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GUIDELINES FOR THE USE OF INTERLOCKING CONCRETE BLOCK PAVEMENT

(First Revision)

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GUIDELINES FOR THE USE OF INTERLOCKING CONCRETE BLOCK PAVEMENT

BACKGROUND

The Guidelines for Interlocking Concrete Block Pavements (ICBP) was first published in October 2004, since then the uses of Interlocking Concrete Block Pavements have increased sharply and the technology for ICBP construction has undergone considerable changes. A need was felt that some special requirements, like repair, drainage system, abrasion value of blocks, grade of concrete for casting of blocks etc. need to be incorporated in the document. For incorporating these aspects it was decided to update the Guidelines.

The revised draft was prepared by the subgroup of Rigid Pavement Committee (H-3) comprising of Shri J.B. Sengupta, Shri R.K. Jain, Shri Ram Avtar, and Shri Binod Kumar. Other than the H-3 Committee members, valuable inputs were received from the officers of S&R Zone of the Ministry. The Rigid Pavement Committee (H-3) deliberated on the document in a series of meetings and finalized it in its meeting held on 27th May, 2017. The revised draft was placed before the Highways Specifications and Standards Committee (HSS) in its meeting held on 24th October, 2017. The HSS Committee approved the draft subject to the consideration of the observations of members. The draft document after carrying out the necessary modifications was considered and approved by the Executive Committee of IRC in its meeting held on 2nd November, 2017 for placing before the Council of IRC. The Council in its meeting held on 3rd November, 2017 at Bengaluru considered and approved the document for printing subject to incorporation of comments of members.

The composition of H-3 Committee is as given below:

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1 SCOPE

1.1 These guidelines cover the design and construction of interlocking concrete block pavements giving the suggested applications, design catalogues, construction practices and specifications for their use.

1.2 The use of interlocking concrete block pavement is not recommended for Expressways, National Highways, State Highways and Major District Road. However, if an MDR or State Highways passes through an habitation, their use is permitted.

1.3 The Constituent materials, products requirements and test methods for solid, unreinforced precast cement concrete paver blocks shall be as per IS:15658 “Precast Concrete Blocks for Paving Specification”.

2 APPLICATIONS

2.1 Interlocking Concrete Block Pavements have been found to have applications in several situations. Such as :

1. Footpaths and Side-walks
2. Cycle Tracks

3. Residential Streets
4. Car Parks
5. Fuel Stations
6. Rural Roads through Villages
7. Toll Plaza
8. Highway Rest Areas
9. Bus Depots
10. Approaches to Railway Level Crossings
11. Intersections
12. City Streets
13. Truck Parking Areas
14. Urban Sections of Highways
15. Road Repairs during Monsoon
16. Container Depots
17. Port Wharf and Roads
18. Roads in High Altitude Areas

2.2 Advantages and Limitations of Interlocking Concrete Block Pavements

2.2.1 *Advantages*

(i) Since the blocks are prepared in the factory, they are of a very high quality, thus avoiding the difficulties encountered in quality control in the field.

(ii) Concrete block pavements restrict the speed of vehicles to about 60 km per hour, which is an advantage in city streets and intersections.

(iii) Because of the rough surface, these pavements are skid-resistant.

(iv) The block pavements are ideal for intersections where speeds have to be restricted and turning stresses are high.

(v) The digging and reinstatement of trenches for repairs to utilities is easier in the case of block pavement.

(vi) These pavements are unaffected by the spillage of oil from vehicles, can perform better at bus stops, bus depots and parking areas.

(vii) They are preferred in heavily loaded areas like container depots and ports as they can be very well designed to withstand the high stresses induced there.

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(viii) In India, the laying of concrete block pavements can be achieved at a low cost because of the availability of cheap labour.

(ix) Since the concrete blocks are grey in colour, so their visibility at night is better than that of flexible pavement.

(x) The cost of maintenance is much lower than a bituminous surface.

(xi) Block pavement does not need in-situ curing and so can be opened to traffic soon after completion of construction.

(xii) Construction of block pavement is simple and labour-intensive, and can be done using simple compaction equipment.

(xiii) Maintenance of block pavement is simple and easy. Also, the need for frequency of maintenance is low as compared to bituminous pavement.

(xiv) Structurally sound blocks can be reused many times over.

(xv) Unlike concrete pavements, block pavement does not exhibit very deterioratory effect due to thermal expansion and contraction, and are free from the cracking phenomenon.

(xvi) Use of permeable block pavement in cities and towns can help replenish depleting underground sources of water, filter pollutants before they reach open water sources, help reduce storm water runoff and decrease the quantum of drainage structures.

2.2.2 *Limitations*

(i) Concrete block pavements cannot be used for high speed facilities.

(ii) The riding quality is reasonably good for low-speed traffic, but is inferior to that observed on a machine laid bituminous or concrete pavement.

(iii) The noise generated is higher than bituminous and cement concrete pavements.

(iv) A very good attention to pavement drainage is needed because the water can seep through the joints.

(v) These Specifications are not recommended for Expressways and National-Highways.

3 TYPES AND SHAPES OF BLOCKS

The blocks can be interlocking horizontally and vertically, as shown in **Fig 1**.

Present day interlocking blocks have evolved in shape after observing their performance. The three phases in the changing of the shape of the blocks are shown in **Fig. 2**.

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The rectangular shape shown in **Fig. 2(i)** is the shape which was intended for imitating the stone set blocks. The shape shown in **Fig. 2(ii)** is an improved version with many dentated faces for better contact between adjoining blocks thus enhancing the interlocking effect and friction between them. This helps in increasing the shear strength of the block system and thus the load dispersal capacity. The block shown in **Fig. 2(iii)** is a further improvement over dentated rectangular block. The block shown in **Fig. 2(iv)** gives still better interlock and is suitable for fully mechanized paving.

The dentated blocks further can be grouped as shown in **Fig. 3** into three categories as under:

Category A: Dentated units are designed to key into each other on all four faces and which, by their plan geometry when keyed together, resist the widening of the joint. These blocks are generally capable of being laid in Herringbone Bond Pattern (as explained in Section 8).

Category B: These blocks are dentated on only two sides. Their dimensional accuracy of laying helps in bringing about the interlock effect on other faces. Generally, with some exceptions, these blocks can only be laid in Stretcher Bond, as explained in Section 8.

Category C: These are not dentated type but depend on dimensional accuracy for interlocking effect.

These blocks can be laid only in a stretcher bond.

The overall dimension of blocks used in various parts of the world ranges as under :

Top surface area : 5,000 to 60,000 mm^2

Horizontal dimension not exceeding : 280 mm

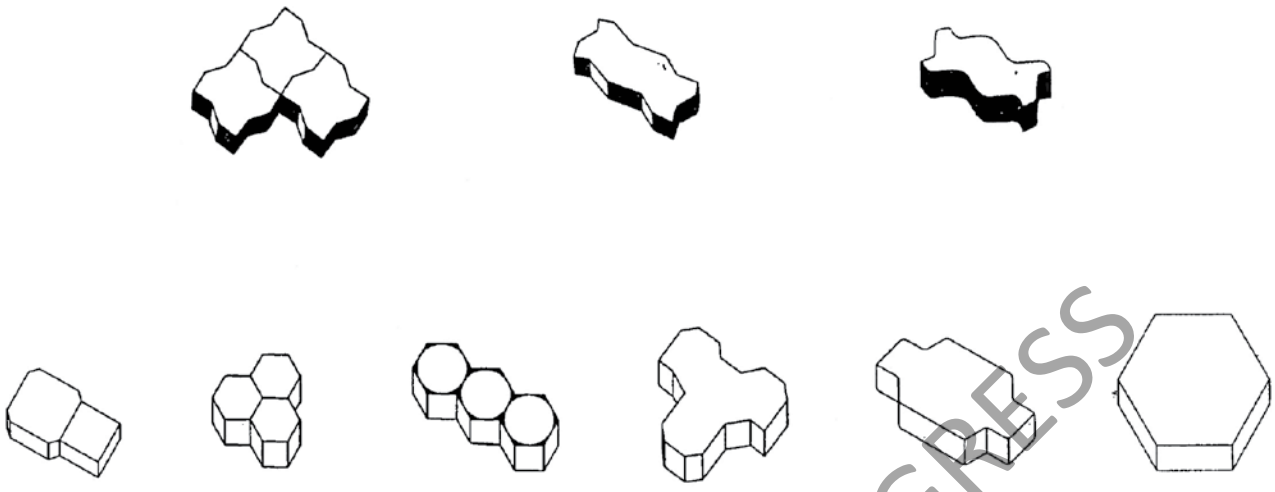
$$1 < \frac{\text{Mean length}}{\text{Mean width}} < 3$$

Thickness : Between 60 to 140 mm

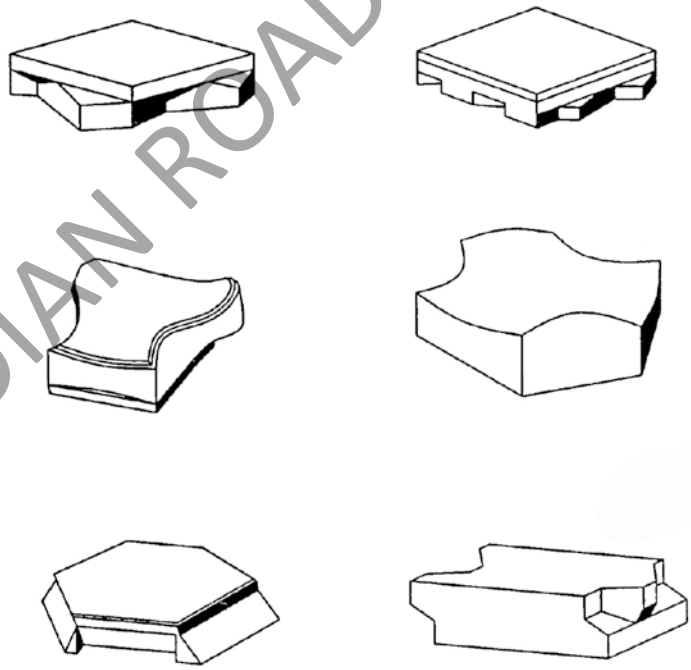
Length/Thickness : ≥ 4

In addition to regular blocks described above, supplementary blocks of half size would be required for paving purpose. In the case of rectangular blocks, more number of half blocks would be generally required than other category of blocks.

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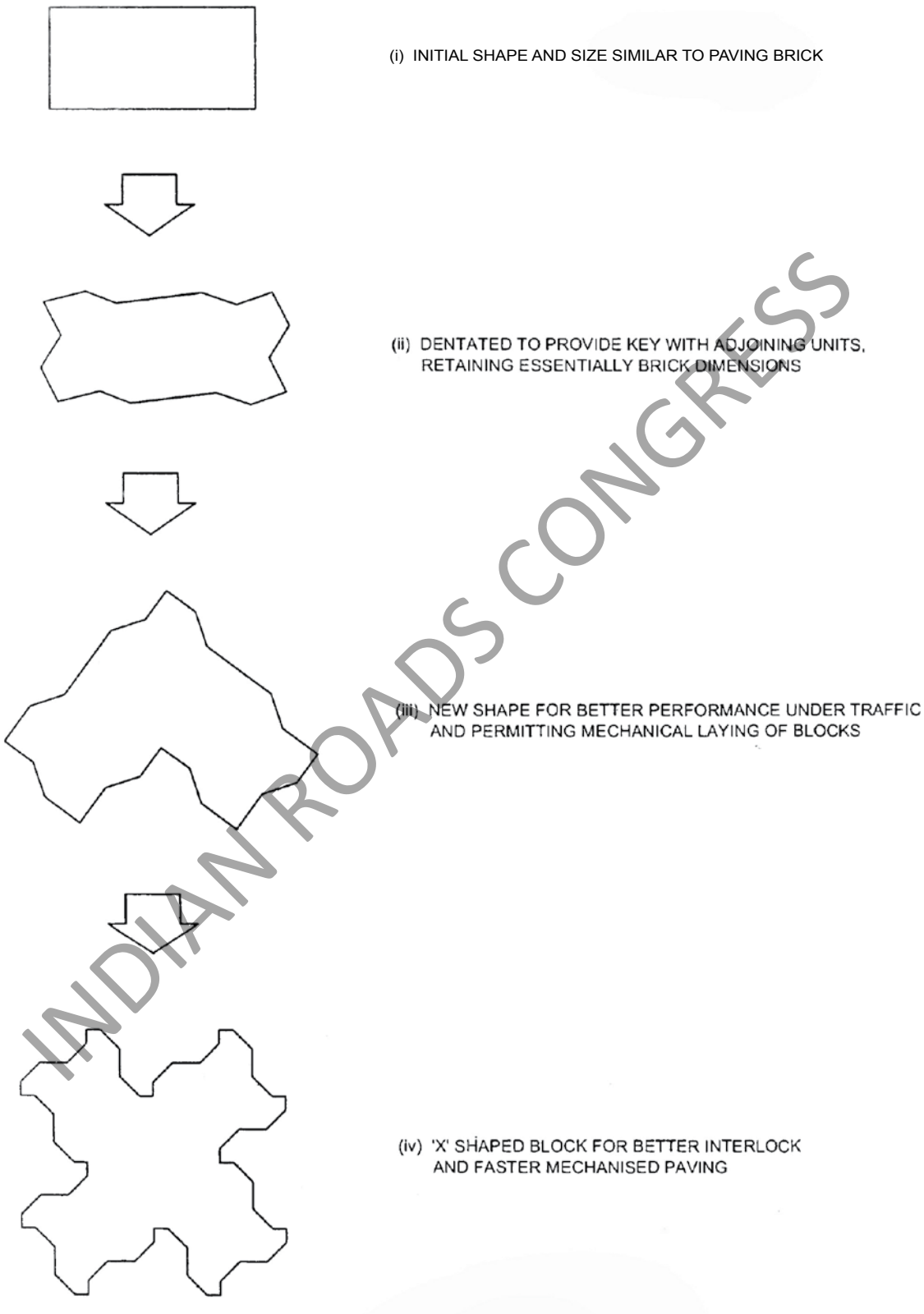
(i) SOME TYPICAL SHAPES OF INTERLOCKING BLOCKS



(ii) SOME TYPICAL SHAPES OF VERTICALLY INTERLOCKING BLOCKS

Fig. 1 Some Shapes of Interlocking Blocks

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Fig. 2 Basic Shapes of Blocks

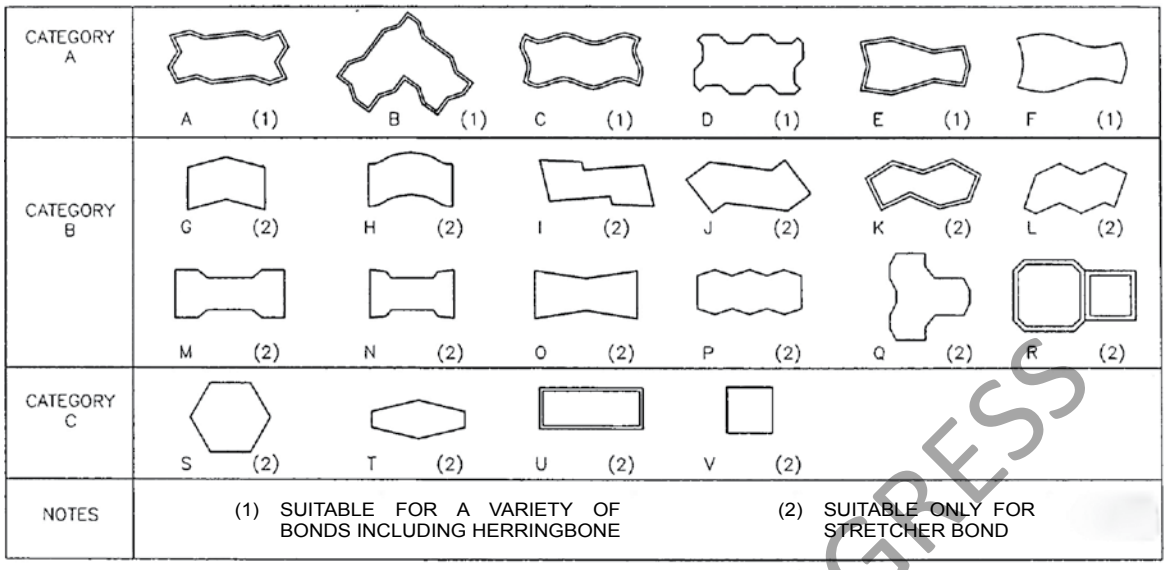


Fig. 3 Different Categories of Blocks

Special Grass Blocks

For improving aesthetic looks of paved areas, architects have been making use of block pavement extensively. The numerous paving blocks and their joints mellow down the harshness created by large transverse joints formed in conventional concrete pavement.

For improving aesthetics further, grass blocks have been developed. These when constructed in a grid formation allow space in the pavement for growing grass as shown in **Fig. 4**. These are best suited for walkways, driveways, etc. Coloured blocks also add to the aesthetic beauty.

4. COMPOSITION OF BLOCK PAVEMENT

4.1 General

Except for the top wearing part of the pavement, the base and sub-base layers are similar to the conventional flexible or rigid pavement. Depending upon the load coming on them, the composition of the pavement differs.

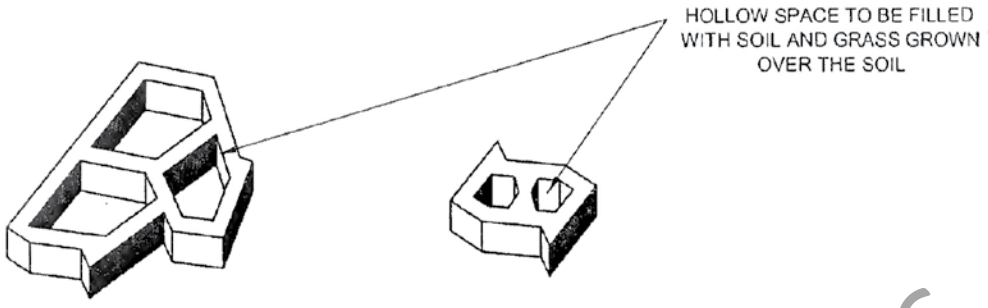
4.2 Typical Pavement Composition

A few typical composition normally used are given in **Figs. 5** and **6**.

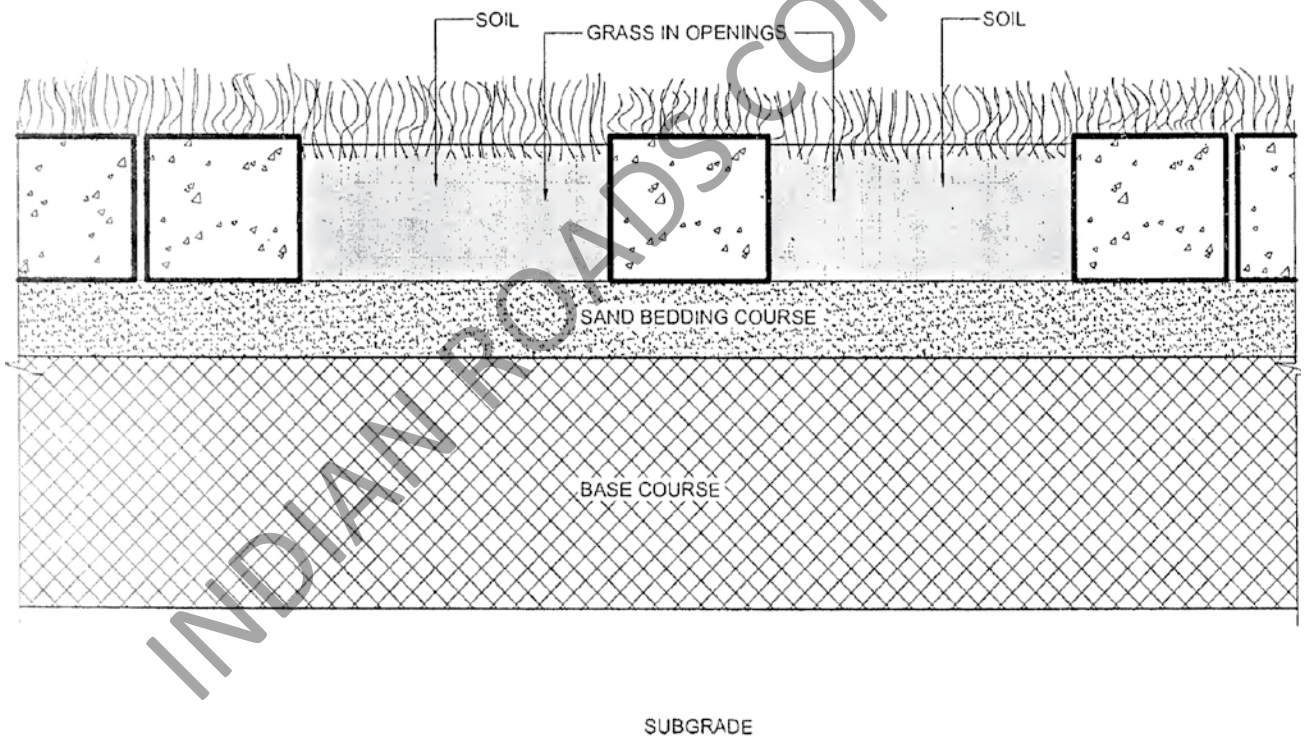
4.3 Block Thickness

Interlocking concrete blocks come in different thicknesses. These blocks serve as wearing surface but at the same time help in reducing the stresses imposed on subgrade and also help in resisting pavement deformation and elastic deflections similar to the base course of a flexible pavement.

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TYPICAL GRASS BLOCKS



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Fig. 4 Grass Blocks and Construction Technique

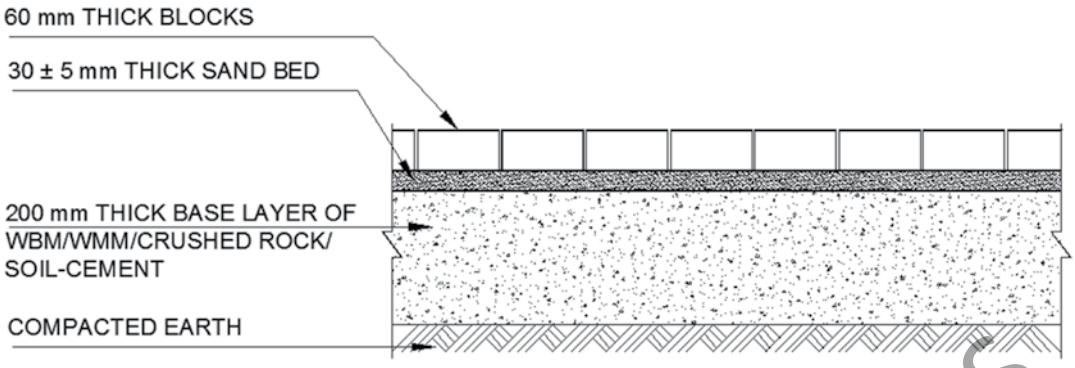


Fig. 5 A Typical Cross Section of Block Pavement used in Sidewalks/Footpaths/Car-Parks/Cycle Tracks

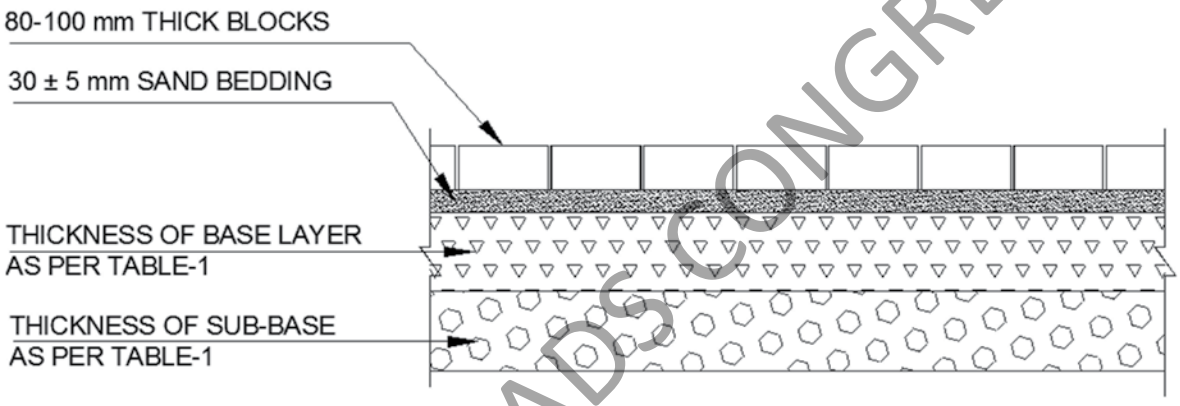


Fig. 6 A Typical Cross Section of Block Pavement for Medium and Heavily Trafficked Roads except National-Highways, Expressways, State Highways and MDR

For light traffic, such as, pedestrians, motor cars, cycles, etc., a block thickness of 60 mm is adequate; for medium traffic, a thickness of 80 mm is generally used; for heavily trafficked roads, blocks of the thickness 100-120 mm are used. Thick blocks are best suited where high volumes of turning movements are involved.

Non-uniformity in thickness of blocks affects the evenness of the surface. A block pavement which is initially paved to a levelled surface will settle unevenly with the movement of vehicles, as shown in **Fig. 7**. In view of this, all blocks should be of the same thickness, with a maximum allowable tolerance limits of ± 2 mm. Similarly, variations in length and width of blocks should be limited to ± 2 to ± 3 mm for ensuring uniform joint width and avoiding staggering effect.

4.4 Sand Bedding and Jointing

A layer of sand bedding is provided between block pavement and base/sub-base for the following reasons:

(i) To provide a cushion between the hard base and the paving blocks.

(ii) The base or sub-base will have some permitted surface unevenness. By providing a layer of sand bed, the paved block can be levelled perfectly.

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(iii) The sand bed acts as a barrier and does not allow propagation of cracks formed in base/sub-base.

(iv) The sand also helps to keep lower part of the joint filled with sand and provides added interlocking effect.

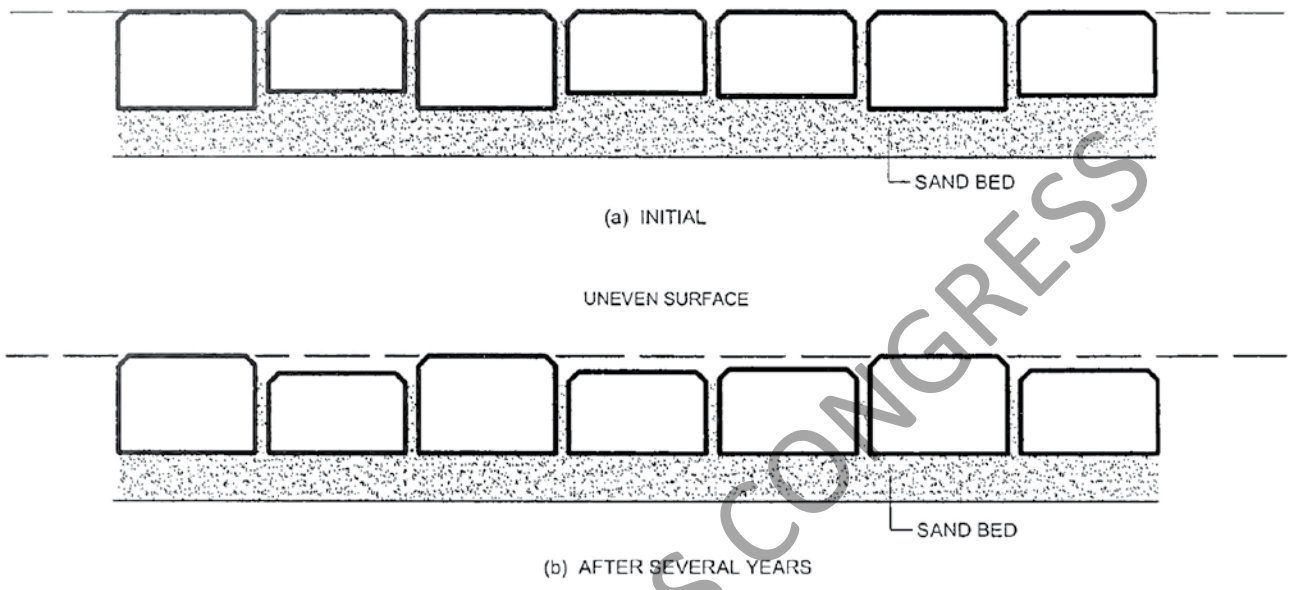


Fig. 7 Effect of Thickness Variations in Paving Blocks

The sand bed should not be too thick lest it would be difficult to control the surface level of the blocks. A layer thickness of 30 ± 5 mm is found to be satisfactory.

For block pavement to perform satisfactorily, it is necessary that the lower layers are profiled to proper level and finish and that the bedding sand layer is of uniform thickness. Varying thickness of sand bed ultimately results in uneven surface of the pavement.

The grading and quality of sand is very important for the block pavement to perform satisfactorily. The sand used should be free from plastic clay and should be angular type. It should not be of degradable type for e.g., sand produced from lime stone, etc. is likely to get powdered under the loading.

Joints between blocks are filled by fine sand. Normally, the bottom 20 to 30 mm of the joint gets filled with bedding sand, whereas, the remainder space has to be filled with jointing sand by brooming it from the top. The joints are normally 2 - 4 mm wide.

4.5 Base and Sub-base Layers

These layers are the important structural layers of a block pavement. The materials used for base construction consist of either bound material like lean concrete or soil-cement or bituminous layers or unbound materials like wet mix macadam or WBM. The sub-bases are generally of granular material. The sub-base can function as drainage layer as well, provided

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proper disposal arrangement for water is made. The base course layer is normally provided where heavy vehicular traffic is likely to ply on the pavement.

Besides intensity of loading, the type of soil encountered determines the type and thickness of base and sub-base. For weak subgrade soils like clays, where ground water table is shallow, bound bases are preferred.

4.6 Edge Restraint Blocks and Kerbs

Concrete blocks on trafficked pavements tend to move sideways and forward due to braking and manoeuvring of vehicles. The tendency to move sideways has to be counteracted at the edges by special edge blocks and kerbs. The edge blocks should be designed such that the rotation or displacement of blocks is resisted. These are to be made of concrete of high strength to withstand the traffic wheel loading without getting damaged. These members should be manufactured or constructed in-situ to have at least a 28 day compressive strength of 30 MPa or flexural strength of 3.8 MPa. As far as possible the edge blocks should have vertical face towards the inside blocks. A few typical edge blocks are also shown in **Fig. 8.**

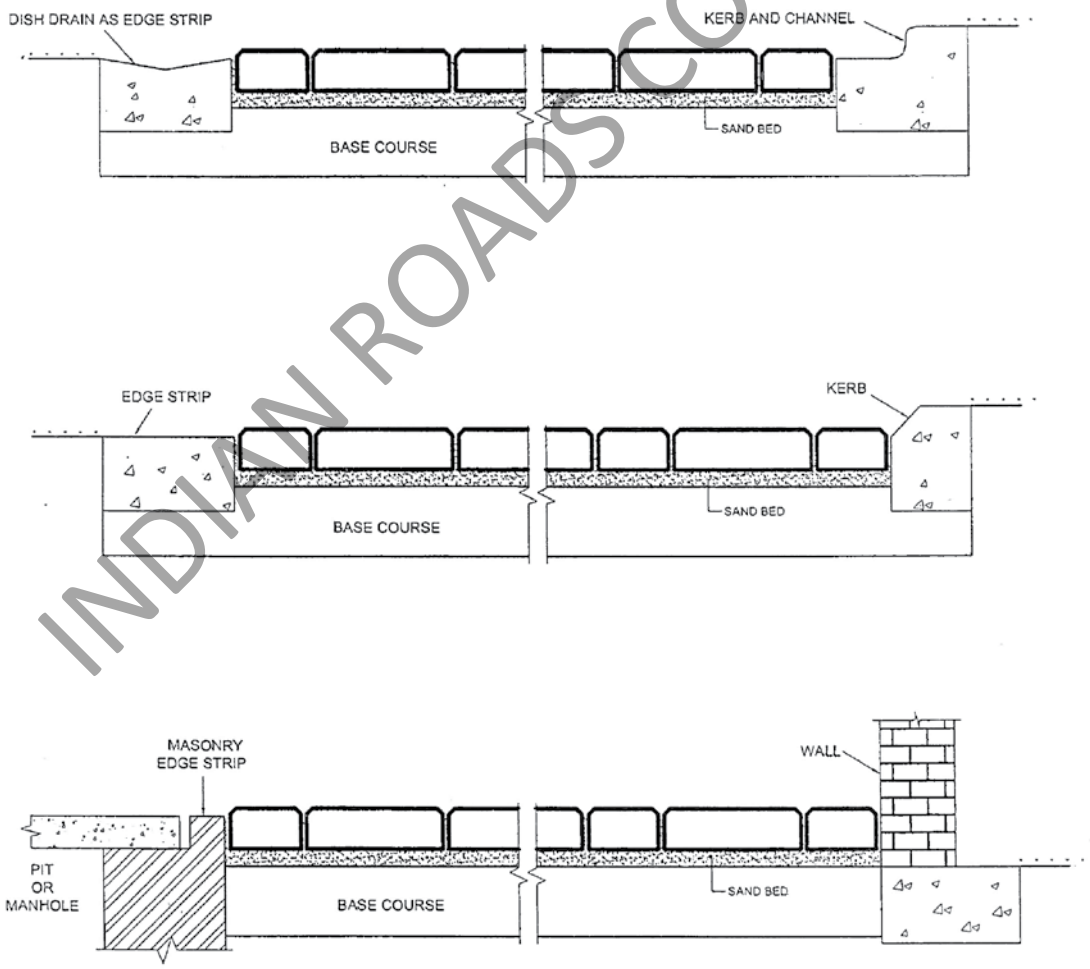


Fig. 8 Edge Restraints

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The road kerbs provided on the edge of the road also serve the purpose of edge blocks as shown in **Fig. 8**. In case the kerbs are not provided, it has to be replaced by edge strips.

5 STRUCTURAL DESIGN OF CONCRETE BLOCK PAVEMENT

5.1 Suggested Design Procedure

It is recommended that the catalogue of design as given in **Table 1** may be used.

5.2 Lightly Trafficked Pavements

Pedestrian side-walks, footpaths, cycle tracks, car parks and malls are lightly trafficked. In such situations, the pavement can consist of blocks 60 mm thick laid over a sand bedding 30 ± 5 mm and a base course 200 mm thick. The base course can be in WBM/WMM/crushed stone/soil-cement. This design can be adopted for the range of subgrade soils met within India. A typical cross-section is given in **Fig. 5**.

5.3 Block Pavements Subjected to Commercial Traffic

City streets and highway (except National-Highways and Expressways) sections subjected to commercial traffic (trucks and buses) require a heavier section. Though design methods based on empirical approach and mechanistic behaviour are available, enough work has not been done in India to evolve the country's own design procedure. In the absence of such knowledge, the ad-hoc design catalogues based on international experience as given in **Table 1** are suggested for adoption. A design life of 20 years can be considered for determining the repetitions of standard axles.

5.4 For block pavements for industrial applications like container yard and port wharf and roads and warehouses the following thickness is recommended:

Block	100 -120 mm
Sand Bedding	30 ± 5 mm
Cement bound base	300 mm
Granular sub-base (out of which the bottom 150 mm is a drainage layer)	300 mm

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6 MATERIALS

6.1 General

The quality of materials, cement concrete strength, durability and dimensional tolerances, etc. are of great importance for the satisfactory performance of block pavements. These aspects and the block manufacturing process itself, which immensely influences the quality of paving blocks, are broadly outlined in the subsequent paragraphs. The desired engineering properties of bedding/joint filling sand layer beneath the block, the base course and sub-base materials are also described.

Table 1 Design Catalogue for Pavement Thickness

Traffic and Road Type	Types of Layers	Subgrade CBR (%)		Grade of Block
		Above 10	5-10	
• Cycle Tracks, Pedestrian Footpaths	Block Thickness Sand Bed Granulated Subase	60 mm 30±5 mm 200 mm	60 mm 30±5 mm 200 mm	M-30
• Commercial Traffic Axle Load Repetitions less than 10 msa • Residential Streets	Block Thickness Sand Bed WBM/WMM Base Granular Sub-base	60-80 mm 30±5 mm 250 mm 200 mm	60-80 mm 30±5 mm 250 mm 250 mm	M-40
• Commercial traffic Axle Load Repetitions 10-20 msa • Collector Streets Industrial Streets, Bus and Truck Parking Areas	Block Thickness Sand Bed WBM/WMM Base Granular Sub-base	80-100 mm 30±5 mm 250 mm 200 mm	80-100 mm 30±5 mm 250 mm 250 mm	M-40
• Commercial traffic (Container yard and see ports) Axle Load Repetitions 20-50 msa • Arterial Streets	Block Thickness Sand Bed WBM/WMM Base or WBM/WMM Base and DLC over it* Granular Sub-base	100-120 30 ±5 mm 250 mm 150 mm 100 mm 200 mm	100-120 30 ±5 mm 250 mm 150 mm 100 mm 250 mm	M-50

Notes: 1. Thickness of layers given above are in mm.

2. Granular sub-base should have at least 150 mm layer at the bottom.

3. A typical cross-section is given in Fig. 5 and Fig. 6.

4. If the subgrade soil has a CBR of less than 5%, it should be improved by suitable stabilisation technique to bring the CBR value to 5%.

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5. msa denotes repetitions in million standard axles

* in case of roads having inadequate drainage or heavy rainfall areas (above 1500 mm per annum)

6.2 Salient Mix Design Aspects

The commonly used processes for the manufacture of pre-cast cement concrete paving units require dry, low-slump mixes. The desired characteristics of the mix are as under:

Water/cement ratio	0.34 to 0.38
Water content of the mix	5 to 7% by weight of total mix
Quantity of cement in mix	Generally not less than 380 kg/m^3 depending on the equipment being used for block making. Upper limit of cement shall not be more than 450 kg/m^3. Flyash also can be used in the mix, replacing Ordinary Portland Cement to an extent of 35 per cent by weight of cementitious material. The above values are for general guidance only. The actual mix design has to be made to suit each individual requirement.
Aggregate/cement ratio	3:1 to 6:1
Aggregate	Aggregates should conform to IS:383. The proportion of coarse aggregate in the mix is typically 40 per cent and the fine aggregate (sand) 60 per cent. The size of coarse aggregate should lie between 6 mm and 12 mm and the gradation should be in the recommended range for cement concrete mixes in general.
Strength	In general terms, the paving block must have adequate strength to withstand handling, construction stresses and effects of traffic. It is suggested that the minimum compressive strength of a single block should be above 30 MPa and blocks of compressive strength of 40 MPa for commercial traffic of less than 20 msa and 50 MPa for commercial traffic more than 20 msa.
Abrasion Resistance	Abrasion Resistance test shall be performed with rolling disc machine as per ASTM C779 procure-A. The depth of wear after 60 minute should not be more than 1.5 mm in case of M-30 Grade blocks,1.25 mm in case of M-40 Grade blocks and 1 mm in case of M-50 Grade of blocks.

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Addition of Pigments	To provide the desired colour to paving blocks, appropriate type and amount of pigments are added during mixing, in the form of powder or slurry. Although organic pigments render brighter colours than inorganic pigments, the former are adversely affected by the alkaline environment of concrete and do deteriorate with time. Inorganic pigments, mostly metal oxides, are more durable and hence preferred for consistency and purity. Saturation of colour takes place with a pigment volume of around 5 to 9 per cent of cement content. Pigments should be finer than cement (fineness value between 2 and 15 m^2/gm). For the same slump, addition of pigments requires increase in mixing water, which in some cases may lead to lowering of flexural and compressive strength of concrete; therefore, suitable adjustments in mix proportions may become necessary.
Other Additives	Under special circumstances, super-plasticizers at around 0.4 per cent of cement by weight, may be added for better workability. Water repellent admixtures of calcium stearate are sometimes used to reduce water absorption. Air entraining agents, when added to the mix, cause some reduction in the needed amount of cement. Further reduction is achieved by substituting part of the cement with blast-furnace slag (50%) or pozzolanas like flyash (35%); besides reducing cost, these also control "efflorescence" (surface deposition of salts as a result of water movement upwards).

6.3 Manufacture of Paving Blocks

The method of manufacture of paving blocks has an important bearing on the quality, durability and level of finish - dimensional tolerance, etc. all of which reflect on the ultimate performance of the block pavement during service. At the very outset, therefore, it is to be emphasized that hand-casted concrete blocks are unacceptable for use and that an appropriate plant with high frequency hydraulic press machine should be used. It would make it possible to apply high pressure together with controlled vibration. Adaptation of production facilities designed for high quality hollow masonry blocks, though feasible, is not as economical and as efficient as the use of purpose designed machinery for paving block manufacture. Essentially, the manufacturing process involves compacting concrete, in a steel mould clamped to a vibrating table, by hydraulic pressure.

Concrete is fed into the mould from a hopper by a drawer - if a second hopper is added, a block can be made of two kinds of concrete having "backing" and "facing" surfaces. In the "facing" of the block, the top 5 mm has greater amounts of cement and sand to make it more durable and skid resistant, and extra pigment is added for the coloured face vis-a-vis the rest of the block. In the first stage of compaction, pre-vibration is effected by running the vibrators

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attached to the vibratory table, the frequency generally being in the range of 50 to 100 Hz. In the second stage of compaction, compression pressure is applied to the tamper heads, also fitted with vibrators for a high level of surface finish. Blocks are extruded from mould by forcing down the tamper heads, after the vibrating table is disengaged from the mould. The blocks thus prepared are stacked either in a single layer or multiple layers for curing.

6.4 Dimensional and other Requirements of Paving Blocks

For normal paving work, the length of a paving block should ordinarily be not greater than twice the mean width; the thickness is a minimum of 60 mm; the maximum length generally not exceeding 280 mm; the width generally is in the range 75 to 140 mm with a chamfer in the range 3-5 mm. The sides of the block should be perpendicular.

To the top and bottom faces except that the top edge may be chamfered. The blocks should have the following dimensional tolerances:

Plan dimensions	±	2 mm
Thickness	±	2 mm

To ensure durability, the average water absorption in a block should not exceed 5 per cent; and for cold regions in a standard freeze-thaw durability test, the weight loss should not exceed 1 per cent.

In situations, where parts of blocks are to be used e.g., around manholes, the block should be purpose-cut at site.

It is to be recognized that variations in the thickness of blocks used for a paving job can be a major cause for the loss of surface profile, as shown in **Fig. 7** on an exaggerated scale. In the interest of maintaining a good surface profile, the block thickness should be controlled carefully; this can be done to advantage by adopting multi-layer method of manufacture of paving blocks, which reduces the variation in block thickness.

Annexure give suggested technical specifications for laying block pavements.

6.5 Bedding and Joint Filling Sand

6.5.1 *Bedding sand*

It is well established that if proper attention is not paid to the quality of bedding sand, and if the thickens of the bedding sand layer is not uniform enough, serious irregularities in surface profile can result; excessive differential deformation and rutting can occur early in service life of the block pavement. The desired gradation of bedding sand should be as per **Annexure I.**

Care should be taken to see that single-sized or gap graded sands or sands with excessive amount of fines or plastic fines should not be used. The shape of sand particles should preferably be sharp rather than rounded, since the sharp sands possess higher strength and resist the migration of sand from under the block to less frequently trafficked areas. Even

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though sharp sands are relatively more difficult to compact than rounded sands, the use of sharp sands should be preferred for the more heavily trafficked pavements. The bedding sand should be free of deleterious materials.

6.5.2 *Joint filling sand*

The gaps in between two paving blocks (typically about 2-3 mm wide) need to be filled by sand, relatively finer than the bedding sand. The desired gradation for the joint filling sand is as under:

IS Sieve Size	Per cent Passing
2.36 mm	100
1.18 mm	90-100
600 micron	60-90
300 micron	30-60
150 micron	15-30
75 micron	0-10

It is necessary to restrict the fines (silt and/or clay) to 10 per cent, since excessive fines make joint filling very difficult. Similarly, it is not advisable to use cement in the joint filling sand which will not only make it difficult to completely fill the joints but would also adversely affect the desired flexibility characteristics of the paving block layer. The joint filling sand should be as dry as possible; otherwise complete filling of joints will be difficult. To overcome the problem of efflorescence on the surface of paving block layer, the joint filling sand should be washed to remove soluble salts.

6.6 Base Layer

The engineering properties of base layer, which include load spreading properties to reduce stresses on the subgrade and desired drainage characteristics, have an important bearing on the performance of a block pavement. Although, local availability and economics generally dictate the choice of base material at the design stage, the commonly used materials considered suitable for base courses are unbound crushed rock, water-bound macadam, wet mix macadam, cement bound crushed rock/granular materials, and lean cement concrete. For heavy duty block pavement, lean concrete base must be provided.

In broad terms, wherever the subgrade is weak (having a CBR value below 5) use of bound granular materials, like, cement treated crushed rock, requiring a relatively thinner base, should be preferred while for high strength subgrades, unbound crushed rock can be used. The climatic and environmental factors also need to be considered during the choice of a base material.

6.7 Sub-base Layer

Generally, a sub-base is warranted where commercial traffic is expected. The quality of subbase material is inferior to the base materials and includes natural gravels, cement treated

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gravels and sands and stabilized subgrade materials. The quality of sub-base materials should be in conformance with IRC:37 or MoRTH Specifications.

7 DRAINAGE

Block pavement with joints filled with sand is not a waterproof layer and hence care has to be taken to drain out the surface water seeping through the joints in initial stage of the construction. This water can find way to sand bed below, base, sub-base and subgrade layers. Unless these layers are free draining, appropriate drainage arrangement has to be provided. The drainage provided generally consists of subsurface drains surrounded by filter material or a geotextile/geocomposite, which would allow the water to pass through and at the same time prevent the escape of bedding jointing sand. Typical subsurface drainage arrangement used in block pavement is shown in **Figs. 9, 10** and **11**. It is a drainage system with pervious concrete provided below the sand bed. The water collected is to be taken through 80 mm diameter perforated pipe.

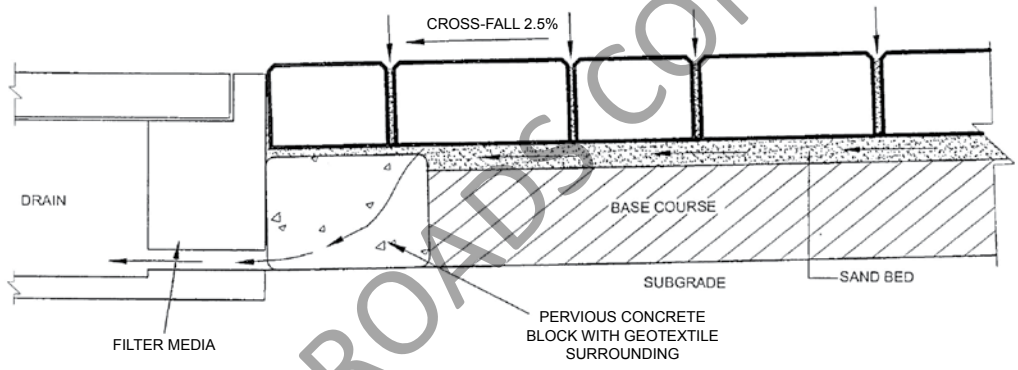


Fig. 9 Sub Surface Drainage in a Block Pavement

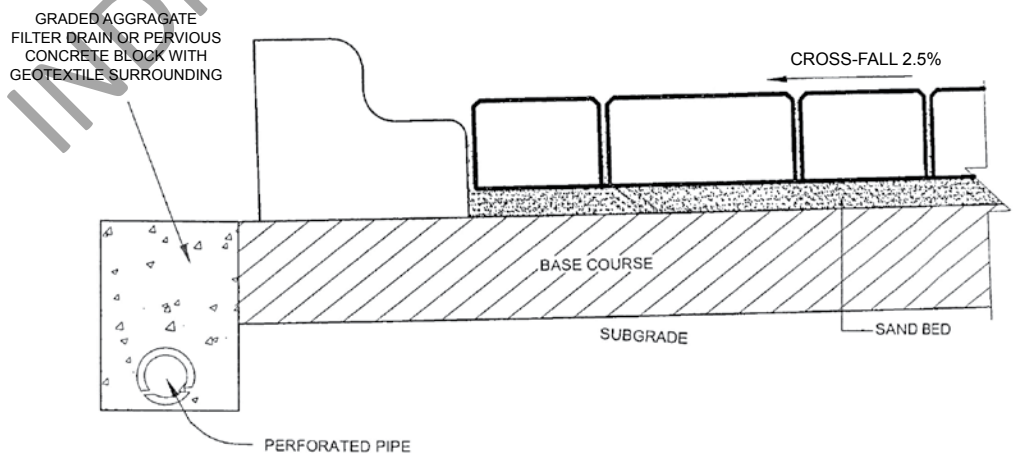


Fig. 10 Sub Surface Drainage in a Block Pavement

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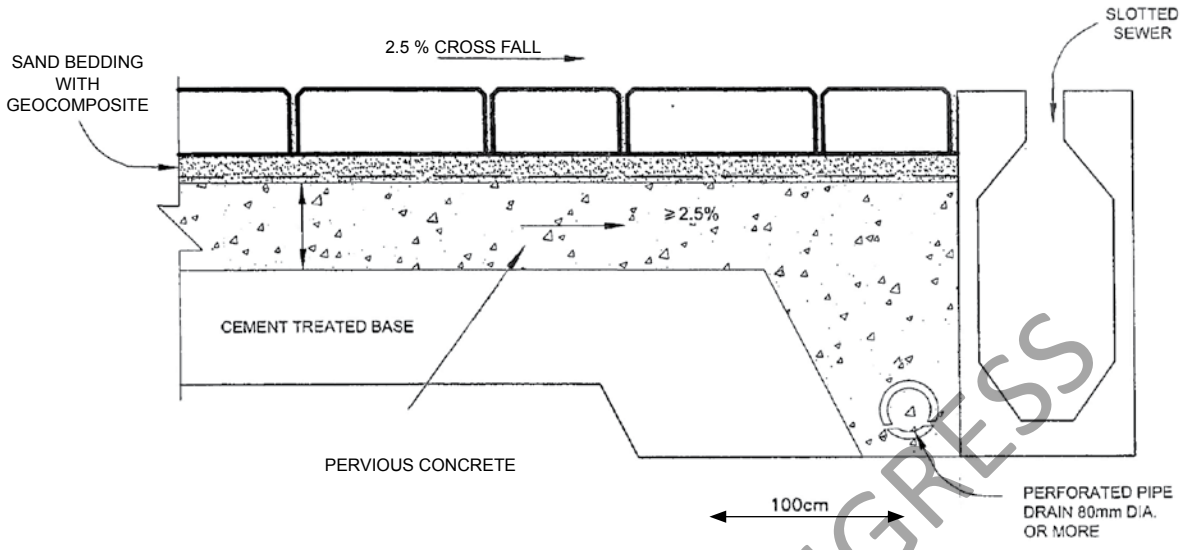


Fig. 11 Heavy Trafficked Concrete Block Pavement Structure with a Base Course of Pervious Concrete for Drainage

A crossfall of 2.5 per cent slope is generally sufficient to drain the surface run-off. The block pavement should be at least 5 mm above the manholes, side drains, etc:

8 CONSTRUCTION

8.1 General

The construction of block pavement involves preparation of subgrade, sub-base and base course layers, bedding sand and finally the laying of blocks. The block paving can be done entirely by manual labour. However, for efficient construction work, the work force has to be properly trained for this specialised job. Paving can also be done by mechanical means. Technical specifications for laying concrete paving blocks is given in **Annexure-I** and specification for controlled low strength material for repair work is given in **Annexure-II**.

8.2 Preparation of Subgrade

This is the foundation layer on which the block pavement is constructed. Like in conventional pavements the water table should be at a minimum depth of 600 mm below the subgrade. Subgrade should be compacted in layers of 150 or 100 mm thickness as per IRC:36/MoRTH Specifications.

8.3 Base and Sub-base Course

Base and sub-base courses are constructed in accordance with standard procedures as per MoRTH Specifications.

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When cement bound base are proposed it may be constructed using dry lean concrete as per IRC:SP:49. The quality control specified in IRC:SP:112 shall apply, in case of repair work where compaction is not possible CLSM may be used as under.

i.	For footpaths and cycle tracks	2 MPa
ii.	For cars and light vehicles	4 MPa
iii.	For heavy vehicles	6 MPa

Constructing the layers to proper level and grade is very essential to maintain the level and surface regularity of the block pavement. In small widths where compaction of GSB, WBM, and WMM may not be done adequately it is recommended that 75 mm to 100 mm thick DLC be provided over these granular layers to maintain the level and surface regularity.

8.4 Placing and Screeding of Bedding Sand

The thickness of the sand bed after compaction should be in the range of 30 ± 5 mm, whereas, in the loose form it can be 30 to 50 mm. It is preferable to restrict the 'compacted thickness to 30 ± 5 mm to reduce the risk of any localized precompaction, which would affect the final block surface level. Bedding sand should not be used to fill-up local depressions on the surface of a base or sub-base. The depressions should be repaired in advance before placing sand.

Sand to be used should be uniformly in loose condition and should have a uniform moisture content. Best moisture content is that when sand is neither too wet nor too dry and have a value of 6 to 8 per cent. Requirement of sand for a day's work should be prepared and stored in advance and covered with tarpaulin or polythene sheets.

The processed sand is spread with the help of screed boards to the required thickness. The screed boards are provided with nails at 2-3 m apart which when dragged gives the desired thickness. The length of nail should take into account the surcharge to be provided in the uncompacted thickness. Alternatively, the screed can be dragged on edge strips kept on both sides as guide. Asphalt paver can be employed in large projects. The sand is subsequently compacted with plate vibrators weighing 0.6 tonnes or more. Level checks shall be carried out on a grid pattern to establish that the desired level is achieved. Local correction can be done either by removing or adding extra sand followed by levelling and compacting the layer. There will be some settlement of sand after the blocks are placed and compacted, which must be allowed for, while fixing the level of sand bed.

The effect of undulating surface of base or sub-base on the profile of block pavement is explained in **Fig. 12**. The blocks will settle after trafficking in such a manner that the surface profile becomes parallel to base/sub-base profile. Sand bed assumes uniform thickness under moving loads.

8.5 Laying of Blocks

Blocks can be laid generally by manual labour but mechanical aids like hand-pushed trolleys can expedite the work.

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Normally, laying should commence from the edge strip and proceed towards the inner side. When dentated blocks are used, the laying done at two fronts will create problem for matching joints in the middle. Hence, as far as possible, laying should proceed in one direction only, along the entire width of the area to be paved.

While locating the starting line, the following should be considered:

On a sloping site, start from the lowest point and proceed uphill on a continuous basis, to avoid downhill creep in incomplete areas.

In case of irregular shaped edge restraints or strip, it is better to start from straight string line as shown in **Fig. 13**.

Influence of alignment of edge restraints on achieving and maintaining laying bond.

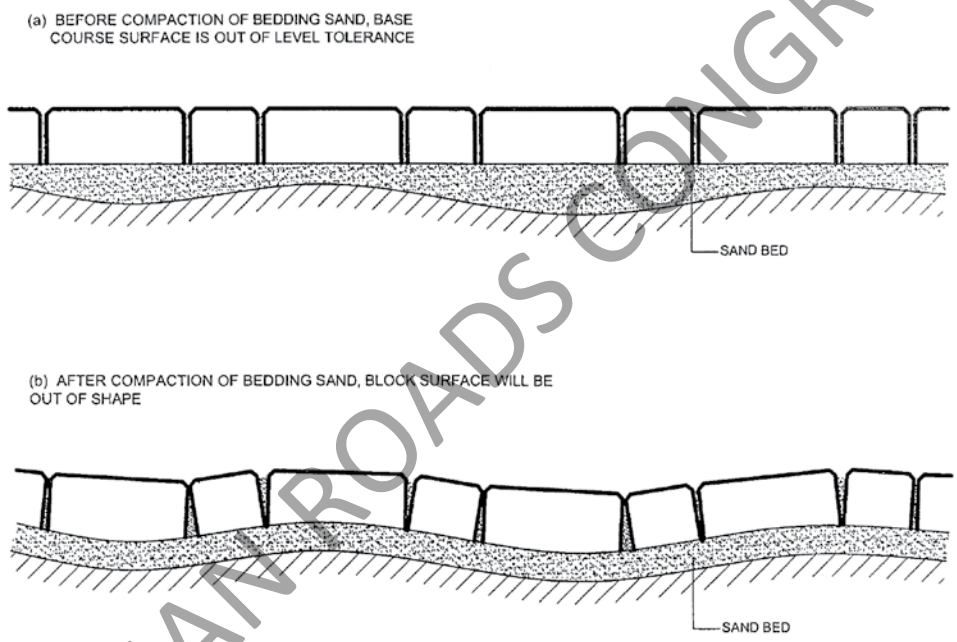


Fig. 12 Effect of Base-Course Surface Shape on Bedding Sand and Block Surface Shape

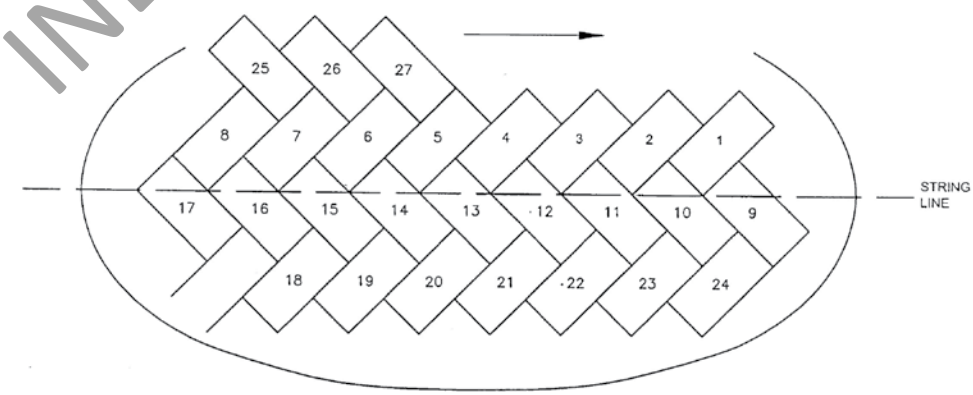


Fig. 13 Starting at Irregular Shaped Edge Restraint

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8.6 Bonds or Patterns of Laying Blocks

The blocks can be placed to different bonds or patterns depending upon choice. Some popular bonds commonly adopted for block paving are:

(i) Stretcher or running bond
(ii) Herringbone bond
(iii) Basket weave or parquet bond

The typical layout of these bonds are given in **Fig. 14**.

8.7 Establishing the Laying Pattern

In relation to the starting line, the blocks should be placed at the correct angle to achieve the final orientation as required by the laying pattern. If the edge restraint is straight and suitably oriented, the first row of blocks can abut it. For irregular-shaped and unfavourably oriented edge restraints, a string line should be established a few rows away to position the first row.

With the help of gauges, the joint width specification (2 to 3 mm) should be checked in the first few square metres, where it should be ensured that the block alignment is correct. The laying patterns and face should be established (**Fig. 15**) to permit fast and easy laying without the necessity of forcing a block between previously positioned blocks. To start with, full blocks should be used; only subsequently, cutting and in-filling at edges be permitted. Under no circumstances should the blocks be forced or hammered into the bedding sand at this stage of laying. For cutting paving blocks, hydraulic or mechanical block cutters, or power saws are used. Cut units less than 50 mm minimum dimension should not be used, as these are difficult to cut accurately and can be dislodged under traffic. Where space does not permit use of a larger segment, use premixed concrete or a sand-cement mortar instead.

The control over alignment, laying pattern and joint widths can be maintained by the use of chalked string lines, at about 5 m intervals.

8.8 Methods of Construction of Block Pavement

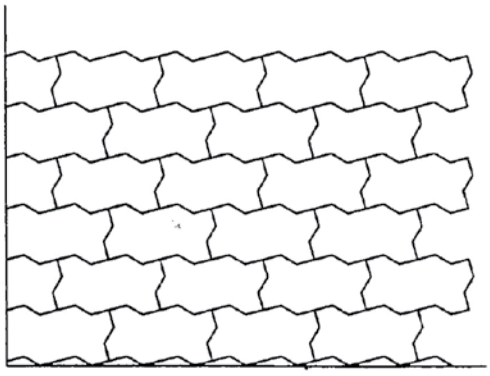
8.8.1 *Manual methods*

In the traditional manual method, the sand is roughly screeded and a skilled worker (called a pavior) levels the sand and then embeds the block using a hammer; he works backwards so as to have a continuous view of the completed pavement in order to obtain a good finish. A pavior, along with an assistant, can lay 50 to 75 m^2 of paving per day.

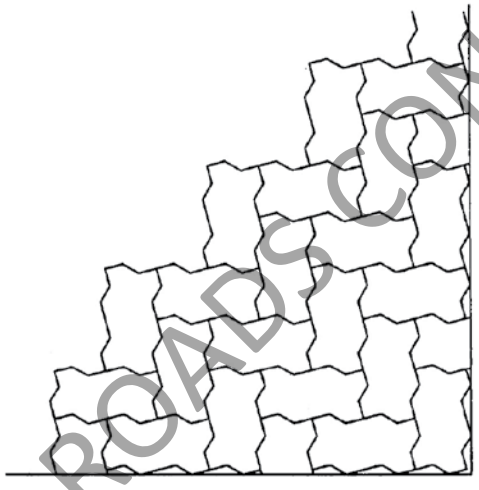
An alternative to the above method, the block layers (generally unskilled labourers) work on the completed surface, moving forward.

For optimum output, it is advantageous to select an easy fitting block shape, with the desirable size being that which can be easily accommodated in the worker's hand; in addition, the blocks should be chamfered for easy handling and their weight should preferably be less than 4 kg.

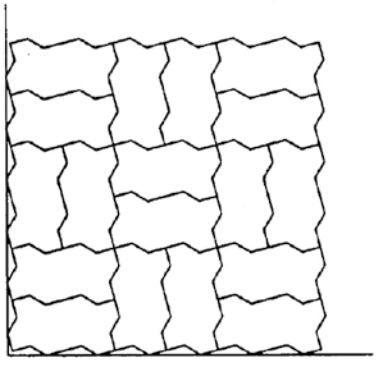
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(a). STRETCHER BOND OR RUNNING BOND



(b). HERRINGBONE BOND



(c). BASKET WEAVE OR PARQUET BOND

Fig. 14 Typical Bond or Laying Pattern of Bond

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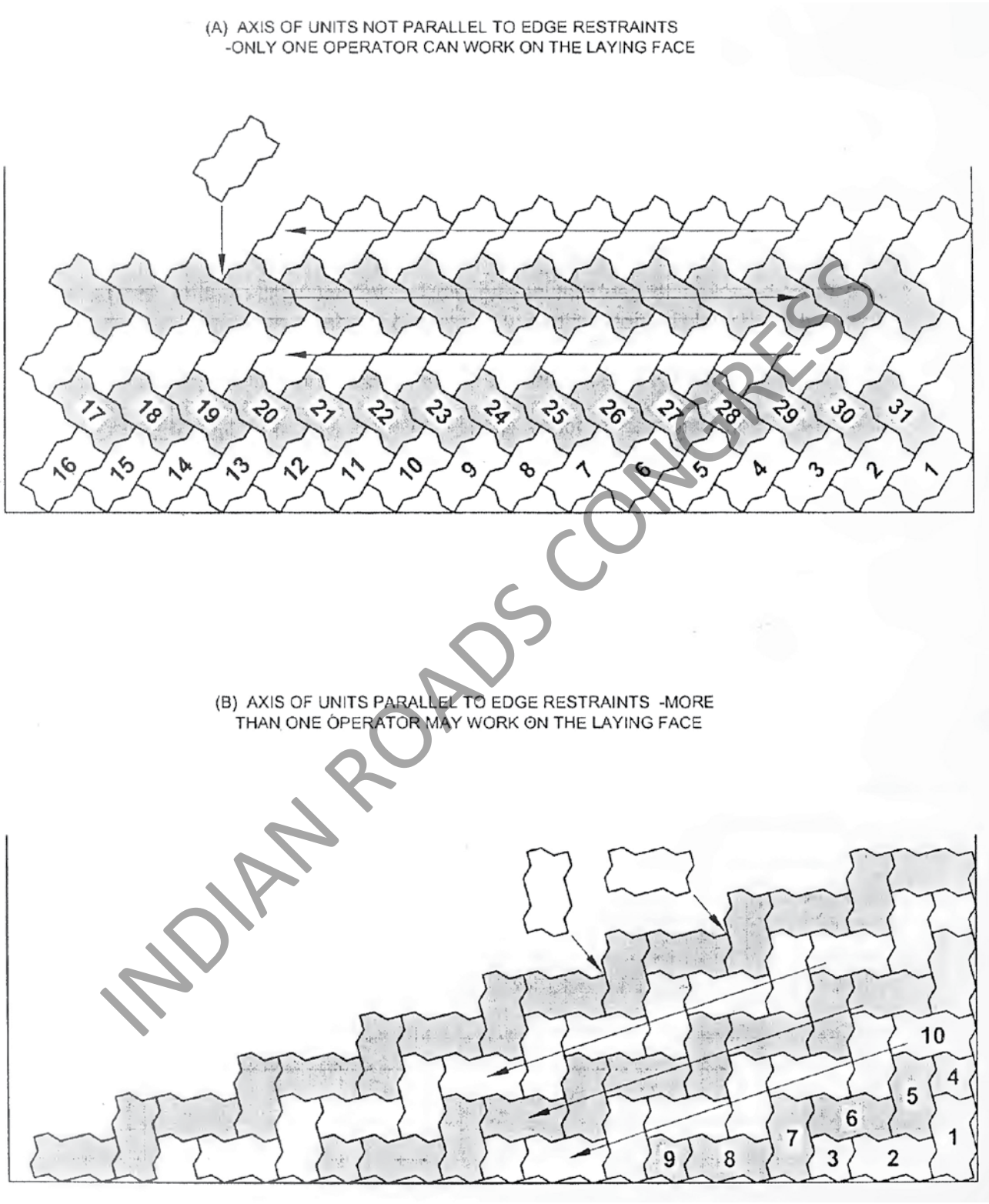


Fig. 15 Establishing Laying Face for Blocks in Herringbone Bond

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The output of finished pavement varies widely with training of workmen, over a wide range from a low of 20 to a high of 120 m^2/man-day. The higher outputs being for industrial hard standings where intrusion like manholes, etc. are minimal. To keep up the speed of work, it is important to maintain an adequate supply of paving blocks to the laying site for manual paving. Ordinarily, hand pushed trolleys are adequate for the purpose, but for large projects employing a number of laying teams, use of powered trolleys is preferable.

Care must be taken to see that paving blocks are not tightly butted against each other, otherwise there could be non-uniformity in the laying patterns and the blocks may spall or even crack. Joint widths of 2 to 3 mm can be maintained if, when laying a paving unit, it is held lightly against the face of an adjacent laid unit and allowed to vertically slide into position.

Since each workman may produce slightly different joint widths, it is desirable to rotate workmen along the workface, and also periodically interchange the personnel laying and transporting blocks.

The average joint width can be measured and checked, by determining statistically the representative values of average length and breadth of blocks at the project site and then obtaining average distance between joints, say 40 blocks apart; or it can be done by measuring joint widths directly, using a calibrated, hardened steel mandrel which is forced into joints at a series of randomly selected location, to obtain a statistically representative figure.

8.8.2 *Mechanised methods*

Mechanised laying requires the use of specialised equipment for transporting and placing clusters of paving blocks. The size of paving block cluster suitable for paving, is usually 0.3 to 0.5 m^2 in area for hand-operated equipment. For fully mechanised equipment, the cluster surface area can be upto about 1.2 m^2. These clusters are designed to maintain a joint space of about 3 mm between blocks, when clamped together (**Fig. 16**).

Since the blocks are placed in separate clusters, there exists the possibility of damage if joints between adjacent clusters run uninterrupted throughout the pavement. To overcome this problem, clusters may be arranged so that the joints are periodically staggered both along and across the cluster axis or link blocks are installed by hand across these joints (**Fig. 17**).

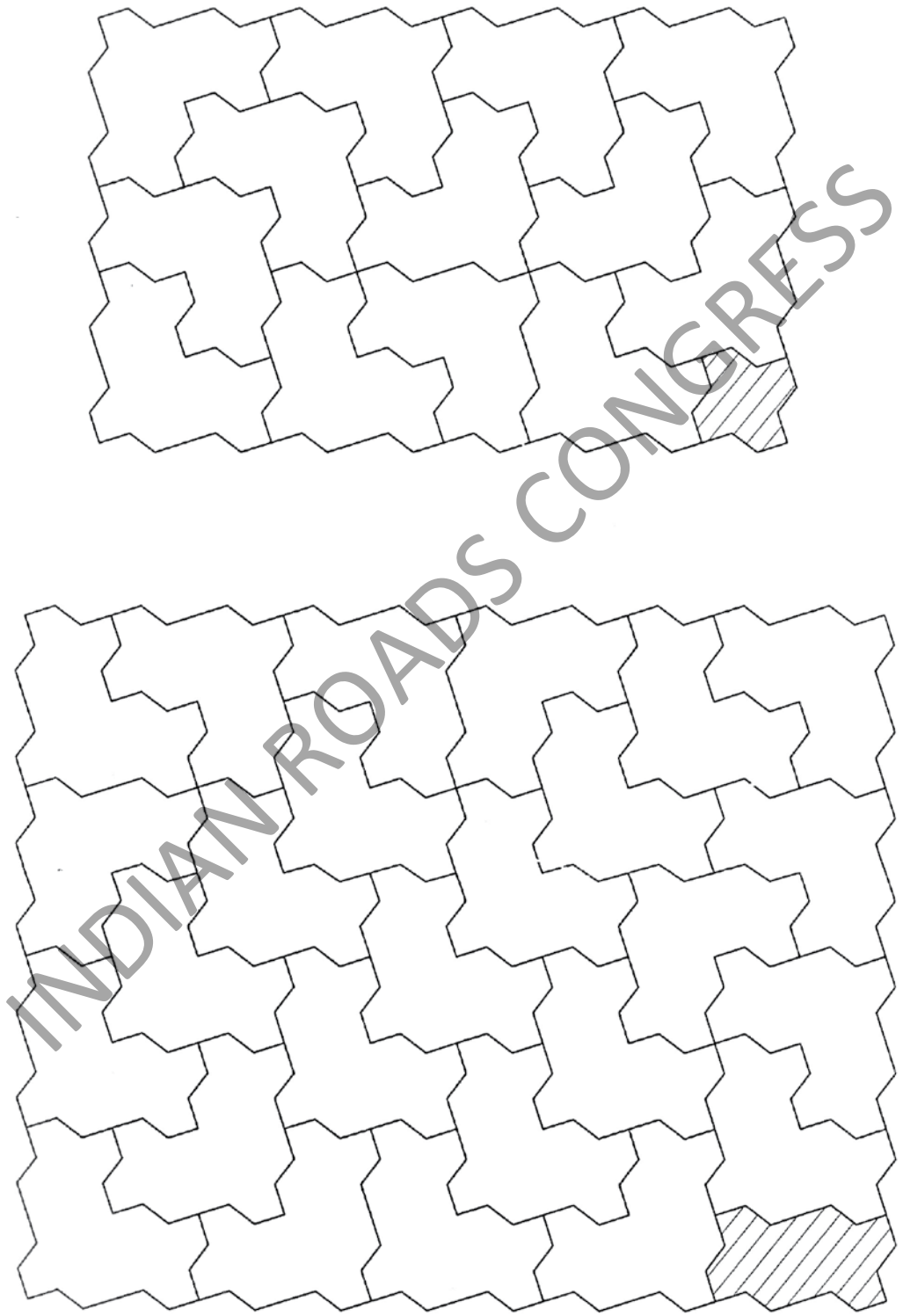
Mechanised laying must be coordinated with the manufacturer, so that the blocks are delivered stacked on pallets in the required pattern; in some cases, spacing ribs may be cast on the sides of blocks to preserve the required joint spacing.

8.8.3 *Compaction*

For compaction of the bedding sand and the blocks laid over it, vibratory plate compactors are used over the laid paving units; at least two passes of the vibratory plate compactor are needed. Such vibratory compaction should be continued till the top of each paving block is level with its adjacent blocks. It is not good practice to leave compaction till end of the day, as some blocks may move under construction traffic, resulting in the widening of joints and corner contact of blocks, which may cause spalling or cracking of blocks. There should

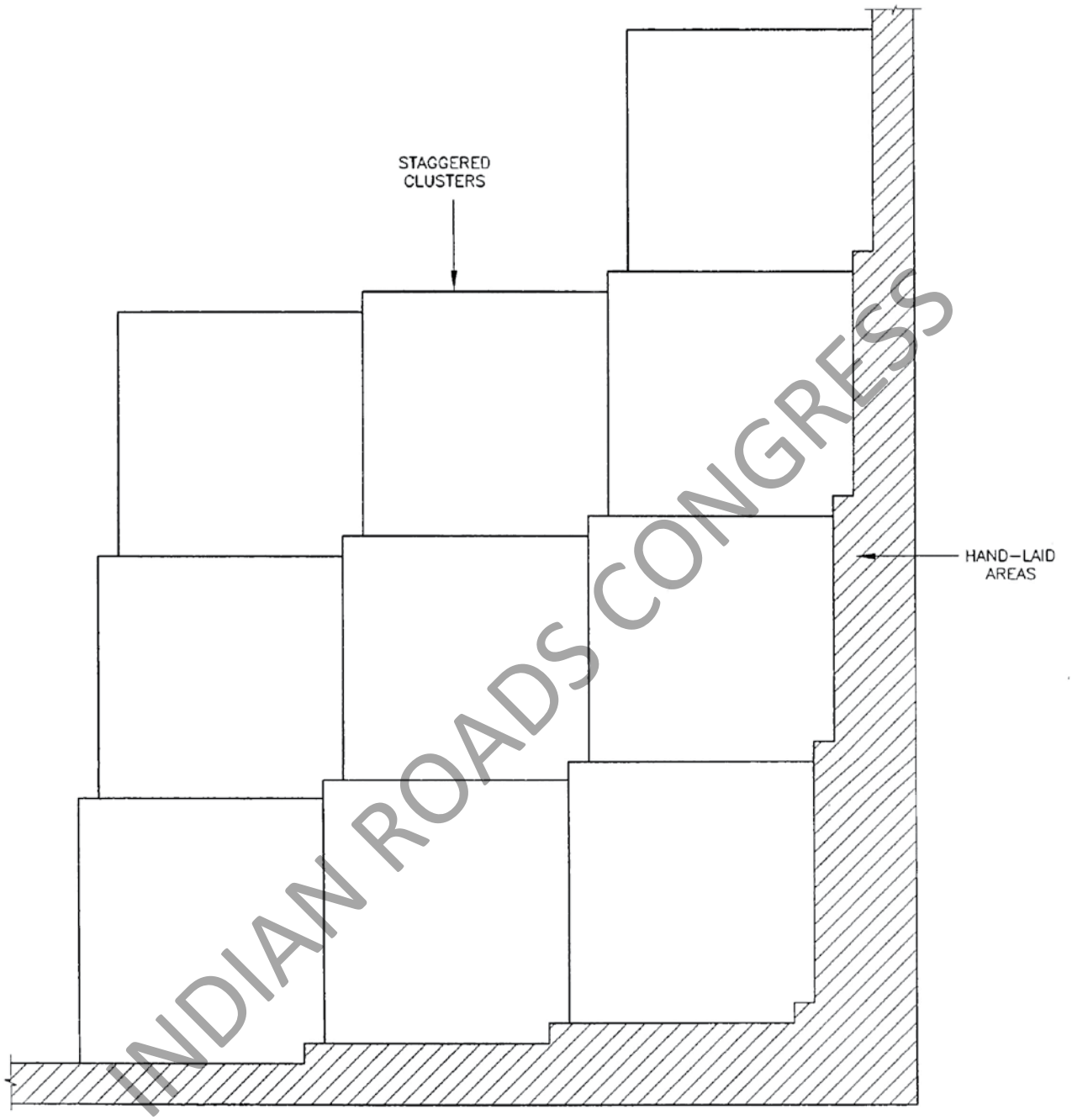
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be minimal delay in compaction after laying of the paving blocks to achieve uniformity of compaction and retention of the pattern of laying; however, compaction should not proceed closer than 1 m from the laying face, except after completion of the pavement.



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Fig. 16 Typical Block Cluster in Merchanised Laying



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Fig. 17 Staggered Installation of Block Clusters

During vibratory compaction of the laid blocks, some amount of bedding sand will work its way into the joints between them. The extent of sand getting worked up into the joints will depend on the degree of pre-compaction of sand and the force applied by the block compactor. Standard compactors may have a weight of about 90 kg, plate area of about 0.3 m^2 and apply a centrifugal force of about 15 kN, while heavy duty compactors may weigh 300-600 kg, have a plate area of about 0.5-0.6 m^2 and apply a centrifugal force of 30-65 kN. Where the bedding sand has been pre-compacted and for heavily trafficked block pavements, heavy

duty compactors should be used. After compaction by vibratory plate compactors, some 2 to 6 passes of a vibratory roller (with rubber coated drums or those of static weight less than 4 tonnes and nominal amplitude of not more than 0.4 mm) will further help in compaction of bedding sand and joint filling.

8.8.4 *Joint filling*

The importance of complete joint filling cannot be over-emphasised. Unfilled or partially filled joints allow blocks to deflect, leading to loose blocks, possibly spalling the edges and a locally disturbing bedding sand layer, as shown in **Fig. 18**.

After the compaction of the bedding sand has been completed and some bedding sand has been forced up in the joints between blocks, the joints should be completely filled with sand meeting the desired specifications, as given in Section 6. The joint filing sand should be stockpiled at suitable locations for convenience. There should be minimum delay in joint filling; the process should in any case, be completed by the end of the day's work.

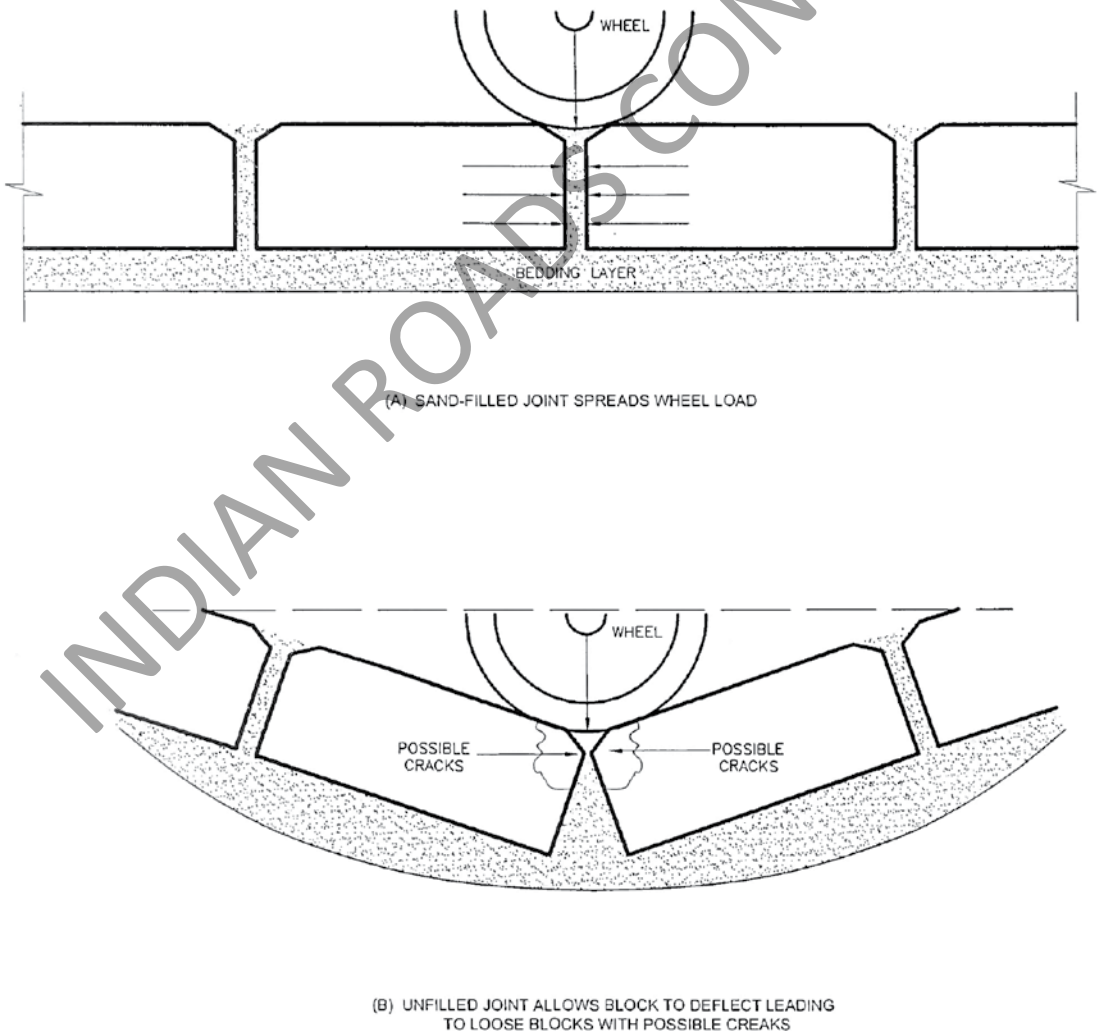


Fig. 18 Need for Complete Filling of Joints

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The operation of joint filling comprises of spreading a thin layer of the joint filling sand on the block surface and working the sand into each joint by brooming. Following this, a few passes of heavy plate compactor are applied to facilitate fine sand to fill the joints. The sand should be broomed or spread over the surface with a small surcharge.

Dry sand and dry blocks are best for the filling of joint, as damp sand tends to stick at the very top of the joints; also, if the block is wet and the sand dry, the sand will again stick at the joint top. Hence, if either the blocks or sand are wet, one may get a false impression of the joints being full, but the next rain will reveal that they are actually hollow. If the weather does not allow sand and blocks to be dry, the joint filling sand should be washed in by light sprinkling of water. In this case, several cycles of application of sand, water-sprinkling and plate compaction will be necessary to completely fill the joints.

8.8.5 *Opening to traffic*

Until all the joints are completely filled, no traffic should be permitted over the block pavement. In case of lime or cement treated layers in the pavement, it must be ensured that these are given at least 14 and 7 days respectively to cure, before traffic is permitted. The block pavement should be inspected frequently, to ensure that any incompletely filled joints, exposed by traffic and/or weather are promptly filled. Such frequent inspection should be continued till dust and detritus from the roadway tightens the surface of the joints.

8.8.6 *Laying and Surface Tolerances*

While laying the surface tolerances, given below may be observed:

Layer/Item	Tolerance
Subgrade	+0, -25 mm of nominated level
Select subgrade/Sub-base	-0, -20 mm of nominated level
Base Course	-0,+10 mm of nominated level 10 mm deviation from a 3 m straight edge
Plan deviation from any 3 m line from any 10 m line	 10 mm (maximum) 20 mm (maximum)
Vertical deviation from 3 m line at kerbs intrusions, channels, edge restraints elsewhere	+3 mm, -0 mm
Maximum difference in surface level between adjacent paving units	+5 mm, -5 mm
Deviation of finished surface level from designated level	+10 mm, -15 mm
Joint width range	2 mm to 3 mm
Percentage of joints outside range	10% max. along 10 m line
Nominal joint width	3 mm
Final finished surface with 3m straight edge	± 3 mm

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8.8.7 *Detailing block pavements*

Essentially, there are three important aspects in detailing. These are

(i) Curves
(ii) Treatment of intrusions
(iii) Changes in alignment

8.8.7.1 Curves

It is necessary to cut the paving units to fit the edge restraints. Rectangular blocks of a similar or contrasting colour as an edging have been used to minimise the visual effects of small errors in block cutting. To avoid unsightly and potentially weak construction joints, it is often preferable to change the laying pattern at the curve. For example, as shown in **Fig. 19**, the curve itself can be installed in herringbone bond and yet the pavement can revert to stretcher bond on the approaches.

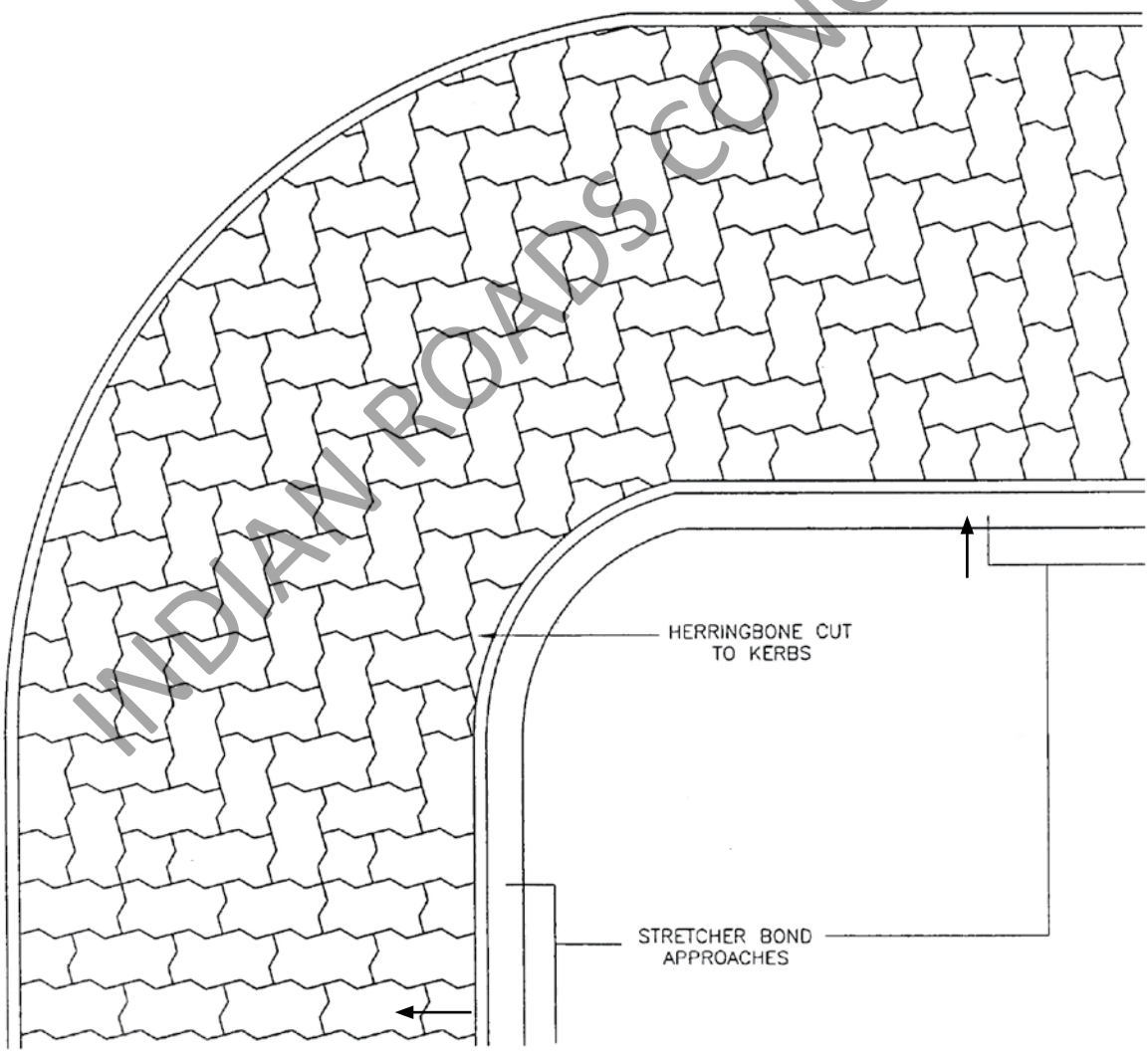


Fig. 19. Curve in Herringbone Bond and Approaches in Stretcher Bond

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8.8.7.2 Pavement intrusions

On some pavements, like in city streets, there could be several intrusions, like, manholes, drainage gulleys, etc. Where meeting these intrusions with the pavement is desirable. **Fig. 20** shows how this should be done around a manhole.

Around intrusions, it is good practice to lay along both sides of the intrusion simultaneously so that closure is made away from the starting workface, rather than carrying the pavement around the intrusion to return to the original laying face (**Fig. 20**) to avoid accumulation of closing error.

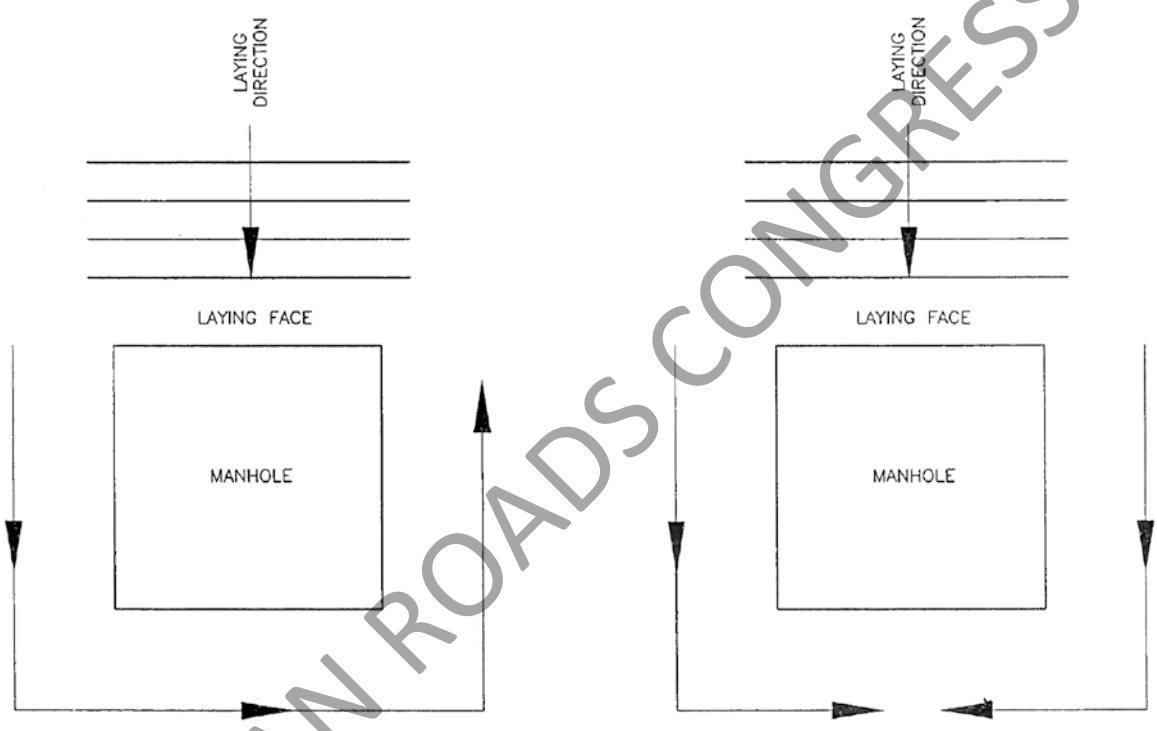


Fig. 20. Laying Block Paving Around a Manhole

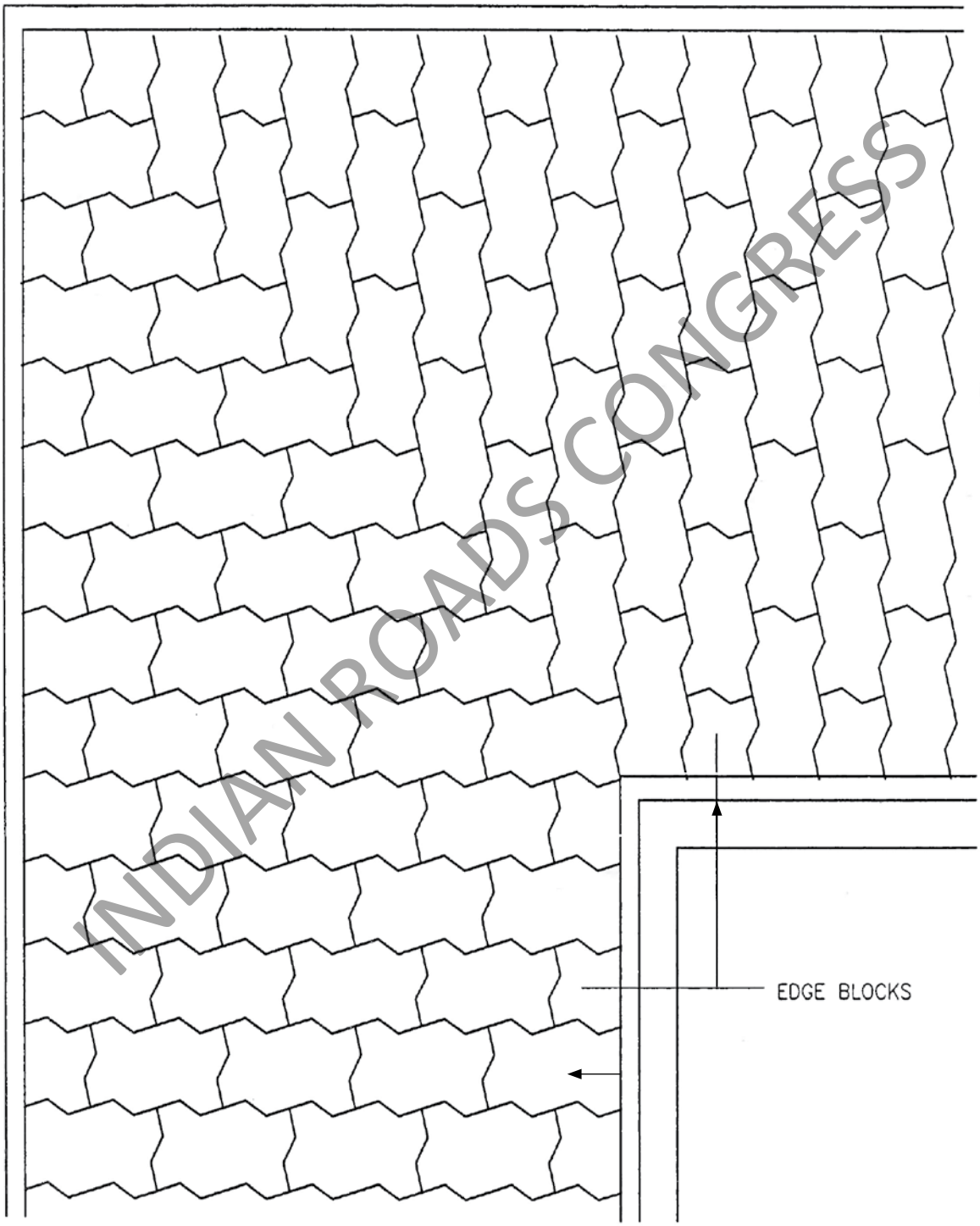
8.8.7.3 Changes in alignment

Changes in alignment of a road pavement can some times be achieved by the use of special blocks. However, it is generally easier to choose a block that can be installed in herringbone bond and simply cut the blocks to fit the edge restraints. Where aesthetic requirements or shape of the paving unit dictate the use of stretcher bond, then only a 90° shape change in alignment can be achieved without cutting the blocks (**Fig. 21**). At intersections, if a herringbone bond laying pattern is adopted, the paving can proceed without the need for construction joints (**Fig. 22**). An alternative to this is to install a shoulder (support) course of rectangular paving units between the main roadway and the side streets; this permits different laying patterns to be used in the two roadways.

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8.9 Specifications

Annexure-I gives the specifications for laying. The BIS Specifications IS:15658:2011 for Precast Concrete Blocks for Paving may be followed for the manufacture and testing of blocks.



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Fig. 21 90° Change in Alignment using Stretcher Bond

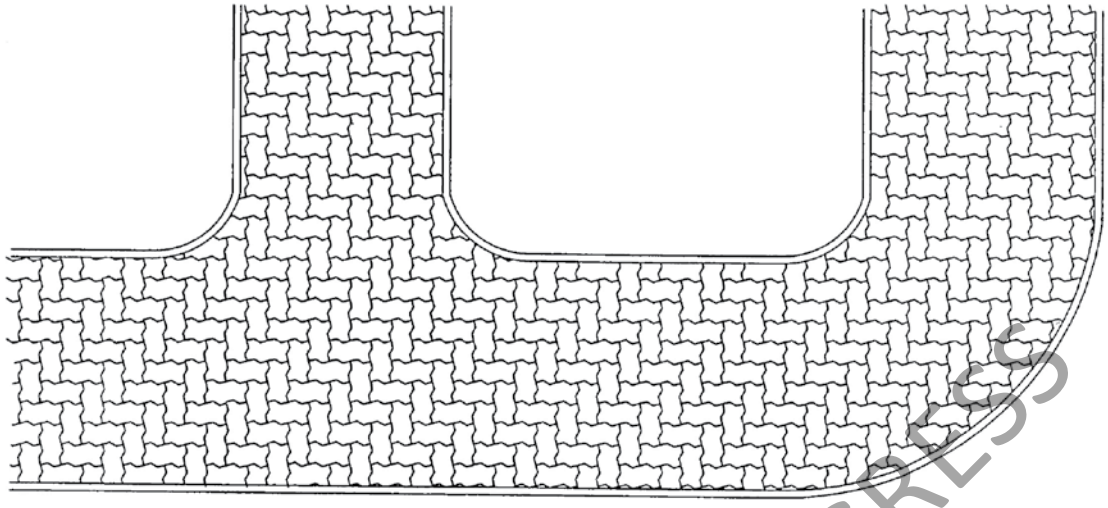


Fig. 22 Adaptation of Herringbone Bond to Changes in Alignment

9. MAINTENANCE

9.1 General

Like any other road work, block pavement also required to be maintained to get long service. The maintenance requirement of block pavement is minimal. The block pavement requires initial maintenance soon after its laying, say after a week or two for checking sand in the joints. Subsequently, the maintenance is in the form of replacing any damaged block/blocks or raising the settled section, if any. Repair especially after laying a cable duct is much simpler in the case of block pavements. The cut area can be reinstated without any blemish.

9.2 Initial Maintenance

After about a week of laying the blocks there is a need to inspect the surface to check for any loss of sand at joints. Wherever sand level has dropped down it should be reinstated. This type of inspection should continue for two to three months till the sand level is stabilized and topping up is no more required. With time the joints receive fine dust and detritus thus making them waterproof. During rains these joints may allow weeds to grow but these normally should get eliminated with the traffic. In case it does not get eliminated these may have to be controlled by spraying herbicide or by manual removal. Annual inspection, however, will be required.

9.3 Storage of Blocks

For the purpose of reinstating damaged blocks it is necessary to stockpile a small percentage of blocks from the lots used in the construction. The size and colour of the blocks may be difficult to obtain at a later date matching with the original blocks. For important projects, it is normal to stockpil blocks from 1 per cent to 3 per cent of initial supply for subsequent use.

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9.4 Coating and Cleaning

As part of preventive maintenance, blocks can be sealed using compounds, like, silicone, acrylics and silica fluorides for enhancing the colour, reducing absorptive nature of the blocks and for improving surface toughness. These coating have life of 1 to 3 years and hence they have to be repeated as per the requirement. The most durable of these chemicals is solvent-borne acrylics which are abrasion resistant and also minimize chemical effects of spillage even at 60°C.

Cleaning of block pavement can be done by mechanical brooms, compressors or even by manual means. For removing certain stains, chemicals, like, oxalic, acetic and phosphoric acids etc. are used. Sometimes it may be expedient to replace the blocks where stains have penetrated to a greater depth.

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Annexure-I

TECHNICAL SPECIFICATIONS FOR LAYING CONCRETE PAVING BLOCKS

1.1 Base

1.1.1 The finished surface of the concrete base shall match the design profile of the concrete blocks within ±10 mm.

1.1.2 Compaction shall be done by normal roller preferably with vibratory roller. In restricted areas where normal rollers cannot operate, hand-held or plate vibrators should be employed.

1.2 Bedding Sand Layer

1.2.1 The bedding sand layer shall be from either a single source or blended to achieve the following grading:

IS Sieve Size	*Per cent Passing*
9.52 mm	100
4.75 mm	95-100
2.36 mm	80-100
1.18 mm	50-95
600 micron	25-60
300 micron	10-30
150 micron	0-15
75 micron	0-10

Single sized, gap-graded sands or those containing an excessive amount of fines shall not be used. The sand particles should preferably be angular type.

1.2.2 The bedding sand should be slightly moist, and the moisture content shall be about 4 per cent by weight.

1.2.3 The joint-filling sand should pass a 2.36 mm sieve and be well graded. The following grading is recommended:

Sieve Size	*Per cent Passing*
2.36 mm	100
1.18 mm	90-100
600 micron	60-90
300 micron	30-60
150 micron	15-30
75 micron	0-10

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1.2.3.1 The use of cement in the joint-filling sand is not recommended as a general practice as the cemented sand is likely to crack into segments which are easily dislodged.

1.2.3.2 Average thickness of this laying course shall be 30 ± 5 mm.

1.2.4 It should contain not more than 3 per cent by weight of clay and silt and the materials shall be free from deleterious salts or contaminates.

1.2.5 The finished surface of the bedding layer shall match exactly the design profile as indicated on the drawings.

1.2.6 Before placing the bedding layers, the surface of concrete should be cleared by sweeping.

1.2.7 Walking or driving on the finished surface of the bedding layer shall not be permitted.

1.3 Concrete Paving Blocks

1.3.1 Laying of the blocks shall be done, precisely at the indicated level and profile and in a way that a good surface draining to the gulley chambers is assured.

1.3.2 Around gulley chambers and inspection pits the pavement shall have a level of 5 mm higher than the above mentioned elements.

1.3.3 The blocks shall be laid to the pattern shown in the drawing/specification or the pattern recommended by the designer. The blocks shall be laid as tight as possible to each other. The maximum joint width shall be limited to 3 mm.

1.3.4 Laying of broken blocks is not allowed except along connections or edges. The maximum length of a purpose broken block is 100 mm. Breaking of the blocks shall be done with a “block splitter” or a mechanical saw.

1.3.5 Fine angular sand as per specification shall be brushed into the joints, and thereafter compaction shall be done with a vibrating plate compactor on a clean surface. After compaction, again fine angular sand shall be brushed into the joints.

1.4 Surface Tolerances

1.4.1 Surface tolerance for finished surface shall be ± 5 mm from the design level.

1.4.2 The surface tolerance for base course shall be in the range of 0 to +10 mm from nominated level and 10 mm deviation from a 3 m straight edge.

1.4.3 The surface tolerance for sub-base shall be within 0 to 20 mm of nominated level.

1.5 Methodology for Laying Blocks on Trench Filled Areas

1.5.1 In urban area it is common practice to leave 1 to 1.5 m wide strip along main concrete road for laying of utilities in future. This is laid as flexible pavement or paver block

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pavement. However after the laying of services the reinstatement is not done properly resulting into undulated surface leading to public inconvenience, WMM and GSB is generally provided as base and subbase, under block pavement, but these layers get disturb during trenching for laying utilities. Reconstruction of these layers after laying utility is not done properly. As a result settlement and undulation occur causing failure and inconvenience it is recommended that a layer of DLC or Controlled Low Strength Material (CLSM) be provided above well compacted GSB & WMM layers. Specification of CLSM are given in **Annexure II**.

CLSM-Controlled Low Strength Material is self compacting, cementations material. The properties of CLSM are between Soil and Concrete. CLSM is manufactured from material similar to those used to produce concrete and is place from equipment in a fashion similar to that of concrete. Guidance should be taken from Report on Controlled Low Strength Material, American Concrete Institute, ACI- 229 R-13, which was referred for drafting this specification. Specification for controlled low strength material is given in **Annexure-II**.

2 FIELD/LABORATORY TESTS

(a) Necessary field/laboratory tests shall be carried out by the contractor while executing the work at his own cost.

(b) The field/laboratory tests may be conducted in an Engineering College/approved technical institution as per specification in contract agreement.

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Annexure-II

SPECIFICATION FOR CONTROLLED LOW STRENGTH MATERIAL (CLSM)

1 INTRODUCTION

CLSM- Controlled Low Strength Material is self compacting, cementations material. The properties of CLSM are between soil and concrete. CLSM is manufactured from material similar to those used to produce concrete and is placed from equipment in a fashion similar to that of concrete. Guidance should be taken from Report on Controlled Low Strength Material, American Concrete Institute, ACI 1229 R-13, which was referred for drafting this specification.

2 APPLICATIONS

2.1 General

The primary application of CLSM is as a structural fill or as a base pavement. Since freshly mixed CLSM is in fluid form, it is self levelling and needs no compaction. It is ideal for use in restricted access areas where placing and compacting fill is difficult e.g. refilling trenches, spaces behind walls, around manholes etc.

The strength of the hardened fill material is measured by unconfined compressive strength, by the method similar to soil testing of remoulded specimen. The size of test specimen can be 38 mm diameter to 150 mm diameter cylinder having length 2 to 2.5 times the diameter. Test can also be performed on cubes 100 mm size or 150 mm size. Normally diameter of the test specimen should be about 8 times the largest particle with size in the mix. The strength has to be specified with size of test specimen to be used, and may change with size of specimen and its aspect ratio. Refer IS 2720 part 10 for unconfined compressive strength of remoulded soil specimen. The strength of CLSM can generally be in range of 1.5 to 5.0 MPa, though fills having strength 0.5 to 8 MPa are possible.

3 MATERIALS

3.1 Controlled Low Strength Material (CLSM) is a mixture of water, Portland cement, sand, fly ash Ground Granulated Blast Furnace Slag (GGBS) and aggregate. For lower strength (say below 2.5 MPa) natural soil, available material excavated from road crust, recycled aggregates, marginal or low aggregates (not conforming to IS 383) can also be used. Selection of material should be based on required characteristics of the mixture including flow- ability and strength. Trial mixes can be done to arrive at proper quality of CLSM.

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3.2 Cement

The cement used shall be any of the following types selected for the intended use.

(i) Ordinary Portland Cement, IS 269-2015 (OPC)

(ii) Portland-Pozzolana Cement, IS 1489 Part 1-2015 (PPC)

(iii) Portland Slag Cement, IS 445-2015(PSC)

(iv) Composite cement, IS 16415-2015 (blended with granulated slag & flyash) Cement can additionally be mixed with more supplementary cementitious materials with multiple blending.

The cement content varies from 60 to 120 kg/m^3.

3.3 Supplementary Cementitious Materials:

Coal combustion fly ash or Ground Granulated Blast Furnace Slag (GGBFS) can be used. The quantity used from 50 to 750 kg/m^3.

3.4 Aggregates

Aggregates are the major constituent of CLSM mixtures. The type, grading and shape of aggregates can affect the physical properties such as flow ability and comprehensive strength. Generally aggregates sizes 10 mm down are utilized. Quarry waste of this size could be utilized. The sand shall be river sand of required gradation. Silty sand could be used. However, sand with clayey fines should not be used. The quantity of total aggregates used could be from 1500 to 1700 kg/m^3.

3.5 Admixtures

Air entraining admixtures and foaming agents can be a useful constituent for the CLSM. The inclusion of air in CLSM can help to provide improved workability and reduced shrinkage, less bleeding, minimum segregation and lower unit weights.

The CLSM mixtures are pumpable but require higher pump pressures. To prevent extended setting times, extra cement or an early setting admixture may be added if required. In such cases Pretesting should be performed to determine acceptability by providing trial stretches. This can give opportunity to effect minor modification in the design.

3.6 Water

Water that is acceptable for normal concrete mixture is acceptable for CSLM mixtures. (Potable water is generally considered satisfactory for mixing of CLSM). Water used is from 150 to 400 kg/m^3.

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4 PROPERTIES

CLSM can be successfully delivered by conventional concrete pumping equipment or by locally preparing in concrete mixers. Proportioning of the mixture is critical. Voids must be adequately filled with particles to provide adequate cohesiveness for transport through the pump line under pressure without segregation. Hardening time is mainly dependent on the type and quantity if cementations material used in CLSM.

Wet density of normal CLSM in place is in the range of 1840 kg/m^3 to 2300 kg/m^3. A CLSM mixture with only fly ash, cement and water should have a density between 1440 to 1600 kg/m^3.

The ability to excavate CLSM in required in future is an important consideration for road shoulder work. In general CSLM can be excavated by pickaxes or with light excavating equipment. However, the limits for excavability are some what arbitrary, depending upon the CLSM mixtures.

CLSM is compatible with Polyethylene materials which are mainly used as protection for the underground utilities or as the conduits themselves. As with any back fill care must be taken to avoid damaging the protective coating of under ground utility lines.

4.1.1 *Flow Ability*

Flow ability is the property that distinguishes CLSM from other fill materials. It enables the materials to be self levelling flow into small size excavated portion and readily fill a void and is a self compacting without the need for conventional placing and compacting equipment. This property represents a major advantage of CLSM compared with conventional fill materials that need mechanical placement and need compaction.

4.1.2 *Hardening Time*

Hardening Time is the approximate period of time required for CLSM to go from fluid state to a hardened state with sufficient working strength. Generally it takes 24 hours under normal conditions without admixtures. With admixtures this time is required to brought between 2 to 4 hours. Broadly speaking, a personal should be able to walk over the laid CLSM within about 2 to 4 hours.

Following are the factors affecting the grading time:

1. Type and quantity of cementations material
2. Moisture content of CLSM
3. Permeability and degree of saturation of surrounding materials that is in contact with CLSM
4. Proportioning of CLSM
5. Mixture and surrounding temperature
6. Humidity
7. Method of filling

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5 MIXTURE PROPORTIONING AND PROCEDURE

Different proportioning of mixes for CLSM have been prescribed in ACI. But trail mixes and stretches can be prepared with different proportion to achieve the CLSM, which hardens sufficiently in 2 to 4 hours. To achieve required strength of M^2 i.e 20 kg/cm^2 mixes with 1 cement and 60 parts of sand/grit/flyash combination is usually required. Trails are, however, necessary to fix actual proportions.

Following is the procedure that can be adopted for mixing:

1. Add 70 to 80% of water required
2. Add 50 % of the aggregate filler
3. Add all cement and fly ash required
4. Add balance of aggregates
5. Add balance water

Generally about 15 min is required to produce a homogenous slurry.

6 MIXING TRANSPORTING AND PLACING

6.1 Mixing

CLSM can be mixed by several methods including ready mix through batching plant conveyed by RMC Trucks. It can be also done by concrete mixers etc.

6.2 Placing

6.3 The placing of CLSM can be done thorough, conveyor, buckets or pumps depending upon the application and its accessibility. As mentioned internal vibration or compaction is not required since the CLSM gets considered essential for CLSM.

7 QUALITY CONTROL

The extent of a quality control of CLSM can vary as per experience, application and basic materials utilized and level of quality desired. Quality control of CLSM can be as simple as a visual check of the completed work, where standard pretested mixtures are being used. Mould cubes should be taken and tested as for normal concrete.

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