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DEVELOPMENT OF SPECIAL PURPOSE PAVING BLOCKS IN INDIA

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SUMMARY

Developments in regard to the use of precast paving blocks have been on different lines in India. Central Road Research Institute has undertaken studies for developing special block pavements for applications such as (1) roads in desert areas, (2) creteways for providing road access to rural areas, (3) warehouse floorings, storage areas, and pavements in the vicinity of service lines, involving utility cuts and their expeditious reinstatement, and (4) pavings for footpaths and bus-stops. The paving blocks for desert areas are hexagonal with 56 cm side and a ribbed bottom having radial and peripheral ribs for confining sand. They also have a sturdy system of inter-connecting steel dowels. The blocks for creteways are 90 cm x 60 cm x 10 cm and are interconnected with steel dowels. They are laid in two strips of 90 cm width, separated by a distance of 75 cm, and are intended to serve light, slow-speed traffic such as bullock carts, tractor-trolleys, jeeps, etc. They can be utilised in areas subject to periodic flooding.

The blocks for warehouse floorings and pavements are uniform-thickness hexagonal blocks with a side of 25 cm. They have an interconnecting system of inclined dowels. The blocks for footpaths and bus-stops are 30 cm x 30 cm x 10 cm. The 10 cm thickness consists of 9 cm lean concrete or lime-puzzolana concrete overlaid with 1 cm layer of cement mortar to improve abrasion resistance.

After necessary laboratory evaluations, field trials are in hand to further refine the concepts and promote their use.

1. INTRODUCTION

1.1 Developments in India with regard to the use of precast paving blocks have been on lines different from those in some other countries. This is essentially because of differences in regard to economics, construction methods and uses. For some years now, the Central Road Research Institute has been engaged in developing different types of paving blocks for specific uses.

1.2 The work at C.R.R.I. has been directed towards the following four uses:-

(a) Hollow hexagonal block paving for roads in desert areas.

(b) Rectangular block paving for providing road access to small rural communities.

(c) Hexagonal blocks for paving of footpaths and passenger shelters at bus-stops.

(d) Square blocks for paving of footpaths and passenger shelters at bus-stops.

The salient features of these special purpose paving blocks are described in this Paper.

2. BLOCK PAVING FOR ROADS IN DESERT AREAS

2.1 In the north-western parts of India lies the Thar Desert where conditions with regard to roads are quite different. There are vast expanses of fine dune sand which is poorly graded. Hard stone is not locally available by and large, and the calcareous deposits available here and there yield only soft aggregates. The rainfall is quite scanty and water tends to be a scarce commodity in dry months. The traffic is generally not heavy and the roadways are susceptible, in varying degrees, to the deposition of drift sand, requiring periodic clearance.

2.2 The conventional road construction in these parts has consisted in sub-bases of soft aggregates, water-bound macadam base courses and thin bituminous surfacing. This involves very considerable transportation of materials and also large quantities of water. Thought was therefore given to the feasibility of a precast block pavement for which precasting would be done at

or close to the site of availability of construction materials, thus requiring the transportation of only the finished components to the paving sites. For the development of this new pavement system (1), the factors kept in view were: as far as possible, the precast blocks may form the complete pavement for being laid directly on the prepared subgrade; the size and weight of the paving blocks be such as is amenable to manual operations; hollow blocks may be more efficient, structurally, in view of the nature of subgrade soil; structural continuity through load transfer would enhance the efficiency of the system; and the pavement system may cater only to medium intensity of traffic. Based on these considerations, a new precast block pavement system was conceived with hexagonal hollow blocks forming the interior and pentagonal hollow blocks forming the edges. These have half-dowels at each mid-face for inter-connection, through a sleeve, with the corresponding half-dowels in adjacent blocks.

2.3 A sandy bed was established on the heavy test-bed of CRRI which has a semi-mobile load frame for static and repetitive (coupled with a load alternator) loading. The blocks were tested individually, as well as in combination, under both static and repetitive loading (Figure 1) and the designs and dimensions were optimised in the light of this test data, including the failure patterns. Shown in Figures 2 and 3 are the under-side views of the interior and edge blocks respectively. A typical paving configuration with these blocks is presented in Figure 4. This pavement is initially intended for roads carrying traffic intensity of upto 200 commercial vehicles per day. A plot of vertical displacements versus load repetitions (4.25 tonnes on 30.5 cm dia plate) is shown in Figure 5.

2.4 The interior blocks of hexagonal shape have 0.56 m as side, with surface area of 0.81 m^2. The solid volume content is 0.091 m^3, with a resulting weight of 210 kg. The pentagonal edge blocks match with the hexagonal blocks. Three slightly different designs have been prepared to have a wide range of carriageway widths. The surface area ranges from 0.54 to 0.68 m^2. The largest edge block has solid volume of

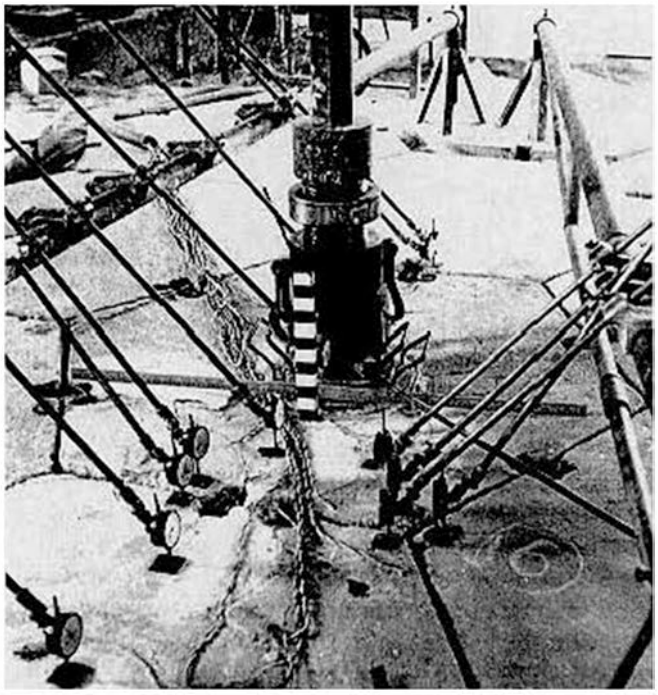


Figure 1: Block paving for desert areas under load test on the test-bed

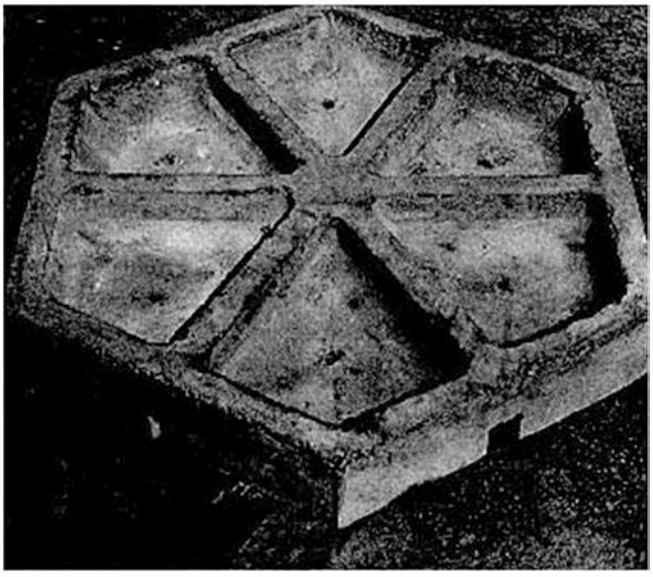


Figure 2: Under-side view of interior block.

0.092 m^3 and weight of 213 kg. The other 2 types of edge blocks are slightly smaller and lighter. The dowel-sleeve system provides load transfer of the order of 40%, thus contributing to the efficiency and continuity in the pavement system.

2.5 The blocks can be handled, for paving, both mechanically and manually. On the densified formation, the blocks are placed in position after loosening

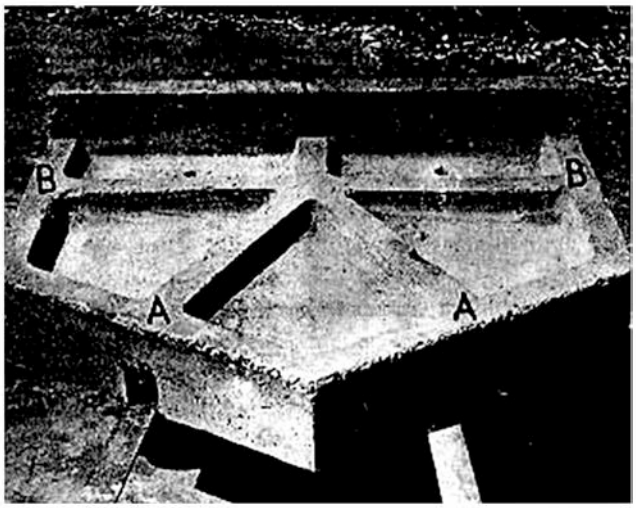


Figure 3: Under-side view of edge block.

the subgrade top for facilitating the embedment of blocks. The hollows under the blocks have a hole each for entrapped air to escape and for putting in extra sand with a sand-pump or otherwise so that the hollows are properly filled with densified sand. The embedment as well as the evenness of the riding surface is improved if a medium weight vibratory roller (Figure 6) is operated on the blocks and then additional sand is injected and sleeves brought on.

2.6 This type of pavement is quite cost-effective, even in terms of initial cost when stone has to be brought in over long leads for conventional pavement construction. Full-scale trials are now in hand

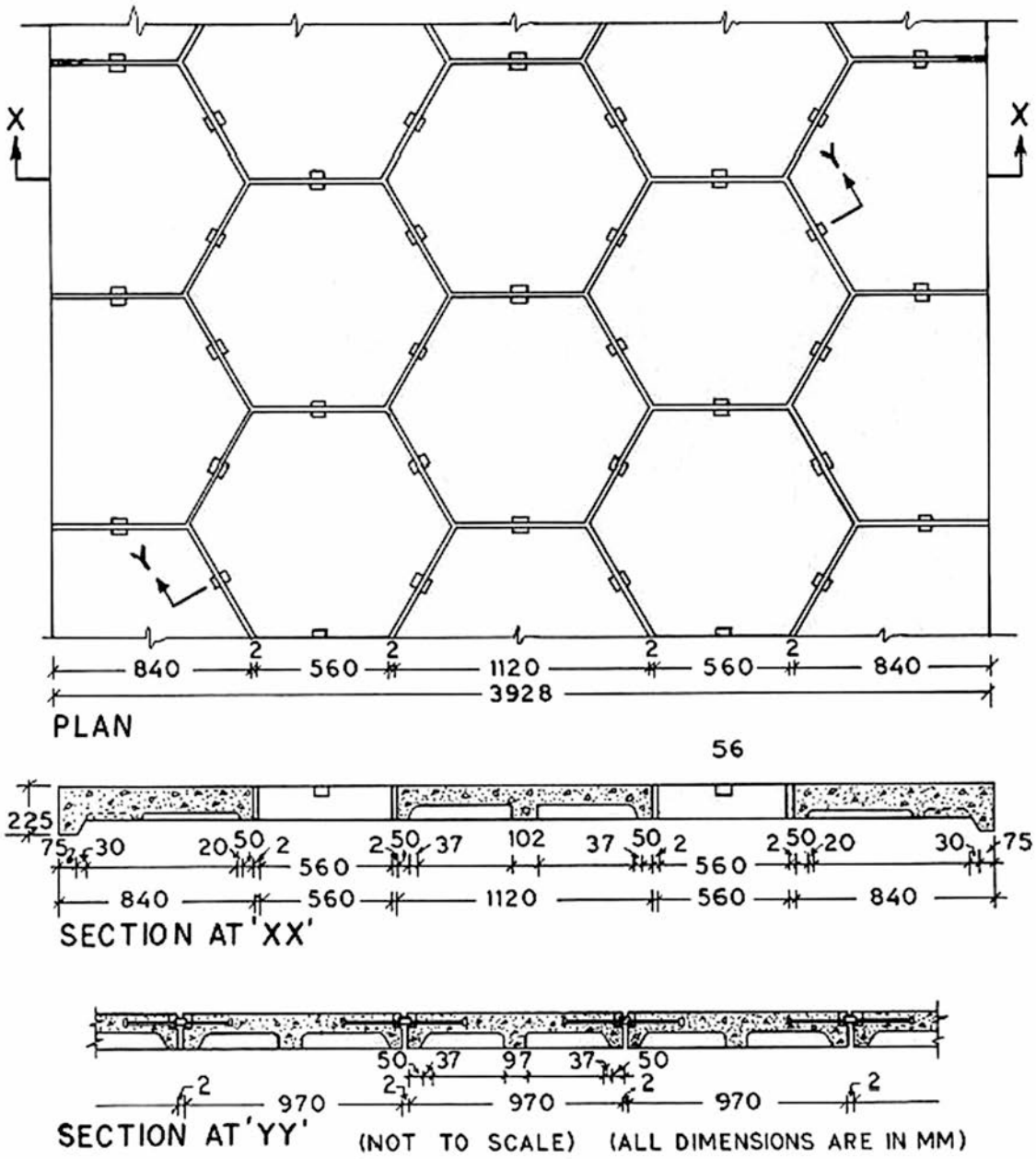


Figure 4: A typical configuration of block paving for desert areas

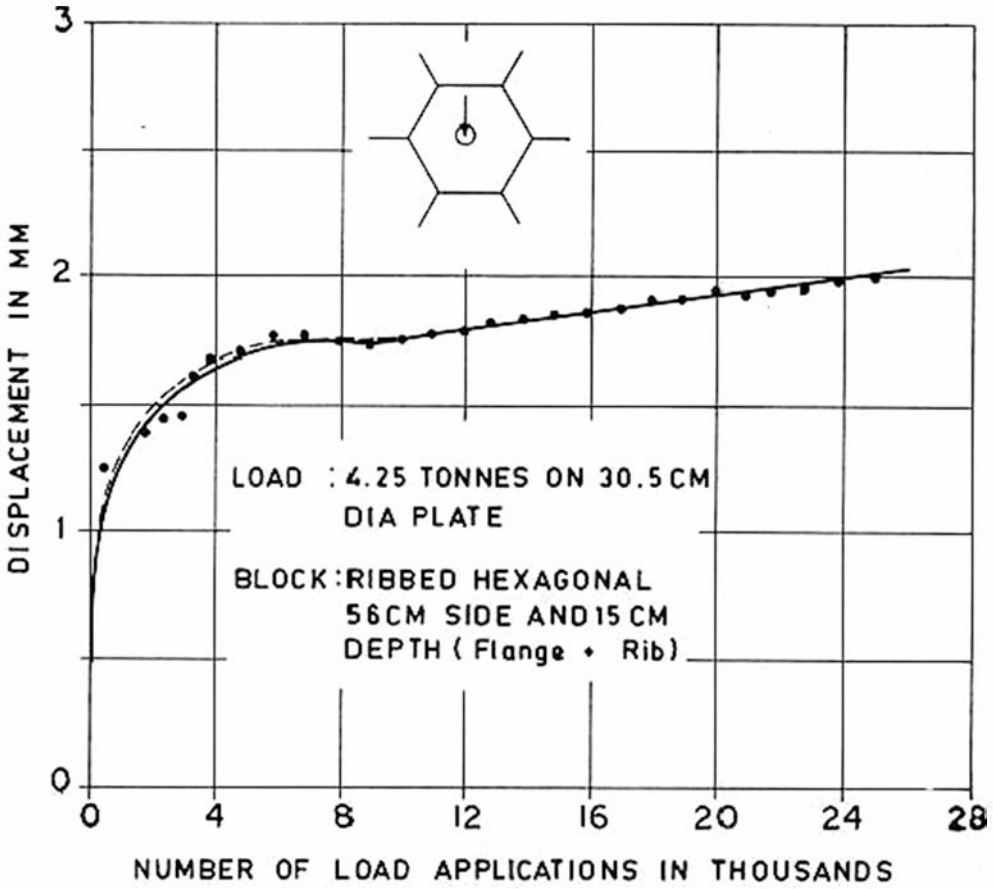


Figure 5: Deflection response of block paving for desert areas under repetitive loading.



Figure 6: Embedment of blocks over sandy subgrade with vibratory roller.

at two sites.

3. BLOCK PAVING FOR ACCESS TO SMALL RURAL COMMUNITIES

3.1 The traffic to and from small rural communities used to consist mostly of bullock carts and horse carriages, which have been partly replaced or augmented, over the last few decades, by tractor trolleys. Light vehicles like jeeps and pick-up vans, are also not uncommon.

3.2 Cast in-situ creteways have been in use in India since long for bullock cart traffic in rural areas, especially in sugar-cane growing areas for transportation of cane to sugar mills by bullock carts. These consist of two strips of concrete, about 0.50 m wide, so spaced as to accommodate the bullock cart wheels. These, however, presented difficulty in replacement when ruts are formed by long use under iron-tyred carts. The conventional flexible pavements can stand this traffic much less, and are also susceptible to washing away under inundation in flood-prone areas.

3.3 To have a system capable of easy replacement whenever required, and having adequate stability under conditions of flooding, concrete paving blocks capable of being interconnected with steel dowels have been developed.

3.4 The concrete paving blocks for creteways are 90 cm x 60 cm rectangular blocks, 10 cm thick, to be laid in two parallel rows or tracks, with the smaller dimension along the direction of traffic, and a clear distance of 75 cm between the two rows. They can be used for all types of light intensity traffic. The dimensions have been so chosen as to accommodate the wheel spacings of bullock carts, tractors, carts, jeeps, pick-up vans, and even buses and trucks, though they are not intended for regular bus and truck traffic. Along the 90 cm side, these blocks are provided with three holes, at mid-depth, at the centre and quarter points, for insertion of mild steel dowel bars of 10 mm dia. and 20 cm length, for interconnecting them to check their dislocation under flooding. For smooth insertion, the dowel holes are kept slightly larger than the dowel dia. To ensure adequate resistance to abrasion, paving grade concrete with a characteristic strength of 40 kg/cm^2 in flexure is recommended for these blocks.

3.5 To provide a firm and stable support for the blocks, a foundation of any type of semi-rigid base, such as lean cement concrete, lean cement fly ash concrete, lime fly ash concrete, soil cement, etc. is provided over the compacted subgrade for laying the creteway. The thickness of this foundation layer would depend upon the type of subgrade and intensity of traffic. For alluvial or sandy soils, and for light traffic, a thickness of 10 cm is considered adequate. The foundation base should have a minimum width of 2.85 m, ensuring its extension by at least 15 cm on either side of outer edges of the creteway blocks, and should be laid over fully compacted subgrade. After assembling the creteway blocks on this base, the space between two rows of the creteway is also filled with the same semi-rigid material as is used for the base.

3.6 Typical cross-section of the suggested creteway paving, showing particulars of its different design features, is given in Figure 7.

3.7 An experimental length of 0.4 km of such creteways was laid in 1980 in the flood-prone rural area of Khadar in the state of Haryana about 100 km north of Delhi, in collaboration with the State Public Works Department. A casting yard for the creteway blocks was established near the site, and the precast blocks were transported to the laying site by bullock cart, and assembled over lean cement concrete foundation base using minimal levelling course of sand wherever necessary. A typical view of the completed creteway is shown in Figure 8. The creteway has been in use by light traffic for over 2 years and has been giving satisfactory service for slow-moving traffic. Even though some blocks have shown some cracking and minor difference in level, no rectification or replacement measures have been called for so far.

4. BLOCK PAVING FOR WAREHOUSE FLOORINGS, STORAGE AREAS AND ROAD PAVEMENTS.

4.1 As these locations are subject to heavy loadings and involve large areas, the size and shape of the blocks were chosen from considerations of positional stability, structural adequacy including load transfer, and ease of transport, handling and replacement. Load-deflection tests were carried out to establish the structural adequacy of the design. With regard to pavements, these blocks are of particular interest as an expeditious surfacing for making good the utility cuts for repairs to service lines crossing the roads.

4.2 These blocks (2) are hexagonal in shape, with 25 cm sides, and have provision for interconnection by means of inclined dowels. For this purpose, each block has three inclined holes starting at top at mid-length of alternate sides and emerging at mid-depth of the vertical edges. The remaining three edges have similar holes from mid-depth to almost the bottom, to match the top holes from adjacent blocks. Interconnecting dowels consist of mild steel bars of 18mm dia and the holes are kept 2mm larger for easy insertion. According to Bradbury Analysis, theoretical load transfer capacity of individual dowels is about 1100 kg. Pentagonal edge blocks are used to obtain straight edges. Pavement width can be adjusted in units

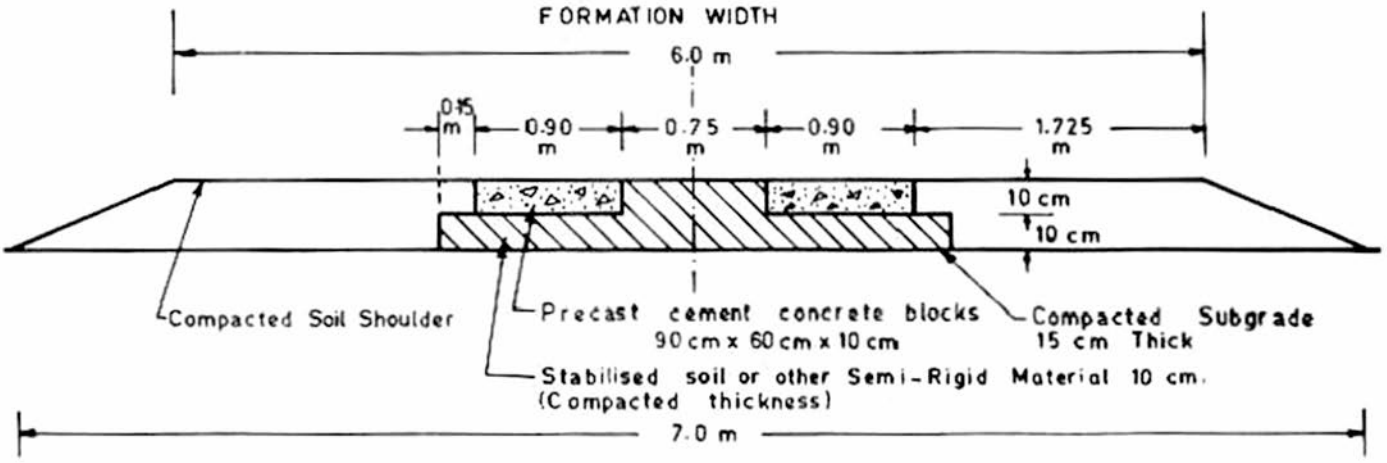


Figure 7: Typical cross-section of block paving for creteways.



Figure 8: A creteway section laid with concrete paving blocks.

of 0.375 m by varying the number of hexagonal blocks. Other intermediate widths can be obtained by altering the width of edge blocks appropriately. The blocks are made from paving grade concrete.

4.3 Foundation for these blocks may consist of at least 15 cm thick granular base like water-bound macadam, or semi-rigid base over compacted subgrade. Improved foundation stability and structural performance would result from the adoption of semi-rigid foundation, but its use is not practicable in case of pavement sections over service lines, for making good utility cuts, as re-digging can be involved.

4.4 Load tests were conducted on an area of 6m x 3m assembled over a granular foundation having a reaction modulus of 5.5kg/cm^3. Two thicknesses of blocks, 15 cm and 10 cm, were tested. Figure 9 shows the design particulars for 15 cm thick hexagonal blocks, and Figure 10 shows a view of the test area.

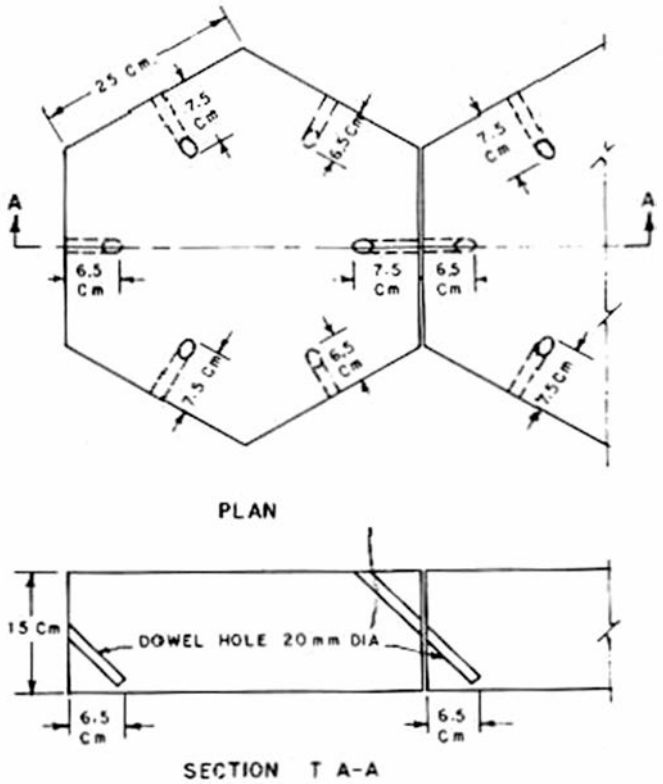


Figure 9: Design particulars of hexagonal blocks for warehouse floorings, storage areas and pavements.



Figure 10: A test assembly of the hexagonal blocks.

4.5 In the load tests, the load transfer capacity of dowels ranged from 10% to 12.5%, which could be taken as the maximum design value for such inclined dowels. The maximum structural capacity was 10 tonnes for 15 cm thick blocks. The 10 cm thick blocks were found to be adequate for highway wheel loadings of the order of 4 tonnes.

4.6 A construction of about 1/2 km. length of road near Bikaner in the State of Rajasthan is planned to be taken up in collaboration with the State Public Works Department.

5. BLOCK PAVING FOR FOOT-PATHS AND PASSENGER SHELTERS AT BUS STOPS

5.1 For expeditious paving of footpaths and passenger shelters at bus-stops, precast blocks of lighter design specific to the purpose and with minimum use of cement, have been developed (3). These blocks make use of semi-rigid materials like lean cement concrete, lean cement fly ash concrete and lime fly ash concrete. Of these, the use of lime fly ash concrete has the maximum cement saving potential and is preferable on that account.

As these semi-rigid materials have low resistance to abrasion, a thin surfacing layer of cement-sand mortar is given on the top to improve the abrasion resistance of these blocks.

5.2 These blocks have a square shape with 30 cm side. They are 10 cm thick, of which lower 9 cm consists of semi-rigid material and top 1 cm of 1:3 cement sand mortar. The blocks can be assembled directly over dressed compacted subgrade, using a thin levelling course (5-10 mm) of fine sand. These blocks have been standardised vide IS:10359-1982(4) and IS:10360-1982(5), which stipulate minimum average compressive and flexural strengths of 35 kg./cm^2 and 5 kg./cm^2, and maximum drying shrinkage, moisture movement and abrasion loss of 0.1%, 0.05% and 0.4% respectively.

5.3 The flooring of a passenger shelter at a local bus stop on Delhi-Mathura road was laid in 1976 with lime-fly ash concrete blocks topped with cement-sand mortar. Another small test section covering about 10 m^2 area was laid in 1977 on an approach road to a residential area. Performance in either case has been found to be very satisfactory. A view of the approach road is shown in Figure 11.



Figure 11: A view of approach road to residential area laid with paving blocks for footpaths.

6. CONCLUSION

6.1 Based on evaluation of need for special purpose precast paving blocks in India, the above four types of blocks have been developed by the Central Road Research Institute. Based on laboratory investigations, field trials are in progress. Performance data from these

trials will not only help refine the concepts, but also promote their use.

6.2 Further work is also in progress on the use of innovations like fibre reinforced concrete and plasticisers for precast paving works, with a view to economising in cement requirement and developing lighter/larger paving blocks.

7. ACKNOWLEDGEMENTS

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