Forestry Commission

Using Technology to Conserve Resources

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What are we trying to conserve?

Visible
- Vegetation encroachment
- Blocked drainage
- Soft surface

Invisible
- Depth of construction
- Subgrade type and strength

Fact
- Direct labour squads are virtually gone so local knowledge is lost

Challenges
- Do we have enough stone to carry the intended traffic and if not, how much extra do we really need?
- How much will the upgrade cost?

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Background

First contact with Roadscanners of Finland in 2004 during ROADEX collaboration

Objective: Analyse the existing road structure using Ground Penetrating Radar (GPR), GPS, video, roughness and Falling Weight Deflectometer (FWD) data in order to target limited upgrading and maintenance resources.

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Concepts

1. Determine the existing road structure thickness from GPR interpretation.
2. Establish the required road thickness by calculating the bearing capacity (stiffness) of the subgrade.
3. Compare actual thickness with required thickness and calculate additional requirements.

Subgrade stiffness can be determined by

- Dynamic Cone Penetrometer (results expressed as California Bearing Ratios) or by
- Falling Weight Deflectometer (results in MPa).

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Dynamic Cone Penetrometer

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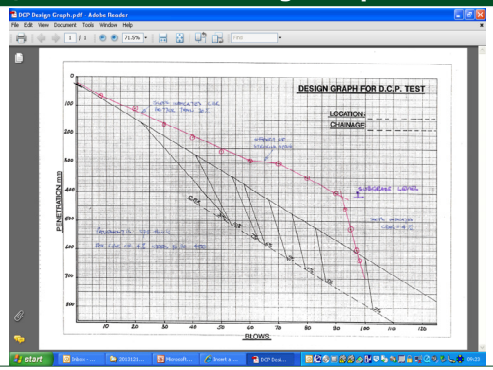
DCP Design Graph



California Bearing Ratio (CBR)

The CBR test was developed by the California Department of Transportation in the 1930s for measuring the load bearing capacity of soils used for building roads. The test is still in use today and the Forestry Commission pavement design table is derived from established CBR values .

The laboratory test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. The measured pressure is then divided by the pressure required to achieve an equal penetration on a standard crushed rock material.

CBR = P/PS x 100 where
P = Measured pressure for site soils (N/mm2)
PS = Pressure required to achieve equal penetration on the standard material

The standard material is crushed California limestone which has a value of 100.

Falling Weight Deflectometer

UK conversion of stiffness to CBR

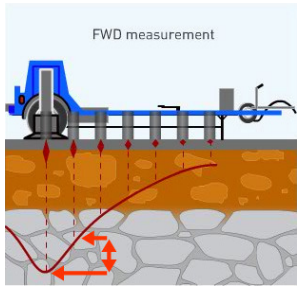
$$E = 17.6 \times CBR^{0.64}$$

Where E is stiffness in MPa

Typical CBR Values

Soil Type	CBR %	Indicative Total Pavement Thickness (mm)
Peat, silt	<2	>850 (consider excavation to firmer subgrade or use of geosynthetic)
Silty clay	2	700
Heavy clay	3	550
Sandy clay	4	475
Saturated sand	7	325
Fine sand	10	250
Graded sandy gravel	20	150
Rock	250+	Min. 100 to allow grading of surface

FWD Principle



The Road Condition Survey Vehicle

Forestry Commission Ground Penetrating Radar

Forestry Commission Video

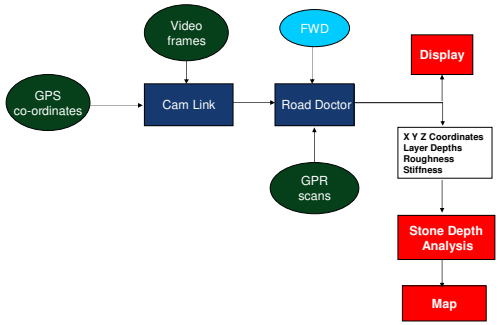
Forestry Commission CamLink & INCA

Forestry Commission Global Positioning System (INCA)

Forestry Commission Distance Measuring Instruments

Forestry Commission Storage

Forestry Commission System Overview



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Road Doctor

- Establish number of existing construction layers and depths by interpretation of GPR data.
- Use video record to inform GPR interpretation and visual analysis
- Establish bearing capacity of subgrade at 50 metre intervals by calculating stiffness moduli from Falling Weight Deflectometer data.

Stone Depth Analysis

- Import distance, GPS, layer depth(s) roughness and stiffness data from Road Doctor
- Convert stiffness to California Bearing Ratio (CBR)
- Establish required structural depths of stone from "look-up" CBR design table, compare required depth with actual depth and calculate additional depth requirements.
- Display results in a table which summarises additional depth requirements at 50 metre intervals
- Use GPS coordinates to produce a GIS map showing the sections of road to be strengthened.

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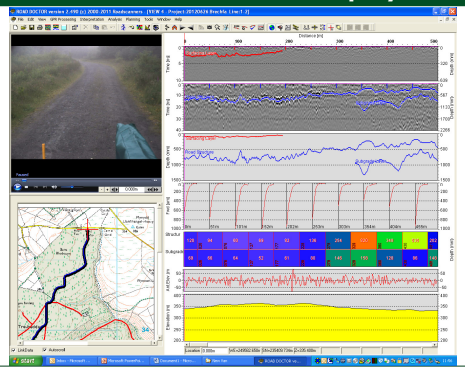
Total length of road to be upgraded	5623 m
Length requiring additional stone	2621 m
Length requiring no additional stone	3002 m
Budget unit cost of upgrading	£20.84/m
Stone production, haulage and application	£18.00/m
Cash saving = 3002 x 18	£54,036
At 3 tonnes /m run stone saving = 3002 x 3	9006 tonnes
Each tonne of stone used generates 7 kg CO^2 (source, Bruce Nicoll, FR) CO^2 saving = 3002x3x7	63,042 kg

Forestry Commission Road Doctor Display



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Two types

- 1. Falling Weight Deflectometer – the stone depth analysis spreadsheet includes a table of additional stone requirements at 50m intervals and a GIS map showing the location of the areas to be strengthened is provided.
- 2. Non-Falling Weight Deflectometer - a modified stone depth analysis spreadsheet is supplied into which the Civil Engineer can enter appropriate CBR value(s) derived from experience or DCP testing. Additional stone depth requirements are then calculated at 50m intervals. A GIS map showing the existing depths of stone is provided.