Light Weight Deflectometer, Principles and Versability

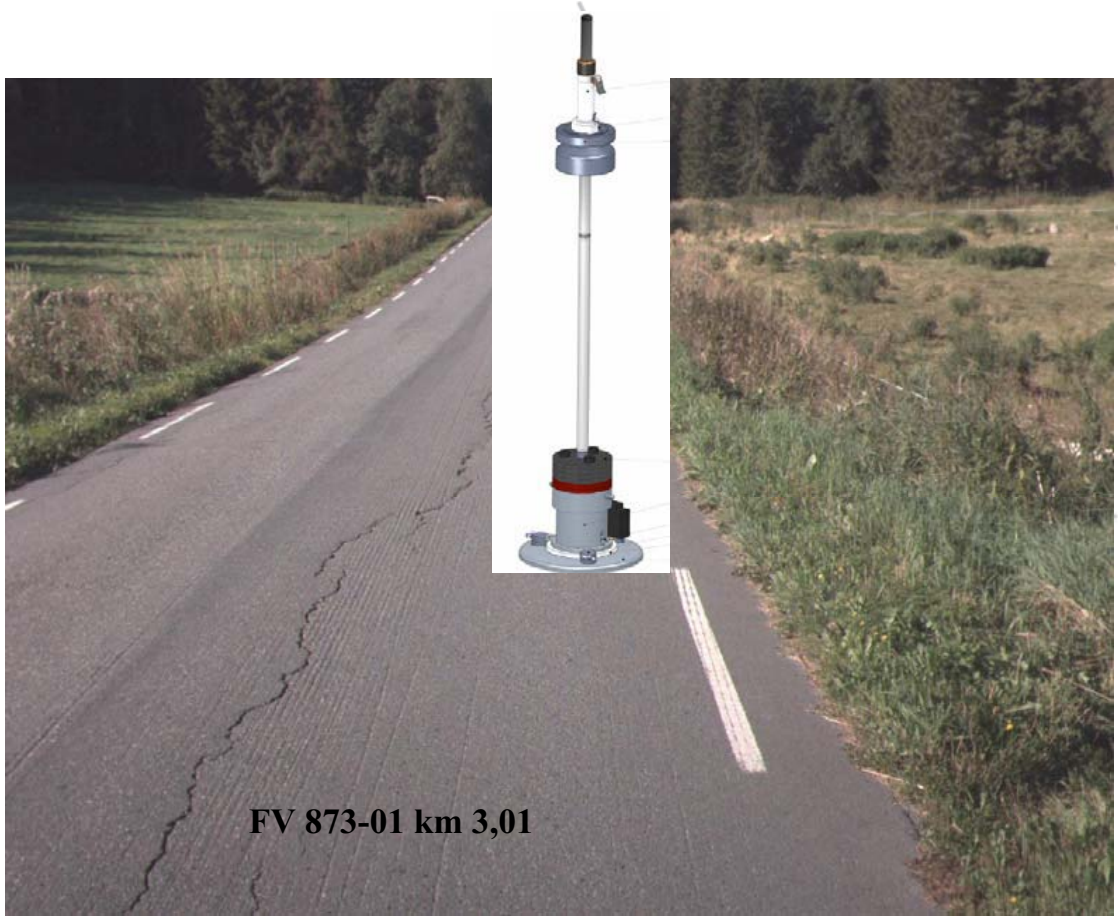
Content:

1. Introduction
2. Dynatest 3031 LWD
3. Field measurements
4. Conclusions

NTNU
Innovation and Creativity

Light Weight Deflectometer

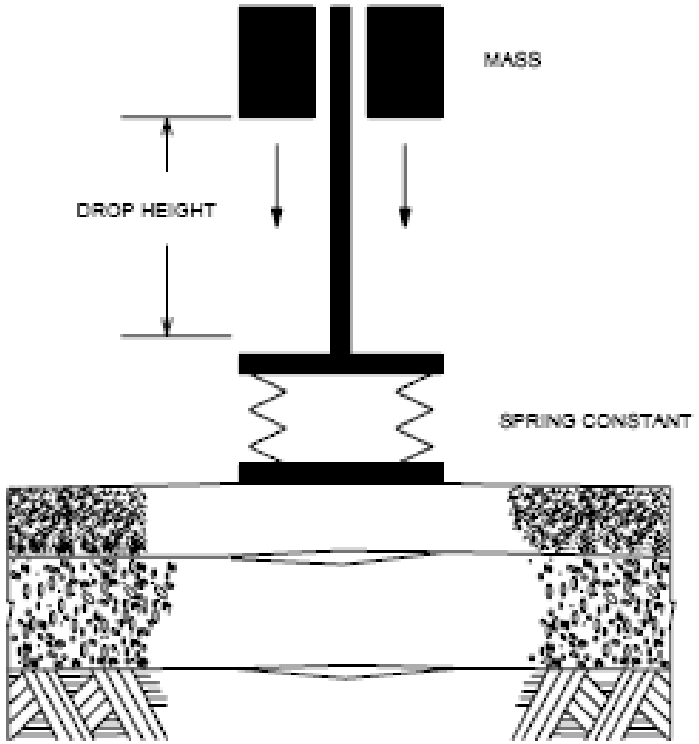
- Introduction
  - Field testing equipment for determination of stiffness of pavement materials
  - Easy to operate, and small enough to be used at any place (especially construction sites)
  - Lower initial cost than an ordinary FWD (≈ 1/10)

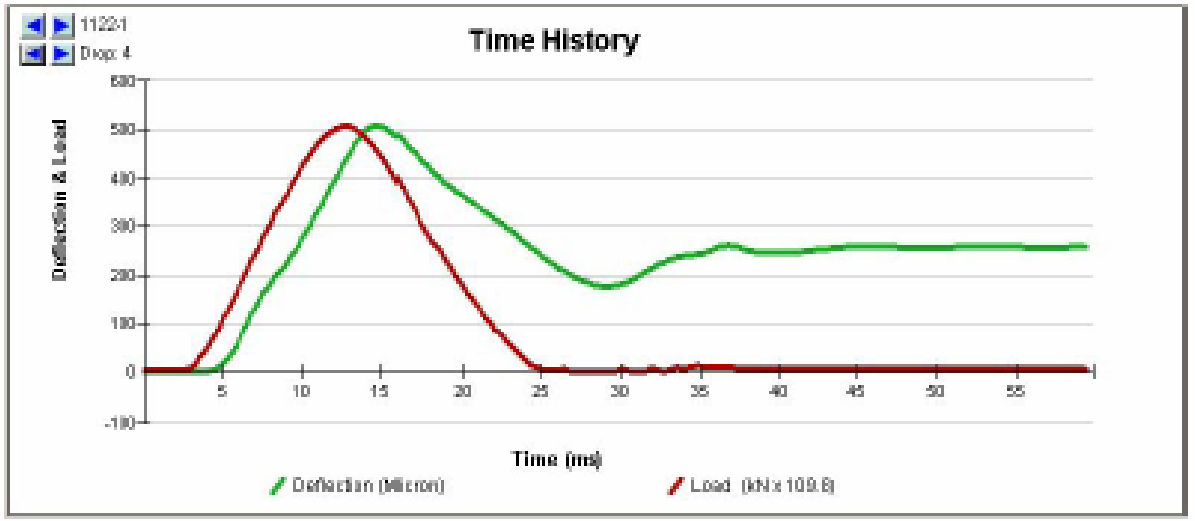


NTNU
Innovation and Creativity

Light Weight Deflectometer

- Basic principles
  - Measurement of deflections induced by dropping weight (up to 20 kg – hence *light weight*) using geophones.





$$P = \sqrt{2 \bullet M \bullet g \bullet h \bullet k}$$

$$p = P/(\pi \bullet a^2)$$

NTNU
Innovation and Creativity

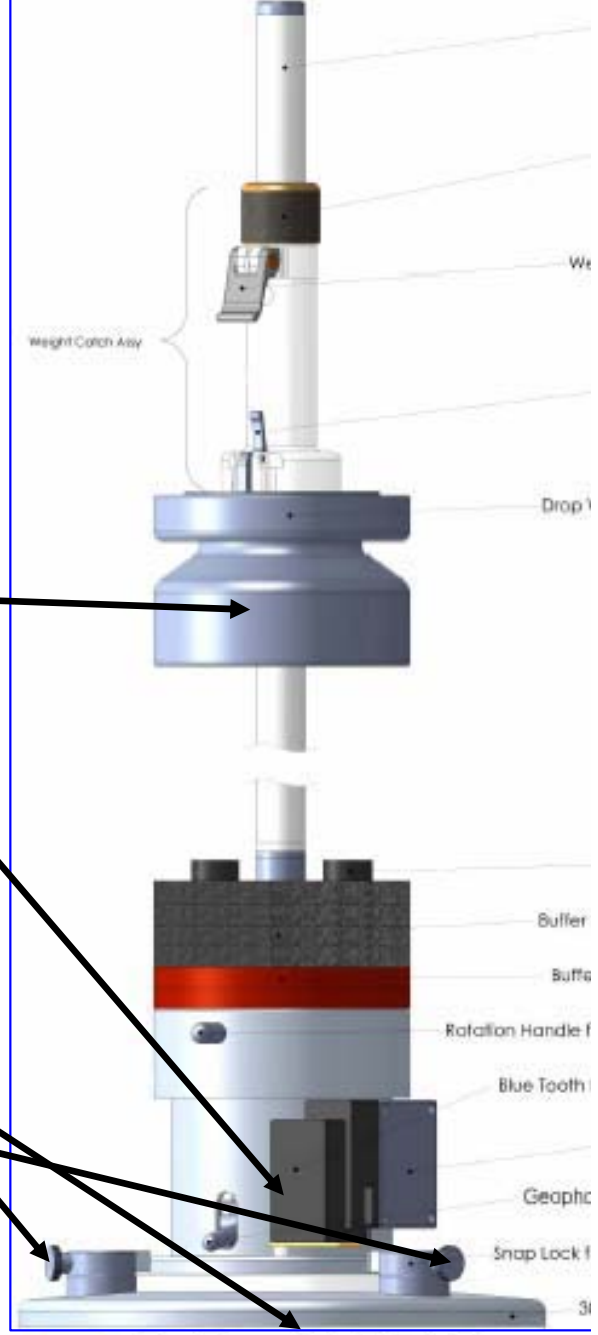
Light Weight Deflectometer

- LWD equipments on the market
  - Dynatest LWD
  - Prima 100, CarlBro (previously Phoenix)
  - Light Drop Weight (LDW), Germany
  - Loadman, Finland

Light Weight Deflectometer

Dynatest 3031 LWD

- It has a basic 10 kg falling mass (+5kg)
- During the test, the falling mass impacts the plate, producing a load pulse up to 15 kN of 15 – 25 ms duration.
- The center geophone sensor measures the deflection caused by the mass impact on the loading plate. (+2 more geophones optional)
- The diameter of the loading plate can easily be varied between 150 and 300 mm
- The software associated with the equipment is LWDmod, which uses the same principle as ELmod for Dynatest FWD.



NTNU
Innovation and Creativity

Light Weight Deflectometer

Dynatest 3031 LWD

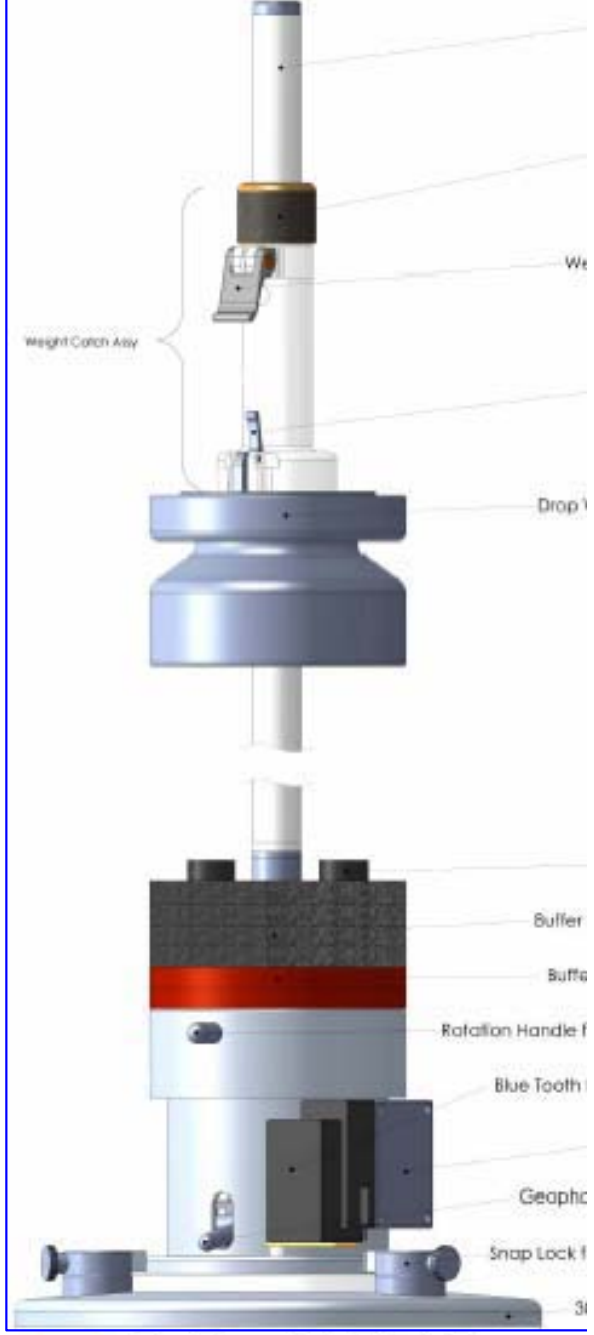
- the surface deflection modulus E_0 is calculated using Boussinesq solution as follows:

$$E_0 = \frac{f*(1-\nu^2)*\sigma_0*a}{d_0}$$

where:

- E_0 : Surface deflection modulus
- f : Factor for stress distribution (2 or π/2)
- ν : Poisson's ratio
- σ_0 : Uniformily distributed stress under plate $\sigma_0 = \frac{P}{\pi a^2}$
- a : Radius of plate
- d_0 : Center deflection

$$E_0 = \frac{3}{2}\left[\frac{\sigma_0 * a}{d_0}\right]$$

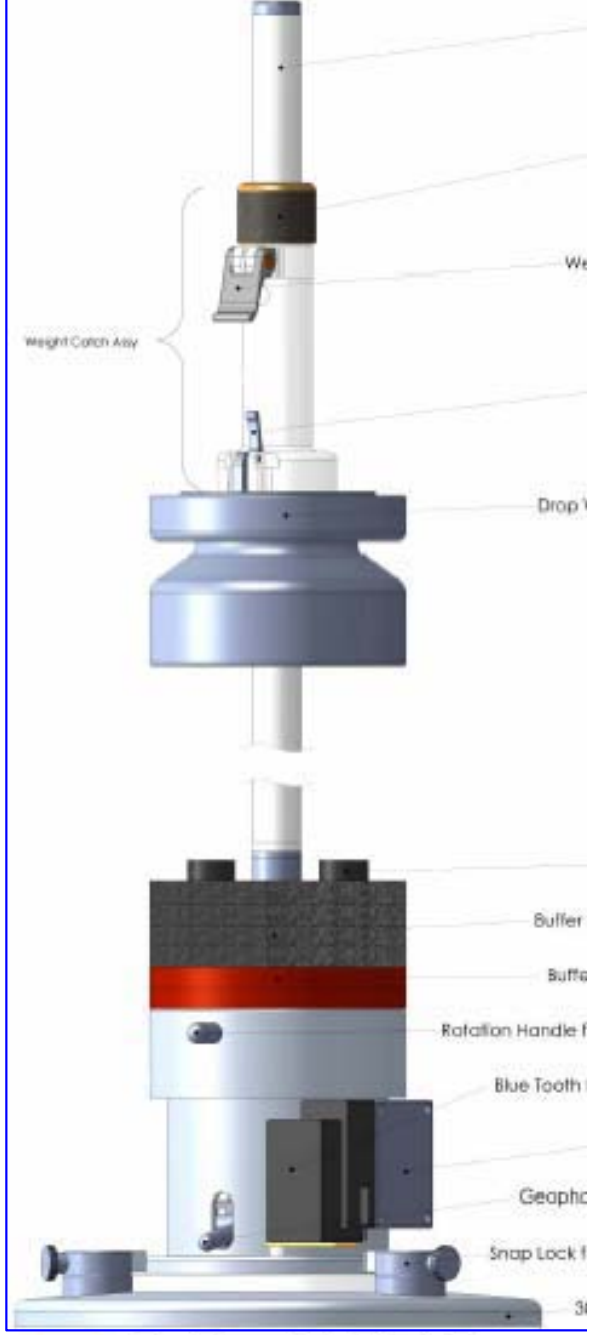


NTNU
Innovation and Creativity

Light Weight Deflectometer

Dynatest 3031 LWD

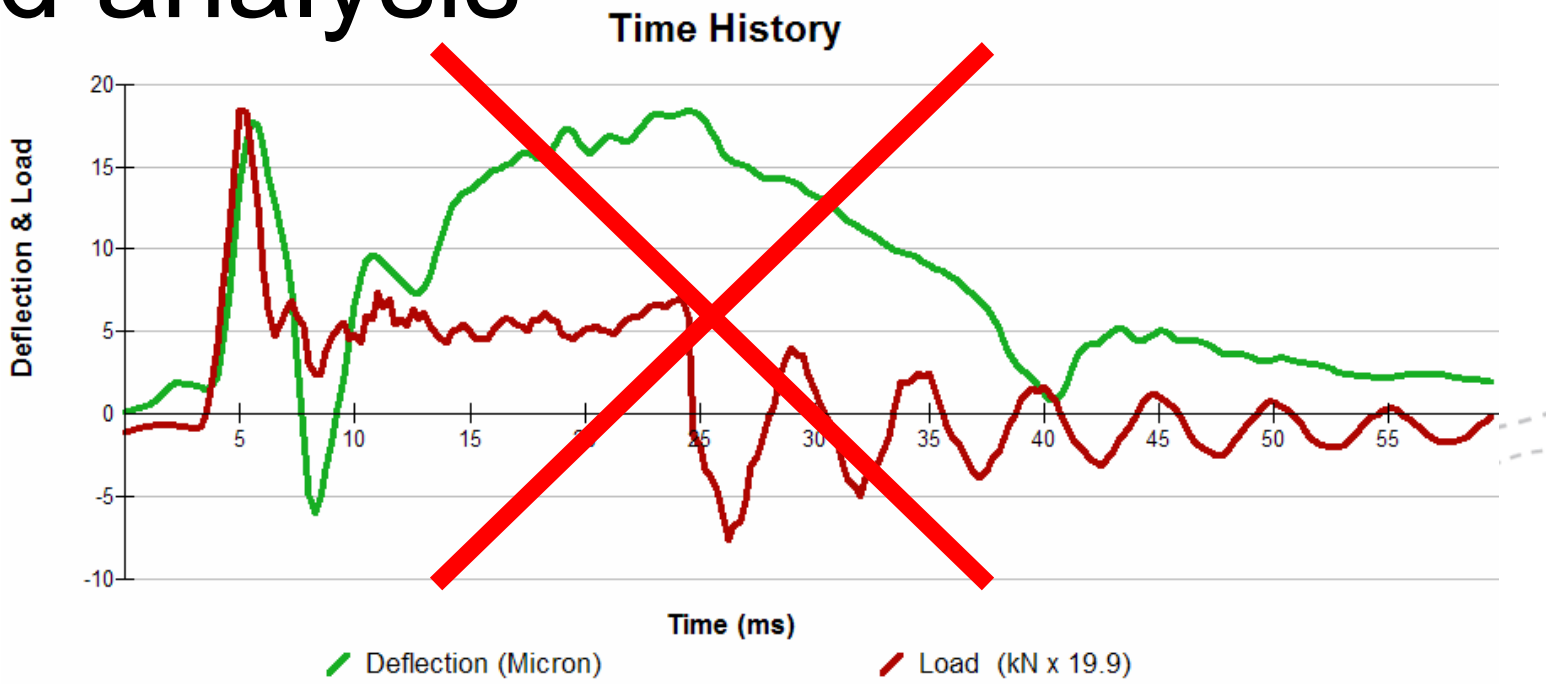
- For multi-layer systems, Odemark's method of equivalent thickness (MET) is used in LWDmod for backcalculation of modulus values

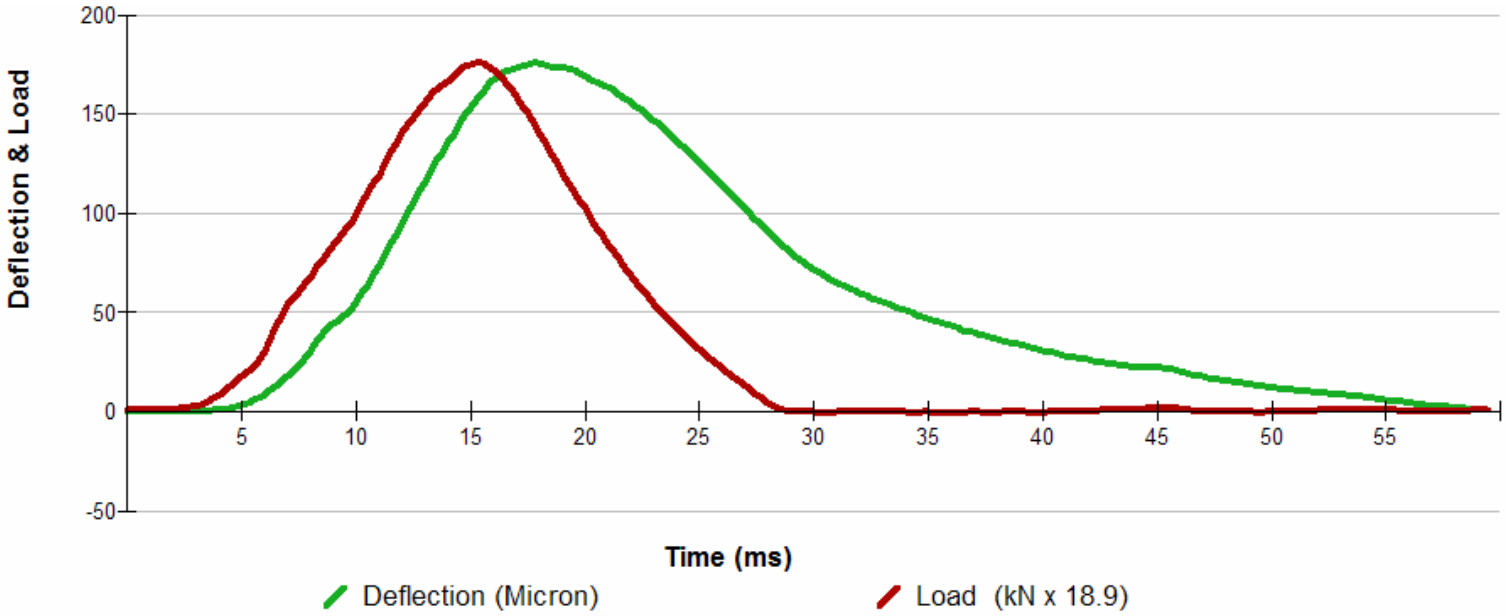


NTNU
Innovation and Creativity

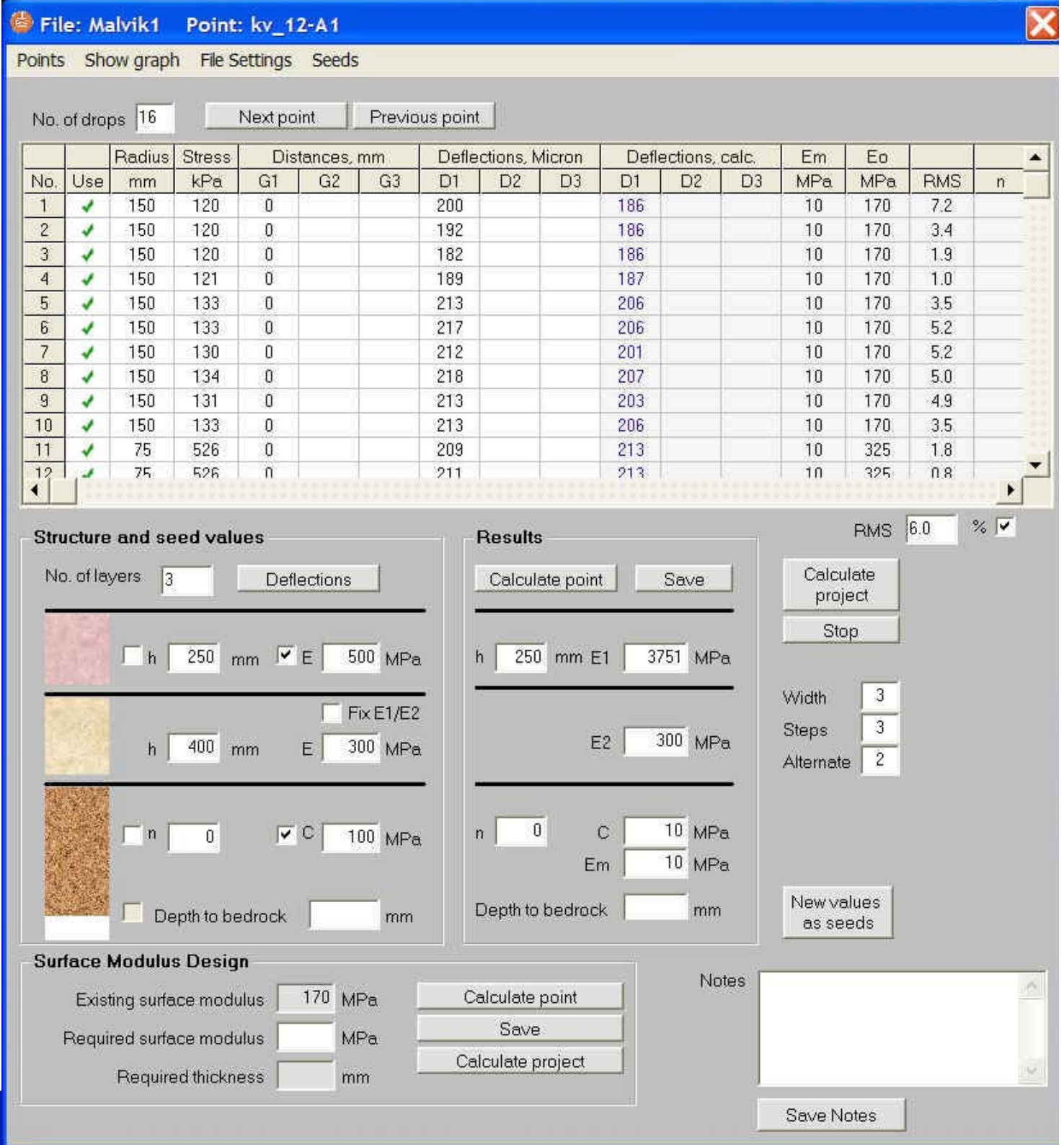
LWDmod analysis

- Analysis starts by filtering out unrealistic drops





LWDmod analysis

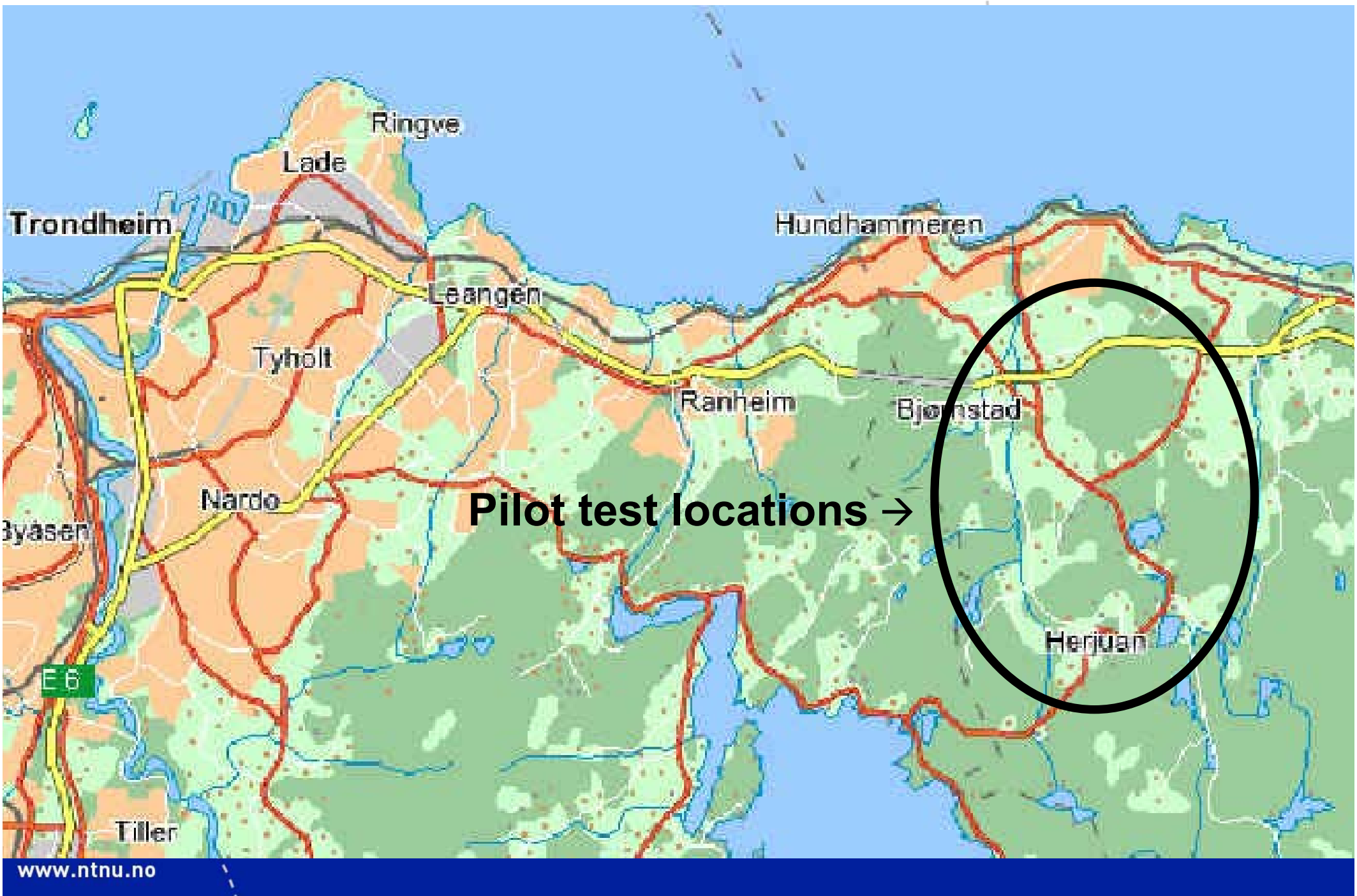


Field measurements

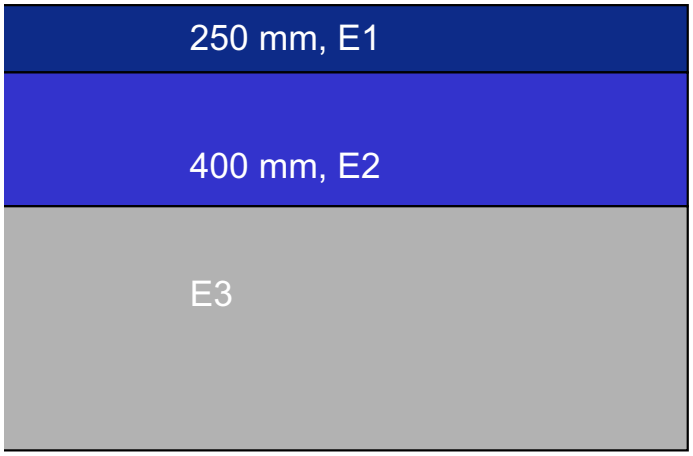
- Objective
  - To compare modulus values of pavement materials determined from field measurements carried out with Light Weight Deflectometer (LWD), Falling Weight Deflectometer (FWD), Dynamic Cone Penetrometer (DCP) and Static Plate Loading Test (SPLT).
  - Evaluate whether LWD could be used for evaluation of low volume roads

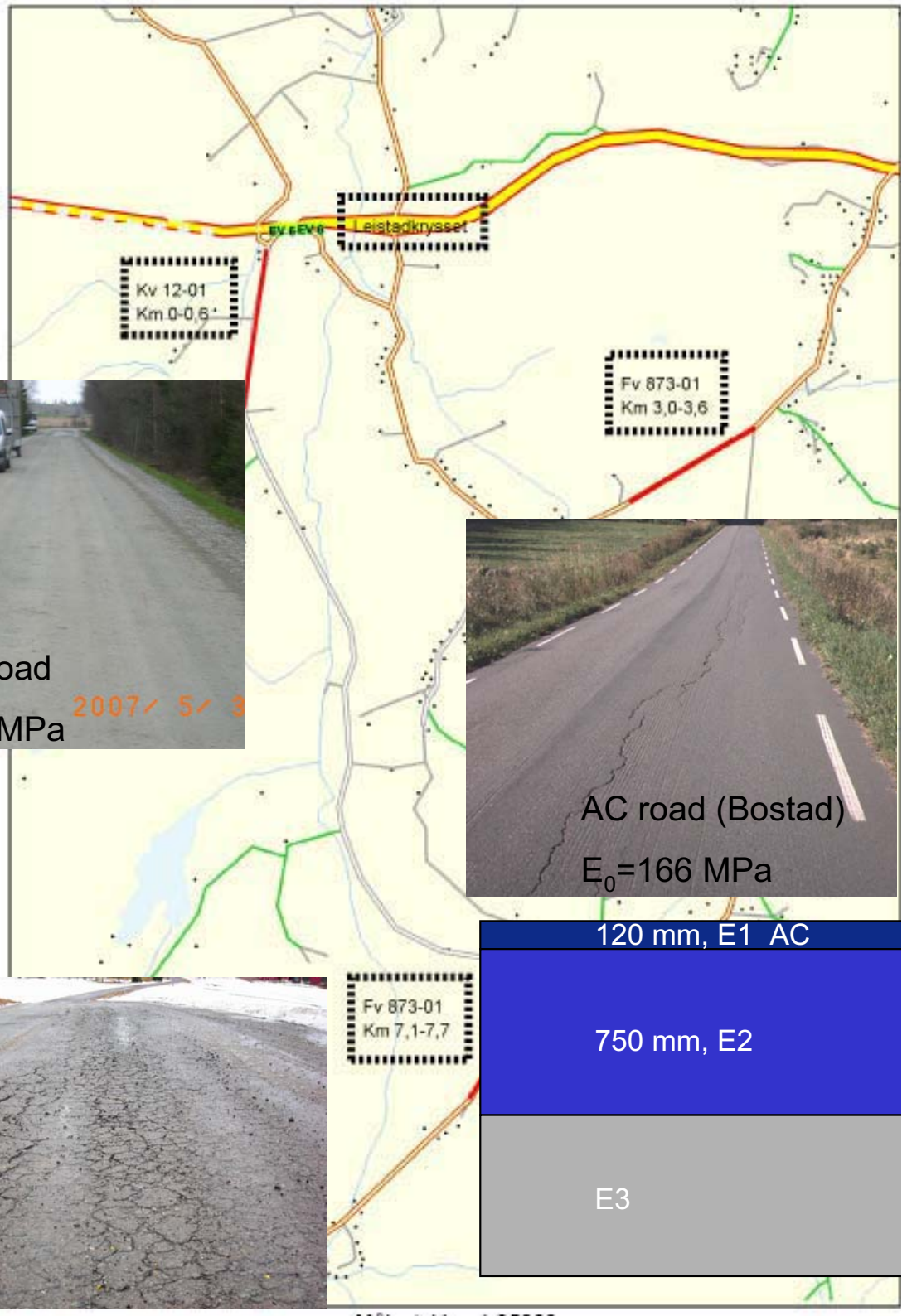
NTNU
Innovation and Creativity

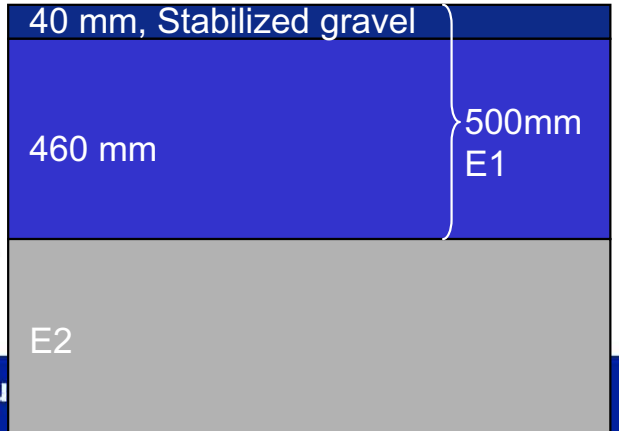
Measurements in the Malvik area



Malvik low volume test roads

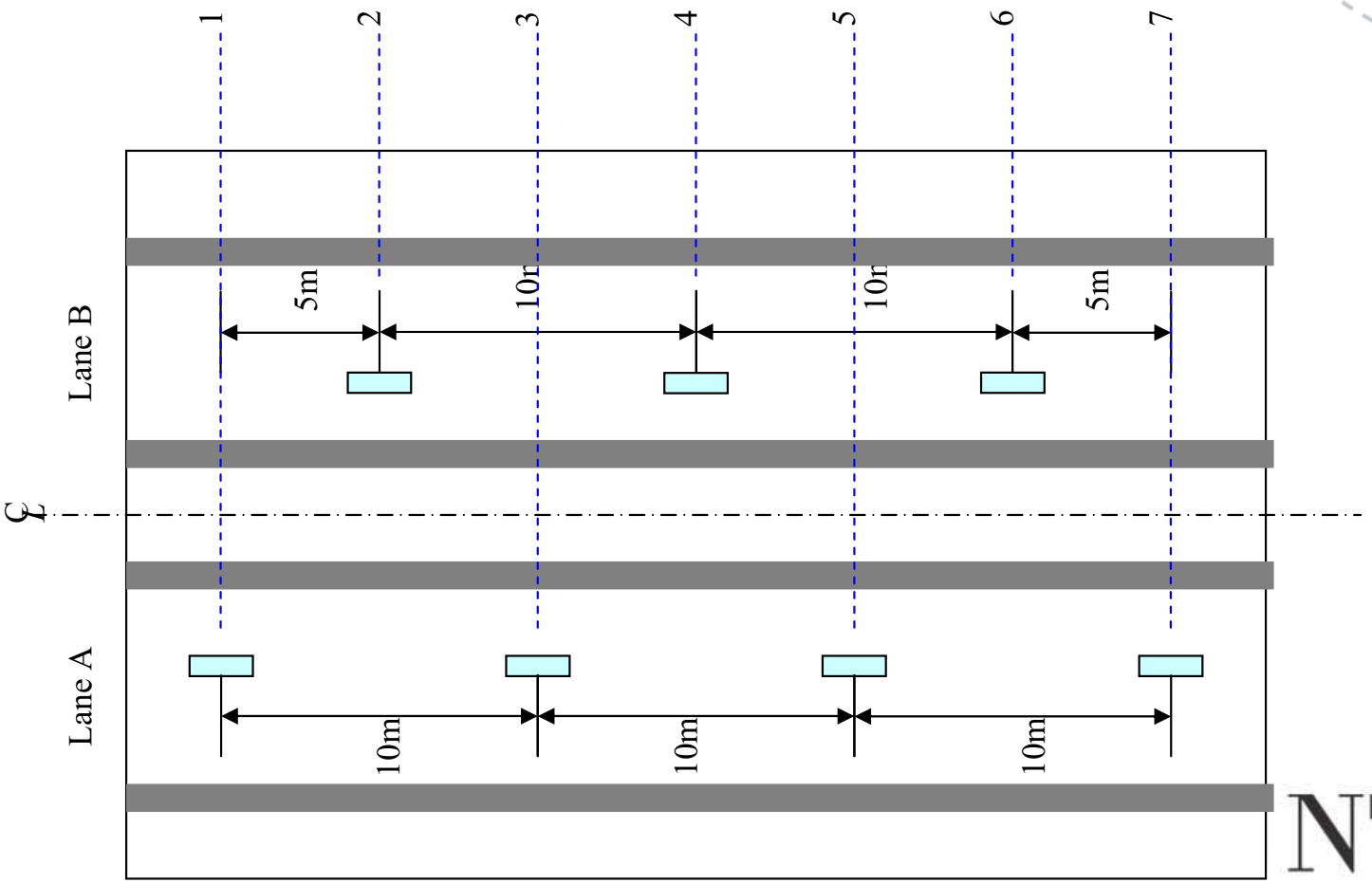




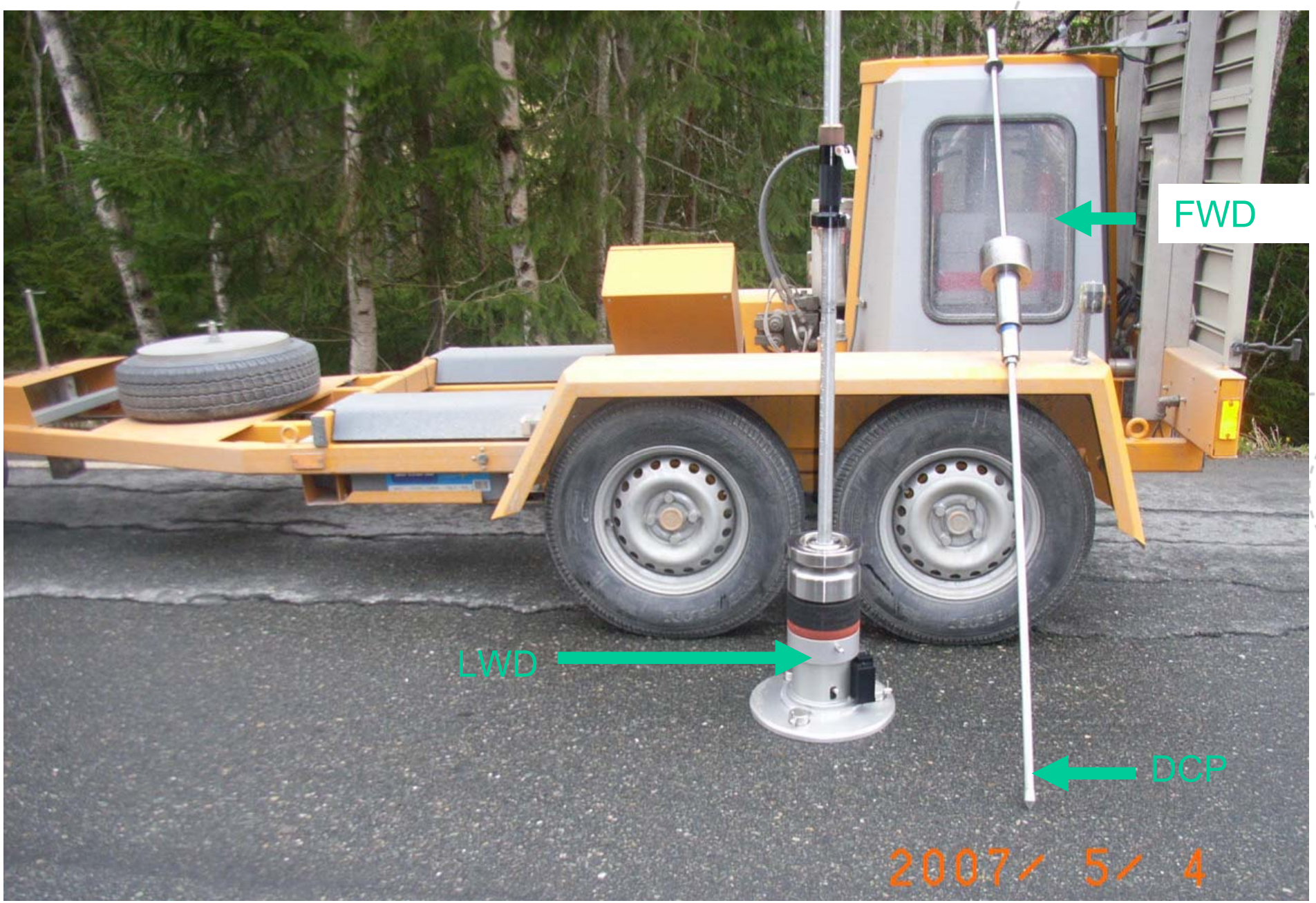


Malvik test roads

- Test point arrangement at each of two sections



NTNU
Innovation and Creativity

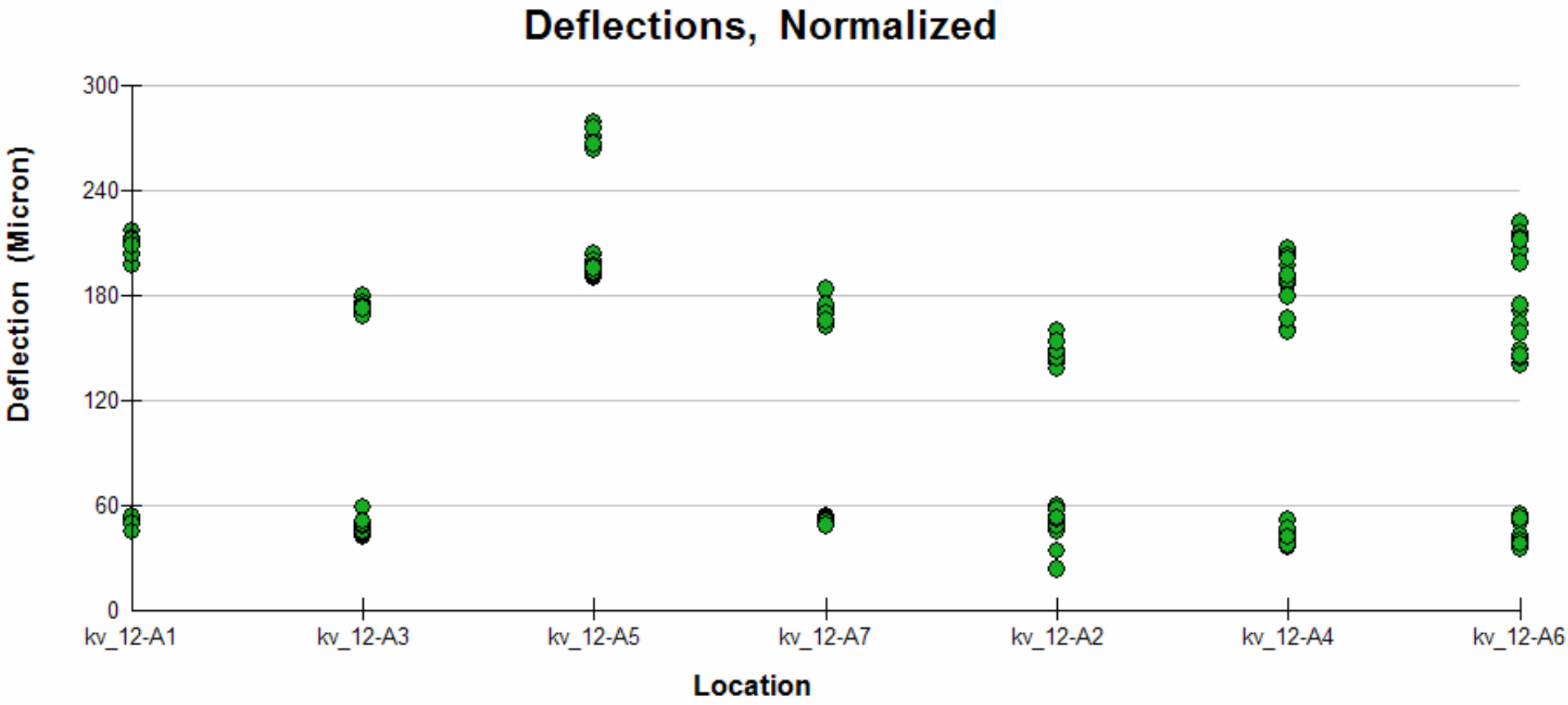


LWD, FWD and DCP used for pilot study at Malvik

NTNU
Innovation and Creativity

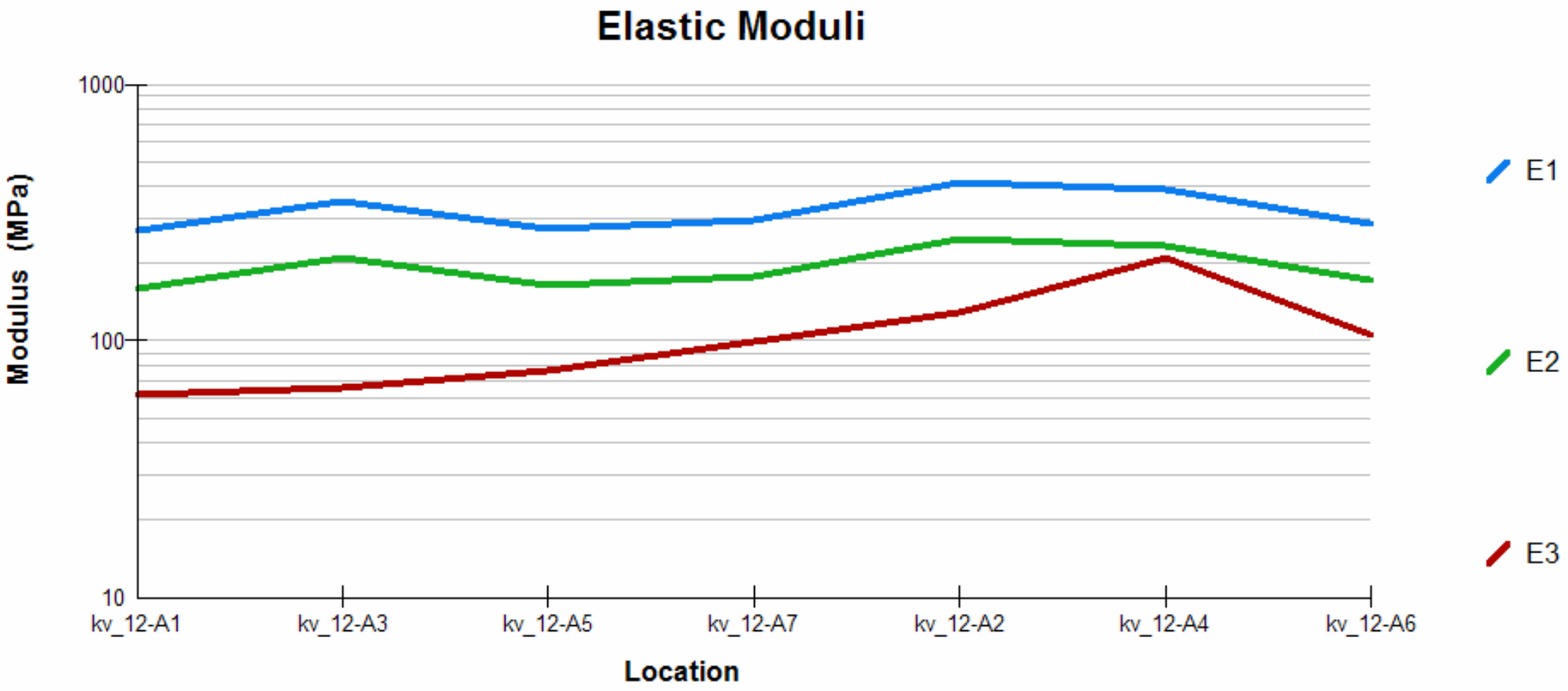
LWD/DCP set-up

LWDmod data analyses



NTNU
Innovation and Creativity

LWDmod data analyses



NTNU
Innovation and Creativity

LWD data analyses

- Comparison of surface modulus values of the three roads

$$E_0 = \frac{2*(1-\nu^2)*\sigma_0*a}{d_0}$$

Road	***KV-12***	***FV 873-01 km 3,0 – km 3,6***	***FV 873-01 km 7,1 – km 7,7***
Surfacing	Gravel	Asphalt Concrete	Bitumen Stabilized
Base/Subbase	Natural gravel	Sandy gravel	Silty gravel
Surface Modulus E_0 (MPa)	192	166	126

NB: The rating of these values agree with the visual condition evaluation

NTNU
Innovation and Creativity

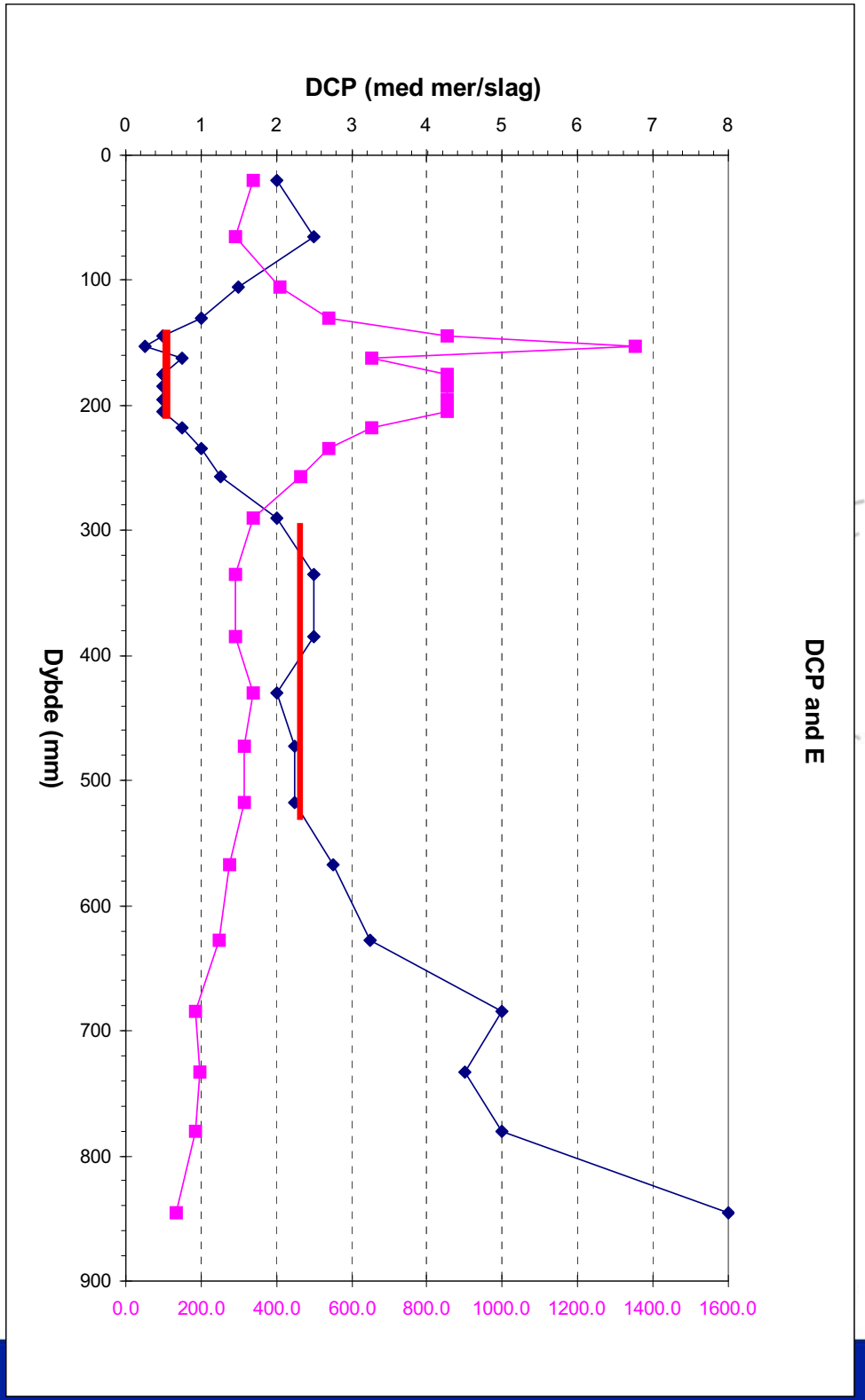
DCP data

- A typical DCP plot.

DCP value [mm/blow]	0.6	2.4	6
Field CBR	*703.6*	*124.4*	*39.6*
E (MPa)	755.1	300.6	163.5

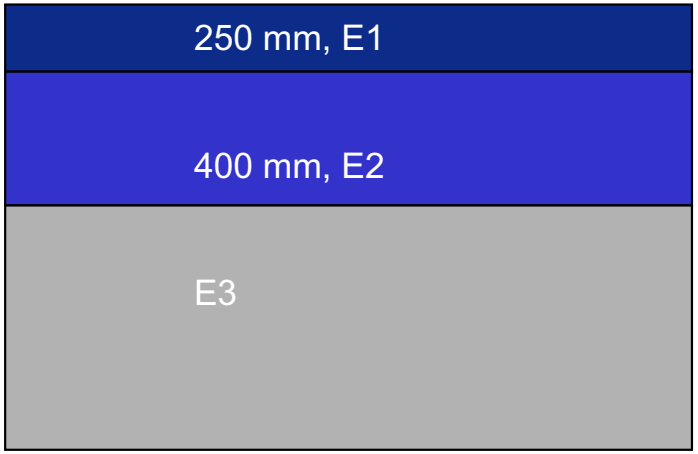
$E = 537.76 * DCP^{-0.6645}$

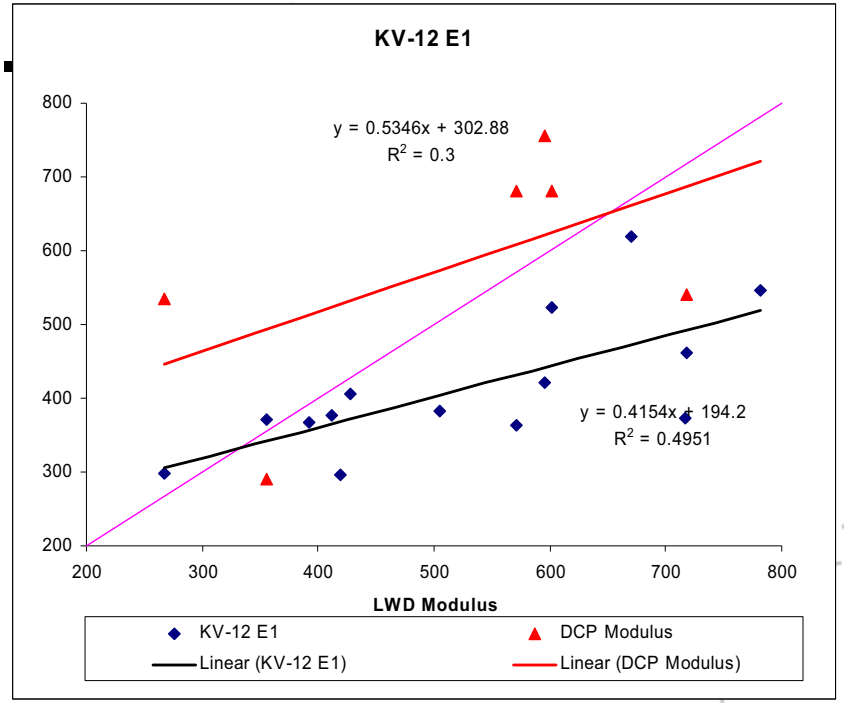
Dang-Fong Lin 2006

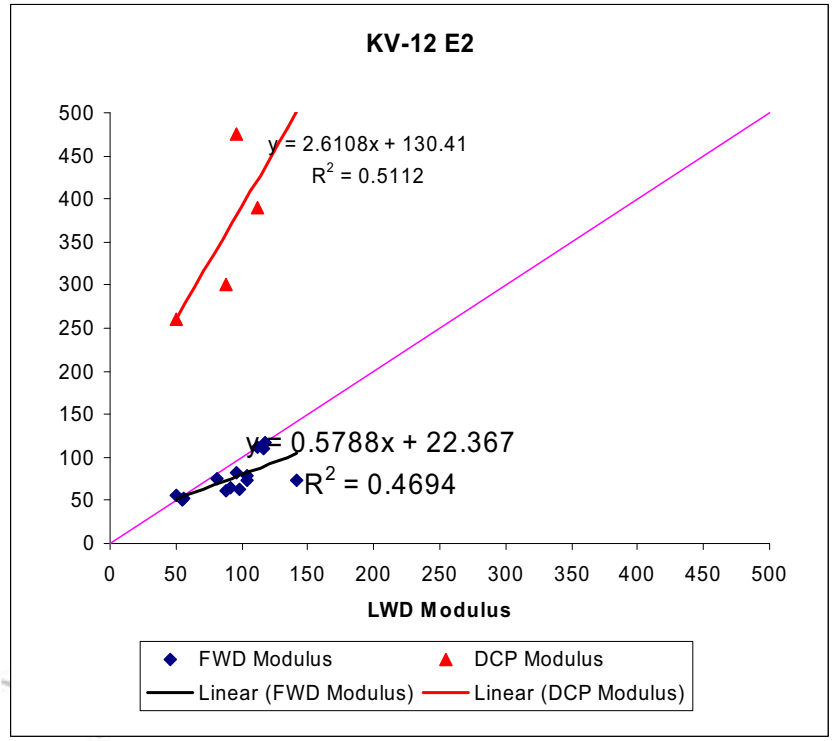


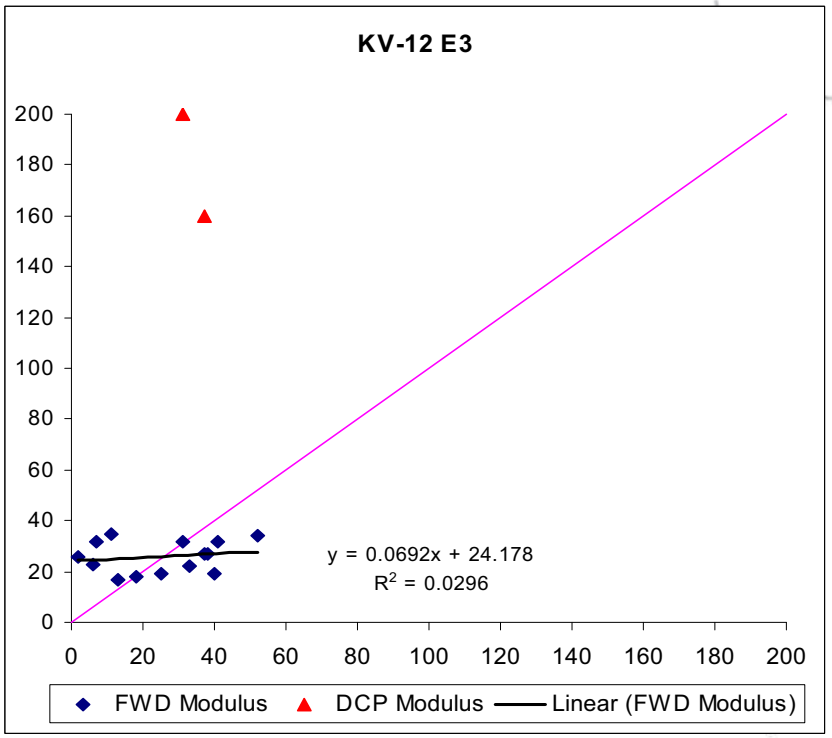
Comparison of results

1. Gravel Road KV-12



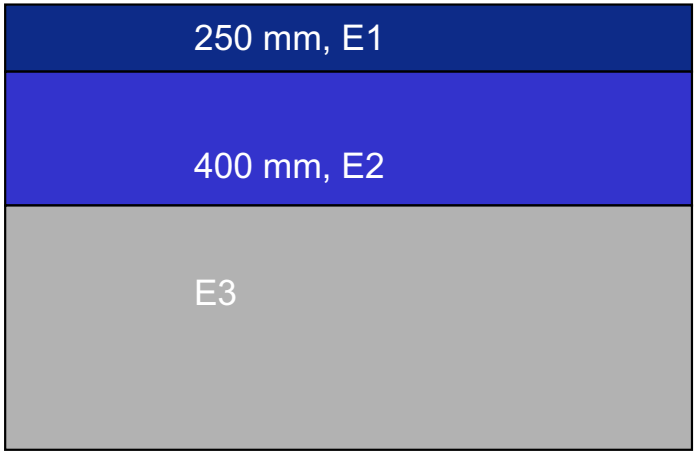


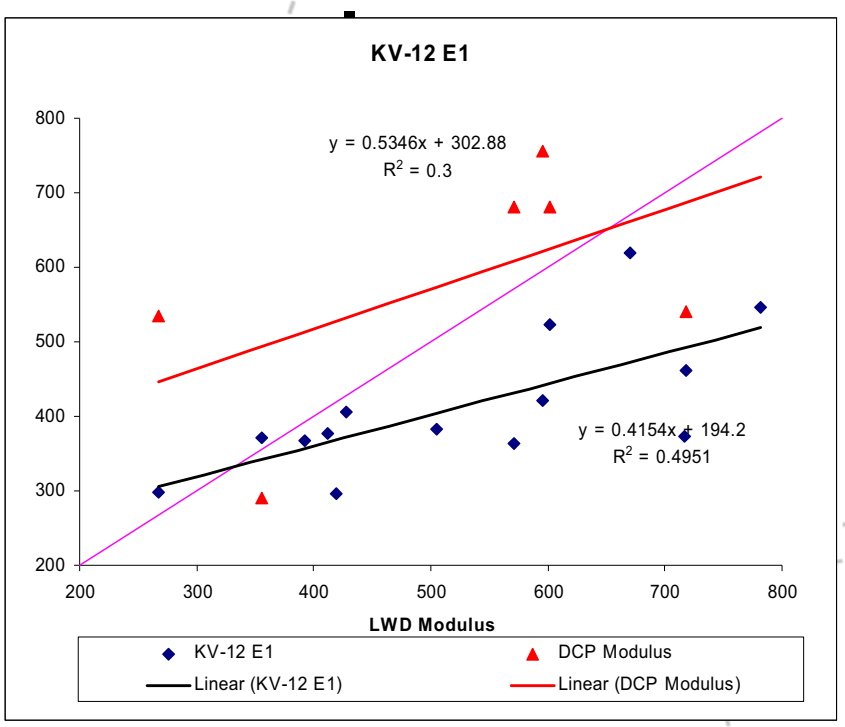


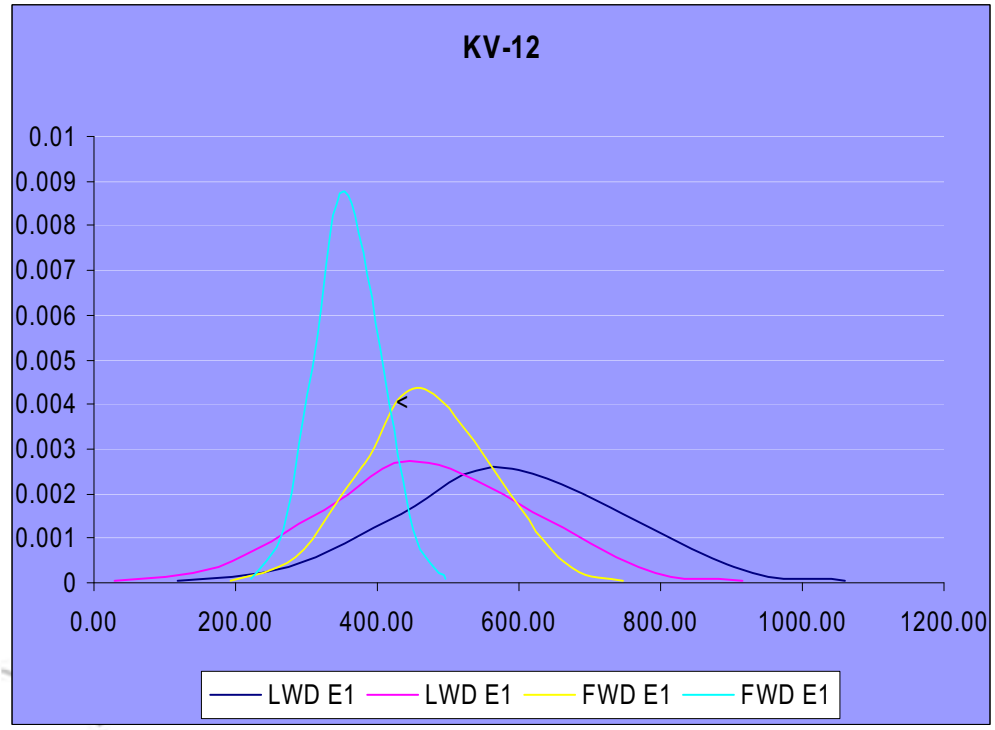


Comparison of results

1. Gravel Road KV-12



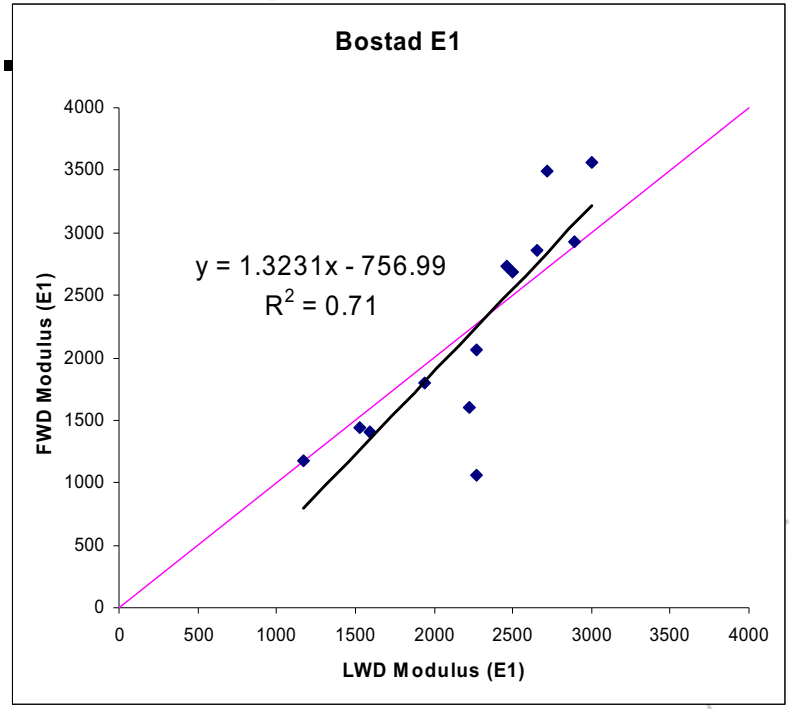


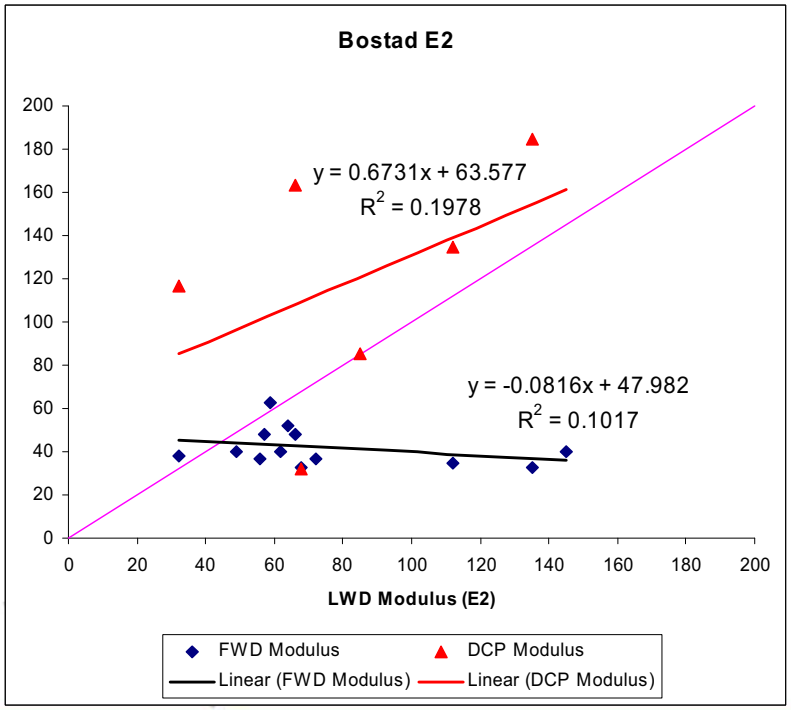


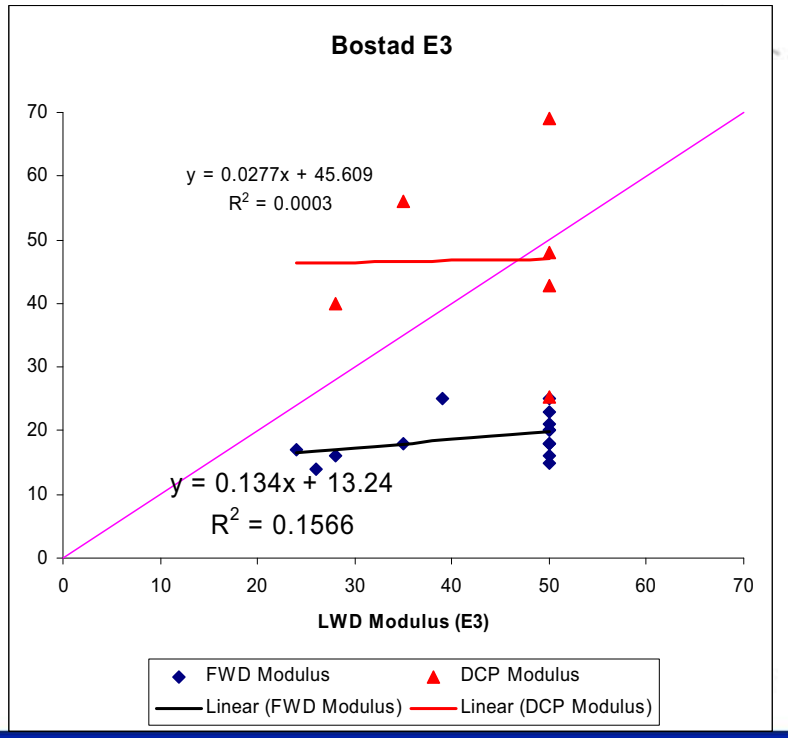
NTNU
Innovation and Creativity

Comparison of results

2. AC Road: FV 873 km 3-3.6 (Bostad)

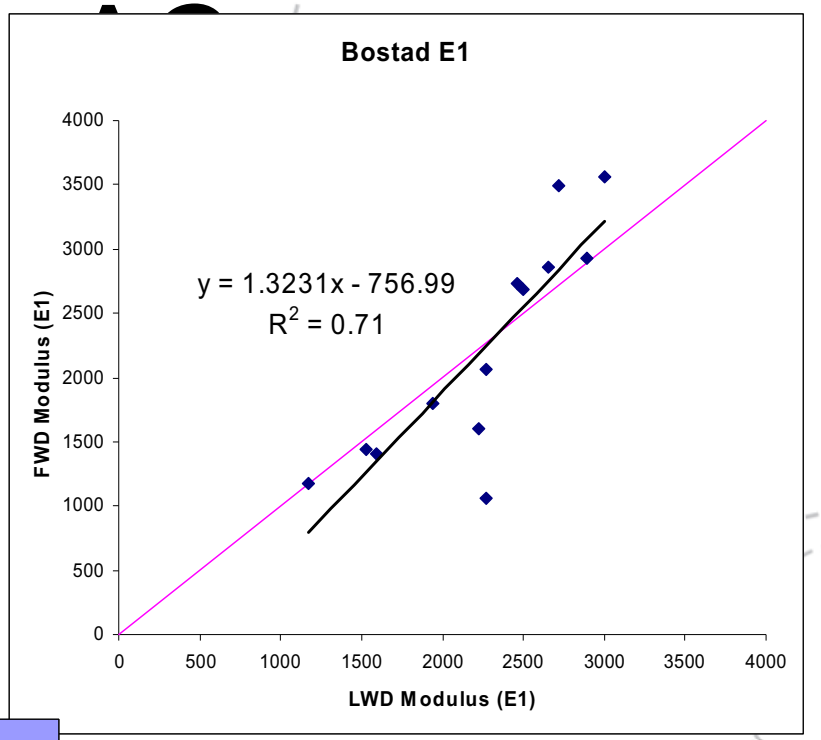


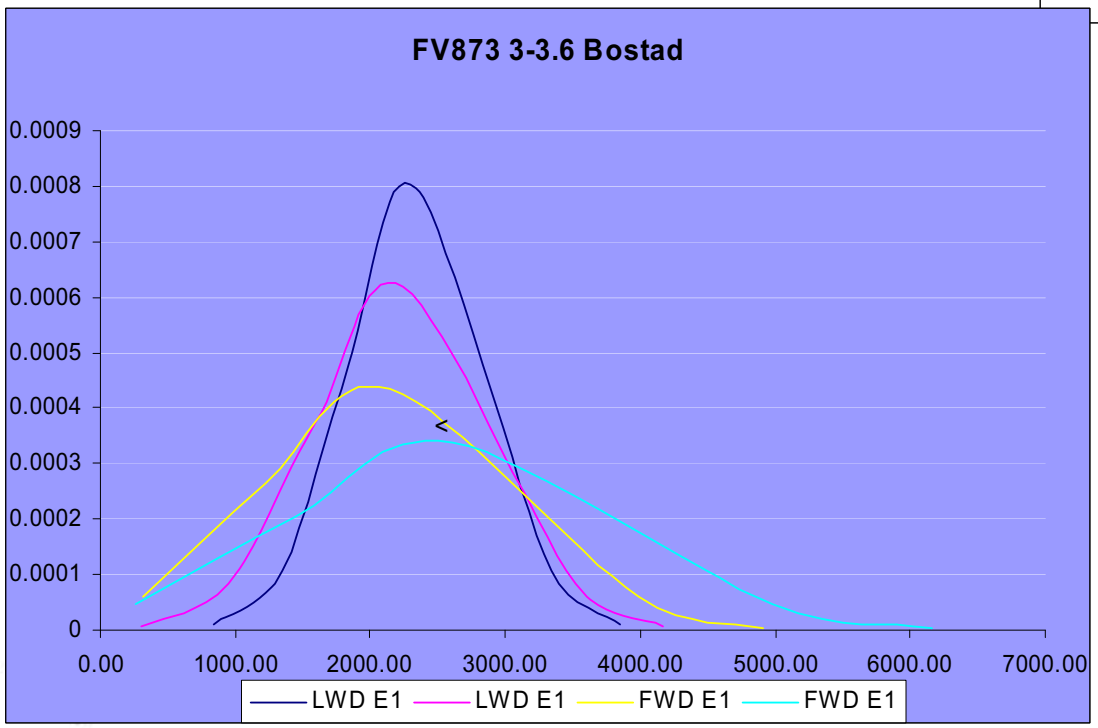




Comparison of results

2. AC Road: FV 873 km 3-3.6 (Bostad)

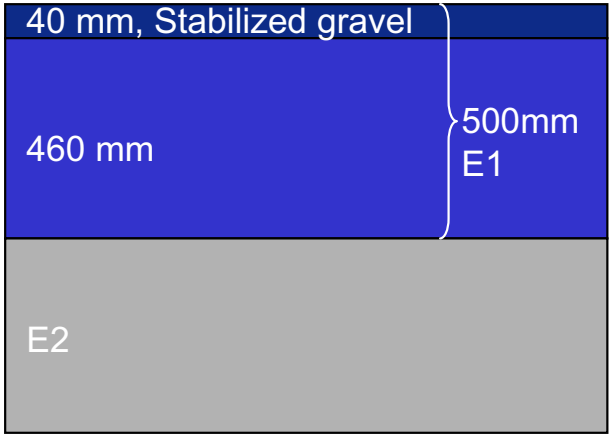


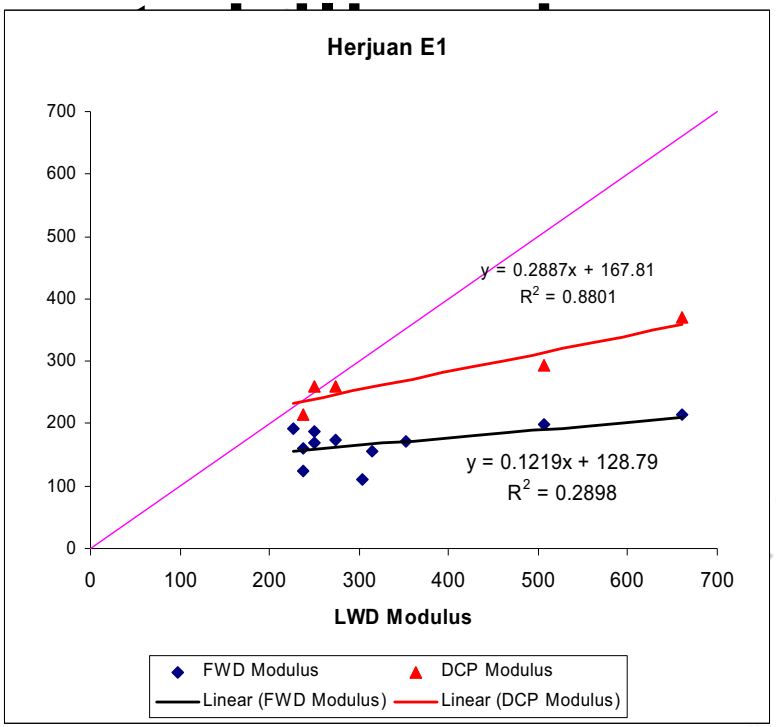


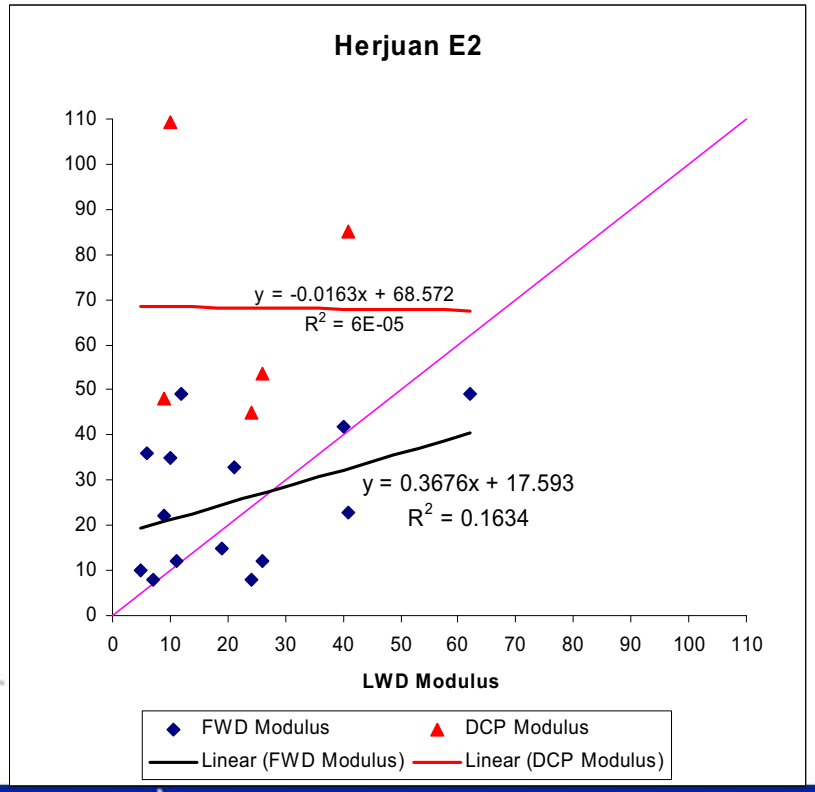
NTNU
Innovation and Creativity

Comparison of results

3. Stabilized Road: FV 873 km 7.1-7.7 (Herjuan)



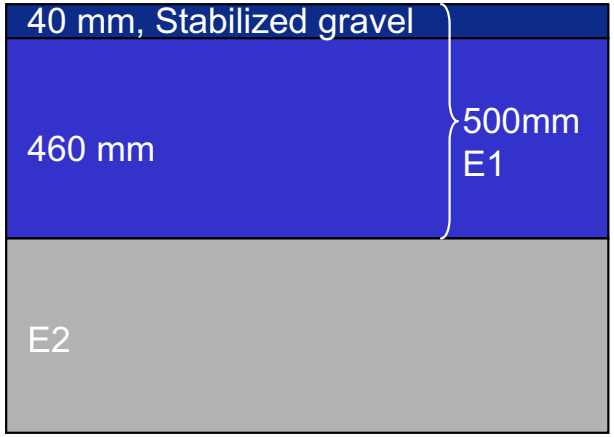


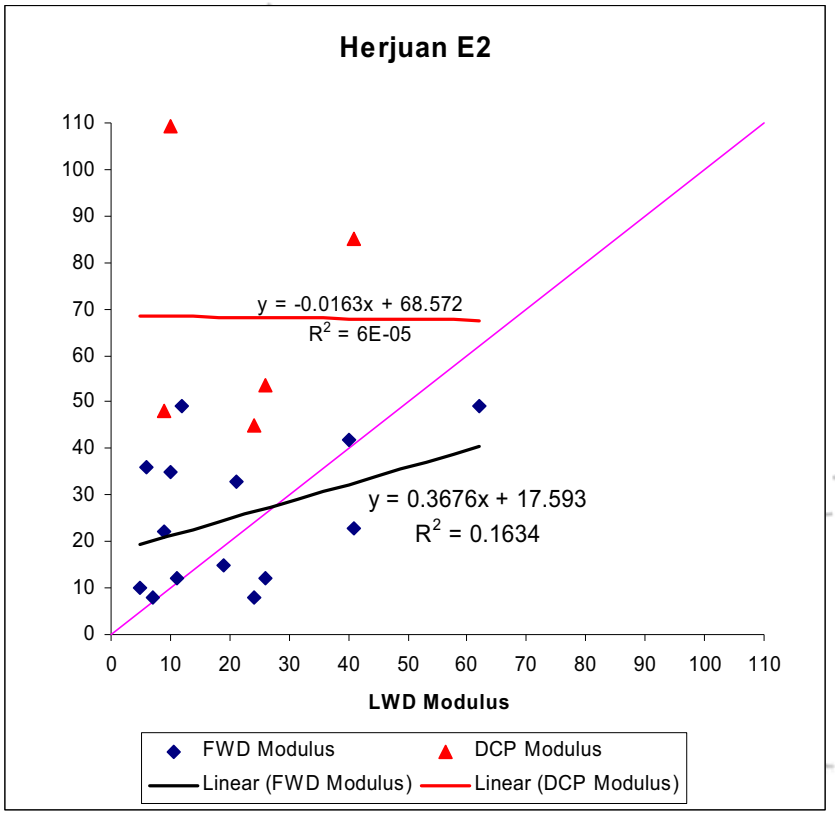


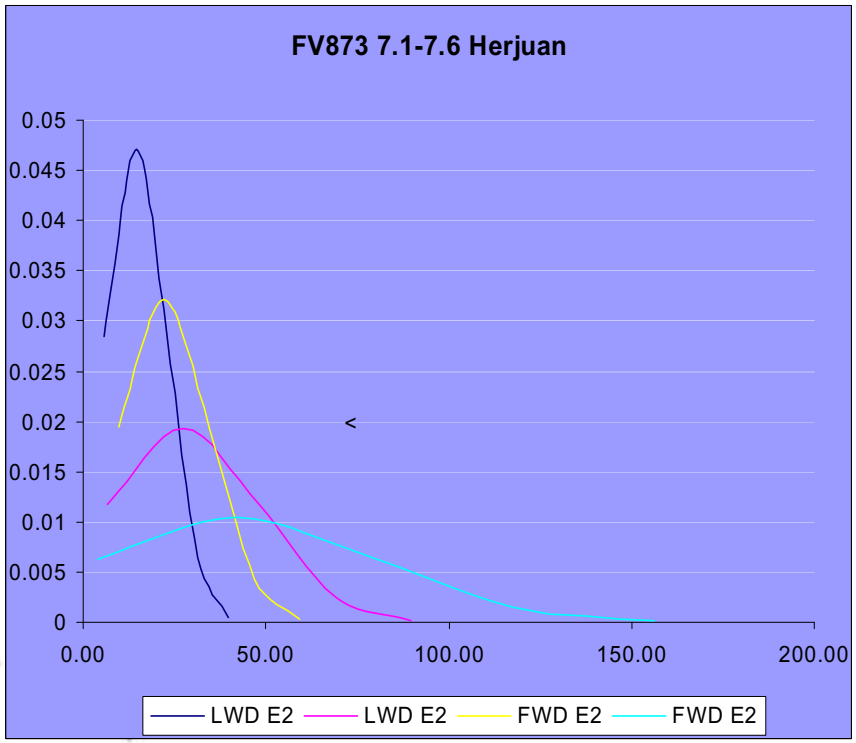
NTNU
Innovation and Creativity

Comparison of results

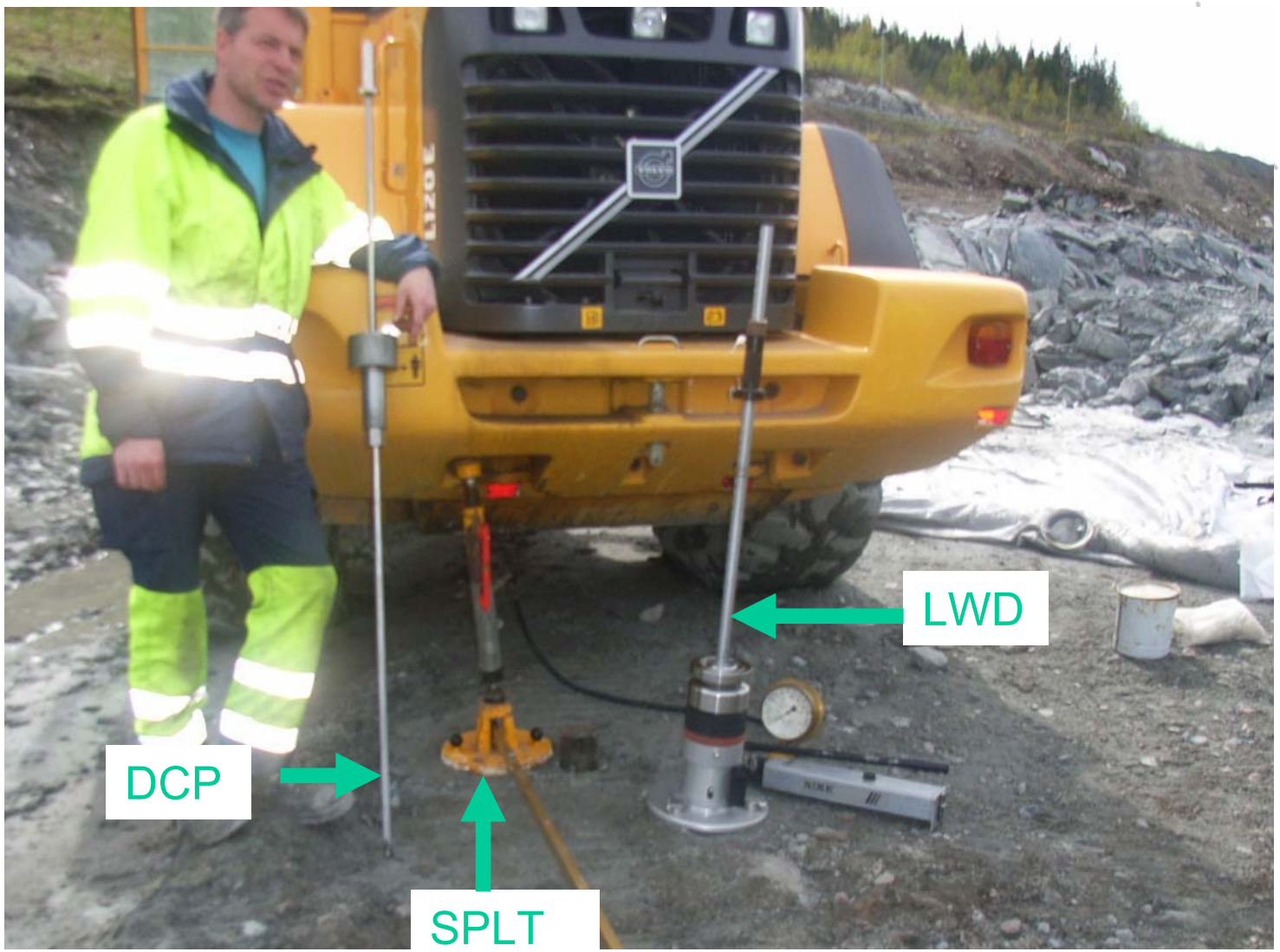
3. Stabilized Road: FV 873 km 7.1-7.7 (Herjuan)







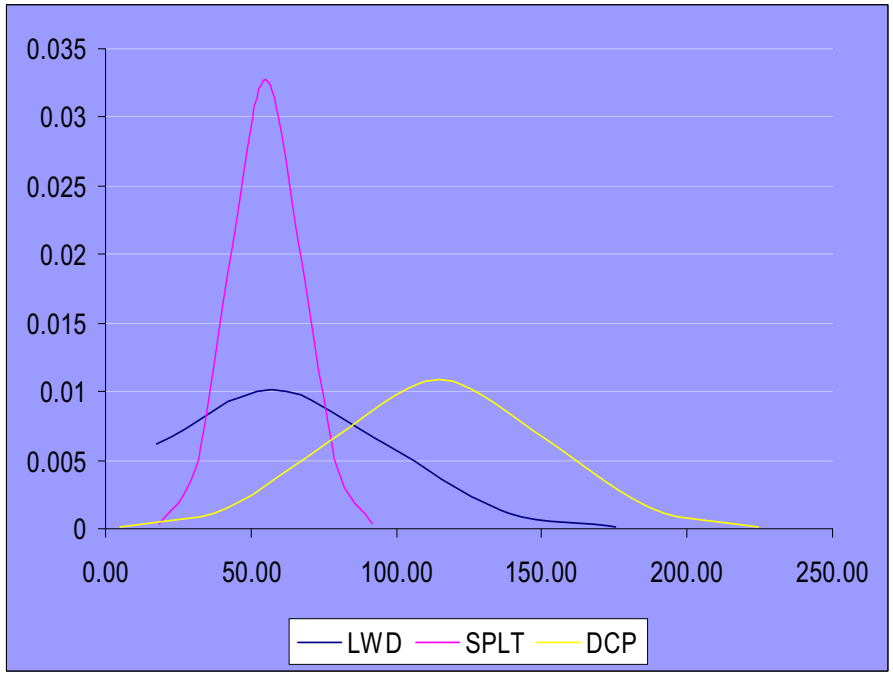
SPLT, DCP and LWD at E6 Steinkjer

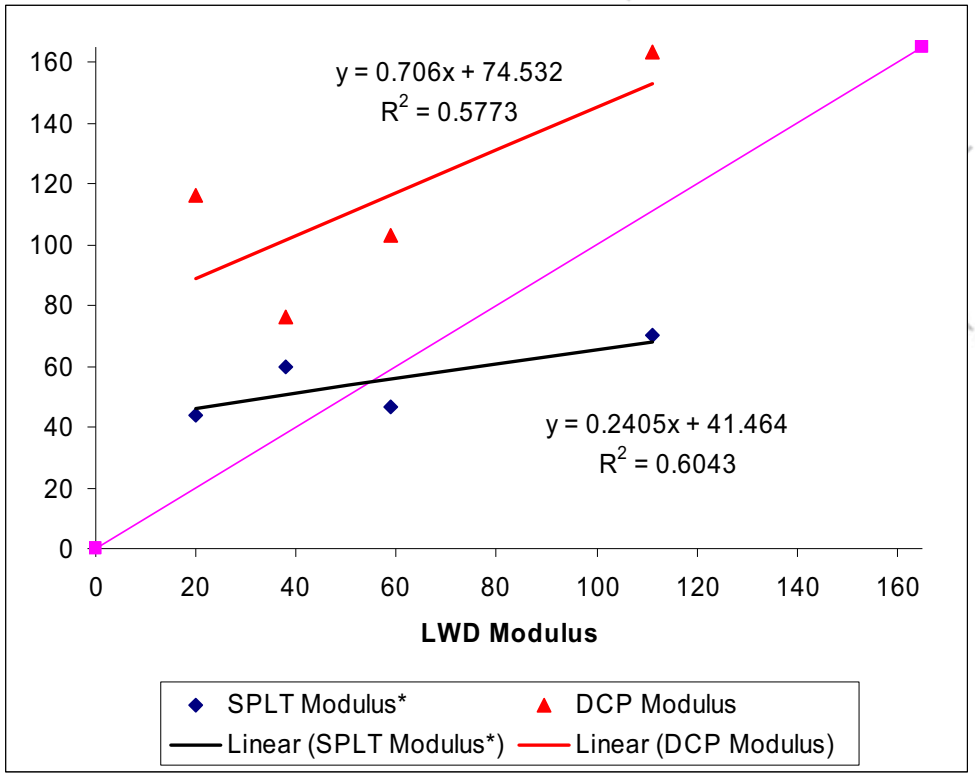


NTNU
Innovation and Creativity

Comparison of results -subgrade

Results of tests on ***clay subgrade*** at E6 construction site, Steinkjer, May 14 2007



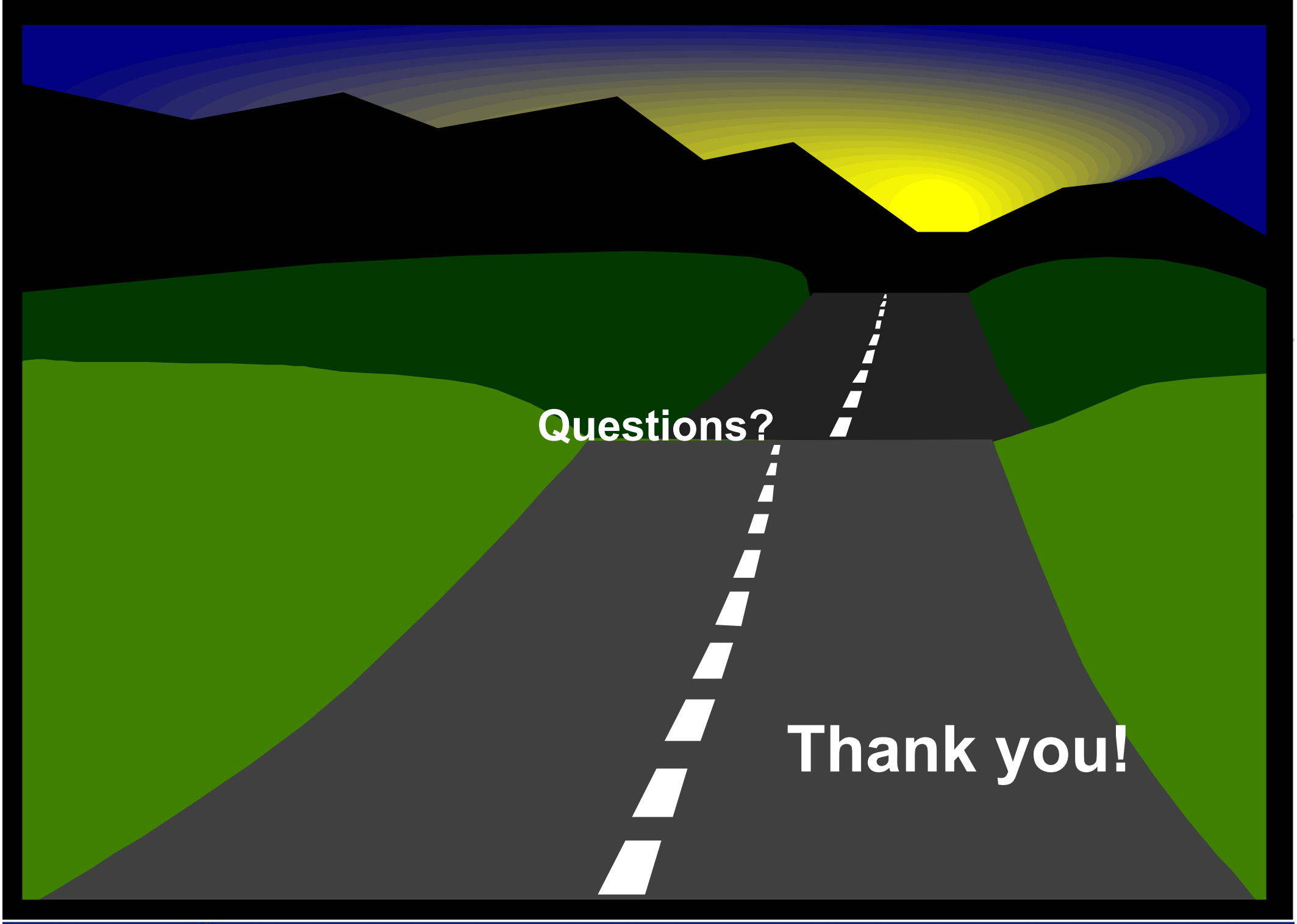


NTNU
Innovation and Creativity

Summary and conclusions

- Observations from the field testing
  - Stability problems encountered when testing with the smaller plate
- Preliminary conclusions:
  - With this exception, generally good practical experiences with the equipment
  - Surface modulus evaluation comply with overall visual condition
  - LWD modulus and SPLT stiffness seem to be comparable
  - Backcalculated results from LWDmod for layered structures using **one** defl. sensor are questionable
  - No correlation found between LWD moduli and DCP values
  - Probably, the load is too low to give a certain determination of subgrade stiffness when performing surface measurements for layered structures
  - There is a relatively wider scatter of LWD modulus values than for moduli backcalculated from FWD measurements
    - There are no significant connections found between the LWD and FWD moduli for subgrade materials, and a very poor link for subbase layers
  - Generally the LWD modulus values tend to be a bit higher than the FWD modulus values, in contradiction with other tests reported elsewhere. The explanation could be:
    - This test is conducted on in-service roads while the others are prototype tests in a laboratory.
    - LWDmod is more realistic up to two layer structures, for three or more layers the results are sensitive to the seed values used.
    - The obtained results can not be used for application due to a limited number of test points

NTNU
Innovation and Creativity


Questions?
Thank you!