



**Norwegian Public Roads
Administration**

ROBUS  Road Barrier
Upgrade
of Standards

ROBUST Computational Mechanics

Conclusions and recommendations

Workshop in Brussels May 30th 2006

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- **All the results from this Robust project will be available at a FTP-site from NPRA. The address on this ftp-site will be presented on the ERF site (link)**



Findings

- **Sampling and computing of data:**
 - Acceleration data sampled ≥ 100 kHz
 - Filtering - CFC60 previous to TRAP w/CFC 180
- **The barrier:**
 - Restrained ends of soft guardrails possibly all guardrails
 - The bolts modelled by spot welds / deformable beams
 - The contact definition influence obvious the result
- **The vehicle:**
 - 900 kg car model - GeoMetro, is comparable to cars used in full scale test
 - Seat improve the stiffness of the floor
 - Spinning wheel, suspension and the steering improved the vehicle trajectory and the behaviour



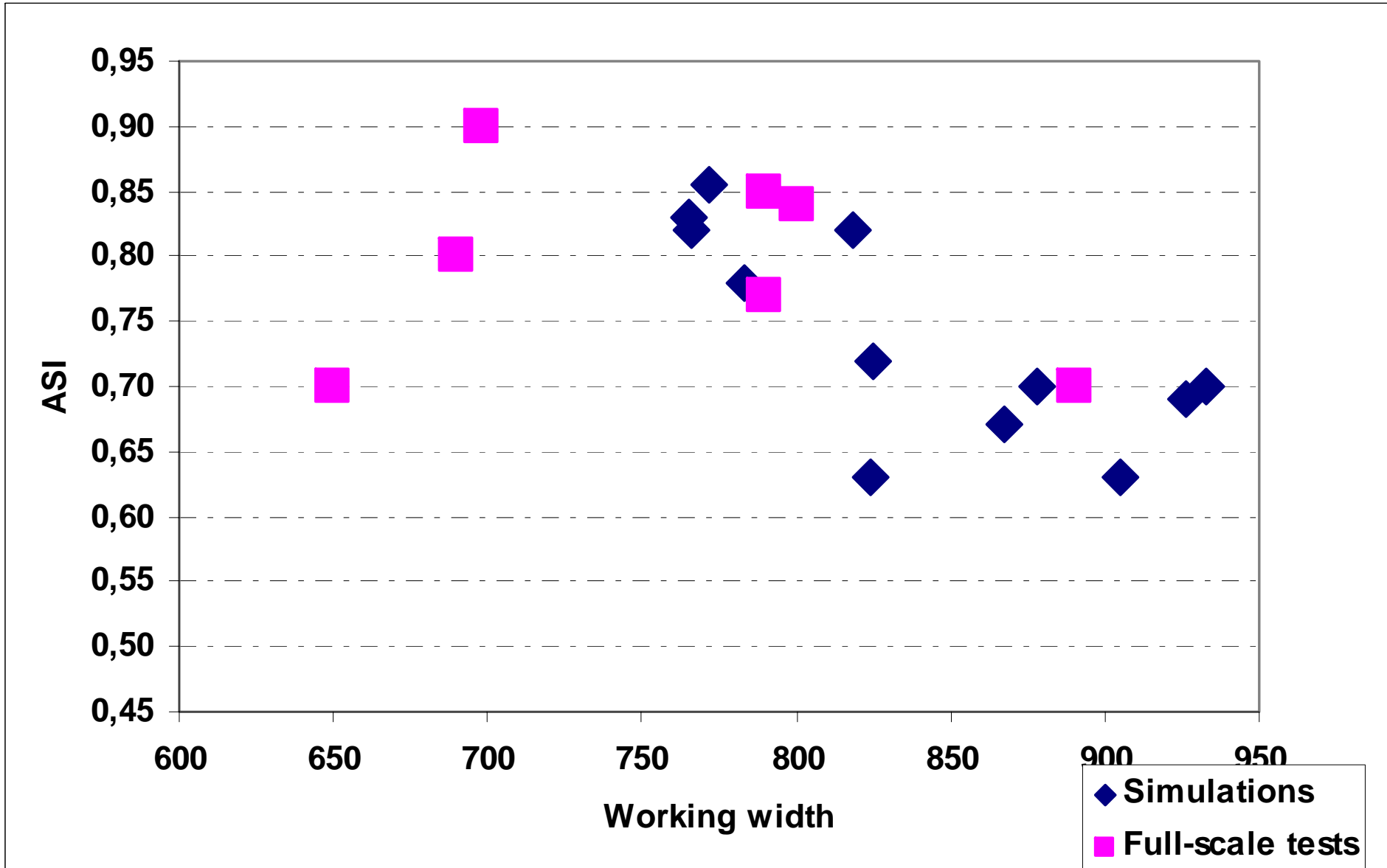
Findings

- **The friction coefficient we found in this project**
- **steel barrier (barrier-vehicle) $\mu = 0-0,1$**
 - **concrete barrier (barrier-vehicle) $\mu = 0,1-0,3$**
 - **sliding barriers (barrier-ground) $\mu = 0,6-0,7$**

- **And I repeat**
All simulation was blind prediction



Barrier B1 – N2



Influence on ground condition

➤ **The condition of the ground influence the performance very much**

- Working width - CM $765 - 935 = 160\text{mm}$
- Working width - FST $650 - 890 = 240\text{ mm}$



Parametric study – material properties

- **The study is an indication**
 - Too few tests is carried out to make a conclusion
- **ASI, THIV and Dynamic deflection varies**
 - Material property as E-module, Yield stress (~0 - 75%)
 - Material dimension as thickness (~0 – 1,3) based on % change
- **The material properties should had an upper and a lower limit**
 - Samples of the test items
 - One do not know what is placed on the road
- **In CM we use representative values**
 - not nominal values
- **A more thoroughly investigating would have been performed if we had more time and funding**



Consequence of variation in thickness

- **Thickness of 3 mm guardrail can vary $\pm 0,23$ mm according to EuroCode**

According to the parameter study

- **Variation of D when the thickness varies within requirement is aprox. 120 mm (717 – 593)**
- **The parameter study gives only an indication**



Recommendation

➤ Criteria and procedures for validation of CM

- The scatter of full scale tests must be taken into account for the validation of CM
- Results from Robust can be used as Benchmarks
- The validation criteria have to be based on checking procedure of the CM and compared to Benchmarks from this ROBUST
- That require a comprehensive documentation of the CM
- A validation body should approve the simulation

➤ Recommendation for further work

- This research have concentrated on a rigid concrete barrier an a soft steel barrier – two extremity points
- More investigations have to be carried out for other barrier types
- Modelling and performance of the barrier as failure criteria
- Improving the vehicle models, additional vehicle model types
- And more

Evaluation

- **ROBUST gives an extensive documentation of CM as a credible tool**
 - **Based on several FST and CM with the same test setup**
- **CM can be used for as well**
 - **Calculation of safety level of the safety barrier**
 - **Will the safety barrier behave as predicted?**
 - **Calculation of probability of failure, risk analyses, reliability analyses**

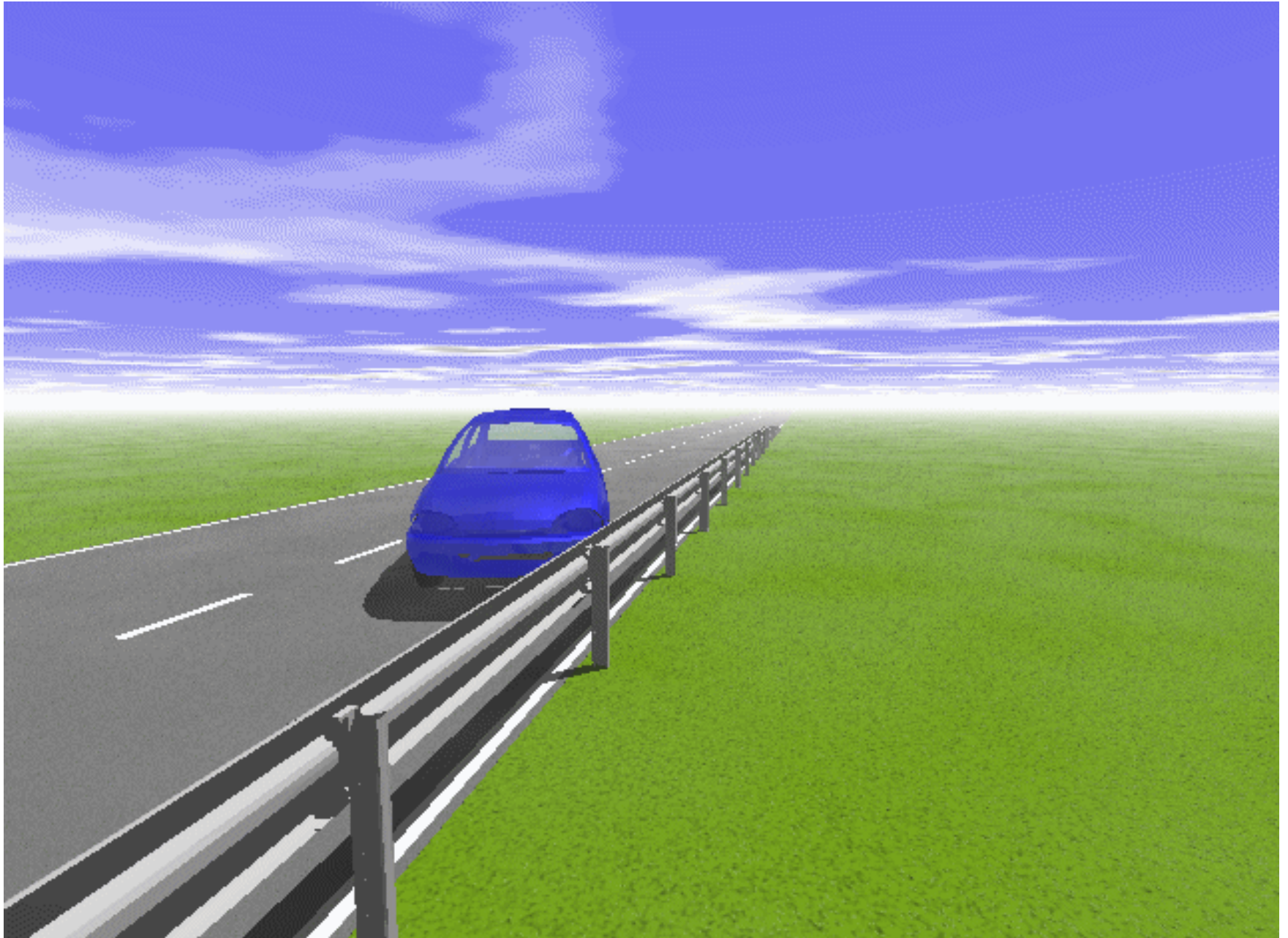
Evaluation

- **ROBUST gives an extensive documentation of CM as a credible tool**
- **I personally wonder sometimes; One can design houses, bridges, aeroplane by using FE methods,
but a safety barrier have to be FST**
- **Robust results may be a basis for improvement of safety products**
- **Procedures need to be established before CM can be in operation – work in progress by CME**

Conclusion

- **CM have a very good comparison to the FST**
 - **The severity indices and the deflection is within the scatter from full scale tests**
 - **Work is already been done and will continue to reduce the scatter for CM**
- **Procedure and restriction for using CM today**
 - **Documentation of the operator and institution have to be established**
 - **Validation criteria for CM have to be established.**
 - **The results from the ROBUST project could be used as benchmark test for some groups of safety barrier.**
 - **More groups of barrier have to be established for benchmark test.**
 - **CM with restriction could be use as an complimentary test to full scale test**

Robust. GRD1-2002-70021



Thank you for your kind attention



Directorate of Public Roads

ROBUST of Standards