PAST AND PRESENT EFFORTS FOR POPULARISATION OF INTERLOCKING CONCRETE BLOCK PAVEMENT TECHNOLOGY IN INDIA

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ABSTRACT

Interlocking Concrete Block Pavement (ICBP) technology was first introduced in India by the Council of Scientific and Industrial Research (CSIR) in the early nineties, when Central Road Research Institute (CRRI) imported a Block Making Machine for experimental purposes, and executed projects for experimental construction of ICBP in the laboratory and field. ICBP was used for construction of a demonstrative stretch of regularly trafficked heavy-duty pavement in the heavy-snow bound regions of Western Himalayas, which continues to give good service after 7 years of construction. In subsequent project work, ICBP was successfully provided as an overlay on existing old concrete driveway for an office complex as well as in the form of new driveways. Subsequently, CRRI undertook detailed laboratory study in two phases to assess the structural response of ICBP under different simulated loading and environmental conditions. CRRI also contributed towards incorporating the guidelines for design, construction and maintenance of ICBP for low volume roads in the Rural Roads Manual recently published by the Indian Roads Congress, whose publications are widely practiced in India. CRRI is presently engaged in drafting Indian Standard Specifications/Codes of Practice for production of concrete paving blocks and for design and construction of ICBP. The paper contains a summary of the past achievements of CRRI in this area as well as the essentials of the draft Indian Standard for Concrete Paving Blocks being widely circulated in India, before its final adoption.

1. INTRODUCTION

This paper starts by outlining the indigenous versions of Concrete Block Pavement (CBP) for special applications which were in practice in India in the seventies and eighties. R& D work on ICBP, being practiced in developed countries since the seventies, was initiated in this country in the early nineties. The laboratory and field projects executed during the nineties and the rich experience gained in this novel technology are briefly dealt with in the paper. Recently published guidelines for application of ICBP for low volume roads are highlighted. Finally, the main features of the draft national specification on concrete paving blocks approved for wider circulation are summarized.

2. DEVELOPMENT AND APPLICATION OF SPECIAL PURPOSE

2.1 Paving Blocks In India – Past Work

Development and application of the concept of precast paving techniques in India was initiated in the seventies and was continued in the eighties.

Central Road Research Institute (CRRI), located in New Delhi, a constituent laboratory of the Council of Scientific and Industrial Research, was the institution which pioneered such activity, and was aimed at developing techniques suitable for application in the locally existing societal environment and by using simpler, labour-intensive, construction methods.

Three such technologies were developed and applied for real-life situations, as listed below:

- Hexagonal and pentagonal shaped, interconnected, heavy-duty Concrete Block Pavement for direct paving in desert/sandy regions,
- Rectangular Block Creteways for small rural communities, and
- Hexagonal and Square Concrete Blocks for paving footpaths and bus-stops in urban areas

The salient features of these special purpose paving blocks were described in a paper published in the Proceedings of the Second International Conference on Concrete Block Paving (CRRI, 1984). Details of the full-scale field experiments conducted for application of the heavy-duty CBP for desert areas during 1986-88 as well as its performance evaluation after 8 years of service were reported in two subsequent publications (Dhir et. al., 1988; Muraleedharan et.al., 1996).

3. FAMILIARISATION WITH NEW TECHNIQUE

During the late eighties and early nineties, high-strength CBP technique was in practice in many countries of the world for specialized applications. The then prevailing practices in regard to the structural requirements of CBP, design and performance aspects, special features of the technique and scope for paving applications in India were brought out through review papers (Muraleedharan et.al., 1988, 1992a, 1992b).

4. R & D WORK ON ICBP

4.1 Field Project on Heavy-Duty ICBP

In the early nineties, simultaneously with the literature survey, a world-wide survey on different models of Block Making Machines available for use in ICBP work was conducted, and a small machine, suitable for R&D purposes, was imported from Germany. The Border Road Development Board of the Govt. of India sponsored a project for construction of an experimental ICBP section in the snow-bound regions of the higher reaches of Western Himalayas in the State of Jammu and Kashmir, on the road connecting Srinagar to Leh. The project was jointly executed by CRRI and the Border Roads Organisation (BRO). The subgrade soil was SM and had soaked CBR in the range of 10 to 16 per cent. The location of the test section was prone to heavy accumulation of snow and occurrence of avalanches during winter.

The experiment essentially consisted of three specifications provided on compacted subgrade, as follows:

- *Specification-1*: 63 mm lean concrete (1:4:8) (cement:sand:coarse aggregate) levelling course + 175 mm In situ Concrete base course + 30 mm compacted bedding sand + (220 X 110 X 120 mm) “UNIPAVE” Interlocking Concrete Blocks (ICBs) paved in stretcher bond pattern, with specially designed Interlocking Edge Restraint Blocks (ERBs) having dimensions of (300 X 300 X 320 mm).
- *Specification-2*: Same as Specification-1, with the ICBs paved in herringbone bond pattern.
- *Specification-3*: 63 mm lean concrete levelling course+ 30 mm compacted bedding sand + (460 X 230 X 150) mm Rectangular Concrete Base Blocks (CBBs) + 30 mm Compacted Bedding Sand + ICBs and ERBs as in (a).

The section remains open to traffic during June-September every year, during which a daily traffic in the range of 600 to 700 heavy, overloaded commercial vehicles was recorded.

After the first snow clearance operations, permanent deformation in the range of 4 to 5 mm was observed. It was also observed that the ERBs had excessive height, which caused fouling of dozer blade during snow clearance. During the subsequent years routine maintenance was sufficient to keep the section in operation. Details of the experiments and field observations during the initial 3 years have been published elsewhere (Kapur et. al., 1996).

4.2 ICBP Overlay Experiment on Old Concrete Driveway

The CSIR Head Office in New Delhi is located very near to the Parliament House Complex. The driveway to the CSIR Office had been constructed 50 years back by providing 125 mm thick cement concrete slab over flat-paved brick sub-base. Measurements with the Schmidt Hammer indicated a compressive strength of 36.4 MPa. During the early nineties a few cracks had appeared on the pavement, but the driveway was assessed to be structurally sound. It was decided to give a face-lift to the pavement by providing ICBP as overlay. The specification adopted was 60 mm Interlocking Concrete Blocks having average compressive strength of 30 MPa, paved over 25 mm compacted bedding sand of specified grading. The blocks were produced in a factory set up at the Institute's premises, and subjected to appropriate quality assurance regime. Red and blue coloured blocks were used for better aesthetic appeal. As the old drainage structures and pavement slopes did not facilitate proper drainage, additional drainage structures were provided and the slope was corrected using 25 mm levelling course with 1:3:6 (cement:sand:coarse aggregate) lean concrete, wherever required. Uniform thickness of the bedding sand and its levelling were accomplished by using specially fabricated gadgets. Compaction of bedding sand was effected by using specially fabricated steel plate rammer. Decorative edge restraints were provided by using the same paving blocks. Blocks were paved in herringbone pattern. 'IN' and "OUT' direction signs were incorporated into the pavement by using coloured blocks. Joints were sealed using a mixture of fine river sand and marble stone powder in the ratio 10:1. Compaction was effected using a plate vibrator. For smoothening the changeover from the block-paved driveway to the main road, mastic asphalt ramps were provided for confinement. During subsequent evaluation water stagnation was observed on vehicle parking lot, and the affected portion was dismantled and reconstructed. The driveway is 7 years old now, and continues to give good service. Details of the experiment have been published elsewhere (Muraleedharan, et. al., 1997).

4.3 New ICBP Driveways for Office Complex

Buoyed by the success of the ICBP overlay experiment, the CSIR Head Office assigned CRRI the work of executing projects for provision of new ICBP for CSIR Jubilee Building and Science Centre premises. Estimated traffic for the driveway was 200 to 250 PCU per day. At the Jubilee Building premises, even though 50 mm lean concrete base course of nominal mix 1:5:10 (cement: sand: coarse aggregate) had been provided earlier, the top layer of the same had been eroded due to frequent movement of construction traffic. Hence a fresh 50 mm thick lean concrete levelling course of nominal mix 1:3:6 (cement:sand:coarse aggregate) was provided over it. The top layer specification used was 60 mm Interlocking Concrete Blocks 9ICBs) having average compressive strength of 40 MPa over 25 mm compacted bedding sand of Zone-II grading as per specification (IS:383-1970).

The old concrete pavement at the Science Centre premises, which was only 10 years old, had developed excessive abrasion of the surface and the slabs had buckled at the joints. Hence the same was dismantled and new concrete base course of 75 mm thickness was provided, using nominal mix of 1:2:4 (cement:sand:coarse aggregate). The top layer specification used was the same as for the Jubilee Building premises. In both cases, joints were filled with a mixture of fine river sand and marble stone powder. A combination of red coloured and cement coloured blocks were used at the Science Centre premises to provide 'Carpet Design" to the pavement surface. Both the driveways have been in good service for the past 5 years, and had not required any maintenance. In particular, the new method of sealing joints was found to be very effective (CRRI, 1998).

4.4 In-House Experiments at CRRI (Phase-I)

The Institute recently undertook a detailed laboratory study in two phases to assess the structural response of ICBP under different simulated loading and environmental conditions. "UNIPAVE" interlocking concrete blocks of 60 mm thickness, having average 28-day compressive strength of 50 MPa were produced under proper quality control and two test sections were constructed in the test bed facility. The test sections covered an area 22.5 m^2 (6 m X 3.75 m). The in situ CBR of compacted subgrade was 16 per cent. Assuming the Poisson's Ratio of the subgrade soil to be 0.5, the elastic modulus of subgrade was assessed to be 80 MPa. One half of the area was provided with 100 mm thick granular base (Water Bound Macadam) and the other half with 100 mm thick Lean Concrete (LC) base course of 1:3:6 nominal mix. The WBM base course was compacted using a light plate vibrator, having an impact force of 20 kN over a plate area of 0.3484 m^2 and vibrating at an amplitude of 3 mm and frequency of 4200 VPM. The LC base course, on the other hand, had to be hand-compacted due to exigencies, and moist-cured for 7 days. Laboratory specimens of LC prepared on the same lines as the in situ LC base course gave very low 28-day compressive strength of 1.75 MPa. Edge restraints were provided by fixing concrete beams along the boundary. Coarse bedding sand having Zone-II grading (IS:383) and fineness modulus 3.3 was provided on top of the base course and was compacted to 25 mm thickness. The interlocking concrete blocks were manually paved on the bedding sand layer in herringbone pattern and were compacted using the light plate vibrator (light compaction). Optimum compaction was achieved after 6 passes. A mixture of fine sand having Zone-IV grading and lime (5 per cent by volume) was used for sealing joints. The testing facility consisted of a concrete load reaction beam, a Load Alternating Machine and a heavy-duty jack.

Under Phase-I Study, static plate load tests were conducted in three stages, namely after light compaction (first stage), after heavy compaction (second stage) and after submergence under water to simulate worst moisture conditions (third stage). Heavy compaction was aimed at simulating the natural compaction of the block pavement during traffic and was effected by applying 4 passes of a heavy plate vibrator, applying a compacting force of 37.5 kN over a plate area of 0.6534 m^2 at 2 mm amplitude and a frequency of 2000 VPM. Inundation was effected by submerging the section in water for 24 hours, draining out the water afterwards, cleaning and recompaction of surface and resealing of joints. Detailed findings of Phase-I Study were published earlier (Muraleedhran et.al., 1999) .

The main findings of the Phase-I Study were:

- It was confirmed that the block layer, though consisting of rigid elements, behaves like a flexible layer.
- Infiltration of water has an adverse effect on the performance of ICBP over WBM base course, in terms of increasing deformation after inundation.
- For the same thickness, even very low strength LC base course can be expected to perform better than WBM base course, in terms of lower deformation.
- Higher elastic deflection of the order of 2.3 mm was observed (in static plate load tests) without any damage to the pavement, confirming similar findings in international studies.
- The area of influence of 60 kN load on 300 mm dia. steel plate was 2 m^2 only, which can be expected to substantially increase under actual traffic conditions, as exemplified by experiments elsewhere.

4.5 Guidelines for Application of ICBP for Low Volume Roads

Guidelines for design, construction and maintenance of ICBP for roads with low-volume traffic have been included in a recently published Rural Roads Manual, for which the inputs had been provided earlier by CRRI (IRC:SP-20, 2002).

The essential design requirements and applicability indicated in the publication are listed below :

- 60 mm blocks using minimum M-25 grade concrete can be used for non-traffic areas like footpaths.
- 80 mm blocks using minimum M-30 grade concrete should be used for roads subjected to low volume traffic.
- The grading of bedding sand should be as per Zone-II of IS : 383-1970
- The compacted thickness of bedding sand should be 30 mm.
- The grading of joint filling sand should be as per Zone-IV of IS : 383-1970
- The Manual gives design graphs for selecting granular base thickness for subgrade CBRs 2, 3, 4, 5 and 10 for daily traffic ranging from 10 to 210 Commercial Vehicles Per Day (CVPD), subject to a minimum thickness of 100 mm.
- Cement-treated aggregates, lime-fly ash bound macadam and lime-fly ash concrete can also be used in place of granular base, by assuming an equivalence factor of 1.5.
- A good drainage layer should be provided over the compacted subgrade before provision of base course.

4.6 In-House Experiments at CRRI (Phase-II)

Phase-II Study was conducted in continuation of Phase-I Study and involved conducting static (non-repetitive) as well as cyclic repetitive plate load tests under incremental loads before inundation (after heavy compaction) and after inundation, draining, recompaction and resealing of joints. The study was aimed at assessing the load-deflection response of the laboratory test sections under fatigue and worst moisture conditions and estimating their structural and functional performance under assumed norms. The results of this study is under publication (Muraleedharan et.al., 2002).

The main conclusions of the study are:

- The study showed that improved compaction of newly constructed ICBP results in better load transfer between blocks reaching up to greater radial distances from the loading center, effectively spreading the load over a larger area of the pavement.
- For both test sections, close linear relationships between applied contact pressure and induced elastic deflection were obtained for both “before inundation” and “after inundation” stages of testing, within the range of pressure applied. Due to very low strength of LC base course and the presence of bedding sand, ICBP/LC behaved like a granular layer, with higher elastic deflection than can be expected for good quality LC base in conventional pavements.
- For ICBP/WBM test section, for a standard contact pressure of 0.722 MPa, the elastic modulus reaches a peak value before inundation and then drops drastically for further increase in contact pressure. However, after inundation, another peak value which is of the order of 86 per cent of the peak value obtained before inundation, is achieved at a lower contact pressure of 0.54 MPa. For the standard contact pressure of 0.722 MPa the value drops to 43 per cent of the peak value obtained before inundation.
- For ICBP/LC test section with very low strength LC base course, for the standard contact pressure of 0.722 MPa the elastic modulus value obtained after inundation was double the value obtained before inundation indicating that indundation did not induce any adverse effect on it. The tests before and after inundation were conducted at two different locations.
- For ICBP/WBM test section, the rate of increase in permanent deformation with increase in contact pressure after inundation was observed to be more than 3 times the rate before inundation. For ICBP/LC test section, the corresponding increase was only 45 per cent. Also, for the same range of applied contact pressure, the a maximum permanent deformation for ICBP/WBM substantially increased after inundation, while for ICBP/LC there was reduction in maximum permanent deformation after inundation.

- Based on the assumption of permanent deformation limits of 17 mm for minimum functional serviceability and 23 mm for minimum structural serviceability, the expected capacity of similar ICBPs was assessed in regard to the safe limits of cyclic applications of an Equivalent Single Wheel Load of 50 kN. It was assessed that after inundation the capacity of ICBP/WBM (in terms of the sustainable cycles of 50 kN load) can be expected to substantially reduce, as compared to the status before inundation. On the other hand, the capacity of ICBP/LC, with a properly constructed LC base course, can be expected to remain unaffected even after inundation.
- Based on the R & D experiments on ICBP, fresh guidelines for design of ICBP for light traffic have been provided in the main paper by modifying the existing IRC guidelines.
- There is scope for further refinement of the design guidelines, based on feedback on construction and performance experience of ICBP using the present guidelines.

4.7 In-House Experiments at IIT

Recently, the Civil Engineering Department of the Indian Institute of Technology (IIT), Kharagpur, has reported a series of laboratory studies to evaluate the performance of ICBP in the laboratory by conducting static plate load tests (Panda et. al., 2000, 2001a, 2001b). Stresses inside the pavement layer were measured by pressure cells embedded in sub-base layer, below the loading plate and along the periphery of a test box measuring 0.6 m^2 area and 450 mm depth. From these experiments they evaluated (a) the influence of block parameters on load spreading ability, (b) the influence of bedding and jointing sand characteristics on performance, and (c) estimation of equivalent elastic modulus of block layer.

Some of the conclusions drawn by them from these experiments are as follows:

- From the point of load spreading ability (LSA), interlocking blocks perform better than rectangular or square blocks of similar thickness installed in the same laying pattern.
- LSA increases with increase in size of block (within the range of block sizes studied).
- Strength of blocks has no influence on LSA.
- Increase in block thickness leads to increase in LSA.
- Use of herringbone pattern of paving leads to higher LSA.
- LSA of block surface increases with increasing load.
- Stiffness of block layer increases with increase in the number of load repetitions.
- For 60 to 100 mm blocks laid over bedding sand of 50 mm loose thickness, the equivalent elastic modulus measured was in the range of 90 to 550 MPa.

5. EXPANSION OF ICBP APPLICATION IN INDIA

Currently, ICBP has been finding increasing applications for diversified uses in many cities, towns, port/container areas etc. in India. Whereas the technology was virtually unknown till the late eighties, currently there are over 35 small, medium and large entrepreneurs engaged in ICBP business. Also, whereas earlier the Block Making Machines were imported, presently there are a couple of manufacturers making indigenous BMMs. However, there are wide variations in the quality of products supplied, as national standards on the subject are yet to be formulated.

6. ECONOMICS OF ICBP

Real life economic data on ICBP vis-à-vis conventional pavements for Indian conditions are yet to be generated. A hypothetical case of application of ICBP for medium-trafficked road (5 MSA; CBR: 4) indicated that, for urban and semi-urban conditions, ICBP is likely to be cheaper than flexible pavement by about 10 per cent initially, and by about 27 per cent after 20 years.

Actual economics for applications will depend upon a number of factors, including availability of materials, expertise and entrepreneurship developed, healthy competition between entrepreneurs, creating market demand for the products through consumer education, uniform quality of products produced as per available standards/guidelines, customers' emphasis on quality of products, optimization of production, capability of firms to deliver turnkey projects (supply, installation and maintenance), and continued innovation and diversification of application through research and development.

7. INDIAN STANDARD SPECIFICATION FOR CONCRETE PAVING BLOCKS

7.1 General

The Bureau of Indian Standards (BIS) has entrusted to CRRI the work for preparation of national standard specification for concrete paving blocks and code of practice for design and construction of ICBP, to be prepared on the basis of the R&D experience and literature published world-wide on the subject. The draft standard for concrete paving blocks has just been approved by the BIS Committee for wider circulation among suppliers and users. The essential features of the specifications are given in subsequent sections.

7.2 Shapes and Classifications

The Draft Standard classifies paver blocks into four generic shapes corresponding to the four types of blocks (types A, B, C, and D). These correspond respectively to non-locking, partial-locking, full-locking and multiple-locking shapes. Currently prevailing typical, but not exhaustive, shapes of blocks that can be put into these four classifications have been illustrated in the Standard.

7.3 Materials and Manufacture

Materials recommended to be used for production of blocks are as per prevailing national specifications. This includes natural and artificial aggregates, admixtures and pigments. Different grades of concrete are recommended to be used for production of blocks required for different paving applications, as summarized in Table 1.

Table 1. Recommended Grades of Concrete for Production of Paver Blocks.

Concrete Classification	**Grade Designation**	**Comp. St. of 150 mm cubes at 28 Days (N/mm^2)**	**Traffic Category**	**Traffic Range**
Standard Concrete	M-25	25	Non-Traffic	--
	M-30 – M-35	30 – 35	Light	Upto 150 Commercial Vehicles per day (CVPD)or 0.5 Million Standard Axles (MSA)
	M-40 – M-45	40 – 45	Medium	150-450 CVPD/ 0.5-2.0 MSA
	M-50 – M-55	50 – 55	Heavy	450-1500 CVPD/ 2.0-5.0 MSA
High Strength Concrete	M-60 And Above	60 And Above	Very Heavy	> 1500 CVPD / > 5 MSA

7.4 Obligatory Requirements

7.4.1 Dimensions and Tolerances

The recommended dimensions and tolerances for type A, B and C paver blocks are given in Table 2. The dimensions and tolerances for type D blocks may be mutually agreed by the purchaser and supplier. Minimum block thickness shall be 60 mm, and maximum 120 mm. The thicknesses 60 mm, 80 mm, 100 mm and 120 mm will be considered as standard thicknesses under this specification. Methods for measurement of dimensions are provided in the draft specification. Blocks meeting this specification are required to have chamfer.

Table 2. Recommended Dimensions and Tolerances for type A, B, and C Paver Blocks.

S. No.	Dimension	Recommended Values	Tolerance Limit
1	Width, W	80 to 115 mm	± 2 mm
2	Length, L	(1.5 to 2.3) X W	± 2 mm
3	Thickness, T	60 to 120 mm	± 3 mm
4	Aspect Ratio (L/T)	Maximum : 4.4	+ 0.275
5	Chamfer	Maximum : 5 mm	+ 1 mm
6	Thickness of Wearing Layer	Minimum : 15 mm	- 2 mm
7	Plan Area,	Maximum : 0.03 m^2	+ 0.001 m^2
8	Wearing Surface Area,	75 % of Plan Area	± 1%
9	Squareness	NIL	± 2 mm

7.4.2 Thickness of Wearing Layer

When blocks are manufactured in two layers, the wearing layer shall have minimum thickness as specified in Table 2.

7.4.3 Water Absorption, Block Density and Compressive Strength

Average water absorption of five units shall be not more than 6 per cent by mass. Average block density of five units, shall be not less than 2.2 Mg/m^3. The grade of concrete used for production of blocks shall be the guiding factor in determining the compressive strength of concrete and the corresponding compressive strength of blocks. When it is desired to express the compressive strength of concrete used in production of blocks in terms of the compressive strength of blocks produced using the same materials, mix proportions and compaction methods, statistical relationship between the compressive strengths of 150 mm cubes and blocks of specified shape and thickness shall be established through experiments. The method of determination of compressive strengths of paver blocks using the correction factors is described in the specification.

7.5 Optional Requirements

7.5.1 Flexural Strength

The flexural strength of paver blocks should be determined as per the method given in the specification. When required by the purchaser, the test values for flexural strength of paver blocks should be specified by the supplier. When required by the purchaser, statistical relationship between the compressive and flexural strengths of paver blocks should be established.

7.5.2 Abrasion Resistance

The abrasion resistance of concrete used for production of paver blocks should be determined as per the method given in existing specification (IS: 9284-1979). The abrasion resistance of paver blocks should be determined as per the method given in the specification, which has been adapted from the Concrete Masonry Association of Australia Specification (CMAA, 1986).

When required, the purchaser should specify limits to the test results, which should be complied with by the supplier. Suggested specification limits are given in the specification.

7.5.3 Freeze-Thaw Durability
The freeze-thaw durability test of paver blocks should be conducted as prescribed in the specification, which has been adapted from Canadian Specification (CAN, 1985). When required, the purchaser should specify limits to the test results, which should be complied with by the supplier.

7.5 4 Colour and Texture
The colour and texture of paver blocks should be mutually agreed by the purchaser and supplier.

8. CONCLUSIONS

This paper outlines the work undertaken by CRRI (CSIR) in developing indigenous versions of Concrete Block Pavements (CBPs) in the seventies and eighties suitable for local conditions, as well as efforts in the nineties for introduction and popularization of small-element, high-strength, Interlocking Concrete Block Pavement (ICBP) for special applications, through laboratory studies, construction and monitoring of pavements and standardization work.

Two decades of work in this direction indicates the following achievements for CSIR:
- Development and application of Hexagonal and pentagonal shaped, interconnected, heavy-duty Concrete Block Pavement for direct paving in desert/sandy regions
- Development and application of Rectangular Block Creteways for small rural communities
- Development and application of Hexagonal and Square Concrete Blocks for paving footpaths and bus-stops in urban areas
- Detailed laboratory study on structural behaviour of ICBP under simulated conditions
- Construction and monitoring of ICBP for light and heavy traffic conditions
- Formulation of guidelines for application of ICBP for light and medium traffic
- Formulation of Draft Indian Standard Specification for Concrete Blocks for Paving

ICBP technology is already in practice in many urban areas of the country. The recent efforts on formulating application guidelines and standardization of block production will give further boost to the ICBP industry. A Code of Practice for Design and Construction of ICBP is being formulated, which will facilitate its application for all types of paving. In the coming years CSIR will continue to make efforts for further refinement of the ICBP technology through collaborative work with the industry.

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Biography

Mr. Tharamal Muraleedharan was born in the historic town of Kodungallur in Kerala State in India in March, 1944. The name of the state means "the land of coconut palms", and, indeed, of late, Kerala State has become one of the international tourist destinations, famous for its coconut palm gardens, backwaters, tea gardens, ayurvedic system of alternative medicines and health spas, and, of course, a society noted for it political awareness.

Mr. Muraleedharan obtained his graduate degree in Mathematics and Physics and postgraduate degree in Mathematics from the University of Kerala. He joined the Central Road Research Institute (CRRI), one of the 42 constituent laboratories under the Council of Scientific and Industrial Research (CSIR), located in New Delhi, as Junior Scientific Assistant in 1970. Presently he is serving as a Senior Scientist there.

During his service in CRRI, he specialized in the area of Special Paving Techniques. During the eighties, he was instrumental in execution of laboratory study and field application of heavy-duty, interconnected, Hexagonal Precast Concrete Block Pavement (PCBP) directly paved on dry sandy subgrades in the desert regions of Rajasthan State in India. These experiments were reported in a paper presented in-absentia at the 3rd International Conference on CBP held in Rome, Italy, in 1988.

Since the early nineties, he has concentrated his efforts in introduction and popularization of the CBP technology, and especially the Interlocking Concrete Block Pavement (ICBP) technology in India. In the early nineties, He had planned and executed the construction of the first heavy-duty ICBP experimental road section in the snow-bound Himalayas at 3500 m height, in collaboration with the Border Roads Organisation of the Ministry of Defense, Govt. of India. His other works in this area include experimental laboratory study on ICBP, providing ICBP overlay for old concrete pavement for office driveway, and construction of ICBP for office complexes. His work on ICBP was reported in a paper presented in-absentia at the 5th Int. Conf. On CBP held in Tel Aviv, Israel, in 1996.

Considering the popularity of ICBP technology in India, the Bureau of Indian Standards has entrusted the standardization work for ICBP to CRRI, and Mr. Muraleedharan is presently engaged in this national task. He has also been conducting regular training programmes on ICBP for professionals in India.

He holds a patent related to PCBP. He is the first inventor of a Concrete Abrasion Resistance Tester, the patent application for which is under process.

He has over 50 research and review publications on pavement engineering to his credit, over 10 of them in the area of ICBP. He has also edited a technical book titled "AIRFIELD PAVEMENTS" published by the Organising Committee of National Seminar on Airfield Pavements, in 1995.