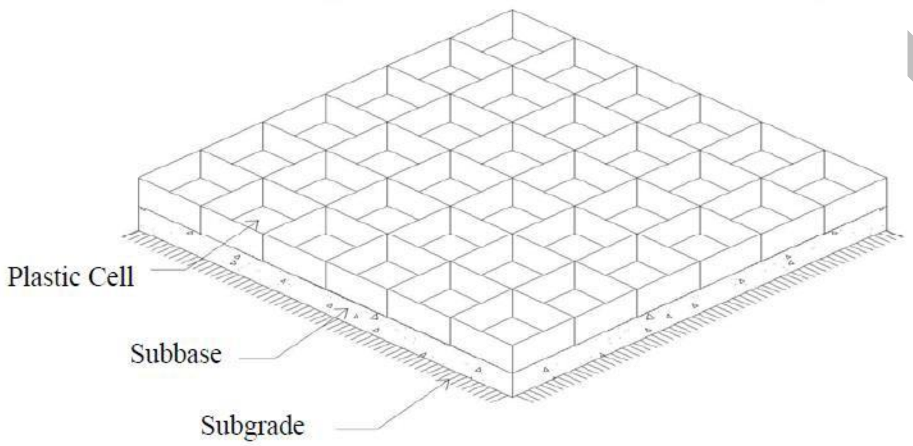
MODERN MATERIALS AND ADVANCED TECHNOLOGIES

CELL FILLED CONCRETE PAVEMENT

Most of the low volume village roads being constructed are flexible pavements provided with a thin bituminous surface. Quite often, these roads get damaged due to overloaded vehicles, inadequate drainage facility and water logging problems, and hence require early periodic maintenance. Also, in the absence of adequate fund and timely maintenance, the serviceability level of the roads deteriorates rapidly. Therefore, to there is a need to come up with new innovative technologies, developed through research and development initiatives, which lead to creation of sustainable assets and reduces the maintenance cost. The technology of cell filled concrete pavement, has proved to be very promising solution for the above mentioned issues. It provides long lasting concrete pavements at low initial cost which are almost maintenance free.



The technology consists of covering the compacted sub grade/ sub base with a formwork of plastic cells as shown in the above f**igure**. The formwork of plastic cells is stretched and iron spikes are driven at the corners of the cells so that the formwork remains taut. Nylon ropes through the cell walls prevent collapse of the cells during the placing concrete or stones into the cells. The plan of the formwork will appear as shown in **Figure-2** on stretching.

Different types of concrete such as conventional concrete/zero slump concrete with the 28 day characteristic strength of 30 MPa is placed into the cells. Since the sub grade/ sub base have the proper camber, the top of the cells also will have the same camber. After levelling the concrete, a vibratory/static road roller of 6 to 8 ton capacity may be used for compaction. The cell walls get curled both vertically and horizontally during the construction to bring about the three dimensional interlocking among the concrete blocks.

Form work of the plastic cells can be made from reclaimed high density polyethylene (HDPE) sheets of thickness 0.22 mm to about 0.25 mm. Plastic sheet manufacturers can supply rolls of strips 50 mm to 100 mm wide depending upon the depth requirement. The strips can be heat welded or stitched to form cells. Colour of plastic sheets is not important since the cells remain buried and reclaimed HDPE/LDPE sheets are usually rendered black in colour. Waste low density polyethylene (LDPE) is available in plenty and the recycled LDPE sheets of thickness 0.30 to 0.35 mm can be used for making the form work of cells. Readymade formwork of cells also can be obtained from the market.

The subgrade forms the top 300 mm thick portion of the embankment and it should be prepared as per specifications. The subgrade in embankment is compacted in two layers usually to a higher standard than the embankment. If the embankment soil is poor, the top 300 mm of the subgrade may consist of good quality material from borrow pits with CBR exceeding five.

The subbase may consist of laterite boulder consolidation, water bound macadam, wet mix macadam, crusher run macadam, lime-fly ash-aggregate mixtures, lime stabilized soil, cement stabilized soils and others with proprietary stabilisers.

The subbase should be provided with stone/concrete block or brick on edge should be laid on either side of the carriage way projecting 50 to 100 mm above the subgrade/subbase for the confinement and protection. Laterite boulders or stabilised local materials may also be used for confinement. The aggregates should not have flakiness index exceeding 40 percent. The maximum size of the aggregates should not exceed 26.5 mm. Fine aggregate should consist of clean natural sand or crushed stone or a combination of the two and meet the requirement as per Specifications. Coarse and fine aggregate should be blended to obtain an Aggregate Gradation as given in Table 1.

Table 1 aggregate gradation for concrete

Sieve size, mm	Percentage passing by weight
26.50	100

19	80-100
9.50	55-80
4.75	35-60
0.60	10-35
0.075	0-8

Formwork of plastic cells may be laid across the compacted subbase and put under tension with iron spikes so that cells are close to squares in plan. Nylon threads passing through the cells 10 mm below the top of the cells should be used to prevent the cells from collapsing during the filling of the cells with concrete. If any stitch of the cells opens up during tensioning, it should be stapled near the top, middle and the bottom. Concrete should be filled into the cells to a depth of about 120 mm which is about 20 mm higher than the depth of the cell. Uniformity of level should be checked before the compaction. The iron spikes should be taken out after the cells are filled up with concrete.

Since the concrete is in the form of blocks of size 150 mm x 150 mm with plastic sheets on the vertical interfaces, no joints are necessary. The concrete blocks would shrink during curing causing a gap of about 20 microns between two neighbouring blocks, which should be able to accommodate the expansion of concrete. Joints are, therefore, not necessary in the construction. The last group of blocks cast at the end of the day may become weak if care is not taken. Aggregates of size 40 -50 mm should be filled into the last group of cells shown as shaded ones before compaction of concrete in the earlier cells. Before commencement of work on the next day, the aggregates should be taken out from the cells and filling of concrete into the plastic cells should commence after spreading another roll of cells.

9.4.1.1 Advantages

- Use of recycled plastic.
- Expansion or contraction joints are not required and hence maintenance of joints is eliminated.
- The cost of construction is considerably reduced when compared to conventional cement concrete pavement
- The consumption of aggregates is almost reduced to 50% when compared to normal CC pavements
- Due to high stiffness, the overall crust requirement gets reduced hence economical for low volume of roads
- If the individual blocks fails, then it can be easily replaced without much effort and with least cost

9.4.1.2 Disadvantages

- The preparation of the cells is cumbersome
- The cells gets disturbed while placing the concrete and hence proper care is required

- Placing of the concrete without disturbing the cells slows down the progress
- Consumption of labour is more, more labour oriented work
- Due to slow progress, the actual turnout of the men and machinery is less than normal construction
- The cost of providing kerb is additional and is time consuming
- Possibility of formation of cold joints between two successive concrete layers leads to failure, requires treatment at cold construction joints

The expected life can be about 15-20 years. The method of construction makes the concrete flexible, and the surface does not crack. It is labour based, maintenance free and ideally suited to rural road construction. It requires less initial cost than the conventional pavement. The technology can also be used for overlays over damaged black top roads, pavements of footpath, roads of housing complex, container yards, parking area of heavy vehicles etc.

9.4.2 WHITE TOPPING

Whitetopping is the covering of an existing asphalt pavement with a layer of Portland cement concrete. It can be used as a road surface course where traditional paving materials have failed due to rutting or general deterioration. Whitetopping is divided into types depending on the thickness of the concrete layer and whether the layer is bonded to the asphalt substrate. Unbonded whitetopping, also called conventional whitetopping, uses concrete thicknesses of twenty cms or more that is not bonded to the asphalt. Bonded whitetopping uses thicknesses of 5 to 15 cm bonded to the asphalt pavement and is divided into two types, thin and ultrathin. The bond is made by texturing the asphalt. Thin whitetopping uses a bonded layer of concrete that is 10 to 15 cm thick while an ultrathin layer is 5 to 10 cm thick. Ultrathin whitetopping is suitable for light duty uses, such as roads with low traffic volume, parking lots and small airports. Fiber reinforced concrete is used in some thin whitetopping overlays and almost all ultrathin whitetopping overlays.

There are three types of whitetopping:

- Conventional (thickness greater than 20cm)
- Thin (thicknesses over 4 but less than 20 cm)
- Ultra-thin (5 to 10cm) Ultra-thin whitetopping (UTW) is a bonded, fiber reinforced concrete overlay.

This rehabilitation option has been used for many years on airport pavements, highways, secondary roads, and other pavements.
Whitetopping offers:

- Sustainability
- Improved performance -- no rutting or washboarding
- Ability to maintain surface grade
- Competitive price with other resurfacing methods

Thin Whitetopping (TWT) is a 10 to 18cm thick concrete overlay bonded to an existing Asphalt Concrete Pavement to create a composite section. TWT is typically constructed at intersections where rutting and shoving in asphalt pavement continue to cause problems. TWT may also be used at access or exit ramps to interstate highways, entire sections of urban roadways, low-volume rural roads, bus lanes, and parking areas. TWT can provide better serviceability, longer service life, lower life-cycle cost, and improved safety over ACP subject to heavy trucks, especially in accelerating/decelerating, turning movement, or slow traffic environments. Design Life of 5 – 10 years is recommended for TWT.

This rehabilitation technique purposely seeks to bond the concrete overlay to the existing asphalt. The composite action significantly reduces the load-induced stresses in the concrete overlay. Therefore, the concrete overlay can be significantly thinner for the same loading as compared to a whitetopping section with no bond to the underlying asphalt. TWT will significantly reduce traffic delays and total maintenance effort accompanying the frequent maintenance of an asphalt surface.

Contraction joints spacings are set at 1.8m to prevent edge loading and reduce the costs of saw cutting. All sawed TWT panels shall be square (length = width) except as necessary in pavement width transitions.

Most of the existing, worn asphalt pavement is left in place and serves as a base. Ruts in the asphalt are milled down to start with a clean level surface. Ultra-thin whitetopping (UTW) should not be placed over asphalt pavement that shows signs of deep pavement distress. If potholes, alligator cracking, or deep fissures exist in the asphalt, the concrete will not form an adequate bond, resulting in pavement that lacks adequate support. Asphalt pavement should be at least 3-inches thick to provide a sufficient base for UTW. Many installers mill off the amount that will be replaced by the UTW so that they don't change the surface grade. Whitetopping can be placed using conventional paving equipment.

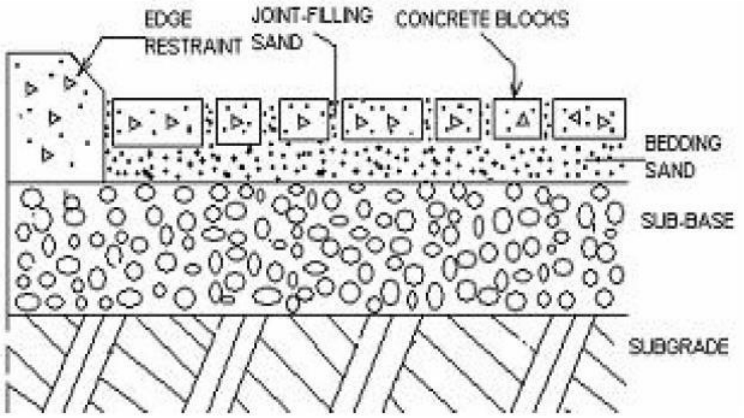
Joint spacing is critical to a good performing UTW project. Successful projects use a short joint spacing to form, in effect, a mini-block paver system. Experience indicates that joint spacings should be no more than 30 to 45cm each way per inch of whitetopping thickness. For example, an 8cm UTW surface should be jointed into 0.9x.9 or 1.2x1.2 m squares. Joints are sawed early to control surface cracking.

9.4.3 INTERLOCKING CONCETE BLOCK PAVEMENT

Interlocking Concrete Block Pavement (ICBP) has been extensively used in a number of countries for quite sometime as a specialized problem-solving technique for providing pavement in areas where conventional types of construction are less durable due to many operational and environmental constraints. ICBP technology has been introduced in India in construction, a decade ago, for specific requirement viz. footpaths, parking areas etc. but now being adopted extensively in different uses where the conventional construction of pavement using hot bituminous mix or cement concrete technology is not feasible or desirable.

Concrete Block Pavement (CBP)/ICBP consists of a surface layer of small-element, solid un-reinforced pre-cast concrete paver blocks laid on a thin, compacted bedding material which is constructed over a properly profiled base course and is bounded by edge restraints/kerb stones. The block joints are filled using suitable fine material. A properly designed and constructed CBP/ICBP gives excellent performance when applied at locations where conventional systems have lower service life due to a number of geological, traffic, environmental and operational constraints. Many number of such applications for light, medium, heavy and very heavy traffic conditions are currently in practice around the world. The main components of a concrete block pavement are shown in figure 3.1.1.

1. Paving blocks. (Made of cement concrete with sufficient compressive strength, available in various size and shapes)
2. Bedding sand which supports the block layer.
3. Jointing sand provided in joint of blocks.
4. Edge restraint.
5. Sub-base.
6. Sub grade.



Pavement Structure - A combination of sub base, base course, and wearing surface placed on a sub grade to support the traffic load and distribute it to the road bed.
Base Course - A material of a designed thickness placed on a sub base or a sub grade to support a surface course. A base course can be compacted aggregate, cement or asphalt stabilized aggregate, asphalt, concrete, or flowable fill.
Bedding Sand - A layer of coarse, clean, sharp sand that is screeded smoothly for bedding the pavers. The sand can be natural or manufactured (i.e. crushed from larger rocks) and should conform to the grading requirements.
Edge Restraint- A curb, edging, building or other stationary object that contains the sand and pavers so they do not spread and lose interlock. They can be exposed or hidden from view.
Joint Sand- Sand swept into the openings between the pavers.

Since zero slump concrete is used in production of paver blocks, the quality of blocks produced will depend upon various parameters like the capacity of compaction and vibration of machine, grade of cement used, water content, quality of aggregates used, their gradation and mix design adopted, additives used, handling equipment employed, curing method adopted, level of supervision, workmanship and quality control achieved, etc. Recommended grades of paver blocks to be used for construction of pavements having different traffic categories are given in Table 1.

Some of the proven areas where ICBP technology is being applied are listed below:
Non-traffic Areas: Building Premises, Footpaths, Malls, Pedestrian Plaza, Landscapes, Monuments Premises, Premises, Public Gardens/Parks, Shopping Complexes, Bus Terminus Parking areas and Railway Platform, etc.
Light Traffic: Car Parks, Office Driveway, Housing Colony Roads, Office/Commercial Complexes, Rural Roads, Residential Colony Roads, Farm Houses, etc.
Medium Traffic: Boulevard, City Streets, Small Market Roads, Intersections/Rotaries on Low Volume Roads, Utility Cuts on Arteries, Service Stations, etc.

Heavy and Very Heavy Traffic: Container/Bus Terminals, Ports/Dock Yards, Mining Areas, Roads in Industrial Complexes, Heavy-Duty Roads on Expansive Soils, Bulk Cargo Handling Areas, Factory Floors and Pavements, Airport Pavement, etc.

There are four generic shapes of paver blocks corresponding to the four types of blocks as below :

Type A: Paver blocks with plain vertical faces, which do not key into each other when paved in any pattern,

Type B: Paver blocks with alternating plain and curved/corrugated vertical faces, which key into each other along the curve/corrugated faces, when paved in any pattern,

Type C: Paver blocks having all faces curved or corrugated, which key into each other along all the vertical faces when paved in any pattern and

Type D: 'L' and 'X' shaped paver blocks which have all faces curved or corrugated and which key into each other along all the vertical faces when paved in any pattern.

The generic shapes and groups of paver blocks identified to four types are illustrated in Figures 1 & 2.

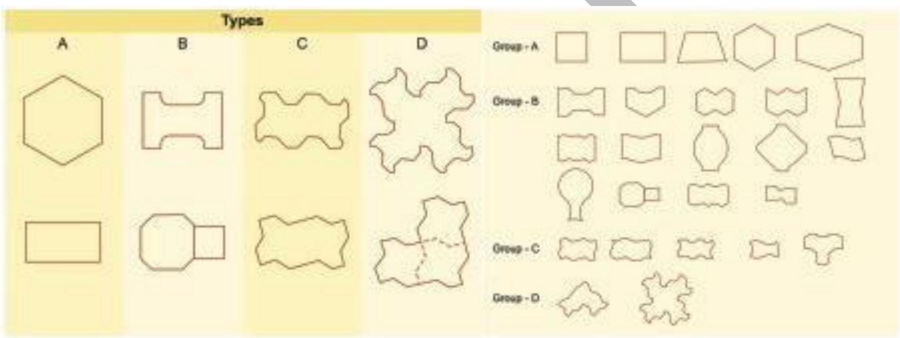


Figure 1: Four generic types of Paver Blocks   Figure 2: Typical shapes of Paver blocks

The quality of materials, strength of cement concrete and durability as well as dimensional tolerances etc. are of great importance for satisfactory performance of block pavement. It is well established that if proper attention is not paid to the quality of bedding sand, and if the thickness of 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 gaps in between two adjacent paving blocks (typically about 3 mm wide) need be filled with sand, relatively finer than the bedding sand itself. The desired gradation for the bedding and joint filling sands are given in Table 2.

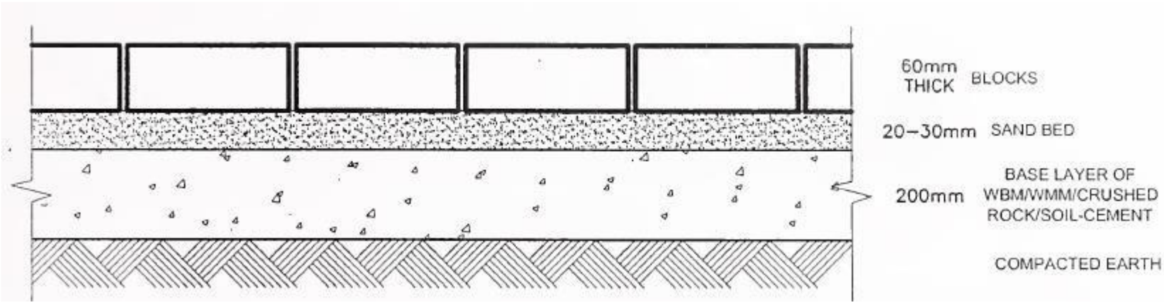
Table 1: Recommended Grades of Paver Blocks for Different Traffic Categories			
Grade Desig-nation of Paver Blocks	Specified Characteristics Compressive Strength of Paver Blocks At 28 Days N/mm²)	Traffic Category	Recommended Minimum Paver Block Thickness (mm)
(1)	(2)	(3)	(4)
M-25-M-30	25-30	Non-traffic	50
M-30-M-35	30-35	light	60
M-35-M-45	35-45	Medium	60, 80
M-45-M- 55	45-55	Heavy to Very Heavy	80, 100, 120

It is necessary to restrict the fines (silt and/or clay passing 75 micron sieve) to 10 percent, since excessive fines make joint filling very difficult. The joint filling sand should be advisably as dry as possible; otherwise complete filling of joints may be difficult.

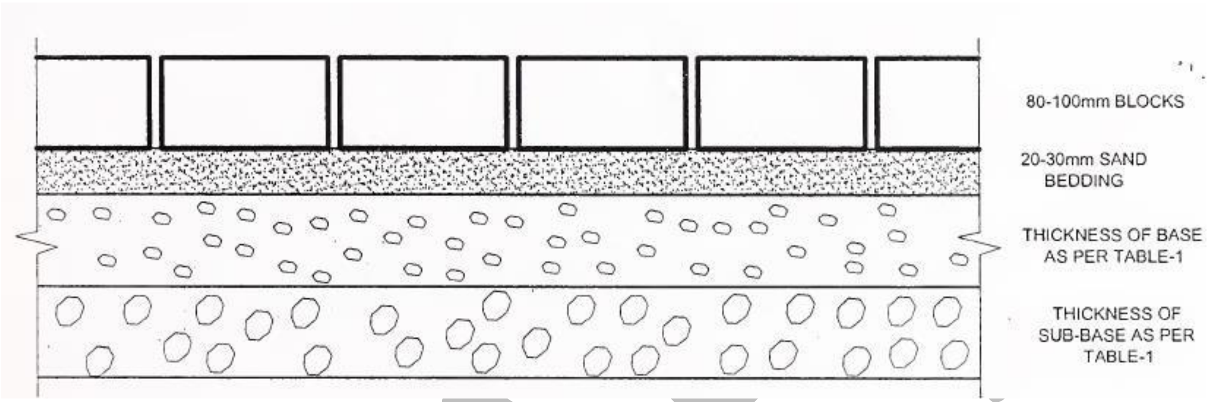
Table 2: Gradation of Bedding and Joint Filling Sand		
IS Sieve Size	Bedding Sand	Joint Filling Sand
	Percent Passing	
9.52 mm	100	--
4.75 mm	95-100	--
2.36 mm	80-100	100
1.18 mm	50-95	90-100
600 micron	25-60	60-90
300 micron	10-30	30-60
150 micron	0-15	15-30
75 micron	0-10	0-10

The engineering properties of base materials are the load spreading properties to disperse stresses to the subgrade and the desired drainage characteristics, having 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, yet 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/ dry lean concrete etc. The quality of sub-base materials should be in conformance with IRC: 37.

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 block should be designed and anchored to the base such that the rotation or displacement of blocks is resisted. These are to be made of high strength concrete for withstanding the traffic wheel-load without getting damaged. These members should be manufactured or constructed in-situ to have at least a 28-day characteristic compressive strength of 30 MPa or flexural strength of 3.8 MPa.



A typical cross section of block pavement for light trafficked roads

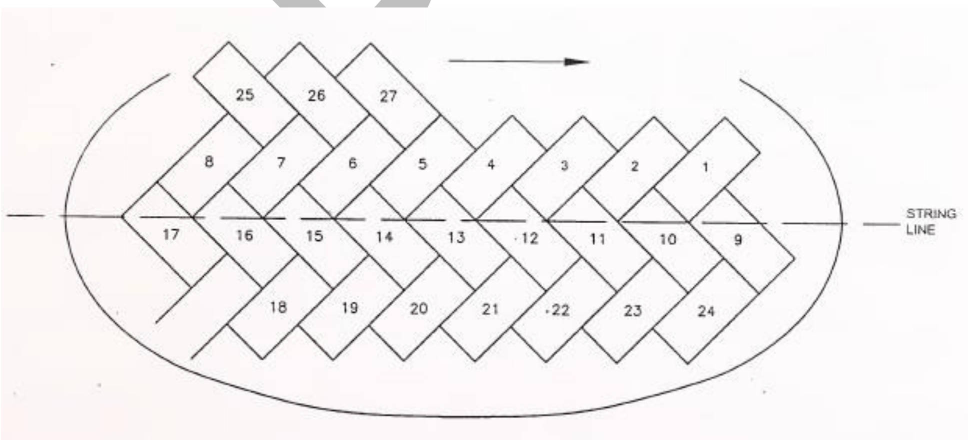


A typical cross section of block pavement for heavily trafficked roads

Normally, laying of blocks should commence from the edge strip and proceed towards central line. 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 to up-slop on a continuous basis, to avoid down-slop creep in incomplete areas.
- In case of irregular shaped edge restraints or strips, it is better to start from straight string line as shown in the above figure.
- Influence of alignment of edge restraints on achieving and maintaining laying bond.



Starting at irregular shaped edge restraint

For compaction of the bedding sand and the blocks laid over it, vibratory plate compactors are used over the laid paving blocks; 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 in level with its adjacent blocks. There should not be delay in compaction after laying of paving blocks to achieve uniformity of compaction and retention of the pattern of laying.

ICBP technology can provide durable and sustainable road infrastructure where construction and maintenance of conventional pavements are not cost effective.
ICBP is much cheaper than rigid (concrete) pavement designed for identical conditions. Compared to bituminous pavement for low traffic volumes and high strength subgrade, the initial construction cost of ICBP is likely to be equal to or marginally higher. For high traffic volumes and low strength subgrade, ICBP will be cheaper than flexible pavement.
Guidelines for use of Interlocking Concrete Block Pavement and Specification on Paver Blocks are published in Codes and available with Indian Roads Congress (IRC:SP:63-2004) and Bureau of Indian Standards which are very useful for Indian industries and highway professions for adoption of block pavement technology.

9.4.3.1 Advantages

There are many distinct features of ICBP as compared to the conventional methods of pavement construction and hence make it a suitable option for application in the specified areas. Some of these are:

- Mass production under factory conditions ensures availability of blocks having consistent quality and high dimensional accuracy.
- Good quality of blocks ensures durability of pavements, when constructed to specifications.
- ICBP tolerates higher deflections without structural failure and will not be affected by thermal expansion or contraction.
- ICBP does not require curing, and so can be opened for traffic immediately after construction.
- Construction of ICBP is labour intensive and requires less sophisticated equipment.
- The system provides ready access to underground utilities without damage to pavement.
- Maintenance of ICBP is easy and simple and it is not affected by fuel and oil spillage.
- Use of coloured blocks facilitates permanent traffic markings.
- ICBP is resistant to punching loads and horizontal shear forces caused by maneuvering of heavy vehicles
- Low maintenance cost and a high salvage value ensures low life cycle cost.

However, important limitations of the technique are the following:

- Quality control of blocks at the factory premises is a prerequisite for durable "ICBP"
- Any deviations of base course profile will be reflected on the "ICBP" surface. Hence extra care needs to be taken to fix the same.
- High quality and gradation of coarse bedding sand and joint filling material are essential for good performance.
- "ICBP" over unbound granular base course is susceptible to the adverse effects of poor drainage and will deteriorate faster. "ICBP" is not suited for high speed roads (speed above 60 km/h)

9.4.3.2 Merits of ICBP over Asphalt Pavement

- Flex without cracking. Do not require expansion joints. Resistant to spilled fuel and oil.
- Resistant to freeze/thaw damage.
- Resistant to de-icing compounds.
- Virtually unlimited combination of solid and blended colors, shapes and laying patterns.
- May be used immediately upon completion of installation.
- May be disassembled to repair sub grade or underground services then reinstalled with no unsightly patch.
- Skid and slip resistant surface.
- Cooler surface.
- Easy to work to grade transitions.
- Long design life.
- Low life cycle costs.
- Virtually maintenance free.

9.4.4 PLASTIC WASTE IN RURAL ROADS CONSTRUCTION.

Plastic is everywhere in today's lifestyle. It is used for packaging, protecting, serving, and even disposing of all kinds of consumer goods. With the industrial revolution, mass production of goods started and plastic seemed to be a cheaper and effective raw material. Today, every vital sector of the economy starting from agriculture to packaging, automobile, building construction, been virtually revolutionized by the applications of communication or InfoTech has plastics. Plastic in different form is found, which is toxic in nature. It creates stagnation of water and associated hygiene problems. Plastic waste hazard to the environment. Plastic is a non-biodegradable material and researchers found that the material can remain on earth for 4500 years without degradation. Several studies have proven the health hazard caused by improper disposal of plastic waste. The best way of disposal of waste plastic is its recycling to the maximum extent and many developed countries have recycled waste plastics to manufacture various products, including some used in heavy construction, eg. railway sleepers. Plastic waste can be reused productively in the construction of road also.

Studies have related that waste plastics have great potential for use in bituminous construction as its addition in small doses, about 5-10%, by weight of bitumen helps in sustainability improving the Marshall stability, strength, fatigue life and other desirable properties of bituminous mix, leading to improved longevity and pavement performance. The use of waste plastic thus contributes to construction of green roads.

The experimentation at several institutes indicated that the waste plastic, when added to hot aggregate will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give higher strength, higher resistance to water and better performance over a period of time. Therefore, it is proposed that we may use waste plastic in the construction of Roads. The process of road laying using waste plastics is designed and the technique is being implemented successfully for the construction of flexible roads at various places in India. The use of waste plastics in road construction is gaining importance these days because plastic roads perform better than ordinary ones and the plastic waste considered to be a pollution menace, can find its use.

9.4.4.1 Specifications for Waste Plastic.

Only plastic conforming to Low Density Polythylene (LDPE), High Density Polyethylene (HDPE), PET and Polyurethane shall only be used in pavement construction.

Waste Plastic and its Source

Waste Plastic	Origin
Low Density Polyethylene (LDPE)	Carry bags, sacks, milk pouches, bin lining, cosmetic and detergent bottles
High Density Polyethylene (HDPE)	Carry bags, bottle caps, house hold articles etc
Polyethylene Teryphthalate (PET)	Drinking water bottles etc
Polypropylene (PP)	Bottle caps and closures, wrappers of detergent, biscuit, wafer packets, microwave trays for readymade meal etc
Polystyrene (PS)	Yoghurt pots, clear egg packs, bottle caps. Foamed Polystyrene: food trays, egg boxes, disposable cups, protective packaging etc
Polyvinyl Chloride (PVC)	Mineral water bottles, credit cards, furniture, folders and pens, medical disposables etc. toys, pipes and gutters, electrical fittings,

There are two processes namely dry and wet processes for manufacturing bituminous mixes using waste plastic. In dry process, processed waste plastic is added after shredding in hot aggregates where as in the wet process, processed waste plastic in the form of powder is added in the hot bitumen. Plastic waste, which is cleaned, is cut into a size between 2.36 mm and 600 microns and of maximum size 2.36 mm length and 2.00 mm width using a shredding machine. It is clean by de-dusting or washing if required.

This shredded plastic-waste is mixed with the bitumen in the Wet process. Firstly, Bitumen was heated up to the temperature about 160°c-170°c which is its melting temp. Shredded plastic waste acts as a strong “binding agent” for tar making the asphalt last long. By mixing plastic with bitumen, the ability of the bitumen to withstand high temperature increases. The plastic waste is melted and mixed with bitumen in a particular ratio. Normally, blending takes place when temperature reaches 45.5°C but when plastic is mixed, it remains stable even at 55°C.

In the Dry process, this shredded plastic-waste is added over hot aggregate with constant mixing to give a uniform distribution, . The plastic got softened and coated over the aggregate. In that time period temperature was kept constant about 160-170°c. Bituminous mixes were prepared with 60/70 or 80/100 grade bitumen and plastic coated aggregates. The road laying temperature is between 110^0C to 120^0C for waste plastic bituminous mix. The use of waste plastic for coating the aggregates of the bituminous mix found to improve its performance characteristics.

The uses of plastic waste helps in substantially improving the abrasion and slip resistance of flexible pavement and also allows to obtain values of splitting tensile strength satisfied the specified limits while plastic waste content is beyond 30% by weight of mix. In hot and extremely humid climate durable and eco-friendly plastic roads are of greatest advantages. This will also help in reliving the earth from all type of plastic waste.

9.4.4.2 Advantages

A well constructed Plastic Tar Road will result in the following advantages.

- Strength of the road increased (Increased Marshall Stability Value)
- Better resistance to water and water stagnation
- No stripping and have no potholes.
- Increased binding and better bonding of the mix.
- Increased load withstanding property(Withstanding increased load transport)
- Overall consumption of bitumen decreases.
- Reduction in pores in aggregate and hence less rutting and 18avelling.
- Better soundness property.
- No effect of radiation like UV.
- Maintenance cost of the road is almost nil.
- The Road life period is substantially increased.
- The optimum content of waste plastic to be used is between the range of 5% to 10%.
- The addition of waste plastic modifies the properties of bitumen.

- The modified bitumen shows good result when compared to standard results.
- The problems like bleeding are reduce in hot temperature region.
- Plastic has property of absorbing sound, which also help in reducing the sound pollution of heavy traffic.
- The waste plastics thus can be put to use and it ultimately improves the quality and performance of road.

The vigorous tests at the laboratory level proved that the bituminous mixes prepared using the treated binder could withstand adverse soaking conditions under water for longer duration. This innovative technology not only strengthened the road construction but also increased the road life.

The durability of the roads laid out with shredded plastic waste is much more compared with roads with asphalt with the ordinary mix. Roads laid with plastic waste mix are found to be better than the conventional ones. The binding property of plastic makes the road last longer besides giving added strength to withstand more loads. While a normal 'highway quality' road lasts four to five years it is claimed that plastic-bitumen roads can last up to 10 years. Rainwater will not seep through because of the plastic in the tar. So, this technology will result in lesser road repairs. And as each km of road with an average width requires over two tonnes of polyblend, using plastic will help reduce non-biodegradable waste. The cost of plastic road construction may be slightly higher compared to the conventional method. However, this should not deter the adoption of the technology as the benefits are much higher than the cost.

COLD MIX TECHNOLOGY

For the construction of roads in India, hot mixes prepared at a temperature of 155^0C are conventionally used. It causes air pollution due to the emission of hydrocarbon and suspended particulate matters and consumes higher energy.

Emulsion based cold mixes offer a potential solution of the above drawbacks due to elimination of heating process. In this technology, cold mixes are prepared by mixing aggregates with bitumen emulsion at ambient temperature. Bitumen emulsion based cold mix offer certain advantages over hot bituminous road mixtures in terms of potential cost savings, protection of environment, energy savings, decrease in carbon footprint, use of damp aggregates and increase in construction period during the year as construction with cold mix is feasible in cold climate and rainy season. The use of emulsion based cold mix provides green technology for road construction as it eliminates heating. This method is also useful for the forest areas, since the conventional method is not allowed there.

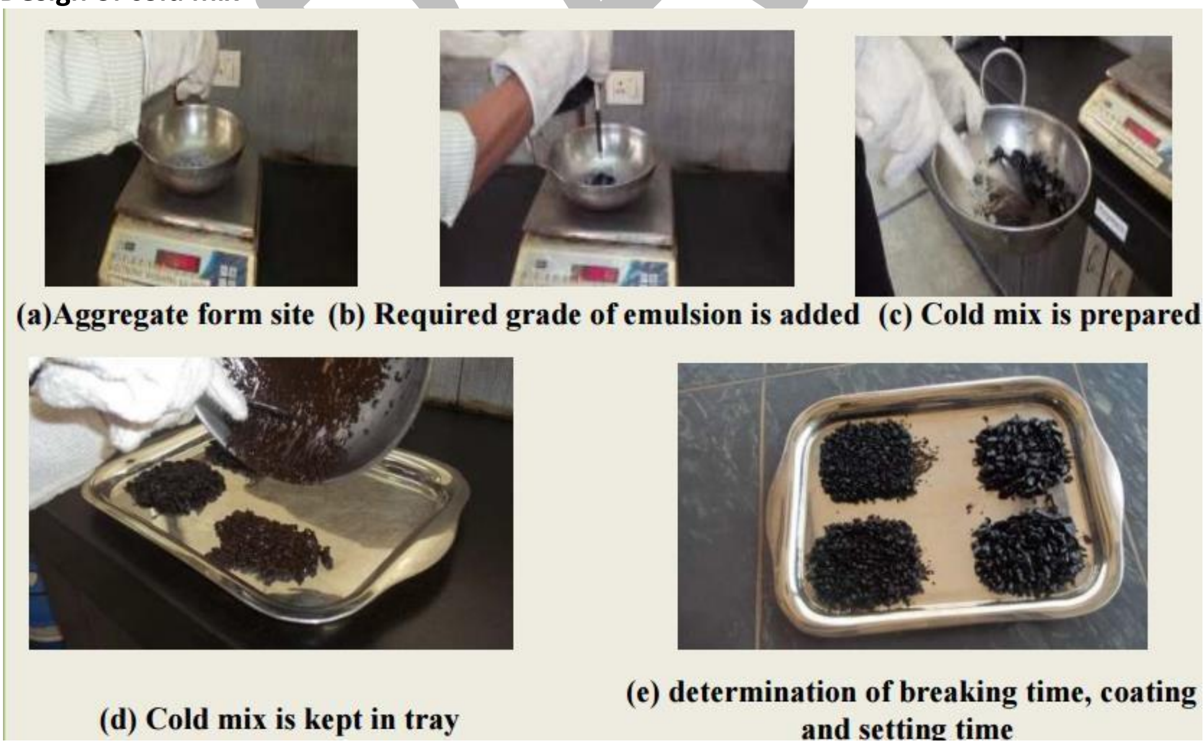
Disadvantages of Hot Mix Technology

- Heating of bitumen binder at 160-170°C
- Heating of aggregates at 150-155oC
- Production of hot mix at 145-150oC
- Laying of hot mix at 125-135°C
- Compaction of hot mix at 115-130°C
- Reduced durability
- High energy consumption
- High GHG emissions

- Higher life cycle cost
- Limited working season- No work during rains and cold winters
- Hazardous for public in general
- Noise and air pollution
- Sensitive to temperature control during entire process.
- Unsafe to workers and their health
- Thermal oxidation of bitumen due to need of heating

A cold mix is defined as a mixture of bitumen emulsion and aggregate that is mixed together at ambient temperature. It can be prepared by a suitable device like concrete mixer or cold mix plant or a modified hot mix plant. Bitumen emulsion being liquid at room temperature, there is no need to heat or dry the mineral aggregate. Cold mix is useful in the areas, where there is long distance between the job site and plant and temperature of climate is low and moderate (<40°C). Further, the versatility of cold mix allows it to be mixed in-place at the job site as well as at a plant site and then subsequently transported to the job site. Cold mix may be used in bituminous base (BM), binder course (BM/SDBC) as well as wearing course (SDBC) of flexible pavement. These mixes may be designed for a broad range of bitumen emulsions, aggregates, field conditions and tailored to specific performance requirement. The cold mix should be designed to meet the performance requirements which include workability, coating, strength development, and other applicable targets. The quality of residual bitumen, aggregate, and climatic conditions should be taken into account.

Design of cold mix



(a)Aggregate form site (b) Required grade of emulsion is added (c) Cold mix is prepared

(d) Cold mix is kept in tray

(e) determination of breaking time, coating and setting time

Procedure for Construction of Open Graded Premix Carpet (Using Hot Mix Plant)

The blended aggregates of 13.2 mm and 11.2 mm nominal sizes in 2:1 ratio, as per the specified requirement, shall be charged in the hot mix plant which shall be used without heating arrangement and with suitable modification for incorporation of emulsion. The optimum water content 1 percent by weight of aggregates (if needed) shall then be added to the aggregate for making it wet. The emulsion of MS grade/SS grade/cold mix binder in required quantity approximately (7 percent by wt. of aggregates) shall then be added into wet aggregate and mixed for two minutes to get uniform coating. Prolonged mixing shall be avoided as it will uncoat the aggregates. The cold mix shall be discharged into trolleys to transport to the construction site. Compaction of cold mix with 8-10 tone roller shall be carried out to get the finished premix carpet surface.

Procedure for Construction of Open Graded Premix Carpet (Using Concrete Mixer)

The cold mixed open graded premix may also be prepared in a concrete mixer. For this purpose, the blended aggregates of 13.2 mm and 10 mm size in 2:1 ratio shall be charged into concrete mixer. The premixing water content @ 1 to 2 percent by weight of aggregate shall be added into the mixer and uniformly mixed with wet the aggregate. The required quantity of emulsion of MS grade or tailor made (cold mix binder) shall then be added and mixed with aggregates for two minutes.

Prolong mixing (move then one minute) shall be avoided as it tends to de-coat the binder from aggregate . The cold mix while indicating brown colour shall be discharged into