Road Construction Technology Using Cement & Concrete
For Rural & Major Road
1. Introduction to Road Pavement

2. About Concrete Road

3. Concrete Road Construction Technology
   - Plant Mixing Material & Transport
   - Method of Laying Concrete
     - Manual Fixed Formwork
   - Slip Form Paver
     - Asphalt Paver

1. Concrete Applications for Road Construction
   - Roller Compacted Concrete (RCC) Pavement
   - Jointed Plain Concrete Pavement

2. Case Study - Hybrid Solutions
   - JPCP-RCC Hybrid Surface
   - JPCP-RCC Layer Combination

3. Advantages/Conclusion
Introduction

Road Pavement Technology
Different Type of Road Pavement

- Flexible Pavement
- Composite Pavement
- Rigid/Concrete Pavement
Type of Road Pavement

- **Road Pavements**
  - **Flexible Pavement**
    - Asphalt Layer(s) With Unbound Sub-base
  - **Composite Pavement**
    - Asphalt Surface With Cemented Base
  - **Rigid/Concrete Pavement**
    - Concrete Surface With Unbound/Bound Base

- Related to Cement Solution
- Total Concrete Solution
About Concrete Road
... However, concrete pavement does not mean CRCP:

Concrete Pavement > Continuous Reinforced Concrete Pavement (CRCP)

Concrete Pavement = Road Layers
Surface Course + Road Base + Sub-grade
Negative Impression About Concrete Pavement

- Very Expensive to Build
- Noisy
- Low Riding Quality
- Difficult to Repair
- Higher Tire Wear & Tear
Positive Impression About Concrete Pavement

- Durability
- Low Maintenance
- Less Public Complaint
- Less Traffic Disturbance
Rigid Concrete Pavement

Flexible Pavement

Composite Pavement

Rigid Pavement

Continuously Reinforced Concrete Pavement
- CRCP

Jointed Reinforced Concrete Pavement
- JRCP

Jointed Plain Concrete Pavement
- JPCP

Roller Compacted Concrete Pavement
- RCC

Using Normal Concrete
Type of Concrete Pavements

1. Continuously Reinforced Concrete Pavement (CRCP)
   - Transverse Steel: 0.6-0.85%
   - Transverse Joints: N/A
   - Transverse Cracks: 0.6-1.8 m (2-6 ft)

2. Jointed Reinforced Concrete Pavement (JRCP)
   - Transverse Steel: 0.06-0.25%
   - Transverse Joints: 12-30 m (40-100 ft)
   - Transverse Cracks: 4.5-6 m (15-20 ft)
Type of Concrete Pavements

Jointed Plain Concrete Pavement (JPCP)
- Transverse Steel: 0%
- Transverse Joints: 3.6-6 m (12-20 ft)
- Transverse Cracks: N/A

Roller Compacted Concrete Pavement (RCC)
- Transverse Steel: 0%
- Transverse Joints: 3-5 m (9-15 ft)
- Transverse Cracks: N/A
Do reinforcement increased strength in concrete road?

Purpose of Reinforcement…

1. Control development of crack
2. To reduce spacing of joints

Not to increase structural strength….

So, reducing reinforcement mean reducing cost….
Different finishing on concrete surfaces:

- Bare Finish
- Broom/Tining Finish
- Expose Aggregate
- Diamond Grinding

Different surface serving different purpose....
Concrete Road Construction Technology

- Plant Mixing Material & Transport
- Method of Laying Concrete
Construction Methods related to Concrete/Cement Pavement Solution

Step 1: Production of the concrete
Step 2: Transporting & Delivering
Step 3: Method of Laying
A. Producing Concrete

1. Central Batching Plant
2. Central Pugmill Plant
3. Dry Concrete Plant
4. Mobile Plant
B. Delivery of Concrete Product

Concrete Mixer Truck
Carrying normal concrete
Used for CRCP, JRCP and JPCP

Normal Tipper Truck
Carrying ‘0-slump’ concrete
Used for RCC, CBM and CTB
Concrete Road Construction Technology

- **In-situ Mixing**
- **Plant Mixing Material & Transport**
- **Method of Laying Concrete**
1. Laying Method – Manual Fixed Formwork
2. Laying Method – Slipform paver
3. Laying Method – Asphalt Paver

For laying RCC, CTB/CBM
Hardstand, Roadbase, Rural/Municipal Road
Concrete & Cement Application for Road Construction

- Roller Compacted Concrete (RCC)
- Jointed Plain Concrete Pavement
Roller Compacted Concrete (RCC)
Uses Asphalt Paving Methods
Method (Production)

- Central Mix Batching Plant
- Continuous Pugmil Plant
- Dry Mix Plant With Concrete Mixer
Method (Placement)

Delivery of material using tipper truck
Method (Compaction)

Tandem Roller

Pneumatic Tire Roller
Method (Curing)

- **Manual Spraying**
- **Moisture curing**
- **White-pigmented membrane forming curing compound**
- **Bituminous surface treatment**
Method (Joints)

Crack Control Joints

End Day Joints
Method (Opening to Traffic)

Can be open to light traffic upon compaction
Method (Surface Treatment)

- Diamond grinding
- Expose Aggregate
- Micro surfacing or Asphalt overlay
What is the difference between Conventional Plain Cement Concrete (PCC) and RCC in term of mechanical behavior?

<table>
<thead>
<tr>
<th>MECHANICAL PROPERTY</th>
<th>RCC Vs PCC</th>
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<tbody>
<tr>
<td>Compressive Strength</td>
<td>=</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>↑</td>
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<tr>
<td>Splitting Tensile Strength</td>
<td>↑</td>
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<tr>
<td>Fatigue Behavior</td>
<td>=</td>
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<tr>
<td>Modulus of Elasticity</td>
<td>=</td>
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<tr>
<td>Bond Strength in case of Multi-layer system</td>
<td>=</td>
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<tr>
<td>Shrinkage</td>
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<tr>
<td>Permeability</td>
<td>=</td>
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Concrete & Cement Application for Road Construction

- Roller Compacted Concrete
- Jointed Plain Concrete Pavement
Jointed Plain Concrete Pavement (JPCP) as a Solution

Advantages of JPCP

- Low in cost, compared to Continuously Reinforced Concrete Pavement & Jointed Reinforced Concrete Pavement
- No Reinforcement, only using dowel bar at joints
- Application for High density traffic, high speed
- Lower initial construction cost against Continuously Reinforced Concrete Pavement (CRCP)
- Better Life-cycle cost compared to asphalt pavement

Laying & Construction Method

- Fix Form/ Formwork
- Slip form Paver

Points of Attention

- Need experience builders to construct
- 6-7 days to allowable traffic
- Surface texture & riding quality need attention
1. Designing Concrete
2. Dowel Bar Preparation

[Images of construction work with emphasis on dowel bar preparation]

[Diagram showing dowel bar placement and joint sealing]
3. Trail Lay for Laying Method

Trial lay with fixed form

Dowel bar basket
4. Laying of Concrete (Manual Laying)
Dismantle formwork (Manual Laying)
Laying Concrete using Slip Form Paver
Case Study
Hybrid Solutions

✓ JPCP-RCC Hybrid Surface

➢ JPCP-RCC Layer Combination
Cross section drawing for JPCP–RCC hybrid concrete pavement solution

7.5 Meter

Earth Sub-Grade

Cement Stabilized

RCC

JPCP

RCC

Car Park

Dual Carriageway

Hardstand

7.5 Meter
Edge of Concrete Pavement with Dowel Bar
Case Study
Hybrid Solutions

- JPCP-RCC Hybrid Surface
- JPCP-RCC Layer Combination
Cross section drawing for JPCP–RCC hybrid concrete pavement solution

Jointed Plain Concrete Pavement

Roller Compacted Concrete

300 mm Crushed Run Layer

Earth Sub-Grade
Conclusions
Benefits of Concrete Pavement

1. Open to traffic quickly

Unlike conventional concrete pavement that require minimum 7-day before open to traffic, RCC benefit from:

- High early strength
- Can support light traffic before cement fully hydrates, i.e. approx. 8 hours
Benefits of Concrete Pavement

2. Low maintenance costs

- Rut and abrasion resistant
- Chemical resistant, i.e. resist to the corrosion of diesel/ hydraulic oil spillage (common issue at toll plaza & rest areas, Parking Bays)
- Low permeability to prevent pothole at flood prone area
Benefits of Concrete Pavement

4. Environmental Friendly & Safety

- Better visibility at night
- Different surface texture to alert drivers to slow down at toll stations

Ref: National Center for Concrete Pavement Technology, Iowa State University
Benefits of Concrete Pavement

5. High Compressive & Flexural Strength

- Better resistance to damage from steel tracks (Excavator & Padi Harvester)
- Will no soften under hot weather
- Will no deform under heavy loading
The Economics
How much cement used in concrete road?

|                     | Per KM Lane | Per 2 Lane | Total Roughly
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<tbody>
<tr>
<td>CRCP/JPCP/JRCP</td>
<td>240 mt</td>
<td>550 mt</td>
<td>54%</td>
</tr>
<tr>
<td>CTB/RCC/CIPR</td>
<td>140 mt</td>
<td>320 mt</td>
<td>32%</td>
</tr>
<tr>
<td>SOIL STABILIZATION</td>
<td>75 mt</td>
<td>170 mt</td>
<td>14%</td>
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**Note:**
*Base on assumption of*
Concrete Pavement 230mm
Base 200mm
Soil Stabilization 300mm

Roughly about 5%-8% of total road construction
The Economics
Concrete Has a Lower Inflation Rate

1. CPI – Consumer Price Index
2. CAGR - Compounded Annual Growth Rate

Oil and Asphalt Import/Export Practices and Refining Processes Impact This On a Local Level!
In Many Areas, Concrete Can Now Compete On Initial Cost Alone!

Source: ACPA EB011, Life Cycle Costs Analysis
The Economics
Concrete Pavements Are Typically Designed to Last Longer

Pavement Life Expectancy: Asphalt vs. Concrete
Years Before a Major Reconstruction is Required

Concrete: Average = 29.3 Years
Asphalt: Average = 13.6 Years

Source: PCA 2008 Highway Report
The Economics

Competition Pays Dividends to the Owner (and TAXPAYERS)

- A complex relationship exists between number of bidders, volume of market, unit price of materials, etc.

- However, there is a clear trend of lower prices for both pavements with increasing levels of competition

- Variability in unit prices also decreases with increasing competition

- Owners can purchase more pavements with the same investment!

Thank you