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Research on Dynamic Soil Compaction – Development Tools for Innovative Systems

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ECOmpact

MOTIVATION

Soil Improvement with reduced requirement of additional material and constructions is getting more and more important in times of increasing scarcity of resources. Recent systems may be distinguished relating to the way of excitation (periodically or transient), to the location of impact (surface or in the depth) such as to the achievable depth of influence [1]. With a better understanding of compacting mechanisms possibilities of improving equipment systems and advantages in the execution of construction work with regard to energy consumption, depth of influence, evenness and quality of compaction such as efficient working methods can be derived.

Since 2012 a group of civil and mechanical engineers of the HTWK Leipzig in Germany supported by national and international academic and industry partners is working on this topic in the project ECOmpact financed by the German Federal Ministry of Education and Research. A main focus was on better understanding of systems like Rapid Impact Compactor (RIC), BOMAG® rollers with a polygon shape of the drum and Impact Roller.

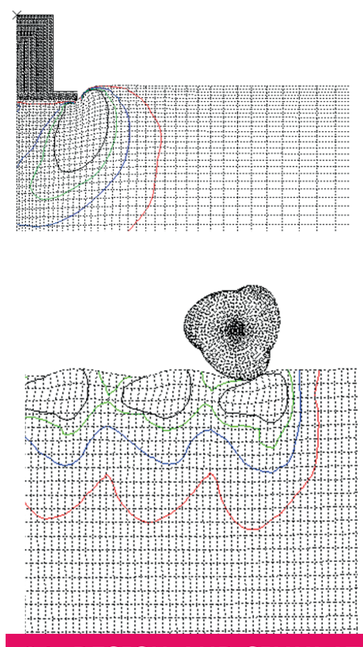
METHODS AND TOOLS

Numerical modeling and simulations are absolutely necessary for essential research and development regarding heavy equipment. Modeling of compactors with high energy inputs of individual pulses and high frequency effects of dynamically excited systems provides a particular challenge to material laws, element deformations and solution algorithms.

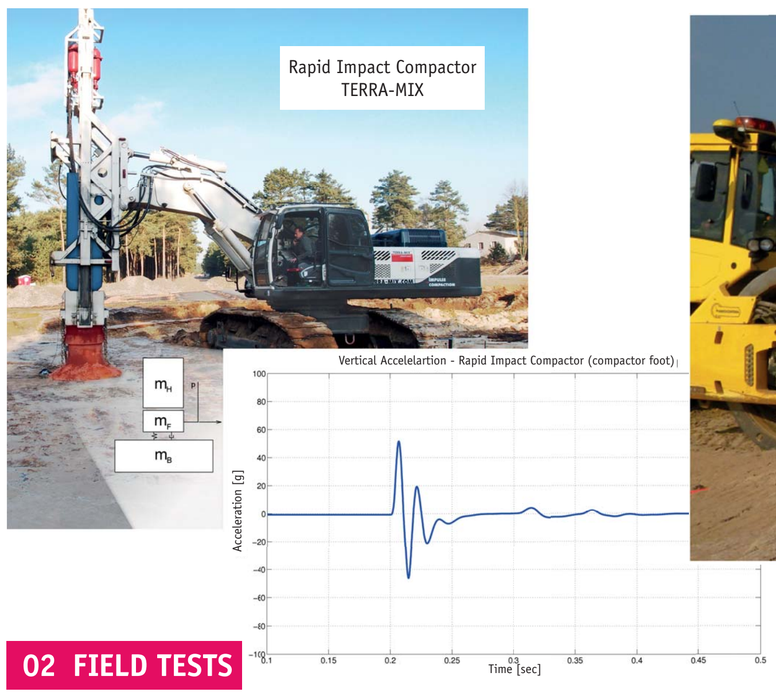
In ABAQUS application limits of the Finite Element Method with using Lagrange Elements can be extended for calculating large deformations by approaches like Coupled Eulerian Lagrange (CEL) or Arbitrary Lagrangian Eulerian (ALE) [2]. For our simulations we used the elastoplastic constitutive soil law according to Drucker-Prager modified with a hydrostatic cap. In consideration of constraints extensive pre studies and sensitivity studies were conducted in the model development, among others performed to mesh fineness, damping and contact description. The numerical models could also be verified and validated in extensive studies with data from centrifuge tests as well as with measured data from real tests of the systems DYNIV, Rapid Impact Compactor, Impact Roller and dynamically excited rollers.

To evaluate the selected model approaches and results, **measurements on heavy equipment in real scale** are required. To evaluate the depth of influence of heavy equipment Cone Penetration Tests, layer by layer excavation and laboratory and field testing are practiced [4]. High resolution methods with use of accelerometers can allow accurate measurements during compaction and evaluating the behavior of soil and of device. In ECOMPACT this was realized successfully on the heavy polygon roller (BOMAG BW 332 DI) and on the Rapid Impact Compactor (TERRA-MIX). Additionally investigations have been done using precise soil mechanic measurements with the TROXLER probe model 3440 (isotope probe) and the PANDA probe (lightweight dynamic penetrometer supplemented with variable driving energy).

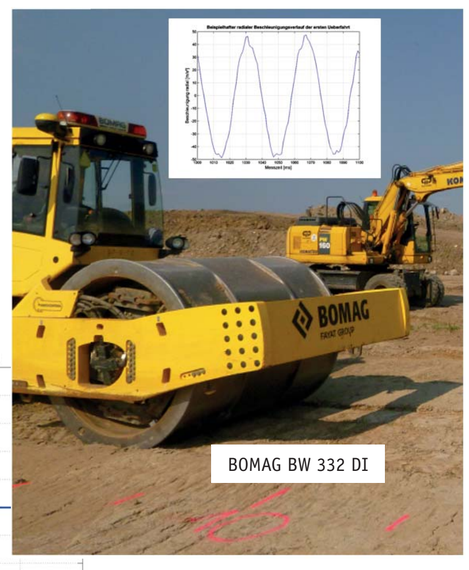
In addition, for the precise validation of the numerical models approaches for **small scaled testing** were examined, evaluated and further developed. As an alternative to experimental setups with disturbing measuring sensors in the ground (eg accelerometers, pressure sensors), non-contact measuring methods such as PIV method (Particle Image Velocimetry) can provide accurate results. The PIV method is particularly used in fluid mechanics and in long-term studies, but can also be used to assess the displacement field of dynamic soil compaction by a pairwise comparison of discrete image areas [3]. Our test station offers by using a 2 m wide sample holder and a high speed camera (1,000 fps at a resolution of 1,280 x 1,024), extensive possibilities and very good correlations for highly dynamic measurements on stationary and moving small scaled compactor models.

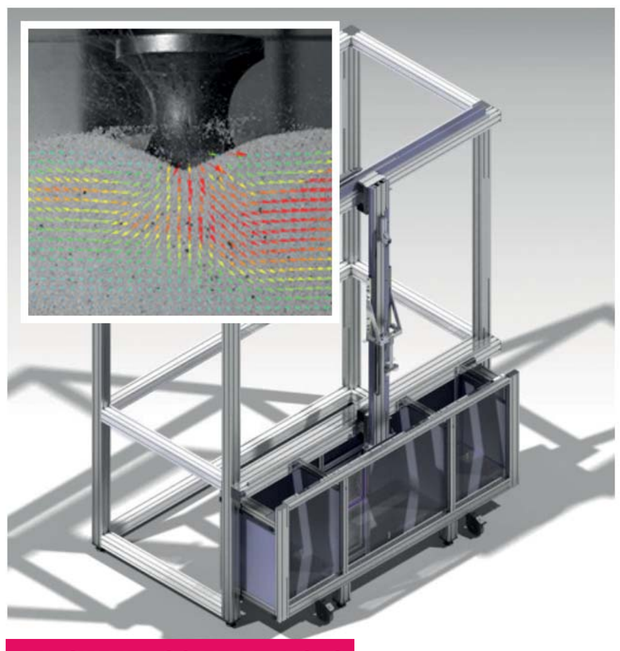


01 DESIGN AND SIMULATION



02 FIELD TESTS





03 SMALL SCALED TESTS

SUMMARY AND OUTLOOK

Within the project **ECOmpact** so far **three** main fields of research to the scientific study of dynamic soil compaction could be developed and improved in an interactive process with use of synergy potentials for proofing and validation.

For **numerical modeling** ABAQUS with implicit and explicit solver was used during the whole project for design and dynamic simulations of high-quality compactors. For high energy inputs and large deformations numerical couplings such as the ALE method could be used combined with the implementation of material laws which are appropriate for compaction. In **tests with real devices**, such as the 32 ton Polygon Roller (BW 332 DEEP IMPACT) and the Rapid Impact Compactor, next to soil-mechanical also device side measurements were utilized and adapted. Non-contact measuring with the PIV method have been adapted and developed for high-speed measurements of soil compaction and of interactions between the **small scaled compactor models** and the ground.

Thus, it was possible to lay the foundations for proofing and linking approaches of optimization, further development and new development of innovative heavy compaction equipment. Focuses of further activities are on a continuation and deepening of the developed interactive methods and the addition of a larger test station for the investigation of hand-leaded compactors and falling weights up to 100 kg by using the PIV method. The measurements on the real equipment will be intensified and extended by tests on our own 7 ton modern single drum roller.

Sources

[1] Adam, D. (2013): *Aktuelle Entwicklungen im Erd- und Grundbau für Straßen und Eisenbahnen.* In: Bauakademie Sachsen (Hg.): 9. Erdbaufachtagung. Aktuelle Entwicklungen in der Geotechnik. Leipzig, 31.01.-01.02.2013, S. 13–77.

[2] Aubram, D. (2013): *An Arbitrary Lagrangian-Eulerian Method for Penetration into Sand at Finite Deformation.* Dissertation. Technische Universität, Berlin. Grundbauinstitut.

[3] Nazhat, Y. (2013): *Behaviour of sandy soil subjected to dynamic loading.* Doctor of Philosophy. University of Sydney, Sydney. Faculty of Engineering & Information Technologies

[4] Thiele. R. /Bammann, U. (2009): *Verfahren der Drucksondierung an Land und im Wasser, Sicherung von Dämmen, Deichen und Stauanlagen*, Universität Siegen.

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