Cell-Filled Pavement, Interlocking Concrete Block Pavement and Panel Concrete Pavements

K. Sudhakar Reddy
Professor, Civil Engineering Department
IIT Kharagpur
Concrete Pavements

Provide when

- Aggregates are costly
- Serious Drainage Problem (for short lengths)
- Low subgrade strength and high traffic volumes
Concrete Pavements

- Subgrade
- Concrete Slab
- Subbase or base
- Longitudinal joint
- Transverse joints
- Tie bars
Contraction Joint - saw Cut

Sawed/Formed Groove in the Slab to create a weakened vertical plane
Load Transfer at Joints

- It is important that load applied on a slab is shared by adjacent slabs also for better performance of the pavement.

- Granular Interlocking is expected along the cracks that form at transverse joint (saw cut).

- For low-volume roads adequate load transfer is expected to be provided by interlocking.

- For higher traffic volumes and thicker slabs dowel bars are provided.
Concrete Pavements Fail due to Direction of Travel Single Axle
Short Panel/slab size

- In a typical highway pavement, the size of the slab is 4.5 m x 3.5 m
- In a typical rural highway, the slab size will be 3.0/3.75 m x 2.5 to 4.0 m
- Cell-filled concrete pavements, Interlocking Concrete Block Pavements (ICBP) and Panel Concrete pavements are essentially pavements with small slab size
- The mode of load transfer (from one slab to another), distribution of load to lower layers and the effect of temperature gradient within the slab (top to bottom) vary with the size and thickness of the slab
Cell-filled Concrete Pavements

- Cell Filled (In-situ Block) Concrete Pavement is a grid of plastic cells into which concrete is placed.
- Has very short joint spacing with unique joint arrangement.
- Thinner Concrete Layer with multiple joints. Hence load spread is not by slab action.
- Joints created in the Slab using Plastic cells.
Cell-filled Concrete Pavements

- Forms a flexible layer having rigid material (concrete). Can be called as Flexible-Rigid Pavement
- Depth 50 to 100 mm
- The Flexible-Rigid Layer should be subjected to limited rotation at the Joints
- Has negligible temperature stresses
- Interlocking between blocks is crucial for the performance of the pavement
Cell-filled Concrete – Lab Experiments
Cell-filled Concrete – Lab Experiments
Cell-filled Concrete- First Village Road
Cell-filled Concrete - First Village Road
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Cell-filled Concrete- First Village Road
Cell-filled Concrete - Test Tracks in IIT Kharagpur
Cell-filled Concrete - Test Tracks in IIT Kharagpur
Cell-filled Concrete – West Bengal PMGSY Roads
Cell-filled Concrete – Mizoram PMGSY Roads
Cell-filled Concrete Pavements

- Trial Sections in Karnataka
- Number of PMGSY roads built in West Bengal and Mizoram
- Training (Technology Transfer) Programmes conducted by IIT Kharagpur for several State PMGSY engineers and NRRDA batches
- Demonstration section in Guntur District in Andhra Pradesh
Cell-filled Concrete Pavements – Salient Features

- Conventional concrete or zero slump concrete with 28-day characteristic strength of 30 MPa

- Static road roller of 6 to 8 ton capacity may be used for compaction of low slump concrete. Normal concrete of required strength having a slump of 50 mm can also be poured into the cells and vibrated with a pan vibrator.

- The cell walls deform during the placement due to rolling or vibration and develop...
Cell-filled Concrete Pavements – Salient Features

- HDPE sheets of thickness 0.20 mm to about 0.22 mm (about 1250 kg for 3.75 m width and 1.0 km length) or LDPE sheets of 0.30 to 0.35 mm thickness

- 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
Cell-filled Concrete Pavements – Salient Features

- Opening to traffic: Light traffic after two days. Iron rimmed bullock carts and heavy traffic like bus, truck, tractor etc can be permitted after 14 days.

- For light traffic, GSB of minimum 100 mm thickness. For higher traffic (> 50 cvpd), a minimum thickness of 150 mm of cementitious subbase with 7-day minimum strength of 3.0 MPa.

- Elastic modulus of cell filled concrete layer of 2000 MPa is recommended for design.

- \[ N = 4.1656 \times 10^{-8} \left( \frac{1}{\varepsilon_z} \right)^{4.5337} \]
Cell-filled Concrete Pavements – Salient Features
Interlocking Concrete Block Pavement (IRC:SP:63-2004)

Typical Block Pavement Section

**Block Thickness:** (a) Light Traffic – 60 mm  (b) medium traffic (less than 10 msa) 60 – 80 mm  (c) heavy traffic (10-20 msa) 100-120 mm

Suitable foundation, joint gap, gradation of bedding sand and joint filling sand are crucial
Panel Concrete Pavement

- Shorter Panel Size: 0.6 m and more
- Smaller Slab Thickness: 100 to 250 mm
- Panels formed by saw-cutting the slab upto 1/3rd depth
- Base/ subbase: DLC, WMM, WBM, Bituminous layer
- Interface: Bonded, Unbonded, Partially bonded
- No Dowel bars
- Load Transfer mostly by aggregate interlocking
Panel Concrete Pavement

• Thinner Concrete Pavements as alternative to Thicker slabs at the cost of more joints
• IRC: SP: 76 – 2015 Conventional, Thin and Ultra-thin Pavement covers the general design principles of Panel Concrete Pavement
• If Panel Concrete overlay is laid over bituminous pavement it is commonly termed as White topping
• Foundation: Cement treated / untreated Granular layer/cement treated soil
Panel Concrete Pavement

• Concrete: Plain and Fiber reinforced
• Fiber: Steel, Polypropelene, Polyester, Nylon, Polyethelene 30-60 mm long, min. 0.2 mm diameter, about 0.3% by volume of concrete
• Joints formed by saw cutting or plastic strips
Design of White Topping

• Determination of effective $k$ value for subgrade for different bases/subbases by correlating with CBR (IRC: 58 – 2015)

• Effective $k$ value over bituminous surface – based on the charts given by ACPA (EB210.02P) (IRC: SP: 76 – 2015)

• Existing bituminous surface over granular subbase

• Existing bituminous surface over cement-treated subbase
Design of White Topping

Determination of effective $k$ value over existing Bituminous Pavement on top of Granular subbase
Design of Thin White Topping

• Thickness: 100 to 200 mm
• Short Joint spacing: 1.0 to 1.5 m in either direction – square or rectangular panel – length/breadth > 1.20
• Surface preparation is needed for effective bonding. Minimum 75 mm thick bituminous surfacing after milling
• Used when the condition of the existing bituminous surface is fair without wide cracks and without material / sub-grade related problems
Design of Thin White Topping

• Corner load stress and Curling stress
• Corner load stress + Curling stress < flexural strength
• Fatigue criteria as per Cumulative linear Fatigue Damage principles - IRC: 58 - 2015
Panel Concrete

Dual Wheel Load

Typical Saw-cuts up to 1/3 rd depth

Traffic direction

@1.0 m to 2.5 m
Panel Concrete

Flexural stress vs. slab thickness plots for different dual wheel loads
Panel size 1.75 m × 2.50 m, $k = 150\text{MPa/m}$
Panel Concrete

Flexural stress vs. joint spacing for different slab thicknesses

$k = 150 \text{ MPa/m}, \text{ Dual Wheel Load} = 100 \text{ kN}$
Panel Concrete Pavement

- Flexural stresses at critical locations – less as compared to those for Conventional concrete pavement

- Flexural stress – reduces with decrease in panel size, increase in panel depth and increase in subgrade strength
Panel Concrete Pavement

Constructed at Different Locations

• Bangalore
• Pune
• Mankar in Burdwan district
• Village roads near IIT Kharagpur
Panel Concrete Pavement

100 mm slab on a village road, panel 0.50 m x 0.50 m in West Bengal
Madiwala in Bangalore
Outer Ring Road
Bangalore
**Experimental Test Section of Paneled Cement Concrete Pavement on Bituminous Base**

**Transportation Engineering Division**  
**IIT Kharagpur**

**NHAI, Govt of India**

**Details of Test Section (July, 2017)**

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<tr>
<td>Thickness of DBM</td>
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<tr>
<td>Panel Dimensions</td>
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<td>Length of Stretch</td>
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<td>Ending Chainage</td>
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Test Section 2, NH-33
Thank You