Railways and critical speed

An empirical approach for evaluating safe and unsafe zones when railway tracks in Denmark cross soft ground

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Main assumptions

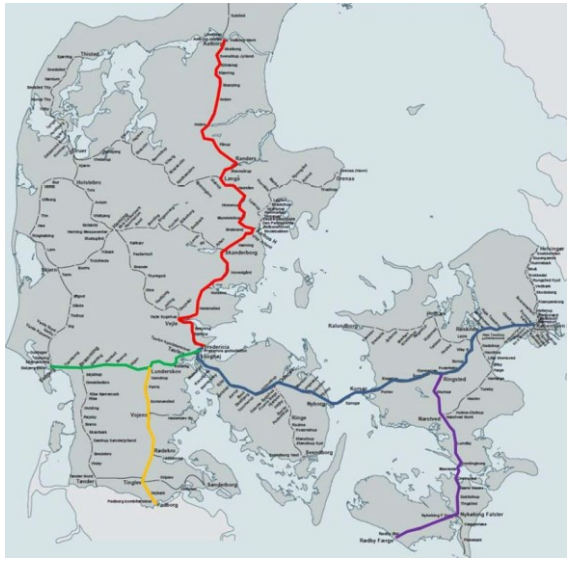
- Site-specific cases are based on geology and soil types as found in Denmark
- The work covers existing railways and speed upgrading up to 200km/h
- Work undertaken through contract with Banedanmark (Rail Net Denmark)
- Presented conclusions are under review (Banedanmark) and are not implemented at this stage

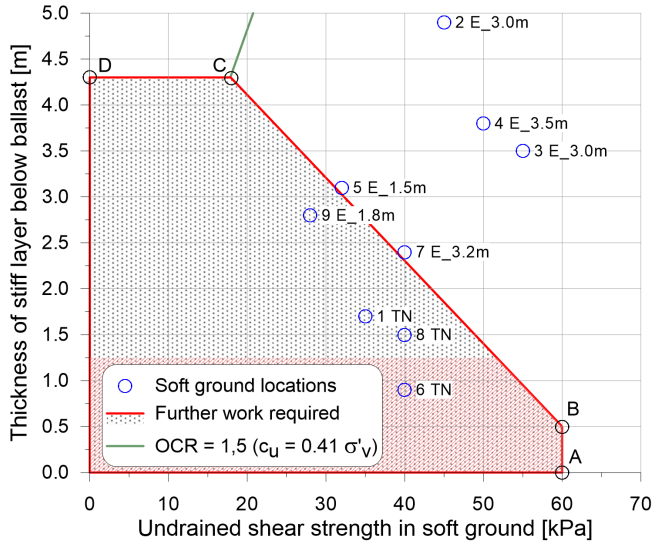
Overall approach taken in the work

1) Main railway line in Denmark surveyed by ETL (EBER Track Lab). Output is the estimated critical speed along the alignment.

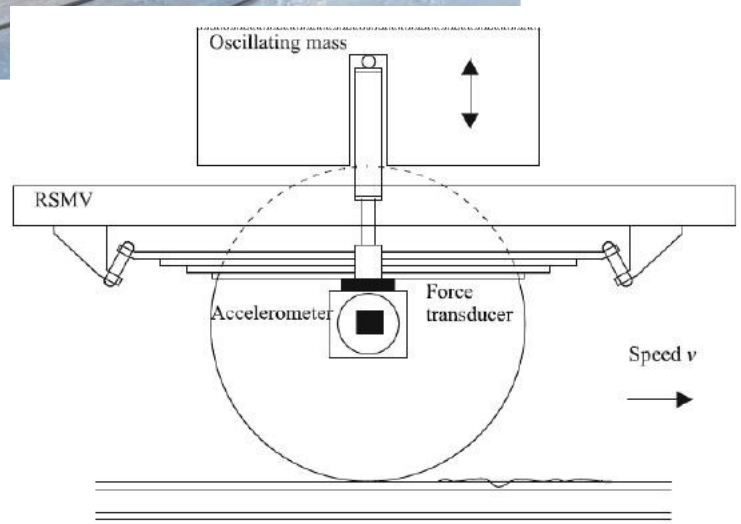
2) Nine “high quality” locations with soft ground are identified (boreholes next to railway line and between the rails, measuring speed of ELT at least 140km/h and undrained shear strength lower than 60kPa).

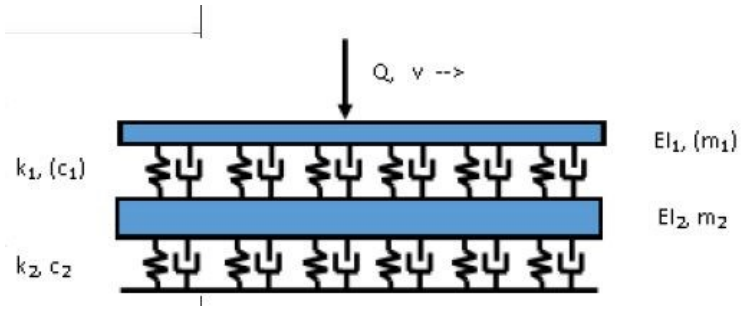
3) Issues 1) and 2) above are merged into one empirical plot guiding when identifying safe and unsafe zones for critical speed.





EBER Track Lab





Track speed of 200km/h
Critical speed is thus 300km/h
Measuring speed of 140km/h

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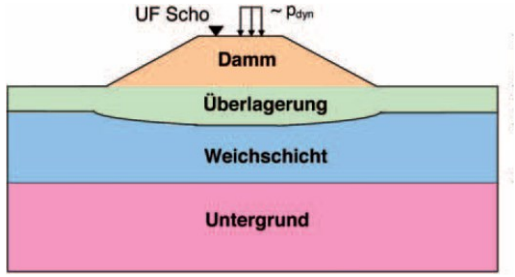
Evaluate spots of soft ground – two-layer model. Part 1 / 3

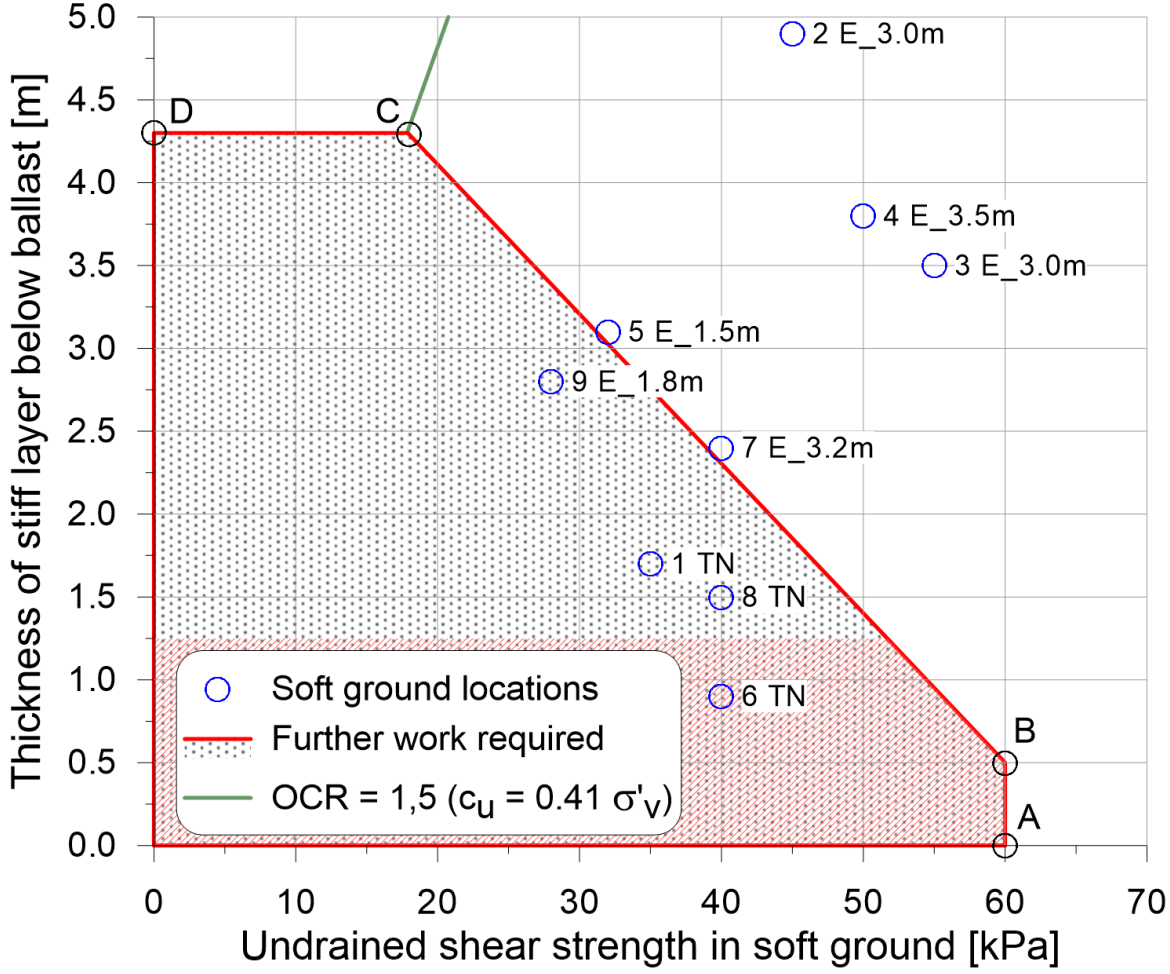
Two-layer model:

- Upper stiff layer below ballast
- Underlain by soft ground

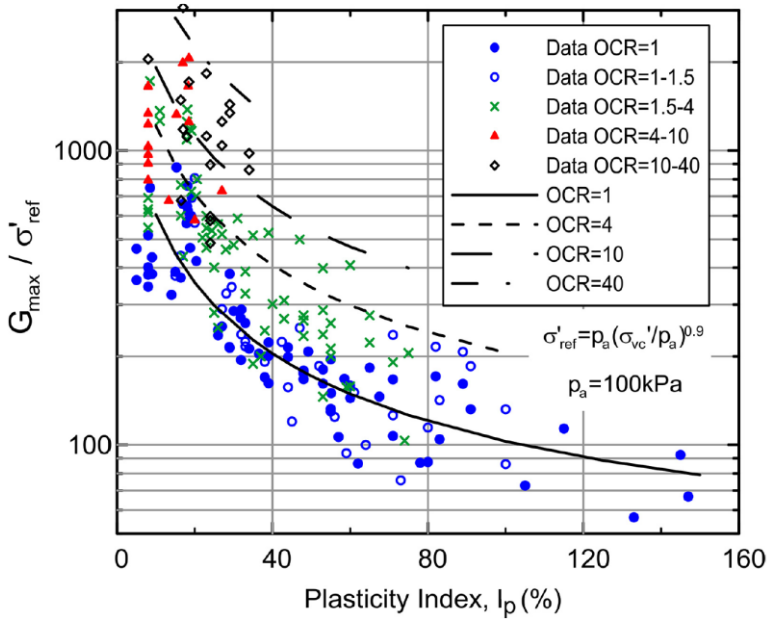


Soft ground:

- Post glacial or late glacial deposits
- Loss on ignition > 1%
- Undrained shear strength ≤ 60kPa
- Plasticity index ≥ 15%



Evaluate soft ground spots – two-layer model. Part 2 / 3



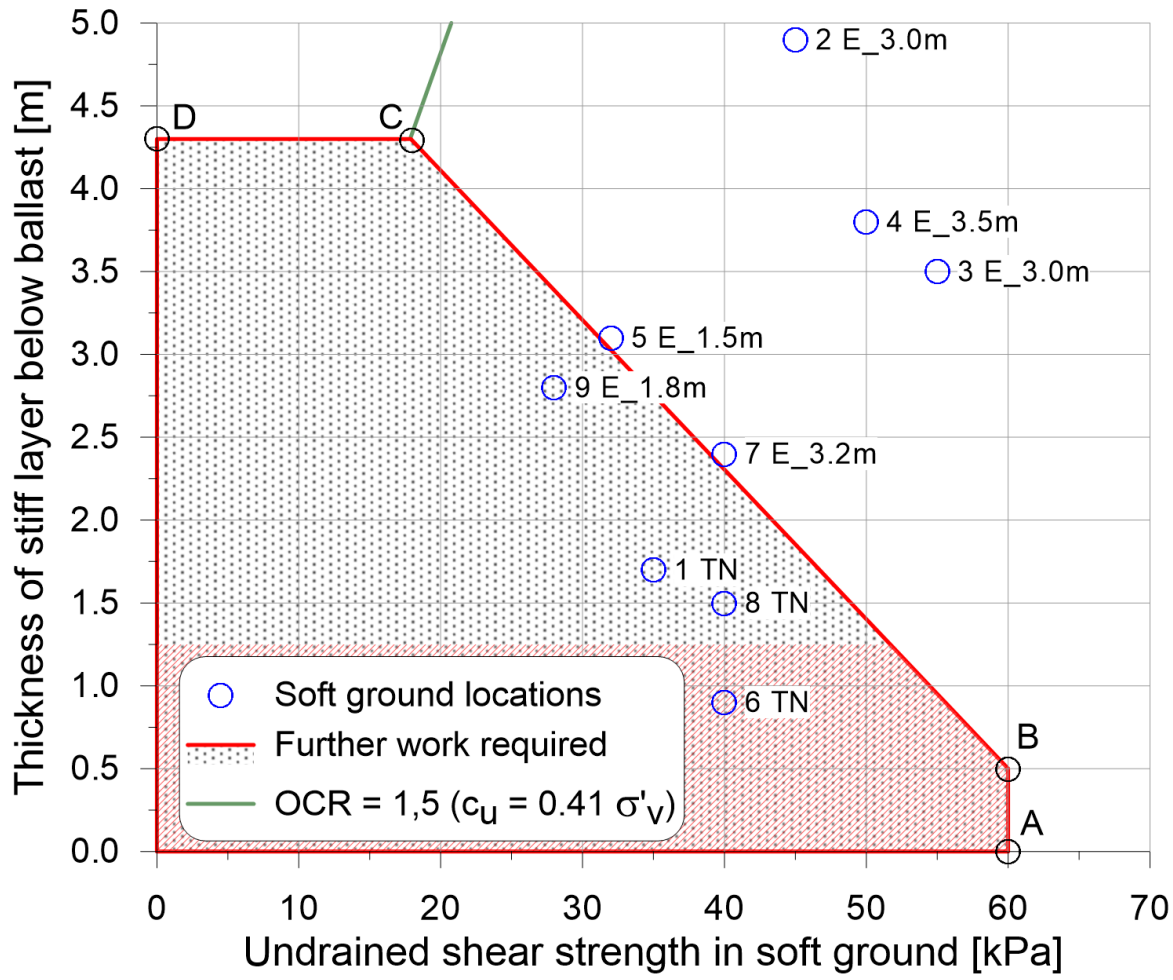
Ip = 100%

OCR from model

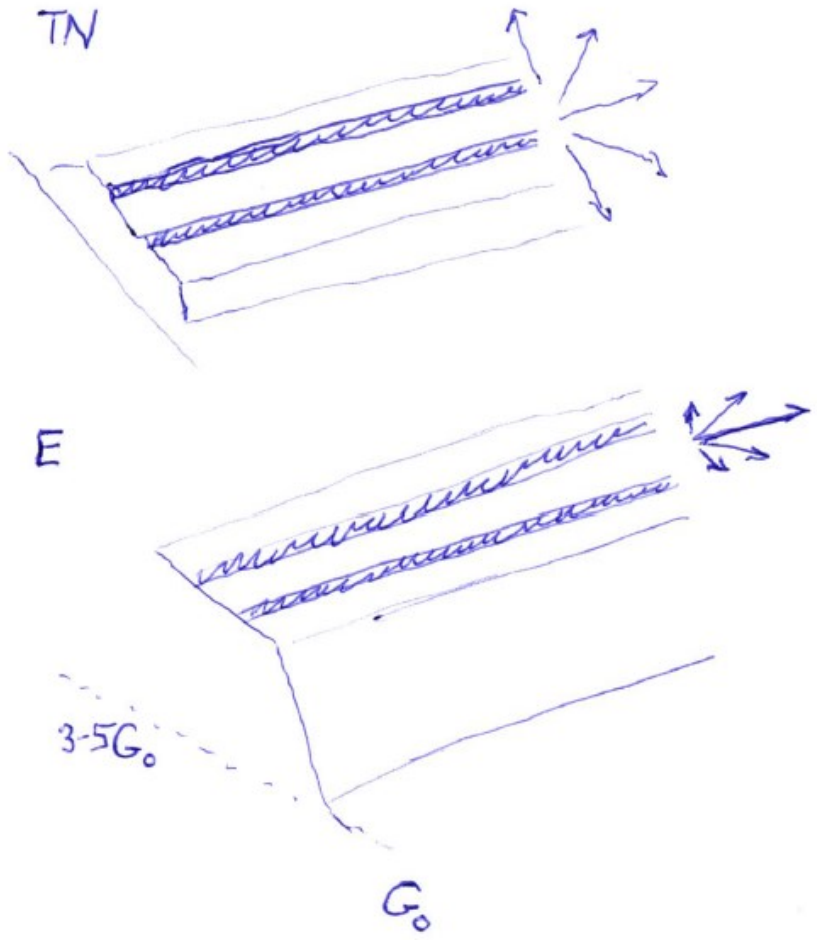
γ = 17kN/m^3 (ρ = 1 733kg/m^3)

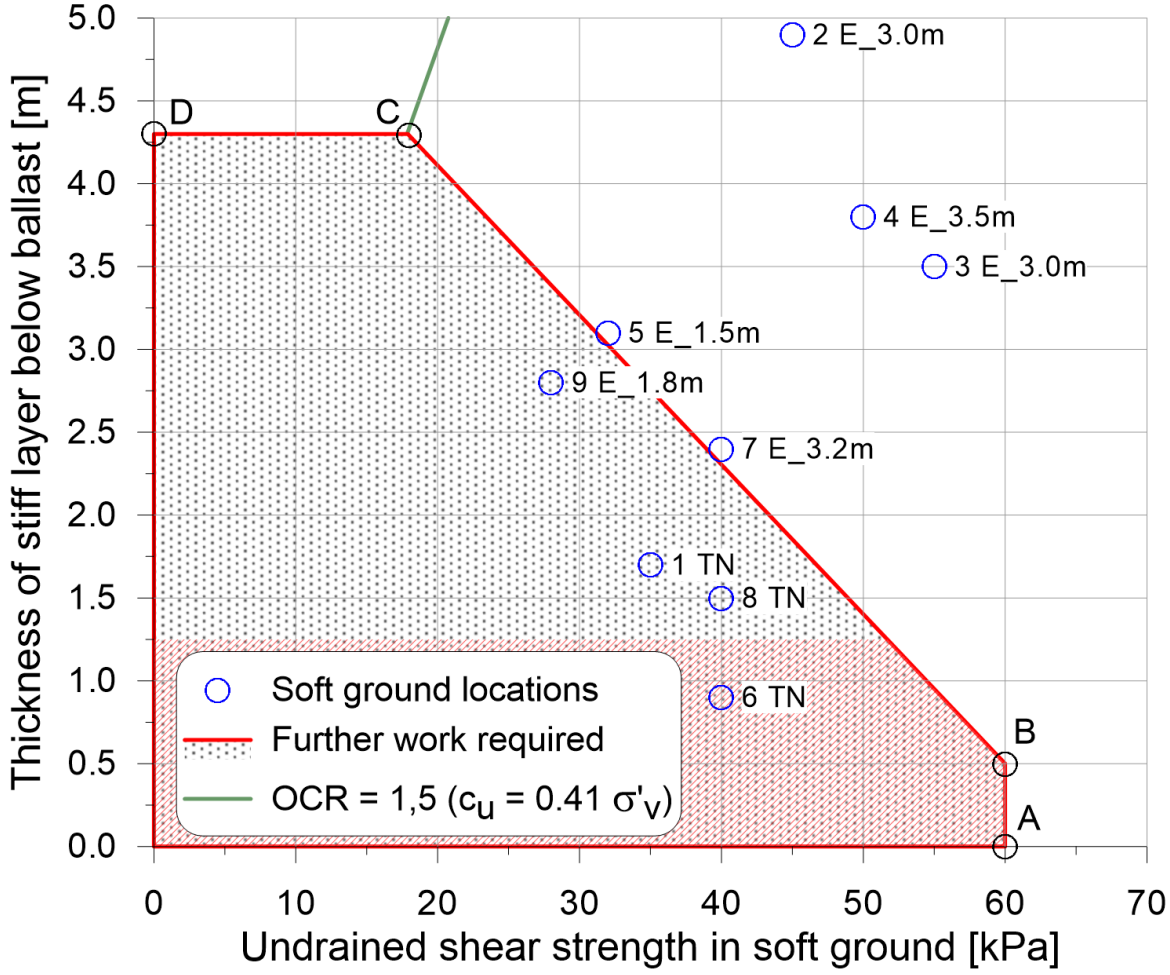
G_{max} = 10MPa

V_s ≈ 280km/h

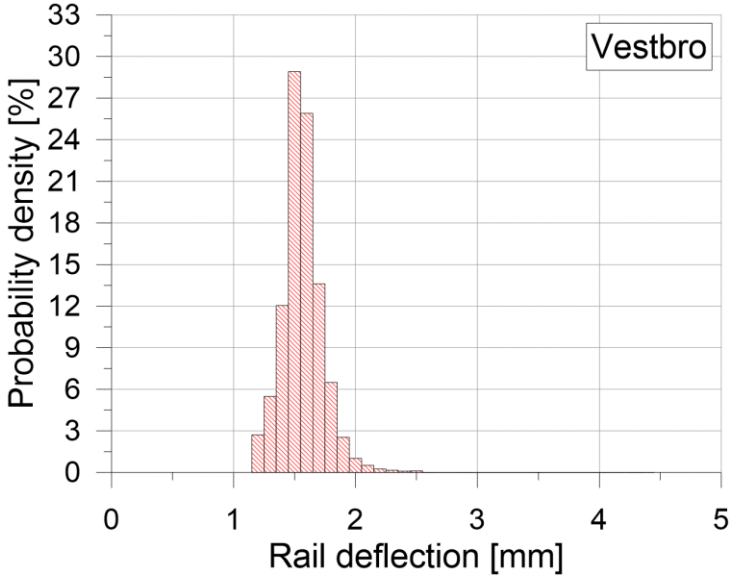


Evaluate soft ground spots – two-layer model. Part 3 / 3



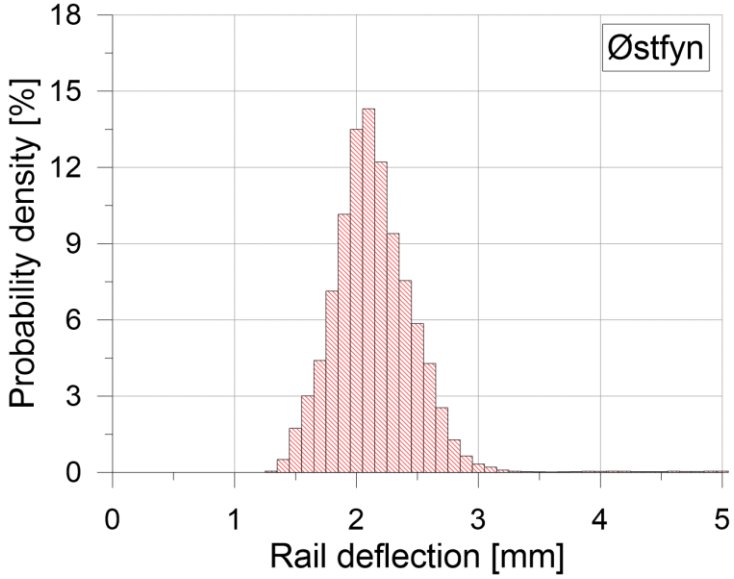


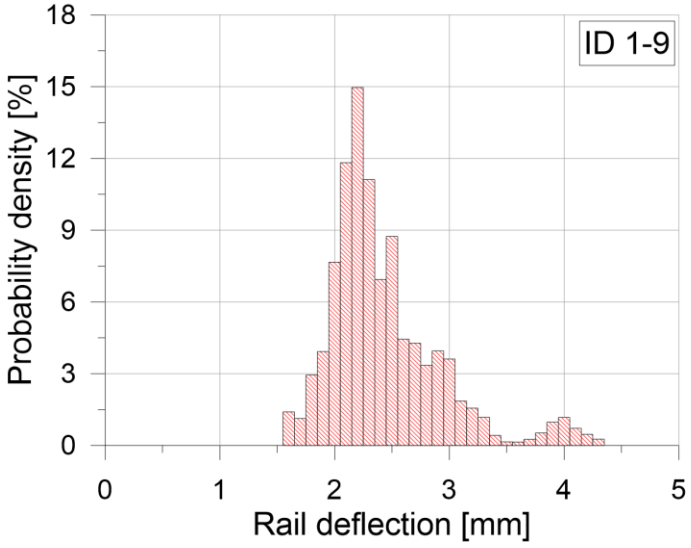
Measured rail deflections and soft ground

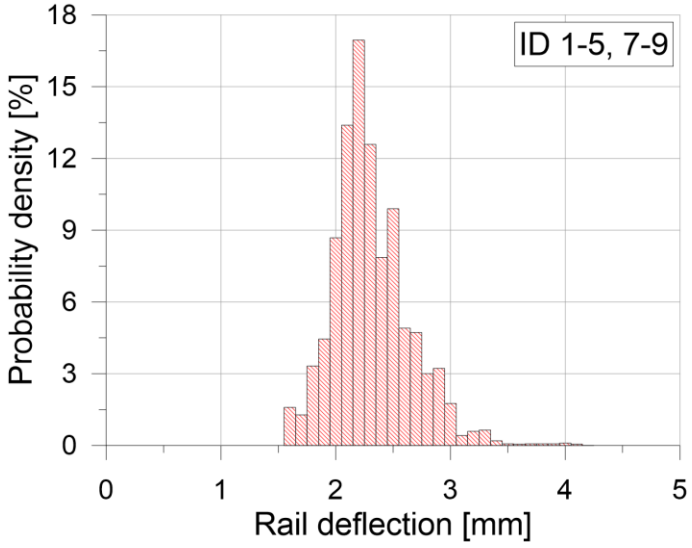


Rail, pad and sleeper: 0.5mm
Ballast: 1.0mm

Rail, pad, sleeper and ballast for traditional railway: 1.2mm







Soft ground spots from suggested model:

Doesn't deviate from "traditional distribu-tion".

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Conclusions

The suggested model is under review.

The x-axis (c_u) is easy to measure by simple means and is assumed to correlate reasonably well with $G_{max.}$

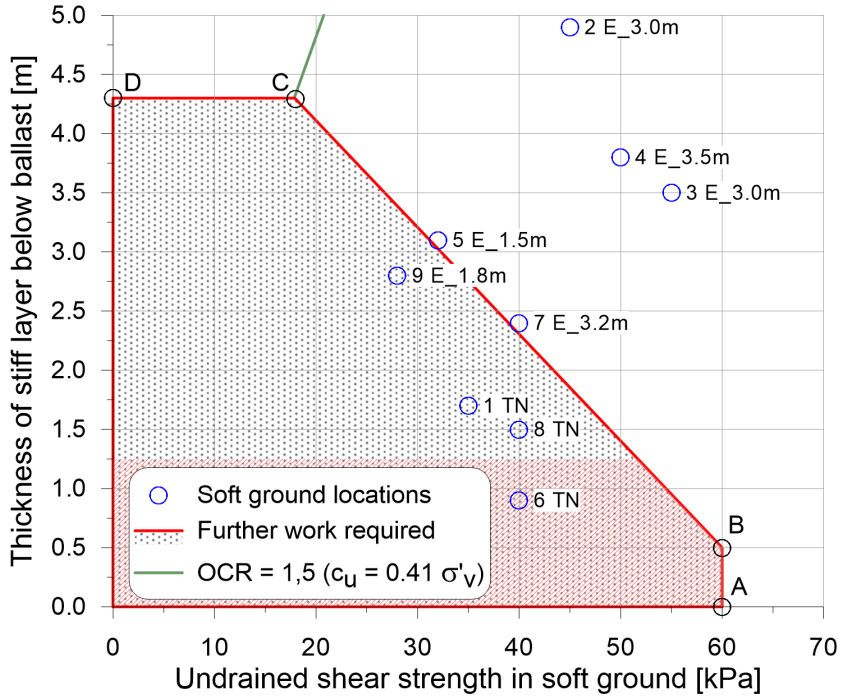
Critical speed aspects should not be critical outside shaded area.

A more detailed evaluation is needed inside the shaded area. Consider activities on the railway bringing the location to safe zone.

Railways placed on the existing terrain directly are likely less challenged by critical speed issues compared to railways on embankments.

Stiff layer to be at least ~1.2m thick.

Rail deflections exceeding ~3.0mm: Consider maintenance costs.



References

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nmGeo-2021-05, 14/10 2022 (Rev. C)