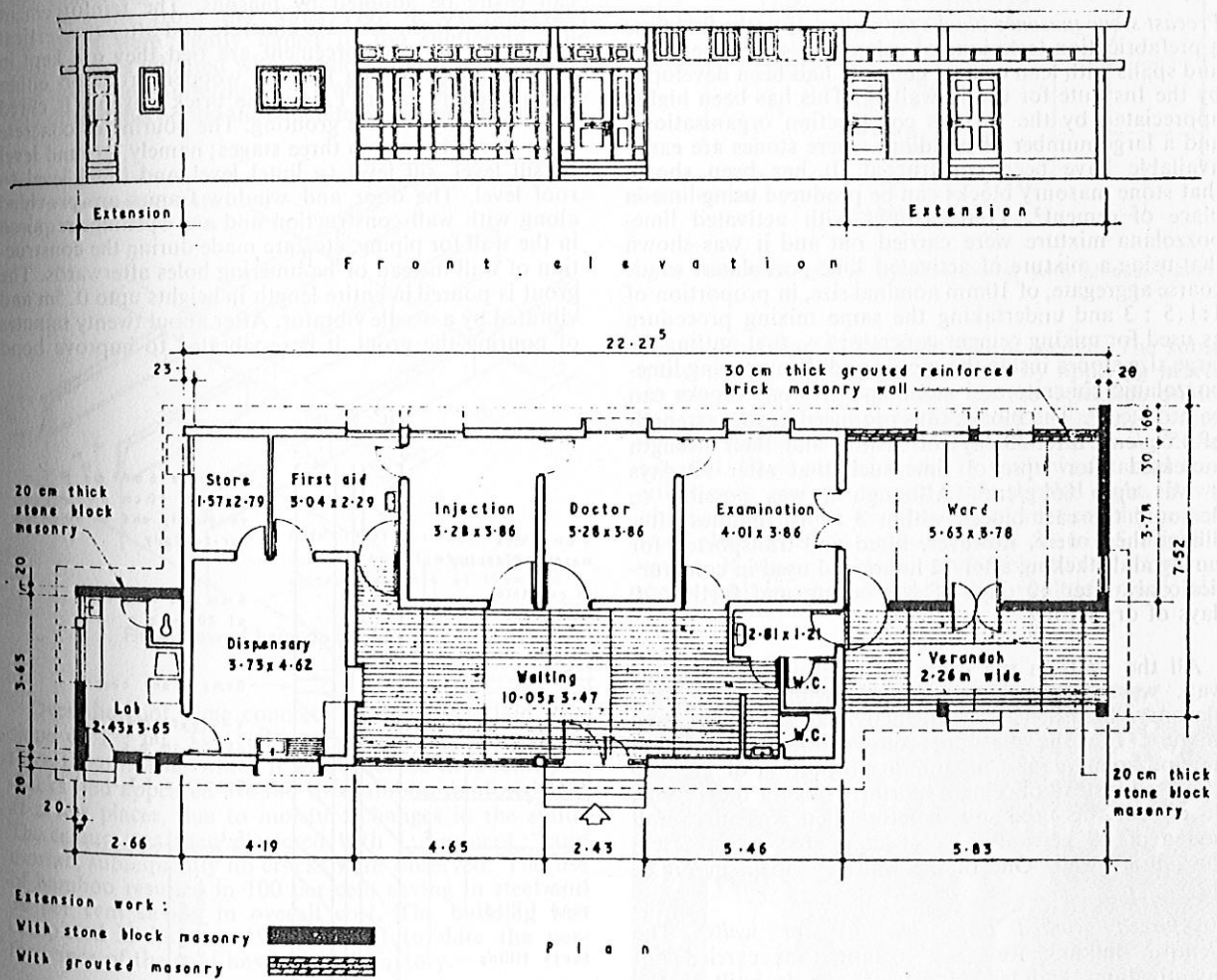

Fig 1 Plan of extension of dispensary

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Types of techniques used

It was decided to use the following two techniques for walling:

(*i*) precast stone masonry blocks built with activated lime-pozzolanic mixture

(*ii*) reinforced grouted brick masonry.

And for the roofs the following three techniques was decided upon:

(*i*) bamboo reinforced concrete slab for the laboratory

(*ii*) brick arch slab with gypsum mortar for the ward room

(*iii*) 600-mm wide precast channel unit for the verandah.

It was also decided that since these were new techniques, the work would be carried out departmentally so as to gain knowledge of any difficulties or points needing attention, and also to assess the economics of their performance as well.

Types of walling units

Precast stone masonry blocks for walls: For the first time a prefabrication technique of using large size stone pieces and spalls with lean cement concrete had been developed by the Institute for use in walling. This has been highly appreciated by the various construction organisations, and a large number of buildings where stones are easily available have been constructed. It has been shown that stone masonry blocks can be produced using lime in place of cement[1]. Trial castings with activated lime-pozzolana mixture were carried out and it was shown that using a mixture of activated lime-pozzolana: sand: coarse aggregate, of 10mm nominal size, in proportion of 1:1.5 : 3 and undertaking the same mixing procedure as used for mixing cement concrete; *i.e.*, first putting the large size stones inside the mould and then pouring lime-pozzolanic concrete and stone spalls, stone blocks can be produced[2]. The blocks thus produced gave a strength of 45kg/cm². after 30 days of casting and their strength increased after lapse of time such that after 90 days it was upto 85kg/cm². Although it was possible to demould the cast blocks within 8 to 10 minutes after filling, these were, however, lifted and transported for curing and stacking after 72 hours and used in construction only after 10 days of wet curing and further 20 days of dry curing.

All the walls in the proposed extension, except one wall, were 20cm thick and built with precast stone masonry blocks cast with activated lime-pozzolana mixture. For the masonry construction, an activated lime-pozzolana: sand mixture in proportion of 1:3 was also used instead of cement mortar. Thus for these walls, no cement was used and therefore there was an overall saving of 19 percent in cost compared to a 23cm thick brick wall. One of the walls is shown in *Fig* 2.

Reinforced grouted brick masonry for walls: The Central Building Research Institute has carried out investigations and testing of wall panels built in the form of reinforced grouted brick masonry and it was found that such walls could be used as load bearing shear walls in high rise buildings[3]. To further investigate the construction of such walls, it was decided that one wall of the dispensary extension should be made of reinforced grouted brick masonry. Hence, the rear wall of the ward was built using this technique, *Fig* 3.

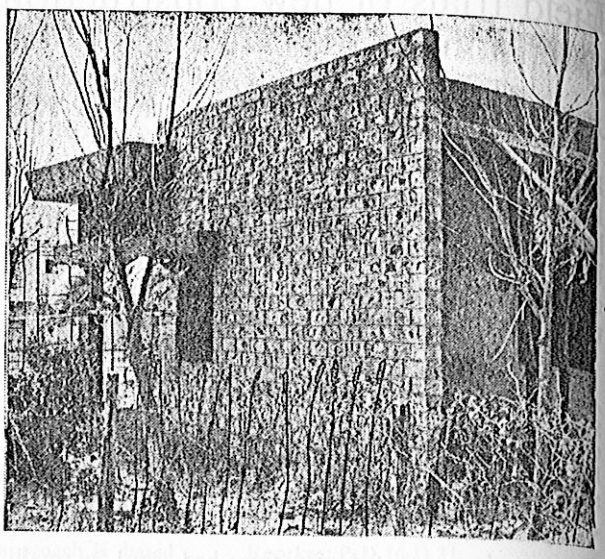

Fig 2 Wall with stone masonry blocks

It was found that the system is simple and one that can easily be adopted by masons. The reinforcement is provided from the base concrete and after the vertical and horizontal reinforcement are tied they are kept in position by providing inclined wooden props on either side placed at about 1.5m. The brick masonry is cured for 3 to 4 days before grouting. The pouring of concrete for a storey is done in three stages; namely, ground level to sill level, sill level to lintel level, and lintel level to roof level. The door and window frames are provided along with wall construction and any openings required in the wall for piping, etc., are made during the construction of wall instead of hammering holes afterwards. The grout is poured in entire length in heights upto 0.5m and vibrated by a needle vibrator. After about twenty minutes of pouring the grout, it is re-vibrated to improve bond

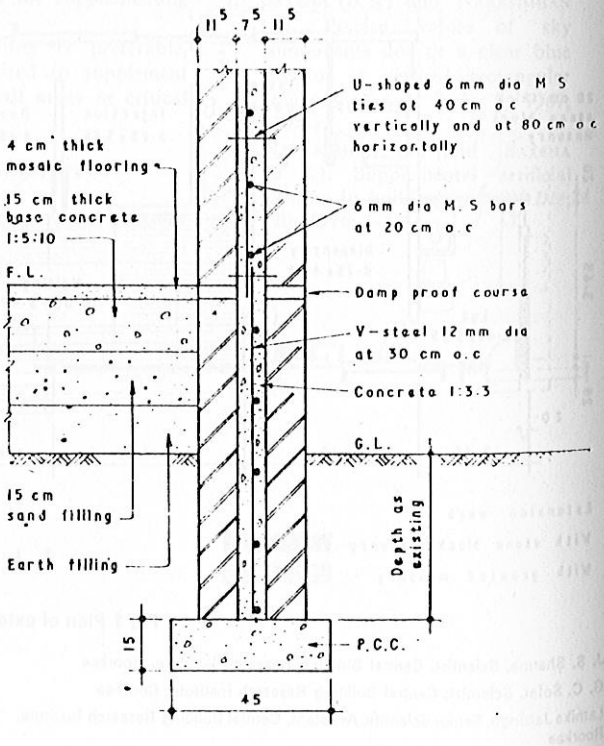

Fig 3 Cross-section of grouted reinforced wall

between the grout and the masonry before it looses its plasticity. The masonry was cured for 14 days by sprinkling water at intervals.

Types of roofing units

Bamboo reinforced concrete slab: The CBRI has carried out studies on the use of split bamboo as reinforcement in concrete slabs and it was found that for spans upto 3.2m, it can be safely used[4]. It was therefore decided to provide the roof of the laboratory of the Shantinagar dispensary with bamboo reinforcement to study its performance.

Since there was a necessity of providing a projection of 0.9m in roof and the reinforced parapet, the bamboo reinforced slab was cast on a lower level and the roof projection and parapet were provided by having a reinforced concrete beam on three sides.

The bamboo splits were given an ascu treatment to protect them from the attack of insects and micro-organisms. The splits were soaked in water for a week and after laying on shuttering and tying of reinforcement the concreting was done within 24 hours of removal of the splits from the water, *Fig* 4. At intervals, the splits were lightly nailed to the shuttering. The concrete was vibrated with needle vibrator as is normal practice. The shuttering was removed after 10 days, and during this period the concrete was cured by ponding.

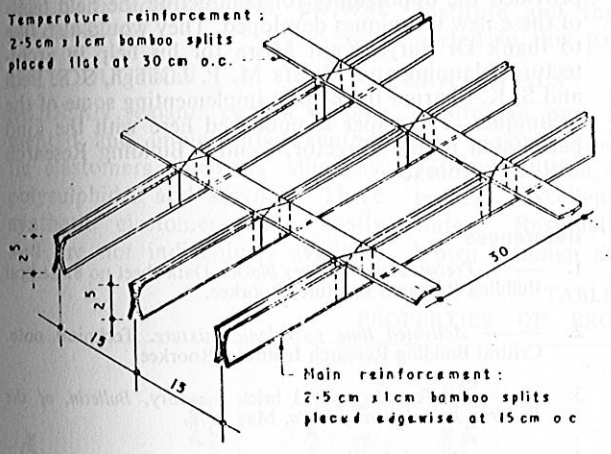

Fig 4 View of bamboo reinforcement

Over the roof, lime concrete terracing was laid to a slope of 1 : 60. The ceiling was kept unplastered for three months after which it was observed that some fine cracks had appeared around the bamboo reinforcement at a few places, due to moisture changes in the splits. The ceiling was then plastered with 1:3 cement : sand mortar; subsequently no cracks were observed. The use of bamboo resulted in 100 per cent saving in steel and 30 per cent saving in overall cost. The building was completed in January 1976 and till to date the performance of the roof has been satisfactory.

Brick arch slab with gypsum mortar: The Institute had carried out studies to make brick vaults using gypsum mortar for which no shuttering is required since the mortar set quickly and attains sufficient strength to hold the bricks togethers. Since gypsum mortar was readily available close-by at Rishikesh, it was decided to undertake a field trial of this technique, so as to work out the labour requirement, and to study its performance. This technique was used for the roof of ward in which three precast reinforced concrete I-joists at 1.2m centres were first placed on the walls, and in the end bays two 16-mm diameter mild steel tie rods were provided, *Fig* 5. In between the I-joists on the walls, a camber of 5cm was formed in masonry and mortar. The first row of the brick vault, 11.5cm thick, was built by laying bricks as headers partly resting on the masonry wall with about 10cm projecting out. The laying was started from either end and proceeded in the profile of the camber upto the centre of the crown, taking care that

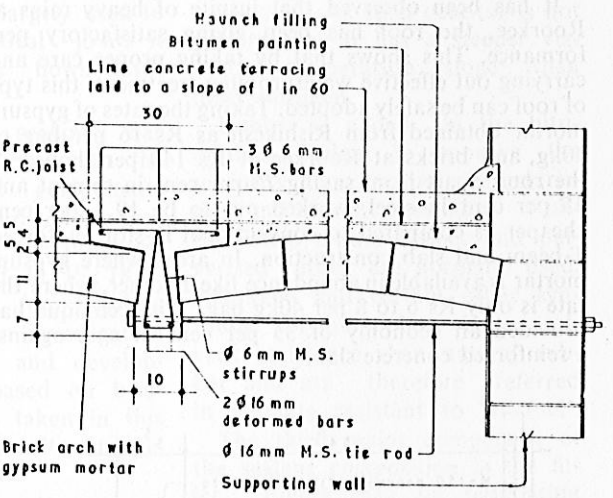

Fig 5 Brick arch laid in gypsum mortar with precast I-joist

the crown brick fitted tight like a wedge. The subsequent rows were laid as stretchers by applying mortar on the previous row and also on the brickside on top and pressing hard, *Fig* 6. The bricks were kept pressed by the masons for about 20 seconds or so and then released. Each row of bricks in vault was started from either ends and the crown brick pressed tight. It was observed that after about a day's practice the masons were able to lay in an hour about 30 to 35 bricks in vaults. It was considered preferable to lay about one metre vault in a bay and then lay a vault in an adjoining

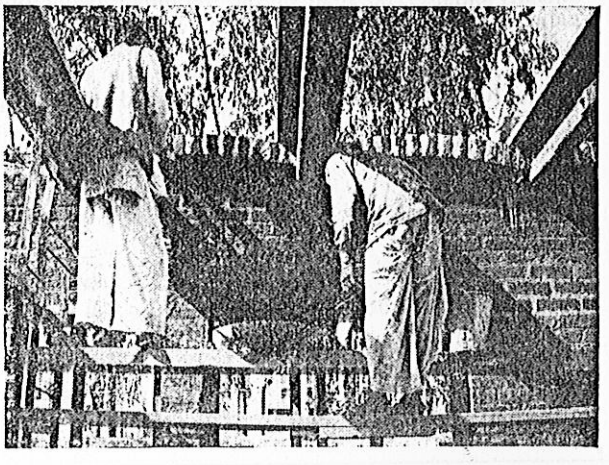

Fig 6 Brick arch slab with gypsum mortar under construction

bay rather than complete one full vault at a time. If more masons are available, the laying of brick vaults can be carried out simultaneously in all bays. The gypsum: sand mortar of proportion 1:2 was found to be suitable and although dry mixing of the gypsum and sand was done in large quantity, water was added only to small quantities to the dry mixture which could be used within 2 to 3 minutes. To see that the brick vaults are laid to proper camber, timber template of the required camber was made and this was placed over the precast I-joists and slid as the work progressed.

When all the vaults were laid, the haunches at top were filled with lime concrete and the roof levelled. Afterwards the top surface was painted with hot bitumen at the rate of 1.7kg/m², over which a lime concrete terracing was laid to a 1 : 60 slope.

It has been observed that inspite of heavy rains at Roorkee, the roof has been giving satisfactory performance. This shows that by taking proper care and carrying out effective waterproofing treatment, this type of roof can be safely adopted. Taking the rates of gypsum mortar obtained from Rishikesh as Rs 16 per bag of 40kg, and bricks at Roorkee at Rs 140 per thousand, the roof, apart from saving 75 per cent in cement and 45 per cent in steel, worked out to be 19.1 per cent cheaper as compared to conventional in-situ reinforced T-beam and slab construction. In areas where gypsum mortar is available in abundance like Bikaner, where the rate is only Rs 6 to 8 per 40kg bag, this technique has provided an economy of 35 per cent in cost against a reinforced concrete slab.

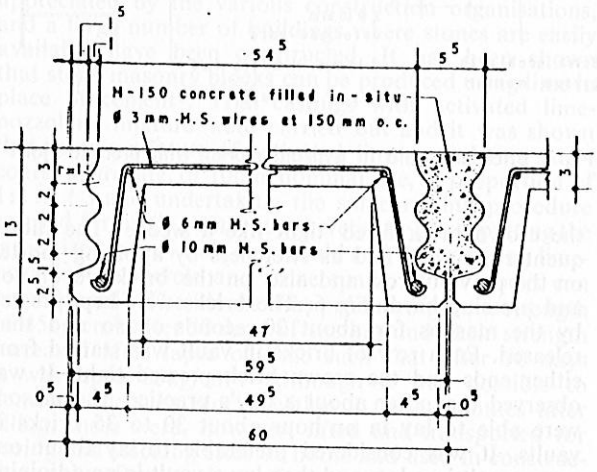

Fig 7 Cross-section of channel unit

Channel units: The span of the verandah being only 2.8m, it was decided to adopt 600-mm wide channel units, *Fig* 7 against the normal 300-mm wide channel units[6]. These channel units were cast in the same way as the 300-mm wide units. They weighed 150kg and were handled and transported by six men. After placing the units on the wall on one side and on the reinforced beam on the other side and aligning properly, cement slurry was first applied in the joint between the units. Afterwards M150 concrete with 10-mm nominal coarse aggregate was filled and compacted upto about 5mm lower than the top of unit. The concrete of the joint was cured for a week by sprinkling water and afterwards allowed to dry for 3 to 4 days. Hot bitumen was then filled over the joints in 5-mm space and afterwards the entire roof surface was painted with hot bitumen at 1.7kg/m². Lime concrete terracing was laid over this to a slope of 1 : 60. The joints at ceiling were pointed with 1 : 3 cement-sand mortar to form a V-groove. The 600-mm wide channel units provide a better view compared to 300-mm wide units. Where handling and lifting facilities are available, these should be adopted as it gives greater saving in cement and steel consumption compared to 300-mm wide units.

Conclusions

Field trials of the new construction techniques adopted for the extension of Shantinagar dispensary shows that these techniques are simple, save scarce materials like cement and steel and give satisfactory performance. They should be adopted where these materials are available in abundance and at low price. The techniques can be easily learnt by the various skilled workers available at construction sites with very little training and practice.

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