The Pavement Mechanistic Design Workshop May 2008

Assessment of Pavement Layer Quality using CUSUM Analysis
- Quality of Pavement Construction

Presented by
Gary Lin
CUSUM - Principles

- What is the basis of CUSUM analysis
  - Cumulative sum of the differences between the values and the average
  - Golf game analogy

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<th>DIFF</th>
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CUSUM - Graphical Representation

OPUS
CUSUM – Quality of Pavement Construction

Example – North Shore Busway

- Pavement Quality Review
  - Subbase Compaction
  - Basecourse Compaction
  - Degree of Saturation
  - Benkelman Beam on Basecourse
  - FWD on Chipseal
CUSUM – NSBW Subbase Densities

CUSUM at mean = 2.47 t/m³

Chainage of Busway Main Alignment

Cumulative Densities

CUSUM at mean = 2.47 t/m³

Chainage of Busway Main Alignment
CUSUM – NSBW Subbase Densities

CUSUM at 100% Plateau Density = 2.4t/m3

Cumulative Densities

Chainage of Busway Main Alignment
CUSUM – NSBW Basecourse Densities

CUSUM at Mean = 2.48 t/m³

Chainage on Busway Main Alignment

Cumulative Densities
CUSUM – NSBW Basecourse Densities

CUSUM at 100% Plateau Density = 2.4t/m3

Cumulative Densities vs Chainage on Main Alignment
CUSUM – NSBW Saturation

**NSBW Degree of Saturation Histogram**

- Degree of Saturation %
- Frequency

![Graph of NSBW Degree of Saturation Histogram](attachment:image.png)
CUSUM – Quality of Pavement Construction

Example – North Shore Busway

- Pavement Quality Review
  - ✔ Subbase Compaction
  - ✔ Basecourse Compaction
  - ✔ Degree of Saturation
CUSUM – NSBW Benkelman Beam

CUSUM at Mean Deflection = 0.60mm

Cumulative Deflection

Chainage on Main Alignment
CUSUM – NSBW Benkelman Beam

CUSUM at deflection = 0.75mm

Cumulative Deflection

Chainage on Main Alignment
## CUSUM – NSBW FWD

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CUSUM – NSBW FWD

NSBW FWD CUSUM at 0.4mm

CUSUM Deflection

Chainage

LHS

RHS
CUSUM – NSBW FWD

NSBW FWD CUSUM at 0.5mm

Chainage

CUSUM Deflection

LHS
RHS
CUSUM – NSBW FWD

NSBW FWD CUSUM at 0.6mm

CUSUM Deflection

Chainage

LHS
RHS

CUSUM – NSBW FWD

OPUS
CUSUM – NSBW FWD

NSBW FWD CUSUM at 0.8mm

CUSUM Deflection

LHS

RHS
CUSUM – NSBW FWD

NSBW FWD Deflections

Deflection (mm)

Chainage

LHS
RHS
CUSUM – Quality of Pavement Construction

Example – North Shore Busway

Pavement Quality Review

✓ FWD & Benkelman Beam Deflections
CUSUM – Quality of Pavement Construction

- Example – UHC: Greenhithe Section
  - Pavement Quality Review
    - Subbase Compaction
    - Basecourse Compaction
    - Degree of Saturation
    - Benkelman Beam on Basecourse
    - FWD on Chipseal
CUSUM – UHC: Greenhithe FWD

Greenhithe FWD Deflections

Deflection (mm)

Chainage

LHS  RHS
CUSUM – UHC: Greenhithe FWD

Greenhithe FWD CUSUM at Mean = 0.43mm

CUSUM Deflection

Chainage

LHS RHS

OPUS
CUSUM – UHC: Greenhithe FWD

Greenhithe FWD CUSUM at 0.5mm
CUSUM – UHC: Greenhithe FWD

Greenhithe FWD CUSUM at 0.6mm

CUSUM Deflection

Chainage

CUSUM Deflection

Chainage

LHS

RHS

OPUS
CUSUM – Quality of Pavement Construction

- Example – UHC: Greenhithe Section
  - Pavement Quality Review
  - FWD Deflections
CUSUM – Quality of Pavement Construction

- CUSUM Analysis is a useful tool to:
  - monitor the consistency in quality of pavement construction.
  - identify possible future areas to monitor.